

**SAMRATE
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JAMB SERIES REMIX

**From
1978
till date**

Past Questions & Answers

On

PHYSICS



COMPILED BY: SAM O. ADEDARA

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PREFACE

This booklet is specifically designed to address the yearning of students over the years for quality texts that would diligently provide solutions to JAMB/UTME past questions. The solutions herein are accurate, detailed and systemically developed. The questions are not arranged in chronological order of their appearance as JAMB's past questions. It is a topic-by-topic approach geared towards making revision easy for both the teachers and the taught.

This is by no means a substitute for your standard texts although it provides basic facts and figures necessary to do well in your examination while informal gist and hints pervade the entire "bookscape". Students preparing for GCE/WASSCE will also find the booklet invaluable.

ADEDARA Samuel Oloosebikan
February, 2019

ACKNOWLEDGEMENT

Special thanks to the Joint Admission and Matriculation Board (JAMB) for the use of its past questions. We also thank those who contributed in one way or the other to make this publication a reality. To my colleagues who read through the manuscript, your professional touches are highly appreciated. You are the best!

ADEDARA Samuel Oloosebikan
February, 2019

HOW TO USE THIS BOOKLET

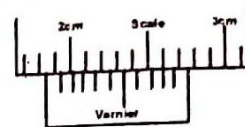
1. Pick a topic of interest and gather enough background knowledge from your standard text.
2. Now approach the topic in this booklet and attempt all the available questions.
3. Assess yourself by using the correct ABC... options suggested in the solutions provided.
4. Then turn to the detail answers with a view to knowing the whys and wherefores of the answers chosen.
5. Make the maximum use of the cross-references involving related questions.
6. Where necessary, facts and figures are provided for your in-depth learning with future questions in mind.
7. Take note of the informal gist, shortcuts and formulae principally engineered to guarantee your satisfaction.
8. This booklet is a dish best served in company of a friend or study group.
9. Approach your teacher for further explanation on any novel idea developed herein.
10. This booklet offers you an opportunity to completely attempt all questions ever set by JAMB because of its topic-by-topic style, leave no stone unturned.

Best Wishes
ADEDARA Samuel Oloosebikan
February 2019

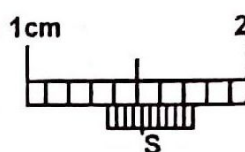
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**CHAPTER 1
MEASUREMENT. DIMENSION. SCALAR
AND VECTOR QUANTITIES**

- The internationally agreed system of units (SI) for physical measurement are A. lb,ft,sec B. g,m,sec C. kg,m,sec D. cm, g, sec E. kg,cm,sec. (1978:Q9)
- To determine the weight of an object you could A. use a beam balance B. use a spring balance C. find the force necessary to give it a certain acceleration D. use none of these methods E. use any of these methods (1978:Q10)
- Which of the following physical quantities is **NOT** a vector? A. Velocity B. Work C. Force D. Electric field intensity E. Magnetic induction. (1980:Q11)
- An example of a scalar quantity is A. Velocity B. weight C. electric charge D. acceleration due to gravity E. momentum. (1981:Q15)
- One of the following readings represents the measurement of the length of a metal rod using vernier callipers. Taking the reading accuracy into consideration, the most likely one is A. 5.16cm B. 5.165cm C. 5.0cm D. 5.160cm E. 5cm (1982:Q3)
- Which of the following is **NOT** a vector quantity A. Force B. Altitude C. Weight D. Displacement E. Acceleration. (1983:Q2)
- Of the following derived units, the one that is not a unit of power is A. Joule/second B. Ampere volt C. Ampere²volt D. Ohm²/volt E. Volts²/ohm. (1983:Q29)
- For which of the under listed quantities is the derived unit ML^2T^{-2} correct? I. Moment of a force II. Work III. Acceleration A. I only B. II only C. III only D. I and II E. II and III (1984:Q3)
- Which of the following is **NOT** a fundamental S.I. unit? A. Metre B. Ampere C. Kelvin D. Second E. Radian (1985:Q1)
- Which of the following statements are true about the spring balance and the chemical balance? I. Both are used to measure the mass of an object. II. Either of them may be used to measure the weight of an object. III. The spring balance works on the principle of Hooke's law while the chemical balance works on the principle of moments. IV. A change in gravity changes the readings of a spring balance but not that of a chemical balance. A. I and IV B. II and III C. III and IV D. I, II, and III E. I and III. (1985:Q3)
- Which of the following represents the correct precision if the length of a piece of wire is measured with a metre rule? A. 35mm B. 35.0mm C. 35.00mm D. 35.01mm (1986:Q1)
- Which of the following is a derived unit? A. Kilogramme B. Metre C. Kelvin D. Newton (1986:Q4)
- Which of the following units is equivalent to $kgms^{-1}$? A. Ns^{-1} B. Nms C. Ns D. Js^{-1} (1987:Q1)
- Which of the following are the correct SI units of the quantities indicated? I. N (Force) II. Nm^{-1} (Torque) III. Watt (power) IV $kgms^{-2}$ (Momentum). A. I and II only B. I, II and III only C. I, II and IV only D. I and III only. (1988:Q2)
- Which of the following quantities are scalars? I. Electrical potential II. Torque III. Momentum IV. Kinetic energy A. II and III only B. I and II only C. III and IV only D. I and IV only. (1988:Q5)
- Which of the following is a set of vectors? A. Force, mass and moment B. Acceleration, velocity and moment C. Mass, weight and density D. Mass, volume and density (1989:Q1)
- What is the reading of the vernier scale above? A. 1.88cm B. 1.80cm C. 1.28cm D. 1.97mm (1990:Q1)

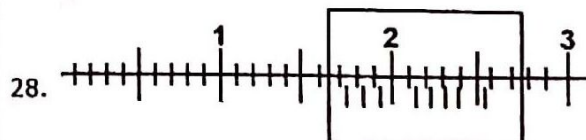


- Which of the following is a fundamental unit? A. Newton B. Watt C. Joule D. Second (1990:Q2)
- What is the least possible error in using rule graduated in centimeters? A. 0.1cm B. 0.5cm C. 1.0cm D. 2.0cm (1992:Q1)
- Which of the following quantities has the same unit as the watt? A. Force x time B. Force x distance C. Force x acceleration D. Force x velocity (1993:Q1)
- The external and internal diameters of a tube are measured as $(32 \pm 2)mm$ and $(21 \pm 1)mm$ respectively. Determine the percentage error in the thickness of the tube. A. 27% B. 14% C. 9% D. 3% (1993:Q2)



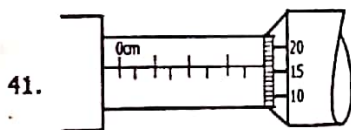
- What is the reading of the vernie calipers shown above? A. 1.79cm B. 1.73cm C. 1.39cm D. 1.34cm (1994:Q1)

- Which of the following is the dimension of pressure? A. $ML^{-1}T^{-2}$ B. MLT^{-2} C. ML^2T^{-3} D. ML^{-3} (1995:Q1)
- At what respective values of x, y and z would the unit of force, the Newton, be dimensionally equivalent to ML^xT^y ? A. -1, 1, 2 B. 1, 2, -2 C. 1,-1, 2 D. -1, 1,-2 (1997:Q1)
- The physical quantity that has the same dimensions as impulse is A. Energy B. Momentum C. Surface tension D. Pressure. (1998:Q1)
- The inner diameter of a small test tube can be measured accurately using a A. Micrometer screw gauge B. Pair of dividers C. Metre rule D. Pair of vernier calipers. (1999:Q9)
- Which of the following consists entirely of vector quantities? A. Velocity, magnetic flux and reaction B. Tension, magnetic lux and mass C. Displacement, impulse and power D. Work, pressure and moment (2001:Q9)



- The length of a piece of glass block was measured by means of a vernier calliper as shown above. The length of a glass block is A. 1.63cm B. 1.64cm C. 1.65cm D. 1.66cm (2003:Q4)
- The pair of physical quantities consisting of vectors only are A. acceleration and speed. B. displacement and torque. C. velocity and distance D. momentum and power. (2005: Q33)
- The correct unit of energy density is A. $kgm^{-3}s^{-2}$ B. $kgm^{-1}s^{-2}$ C. kgm^2s^{-2} D. kgm^2s^{-2} (2006: Q20)
- The dimensions of electromotive force are A. $ML^2T^{-1}I^{-1}$ B. $ML^2T^{-2}I^{-1}$ C. $M^2LT^{-1}I^{-1}$ D. $M^2LT^{-1}I^{-1}$ (2008:Q1)
- I. Force (N) II. Torque (Nm^{-1}) III. Current (A) IV. Power (W). Which of the above are the correct S.I. units of the quantities indicated? A. I and II only B. I and III only C. I, II and III only D. I, III and IV only (2008:Q2)
- Which of the following is **NOT** a vector quantity? A. Altitude B. Acceleration C. Displacement D. Weight (2008:Q4)

34. The values of x, y and z respectively in the expression $MxLyTz$ for the universal gravitational constant G are
 A. 2, -3, -2. B. -1, 3, -2. C. -1, 2, -3 D. -2, -1, 3 (2009:Q1)
35. I. Diameter of a small ball bearing. II. Thickness of a piece of paper. III. Diameter of a measuring cylinder. IV. Length of a piece of wire. Which of the above can be measured using a micrometer screw gauge? A. I, II and IV only B. I and II only C. II and III only D. III and IV only (2009:Q2)
36. In order to remove the error of parallax when taking measurements with a metre rule, the eye should be focused
 A. slantingly towards the left on the markings B. slantingly towards the right on the markings C. vertically downwards on the markings D. vertically upwards on the markings. (2012:Q2)
37. The pair of physical quantities that are scalar only are A. volume and area. B. moment and momentum C. length and displacement. D. impulse and time. (2013:Q4)
38. What is the least possible error encountered when taking measurement with a meter rule? A. 1.0mm. B. 0.5mm. C. 0.2mm D. 0.1m (2014:Q2)
39. A quantity which requires magnitude and direction to be specified A. distance B. displacement. C. mass D. temperature (2014:Q3)
40. I. Electrical potential II. Torque III. Kinetic energy IV. Momentum. Which of the quantities listed above are vectors? A. I and II. B. I and III. C. II and III. D. II and IV. (2014:Q4)



41. From the diagram above, the measuring accuracy of the micrometer screw gauge is
 A. 4.70mm B. 4.78mm
 C. 4.66mm D. 4.16mm (2015:Q33)
42. An instrument whose accuracy is 0.05cm is the A. metre rule B. vernier callipers C. micrometer screw gauge D. lever balance (2016:Q13)
43. The dimension of work and energy are A. ML^2T^{-3} B. MLT^{-1} C. ML^2T^{-2} D. ML^{-3} (2016:Q23)
44. The dimension of power are A. ML^2T^{-3} B. ML^1T^{-1} C. MLT^{-2} D. MLT^{-3} (2017:Q28)
45. Which of the following is the dimension of pressure? A. ML^{-1} B. MLT^{-2} C. ML^2T^{-3} D. ML^{-3} (2018:Q33)

CHAPTER 1: ANSWERS

- 1C The 3 most basic units and the quantities they measure are
- | | | |
|----------------|---|------------|
| kilogram (kg) | — | Mass (m) |
| Metre (m) | — | Length (s) |
| Second (s/sec) | — | Time(t) |
- NOTE**
- Basic units are also called fundamental units and they are not based on other units
 - Fundamental units other than kg, m, s are:

| | | |
|--------------|---|------------------------|
| Ampere (A) | — | Electric current (I) |
| Kelvin (K) | — | Temperature (0) |
| Moles (mol) | — | Amount of substance |
| Candela (cd) | — | Luminous Intensity (L) |
 - A derived quantity and its unit are derived from one or more fundamental quantity
- 2B While a spring balance operates on the basis of Hooke's law, a beam balance which measures mass operates on the Principle of moment
- 3B Work is a scalar quantity because it is defined in terms of magnitude (size) only

| Scalar | Vector |
|----------------------|--------------------|
| Mass | Weight/force |
| Distance/length | Displacement |
| Speed | Velocity |
| Time | Acceleration |
| Area/Volume | Momentum |
| Temperature | Moment/Torque |
| Pressure/Density | Electric Field |
| Power/Energy/Work | Magnetic Induction |
| Electric charge | Magnetic Flux |
| Electrical Potential | |

Note:

- A vector quantity is only fully described by its size and direction.
- Sometimes temperature could be vector especially when it determines the direction of flow of heat energy between two bodies.

4C See Q3

5A Consider the following and their reading accuracy.

| | | |
|------------------------|---|-------------------|
| Metre rule | - | 1mm or 0.1cm |
| Vernier calipers | - | 0.1mm or 0.01cm |
| Micrometer screw gauge | - | 0.01mm or 0.001cm |
| Beam balance | - | 0.001g |
| Stop clock/stop watch | - | 0.1 sec |

Note:

- Reading accuracy is the smallest possible graduation on the instrument.
- The 0.01cm reading accuracy for V. callipers above means it reads up to 2 decimal places on the "cm" scale or 1d.p. on the "mm" scale

6B Altitude is simply a vertical distance

7B (A): Power = $\frac{\text{Energy expended or work done}}{\text{Time taken}}$

Power \rightarrow Joule/Sec

(B): Power = Current x voltage = IV
 Power \rightarrow Ampere Volt

(C): But $V = IR \therefore P = I^2R$
 Power \rightarrow Ampere²ohm (not Ampere²volt)

(E): $I = \frac{V}{R} \therefore P = \frac{V^2}{R}$ Power \rightarrow volt²/ohm

Hence (C) and (D) are not units of power

8D Using M = Mass L = Length and T = Time

Velocity = $\frac{\text{Distance}}{\text{Time}} = \frac{L}{T} \rightarrow LT^{-1}$

Acceleration = $\frac{\text{velocity}}{\text{Time}} = \frac{LT^{-1}}{T} \rightarrow LT^{-2}$

Force = Mass x acceleration = $M \times LT^{-2} \rightarrow MLT^{-2}$

Moment = Force x distance $\Rightarrow MLT^{-2} \times L \rightarrow ML^2T^{-2}$

Also work = Force x distance $\Rightarrow ML^2T^{-2}$

9E Radian is a dimensionless unit which could be regarded as a derived unit from its definition

Angle (in rad) = $\frac{\text{Length of Arc}}{\text{Radius of circle}} = \frac{L}{L} \rightarrow \frac{\text{Metre}}{\text{Metre}} = 1$

Thus radian is a pure number because it is the ratio of two lengths

10C See Q2 and also chapter 5

11A See Q5 but note that (B) is only correct as 35.0cm not as 35.0mm. because a meter rule measures length to the nearest mm

12D Force (in Newton) = Mass x acceleration
 $\rightarrow kg \times ms^{-2} = kgms^{-2}; 1kgms^{-2} = 1 \text{ Newton}$

13C $F = \text{Mass} \times \text{acceleration}$ hence Newton(N) $\rightarrow kg \times ms^{-2}$
 $\therefore N.s \rightarrow kg \times ms^{-2} \times s; Ns = kgms^{-1}$

See chapter 3 for details about the units of momentum and impulse

- 14D. Torque = Force x distance \rightarrow F.s
 15D. See Q3 16B. See Q3
 17A. Main scale: M = 1.80cm; Vernier Scale: V = 0.08cm
 Total (M + V) = 1.88cm
NOTE: Vernier scale reading is taken where M coincides with V.
 18D. See Q1 19A. See Q5
 20D. Power (Watt) = $\frac{\text{Work/Energy}}{\text{Time}}$ But Work = Force x Distance

$$\therefore \text{Power} = \frac{\text{Force} \times \text{Distance}}{\text{Time}} = \text{Force} \times \frac{\text{Distance}}{\text{Time}}$$

Hence Power = Force x velocity

- 21C. Actual Thickness = 32 - 21 = 11mm
 Error in thickness = 2 - 1 = 1mm
 $\% \text{ Error} = \frac{\text{Error}}{\text{Actual Thickness}} \times 100\% = \frac{1}{11} \times 100\% = 9\%$
NOTE: Take the absolute value of the error without recourse to the \pm sign.
 22C M = 1.30cm; V = 0.09cm; T (M + V) = 1.39cm

- 23A Pressure = $\frac{\text{Force}}{\text{Area}}$, But Force \rightarrow MLT⁻² (Q8);
 and Area = Length x Breadth = L²
 \therefore Pressure = $\frac{\text{MLT}^{-2}}{\text{L}^2} = \text{ML}^{-1}\text{T}^{-2}$

- 24B Force \rightarrow MLT⁻² (Q8) \therefore M¹L¹T⁻² = MLT⁻²
 Comparing LHS and RHS: x = 1 y = 1 and z = -2

- 25B Force = $\frac{\text{Change in momentum}}{\text{Time}}$
 $F = \frac{mv - mu}{t}$ or Ft = mv - mu

(Impulse = Force x time) \therefore Impulse \rightarrow Momentum

- 26D While calipers would measure the diameter of a tube or a rod, a micrometer screw gauge measures even smaller lengths such as thickness of a paper, diameter of a wire or pendulum bob
 27A See Q3 and note that **reaction** is a force.
 28B M = 1.60cm; V = 0.04cm; T = 1.64cm
 29B See Q3

- 30B Energy Density = $\frac{\text{Energy}}{\text{Volume}}$
 But Energy = F x s \rightarrow kgms⁻². m
 and volume = L³ \rightarrow m³ \therefore Energy Density \rightarrow $\frac{\text{kgm}^2\text{s}^{-2}}{\text{m}^3}$
 \rightarrow kgm²s⁻². m³ = kgm⁻¹s⁻²

- 31A By definition, the e.m.f. or V is the work done in moving a unit charge round a circuit

$$V = \frac{\text{Work done}}{\text{Quantity of electricity}} \rightarrow V = \frac{W}{Q} = \frac{F \times S}{It}$$

Inserting units into the above

$$V \rightarrow \frac{\text{kgms}^{-2} \times \text{m}}{\text{A} \times \text{s}} \rightarrow \text{kgm}^2\text{s}^{-3}\text{A}^{-1}$$

Remember current (I) and ampere (A) are fundamental quantity and unit respectively, then insert MLT and I.
 kgm²s⁻³A⁻¹ \rightarrow ML²T⁻³I⁻¹

- 32D Torque \rightarrow Nm not Nm¹ 33A See Q6
 34B Considering the law of Gravitation

$$F = \frac{GMm}{r^2}; \text{ then } G = \frac{Fr^2}{Mm} \rightarrow \frac{\text{kgms}^{-2} \cdot \text{m}^2}{\text{kg} \cdot \text{kg}}$$

$$\rightarrow \text{kg}^{-1}\text{m}^3\text{s}^{-2} = \text{M}^{-1}\text{L}^3\text{T}^{-2} \rightarrow \text{M}^{-1}\text{L}^3\text{T}^{-2} = \text{M}^{-1}\text{L}^3\text{T}^{-2}$$

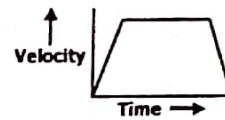
$$\therefore x = -1, y = 3, z = -2$$

- 35B See Q26
 36C Slanting view from either side of the vertical predisposes to error due to parallex
 37A. See Q3 38D. See Q5 39A. See Q3 40C. See Q3
 41D. 4mm + 0.16mm = 4.16mm
 42C. See Q5
 43C See Q8
 44A Power = $\frac{\text{Energy}}{\text{Time}} = \frac{\text{ML}^2\text{T}^{-2}}{\text{T}} = \text{ML}^2\text{T}^{-3}$
 45A See Q23

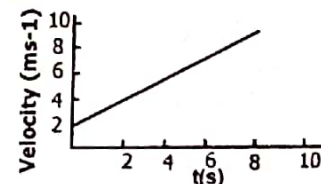
CHAPTER 2

LINEAR MOTION. PROJECTILES

- An air force jet flying with a speed of 335 ms⁻¹ went past an anti aircraft gun. How far is the aircraft 5s later when the gun was fired? A. 838m B. 3350m C. 670m D. 1675m E. 67m (1978:Q3)
- A palm fruit dropped to the ground from the top of a tree 45m tall. How long does it take to reach the ground? A. 9s B. 4.5s C. 6s D. 7.5s E. 3s (g=10ms⁻²) (1978:Q4)

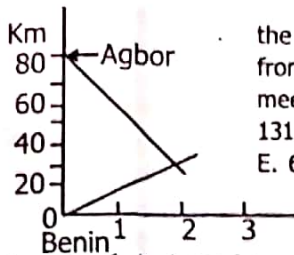


3. The figure below shows the velocity-time graph of a car which starts from rest and is accelerated uniformly at the rate of 3m sec⁻² for 5 seconds. It attains a velocity which is maintained for 1 minute, another 3 seconds. Calculate the total distance covered A. 900 metres B. 1 920 metres C. 1 020 metres d. 960 metres E. 860 metres (1979:Q49)
- The motion of the moving skin of a talking drum can rightly be described as A. translational B. random C. rotational D. oscillatory E. transitory (1980:Q12)



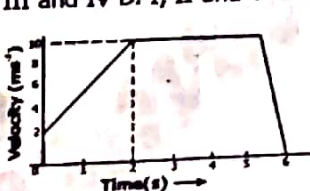
5. What is the acceleration of a particle whose motion is graphically displayed in the above figure? A. 0.67ms⁻²
 B. 0.83ms⁻² C. 0.87ms⁻² D. 92ms⁻² E. 2.0ms⁻² (1980:Q23)
- The driver in a motor car, of which the total mass is 800kg and which is travelling at 20ms⁻¹, suddenly observes a stationary dog in his path 50m ahead. If the car brakes can exert a force of 2000N, what will most likely happen?
 A. The car will be able to stop immediately the driver notices the dog B. The car will stop 30m after hitting the dog C. The car will stop 20m in front of the dog D. The driver will quickly reverse the car E. The car will stop 5m beyond the dog. (1981:Q25)

- A body falls freely under gravity (g = 9.8ms⁻²) from a height of 40m on to the top of platform 0.8m above the ground. Its velocity on reaching the platform is A. 784ms⁻¹ B. 80ms⁻¹ C. 78.4ms⁻¹ D. 39.2ms⁻¹ E. 27.7ms⁻¹ (1981:Q33)
- Two particle X and Y starting from rest cover the same distance. The acceleration of X is twice that of Y. The ratio of the time taken by X to that taken by Y is A. $\frac{1}{2}$ B. 2 C. $\frac{1}{\sqrt{2}}$ D. $\sqrt{2}$ E. 4 (1981:Q35)
- Two taxis leave Benin and Agbor some 80km apart at 1200hr (Fig. 1). From the distance time graph shown,



the distance of their meeting point P from Benin, and the time of their meeting are A. 27km, 1218hr B. 29km, 1315hr C. 40km, 1418km D. 53km, 1436hr E. 60km, 1500hr (1982:Q12)

10. A mango fruit drops from a branch 10m above the ground. Just before hitting the ground its velocity is ($g = 10\text{ms}^{-2}$).
 A. $10\sqrt{2}\text{ms}^{-1}$ B. $\frac{10}{\sqrt{2}}\text{ms}^{-1}$ C. 100ms^{-1} D. $5\sqrt{2}\text{ms}^{-1}$ E. 200ms^{-1} . (1982:Q13)
11. Which of the following statements is true of a body which is moving in a straight line with uniform acceleration? The velocity of the body A. is also uniform B. must always be zero when the body stops accelerating C. will increase with time in the direction of the acceleration D. is equal to the quotient of distance travelled and time E. is the product of the distance travelled and time. (1982:Q35)
12. A train has an initial velocity of 44m/s and an acceleration of -4m/s^2 . Its velocity after 10 seconds is A. 2m/s B. 4m/s C. 8m/s D. 12m/s E. 16m/s . (1983:Q15)
13. The distance travelled by a particle starting from rest is plotted against the square of the time elapsed from the commencement of motion. The resulting graph is linear. The slope of this graph is a measure of A. Initial displacement B. Initial velocity C. Acceleration D. Half the acceleration E. Half the initial velocity (1984:Q1)
14. Which of the following types of motion are oscillatory?
 I. A diving board when used by a diver. II. The motion of the balance wheel of a wristwatch. III. The motion of the turntable of a record player. IV. The motion of the center of a ten kobo piece as it rolls down an inclined plane. V. The motion of the needle of a D.C. ammeter into which a low A.C. current is passed. A. I and II only B. I, II and III C. II, III and IV D. I, II and V E. III, IV, and V. (1985:Q4)



The graph above describes the motion of a particle. The acceleration of the particle during the motion is A. 0.00ms^{-2} B. 0.25ms^{-2} C. 4.00ms^{-2} D. 8.00ms^{-2} E. 10.00ms^{-2}

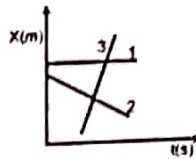
15. (1985:Q5)
16. If a car starts from rest and moves with a uniform acceleration of 10ms^{-2} for ten seconds, the distance it covers in the last one second of the motion is A. 95m B. 100m C. 500m D. 905m E. 1000m (1985:Q6)
17. Two objects, one having three times the mass of the other, are dropped at the same time from a tall building. When they are above the ground, the two objects will have the same A. Momentum B. Kinetic energy C. Potential energy D. Acceleration. (1986:Q5)
18. A ball is thrown vertically into the air with an initial velocity. What is the greatest height reached?
 A. $\frac{u}{2g}$ B. $\frac{3u^2}{2g}$ C. $\frac{u^2}{g}$ D. $\frac{u^2}{2g}$ (1986:Q7)



19. The velocity-time graph above describes the motion of a particle between two points P and Q. What is the distance between P and Q? A. 17.0m B. 18.0m

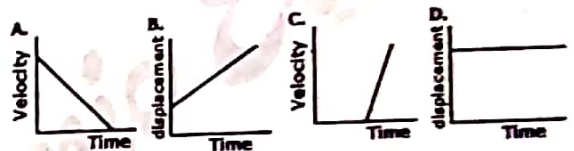
C. 22.5m D. 30.0m (1987:Q3)

20. A particle starts from rest and moves with a constant acceleration of 0.5ms^{-2} . The distance covered by the particle in 10s is A. 2.5m B. 5.0m C. 25.0m D. 50.0m (1988:Q6)



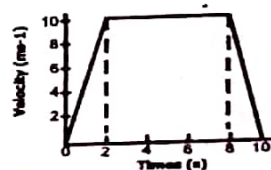
21. The figure above show the displacement-time graphs for three different motions. Which of the following statements is correct? A. Graph 2 corresponds to the highest velocity B. Graph 1 corresponds to zero velocity C. Graph 3 corresponds to a particle moving in the negative x direction. D. Graph 2 corresponds to a particle moving in the positive x directions. (1988:Q9)

22. Two points on a velocity-time graph have coordinates $(5, 3)$ and $(20, 20\text{ms}^{-1})$. Calculate the mean acceleration between the two points. A. 0.67ms^{-2} B. 0.83ms^{-2} C. 1.50ms^{-2} D. 2.00ms^{-2} (1989:Q3)
23. Which of the following graphs represents motion with uniform velocity?



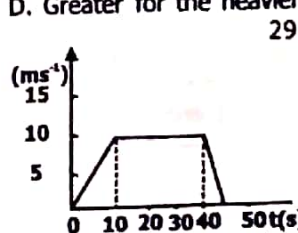
(1989:Q5)

24. A car moving with a speed of 90kmh^{-1} was brought uniformly to rest by the application of the brakes in 10s. How far did the car travel after the brakes were applied? A. 125m B. 150m C. 250m D. 15km (1990:Q4)



What is the average velocity of the sprinter whose velocity-time graph is shown in the figure above? A. 85.0ms^{-1} B. 17.0ms^{-1} C. 8.5ms^{-1}

25. D. 1.7m s^{-1} (1990:Q6)
26. A small metal ball is thrown vertically upwards from the top of a tower with an initial velocity of 20ms^{-1} . If the ball took a total of 6s to reach ground level, determine the height of the tower. A. 60m B. 80m C. 100m D. 120m [$g = 10\text{ms}^{-2}$] (1991:Q3)
27. A body starts from rest and moves with uniform acceleration of 6ms^{-2} . What distance does it cover in the third second? A. 15m B. 18m C. 27m D. 30m (1992:Q4)
28. A stone, Q is thrown with velocity at an angle of 75° to the horizontal. Another stone R is thrown with the same velocity but at an angle of 15° to the horizontal. The ranges covered by the stones will be A. Greater for Q B. Greater for R C. The same for Q and R D. Greater for the heavier of the stones (1992:Q5)

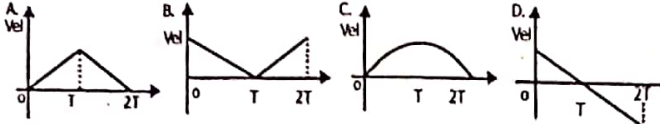


29. The diagram above shows a velocity-time graph representing the motion of a car. Find the total distance covered during the acceleration and the retardation periods of the motion. A. 75m B. 150m C. 300m D. 375m (1993:Q3)

30. An aeroplane lands on a runway at a speed of 180kmh^{-1} and is brought to a stop uniformly in 30 seconds. What distance does it cover on the runway before coming

to rest A. 360m B. 540m C. 750m D. 957m (1993:Q5)

31. An object is projected with velocity of 80 ms^{-1} at an angle of 30° to the horizontal. The maximum height reached is
A. 20m B. 8m C. 160m D. 320m (1994:Q4)
32. A motor vehicle is brought to rest from a speed of 15 ms^{-1} in 20 seconds. Calculate the retardation. A. 0.75 ms^{-2} B. 1.33 ms^{-2} C. 5.00 ms^{-2} D. 7.50 ms^{-2} (1994:Q5)
33. A stone thrown vertically upwards returns to the ground. Which of the following figures represents the velocity-time graph?



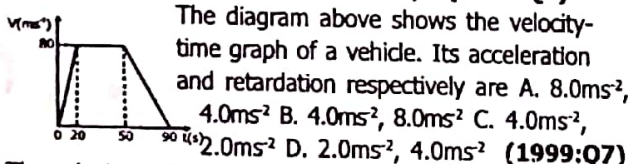
(1994:Q7)

34. When a ball rolls on a smooth level ground, the motion of its centre is A. Translational B. Oscillatory C. Random D. Rotational (1995:Q5)
35. The velocity-time graph of a body moving in a straight line and decelerating uniformly to rest is represented by



(1995:Q6)

36. The distance x m traveled by a particle in time t seconds is described by the equation $x = 10 + 12t^2$. Find the average speed of the particle between the time interval $t = 2\text{s}$ and $t = 5\text{s}$. A. 60 ms^{-1} B. 72 ms^{-1} C. 84 ms^{-1} D. 108 ms^{-1} (1997:Q2)
37. Two bodies X and Y are projected on the same horizontal plane, with the same initial speed but at angles 30° and 60° respectively to the horizontal. Neglecting air resistance, the ratio of the range of X to that of Y is A. 1:1 B. 1:2 C. $\sqrt{3} : 1$ D. $1 : \sqrt{3}$ (1997:Q5)
38. In free fall, a body of mass 1kg drops from a height of 125m from rest in 5s. How long will it take another body of mass 2kg to fall from rest from the same height? A. 5s B. 10s C. 12s D. 15s ($g = 10 \text{ ms}^{-2}$) (1998:Q4)

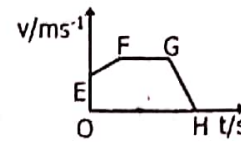


The diagram above shows the velocity-time graph of a vehicle. Its acceleration and retardation respectively are A. 8.0 ms^{-2} , 4.0 ms^{-2} B. 4.0 ms^{-2} , 8.0 ms^{-2} C. 4.0 ms^{-2} , 2.0 ms^{-2} D. 2.0 ms^{-2} , 4.0 ms^{-2} (1999:Q7)

39. The velocity v of a particle in a time t is given by the equation $v = 10 + 2t^2$. Find the instantaneous acceleration after 5 seconds. A. 10 ms^{-2} B. 15 ms^{-2} C. 20 ms^{-2} D. 60 ms^{-2} (2000:Q8)
41. A motorcyclist travelling at 30 ms^{-1} starts to apply his brakes when he is 50m from the traffic light that has just turned red. If he just reached the traffic light, his deceleration is A. 5 ms^{-2} B. 9 ms^{-2} C. 10 ms^{-2} D. 18 ms^{-2} . (2005:Q28)
42. The motion of smoke particles from a chimney is typical of A. oscillatory motion. B. rotational motion. C. circular motion D. random motion. (2006:Q13)
43. A shooter wants to fire a bullet in such a way that its horizontal range is equal to three times its maximum height. At what angle should he fire the bullet to achieve this? A. 53° B. 68° C. 30° D. 45° (2006:Q19)
44. What is the acceleration between two points on a velocity-time graph which has coordinates $(10\text{s}, 15 \text{ ms}^{-1})$ and $(20\text{s}, 35 \text{ ms}^{-1})$? A. 1.75 ms^{-2} B. 3.50 ms^{-2} C. 1.00 ms^{-2} D. 2.00 ms^{-2} (2009:Q4)
45. A car accelerates uniformly from rest at 4 ms^{-2} . How far will

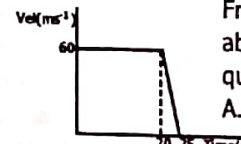
it travel in the fifth complete second? A. 100m B. 50m C. 32m D. 18m (2009:Q5)

46. A bullet fired vertically upward from a gun held 2.0m above the ground reaches its maximum height in 4.0s. Calculate its initial velocity. A. 10 ms^{-1} B. 8 ms^{-1} C. 40 ms^{-1} D. 20 ms^{-1} ($g = 10 \text{ ms}^{-2}$) (2009:Q8)



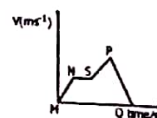
The diagram above shows a velocity-time graph. The statement that is true about this motion is that the car

47. A. decelerates between points F and H. B. accelerates between points F and G. C. has a constant speed between points E and F D. has no acceleration between point F and G. (2010:Q3)
48. A stone and a feather are dropped from the same height above the earth surface. Ignoring air resistance, which of the following is correct? A. The stone and feather will both reach the ground at the same time B. The stone will reach the ground first C. The feather will reach the ground first D. The feather will be blown away by the wind while stone will drop steadily (2010:Q4)
49. A car moves with an initial velocity of 25 ms^{-1} and reaches a velocity of 45 ms^{-1} in 10s. What is the acceleration of the car? A. 5 ms^{-2} B. 25 ms^{-2} C. 20 ms^{-2} D. 2 ms^{-2} (2010:Q5)
50. Two balls X and Y weighing 5 g and 50kg respectively were thrown up vertically at the same time with a velocity of 100 ms^{-1} . How will their positions be one second later? A. X will be 500m ahead of Y B. X and Y will be 500m from the point of throw C. X and Y will be 500m from each other D. Y will be 500m ahead of X. (2011:Q3)
51. If it takes an object 3s to fall freely to the ground from a certain height, what is the distance covered by the object? A. 45m B. 60m C. 90m D. 30m (2011:Q7)



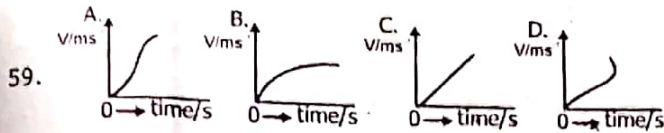
From the velocity-time graph shown above, which of the following quantities CANNOT be determined?

52. A. Deceleration B. Initial velocity C. Total distance travelled D. Initial acceleration (2012:Q5)
53. Calculate the total distance covered by a train before coming to rest if its initial speed is 30 ms^{-1} with a constant retardation of 0.1 m^{-2} . A. 5 500m B. 4 500m C. 4 200m D. 3 000m (2012:Q6)
54. A car starts from rest and moves with a uniform acceleration of 30 ms^{-2} for 20s. Calculate the distance covered at the end of the motion. A. 6km B. 12km C. 18km D. 24km (2012:Q7)
55. A train with an initial velocity of 20 ms^{-1} is subjected to a uniform deceleration of 2 m^{-2} . The time required to bring the train to a complete halt is A. 5s. B. 10s. C. 20s. D. 40s. (2013:Q6)
56. Which type of motion do the wheels of a moving car undergo? A. Random and translational motion. B. Rotational and oscillatory motion. C. Translational and rotational motion D. Vibratory and translational motion (2014:Q5)



From the diagram above, the region of zero acceleration is A. MN. B. NS. C. SP. D. PQ (2014:Q6)

58. A car starts from rest and accelerates uniformly, its velocity after travelling a distance of 24m is A. 144 ms^{-1} B. 72 ms^{-1} C. 36 ms^{-1} D. 12 ms^{-1} (2014:Q7)



59. Which of the velocity-time graphs shows uniform acceleration of a body from rest? (2015:Q26)
60. A projectile is fired from the ground level with a velocity of 300ms^{-1} at an angle of 30° to the horizontal. Calculate the time taken to reach the maximum height. [$g = 10\text{ms}^{-2}$]
A. 25s B. 30s C. 20s D. 15s (2015:Q28)
61. A train with an initial velocity 20ms^{-1} is subjected to a uniform deceleration of 2ms^{-2} . The time required to bring the train to a complete halt is A. 20s B. 40s C. 10s D. 5s. (2015:Q50)
62. A football is hit with a velocity of 6ms^{-1} at an angle of 30° to the horizontal. The time of flight of the ball is A. 0.6s B. 0.4s C. 5s D. 0.3s (2016:Q43)
63. A car has an initial velocity of 40ms^{-1} and retards at 3ms^{-2} . Calculate its velocity after 10s. A. 10ms^{-1} B. 4ms^{-1} C. 40ms^{-1} D. 20ms^{-1} (2015:Q48)
64. A body moving at 20ms^{-1} decelerates uniformly at 5ms^{-2} till its speed becomes 10ms^{-1} . The distance covered within this period is A. 30m B. 20m C. 50m D. 60m (2017:Q17)

CHAPTER 2 ANSWERS

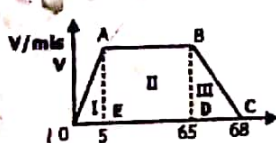
- 1D At constant speed: $s = vt$ where
 $s = \text{distance}; v = \text{speed} = 335\text{ms}^{-1}; t = \text{time} = 5\text{s}$
 $s = 335 \times 5 = 1675\text{m}$
2. $u = 0; s = h = 45\text{m}; a = +g = 10\text{ms}^{-2}; t = ?$
Using the equation of motion:
 $s = ut + \frac{1}{2}at^2 \rightarrow 45 = 0(t) + \frac{1}{2} \times 10 t^2$
 $\rightarrow 45 = 5t^2; \text{ and } t = 3\text{s}$

NOTE

- For motion under gravity (in a free fall) take
 - $a = +g$ for downward motion
 - $a = -g$ for upward motion
- If the body is released from a height, take $u = 0$
- If thrown vertically upwards with an initial velocity u then take final velocity as $v = 0$
- An upward journey is identical, except in direction, to the downward journey for a body under gravity.

| Parameter | Upward | Downward |
|------------------|------------------------|------------------------|
| Initial velocity | $u_u = 0$ | $u_d = u_{\text{max}}$ |
| Final velocity | $v_u = v_{\text{max}}$ | $v_d = 0$ |
| Acceleration | $a = -g$ | $a = +g$ |
| Time | $t_u = t$ | $t_d = t$ |
| Distance | $s = h$ | $s = h$ |

5. From the table above, u_u of upward is the v_d of downward and vice versa and the time taken for both are the same
 $\rightarrow t_u = t_d = t$



From the graph: $v = 3 \times 5 = 15\text{ms}^{-1}$.
Consider trapezium OABC:
Area = $\frac{1}{2}$ (sum of parallel sides) \times height

$\therefore s = \frac{1}{2} (AB + OC) \times AE = \frac{1}{2} (60 + 68) 15 = 960\text{m}$

Alternatively: consider the journey in 3 stages I, II and III

Stage I: Area of $\triangle QAE = \frac{1}{2}$ base \times height

$S_1 = \frac{1}{2} OE \times AE = \frac{1}{2} \times 5 \times 15 = 37.50\text{m}$

Stage II: Area of $\square ABDE = \text{length} \times \text{breadth}$

$S_2 = AE \times AB = 15 \times (65 - 5) = 900\text{m}$

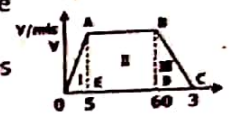
Stage III: Area of $\triangle BCD: S_3 = \frac{1}{2} DC \times BD$

$S_3 = \frac{1}{2} (68 - 65) \times 15 = 22.50\text{m}$

Total distance covered: $S_T = S_1 + S_2 + S_3$
 $S_T = 37.50 + 900 + 22.50$
 $S_T = 960\text{m}$ (as before)

NOTE:

- In the labelling of the graph above, O is both a letter and a number (Zero)
- In an exam, not involving multiple choice (Obj.), it is wrong and unscientific to label the graph as shown below otherwise
ED $60 - 5 = 55\text{s}$; and
DC $= 60 - 3 = 57$



4D The skin vibrates when beaten

NOTE:

- Translational motion** - Motion on a more or less straight line, also called linear motion
- Random motion** - follows no regular pattern
- Rotational motion** - describes a circle
- Oscillatory** - A to-and-fro motion describes a vibration and is usually called simple Harmonic motion

5A Acceleration = slope of graph

6B $F = Ma$ (Newton's 2nd Law of Motion; See Chapter 3)

$\therefore a = \frac{-F}{m} = \frac{-2000}{800} = 2.5\text{ms}^{-2}$

Now $a = -2.5\text{ms}^{-2}; u = 20\text{ms}^{-1}; v = 0$ and $s = ?$
Using the relation: $v^2 = u^2 + 2as$

$0 = 20^2 + 2(-2.5)s$; and $s = 80\text{m}$

The result suggests that the car travels 80m after the brake is applied i.e. extra 30m after running the dog over.

NOTE:

- The force is negative because it is a braking force whose direction is opposite the motion of the car
- This produces a negative acceleration (or retardation)
- ...otherwise your final answer would be -80m for distance, a scalar quantity

7E $u = 0; s = h = 40 - 0.8 = 39.2\text{m}; a = +g = 9.8\text{ms}^{-2}; v = ?$
Using $v^2 = u^2 + 2as \rightarrow v^2 = 0^2 + 2 \times 9.8 \times 39.2$; and $v = 27.7\text{ms}^{-1}$

NOTE: To know which equation of motion is appropriate for a problem.

- Consider five parameters involved: u, v, s, t, a
- You will be implicitly or explicitly given information on 3 of these and asked to solve one or both of the others.
- Choose an equation which does not contain the silent parameter.

i. $s = \frac{(u+v)t}{2}$ (No parameter 'a')

ii. $v = u + at$ (No parameter 's')

iii. $s = ut + \frac{1}{2}at^2$ (No parameter 'v')

iv. $v^2 = u^2 + 2as$ (No parameter 't')

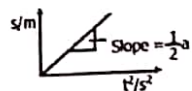
8C Since v is not involved, use: $s = ut + \frac{1}{2}at^2$

$\rightarrow s = \frac{1}{2}at^2$ ($u = 0$ for both)

$S_{1,n} = 2a_1$ and $S_2 = S_1$

Then $\frac{S_2}{S_1} = \frac{\frac{1}{2}a_2t_2^2}{\frac{1}{2}a_1t_1^2} \rightarrow 1 = \frac{a_2t_2^2}{a_1t_1^2} = \frac{2a_2t_2^2}{a_1t_1^2}$

$$2t_x^2 = t_y^2 \rightarrow \frac{t_x^2}{t_y^2} = \frac{1}{2} \rightarrow \left(\frac{t_x}{t_y}\right)^2 = \frac{1}{2} \rightarrow \frac{t_x}{t_y} = \sqrt{\frac{1}{2}} = \frac{1}{\sqrt{2}}$$

- 9B Do some tracing to the vertical and horizontal axes
- 10A $s = 10m$ $u = 0$ $a = 10ms^{-2}$ $v = ?$
Using: $v^2 = u^2 + 2as \rightarrow v^2 = 0 + 2 \times 10 \times 10$ $v = \sqrt{200} = 10\sqrt{2}$
- 11C Acceleration here means for every given interval of time, v and the increase is constant for equal time interval for uniform acceleration
- 12B $u = 44m/s$; $a = -4m/s^2$; $t = 10s$ $v = ?$
 $v = u + at \rightarrow v = 44 + (-4)(10)$; $v = 4m/s$
NOTE: The body is decelerating hence $v < u$
- 13D Remember the relation: $s = ut + \frac{1}{2}at^2 \rightarrow s = \frac{1}{2}at^2$ (when $u = 0$). Plotting a graph of s/m against t^2/s^2 the slope is $\frac{1}{2}a$
- 
- 14A See Q4
- 15C $a = \frac{10 - 2}{2 - 0} = \frac{8}{2} = 4ms^{-2}$ (See Q5)
- 16A Distance travelled after 10s: $S_{10} = ut + \frac{1}{2}at^2$
 $= \frac{1}{2} \times 10 \times 10^2 = 500m$
Distance travelled after 9s: $S_9 = \frac{1}{2} \times 10 \times 9^2 = 405m$
Distance covered in the last 1 sec: $S_{10} - S_9 = 500 - 405 = 95m$
- 17D All bodies irrespective of mass have the same acceleration ($a = g$) under the influence of gravity and for same reason, the two objects here reach the ground level at the same time (t) as classically experimented by Galileo Galilee from the top of the famous Leaning Tower of Pisa.
NOTE: Other parameters are mass dependent
Option A: Momentum = mass x velocity
Option B: Kinetic energy = $\frac{1}{2}$ mass x velocity²
Option C: Potential energy = mass x acceleration due to gravity x height
- 18D $v = 0$; $a = -g$; $u = u$; $s = h$
But $v^2 = u^2 + 2as \rightarrow 0 = u^2 - 2gh$
And $h = \frac{-u^2}{-2g}$; $h = \frac{u^2}{2g}$
- 19B The journey is in 4 stages
(i) Stage I is a triangle: $S_1 = \frac{1}{2}(1)(4) = 2m$
(ii) Stage II is a trapezium: $S_2 = \frac{1}{2}(4 + 6)(1) = 5m$
(iii) Stage III is a rectangle: $S_3 = 6 \times 1.5 = 9m$
(iv) Stage IV is a trapezium: $S_4 = \frac{1}{2}(2 + 6)0.5 = 2m$
Total distance = $S_1 + S_2 + S_3 + S_4 = 18m$
- 20C. $u = 0$; $a = 0.5ms^{-2}$; $t = 10s$; $s = ?$
 $s = ut + \frac{1}{2}at^2 = 0(10) + \frac{1}{2}(0.5)(10)^2 = 25m$
- 21B Since $v = \frac{x}{t} \rightarrow$ slope, $v = \frac{x-x}{t-t}$
The body is stationary since $v = \frac{0}{t} = 0$ (at all time)
- 22A $a =$ slope of the graph: $a = \frac{y_2 - y_1}{x_2 - x_1} = \frac{20 - 10}{20 - 5} = \frac{10}{15} = 0.67$
- 23D Uniform velocity means $a = 0$ i.e. velocity is constant (or $v = u$) at any interval of time: $a = \frac{v - u}{t} = \frac{v - v}{t} = \frac{0}{t} = 0$
Hence graph is parallel to t -axis (Compare Q20)
- 24A $90kmh^{-2} = \frac{90 \times 1000}{60 \times 60} = 25m/s \rightarrow u = 25m/s$; $v = 0$; $t = 10s$

$$\text{Using } s = \frac{(u + v)t}{2} \text{ (if not mentioned)} \rightarrow s = \frac{(25 + 0)10}{2} = 125m$$

NOTE: All the units must agree: i. m, s, ms^{-2}, ms^{-1} or ii. $km, hr, kmh^{-2}, kmh^{-1}$

25. Total distance = Area under the graph
 $s = \frac{1}{2}(6 + 10)10 = 80m \rightarrow$ Total time taken = 10s
Average velocity = $\frac{\text{Total distance}}{\text{Total time}} = \frac{80}{10} = 8ms^{-1}$
No correct option
- 26A From top of tower to maximum height:
 $u = 20$; $v = 0$; $a = -g$; $t = ?$ $S = h_1$
 $v = u + at$; and $t = 2s$
Also $v^2 = u^2 + 2as \rightarrow 0^2 = 20^2 + 2(-10)h_1$ and $h_1 = 20m$
From maximum height to ground level:
 $u = 0$; $a = +g$; $t = (6 - 2)s$; $s = h_2$
 $h_2 = ut + \frac{1}{2}at^2 = 0(4) + \frac{1}{2} \times 10 \times 4^2 \rightarrow h_2 = 80m$
Height of tower $H_T = h_2 - h_1 = 80 - 20 = 60m$
- 27A Distance after 2s: $S_2 = \frac{1}{2}at^2 = \frac{1}{2} \times 6 \times 2^2 = 12m$
Distance after 3s: $S_3 = \frac{1}{2}at^2 = \frac{1}{2} \times 6 \times 3^2 = 27m$
Distance in the last 1s: $S = S_3 - S_2 = 27 - 12 = 15m$
NOTE: Whenever $u = 0$ and the relation $s = ut + \frac{1}{2}at^2$ applies, just use $s = \frac{1}{2}at^2$ to save time
- 28C Range (R) is given by $R = \frac{u^2 \sin 2\theta}{g}$
For $R_Q \rightarrow \sin 2(75^\circ) = \sin 150 = 0.5$
For $R_R \rightarrow \sin 2(15^\circ) = \sin 30 = 0.5$
Hence $R_Q = R_R$ (since g is the same for both)
- 29A Consider the first Δ (Stage I): $S_1 = \frac{1}{2} \times 10 \times 10 = 50$
Consider the second Δ (Stage III): $S_2 = \frac{1}{2} \times 5 \times 10 = 25$
- 25 Total distance = $50 + 25 = 75m$
- 30C $180kmh^{-1} = \frac{180 \times 1000}{60 \times 60} = 50ms^{-1}$
 $u = 50ms^{-1}$; $v = 0$; $t = 30$; $s = ?$
 $s = \frac{(u + v)t}{2} = \frac{(50 + 0)30}{2} = 750m$
NOTE:
1. The equation of motion above suggests:
Distance = Average Speed x time
2. This is particularly applicable when a body is uniformly accelerating or decelerating
3. When the body moves with uniform (constant) speed, simply use: Distance = Speed x time
 $s = vt$ (since $v = u$)
- 31B Maximum height given by: $H = \frac{u^2 \sin^2 \theta}{2g} = \frac{80^2 \sin^2 30^\circ}{2 \times 10} = 80m$
NOTE: $\sin^2 \theta = (\sin \theta)^2$
- 32A $a = \frac{v - u}{t} = \frac{0 - 15}{20} = -\frac{3}{4} = -0.75ms^{-2}$
(The negative sign indicates retardation)
- 33B Upward journey is against gravity hence the stone undergoes retardation and comes to rest at maximum height and on the return journey, it accelerates from rest to a maximum velocity just before hitting the ground - Graph B
- 34D See Q4
- 35C A downward-sloping straight line indicates deceleration

36C $v = \frac{dx}{dt}$; $v = \frac{d(10 + 12t^2)}{dt} = 24t$

When $t = 2s$: $v_2 = 24t = 48ms^{-1}$

When $t = 5s$: $v_5 = 24t = 120ms^{-1}$

Average speed = $\frac{V_2 + V_5}{2} = \frac{48 + 120}{2} = 84ms^{-1}$

Alternatively: Distance travelled after 5s:

$x_5 = 10 + 12t^2 = 10 + 12(5)^2 = 310m$

Distance travelled after 2s: $x_2 = 10 + 12(2)^2 = 58$

Distance in the interval: $x_5 - x_2 = 310 - 58 = 252m$

Average speed = $\frac{\text{Total distance}}{\text{Total time taken}} = \frac{252}{5 - 2} = 84ms^{-1}$

NOTE:

1. $v = \frac{dx}{dt}$ gives the concept of instantaneous velocity

i.e. the velocity of the body at any given time.

2. To calculate the acceleration of the body, you have to differentiate further $v = 24t \therefore a = 24ms^{-2}$

(i.e. acceleration is independent of time)

3. To confirm the veracity of this claim ($a = 24ms^{-2}$),

insert the value into the appropriate equation of

motion to confirm the value of the distance

covered (i.e. 252m) between the time interval

$2s - 5s: v^2 = u^2 + 2as$

$\rightarrow s = \frac{v^2 - u^2}{2a} = \frac{120^2 - 48^2}{2 \times 24} = 252m$ (as before)

37A $\frac{R_x}{R_y} = \frac{u^2 \sin^2(30^\circ)}{g} \times \frac{g}{u^2 \sin^2(60^\circ)}$

$\frac{R_x}{R_y} = \frac{\sin 60^\circ}{\sin 120^\circ} = \frac{\sin 60^\circ}{\sin 60^\circ} = 1; R_x : R_y = 1:1$

NOTE: When $90^\circ < \theta < 180^\circ$; $\sin \theta = \sin(180^\circ - \theta)$
 $\therefore \sin 120^\circ = \sin(180^\circ - 120^\circ) = \sin 60^\circ$

38A Neglecting air resistance, mass is inconsequential (Q17)

39C Acceleration = $\frac{80 - 0}{20 - 0} = 4ms^{-2}$ Retardation = $\frac{0 - 80}{90 - 50} = -2ms^{-2}$

40C $a = \frac{dv}{dt} = 4t = 4 \times 5 = 20ms^{-2}$ (Compare Q36)

41B $a = 30ms^{-1}; s = 50m; v = 0; a = ?$

$v^2 = u^2 + 2as$ and $a = \frac{v^2 - u^2}{2s} = \frac{0^2 - 30^2}{2 \times 50}; a = -9ms^{-2}$

42D See Q4

43A Let the angle be θ : Range $R = \frac{u^2 \sin 2\theta}{g}$

Maximum height $H = \frac{u^2 \sin^2 \theta}{2g}$

But $R = 3H$: $\frac{R}{H} = 3$; Using: $\frac{u^2 \sin 2\theta}{g} = 3 \times \frac{u^2 \sin^2 \theta}{2g} = 3$

or $\frac{u^2 \sin 2\theta}{g} \times \frac{2g}{u^2 \sin^2 \theta} = 3 \rightarrow \frac{2 \sin 2\theta}{\sin^2 \theta} = 3$

But $\sin 2\theta = 2 \sin \theta \cos \theta$ (Trigonometry)

$\frac{4 \sin \theta \cos \theta}{(\sin \theta)(\sin \theta)} = 3; \frac{4 \cos \theta}{\sin \theta} = 3; \frac{4}{\tan \theta} = 3$ (Recall: $\tan \theta = \frac{\sin \theta}{\cos \theta}$)

$\tan \theta = \frac{4}{3}; \theta = \tan^{-1} 1.333; \theta = 53^\circ$

44D $a = \frac{v_2 - v_1}{x_2 - x_1} = \frac{35 - 15}{20 - 10} = 2ms^{-2}$

45D, $S_4 = \frac{1}{2}(4)(4)^2 = 32m$ (Recall: $s = \frac{1}{2}at^2$) $S_5 = \frac{1}{2}(4)(5)^2 = 50m$

Distance travelled in the fifth second: $S_5 - S_4 = 50 - 32 = 18m$

NOTE:

1. There is a difference between cardinal "five" and ordinal "fifth" used in the question.

2. Besides, consider the singular noun "second" (time interval of 1s involved).

3. JAMB was lenient that year otherwise, it should have set a booby trap by including "50m" in the options to punish the unwary.

46C $v = 0; t = 4s; a = -g; u = ?$

$v = u + at \rightarrow 0 = u - 10(4);$ and $u = 40ms^{-1}$

NOTE: Disregard the given $h = 2.0m$ completely.

47D It accelerates between E and F; it has constant speed between F and G; it decelerates between G and H; constant speed means zero acceleration.

48A See Qs 17 and 38

49D $a = \frac{v - u}{t} = \frac{45 - 25}{10} = 2ms^{-2}$

50B u, t and a (or g) are the same for both hence the height ascended is the same under gravity (Qs 17, 38)

51A $u = 0; a = +g; t = 3s \rightarrow s = \frac{1}{2}at^2 = \frac{1}{2} \times 10 \times 3^2 = 45m$

52D The body at no time accelerates.

53B $u = 30ms^{-1}; v = 0; a = -0.1ms^{-2}$

$v^2 = u^2 + 2as \rightarrow 0^2 = 30^2 - 2(0.1)s \rightarrow s = 4500m$

54A $u = 0; a = 30ms^{-2}; t = 20; s = ?$

$s = \frac{1}{2}at^2 = \frac{1}{2}(30)(20)^2 = 6000m = 6km$

55B $u = 20ms^{-1}; a = -2ms^{-2}; v = 0; t = ?$

$v = u + at \rightarrow 0 = 20 - 2t; \text{ and } t = 10s$

56C See Q4

57B NS parallel to t-axis

58D $u = 0; a = 3; s = 24; v = ?$

$v^2 = u^2 + 2as = 0^2 + 2 \times 3 \times 24; \text{ and } v = 12ms^{-1}$

59C Straight line graph starting from origin

60D $U_v = U \sin \theta; V_v = 0; a = -g; t = ?$

But $v = u + at \rightarrow 0 = u \sin \theta - gt$

and $t = \frac{U \sin \theta}{g} = \frac{300 \sin \theta}{10} = 15s$

61C $u = 20ms^{-1}; a = -2ms^{-2}; v = 0; t = ?$

$v = u + at \rightarrow 0 = 20 + (-2)t; \text{ and } t = 10s$

62D $T = \frac{2U \sin \theta}{g} = \frac{2 \times 6 \sin 30^\circ}{10} = 0.3s$

CHAPTER 3

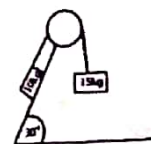
NEWTON'S LAWS OF MOTION.

LAW OF CONSERVATION OF MOMENTUM

1. A machine gun with a mass of 5kg fires a 50g bullet at a speed of 100 ms⁻¹. The recoil speed of the machine gun is A. 0.5 m/sec B. 1.5 m/sec C. 1 m/sec D. 2 m/sec E. 4m/sec. (1978:Q7)


2. A man stands on a spring scale placed in a lift. The lift descends at constant velocity. As a result, the scale reads a weight A. greater than the weight of the man B. the same as the weight of the man C. of zero D. less than the weight of the man E. greater than the weight of the man by 1kg. (1982:Q2)

3. A rockets burns 0.01kg of fuel each second and ejects it as a gas with a velocity of 5,000m/s. What force does the gas exert on the rocket? A. 500 000N B. 500N C. 50N D. 5 000N E. 50 000N (1982: Q34)




A body of mass 10kg on a smooth inclined plane is connected over a smooth pulley to a mass of 15kg as shown (Fig. 13). The acceleration of the system is A. $\frac{1}{4}g$ B. $\frac{8}{25}g$ C. $\frac{1}{2}g$ D. g E. $\frac{3}{4}g$ (1982: Q48)


5. A force of 16N applied to a 4.0kg block that is at rest on

- a smooth horizontal surface. What is the velocity of the block at $t = 5$ seconds? A. 4 m/s B. 10 m/s C. 20 m/s D. 50 m/s E. 80 m/s (1983:Q30)
6. A gun of mass 2.0kg fires a bullet of mass 1.6×10^{-2} kg due East. If the bullet leaves the nozzle of the gun with a velocity of 150ms^{-1} , what is the recoil velocity of the gun? A. 150ms^{-1} due West B. $1.2 \times 10^{-4}\text{ms}^{-1}$ due West C. 1.2ms^{-1} due West D. 1.2ms^{-1} due East E. 150ms^{-1} due East (1984:Q36)
7. Which of the following is a correct explanation of the inertia of a body? A. Ability to overcome the earth's gravity B. Reluctance to stop moving C. Readiness to start moving D. Reluctance to start moving and its readiness to stop moving once it has begun to move E. Reluctance to start moving and its reluctance to stop moving once it has begun to move. (1984:Q38)
8. Which of the following is NOT a force? A. Friction B. Tension C. Upthrust D. Weight E. Impulse (1985:Q9)
9. A 0.05kg bullet traveling at 500ms^{-1} horizontal strikes a thick vertical wall. It stops after penetrating through the wall a horizontal distance of 0.25m. What is the magnitude of the average force the wall exerts on the bullet? A. 25N B. 50N C. 250N D. 5 000N E. 25 000N (1985:Q12)
10. A constant force of magnitude F acts on an object of mass 0.04kg initially at rest at a point O. If the speed of the object when it has moved 50m from O is 500ms^{-1} , what is the value of F ? A. 0.4N B. 100.0N C. 250.0N D. 1000.0N (1986:Q13)
11. A 1000kg elevator is descending vertically with an acceleration of 1.0ms^{-2} , if the acceleration due to gravity is 10.0ms^{-2} , the tension in the suspending cable is A. 1.0N B. 10.0N C. 9 000.0N D. 11 000.0N (1986:Q15)
12. A jet engine develops a thrust of 270Ns when the velocity of the exhaust gases relative to the engine is 300ms^{-1} . What is the mass of the material ejected per second? A. 81.00kg B. 9.00kg C. 0.90kg D. 0.09kg (1987:Q4)
13. An elevator of mass 4 800kg is supported by a cable which can safely withstand a maximum tension of 60 000N, the maximum upward acceleration the elevator can have is A. 2.5ms^{-2} B. 5.0ms^{-2} C. 7.5ms^{-2} D. 10.0ms^{-2} ($g = 10\text{ms}^{-2}$) (1987:Q6)
14. When taking a penalty kick, a footballer applies a force of 30.0N for a period of 0.05s. If the mass of the ball is 0.075kg, calculate the speed with which the ball moves off. A. 4.50ms^{-1} B. 11.25ms^{-1} C. 20.00ms^{-1} D. 45.00ms^{-1} (1988:Q7)
15. A particle of mass M which is at rest splits up into two. If the mass and velocity of one of the particles are m and v respectively, calculate the velocity of the second particle. A. $\frac{mv}{M}$ B. $\frac{Mv}{M-m}$ C. $\frac{mv}{M+m}$ D. $\frac{mv}{M-m}$ (1990:Q5)
16. A body of mass 100g moving with a velocity of 10.0ms^{-1} collides with a wall. If after the collision, it moves with a velocity of 2.0ms^{-1} in the opposite direction, calculate the change in momentum. A. 0.8Ns B. 1.2Ns C. 12.0Ns D. 80.0Ns (1991:Q5)
17. A rocket burns fuel at the rate of 10kgs^{-1} and eject it with a velocity of $5 \times 10^3\text{ms}^{-1}$. The thrust exerted by the gas on the rocket is A. $2.5 \times 10^7\text{N}$ B. $5.0 \times 10^6\text{N}$ C. $5.0 \times 10^3\text{N}$ D. $2.0 \times 10^3\text{N}$ (1993:Q6)
18. If it takes 5.0 hours to drain a container of 540.0cm^3 of water, what is the flow rate of water from the container in kgs^{-1} ? A. 32.5 B. 31.5 C. 30.8 D. 30.0 (Density of water = 1000kgm^{-3}) (1994:Q2)
19. The acceleration of the system shown above is A. 2ms^{-2} B. 4ms^{-2} C. 6ms^{-2} D. 8ms^{-2} (1995:Q7)
20. A 5kg block is released from rest on a smooth plane inclined at an angle of 30° to the horizontal. What is its acceleration down the plane? A. 5.0ms^{-2} B. 5.8ms^{-2} C. 8.7ms^{-2} D. 25.0ms^{-2} [$g = 10\text{ms}^{-2}$] (1997:Q3)
21. An arrow of mass 0.1kg moving with a horizontal velocity of 15ms^{-1} is shot into a wooden block of mass 0.4 kg lying at rest on a smooth horizontal surface. Their common velocity after impact is A. 15.0ms^{-1} B. 7.5ms^{-1} C. 3.8ms^{-1} D. 3.0ms^{-1} (1997:Q4)
22. A body of mass 2kg moving vertically upwards has its velocity increased uniformly from 10ms^{-1} to 40ms^{-1} in 4s. Neglecting air resistance, calculate the upward vertical force acting on the body. A. 15N B. 20N C. 35N D. 45N [$g = 10\text{ms}^{-2}$] (1997:Q7)
23. A ball of mass 0.15kg is kicked against a rigid vertical wall with a horizontal velocity of 50ms^{-1} . If it rebounded with a horizontal velocity of 30ms^{-1} , calculate the impulse of the ball on the wall. A. 3.0Ns B. 4.5Ns C. 7.5Ns D. 12.0Ns (1998:Q5)
24. In an experiment, a constant force is applied to several masses (m) and the corresponding accelerations (a) are measured. Which of the following graphs correctly represents the experiment?
- 


I. a vs m



II. a vs $1/m$



III. a vs $1/m$



IV. a vs m
- A. III and IV only B. II and IV only
C. I and III only D. I and II only (1998:Q7)
25. A bullet fired at a wooden block of thickness 0.15m manages to penetrate the block. If the mass of the bullet is 0.025kg and the average resisting force of the wood is $7.5 \times 10^3\text{N}$, calculate the speed of the bullet just before it hits the wooden block. A. 450ms^{-1} B. 400ms^{-1} C. 300ms^{-1} D. 250ms^{-1} (1998:Q9)
26. A lead bullet of mass 0.05kg is fired with a velocity of 200ms^{-1} into a lead block of mass 0.95 kg. Given that the lead block can move freely, the final kinetic energy after impact is A. 50J B. 100J C. 150J D. 200J (1999:Q2)
27. Two bodies have masses in the ratio 3:1. They experience forces which impart to them accelerations in the ratio 2:9 respectively. Find the ratio of the forces the masses experience. A. 1:4 B. 2:1 C. 2:3 D. 2:5 (1999:Q6)
28. A rope is being used to pull a mass of 10kg vertically upward. Determine the tension in the rope if, starting from rest, the mass acquires a velocity of 4ms^{-1} in 8s. A. 105N B. 95N C. 50N D. 5N (2000:Q11)
29. If the total force acting on a particle is zero, the linear momentum will A. increase then decrease B. be constant C. increase D. decrease. (2002:Q1)
30. A body weighing 80N stands in an elevator that is about to move. The force exerted by the floor on the body as the elevator moves upwards with an acceleration of 5ms^{-2} is A. 160N B. 120N C. 80N D. 40N (2002:Q9)
31. A force of 100N is used to kick a football of mass 0.8kg. Find the velocity with which the ball moves if it takes 0.8s to be kicked. A. 32ms^{-2} B. 50ms^{-2} C. 64ms^{-2} D. 100ms^{-2} (2003:Q7)
32. I. Jet-propelled aircraft II. Rocket propulsion III. The recoil of a gun IV. A person walking. Which of the above is based on Newton's third law of motion? A. I, II, III and IV B. I and III only C. I and II only D. I, II and III only. (2004:Q14)
33. A body of mass 12kg travelling at 4.2ms^{-1} collides with a second body of mass 18kg at rest. Calculate their common velocity if the two bodies coalesce after collision.

- A. 1.5ms^{-1} B. 1.4ms^{-1} C. 2.1ms^{-1} D. 1.7ms^{-1} (2009:Q7)
34. A man standing on a lift that is descending does not feel any weight because A. There is no reaction from the floor of the lift B. There is no gravitational pull on the man in the lift C. The inside of the lift is airtight D. The lift is in vacuum. (2011:Q4)
35. Calculate the apparent weight loss of a man weighing 70kg in an elevator moving downwards with an acceleration of 1.5ms^{-2} A. 686N B. 595N C. 581N D. 105N [$g = 10\text{ms}^{-2}$] (2013:Q7)
36. What force has to be exerted on a mass 60kg to give it an acceleration of 10ms^{-2} vertically upwards? [$g = 10\text{ms}^{-2}$] A. 600N B. 1 200N C. 400N D. 300N (2015:Q4)
37. When an x-ray collides elastically with a free electron, there is conservation of A. neither momentum nor energy B. both momentum and energy C. energy but not momentum D. momentum but not energy (2016:Q1)
38. The tendency of a body to remain at rest when a force is applied to it is called A. impulse B. momentum C. inertia D. friction (2018:Q3)
39. A ball of mass 5.0kg hits a smooth vertical wall normally with a speed of 2ms^{-1} . Determine the magnitude of the resulting impulse. A. 20.0kgms^{-1} B. 10.0kgms^{-1} C. 5.0kgms^{-1} D. 2.5kgms^{-1} (2018:Q4)
40. A body of mass 100g moving with a velocity of 10.0ms^{-1} collides with a wall if after collision it moves with a velocity of 2.0ms^{-1} in the opposite direction, calculate the change in momentum A. 0.8Ns B. 1.2Ns C. 12.0Ns D. 80.0Ns (2018:Q24)

CHAPTER 3 ANSWERS

- 1C For a gun-bullet pair, the law of conservation of momentum: $m_B v_B + m_G v_G = 0$
(Where subscripts B and G stand for Bullet and Gun)
 $\therefore v_G = \frac{m_B v_B}{m_G}$; But: $m_B = 50\text{g} = 0.05\text{kg}$; $v_B = 100\text{ms}^{-1}$; $m_G = 5\text{kg}$
 $v_G = -\frac{0.05 \times 100}{5} = -1\text{ms}^{-1}$
- NOTE:** The negative sign suggests the recoil velocity of the gun is in opposite direction to the direction of the velocity of the bullet.
- 2B Two forces act on the man: i. Tension in the spring, T (upwards)
ii. Weight of the man, W (downwards)
Net force on the body: $F = W - T = Ma$
But velocity is constant hence $a = 0$; $\therefore W - T = 0$; and $W = T$.
Thus the man feels his normal weight.
NOTE: Consider other possibilities
- Lift accelerates upwards: $T > W$
 $\therefore T - W = ma$ or $T = ma + mg$ (Recall: $W = mg$)
or $T = m(a + g)$ [The man feels heavier]
 - Lift accelerates downwards: $W > T$
 $\therefore W - T = ma$; or $T = W - ma$ and $T = mg - ma$
 $T = m(g - a)$ [The man feels lighter]
 - Lift falls freely when its cable cuts: $a = g$
 $W - T = ma$; or $T = W - ma \therefore T = mg - ma = 0$ (since $mg = ma$)
[The scale reads zero and the man feels weightless]
- 3C $u = 0$; $v = 5\,000\text{ms}^{-1}$; $m = 0.01\text{kg}$; $t = 1\text{s}$
Using Newton's 2nd Law: $F = \frac{mv - mu}{t}$
 $F = \frac{0.01(5\,000 - 0)}{1} = 50\text{N}$
4. For the 10kg body, force acting downwards along the plane:
 $F = m_g \sin\theta$; (While tension T in the rope acts upwards along the plane)
Net force acting on the body: $T - m_g \sin\theta = m_1 a$

$$\therefore T = m_1 a + m_1 g \sin\theta \dots\dots\dots (i)$$

For the 15kg body, net force produces upwards acceleration

$$a: m_2 g - T = m_2 a; \text{ Again: } T = m_2 g - m_2 a \dots\dots\dots (ii)$$

Compare the RHS of (i) and (ii):

$$m_1 g - m_1 a = m_1 a + m_1 g \sin\theta$$

$$15g - 15 = 10a + 10g \times 0.5$$

$$-15a - 10a = 5g - 15g$$

$$-25a = -10g \rightarrow a = \frac{-10g}{-25} = \frac{2g}{5} \text{ No option is correct}$$

NOTE:

- The tension is the same throughout the entire length of the rope.
- For 10kg body, $T > m_g \sin\theta$ (hence upward movement)
- For 15kg body, $mg > T$ (hence downward movement)
- Since the two bodies are joined, they move with the same velocity, same acceleration

5C $F = \frac{m(v - u)}{t}$ (Newton's second law of motion)

$$16 = \frac{4(v - 0)}{5}; \text{ rearranging: } v = 20\text{ms}^{-2}$$

6C $v = -\frac{1.6 \times 10^{-2} \times 150}{2}$ [Same principle as in Q1]

$$v = -1.2\text{ms}^{-1} \text{ (i.e. } 1.2\text{ms}^{-1} \text{ due West (Opposite of East))}$$

7E This reluctance or inertia depends on the mass of the body

8E The Impulse I, is the product of a force and the time it takes to act on a given body $I = Ft$

9E Concerning the journey into the wall:

$$u = 500\text{ms}^{-1}; v = 0; s = 0.25\text{m}; a = ?$$

$$\text{But: } v^2 = u^2 - 2as \rightarrow 0^2 = 500^2 + 2 \times a \times 0.25$$

$$\text{and } a = -500\,000\text{ms}^{-2}$$

$$\text{But: } F = ma \rightarrow F = 0.05 \times 5 \times 10^5 = 25\,000\text{ N}$$

10B $v^2 = u^2 + 2as \rightarrow 500^2 = 0^2 + 2 \times a \times 50$

$$\text{And } a = 2\,500\text{ms}^{-2}; \therefore F = 0.04 \times 2\,500 = 100\text{N}$$

[Recall: $F = ma$]

11C $T = m(g - a)$ (See Q2) $T = 1000(10 - 1) = 9\,000\text{N}$

12C Thrust here means Impulse

$$I = Ft = mv \text{ (since } mu = 0) \therefore 270 = 300m; \text{ and } m = 0.9\text{kg}$$

13A $T = m(g + a)$ (see Q2); $60\,000 = 4\,800(10 + a)$

$$\text{And } a = 2.5\text{ms}^{-2}$$

14C $F = \frac{m(v - u)}{t} \rightarrow 30 = 0.075 \frac{(v - 0)}{0.05}; \text{ and } v = 20\text{ms}^{-1}$

15D Total momentum before and after splitting is zero

Mass of first body = m_1 ; Mass of second body = $(M - m)$

$$\text{Hence } mv_1 + (M - m)v_2 = 0; \text{ Rearranging: } v_2 = -\frac{mv_1}{M - m}$$

The negative sign suggests body 2 moves in opposite direction to body 1

16B $m = 100\text{g} = 0.1\text{kg}$; $u = 10\text{ms}^{-1}$; $v = -2\text{ms}^{-1}$

$$\text{Change in momentum} = mv - mu = 0.1(-2) - 0.1(10) = -1.2\text{Ns}$$

The negative sign only suggests that the change is a decrease in momentum rather than an increase.

NOTE: The result above would be different if we used $v = 2\text{ms}^{-1}$ and this would be an error.

17B Thrust = mv (since $mu = 0$) = $10 \times 5 \times 10^3 = 5 \times 10^4\text{N}$

18D Density ρ is given by $\rho = \frac{m}{V}$ and $m = \rho V$

$$P = 1\,000\text{kgm}^{-3} \text{ (water); } V = 540\text{cm}^3 = 5.4 \times 10^{-4}\text{m}^3$$

$$\therefore m = 1\,000 \times 5.4 \times 10^{-4} = 5.4 \times 10^{-1}\text{kg}$$

$$\text{But flow rate} = \frac{\text{Mass}}{\text{Time}} = \frac{5.4 \times 10^{-1}}{5 \times 60 \times 60} = 3 \times 10^{-4}\text{kg s}^{-1}$$

NOTE: JAMB's predetermined answer was obviously (D) but it was not correct even if expressed in gs^{-1}

19B Taking a cue from Q4: $m_2g - m_2a = m_1a + m_1g\sin\theta$
 $\rightarrow 30(10) - 30(a) = 20(a) + 20(10)(0.5)$
 Solving for a: $a = 4\text{ms}^{-2}$

20A Force acting downwards along the surface is given by
 $F = mg \sin\theta = ma; \therefore a = g\sin\theta = 10 \times 0.5 = 5\text{ms}^{-2}$

NOTE: $R = mg\cos\theta$, but $g\cos\theta$, the component of "g" vertical to the plane, is irrelevant here

21D $m_A = 0.1\text{kg}; u_A = 15\text{ms}^{-1}; m_B = 0.4\text{kg}; u_B = 0$; while $v_A = v_B = V$
 Using: $m_A u_A + m_B u_B = (m_A + m_B)V$
 $\therefore V = \frac{m_A u_A + m_B u_B}{m_A + m_B} = \frac{0.1(15) + 0.4(0)}{0.1 + 0.4} = 3\text{ms}^{-1}$

22A $F = \frac{2(40 - 10)}{4} = 15\text{N}$

23D Taking the rebound velocity of 30ms^{-1} as positive
 And Impulse = change in momentum
 $\rightarrow 0.15(30) - 0.15(-50) = 12\text{Ns}$

24A $F = ma; \therefore a = \frac{F}{m}$ or $a \propto \frac{1}{m}$
 If we re-introduce a constant k, then $k = F$
 Mathematically $a \propto \frac{1}{m}$ means

- i. a is directly proportional to $\frac{1}{m}$ (graph III)
- ii. a is inversely proportional to m (graph IV)

25C $a = \frac{F}{m} = \frac{7.5 \times 10^3}{0.025} = 300\,000\text{ms}^{-2}$
 $s = 0.15\text{m}; a = -3 \times 10^5\text{ms}^{-2}; v = 0$
 Using $v^2 = u^2 + 2as; 0^2 = u^2 + 2 \times 3 \times 10^5 \times 0.15$; and $u = 300\text{ms}^{-1}$
 The force is a resisting one just like the acceleration and it is directed opposite to the direction of motion of the bullet hence both are negative

26A $V = \frac{m_A u_A + m_B u_B}{m_A + m_B} = \frac{0.05(200) + 0.95(0)}{0.05 + 0.95} = 10\text{ms}^{-1}$

Final Kinetic Energy: $K.E = \frac{1}{2}(m_A + m_B)V^2$
 $= \frac{1}{2}(0.05 + 0.95)(10)^2 = 50\text{J}$

NOTES:

1. Computing the initial kinetic energy
 $K.E = \frac{1}{2}m_A u_A^2 + \frac{1}{2}m_B u_B^2 = \frac{1}{2}(0.05)(200)^2 + \frac{1}{2}(0.95)(0)^2$
 $= 1\,000\text{J}$ [Kinetic energy is not conserved]
2. This is an example of inelastic collision as the two colliding objects (bullet and block) stick together after collision with a common velocity ($V = 10\text{ms}^{-1}$) as calculated above.
3. If the two objects separate after collision, it is an elastic collision.
4. Only momentum, but not kinetic energy is conserved in inelastic collision.
5. Both momentum and kinetic energy are conserved in elastic collision.

27C $m_1 : m_2 = 3:1 \therefore \frac{m_1}{m_2} = \frac{3}{1}; a_1 : a_2 = 2.9 \therefore \frac{a_1}{a_2} = \frac{2}{9}$

$\frac{F_1}{F_2} = \frac{m_1 a_1}{m_2 a_2} = \left(\frac{m_1}{m_2}\right) \cdot \left(\frac{a_1}{a_2}\right) = \frac{3}{1} \times \frac{2}{9} \therefore F_1 : F_2 = 2:3$

28A $a = \frac{v - u}{t} = \frac{4 - 0}{8} = 0.5\text{ms}^{-2}$

$T = m(g+a) = 10(10 + 0.5)$ (See Q2) $T = 105\text{N}$

29B $mu - mv = Ft$, if $F = 0$; then $mu - mv = 0$
 $mu = mv$ [initial momentum = final momentum]

30B $W = mg \therefore m = \frac{W}{g}; m = \frac{80}{10} = 8\text{kg}$
 $R = T = m(g + a) = 8(10 + 5) = 120\text{N}$

31D $F = \frac{m(v - u)}{t} \rightarrow 100 = \frac{0.8(v - 0)}{0.8}$ and $v = 100\text{ms}^{-1}$

32A In each case, a reaction is equal but opposite in direction

to an original action that causes the movement.

33D $V = \frac{m_1 u_1 + m_2 u_2}{m_1 + m_2}$ (See Q21) $= \frac{12(4.2) + 18(0)}{12 + 18} = 1.68\text{ms}^{-1}$

34A See Q2

35D Apparent weight recorded: $T = m(g - a)$
 $T = 70(10 - 1.5) = 595\text{N}$
 Normal weight of the body: $W = mg = 700\text{N}$
 Weight loss = $700 - 595 = 105\text{N}$

36B $F - mg = ma \rightarrow F = m(g+a) = 60(10+10); F = 1\,200\text{N}$

- NOTE:**
1. The accelerates ($a=10\text{ms}^{-1}$) quoted is not the acceleration due to gravity ($g = 10\text{ms}^{-2}$).
 2. a and g act in opposite direction, the former is an acceleration and the later, a retardation.
 3. The force required F is large enough to first overcome W = mg and then its excess value gives the body a = 10ms^{-2}
 4. In the long run, the effect of F thins out and the body assumes $v = 0$ at maximum height.

37B See Q26

38C The tendency/reluctance/hesitation/unwillingness of a body to move when at rest or to stop when already moving is called **inertia**.

NOTE:

1. This word is semantically related to "inert" (adj.) as in "inert gases" in your chemistry class and recall that these gases (noble gases) are hesitant or lack the will to react with other chemical substances.
2. The larger the mass, the larger the inertia as in it is easier to push a car than a lorry and a lorry than a trailer.

39A $I = Ft = mv - mu = m(v-u)$; but $v = 2\text{ms}^{-1}$ and $u = -2\text{ms}^{-1}; \therefore I = 5[2 - (-2)] = 20\text{kgms}^{-1}$

NOTE:

1. The impulse acts opposite in direction to the original direction of the ball and the latter is taken as negative ($u = -2\text{ms}^{-1}$)
2. The force with which the ball is thrown at the wall, F , is action and the force component of $I = Ft$ is the **reaction** equal in magnitude to the **action** (Newton's Third Law).
3. Hence $v = u$ but opposite in direction.
4. The more effort applied at throwing the ball, the more forcefully the ball bounces off the wall.

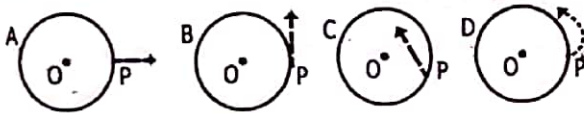
40B Change in momentum = final momentum - initial momentum.
 But $u = 10\text{ms}^{-1}$ $v = -2\text{ms}^{-1}$ and $m = 0.1\text{kg}$
 \therefore change in momentum = $m(v-u) = 0.1(-2 - 10) = -1.2\text{Ns}$
NOTE: The negative sign indicates decrease in momentum.

CHAPTER 4

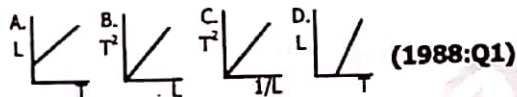
CIRCULAR MOTION. SIMPLE HARMONIC MOTION.

1. The force required to make an object of mass m, travelling with velocity v, turn in a circle of radius r is A. $\frac{mv^2}{r}$ B. $\frac{mv}{r}$ C. $\frac{mr}{v}$ D. $\frac{mv}{r^2}$ E. $\frac{mv}{r}$ (1978:Q11)
2. If in a simple pendulum experiment the length of the inextensible string is increased by a factor of four, its period is increased by a factor of A. 4 B. $\frac{1}{4}$ C. $\frac{1}{2}$ D. 2π E. 2 (1979:Q7)
3. The relationship between the period T and the length l of a simple pendulum is $T = 2\pi\left(\frac{l}{g}\right)^{1/2}$. From experimental data of T and l, one can obtain the following graphs. (i) T vs. l (ii) T vs. l² (iii) T² vs. l (iv) T vs. l^{1/2} (v) log T vs. log l. Which of the graphs are linear? A. All B. Only (i) and (ii) C. Only (iii) and (iv) D. (iii), (iv) and (v) E. None of them. (1981:Q46)

4. The force responsible for holding the moon in its orbits around the earth against the gravitational pull of the earth is
A. centrifugal B. rotational C. reaction D. centripetal E. tractional. (1982:Q11)
5. A simple pendulum, 0.6m long, has a period of 1.5s. What is the period of a similar pendulum 0.4m long in the same location?
A. $1.5\sqrt{\frac{2}{3}}$ B. $1.5\sqrt{\frac{3}{2}}$ C. 2.25s D. 1.00s E. 2.00s (1984:Q23)
6. A particle moves in a circular orbit of radius 0.02m. If the speed of the particle is 0.88ms^{-1} , calculate its frequency in cycles per second. A. 2.0 B. 7.0 C. 8.8 D. 14.0 E. 17.6 (1984:Q26)
7. A simple pendulum with a period of 2.0s has its length doubled. Its new period is A. 1.00s B. 1.41s C. 0.35s D. 2.83s E. 4.00s (1985:Q2)
8. Which of the following assumptions is made in a simple pendulum experiment? The A. Suspending string is inextensible B. Bob has a finite size C. Bob has a definite mass D. Initial angle of oscillation must be large. (1986:Q8)
9. A ball attached to one end of a string moves anticlockwise around a circle whose centre is O. If the string suddenly breaks when the ball is at point P, along which of the following paths will it move? (1986:Q16)



10. Which of the following diagrams correctly represents the relationship between the time (T) of swing of a simple pendulum and its length (L)?



11. A simple pendulum of mass, m moves along an arc of a circle radius R in a vertical plane as shown in the figure above. What is the work done by gravity in a downward swing through the angle θ to 0° ?
A. $mgR\sin\theta$
B. $mgR(1 - \cos\theta)$
C. mgR
D. $mgR(1 - \sin\theta)$ (1989:Q6)

12. An object moves with uniform speed round a circle. Its acceleration has
A. Constant magnitude and constant direction.
B. Constant magnitude and varying direction.
C. Varying magnitude and constant direction
D. Varying magnitude and varying direction. (1991:Q4)
13. A boy timed 30 oscillations of a certain pendulum thrice and obtained 1 min. 10s, 1min. 12s and 1 min. 7s respectively. The mean period of oscillation of the pendulum is A. 0.14s B. 0.43s C. 2.32s D. 6.97s (1991:Q23)
14. Which of the following affects the period of a simple pendulum?
I. Mass of the pendulum bob II. Length of the pendulum III. Acceleration due to gravity. A. I, II and III B. II and III only C. I and III only D. I and II only. (1992:Q2)
15. Which of the following is TRUE of a particle moving in a horizontal circle with constant angular velocity?
A. The energy is constant but the linear momentum varies
B. The linear momentum is constant but the energy varies.
C. Both energy and linear momentum are constant.
D. The speed and the linear velocity are both constant. (1994:Q6)
16. The length of a displaced pendulum bob which passes its lowest point twice every second is A. 0.25m B. 0.45m C. 0.58m D. 1.00m ($g = 10\text{ms}^{-2}$) (1995:Q2)
17. Which of the following with respect to a body performing simple harmonic motion are in phase?
A. Displacement and velocity of the body.
B. Displacement and force on the body
C. Velocity and acceleration of the body.
D. Force acting on the body and

- the acceleration. (1997:Q6)
18. A particle of mass 10^{-2}kg is fixed to the tip of a fan blade which rotates with angular velocity of 100rad s^{-1} . If the radius of the blade is 0.2m, the centripetal force is
A. 2N B. 20N C. 200N D. 400N (1999:Q8)
19. A simple pendulum has a period of 17.0s. When the length is shortened by 1.5m, its period is 8.5s. Calculate the original length of the pendulum.
A. 1.5m B. 2.0m C. 3.0m D. 4.0m (2000:Q5)
20. I. Its velocity is constant II. No work is done on the body III. It has constant acceleration away from the center IV. The centripetal force is directed towards the center. Which combination of the above is true of a body moving with constant speed in a circular track?
A. I and III
B. I and IV C. II and III D. II and IV (2000:Q7)
21. A particle in circular motion performs 30 oscillations in 6s. Its angular velocity is
A. $10\pi\text{rads}^{-1}$ B. $5\pi\text{rads}^{-1}$ C. $6\pi\text{rads}^{-1}$ D. $5\pi\text{rads}^{-1}$ (2002:Q12)
22. A piece of stone attached to one end of a string is whirled round in horizontal circle and the string suddenly cuts. The stone will fly off in a direction
A. perpendicular to the circular path
B. parallel to the circular path
C. tangential to the circular path
D. towards the centre of the circle. (2003:Q10)
23. A car of mass 1500kg goes round a circular curve of radius 50m at a speed of 40ms^{-1} . The magnitude of the centripetal force on the car is
A. $1.2 \times 10^3\text{N}$ B. $1.2 \times 10^4\text{N}$ C. $4.8 \times 10^3\text{N}$ D. $4.8 \times 10^4\text{N}$. (2007:Q44)
24. A gramophone record takes 5s to reach its constant angular velocity of $4\pi\text{rads}^{-1}$ from rest. Find its constant angular acceleration.
A. $20.0\pi\text{rads}^{-2}$ B. $1.3\pi\text{rads}^{-2}$ C. $0.8\pi\text{rads}^{-2}$ D. $0.4\pi\text{rads}^{-2}$. (2007:Q48)
25. From the diagram above, the bob of the pendulum has the fastest speed at
A. W B. Z C. Y D. X (2007:Q50)
26. A force F is required to keep a 5kg mass moving round a cycle at speed v. What is the speed, if the force is tripled?
A. 4.0ms^{-1} B. 6.6ms^{-1} C. 12.1ms^{-1} D. 21.0ms^{-1} (2008:Q5)
27. If a wheel 1.2 m in diameter rotates at one revolution per second, calculate the velocity of the wheel.
A. 3.6ms^{-1} B. 3.8ms^{-1} C. 4.0ms^{-1} D. 7.5ms^{-1} (2008:Q6)
28. What is the frequency of vibration if the balance wheel of a wrist-watch makes 90 revolutions in 25s?
A. 0.01Hz B. 0.04Hz C. 2.27 Hz D. 3.60 Hz (2008:Q10)
29. I. The motion of the tyres of a moving car. II. The motion of a loaded test tube oscillating vertically. III. The beating of the heart. IV. A stone tied to a string and whirled round. V. The motion of the pistons in a gasoline engine. Which of the motions above is simple harmonic?
A. III, IV and V only B. II, III and V only C. II, III and IV only D. I, II and III only (2009:Q9)
30. An object of mass 2kg moves with a velocity of 10ms^{-1} round a circle of radius 4 m. Calculate the centripetal force on the object.
A. 50N B. 40N C. 25 N D. 100 N (2011:Q6)
31. If a freely suspended object is pulled to one side and released, it oscillates about the point of suspension because
A. acceleration is directly proportional to the displacement.
B. motion is directed away from the equilibrium point
C. acceleration is directly proportional to the square of the displacement
D. velocity is minimum at the equilibrium point. (2012:Q9)

32. An object moves in a circular path of radius 0.5m with a speed of 1ms^{-1} . What is its angular velocity? A. 8rads^{-1} B. 4rads^{-1} C. 2rads^{-1} D. 1rads^{-1} (2012:Q10)
33. A simple pendulum of length 0.4m has a period of 2s. What is the period a similar pendulum of length 0.8m at the same place? A. 8s B. 4s C. $2\sqrt{2}\text{s}$ D. $\sqrt{2}\text{s}$. (2013:Q5)
34. A body weighing 100N moves with a speed of 5ms^{-1} in a horizontal circular path of radius 5m. Calculate the magnitude of the centripetal force acting on the body [$g=10\text{ms}^{-2}$] A. 10N B. 50N C. 75N D. 100N (2018:Q14)

CHAPTER 4 - ANSWERS

- 1A This force which restrains the body in the circular path is called the centripetal force F_c .
- NOTES**
- The force and its acceleration which are in phase are directed towards the centre of the circle being described by the body.
 - The velocity is constant in magnitude but varies in direction and it is always tangential to the circle at any given point.
 - Thus F_c and a are perpendicular to v .
- Where: $a = \frac{v^2}{r}$; $\therefore F_c = ma = \frac{mv^2}{r}$
4. The acceleration is proportional to the displacement
- 2E For a simple pendulum: $T = 2\pi\sqrt{\frac{l}{g}}$
 $T = \text{period}$; $l = \text{length of string}$ $g = \text{acceleration due to gravity}$ since 2π and g are constants
- $T \propto \sqrt{l}$ or $T^2 \propto l$ or $\frac{T^2}{l}$; Hence, $\frac{T_1^2}{l_1} = \frac{T_2^2}{l_2} = \frac{T_3^2}{l_3} \dots$
- Now $l_2 = 4l_1 \rightarrow \frac{T_1^2}{l_1} = \frac{T_2^2}{4l_1}$; Rearranging: $\left(\frac{T_2}{T_1}\right)^2 = 4$ and $\frac{T_2}{T_1} = \sqrt{4} = 2$
- Alternatively: $\frac{T_1}{T_2} = \frac{\sqrt{l_1}}{\sqrt{l_2}} \rightarrow \frac{T_1}{T_2} = \frac{\sqrt{l_1}}{\sqrt{4l_1}} = \frac{1}{2}$ or $\frac{T_2}{T_1} = 2$
- 3D. From the slope of each graph, one can calculate the value of g .
- 4A See Q1
- NOTE:** The gravitational pull constitutes the centripetal force and it is an action while centrifugal force is its corresponding reaction on the same body following from Newton's third law of motion.
- 5A The value of 'g' for both pendula is the same at the same location. $\frac{T_2}{T_1} = \sqrt{\frac{l_2}{l_1}} \rightarrow \frac{T_2}{1.5} = \sqrt{\frac{0.4}{0.6}} \rightarrow T_2 = 1.5\sqrt{\frac{2}{3}}$
- NOTE:** $T = 2\pi\sqrt{\frac{l}{g}} \rightarrow \frac{T^2}{l} = \frac{4\pi^2}{g}$
- Thus a graph of T^2 against l produces a slope equal to $\frac{4\pi^2}{g}$ from which the value of "g" can be deduced.
- 6B $v = r\omega$; or $\omega = \frac{v}{r}$ where $\omega = \text{angular speed}$; $v = \text{linear speed}$; $r = \text{radius}$ $\therefore \omega = \frac{0.88}{0.02} = 44\text{rads}^{-1}$
 But $2\pi f = \omega$ ($f = \text{frequency}$)
 $f = \frac{\omega}{2\pi} = 7\text{Hz} = 7\text{cycles/sec}$. (Recall: $\pi = \frac{22}{7}$)
- 7D $\frac{T_2}{T_1} = \sqrt{\frac{l_2}{l_1}} \rightarrow T_2 = T_1\sqrt{\frac{l_2}{l_1}} \therefore T_2 = 2\sqrt{2} = 2.828\text{s}$
- 8A The bob on the inextensible string need not be of a specific mass although it must be heavy enough to prevent draught (air resistance) while the initial angle of oscillation must be small.

- 9B The ball moves at a tangent to the circle (See Q1)
- 10B See Q5
- 11B Consider $\triangle ABC$: $\frac{AB}{AD} = \cos\theta \rightarrow P = R \cos\theta$
 But $BC = AC - AB$; or $h = R - P$
 $\therefore h = R - R \cos\theta \quad h = R(1 - \cos\theta)$
 The work done by gravity to move the bob from D to C is $W = mgh = mgR(1 - \cos\theta)$
- 12B Since the direction of v changes, the direction of a also changes so that at any point a is perpendicular to v
- 13C $T = \frac{t}{n}$; where $T = \text{period}$ $t = \text{time}$; $n = \text{no of oscillations}$
 $T_1 = \frac{70}{30} = 2.33$; $T_2 = \frac{72}{30} = 2.40$; $T_3 = \frac{67}{30} = 2.23$
 Mean period = $\frac{T_1 + T_2 + T_3}{3} = \frac{2.33 + 2.40 + 2.23}{3} = 2.32$
- NOTES:** 1. $f = \frac{n}{t} \rightarrow \therefore T = \frac{1}{f}$ or $f = \frac{1}{T}$
 2. Period is in sec/cycle or simply in sec.
 3. Frequency is in cycle/sec or Hertz (Hz)
 (One complete oscillation = one cycle)
- 14B Mass is not part of the equation $T = 2\pi\sqrt{\frac{l}{g}}$
- 15A Energy is a scalar quantity; its value is solely determined by $E = \frac{1}{2}mv^2$ while momentum is a vector quantity and it is defined by $P = mv$...as well as the ever-changing direction of the velocity.
- 16A To make one complete cycle, the bob must pass through the lowest point (or anywhere else) twice
 $\therefore T = \frac{t}{n} = \frac{1\text{ second}}{1\text{ cycle}} = 1\text{s}$
- Using $T = 2\pi\sqrt{\frac{l}{g}} \rightarrow l = \frac{gT^2}{4\pi^2} = \frac{10 \times 1^2}{4 \times 3.142^2} = 0.25\text{m}$
- 17D The restoring force and the acceleration are in phase and are directed towards the equilibrium position or centre of the reference circle in opposite direction to the displacement.
- 18B $a = r\omega^2$ [where $a = \text{linear acceleration}$; see Q6]
 But $F = ma$; $\therefore F = mr\omega^2 = 10^2 \times 0.2 \times 100^2 = 20\text{N}$
- 19B Original length = l \therefore New length = $l - 15$
 Using $\left(\frac{T_2}{T_1}\right)^2 = \frac{l_2}{l_1}$ (Q2) $\rightarrow \left(\frac{8.5}{17}\right)^2 = \frac{l - 1.5}{l}$; $l = 2.0\text{m}$
- NOTE:** Next time, if the question is framed "...shortened to 1.5m" instead of "...shortened by 1.5m..." then New Length = 1.5m (not $l - 1.5$)
- 20B See Q1
- 21A 1 oscillation = 2π rad (radian measure)
 $\therefore 30$ oscillations = 60π rad
 Hence Angular velocity = $\frac{\theta}{t} = \frac{60\pi}{6} = 10\pi$
- Alternatively, $f = \frac{n}{t} = \frac{30}{6} = 5\text{Hz}$ (Q13)
 But angular velocity is given by $\omega = 2\pi f$ (See Q6)
 $\omega = 2\pi \times 5 = 10\pi$ (as before)
- 22C Because the velocity of the stone is always tangential to the circular path (See Q1)
- 23D $F_c = \frac{mv^2}{r} = \frac{1500 \times 40^2}{50} = 48000\text{N} = 4.8 \times 10^4\text{N}$
- 24C $\alpha = \frac{\omega_2 - \omega_1}{t} = \frac{4\pi - 0}{5} = 0.8\pi\text{rads}^{-2}$
- 25D The bob accelerates from Z to X; decelerates from X to W; it accelerates from W to X and decelerates from X to Z.

Hence $v = \text{Maximum (at X)}$ $v = 0$ (at W and Z)

$$26C \quad F = \frac{mv^2}{r} = \frac{5 \times 7^2}{3.5} = 70N$$

If F is tripled: $3F = 210N$

$$\text{Again: } 210 = \frac{5 \times v^2}{3.5}; \text{ and } v = 12.12 \text{ms}^{-1}$$

27B The wheel travels a distance (s) equal to its own circumference in one second ($t = 1s$)

$$v = \frac{\text{Circumference}}{\text{Time}} = \frac{2\pi r}{t} = \frac{\pi D}{t} = 3.142 \times 1.2 = 3.8 \text{ms}^{-1}$$

$$28D \quad F = \frac{\eta}{t} = \frac{90}{25} = 3.6 \text{ rev. s}^{-1} = 3.6 \text{Hz}$$

29B I and IV are circular motion

$$30A \quad F = \frac{2 \times 10^2}{4} = 50N \quad 31A \quad \text{See Q1}$$

$$32C \quad v = r\omega; \text{ and } \omega = \frac{v}{r} = \frac{1}{0.5} = 2 \text{rads}^{-1}$$

$$33C \quad \frac{T_2}{T_1} = \sqrt{\frac{l_2}{l_1}} \rightarrow T_2 = 2\sqrt{\frac{0.8}{0.4}} = 2\sqrt{2}$$

$$34B \quad m = \frac{W}{g} = \frac{100}{10} = 10 \text{kg but } F = \frac{mv^2}{r}; \therefore F = \frac{10 \times 5^2}{5} = 50N$$

CHAPTER 5

GRAVITATIONAL FIELD. MASS AND WEIGHT. SATELLITE

- Which of the following statements is true of the law of universal gravitation? A. Any two bodies attract each other with a force which is proportional to the difference of their masses. B. Any two bodies attract each other with a force which is inversely proportional to the square of the distance between them. C. Any two bodies attract each other with a force which is proportional to the product of their masses and inversely proportional to the square of the distance between them. D. Any two bodies attract each other with a force which is directly proportional to the square of the distance between them. E. Any two bodies attract each other with a force which is proportional to the sum of their masses. (1980:Q1)
- The force with which an object is attracted to the earth is called its A. Acceleration B. Mass C. Gravity D. Impulse E. Weight. (1983:Q6)
- The force experienced by an object of mass 60.0kg in the moon's gravitational field is $1.002 \times 10^2 \text{N}$. What is the intensity of the gravitational field? A. 0.60Nkg^{-1} B. 1.67Nkg^{-1} C. $6.12 \times 10^2 \text{Nkg}^{-1}$ D. 9.81ms^{-1} (1993:Q7)
- What is the acceleration due to gravity 'g' on the moon, if g is 10ms^{-2} on the earth? A. 0.10ms^{-2} B. 0.74ms^{-2} C. 1.67ms^{-2} D. 10.00ms^{-2} (1995:Q8)
- A body is projected from the earth's surface with the intention of letting it escape from the earth's gravitational field. What is the minimum escape velocity of the body? A. 14kms^{-1} B. 13kms^{-1} C. 12kms^{-1} D. 11kms^{-1} (1995:Q9)
- A planet has mass m_1 and is at a distance r_1 from the sun. A second planet has mass $m_2 = 10m_1$ and is at a distance of $r_2 = 2r_1$ from the sun. Determine the ratio of the gravitational force experienced by the planets. A. 1:5 B. 2:5 C. 3:5 D. 4:5 (1997:Q8)
- The force of attraction between two point masses is 10^{-4}N when the distance between them is 0.18m. If the distance is reduced to 0.06m, calculate the force. A. $1.1 \times 10^{-5} \text{N}$ B. $3.3 \times 10^{-5} \text{N}$ C. $3.0 \times 10^{-4} \text{N}$ D. $9.0 \times 10^{-4} \text{N}$ (1998:Q6)
- I. The earth is not spherical but elliptical in shape. II. Variation in latitude and longitude. III. Rotation of the earth on its axis. IV. Variation in the density of the earth. On which combination of the above does the weight of an object vary on the earth's surface? A. I, II, III and IV. B. II, III and IV only C. I, II and III only D. I and II only. (2001:Q7)
- If the distance between two suspended masses 10kg each is tripled, the gravitational force of attraction between them is reduced by A. one quarter B. one ninth C. one half D. one third. (2002:Q3)
- A satellite is in a parking orbit if its period is A. less than the period of the earth B. more than the period of the earth C. equal to the period of the earth D. the square of the period of the earth (2003:Q13)
- The earth is four times the size of the moon and the acceleration due to gravity on the earth is 80 times that on the moon. The ratio of the mass of the moon to that of the earth is A. 1:320. B. 1:1280 C. 1:80 D. 1:4. (2004:Q17)
- A force of 200N acts between two objects at a certain distance apart. The value of the force when the distance is halved is A. 100N. B. 200N. C. 800N D. 400N (2005:Q32)
- If the radius of the earth is $6.4 \times 10^6 \text{m}$, the escape velocity of a satellite from the earth is A. $8.00 \times 10^3 \text{ms}^{-1}$. B. $9.00 \times 10^3 \text{ms}^{-1}$. C. $1.13 \times 10^4 \text{ms}^{-1}$ D. $1.27 \times 10^4 \text{ms}^{-1}$ [$g = 10 \text{ms}^{-2}$] (2006:Q17)
- Two spheres of masses 5.0 kg and 10.0 kg are 0.3 m apart. Calculate the force of attraction between them. A. $3.71 \times 10^9 \text{N}$. B. $3.57 \times 10^7 \text{N}$ C. $4.00 \times 10^9 \text{N}$. D. $3.50 \times 10^{10} \text{N}$. (2007:Q43)
- The values of x, y and z respectively in the expression $\text{M}^x \text{L}^y \text{T}^z$ for the universal gravitational constant G are A. 2, -3, -2. B. -1, 3, -2. C. -1, 2, -3. D. -2, -1, 3. (2009:Q1)
- An object is weighed at different locations on the earth. What will be the right observation? A. Both the mass and weight vary B. The weight is constant while the mass varies C. The mass is constant while the weight varies D. Both the mass and weight are constant. (2010:Q6)
- A rocket is fired from the earth's surface to a distant planet. By Newton's law of universal gravitation, the force F will A. increase as r reduces B. increase as G varies C. remains constant D. increases as r increases (2012:Q8)
- When a brick is taken from the earth's surface to the moon, its mass A. remains constant. B. reduces C. increases. D. becomes zero. (2013:Q2)
- Calculate the escape velocity of a satellite launched from the earth's surface if the radius of the earth is $6.4 \times 10^6 \text{m}$ A. 25.3kms^{-1} B. 4.2kms^{-1} C. 4.0kms^{-1} D. 11.3kms^{-1} [$g = 10 \text{ms}^{-2}$] (2014:Q8)
- An object of weight 80kg on earth is taken to a planet where the acceleration due to gravity is one-third of its value on earth. The weight of the object on the planet is A. 48N B. 12N C. 27N D. 36N [$g = 10 \text{ms}^{-2}$] (2014:Q9)
- A satellite moves in a circular orbit of radius 4R round the earth. The acceleration of the satellite in terms of g is A. $4/g$ B. $g/4$ C. $g/16$ D. $16/g$ (2015:Q1)
- A satellite revolving around the earth is kept on its orbit by A. centrifugal forces only b. centripetal forces only C. centripetal and frictional forces D. centripetal and centrifugal forces (2015:Q5)
- The gravitational potential at a point in a gravitational field is the work done in taking a unit mass from A. zero to infinity B. infinity to the point C. one point to another point D. a distance to a given point (2016:Q49)

24. In the earth's gravitational field A. work is done when a force moves its point of application around a closed path B. bodies repel themselves when they come close C. energy is released when an object is raised above the ground D. a body experiences no decrease in its deceleration when its moves freely upwards (2017:Q1)

Chapter 5: ANSWERS

1C $F = \frac{Gm_1m_2}{r^2}$ or $F \propto \frac{m_1m_2}{r^2}$

2E While Gravity is the concept of the earth's pull on the body of mass, m, that moves with an acceleration a ($g = 9.8ms^{-2}$) towards the earth secondary to the pull to register a force $F (= W)$ If $F = ma$; then $W = mg$

3B Gravitational field intensity is force per unit mass

$g_m = \frac{1.002 \times 10^2}{60} = 1.67Nkg^{-1} = 1.67ms^{-2}$

NOTE: This is acceleration due to gravity on the moon compared to the $9.8ms^{-2}$ of the earth's hence a 60kg body weighs ($60 \times 1.67 = 100.2N$) on the moon and ($60 \times 9.8 = 588N$) on earth while the mass remains unchanged on both planetary bodies.

4C The information here is incomplete unless you have a pre-knowledge of the answer to Q3 above. At least you need the masses of the earth and the moon to proceed as follows: Let a body of mass m be placed at a distance r from the centre of the moon and then the earth

Weight on the moon:

$W_m = mg_m = \frac{GM_m m}{r^2} \rightarrow g_m = \frac{GM_m}{r^2} \dots (i)$

Similarly, on Earth: $g_e = \frac{GM_e}{r^2} \dots (ii)$

Dividing (i) by (ii): $\frac{g_m}{g_e} = \frac{GM_m}{r^2} \times \frac{r^2}{GM_e} \rightarrow \frac{g_m}{g_e} = \frac{M_m}{M_e} \dots (iii)$

From which g_m could be calculated since $g_e = 9.8ms^{-2}$

NOTE:

- The steps above are given here only for didactic reason.
- Just master equation(iii) for comparing any two "gravitational jurisdictions" like the Moon and the Earth

5D The escape velocity is $V_e = \sqrt{2gR}$

And $R = 6.4 \times 10^3 km = 6.4 \times 10^6 m$

$\therefore V_e = \sqrt{2 \times 10 \times 6.4 \times 10^6} = 11314ms^{-1} = 11.314kms^{-1}$

6B $F_1 = \frac{GMm_1}{r_1^2} \dots (i)$ $F_2 = \frac{GMm_2}{r_2^2} = \frac{10GMm_1}{(2r_1)^2}$ ($m_2 = 10m_1$; and $r_2 = 2r_1$)

$\therefore F_2 = \frac{10GMm_1}{4r_1^2} \dots (ii)$; Dividing (i) by (ii): $\frac{F_1}{F_2} = \frac{GMm_1}{r_1^2} \times \frac{4r_1^2}{10GMm_1}$

$\frac{F_1}{F_2} = \frac{4}{10} \therefore F_1:F_2 = 2:5$

NOTE: M = Mass of the sun while G is a constant throughout the entire universe.

7D $F \propto \frac{1}{r^2} \therefore \frac{F_1}{F_2} = \left(\frac{r_2}{r_1}\right)^2 \rightarrow F_2 = F_1 \left(\frac{r_1}{r_2}\right)^2 = 10^4 \left(\frac{0.18}{0.06}\right)^2 = 9.0 \times 10^4$

8A Factors affecting the weight of a body

9B From Q7: $\frac{F_2}{F_1} = \left(\frac{r_1}{r_2}\right)^2 = \left(\frac{1}{3}\right)^2 = \frac{1}{9}$ (See Q7)

10C Thus the satellite is geosynchronous with the 24-hour period of the earth's rotation and it appears stationary to an observer on earth.

11B $g_e = \frac{GM_e}{r_e^2} \dots (i)$ $g_m = \frac{GM_m}{r_m^2} \dots (ii)$

$\frac{g_m}{g_e} = \frac{GM_m}{r_m^2} \times \frac{r_e^2}{GM_e} \rightarrow \frac{g_m}{g_e} = \left(\frac{M_m}{M_e}\right) \cdot \left(\frac{r_e}{r_m}\right)^2$

$\rightarrow \frac{1}{80} = \left(\frac{M_m}{M_e}\right) \cdot \left(\frac{4}{1}\right)^2 \rightarrow \frac{M_m}{M_e} = \frac{1}{80} \times \frac{1}{16}$

$\rightarrow M_m:M_e = 1:1280$

12C $F \propto \frac{1}{d^2} \rightarrow \frac{F_2}{F_1} = \left(\frac{d_1}{d_2}\right)^2 \rightarrow F_2 = 200 \left(\frac{2}{1}\right)^2 = 800N$

13C $v = \sqrt{2gR} = \sqrt{2 \times 10 \times 6.4 \times 10^7} = 11314ms^{-1}$

14A $F = \frac{GM_1M_2}{d^2} = \frac{6.67 \times 10^{-11} \times 5 \times 10}{0.3^2} = 3.71 \times 10^{-9}N$

15B $F = \frac{GM_1M_2}{r^2} \rightarrow G = \frac{F \cdot r^2}{M_1M_2}$; $G \rightarrow \frac{N \cdot m^2}{Kg^2}$

$\rightarrow \frac{Kgms^{-2} \cdot m^2}{Kg^2} \rightarrow Kgms^{-2} \cdot m^2 \cdot Kg^{-2}$

$\rightarrow Kg^{-1} m^3 s^{-2} \rightarrow M^{-1}L^3T^{-2} = M^{-1}L^3T^{-2}$

$x = -1$ $y = 3$ $z = -2$ (See Chapter 1)

16C If the same object is taken to another planet, its mass still remains constant.

Note the differences between mass and weights.

| Mass | Weight |
|---------------------------------|---|
| 1. Quantity of matter in a body | Earth's gravitational pull on the same body |
| 2. Universally constant | Varies from one location to another |
| 3. It is not a force | It is a force |
| 4. Measured in kilogram (kg) | Measured in Newton (N) |
| 5. Measured by beam balance | Measured by spring balance |

17A $F \propto \frac{1}{r^2}$

18A See Q16 19D See Q13

20C Since $W = mg$ and $g_{planet} = \frac{1}{3}g_{earth}$

Then $W_{planet} = \frac{1}{3}W_{earth} = \frac{1}{3} \times 80 = 26.67N$

80kg was an error, JAMB meant 80N

21C. For a satellite of mass m the centripetal force keeping it in the earth's orbit is given by

$F = \frac{Gmm_e}{R^2}$ where $m_e =$ mass of earth, $R =$ radius of earth

$mg = \frac{Gmm_e}{R^2} \rightarrow g = \frac{Gm_e}{R^2}$ and $G = \frac{gR^2}{m_e}$

To keep the satellite in the orbit of radius $r = 4R$

$F = \frac{Gm_e m}{(4R)^2} \rightarrow ma = \frac{Gm_e m}{16R^2} \rightarrow a = \frac{Gm_e}{16R^2}$

Now, substitute $\frac{gR^2}{m_e}$ for G in the equation above.

$a = G \left(\frac{m_e}{16R^2}\right) = \frac{gR^2}{m_e} \left(\frac{m_e}{16R^2}\right) = \frac{g}{16}$ and $a = \frac{g}{16}$

NOTE: The satellite has acceleration $a = g$ at $r = R$ but $a = g/16$ at $r = 4R$

22D Both forces are important (see Q1 and 4).

23B Gravitational potential energy V is given by

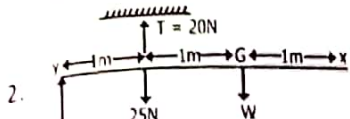
$V = \frac{Gm}{r}$ and its unit is Jkg^{-1}

24D Acceleration of force fall (downwards) or deceleration of upward journey, under gravity, remains constant at $9.8ms^{-2}$

CHAPTER 6

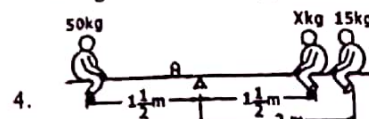
VECTORS. EQUILIBRIUM OF FORCES

1. A man walks 1km due east and then 1km due north. His displacement is A. 1km N15°E B. 1km N30°E C. $\sqrt{2}$ km N45°E D. $\sqrt{2}$ km N60°E. 2km N75°E. (1978:Q1)



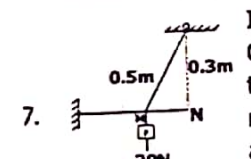
In the diagram below, what is the value of W? A. 5N B. 10N C. 15N D. 20N E. 30N (1978:Q12)

3. A uniform beam HK of length 10m and weighing 2000N is supported at both ends as shown. A man weighing 1000N stands at a point P on the beam. If the reactions at H and K are respectively 800N and 400N, then the distance HP is A. 4m B. $3\frac{1}{3}$ m C. 3m D. $6\frac{2}{3}$ m E. 7m (1979:Q25)



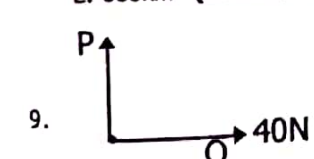
The figure shows a see-saw which is exactly in balance. The weights of the people sitting on it are 50kg, Xkg and 15kg as shown. They sit at distances of $1\frac{1}{2}$ m, $1\frac{1}{2}$ m and 2m from the pivot respectively. The value of X is. A. 30 B. 35 C. 70 D. 26 E. impossible to find. (1979:Q39)

5. A weight of 1000 grams hangs from a lever 20cm to the right of the fulcrum. At the left is a 500gram weight 20cm from the fulcrum. What is the value of x that will make the lever balanced? A. 50cm B. 20cm C. 10cm D. 30cm E. 70cm (1979:Q47)
6. A tugboat is travelling from Asaba to Onitsha across the River Niger with a resultant velocity of 20 knots. If the river flows at 12 knots, the direction of water flow is A. 36.870 B. 53.130 C. 900 D. 136.870 E. 143.130 (1980:Q27)

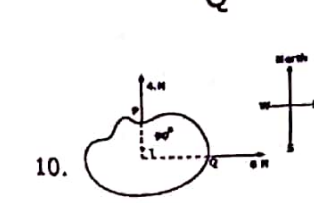


In the above diagram MN is perpendicular to ON and MP. What is the difference between the moment about N of the force of 20 newtons applied along MP and its moment about O? A. Zero B. 0.2N.m C. 0.4N.m D. 0.8N.m E. 0.6N.m (1980:Q31)

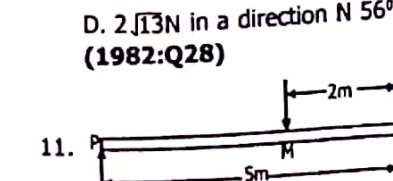
8. An aircraft travelled from Calabar to Kano as follows: It flew first to Ilorin covering a distance of 300km, 300 West of North, and then flew 400km, 600 East of North to Kano. What is the resultant displacement? A. 567km B. 410km C. 594km D. 500km E. 600km (1981:Q23)



A particle is under the action of three forces in equilibrium. Two of the forces are as shown in Fig. 5. the third force is A. 80N along P B. 160N at 60° to P C. $40\sqrt{2}$ N at 45° to either P or Q D. 0N E. $40\sqrt{2}$ N at 30° to Q. (1981:Q41)



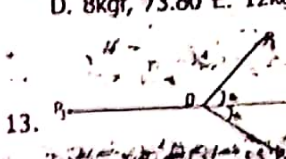
A body is acted on by forces applied at points P and Q as shown. Their resultant is equal to A. $2\sqrt{2}$ N in a direction E B. $2\sqrt{2}$ N in a direction N 56° W C. $2\sqrt{13}$ N in a direction N 56° E D. $2\sqrt{13}$ N in a direction N 56° E. E. $\sqrt{10}$ N in a direction N 56° E (1982:Q28)



A uniform beam PQ of mass 20kg and length 5m is balanced as shown (Fig. 8). A man of weight 800 N stands at M such that QM = 2m. The reactions at P and Q respectively are (take $g = 10\text{ms}^{-2}$) A. 300 N and 500 N B. 420 N and 580 N C. 220 N and 380 N D. 580 N and 420 N E. 380 N and 220 N (1982:Q29)

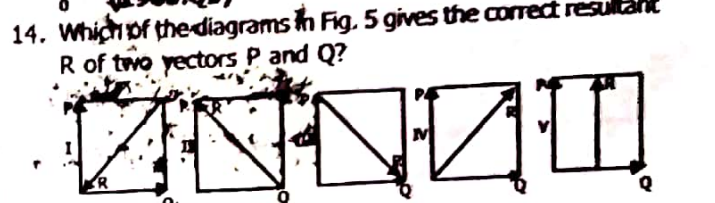
11. reactions at P and Q respectively are (take $g = 10\text{ms}^{-2}$) A. 300 N and 500 N B. 420 N and 580 N C. 220 N and 380 N D. 580 N and 420 N E. 380 N and 220 N (1982:Q29)

12. In the give diagram (Fig. 11), the values of the vertically suspended weight W and the angle X are A. 2kgf, 30.90 B. 4kgf, 36.90 C. 6kgf, 53.10 D. 8kgf, 73.80 E. 12kgf, 106.20 (1982:Q46)

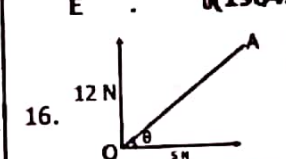


Consider the three forces acting at O and in equilibrium as shown in Fig. 1. Which of the following equations is/are CORRECT? I. $\cos\theta = P_1 \cos\theta$, II. $P = P_1 \cos\theta + P_2 \cos\theta$, III. $P_1 \sin\theta = P_2 \sin\theta$, A. I only B. II only C. III only D. II and III only E. I and III (1988:Q3)

13. Which of the diagrams in Fig. 5 gives the correct resultant R of two vectors P and Q? A. I B. II C. III D. IV E. V (1983:Q25)



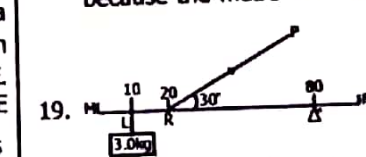
14. In Fig. 1, PT is a uniform metre rule pivoted at R, the 70cm mark. Two forces 0.1N and 0.4N are applied at Q, the 60cm mark and S, the 85cm mark. If the metre rule is kept in equilibrium by the forces and its weight, then the weight of the metre rule is A. 0.25 N B. 0.30 N C. 0.35 N D. 0.50 N E. (1984:Q2) I



A body of mass 5kg initially at rest is acted upon by two mutually perpendicular forces 12N and 5N as shown in Fig.3. If the particle moves in the direction QA, calculate the magnitude of the acceleration. A. 0.40ms^{-2} B. 1.40ms^{-2} C. 0.26ms^{-2} D. 2.60ms^{-2} E. 3.40ms^{-2} (1984:Q21)

16. A block of mass 2.0kg resting on a smooth horizontal plane is acted upon simultaneously by two forces, 10N due North and 10N due East. The magnitude of the acceleration produced by the forces on the block is A. 0.10ms^{-2} B. 7.05ms^{-2} C. 10.00ms^{-2} D. 14.10ms^{-2} E. 20.00ms^{-2} (1985:Q7)

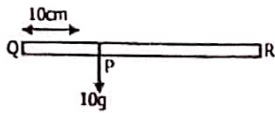
17. Two masses 40g and 60g respectively, are attached firmly to the ends of a light metre rule. The centre of gravity of the system is A. At the mid-point of the metre rule B. 40cm from the lighter mass C. 40cm from the heavier mass D. 60cm from the heavier mass E. indeterminate because the metre rule is light. (1985:Q10)



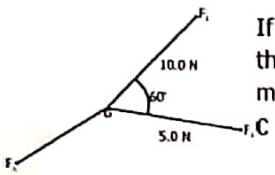
In the figure above. MN is a light uniform metre rule pivoted at O, the 80cm mark. A load of mass 3.0kg is suspended on the rule at L, the 10cm mark. If the rule is kept in equilibrium by a string RP, fixed at P and attached to the rule at R, the 20cm mark, then the tension T in the string is A. 3.0N B. 3.4N C. 3.5N D. 6.0N E. 7.0N (1985:Q11)

18. Which of the following is in a neutral equilibrium? A. A heavy weight suspended on a string. B. A cone resting on its slant edge. C. A heavy based table lamp.

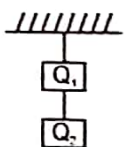
- D. The beam of a balance in use. (1986:Q6)
21. A uniform metre rule QR is balanced on a knife edge which is 55cm from R. when a mass of 10g is hung at P as shown in Fig. 2, the mass of the metre rule is A. 550g B. 350g C. 70g D. 35g (1986:Q9)



22. In Fig., F_1, F_2, F_3 , acting at O are in equilibrium. If the magnitude of F_1 is 10.0N and the magnitude of F_2 is 5.0N, find the magnitude of F_3 . A. 26.4 N B. 15.0 N C. 13 D. 3 (1986:Q10)



23. A man walks 8km north and then 5km in a direction 60° east of north. Find the distance from his starting point. A. 11.36km B. 12.36km C. 13.00km D. 14.36km. (1987:Q2)
24. The figure shows a system in equilibrium under gravity. The tension in the upper string is A. $(m_1 - m_2)g$ B. m_1g C. m_2g D. $(m_1 + m_2)g$. (1987:Q5)



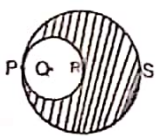
25. A lorry travels 10km northwards, 4km eastwards, 6km southwards and 4km westwards to arrive at a point T. What is the total displacement? A. 6km south B. 4km north C. 6km north D. 4km east. (1988:Q3)
26. Two forces whose resultant is 100N, are at right angles to each other. If one of them makes an angle of 30° with the resultant, determine its magnitude. A. 8.66 N B. 50.0 N C. 57.7 N D. 86.6 N (1988:Q4)

27. The figures above show three different ways of hanging a heavy picture from a hook. The tension in the string would be A. Greatest in X B. Greatest in Y C. Greatest in Z D. Same in each one. (1988:Q10)

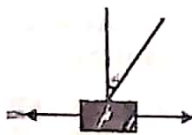


28. The magnitude of the resultant of two mutually perpendicular forces, F_1 and F_2 is 13N. If the magnitude of F_1 is 5N, what is the magnitude of F_2 ? A. 2.6 N B. 8.0 N C. 12.0 N D. 18.0 N (1989:Q2)

29. The figure above shows a uniform circular object, Centre R and diameter PS. A circular section, centre Q and diameter PR is cut away from it. If PQRS is a straight line, where is the centre of gravity of the figure? A. Q B. R C. A point between P and R D. A point between R and S. (1989:Q4)

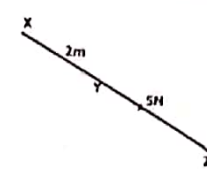


30. Two horizontal forces, 10N and 8N and another force F , inclined at 30° to the vertical acting as shown in the diagram above, keep the body P in equilibrium. The weight of the body is A. $\frac{2\sqrt{3}}{3}$ N B. $\sqrt{3}$ N C. $\frac{4\sqrt{3}}{3}$ N D. $2\sqrt{3}$ N (1990:Q3)

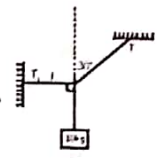


31. Which of the following statements are correct about an object in equilibrium under parallel forces? I. The total clockwise moments of the forces about any point equals the total anticlockwise moments about the same point. II. The total forces in one direction equals the total forces in the opposite direction III. The resolved components along the x axis equals the resolved component along the y-axis. A. I and II only B. I and III only C. II and III only D. I, II and III. (1990:Q7)

32. A force of 5N acts at a point Y on a rod XYZ as shown in the diagram above. If XY is 2m, what is the moment of the force about point X? A. 0Nm B. 3Nm C. 7Nm D. 10Nm. (1990:Q8)

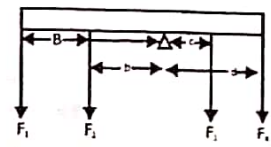


33. A body of weight W N rests on a smooth plane inclined at an angle θ° to the horizontal. What is the resolved part of the weight in Newton along the plane? A. $W \sin \theta$ B. $W \cos \theta$ C. $W \sec \theta$ D. $W \tan \theta$ (1991:Q2)
34. Find the tension T_1 in the diagram above if the system is in equilibrium. A. $\frac{200}{3}$ N B. $\frac{100}{3}$ N C. $\frac{300}{3}$ N D. 100 N [$g = 10ms^{-2}$] (1991:Q6)



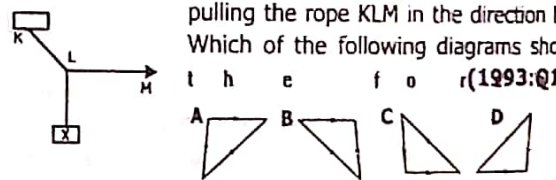
35. A boy sits in a train moving with uniform speed on a straight track. If from his outstretched palm he gently tosses a coin vertically upwards, the coin will fall A. In front of his palm B. Behind his palm C. Beside his palm D. Into his palm (1992:Q3)

36. A uniform light rod is kept in horizontal equilibrium under the influence of four forces as shown above. Which of the following equations correctly represents the condition of equilibrium for the rod? A. $F_1 + F_2 = F_3 + F_4$ B. $F_1 + F_2 - F_3 + F_4 = 0$ C. $(F_1 + F_2)ab = (F_3 + F_4)cd$ D. $F_1a + F_2b - F_3c - F_4d = 0$ (1992:Q7)

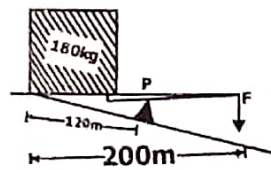


37. Two forces of magnitudes 7N and 3N act at right angles to each other. The angle θ between the resultant and the 7N force is given by A. $\cos \theta = \frac{3}{7}$ B. $\sin \theta = \frac{3}{7}$ C. $\tan \theta = \frac{3}{7}$ D. $\cos \theta = \frac{3}{7}$ (1993:Q4)

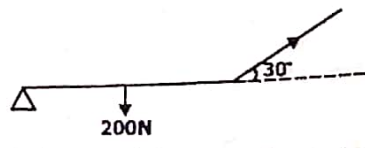
38. In the figure, the weight X is held in position by pulling the rope KLM in the direction LM. Which of the following diagrams shows the force (1993:Q11)



39. In the diagram above, a lever of length 200m is used to lift a load of mass 180kg. The pivot at P is 120m from the load. W m l i n l₁ must be applied at the end of the lever? [$g = 10ms^{-2}$] A. 9N B. 18N C. 20N D. 200N (1993:Q12)

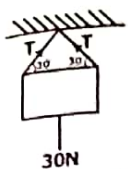


40. A boat travels due east at a speed of $40ms^{-1}$. What is the resultant speed of the boat? A. $1.3ms^{-1}$ B. $10.0ms^{-1}$ C. $50.0ms^{-1}$ D. $70.0ms^{-1}$ (1994:Q3)
41. The diagram above shows a uniform wood of weight 200N and length 50 m. it is pivoted at one end and suspended by a cord at the other end at an angle of 30° to the wood. Calculate the tension in the cord if the wood is horizontal (1994:Q4)



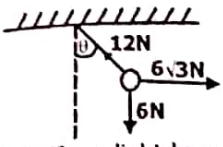
42. In the diagram above, P, Q and R are vectors. Which of the following options gives the correct relationship between the vectors? A. $P = Q + R$ B. $P = Q - R$ C. $P = R - Q$ D. $P + Q + R = 0$ (1995:Q3)



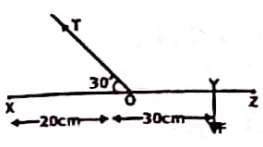


The value of T in the figure above is
 A. 10.0N B. 11.8N C. 20.0N D. 40.0N
 (1995:Q4)

43. The uniform rod PQ of length 1m and mass 2kg is pivoted at the end P. If a load of 14N is placed at the centre of the rod, find the force that should be applied vertically upwards at Q to maintain the rod in equilibrium horizontally. A. 68N B. 28N C. 17N D. 7N
 (1995:Q10)

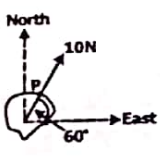


45. For what value of θ are the forces in the diagram above in equilibrium? A. 15° B. 30° C. 45° D. 60°
 (1997:Q9)



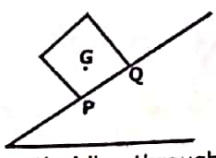
46. A uniform light beam XZ is hinged at X and kept in equilibrium by the forces T and F as shown in the diagram above. If $XO = 20\text{cm}$ and $OY = 30\text{cm}$, express T in terms of F.
 A. $T = 2\frac{\sqrt{3}}{3}F$ B. $T = 2F$ C. $T = 5\frac{\sqrt{3}}{3}F$
 D. $T = 5F$ (1997:Q11)

47. A ball is moving at 18ms^{-1} in a direction inclined at 60° to the horizontal. The horizontal component of its velocity is
 A. $9\sqrt{3}\text{ms}^{-1}$ B. $6\sqrt{3}\text{ms}^{-1}$ C. $6\sqrt{3}\text{ms}^{-1}$ D. 9ms^{-1} (1998:Q2)



48. A body on the ground is acted on by a force of 10N at a point P as shown in the diagram above. What force is needed to stop the body from moving eastward?
 A. 5N in the direction of East
 B. 5N in the direction of West
 C. $5\sqrt{3}\text{N}$ in the direction of West
 D. 10N in the South west direction. (1998:Q3)

49. A uniform metre rule weighting 0.5N is to be pivoted on a knife edge at the 30cm-mark. Where will a force of 2N be placed from the pivot to balance the metre rule?
 A. 95cm B. 25cm
 C. 2 D. 1 (1998:Q8)



50. The diagram above shows a solid figure with base PQ and centre gravity G on an inclined plane. Which of the following statements is correct?
 A. The solid will fall over if the vertical line through G lies outside the base.
 B. The solid will fall over if the vertical line through G lies inside the base.
 C. The solid will not fall over if the vertical line through G lies outside the base.
 D. The solid can never fall over. (1999:Q5)

51. A hand bag containing some load weighting 162N is carried by two students each holding the handle of the bag next to him. If each handle is pulled at 60° to the vertical, find the force on each student's arm
 A. 324N B. 162N C. 121N
 D. 81N (2000:Q2)

52. A stream is flowing at 0.75ms^{-1} and at boat heading perpendicular for the stream landed at the opposite bank at an angle 30° . Calculate the velocity of the boat.
 A. 0.65ms^{-1} B. 0.86ms^{-1} C. 1.00ms^{-1} D. 1.50ms^{-1} (2000:Q12)

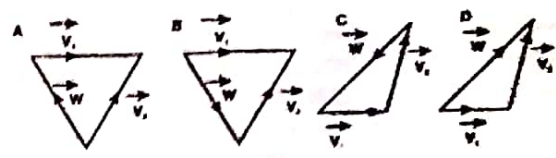
53. The resultant of two forces acting on an object is maximum if the angle between them is
 A. 45° B. 0° C. 90° D. 180°
 (2001:Q6)

54. Two forces each of 10N act on a body, one towards the north and the other towards the east. The magnitude and the direction of the resultant force are
 A. $10\sqrt{2}\text{N}$, 45°E
 B. $10\sqrt{2}\text{N}$, 45°W C. 20N, 45°W D. 20N, 45°E . (2002:Q7)

55. A 90cm uniform lever has a load of 30N suspended at 15cm from one of its ends. If the fulcrum is at the centre of gravity,

the force that must be applied at its other end to keep it in horizontal equilibrium is
 A. 15N B. 20N C. 30N
 D. 60N (2003:Q11)

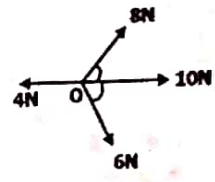
56. The figure shows vectors v_1 and v_2 . Which of the following diagrams correctly represents the vector difference $w = v_1 - v_2$?



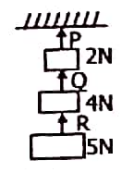
(2003:Q12)

57. If the angle between two vectors P and Q is 0° , the vectors are said to
 A. be perpendicular B. be parallel
 C. intersect at angle 60° D. intersect at angle 45°
 (2004:Q10)

58. The diagram shows forces 4N, 6N and 10N and 8N which act at a point O in the directions indicated. The net horizontal force is
 A. $7\sqrt{3}\text{N}$ B. 17N
 C. $\sqrt{3}\text{N}$ D. 13N (2004:Q18)



59. The value of F in the figure above when in equilibrium is
 A. 10N B. 12N C. 27N D. 20N
 (2005:Q25)

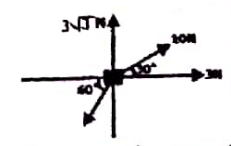


If the system above is in equilibrium, the tension in the string Q is
 A. 6N B. 4N
 C. 11N D. 9N. (2005:Q29)

60. A mirror of weight 75N is hung by a cord from a hook on the wall. If the cord makes an angle of 30° with the horizontal, the tension in the cord is
 A. 150N B. 100N
 C. 15 D. 15 (2006:Q18)

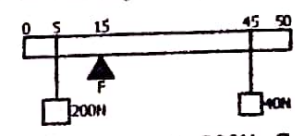
61. The component of vector X along the direction of vector Y is zero when
 A. X is at an angle of 45° to Y
 B. X and Y are in opposite directions to each other
 C. X and Y are parallel to each other
 D. X is perpendicular to Y.
 (2006:Q14)

62. The figure above shows 4 forces 3N, 10N, $3\sqrt{3}\text{N}$ and 6N acting on a particle P. The resultant of the four forces is
 A. $10\sqrt{3}\text{N}$
 B. 10N C. $5\sqrt{3}\text{N}$ D. 5N. (2007:Q42)



63. The unit of moment of a couple can be expressed in
 A. N^{-1} C. Nm^2 D. Nm^{-2} (2007:Q45)

64. In the diagram above, a rod 50cm long of uniform cross section is suspended horizontally on a fulcrum, F, by the action of two forces. What is the weight of the rod?
 A. 120N B. 200N C. 40N D. 80N (2007:Q47)

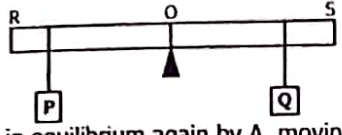


65. The resultant of two forces 12N and 5N is 13N. What is the angle between them?
 A. 45° B. 90°
 C. 180° D. 180° (2008:Q3)

66. A body of mass 4kg resting on a smooth horizontal plane is simultaneously acted upon by two perpendicular forces

6N and 8N. Calculate the acceleration of the motion
 A. 2.5ms^{-1} B. 3.0ms^{-1} C. 4.0ms^{-1} D. 4.5ms^{-1} (2008:Q7)

68. The diagram above shows plank RS pivoted at its centre of gravity O and is in equilibrium with the weights P and Q. If a weight 2P is added to P, the plank will be in equilibrium again by
 A. moving Q nearer to O. B. moving P nearer to O. C. adding a weight Q to Q. D. moving P further away from O. (2008:Q8)



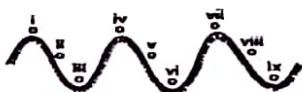
69. I. All the three forces must be concurrent II. The upward force is equal to the downward force III. The algebraic sum of the moment about any point must be zero. Which of the above conditions must hold for a body acted upon by a system of three coplanar forces in equilibrium? A. I and II only B. I and III only C. II and III only D. I, II and III (2008:Q9)

70. An aircraft attempts to fly due north at 100kmh^{-1} . If the wind blows against it from east to west at 60km^{-1} , its resultant velocity is
 A. 117kmh^{-1} , $\text{N}31^\circ\text{E}$. B. 127kmh^{-1} , $\text{N}31^\circ\text{E}$.
 C. 117kmh^{-1} , $\text{N}31^\circ\text{W}$. D. 127kmh^{-1} , $\text{N}31^\circ\text{W}$. (2009:Q3)

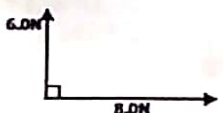
71. Which of the diagrams below shows the position at which a small ball-bearing is in neutral equilibrium?
 A. B. C. D. (2009:Q6)

72. Two cars moving in the same direction have speeds of 100kmh^{-1} and 130kmh^{-1} . What is the velocity of the faster car as measured by an observer in the slower car? A. 130kmh^{-1} B. 230km^{-1} C. 200kmh^{-1} D. 30kmh^{-1} (2010:Q2)

73. The diagram above represents balls in an undulating surface. Which of the following options represents of stable equilibrium?
 A. II, V and VIII B. I, IV and VII C. III, VI and IX D. III, IV and VIII (2010:Q7)



74. The diagram above shows two vectors at right angles to each other. The value of the resultant vector is
 A. 12.0N B. 13.0N C. 14.0N D. 10.0N (2011:Q5)



75. The diagrams above show the positions of a cone. The position which can be described as neutral equilibrium is represented as
 A. Y and Z B. Y and X C. Z only D. X only (2011:Q8)



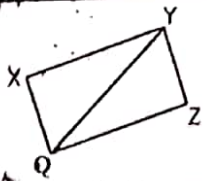
76. The resultant of two forces is 50N. If the forces are perpendicular to each other and one of them makes an angle of 30° with the resultant, find its magnitude.
 A. 100.0N B. 57.7N C. 43.3N D. 25.0N (2013:Q3)

77. One of the conditions necessary for an object to be in equilibrium when acted upon by a number of parallel forces is that the vector sum of the forces is
 A. Average B. zero C. negative d. positive (2014:Q10)

78. What happens when three coplanar non-parallel forces are in equilibrium? A. their lines of action are parallel B. they are represented in magnitude only C. they are represented in direction only D. their lines of action meet at a point (2014:Q11)

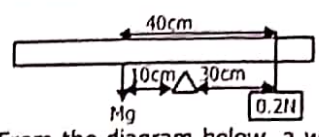
79. A metre rule is pivoted at its mid-point with a vertical force of 10N hanging from the distance 30cm from the mid-point. At what distance must a 15N force hang to balance the ruler horizontally? A. 25cm B. 30cm C. 20cm D. 10cm (2015:Q30)

80. In the diagram below, the forces whose resultant is represented in magnitude and direction by QY are

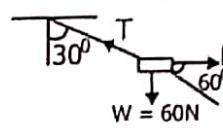


A. \vec{QX} and \vec{QZ} B. \vec{QX} and \vec{ZY}
 C. \vec{XQ} and \vec{QZ} D. \vec{XQ} and \vec{ZY} (2016:Q16)

81. In the diagram below, the mass of the uniform metre rule is $[g=10\text{ms}^{-2}]$
 A. 0.4kg B. 0.2kg C. 0.6kg D. 0.5kg (2016:Q34)



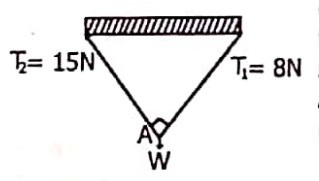
82. From the diagram below, a weight $W = 60\text{N}$ is suspended horizontally by a string attached to a wall. Find the tension T on the string?
 A. $60\sqrt{3}$ B. $20\sqrt{3}$ C. $40\sqrt{3}$ D. 120N (2017:Q18)



83. A moves 20m North, then 12m East and finally 15m south. His displacement from the starting point is now
 A. 13m B. 27m C. 47m D. 23m (2017:Q29)

84. A boy travels 8km eastwards to a point B in air and water. Determine the relative density of the solid
 A. 0.33 B. 0.50 C. 1.50 D. 3.00 (2018:Q9)

85. An object, A is held in equilibrium as illustrated in the diagram. Using the data on the diagram, determine the magnitude w of the weight
 A. 23N B. 17N C. 2N D. 5N (2018:Q10)



CHAPTER 6: ANSWERS

Magnitude of his displacement = OB
 $OB^2 = OA^2 + AB^2$ (pythagoras) \rightarrow
 $OB = \sqrt{1^2 + 1^2} = 2\text{km}$
 Direction of his displacement = ∞
 But $\tan \theta = \frac{1}{1} = 1$ (Trig.) $\rightarrow \theta = \tan^{-1} 1 \therefore \theta = 45^\circ$
 And $\infty = 90^\circ - \theta \rightarrow \infty = 45^\circ = \text{N}45^\circ\text{E}$

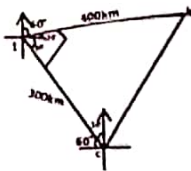
2. Incomplete diagram
 3C Let HP = x and y = 5 - x
 Taking moment about H

800N $1000(x) + 200(5) = 400(10) \rightarrow 1000x = 3000 \rightarrow x = 3\text{m}$
 To verify, take moment about K.
 $1000(10 - x) + 200(5) = 800(10)$
 $10000 - 1000x + 1000 = 8000$
 $-1000x = 8000 - 11000 \rightarrow x = 3$ (as before)

8A Taking moment about fulcrum: $\frac{3}{2}x + 15(2) = 50 \times \frac{3}{2}$
 $\rightarrow 3x + 15(2)(2) = 50(3) \rightarrow x = 30\text{kg}$
NOTE: It amounts to waste of time converting the masses to weights as some students are apt to do (since moment = $F \times s$). It is not necessary!

5A Taking moments: $200x + 500(20) = 1000(20)x = 50\text{cm}$
 5B $\cos \theta = \frac{12}{20} = 0.6$
 $\rightarrow \theta = \cos^{-1} 0.6$

If required, calculate the real speed of the boat as follows
 $V = \sqrt{20^2 - 12^2}$ (Pythagoras)
 7A Both O and N are at equal perpendicular distances from M hence difference is zero.
 8D In the right angled $\triangle CIK$: $CK = \sqrt{400^2 + 300^2}$ (pythagoras)
 $\rightarrow CK = 500\text{km}$



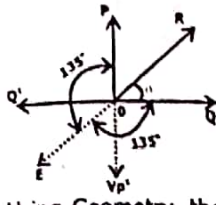
9C Using parallelogram law

$$R = \sqrt{40^2 + 40^2} \text{ (pythagoras)}$$

$$\rightarrow R = 40\sqrt{2} \text{ N}$$

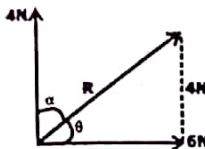
$$\theta = \tan^{-1} 1 = 45^\circ$$

The third force which balances the other two is their equilibrant (E) and it is equal in magnitude but opposite in direction to the resultant (R).



Using Geometry, the equilibrant makes angle 135° with each of the two perpendicular forces. Ordinarily, no option was right but JAMB's predetermined answer was (C)

10D

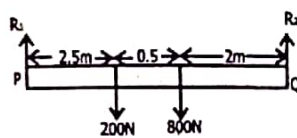


$$R = \sqrt{4^2 + 6^2} = 2\sqrt{13}$$

$$\tan \theta = \frac{4}{6} \rightarrow \tan \alpha = \frac{6}{4}$$

$$\alpha = N56.3E$$

11B Balancing upward and downward forces:



$$R_1 + R_2 = 200 + 800$$

$$\rightarrow R_1 + R_2 = 1000 \text{ N} \dots (i)$$

Taking moments about P:

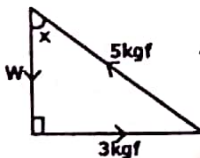
$$5R_2 = 200(2.5) + 800(3)$$

$$\rightarrow R_2 = 580 \text{ N}$$

From equation (i): $R_1 = 1000 - 580 \rightarrow R_1 = 420 \text{ N}$

NOTE: In this case, you have to convert the mass of the beam (20kg) to Newton so as to be in tandem with other forces in the problem.

12B Using triangle of forces:



$$W = \sqrt{5^2 - 3^2} = 4 \text{ kgf}$$

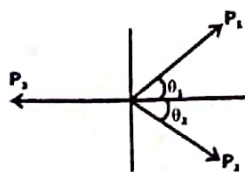
$$x = \sin^{-1} \frac{3}{5} = 36.9^\circ$$

NOTE:

1. Each side of the triangle is drawn parallel to the original force it represents.

2. The sides are in order i.e. the arrows follow one another as their directions is similar to those of the forces.

13D Draw a vertical line through O and apply parallelogram law



Vertical components:

$$P_1 \rightarrow + P_1 \sin \theta_1; P_2 \rightarrow + P_2 \sin \theta_2$$

$$P_3 \rightarrow 0$$

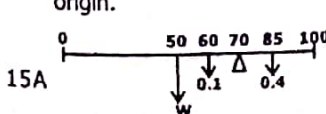
Horizontal components: $P_1 \rightarrow P_1 \cos \theta_1$

$$P_2 \rightarrow P_2 \cos \theta_2; P_3 \rightarrow P_3$$

Balancing vertically: $P_1 \sin \theta_1 = P_2 \sin \theta_2 \dots (III)$

Balancing horizontally: $P_3 = P_1 \cos \theta_1 + P_2 \cos \theta_2 \dots (II)$

14D According to parallelogram law, the resultant is the diagonal of the parallelogram of which the two vectors are adjacent sides and the resultant is drawn from their common point of origin.



15A

Taking moment about R:

$$20W + 0.1(10) = 0.4(15)$$

$$W = 0.25 \text{ N}$$

16D $QA = \sqrt{12^2 + 5^2} = 13 \text{ N}; a = \frac{F}{m} = \frac{13}{5} = 2.6 \text{ ms}^{-2}$

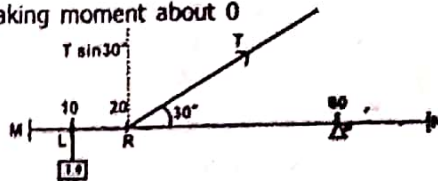
17B $F = \sqrt{10^2 + 10^2} = 14.142 \text{ N}; a = \frac{F}{m} = \frac{14.142}{2} = 7.07 \text{ ms}^{-2}$

18C Let centre of gravity from the lighter mass be x

$$40x = 60(100 - x) \rightarrow 40x = 6000 - 60x$$

$$x = 60 \text{ cm (or 40cm from heavier mass).}$$

19E Taking moment about O

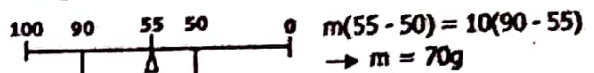


$$T \sin 30^\circ (80 - 20) = 30(80 - 10)$$

$$T = \frac{30 \times 70}{0.5 \times 60} = 70 \text{ N. (Don't mind the error in value).}$$

20B Cone on its apex - unstable; Cone on its base - stable
Cone on its slant edge - Neutral

21C Taking moment about the 55cm mark:



22C F_3 is the equilibrant of F_1 and F_2 , hence just find the resultant of F_1 and F_2 (See Q9)

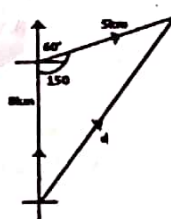


$\angle OCB = 180^\circ - \angle OAC; \angle OCB = 120^\circ$ (Adj. sides of a //gram)
Using cosine rule in $\triangle OCB$

$$R^2 = F_1^2 + F_2^2 - 2(F_1)(F_2) \cos 120^\circ$$

$$R^2 = 10^2 + 5^2 - 2(10)(5)(-0.5); R = \sqrt{125 + 50} \rightarrow R = 13.2 \text{ N}$$

23C The distance from starting point is simply



$$\rightarrow 8 + 5 = 13 \text{ km (scalar)}$$

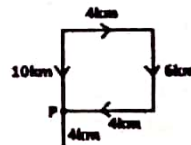
NOTE: The diagram above is only necessary if asked to find the displacement, a vector quantity (See Q1) where

$$d = \sqrt{8^2 + 5^2 + 2(8)(5) \cos 150^\circ}$$

$$= 11.36 \text{ km}$$

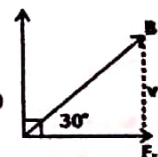
24D Total $w \rightarrow w_{w_1} + w_{w_2} = (M_1 + M_2)g$

25B His final position P is 4km due north of his starting point.



NOTE: His distance would have been $(10 + 4 + 6 + 4) \text{ km}$ or 24km (see Q23)

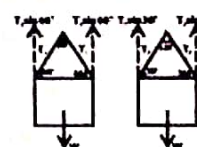
26D



$$F_x = F \cos 30^\circ = \frac{100\sqrt{3}}{2} = 86.6 \text{ N}$$

27B In Z the tension in the strings $2T_x = w \rightarrow T_x = \frac{w}{2}$

Lets assume the vertical angles in X and Y are 60° and 120° respectively ($Y > X$)



In X: $T_x \sin 60^\circ + T_x \sin 60^\circ = W$

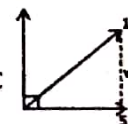
$$\therefore 2T_x \sin 60^\circ = W \rightarrow T_x = \frac{W}{2 \sin 60^\circ}$$

Similarly in Y: $T_y = \frac{W}{2 \sin 30^\circ}$

Comparing: $\frac{W}{2 \sin 30^\circ} > \frac{W}{2 \sin 60^\circ} > \frac{W}{2}$

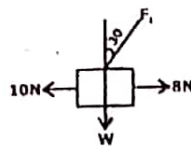
Since: $\sin 30^\circ < \sin 60^\circ < 1 \rightarrow \therefore T_y > T_x > T_z$

28C



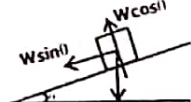
$$V = \sqrt{13^2 - 5^2} \text{ (pythagoras)} \rightarrow V = 12 \text{ N}$$

29D The weight is now concentrated between R and S

30D  Horizontal component of $F_1 \rightarrow F \sin 30^\circ$
For horizontal equilibrium:
 $F \sin 30^\circ + 8 = 10 \rightarrow F = 4\text{N}$
For vertical equilibrium:
 $W = F \cos 30^\circ = 4 \frac{\sqrt{3}}{2} = 2\sqrt{3}$

31A Resolved components on positive x-axis is equal to resolved components on negative x-axis and this is also applicable to y-axis


32A X is in the line of the force hence moment is zero

33A  Resolved part perpendicular to the plane is $W \cos \theta$
34A $T_2 \cos 30^\circ = 100$ (vert. equilibrium)

$$T_2 = \frac{100}{\cos 30^\circ} = \frac{100}{\frac{\sqrt{3}}{2}} \rightarrow T_2 = \frac{200}{\sqrt{3}}$$

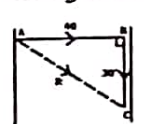
35B Before the coin returns to his palm, the train has moved on hence the coin falls behind his palm - a common experience

36D Anticlockwise moment = clockwise moment
 $F_1 a + F_2 b = F_3 c + F_4 d \rightarrow F_1 a + F_2 b - F_3 c - F_4 d = 0$

37C  $\tan \theta = \frac{3}{7}$

38B From triangle of forces, the forces must be in order (see Q12)

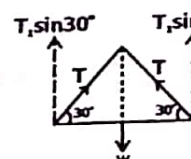
39D Taking moment about P; $180F = 1800 \times 20 \rightarrow F = 200\text{N}$

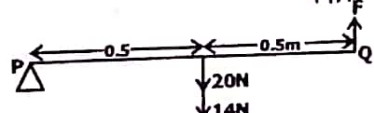
40C  $\text{In } \triangle ABC: R = \sqrt{40^2 + 30^2}$ (pythagoras) $\rightarrow R = 50\text{ms}^{-1}$
AB = speed of boat in magnitude and direction
BC = Speed of river in magnitude and direction
AC = Resultant speed of boat

41D Only the vertical component of the tension (T) has a turning effect at the pivot $\therefore T = 2 \times 200\text{N}$

42A Since P is not in order with Q and R, it is their resultant, not their equilibrant $P = Q + R$ (i) i.e. vector addition as appropriate. If they had been in order then one of them is an equilibrant of the other two hence $P + Q + R = 0$ or $P = -(Q + R)$ (ii)

The negative sign means that P in (ii) is opposite in direction but equal in magnitude to P in (i) i.e. equilibrant vs resultant (see Q9 as instructed)

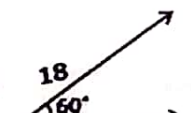
43C  $2(T \sin 30^\circ) = 20 \rightarrow T = 20\text{N}$
If the ropes had been vertical:
 $2T = W \rightarrow T = 10\text{N}$

44A  Taking moment about P
 $F(1) = (20 + 14)(0.5)$
 $\rightarrow F = 68\text{N}$

45D Resolve 12N force horizontally and balance against $6\sqrt{3}$ force:
 $12 \sin \theta = 6\sqrt{3} \rightarrow \sin \theta = \frac{6\sqrt{3}}{12} = \frac{\sqrt{3}}{2} \therefore \theta = 60^\circ$ (Trig.)

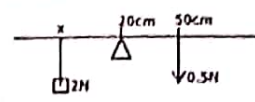
Alternatively, resolve 12N force vertically and balance against the 6N force: $12 \cos \theta = 6 \rightarrow \theta = 60^\circ$ (Trig.)

46D Resolve T vertically and take moment about x
 $T \sin 30^\circ (20) = (20 + 30)F \rightarrow T = 5F$

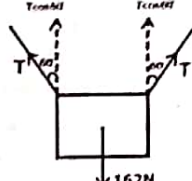
47D  $V_x = 18 \cos 60^\circ = 9\text{ms}^{-1}$

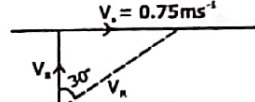
48B $F_x = 10 \cos 60^\circ = 5\text{N}$ Eastward

Then a 5N force Westward is needed

49D Sketch and take moment about the 30cm mark
 $2(30 - x) = 0.5(50 - 30) \rightarrow 60 - 2x = 10 \rightarrow x = 25\text{cm}$
Hence the force is $(30 - 25)\text{cm}$ away from the knife edge

50A This suggests that the angle of inclination has been increased enough to cause the downward slide

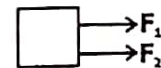
51B  Resolving Tension vertically:
 $2 T \cos 30^\circ = 162 \rightarrow T = 162$

52D  $\sin 30^\circ = \frac{0.75}{V_R} \rightarrow V_x = 1.5\text{m}$

NOTE:

- This question is somewhat ambiguous in that JAMB should have specified what was required between
 V_B = Real velocity of boat
 V_R = Resultant Velocity of boat under the influence of
 V_S = Velocity of stream
- The angle given (30°) also had no reference point hence candidate's discretion as worked out above is advised

53B The angle is 0° when the two forces are applied in the same direction

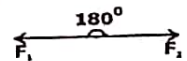


NOTES:

1. As we increase the angle between the two forces, the diagonal of our parallelogram (resultant) shortens

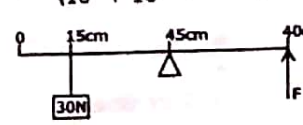
2. When $\theta = 90^\circ$; $R = \sqrt{F_1^2 + F_2^2} < F_1 + F_2$

3. When $\theta = 180^\circ$ it means that the two forces are exactly in opposite direction and resultant is minimum

 $R = F_1 - F_2$

And in this case, parallelogram law cannot be applied, so applying cosine rule is futile

54A $R = \sqrt{10^2 + 10^2} \rightarrow R = 10\sqrt{2}\text{N}$; $\tan \theta = \frac{10}{10} = 1 \rightarrow \theta = 45^\circ$

55B  Taking moment about the 45cm mark $F = (90 - 45) = 30(45 - 15)$
 $F = \frac{30 \times 30}{45} \rightarrow F = 20\text{N}$

56B See Q9 and 42

57B Now revisit Q53

58D For horizontal equilibrium:

8N force $\rightarrow 8 \cos 60^\circ = +4\text{N}$

6N force $\rightarrow 6 \cos 60^\circ = +3\text{N}$

10N force $\rightarrow +10 = +10\text{N}$

4N force $\rightarrow -4 = -4\text{N}$

Net = +13N

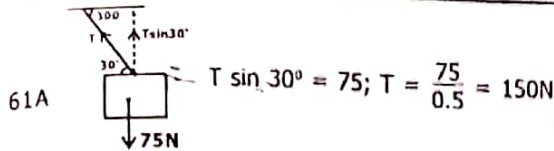
The + sign indicates that the net force is along the +ve x-axis

59D F is the equilibrant of 10N and 17N forces hence their resultant is equal to F in magnitude

$F = \sqrt{17^2 + 10^2}$ (pythagoras) = 19.72N

60D Tension in P = 2 + 4 + 5 = 11N

Q = 4 + 5 = 9N; R = 5N



62C i.e. they are in the same direction

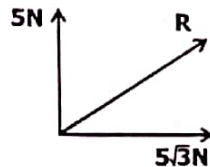
63B For vertical equilibrium:
 10N force $\rightarrow 10 \sin 30^\circ = +5\text{N}$
 6N force $\rightarrow 6 \sin 60^\circ = 3\sqrt{3}\text{N}$
 3N force $\rightarrow +3\sqrt{3} = +3\sqrt{3}\text{N}$
 Net = +5N

For horizontal equilibrium:

10N force $\rightarrow 10 \cos 30^\circ = +5\sqrt{3}\text{N}$
 6N force $\rightarrow 6 \cos 60^\circ = -3\text{N}$
 3N force $\rightarrow +3 = +3\text{N}$
 Net = +5N

Now, we have:

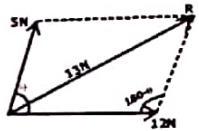
$R = \sqrt{5^2 + (5\sqrt{3})^2} = 10\text{N}$



64A The moment is simply the product of one of the two equal forces (N) and the perpendicular distance between them (m)

65D The weight acts at the 25cm mark, the centre of gravity:
 $10W + 1200 = 2000 \rightarrow W = 80\text{N}$

66C Note that adjacent angles in a parallelogram are supplementary. Now, using cosine rule:



$\cos(180 - \theta) = \frac{12^2 + 5^2 - 13^2}{2(12)(5)} = 0$
 $180 - \theta = \cos^{-1} 0 \rightarrow \theta = 90^\circ$

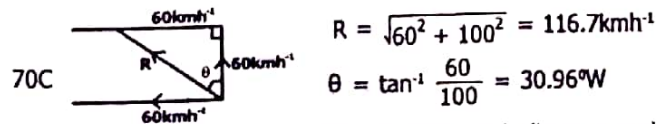
However, the above is needless if the two forces form a pythagoras triplet (triple) with their resultant: (0 = 90) e.g. 5, 12 and 13; 3, 4 and 5 etc.

67A Look for the pythagoras triplet of 6 and 8 i.e. 10 as the resultant force on the body:

$F = ma \rightarrow a = \frac{F}{m} \rightarrow a = \frac{10}{4} = 2.5\text{ms}^{-2}$

68B Since the weight of P has been increased, its distance from the fulcrum must be reduced to maintain the original moment of P about O.

- 69D I \rightarrow All the forces must be acting on the body simultaneously
 II \rightarrow In fact, all forces in any other direction must be equal to all forces in the opposite direction
 III \rightarrow Clockwise moment = anticlockwise moment



71D If tilted, it moves on but comes to rest in its new position.
 A \rightarrow stable equilibrium
 B \rightarrow unstable equilibrium
 C \rightarrow testing the validity of (A)

72D This is called relative speed
 $V_r = 130 - 100 = 30\text{kmh}^{-1}$
 If the two cars are in opposite direction
 $V_r = 130 + 100 = 230\text{kmh}^{-1}$
 A common everyday experience when we travel in vehicles.

73C See Q70

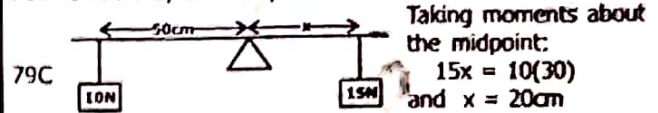
74D Triplet 6, 8 and 10 75C See Q20

76. $F_x = R \cos \theta = 50 \times \cos 30^\circ = \frac{50\sqrt{3}}{2} = 25\sqrt{3} = 42.30$

77D Or sum of forces in a given direction is equal to sum of

forces in the opposite direction. Again, clockwise moment is equal to anticlockwise moment about the same point.

78D Since they are not parallel



80A Note that QY starts from the common origin of QX and QZ

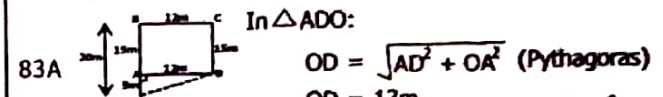
81C Moments about the fulcrum: $Mg(10) = 0.2(30)$

$M = \frac{0.2 \times 30}{10 \times 10} = 0.06\text{kg}$

Pick option C all the same... it is JAMB's error.

82C Resolving T vertically against W:

$T \cos 30^\circ = W$ and $T = \frac{60}{\cos 30^\circ} = 40\sqrt{3}$



84B Distance travelled, $s = 8 + 6 = 14\text{km}$

But displacement, $d = \sqrt{8^2 + 6^2} = 10\text{km}$
 $s - d = 14 - 10 = 4\text{km}$



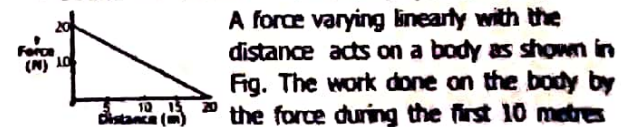
85B W is the equilibrant (E) of T_1 and T_2 hence W is also equal to their resultant (R) in opposite direction.

$\therefore E = R = \sqrt{T_1^2 + T_2^2} = \sqrt{15^2 + 8^2} = 17\text{N}$

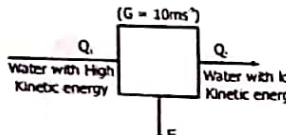
CHAPTER 7

WORK. ENERGY. POWER.

- A 500kg car which was initially at rest travelled with an acceleration of 5ms^{-2} , its kinetic energy after 4 seconds was A. 10^5J B. $2.5 \times 10^5\text{J}$ C. $2 \times 10^5\text{J}$ D. $5 \times 10^5\text{J}$ E. $5 \times 10^5\text{J}$ (1979: Q3)
- A body is released from rest and allowed to fall freely from a given height under gravity. The kinetic energy at its half-way point is A. a little above half of its initial energy B. a little below half of its initial energy C. a half of its initial energy D. a little above its initial energy E. a little below its initial energy. (1979: Q44)
- The water at the bottom of a waterfall is slightly warmer than that at the top because part of the A. potential energy raises the water temperature B. water absorbs latent heat from the atmosphere C. kinetic energy is changed into internal energy D. dropping mass of water increases the heat capacity E. A and C above. (1980: Q15)
- The area under a force-distance graph represents A. acceleration B. velocity C. power D. work E. momentum (1982: Q42)
- A man of mass 50kg ascends a flight of stairs 5m high in 5 seconds. If acceleration due to gravity is 10ms^{-2} , the power expended is A. 100W B. 200W C. 250W D. 400W E. 500W (1983: Q17)
- Which of the following best describes the energy changes which take place when a steam engine drives a generator which lights a lamp? A. Heat \rightarrow Light \rightarrow Sound \rightarrow Kinetic B. Kinetic \rightarrow Light \rightarrow Heat \rightarrow Electricity C. Heat \rightarrow Kinetic \rightarrow Electricity \rightarrow Heat and Light D. Electricity \rightarrow Kinetic \rightarrow Heat \rightarrow Light E. Heat \rightarrow Sound \rightarrow Kinetic \rightarrow Electricity. (1983: Q41)

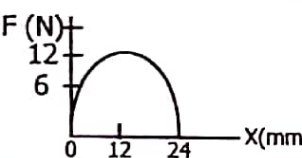


- of motion is A. 100 J B. 150 J C. 200 J D. 300 J E. 600 J (1984:Q22)
8. If a water pump at Kanji Dam is capable of lifting 1000kg of water through a vertical height of 10m in 10s, the power of the pump is A. 1.0kW B. 10.0kW C. 12.5kW D. 15.0kW E. 20.0kW ($g = 10\text{ms}^{-2}$) (1984:Q39)
9. A device that converts sound energy into electrical energy is A. The horn of a motor car B. An A.C. generator C. A microphone D. The telephone earpiece E. A loudspeaker. (1984:Q43)
10. A constant force of 40N acting on a body initially at rest gives an acceleration of 0.1ms^{-2} for 4s. Calculate the work done by the force. A. 8 J B. 10 J C. 32 J D. 160 J (1987:Q8)
11. A body rolls down a slope from a height of 100m. Its velocity at the foot of the slope 20ms^{-1} . What percentage of its initial potential energy is converted into kinetic energy? A. 40% B. 35% C. 20% D. 15% ($g = 10\text{ms}^{-2}$) (1987:Q9)

12.  The figure above represents the main sequence of energy conversion at Kanji dam. The efficiency of the system is

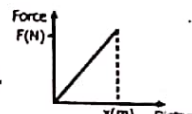
A. $\frac{Q_1}{Q_2}$ B. $\frac{E}{Q_1}$ C. $\frac{E}{(Q_1 - Q_2)}$ D. $\frac{E}{(Q_1 + Q_2)}$ (1987:Q10)

13. How long will it take a 60kg man to climb a height of 22m if he expended energy at the rate of 0.25kW? A. 5.3s B. 34.5s C. 41.6s D. 52.8s ($g=10\text{ms}^{-2}$) (1988:Q11)
14. To keep a vehicle moving at a constant speed v , requires power P , from the engine. The force provided by the engine is A. $\frac{P}{v}$ B. $\frac{1}{2}v$ C. pv D. $\frac{P}{v^2}$ (1990:Q9)
15. A stone of mass m kg is held h meters above the floor for 50s. The work done in joules over the period is A. mh B. mgh C. $mgh/50$ D. 0 (1990:Q10)

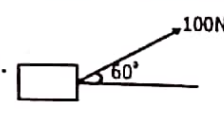
16.  A body is under the action of a force F such that the force displacement graph of the body is semicircular as shown above. The work done on the body by the force in moving through 24metres is A. 36π B. 72π C. 144π D. 288π (1991:Q9)

17. A man weighting 800N climbs up a flight of stairs to a height of 15m in 12.5s. What is the man's average power output? A. 667W B. 810W C. 960W D. 15000W (1992:Q6)
18. Which of the following correctly describe the energy changes in the generation of light by a hydroelectric power station? A. Electrical \rightarrow mechanical \rightarrow potential \rightarrow light. B. Potential \rightarrow mechanical \rightarrow electrical \rightarrow light. C. Mechanical \rightarrow sound \rightarrow electrical \rightarrow light D. Kinetic \rightarrow mechanical \rightarrow electrical \rightarrow light. (1993:Q8)
19. An object of mass 50kg is released from a height of 2m. Find the kinetic energy just before it strikes the ground. A. 250J B. 1 000J C. 10 000J D. 100 000J (1994:Q9)
20. A cone in an unstable equilibrium has its potential energy A. Decreased B. Increased C. Unchanged D. Oscillating (1994:Q10)
21. A vehicle of mass m is driven by an engine of power P from rest. Find the minimum time it will take to acquire a speed A. $\frac{mv^2}{P}$ B. $\frac{mv^2}{2P}$ C. $\frac{mv}{P}$ D. $\frac{mv}{2P}$ (1995:Q11)
22. An object of mass 100g projected vertically upwards from the ground level has a velocity of 20ms^{-1} at a height of 10m. Calculate its initial kinetic energy at the ground level. A. 10J B. 20J C. 30J D. 50J [Take g as 10ms^{-2} , neglect air resistance] (1997:Q12)

23. A man whose mass is 80kg climbs a staircase in 20s and expends a power of 120W. Find the height of the staircase. A. 1.8m B. 2.0m C. 2.5m D. 3.0m ($g = 10\text{ms}^{-2}$) (1998:Q10)
24. A car of mass 800kg attains a speed of 25ms^{-1} in 20 seconds. The power developed in the engine is A. $1.25 \times 10^4\text{W}$ B. $2.50 \times 10^4\text{W}$ C. $1.25 \times 10^6\text{W}$ D. $2.50 \times 10^6\text{W}$ (1999:Q1)
25. A ball of mass 0.1kg is thrown vertically upwards with a speed of 10ms^{-1} from the top of a tower 10m high. Neglecting air resistance, its total energy just before hitting the ground is A. 5J B. 10J C. 15J D. 20J ($g = 10\text{ms}^{-2}$) (1999:Q3)
26. If the force and the velocity on a system are each reduced simultaneously by half, the power of the system is A. Doubled B. Constant C. Reduced to a quarter D. Reduced by half. (2000:Q9)
27. A stone of mass 1kg is dropped from a height of 10m above the ground and falls freely under gravity. Its kinetic energy 5m above the ground is then equal to A. its kinetic energy on the ground B. twice its initial potential energy C. its initial potential energy D. half its initial potential energy (2001:Q3)

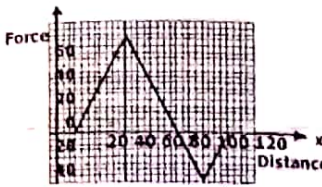
28.  The diagram above shows the force (F) acting on an object through a distance (x). The work done on this object through a distance (x) is expressed as A. Fx^2 B. Fx C. $\frac{F}{x}$ D. $\frac{Fx}{2}$ (2002:Q5)

29. A body of mass 4kg is acted on by a constant force of 12N for 3 seconds. The kinetic energy gained by the body at the end of the time. A. 162J B. 144J C. 72J D. 81J. (2004:Q12)

30.  In the figure above, the work done by the force of 100N inclined at an angle θ to the object dragged horizontally to a distance of 8 m is A. 600J. B. 800J. C. 400J. D. 100J. [neglect frictional effect] (2005:Q30)

31. An engine of a car of power 80kW moves on a rough road. The force required to bring it to rest is A. $2.50 \times 10^6\text{N}$ B. $2.50 \times 10^8\text{N}$ C. $2.56 \times 10^6\text{N}$ D. $2.80 \times 10^8\text{N}$ (2006:Q16)
32. A boy drags a bag of rice along a smooth horizontal floor with a force of 2N applied at an angle of 60° to the floor. The work done after a distance of 3m is A. 6J. B. 5J. C. 4J. D. 3J. (2007:Q41)
33. If a body of mass 5kg is thrown vertically upwards with velocity u , at what height will the potential energy equal to the kinetic energy? A. $h = \frac{u^2}{g}$ B. $h = \frac{u^2}{4g}$ C. $h = \frac{2u^2}{g}$ D. $h = \frac{u^2}{2g}$ (2008:Q11)
34. If a cage containing a truck of coal weighing 750kg is raised to a height of 90 m in 1 minute, what is the total power expended? A. 11.50kW B. 12.60kW C. 11.25kW D. 12.10kW [$g = 10\text{ms}^{-2}$] (2009:Q10)
35. A bob of weight 0.1 N hangs from a massless string of length 50cm. A variable horizontal force which increases from zero is applied to pull the bob until the string makes an angle of 60° with the vertical. The work done is A. 0.250J. B. 0.025J. C. 0.050J. D. 0.500J. (2010:Q8)
36. A carpenter on top of a roof 20.0 m high dropped a hammer of mass 1.5kg and it fell freely to the ground. The kinetic energy of the hammer just before hitting the ground is

A. 300J. B. 460J C. 600J. D. 150J. [$g = 10\text{ms}^{-2}$] (2011:Q2)



From the diagram above, calculate the work done when the particle moves from $x = 0\text{m}$ to $x = 80\text{m}$ A. 1 200J B. 2 400J C. 6 000J D. 7 000J. (2012:Q11)

37. An object is moving with a velocity of 5ms^{-1} . At what height must a similar body be situated to have a potential energy equal in value with kinetic energy of the moving body?
A. 2 B. 5 C. 10 D. 20 m (2013:Q9)
38. If a pump is capable of lifting 5 000 kg of water through a vertical height of 60m in 15min, the power of the pump is A. $2.5 \times 10^3\text{J}^{-1}$ B. $2.5 \times 10^4\text{J}^{-1}$ C. $3.3 \times 10^3\text{J}^{-1}$ D. $3.3 \times 10^2\text{J}^{-1}$. (2013:Q10)
39. An object of mass 20kg is released from a height of 10m above the ground level. The kinetic energy of the object just before it hits the ground is A. 2 000J B. 500J C. 200J D. 4 000J (2014:Q12)
40. The energy in the nucleus of atoms produce heat which can be used to generate A. electrical energy B. potential energy C. kinetic energy D. mechanical energy. (2014:Q13)
41. A car travelling at 60ms^{-1} produces a force of 400N. Calculate the power of the engine in kW A. 25 B. 22 C. 24 D. 20 (2016:Q38)
42. To keep a vehicle moving at a constant speed V requires power P , from the engine. The force provided by the engine is A. P/V B. $(\frac{1}{2})V$ C. PV D. P/V^2 (2018:Q17)

CHAPTER 7 ANSWERS

- 1A $m = 500\text{kg}$; $u = 0$; $a = 5\text{ms}^{-2}$; $t = 4\text{s}$; $v = ?$; $\text{KE} = ?$
But $v = u + at \therefore v = 0 + 5(4) \rightarrow v = 20$
But $\text{KE} = \frac{1}{2}mv^2$; $\text{KE} = \frac{1}{2} \times 500 \times 20 \times 20 = \text{KE} = 10^5\text{J}$
- 2C According to the law of conservation of energy, Energy lost as PE = energy gained as KE; Energy lost as PE = $mg \times \frac{1}{2}h = \frac{mgh}{2}$
This is one-half the original mgh
- 3C The warmth suggests increase in the motion of water molecules
NOTE:
1. Heat is not strictly synonymous to internal energy but only a measure of the latter as reflected by temperature
2. Internal energy can be raised by either (i) heating a body or (ii) doing work on the body
- 4D $W = F \times d$
- 5E Energy expended or work done against gravity:
 $\rightarrow \text{PE} = mgh = 50 \times 10 \times 5 = 2500\text{J}$
But power = $\frac{\text{Energy expended}}{\text{Time}} = \frac{2500}{5} = 500\text{W}$
- 6C If it had been a gasoline engine, conversion would have been chemical \rightarrow kinetic \rightarrow electrical \rightarrow heat + light
Work done during the first 10m \rightarrow
 $W = \text{Area of trapezium OABD} = \frac{1}{2}(\text{BD} + \text{OA}) \text{OD} = \frac{1}{2}(10 + 20)10 = 150\text{J}$
- 7C
Total work would have been $W = \text{Area of } \triangle \text{AOC} = \frac{1}{2} \text{OC} \times \text{OA} = 200\text{J}$
This is consistent with $W = \text{Average force} \times \text{distance}$
When force is not constant
- 8B $P = \frac{\text{Energy}}{\text{Time}} = \frac{mgh}{t} = \frac{1000 \times 10 \times 10}{10} = 10\text{KW}$

- 9C And the loudspeaker now re-converts the electrical energy to sound energy (amplified manifold)
- 10C $u = 0$ $a = 0.1\text{ms}^{-2}$ $t = 4\text{s}$; $s = ?$ hence $W = ?$
Using $s = ut + \frac{1}{2}at^2 = \frac{1}{2}(0.1)(4)^2 = 0.8\text{m}$
But $W = F \times s = 40 \times 0.8 = 32\text{J}$
- 11C $\text{PE} = mgh$ [where $h = \text{vertical height (not length of slope)}$]
 $\text{PE} = m \times 10 \times 100 = 1000\text{m}$
 $\text{KE} = \frac{1}{2}mv^2 = \frac{1}{2} \times m \times 20^2 = 200\text{m}$
 $\% \text{ conversion} = \frac{\text{Energy converted to KE}}{\text{Initial PE}} \times 100\%$
 $= \frac{200\text{m}}{1000\text{m}} \times 100\% = 20\%$
NOTE: The 80% difference is energy lost to friction
- 12B This is a resemblance of Q11
 $\text{Efficiency} = \frac{\text{Useful Energy Output}}{\text{Energy Input}} \times 100\%$
- 13D $P = \frac{E}{t} \therefore t = \frac{E}{P} = \frac{mgh}{P} = \frac{60 \times 10 \times 22}{0.25 \times 10^3} = 52.8\text{s}$
- 14A Power = $\frac{\text{Work done}}{\text{Time}} \therefore P = \frac{F \times s}{t} = F \times (\frac{s}{t})$
But $\frac{s}{t} = v \therefore P = F \times v \rightarrow F = \frac{P}{v}$
- 15D The potential energy (mgh) possessed by the stone at this height h_1 is not converted to work since there is no motion ($v = 0$)
- 16B Area of a semi-circle $\rightarrow \frac{1}{2}\pi r^2 = \text{work done}$
 $\therefore W = \frac{1}{2}\pi \times 12 \times 12 = 72\pi$
- 17C. Energy = $mgh = Wh = 800 \times 15$
Power = $\frac{800 \times 15}{12.5} = 960\text{W}$
- 18B A mass of water is released from a height (potential) to turn some turbines (mechanical) which generates electrical energy that causes lighting
NOTE: Although mechanical energy involves potential energy (due to position) and kinetic energy (due to motion), it was used exclusively here to mean kinetic energy
- 19B. All PE has been converted to KE
 $\therefore \text{KE} = mgh = 50 \times 10 \times 2 = 1000\text{J}$
- 20B $mgh_2 > mgh_1$ since $h_2 > h_1$
- 21B $P = \frac{\frac{1}{2}mv^2}{t} = \frac{mv^2}{2t}$; Rearranging: $t = \frac{mv^2}{2P}$
Alternatively: $P = \frac{\text{Average force} \times \text{distance}}{\text{Time}} = \left(\frac{1}{2}F \times s\right) / t$
 $P = \frac{ma \cdot s}{2t} \rightarrow 2P = m \left(\frac{v}{t}\right) \cdot \left(\frac{s}{t}\right) \rightarrow 2P = m \left(\frac{v}{t}\right) v$
 $\rightarrow 2P = \frac{mv^2}{t} \rightarrow t = \frac{mv^2}{2P}$
Note: We use average force here and P is average power developed i.e. velocity is not constant as the body is accelerating from u until v .
- 22A At ground level: $\text{PE} = mgh = 0$; $\text{KE} = \text{Maximum}$
At maximum height, $h = 10\text{m}$; $\text{PE} = \text{Max}$; $\text{KE} = 0$
 $(\text{PE} + \text{KE})_1 = (\text{PE} + \text{KE})_2$ (Law of Conservation of energy)
 $\therefore \text{KE}_1 = \text{PE}_2 = mgh = \frac{100}{1000} \times 10 \times 10 = 10\text{J}$
- 23D Power \times time = energy $\rightarrow Pt = mgh$
 $120 \times 20 = 80 \times 10 \times h \rightarrow h = 3\text{m}$

CHAPTER 8

FRICITION, VISCOSITY, SURFACE TENSION

24A E $\frac{1}{2}mv^2$; Power = $\frac{mv^2}{2t} = \frac{800 \times 25^2}{2 \times 20} = 12500W$

25C First calculate the distance from the top of the tower to the maximum height attained: $u = 10ms^{-1}$ $v = 0$ $a = -g$ $s = ?$

$v^2 = u^2 + 2as \rightarrow s = \frac{v^2 - u^2}{2a} = \frac{0^2 - 10^2}{2(-10)} = \frac{100}{-20} = 5m$

\therefore Max height from ground level $\rightarrow 10m + 5m = 15m$

$PE_{max} = mgh = 0.1 \times 10 \times 15 = 15J$

But PE_{max} is finally converted to KE at ground level Energy = 15J

26C $P = F \times V$ (see Q14) $P_1 = F_1 \times v_1$; But $F_2 = \frac{1}{2} F_1$ and $v_2 = \frac{1}{2} v_1$

$\therefore P_2 = F_2 \times v_2 = \frac{1}{2} F_1 \times \frac{1}{2} v_1$; $P_2 = \frac{F_1 v_1}{4}$ Hence $\frac{P_2}{P_1} = \frac{F_1 v_1}{4} \times \frac{1}{F_1 v_1} = \frac{1}{4}$

27D See Q2

28D Area of the triangle ($\frac{1}{2}FX$) is consistent with

$W =$ Average force \times distance where force is not constant

29A $a = \frac{F}{m} = \frac{12}{4} = 3ms^{-2}$ and $t = 3$ where $u = 0$

Using $v = u + at$ $v = at = 3 \times 3 = 9ms^{-1}$

Kinetic Energy = $\frac{1}{2}mv^2 = \frac{1}{2} \times 4 \times 9 \times 9 = 162J$

To cross check use: $s = ut + \frac{1}{2}at^2$; $s = \frac{1}{2} \times 3 \times 3 \times 3 = \frac{27}{2}m$

But $W = F \times s = ma \times s = 4 \times 3 \times \frac{27}{2} = 6 \times 27 = 162N$

30C Only the horizontal component of 100N force causes horizontal motion: $W = 100\cos60 \times 8W = 400J$

31B $P = F \times V$ (see Q14); $F = \frac{80 \times 1000}{32} = 2500N$

32D $W = F \cos\theta$ $s = 2 \cos60^\circ \times 3 = 3J$

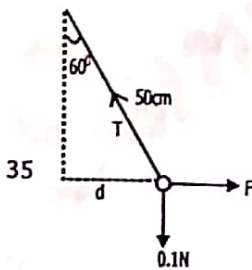
33D At maximum height total kinetic energy is converted to total

potential energy: $mgh_{max} = \frac{1}{2}mu^2 \rightarrow h = \frac{mu^2}{2mg} = \frac{u^2}{2g}$

But midway through the journey one-half KE is converted to

one-half PE $\therefore PE = \frac{1}{2}KE$ when $h = \frac{1}{2}h_{max} = \frac{u^2}{2g}$

34C $P = \frac{mgh}{t} = \frac{250 \times 10 \times 10}{1 \times 60} = 11250W$



Resolve T vertically against W:
 $T\cos60^\circ = 0.1$ and $T = 0.2N$
Resolve T horizontally against F:

$F = T\sin60^\circ$; $F = \frac{0.2\sqrt{3}}{3} = 0.1\sqrt{3}$

35 $d = \frac{50\sin60^\circ}{100} = 0.25\sqrt{3}$

$W = F \times d = 0.1\sqrt{3} \times 0.25\sqrt{3} = 0.075J$

(No correct option)

36A $K E_{max} = 1.5 \times 10 \times 20 = 300J$

37. Just calculate the area captured by the time interval

$W = \frac{1}{2}(80)(80) = 3200J$ (No correct option)

38C $KE = \frac{1}{2}mv^2 = \frac{25m}{2}$

But $PE = mgh \therefore mgh = \frac{25m}{2}$ and $h = 1.25m \approx 1.30m$

39C $P = \frac{50 \times 10 \times 60}{15 \times 60} = 3333Js^{-1}$

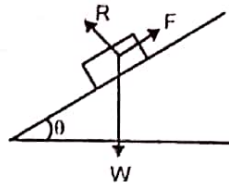
40A $KE = PE = mgh = 20 \times 10 \times 10 = 2000J$

41A Nuclear energy to heat energy to electrical energy

42C $P = FV$ (See Q14): $P = 400 \times 60 = 24000W = 24Kw$

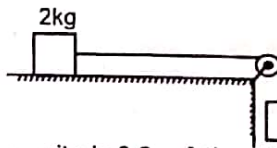
43A See Q14

- The frictional force between two bodies A. exists only when there is relative motion or tendency for motion B. acts so as to oppose the motion C. depends on the normal reaction between the two surfaces D. is relatively independent of the area in contact E. has all of these characteristics. (1978:Q2)
- Which of the following does NOT cause a reduction of the surface tension of water? A. Soap solution B. Detergent C. Alcohol D. Camphor E. Grease (1980:Q13)



A body of mass 6kg rests on an inclined plane. The normal reaction is R and the limiting frictional force is F as shown in the diagram. If F is 30N and $g = 10ms^{-2}$, then the angle of inclination is A. 15° B. 30° C. 45° D. 60° E. 75° (1981:Q19)

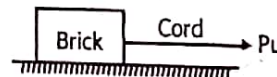
- A mass of 2kg on a surface ($\mu = \frac{1}{2}$) is connected to



second mass of 4kg over a frictionless pulley as shown in the diagram. If

gravity is $9.8ms^{-2}$ then the masses will A. accelerate at $4.9ms^{-2}$ B. remain stationary C. accelerate at $9.8ms^{-2}$ D. accelerate at $19.6ms^{-2}$ E. accelerate at $39.2ms^{-2}$ (1981:Q28)

- Which of the following statements about friction is NOT correct? A. The force of kinetic friction is less than the force of static friction. B. The force of kinetic friction between two surfaces is independent of the areas in contact provided the normal reaction is unchanged. C. The force of rolling friction between two surfaces is less than the force of sliding friction. D. The angle of friction is the angle between the normal reaction and the force friction. E. Friction may be reduced by lubrication. (1983:Q4)



- A brick at rest on a horizontal table is pulled by a horizontal cord, as shown in diagram. The force of friction on the brick A. increase if the pull increases but the brick does not move. B. is directly horizontal to the right C. decreases if an identical brick is placed on the first. D. is zero if the brick is pulled hard enough to make it slide. E. change if the brick is turned on its side. (1983:Q5)

- A metal block of mass 5kg lies on a rough horizontal platform. If a horizontal force of 8N applied to the block through its centre of mass just slides the block on the platform, then the coefficient of limiting friction between the block and the platform is A. 0.16 B. 0.63 C. 0.80 D. 1.60 E. 2.00 (1985:Q8)

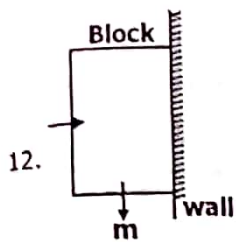
- W h e n a b o x slides along a horizontal floor a distance of 3m before coming to rest. What is the coefficient of the kinetic friction between the box and the floor? ($g = 10ms^{-2}$) A. $\frac{5}{6}$ B. $\frac{5}{12}$ C. $\frac{1}{3}$ D. $\frac{2}{3}$ (1986:Q11)

- The coefficient of static friction between a 40kg crate and a concrete surface is 0.25. Find the magnitude of the minimum force needed to keep the crate stationary on the concrete base inclined at 45° to the horizontal. [$g = 10ms^{-2}$] A. 400 N B. 300 N C. 283 N D. 212 N (1987:Q11)

- If a beaker is filled with water, it is observed that the

surface of the water is not horizontal at the glass-water interface. This behaviour is due to A. Friction B. Viscosity C. Surface tension D. Evaporation. (1987:Q12)

11. A force, 10N, drags a mass 10kg on a horizontal table with an acceleration of 0.2ms^{-2} . If the acceleration due to gravity is 10ms^{-2} , the coefficient of friction between the moving mass and the table is A. 0.02 B. 0.08 C. 0.20 D. 0.80 (1988:Q12)

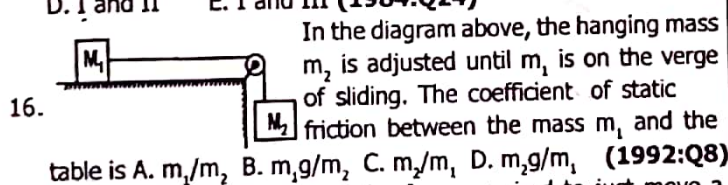


12. A block of mass m is held in equilibrium against a vertical wall by a horizontal force. If the coefficient of friction between the block and the wall is μ , the minimum value of the horizontal force is A. μmg B. $(1 - \mu)mg$ C. $(1 + \mu)mg$ D. mg/μ (1989:Q7)

13. A body of mass 10kg rests on a rough inclined plane whose angle of tilt q is variable. This gradually increases until the body starts to slide down the plane at 30° . The coefficient of limiting friction between the body and the plane is A. 0.30 B. 0.50 C. 0.58 D. 0.87. (1990:Q11)

14. In which of the following is surface tension important? A. The floating of a ship in water B. The floating of a dry needle in water C. The floating of a balloon in air D. The diffusion of a sugar solution across membrane. (1991:Q14)

15. A small steel needle is carefully floated on water in a beaker. When a few drops of kerosene are introduced into the water the needle sinks. Which of the following statements correctly explain(s) the observation? I. There is a tension on the water surface. II. Kerosene reduces the density of water so that the needle becomes denser than water. III. Kerosene reduces the surface tension of water. A. I only B. II only C. III only D. I and II E. I and III (1984:Q24)

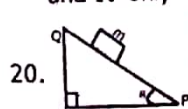


16. In the diagram above, the hanging mass m_2 is adjusted until m_1 is on the verge of sliding. The coefficient of static friction between the mass m_1 and the table is A. m_1/m_2 B. m_1g/m_2 C. m_2/m_1 D. m_2g/m_1 (1992:Q8)

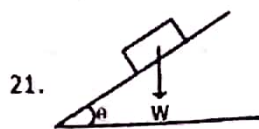
17. Calculate the magnitude of the force required to just move a 20kg object along a horizontal surface if the coefficient of friction is 0.2 A. 400.0 N B. 40.0 N C. 4.0 N D. 0.4 N [$g=10\text{ms}^{-2}$] (1994:Q11)

18. A box of mass 40kg is being dragged along the floor by a rope inclined at 60° to the horizontal. The frictional force between the box and the floor is 100N and the tension on the rope is 300N. How much work is done in dragging the box through a distance of 4m? A. 680 J B. 400 J C. 200 J D. 100 J (1995:Q12)

19. Which of the following statements are TRUE about frictional force? I. It is always a disadvantage II. It is sometimes a disadvantage III. It always exists where there is a relative motion of two bodies that are in contact. IV. It is sometimes very useful. A. I and III only B. I and IV only C. II and III only D. II and IV only (1995:Q13)



20. The figure above shows a block of mass m sliding down a rough inclined plane QP at angle θ . The forces acting on the block along the plane QP are A. $mg\sin\theta$ and the normal reaction B. $mg\sin\theta$ and the force of friction C. $mg\cos\theta$ and the normal reaction D. $mg\cos\theta$ and the force of friction. (1997:Q10)



21. For a rough inclined plane on which lies a body of weight W , the angle θ in the diagram above becomes the angle of friction if A. $\tan\theta =$ coefficient of static friction B. $\cos\theta =$ coefficient of dynamic friction C. $\sin\theta =$ coefficient of sliding friction D. $\sec\theta =$ limiting frictional force. (1997:Q14)

22. A piece of wire gauze can be made to lie on water because A. the wire gauze is less dense than water B. the water molecules repel the wire gauze upwards C. the water surface has the effect of an elastic thin skin D. of the cohesive forces between the water and the wire gauze molecules. (1997:Q17)

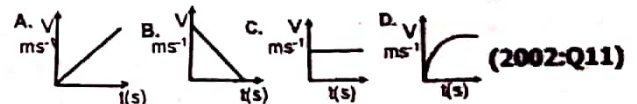
23. A parachute attains a terminal velocity when A. Its density is equal to the density of air B. The viscous force of the air and the upthrust completely counteract its weight. C. It expands as a result of reduced external pressure D. The viscous force of the air is equal to the sum of the weight and upthrust. (1998:Q11)

24. When the brakes in a car are applied, the frictional force on the tyres is A. A disadvantage because it is in the direction of motion of the car B. A disadvantage because it is in the opposite direction of motion of the car. C. An advantage because it is in the direction of motion of the car. D. An advantage because it is in the opposite direction of motion of the car. (1999:Q18)

25. I. The frictional force is independent of the area of the surfaces in contact, II The frictional force depends on the nature of the surfaces in contact III The frictional force depends on the speed sliding IV The frictional force is directly proportional to the normal reaction Which combination of the above is true of sliding friction? A. I, II and IV B. I, II and III C. I, III and IV D. II, III and IV. (2000:Q3)

26. The effect of a particle in a fluid attaining its terminal velocity is that the A. weight is equal to the retarding force B. acceleration is maximum C. buoyancy force is more than the weight of the fluid displaced D. buoyancy force is equal to the viscous retarding force. (2002:Q2)

27. Which of the following is the correct shape of the velocity-time graph of a spherical steel ball dropped into a viscous fluid in a tall cylinder?



28. A bead travelling on a straight wire is brought to rest at 0.2m by friction. If the mass of the bead is 0.01kg and the coefficient of friction between the bead and the wire is 0.1, determine the work done by the friction. A. $2 \times 10^{-4}\text{J}$ B. $2 \times 10^{-3}\text{J}$ C. $2 \times 10^{-2}\text{J}$ D. $2 \times 10^3\text{J}$ [$g = 10\text{ms}^{-2}$] (2003:Q1)

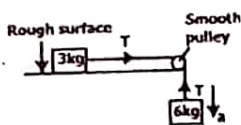
29. If an object just begins to slide on a surface inclined at 30° to the horizontal, the coefficient of friction is A. $\sqrt{3}$ B. $\frac{\sqrt{3}}{2}$ C. $\frac{1}{\sqrt{2}}$ D. $\frac{1}{\sqrt{3}}$ (2003:Q6)

30. Water does not drop through an open umbrella of silk material unless the inside of the umbrella is touched. This is due to A. capillarity B. osmotic C. viscosity D. surface tension (2003:Q8)

31. As the pressure of a fluid increases, its viscosity A. decreases B. remains constant C. increases then decreases D. increases (2004:Q13)

32. A 100kg box is pushed along a road with a force of 500N. If the box moves with a uniform velocity, the coefficient of friction between the box and the road is A. 0.5 B. 0.4 C. 1.0 D. 0.8 (2004:Q16)

33. In the figure below, the coefficient of static friction is 0.5.



If the tension in the string T , the acceleration of the system in motion is A. 15ms^{-2} B. 3ms^{-2} C. 5ms^{-2} D. 9ms^{-2} [$g = 10\text{ms}^{-2}$] (2005:Q26)

34. In an experiment to determine terminal velocity, as the pressure increases, the viscosity of a liquid A. increases then decreases. B. decreases. C. remains constant. D. increases. (2006:Q18)
35. Counting of currency notes with moist fingers is based on the principles of A. diffusion. B. cohesion. C. adhesion D. viscosity. (2008:Q12)
36. A motorcycle of mass 100 kg moves round in a circle of radius 10m with a velocity of 5ms^{-1} . Find the coefficient of friction between the road and the tyres. A. 25.00. B. 2.50. C. 0.50. D. 0.25. [$g=10\text{ms}^{-2}$] (2008:Q13)
37. An object of mass 80kg is pulled on a horizontal rough ground by a force of 500N. Find the coefficient of static friction. A. 0.8. B. 0.4. C. 1.0. D. 0.6. (2009:Q11)
38. The terminal velocity of a ball-bearing falling through a viscous fluid is reached when the A. upthrust is equal to the weight of the ball. B. ball accelerates uniformly. C. upthrust is equal to the velocity of the ball. D. velocity is uniform. (2009:Q13)
39. The surfaces of conveyor belts are made rough so as to A. prevent the load from slipping B. make them stronger. C. enable them to carry more load D. protect them while carrying loads. (2010:Q9)
40. Which of the following could be effectively used to reduce friction? A. Water B. Petrol C. Kerosene D. Grease (2011:Q13)
41. A load is pulled at a uniform speed along a horizontal floor by a rope at 45° to floor. If the force in the rope is 1500N, what is the frictional force on the load? A. 1 524N B. 1 350N C. 1 260N D. 1 061N. (2012:Q3)

42. The diagram above shows a wooden block just about to slide down an inclined plane whose inclination to the horizontal is θ . The coefficient of frictional force between the block and the plane is A. $\sin\theta$ B. $\tan\theta$ C. $\cot\theta$ D. $\cos\theta$ (2012:Q12)

43. An object of mass 20kg slides down an inclined plane at an angle of 30° to the horizontal. The coefficient of static friction is A. 0.2 B. 0.3 C. 0.5 D. 0.6. [$g=10\text{ms}^{-2}$] (2012:Q13)
44. The coefficient of friction between two perfectly smooth surface is A. infinity. B. one. C. half. D. zero. (2013:Q11)
45. When the temperature of a liquid is increased, its surface tension A. decreases B. increases C. remains constant D. increases then decreases (2013:Q11)
46. The friction which exists between two layers of liquid in relative motion is called A. capillary B. surface C. tension D. viscosity E. cohesion (2018:Q2)

CHAPTER 8 ANSWERS

- 1E i. Friction also depends on the nature of the surfaces in contact (i.e. friction is less in smooth surfaces) ii. Frictional force also increases to the same extent as the force which tends to cause it
- 2D A substance which lowers the surface tension of water is called a surfactant and may be
1. Detergent (including soap)
 2. Petroleum fractions (including grease)
 3. Natural fat/Oil (e.g. palm oil)
 4. Alcohol (and synthetic alcohol)
 5. Warming also reduces surface tension
 6. Changing the medium above the water also reduces tension
- 3B Resolving W along the surface:

$$W\sin\theta = F \rightarrow \theta = \sin^{-1} \frac{30}{6 \times 10} = 30^\circ$$

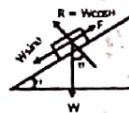
NOTE:

1. The limiting frictional force F_L is the maximum frictional force possible and when it is equal to the "W resolved along the plane", the body just begins to move down the plane.
2. When the body now moves, the operational frictional force is called dynamic or sliding friction F_d or kinetic friction where $F_d < F_L$
 $F_L = \text{limiting friction} = \text{static friction}$

4A Frictional force = $\mu R = \mu mg$
 $\therefore F = \frac{1}{2} \times 10 = 98\text{N}$
 $\therefore T - F = ma \rightarrow T = ma + F \rightarrow T = 2a + 9.8 \dots (i)$

$W - T = ma \rightarrow T = W - ma = mg - ma$
 $= 4 \times 9.8 - 4a \rightarrow T = 29.2 - 4a \dots (ii)$
 Comparing (i) and (ii)
 $2a + 9.8 = 39.2 - 4a$
 $6a = 39.4 \quad a = 49\text{ms}^{-2}$

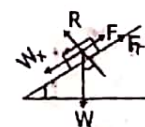
- 5D A \rightarrow see Q3
 B \rightarrow see Q1
 C \rightarrow Rolling friction as opposed to sliding friction is the frictional force that comes into play when ball bearings or rollers are used to REDUCE friction.
 E \rightarrow Lubricant prevents direct contact between surfaces and thus lessen friction.
 D \rightarrow the angle of friction of a plane is the angle the plane makes with the horizontal and beyond which a body placed on it begins to slide down



Note $\mu = \tan\theta$

- 6A The pull must be in excess of the frictional force to cause the movement of the block
- 7A $F = \mu R \rightarrow \mu = \frac{F}{R}$ but $R = W = mg$
 $\therefore \mu = \frac{8}{5 \times 10} = 0.16$
- 8B It is the frictional force that causes the retardation of the box: $u = 5 \quad v = 0 \quad s = 3\text{m} \quad a = ?$
 $v^2 = u^2 + 2as \rightarrow 0^2 = 5^2 + 2 \times a \times 3 \rightarrow a = \frac{25}{6}$
 $\therefore F = ma = \frac{45 \times 25}{6}$ and $R = mg = 45 \times 10$
 But $\mu = \frac{F}{R} = \frac{45 \times 25}{6} \times \frac{1}{45 \times 10} = \frac{5}{12}$

- 9D The force which tends to move crate down the plane is the W resolved parallel to plane
 $W_x = W\sin\theta = mg\sin\theta$
 $W_x = 40 \times 10\sin 45^\circ = 282.84\text{N}$
 The downward motion is opposed by frictional force F_f :



$F_f = \mu R$ But $R = W\cos\theta$ (W resolved vertical to plane)
 $\therefore F_f = \mu mg\cos\theta = 0.25 \times 40 \times 10 \times \cos 45^\circ = 70.71\text{N}$
 Since $W_x > F_f$, then a force must be applied upwards along the plane to balance up the difference
 $F = W_x - F_f = 212\text{N}$

Alternatively, for equilibrium of forces along the plane
 $F + F_f = W_x \rightarrow F = W_x - F_f$ (as before)

- 10C The surface behaves like an elastic skin and the concave meniscus is due to the adhesion of water to glass being greater than its cohesion. Adhesion - force of attraction between the molecules of a substance and of another

substance e.g. water and glass cohesion - force of attraction between molecules of the same substance e.g. water

110 The net force on the body (not the 10N force alone) causes the acceleration ($a = 0.2\text{ms}^{-2}$)

Net force = 10-N force - frictional force

$\therefore ma = 10 - \mu mg \rightarrow 10 \times 0.2 = 10 - \mu \times 10 \times 10 \rightarrow \mu = 0.08$

12B Without the horizontal force F , the body slides down as $mg > F$, but F is negligible. When the horizontal force is applied $R = F$ and F is now μF . Thus the value of F , $= \mu F$ increases enough to balance up the vertically downward force, the

weight of the body $\therefore \mu F = W$ or $\mu F = mg$ and $F = \frac{mg}{\mu}$

13C $\theta = 30^\circ$ is the angle of inclination: $\mu = \tan 30^\circ = 0.58$

14B The water surface behaves like an elastic skin

15E See also Q14

16C Since the system is merely on the verge of moving take resultant force on m_1 and m_2 as $F = 0$

For m_2 : $F = m_2g - T = 0 \therefore T = m_2g$

For m_1 : $F = T - \mu mg = 0 \therefore T = \mu m_1g$

$\therefore \mu m_1g = m_2g \rightarrow \mu = m_2/m_1$

17B The force must be equal to the frictional force

$F = \mu R = \mu mg \rightarrow F = 0.2 \times 20 \times 10 = 40\text{N}$

18C You need only the horizontal component of T

\therefore Net force on box:

$T \cos 60^\circ - F = 30^\circ(0.5) - 100 \rightarrow F = 50\text{N}$

Work done = Force \times distance = $50 \times 4 = 200\text{J}$

19C **Disadvantages of Friction**

- i. Causes wear and tear
- ii. Generates heat
- iii. Makes machines less efficient as it wastes energy

Advantages of Friction

- i. Makes walking possible
- ii. Prevents tyres of automobiles from skidding
- iii. Prevents fan belt of machinery from slipping
- iv. Enables the brake system to work
- v. Friction makes screwing and nailing possible
- vi. Grinding stone works on the principle of friction

20B Weight of the block resolved along the surface and frictional force respectively

21A See Q13 22C See 14

23B W = weight of parachute (acting downwards)
 U = upthrust of air on parachute (upwards)
 V = viscous force or drag upwards against motion of chute
 Taking downward direction as +ve

$W - U - V = ma$ (Where m = mass of chute)

At terminal velocity v_0 , v_0 is maximum and constant

$\therefore a = 0 \rightarrow W - (U + V) = 0$ or $W = U + V$ (a counterbalance)

24D The target is to slow down or stop the car (see Q19)

25A Once sliding or dynamic friction comes into play, it remains constant although it is smaller than limiting or static friction

26A The combination of viscous drag (v) and buoyancy force (upthrust) constitutes the retarding force (see Q23)

27D When the ball reaches terminal velocity, acceleration becomes zero hence the slope is now parallel to time axis at v_0 (See Q23)

28B $F = \mu mg = 0.1 \times 0.01 \times 10 \quad F = 0.01\text{N}$
 $W = F \times s = 0.01 \times 0.2 \quad W = 2.0 \times 10^{-3}\text{J}$

29D $\mu = \tan 30^\circ$ (See Q13) $\mu = \frac{1}{\sqrt{3}}$ (trig.)

30D See Q14

31D. The decrease, however, is negligible unless the pressure increases appreciably

32A. Net force on box = 0 \therefore Frictional force = 500N
 But $F = \mu mg \rightarrow 500 = \mu \times 100 \times 10 \rightarrow \mu = 0.5$

NOTE:

1 Uniform velocity means zero acceleration hence the net force on the body is zero: $F_{\text{net}} = F_r = ma = m(0) = 0$
 When F_{push} is the force that pushes the box.

2 The friction called into play here is sliding friction.

33C For 6kg body: $6(10) - T = 6a \rightarrow T = 60 - 6a \dots\dots(i)$

For 3kg body: $T - 5(3)(10) = 3a \rightarrow T - 15 = 3a \dots\dots(ii)$

Substituting: $(60 - 6a)$ for T in $\dots\dots(ii)$

$(60 - 6a) - 15 = 3a \rightarrow a = 5\text{ms}^{-2}$

35C Adhesion of notes to water being greater than their cohesion to one another

36D The frictional force provides the centrifugal force necessary to keep the motorcycle in the circle

$\therefore F = \frac{mv^2}{r} = \frac{100 \times 5^2}{10} = 250\text{N}; R = mg = 1000\text{N}$

But $\mu = \frac{F}{R} = \frac{250}{1000} = 0.25$

37D $\mu = \frac{F}{R} = \frac{500}{800} = 0.625$

38D See Q23 39A See Q19 40D See Q2

41D Horizontal component of 1 500N force:

$1\ 500 \cos 45^\circ = 1\ 061\text{N} \therefore$ Frictional force $F = 1\ 061\text{N}$

42B See Q13

43D $\mu = \tan 30^\circ = 0.577$

44D. Friction is theoretically absent 45A See Q2

46C Viscosity determines the rate of flow of a liquid

**CHAPTER 9
SIMPLE MACHINE**

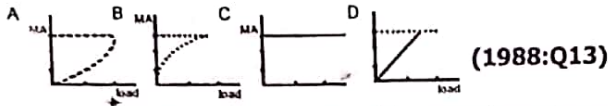
1. Which of the following statements defines correctly the efficiency of a machine? A. The load carried by the machine divided by effort required in carrying the load B. The distance moved by the load divided by the distance moved by the effort C. The useful work done by the machine divided by the total work put into it. D. The movement of the load divided by the movement of the effort about the same point. E. The temperature at the end of the application of the machine divided by the initial temperature. (1979:Q2)
2. An inclined plane of angle θ , acting as a simple machine, has a velocity ratio A. $\sin \theta$ B. $1/\sin \theta$ C. $\cos \theta$ D. $1/\cos \theta$ E. $\sin \theta \cos \theta$. (1981:Q10)
3. Which of the following machines does NOT apply the lever principle? A. Claw hammer B. Wheel barrow C. Single moving pulley D. Sugar tongs E. Nutcrackers. (1982:Q14)
4. A machine has a velocity ratio of 5. It requires a 50kg weight to overcome a 200kg weight. The efficiency is A. 4% B. 5% C. 40% D. 50% E. 80% (1983:Q36)
5. A plane inclined at an angle of 30% to the horizontal has an efficiency of 60%. The force parallel to the plane required to push a load of 120N uniformly up the plane is A. 60 N B. 100 N C. 120 N D. 200 N E. 240 N (1984:Q20)



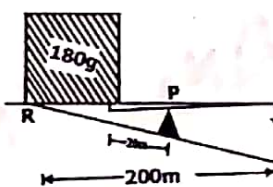
The figure represents a block-and-tackle pulley system on which an effort of W Newton supports a load of 120.0N. If the efficiency of the machine is 40%, then the value of W is A. 28.0 N B. 48.0 N C. 50.0 N D. 288.0 N (1986:Q12)

6.

7. The mechanical advantage (MA) of an inclined plane depends on
 A. Its length B. Its height C. The product of its length and height D. The ratio of its length and its height. **(1987:Q13)**
8. A 20-toothed gear wheel drives a 60-toothed one, if the angular speed of the smaller wheel is 120 revs^{-1} , the angular speed of the wheel is A. 3 revs^{-1} B. 40 revs^{-1} C. 360 revs^{-1} D. $2\ 400 \text{ revs}^{-1}$ **(1988:Q8)**
9. Which of the following graphs correctly describes the variation of the mechanical advantage with load for a simple machine whose velocity ratio is 3?

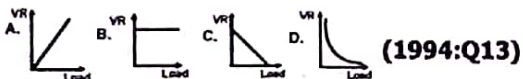


10. A block-and-tackle system is used to lift a load of 20N through a vertical height of 10cm. If the efficiency of the system is 40%, how much work is done against friction? A. 80J B. 120J C. 300J D. 500J **(1989:Q9)**
11. An inclined plane which makes an angle of 30° with the horizontal has a velocity ratio of A. 2 B. 1 C. 0.866 D. 0.50 **(1990:Q12)**
12. A wheel and axle have radius 80cm and 10cm respectively. If the efficiency of the machine is 0.85, an applied force of 1200N to the wheel will raise a load of A. 8.0 N B. 6.8 N C. 8160.0 N D. 9600.0 N **(1991:Q8)**
13. A 20kg mass is to be pulled up a slope inclined at 30° to the horizontal. If the efficiency of the plane is 75%, the force required to pull the load up the plane is A. 13.3 N B. 73.5 N C. 133.3 N D. 533.2 N [$g=10\text{ms}^{-2}$] **(1991:Q10)**
14. A machine requires 1000 J of work to raise a load of 500N through a vertical distance of 1.5m. Calculate the efficiency of the machine. A. 80% B. 75% C. 50% D. 33% **(1992:Q9)**
15. A plane inclined at angle θ has a velocity ratio of 10: 1. The inclination of the plane to the horizontal is given by A. $\tan \theta = 1/10$ B. $\cot \theta = 1/10$ C. $\cos \theta = 1/10$ D. $\sin \theta = 1/10$ **(1993:Q9)**

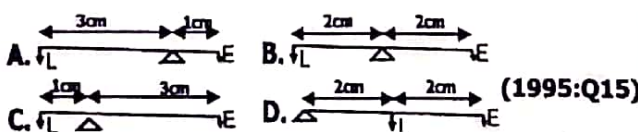


In the diagram above, a lever of length 200m is used to lift a load of mass 180kg. The pivot at P is 20m from the load.

16. What minimum force, F must be applied at the end of the lever? A. 9 N B. 18 N C. 20 N D. 200 N [$g=10\text{ms}^{-2}$] **(1993:Q12)**
17. Calculate the velocity ratio of a screw jack of pitch 0.3cm if the length of the tommy bar is 21cm. A. $1/140\pi$ B. 14π C. 70π D. 140π **(1994:Q12)**
18. Which of the following graphs correctly represents the relationship between the load and the velocity ratio of a machine?



19. Which of the following levers has the greatest mechanical advantage?



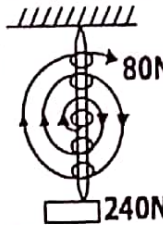
20. An electric water pump rated 1.5KW, lifts 200kg of water through a vertical height of 6 metres in 10 seconds. What is the efficiency of the pump? A. 90.0% B. 85.0% C. 80.0% D. 65.0% [$g = 10\text{ms}^{-2}$; neglect air resistance] **(1997:Q13)**
21. In a wheel-and-axle mechanism, the diameters of the wheel

and axle are 40cm and 8cm respectively. Given that the machine is 80% efficient, what effort is required to lift a load of 100N? A. 20 N B. 25 N C. 50 N D. 80 N **(1998:Q12)**



The figure above represents a frictionless pulley system in which a weight W is in equilibrium with a weight of 40N. Find the value of W A. 13.3N B. 20.0N C. 40.0N D. 80.0N **(1999:Q4)**

22. The velocity ratio of a machine is 5 its efficiency is 75%. What effort would be needed to lift a load of 150N with the machine? A. 50 N B. 40 N C. 30 N D. 20 N **(2000:Q10)**



The diagram above is a block-and-tackle pulley system in which an effort of 80 N is used to lift a load of 240 N. The efficiency of the machine is A. 60% B. 50% C. 40% D. 33% **(2001:Q4)**

23. The efficiency of a machine is always less than 100% because the A. work output is always greater than the work input B. load lifted is always greater than the effort applied? C. effort applied is always greater than the load lifted D. velocity ratio is always greater than the mechanical advantage. **(2001:Q8)**
24. A wheel and axle is used to raise a load of 500 N by the application of an effort of 250N. If the radii of the wheel and the axle are 0.4cm and 0.1cm respectively, the efficiency of the machine is A. 60% B. 50% C. 40% D. 20% **(2002:Q6)**
25. A machine whose efficiency is 60% has a velocity ratio of 5. If a force of 500N is applied to lift a load P, what is the magnitude of P? A. 750N B. 4166N C. 500N D. 1500N **(2004:Q11)**
26. In an ideal wheel and axle system, R stands for the radius of the wheel and r is the radius of the axle. The mechanical advantage is A. R/r B. $(r/R)^2$ C. r/R D. $(R/r)^2$. **(2005:Q27)**
27. I. Work done by load is always less than the work done by effort II. All machines are made of levers, pulleys, screws and gear wheels. III. A fishing rod is a machine IV. Effort is always larger than load. Which of the statements above about machines are true? A. III and IV B. I and II C. I and III D. II and III **(2006:Q15)**
28. A machine has a velocity ratio of 4. If it requires 800 N to overcome a load of 1600 N, what is the efficiency of the machine? A. 2% B. 40% C. 50% D. 60%. **(2007:Q46)**



The efficiency of the pulley system show above is 80%. Find the effort E required to lift a load of 1200 N. A. 275 N. B. 325 N. C. 375 N. D. 573 N. **(2008:Q14)**

29. If a heavy barrel is rolled up a plane inclined at 30° to the horizontal, its velocity ratio will be A. 3.0. B. 3.1. C. 3.2. D. 2.0. **(2009:Q12)**
30. A machine of velocity ratio 6 requires an effort of 400 N to raise a load of 800 N through 1 m. Find the efficiency of the machine. A. 50.0%. B. 22.2% C. 33.3%. D. 55.6%. **(2010:Q10)**
31. A machine is used to lift a load of 20 N through a height of 10m. If the efficiency of the machine is 40%, how much work is done? A. 300 J B. 120 J C. 80 J D. 500 J **(2011:Q12)**

35. A block and tackle is used to raise a load of 250N through a vertical distance of 30m. What is the efficiency of the system if the work done against friction is 1500J? A. 62.5% B. 73.3% C. 83% (2012:Q14)
36. What effort will a machine of efficiency 90% apply to lift a load of 180N if its efforts arm is twice as long as its load arm? A. 80N. B. 90N. C. 100N. D. 120N. (2013:Q12)
37. A machine whose efficiency is 75% is used to lift a load of 1 000N. Calculate the effort put in to the machine if it has a velocity ratio of 4. A. 233.33 N. B. 333.33 N. C. 334.33 N. D. 343.32 N. (2014:Q14)
38. A wheel and axle is used to raise a load whose weight is 800N when an effort of 250N is applied. If the radii of the wheel and axle are 800 mm and 200 mm respectively, the efficiency of the machine is A. 80%. B. 85%. C. 87%. D. 90%. (2014:Q15)
39. The efficiency of a machine is 70%. Calculate the work done using this machine to raise a load of 100kg through a vertical height of 2.0m. [g = 10ms⁻²] A. 2 000 J B. 3000 J C. 1 500 J D. 1 000 J (2015:Q8)
40. Which of the following is NOT affected by friction in machines? A. Efficiency B. Effort C. Velocity ratio D. Mechanical advantage. (2015:Q36)
41. A lever is used to overcome a load of 50N by applying an effort of 10N. Find the mechanical advantage of the level. A. 40 B. 10 C. 30 D. 5 (2016:Q9)
42. Which of the following is TRUE about a machine? A. Efficiency is zero B. Efficiency is greater than 100% C. Efficiency is less than 100% D. Efficiency is 100% (2017: Q24)
43. A block and tackle system has 6 pulleys. If the efficiency of the machine is 60%, determine its mechanical advantage? A. 12.0 B. 10.0 C. 3.6 D. 1.8 (2018:Q6)
44. The velocity of a machine is 5 and its efficiency is 75%. What effort would be needed to lift a load of 150N with the machine? A. 50N B. 40N C. 30N D. 20N (2018:Q40)

CHAPTER 9 ANSWERS

1C Efficiency = $\frac{\text{work output}}{\text{work input}} \times 100\%$

2B $VR = \frac{1}{\sin\theta}$

3C **Classifying machine**

1. Lever System
 - a. 1st order - scissors, crowbar, claw hammer, pliers
 - b. 2nd order - wheel barrow, nutcracker
 - c. 3rd order - tongs, forceps, fore arm
2. Pulley systems
3. Inclined plane
4. Wedge (combination of two inclined plane)
5. The screw(jack)
6. The wheel and axle
7. The gear wheel

4E Mechanical Advantage, $MA = \frac{\text{Load}}{\text{Effort}} = \frac{200}{50} = 4.0$

But Efficiency = $\frac{\text{Mechanical Advantage}}{\text{velocity ratio}} \times 100\%$

$\epsilon = \frac{MA}{VR} = \frac{4}{5} \times 100\% = 80\%$

NOTES

1. MA is also called **force ratio**
2. The need to convert the masses to weights does not arise, it is mere waste of time
3. MA is always greater than 1 or else the machine is mechanically disadvantageous
4. VR is always greater than 1 and also greater than MA

otherwise the machine is 100% or more efficient - no such machine exists because work must be done to overcome friction.

5B $VR = \frac{1}{\sin\theta}$ (Q2) $\therefore VR = \frac{1}{\sin 30^\circ} = 2$

But $MA = \epsilon \times VR$. (See Q4) $\therefore Ma = \frac{60}{100} \times 2 = 1.2$

But $\frac{L}{E} = MA \therefore E = \frac{L}{MA} = \frac{120}{1.2} = 100N$

6C $VR = \text{No of pulleys} = 6$

$MA = \epsilon \times VR = \frac{40}{100} \times 6 = 2.4$

$\frac{L}{E} = MA \therefore E = \frac{L}{MA} \rightarrow E = 50N$

7D $MA = \frac{\text{Length of plane}}{\text{vertical height of plane}} = \frac{L}{H}$ (diagram)

8C $\frac{\text{No of teeth of driven wheel}}{\text{No of teeth of driving wheel}} = \frac{\text{Speed of driven wheel}}{\text{Speed of driving wheel}}$

$\frac{60}{20} = \frac{v}{120} \rightarrow v = 360 \text{ revs}^{-1}$

9C For an ideal machine: $E = 100\%$
 $\therefore MA = VR = 3$ (MA is a constant)

10C Work output = $F \times S = 20 \times 10 = 200J$

But $\epsilon = \frac{W_2}{W_1} \times 100\% \rightarrow 40 = \frac{200}{W_1} \times 100\% \rightarrow W_1 = 500J$

$W_f = W_1 - W_2 = 500 - 200 = 300J$

$W_f = \text{work against friction}$

$W_1 = \text{work input}$ $W_2 = \text{work output}$

11A See Q2 and 5

12C $VR = \frac{\text{Radius of wheel}}{\text{Radius of axle}} = \frac{80\text{cm}}{10\text{cm}} = 8$

But $MA = \epsilon \times VR = 0.85 \times 8 = 6.8$

Also $\frac{L}{E} = MA \rightarrow L = MA \times E = 6.8 \times 1200 = 8160N$

NOTE: The efficiency 0.85 means 85% hence don't use 100 again in the maths

13C $VR = \frac{1}{\sin\theta} = 2$. $\epsilon = 75\%$

But $MA = \epsilon \times VR = \frac{75 \times 2}{100} = 1.5$

$E = \frac{L}{MA} = \frac{mg}{MA} = \frac{200}{1.5} = 133.3N$

NOTES

1. In an inclined plane, load is the weight ($W = mg$) of the body of mass m
2. Work output is the work done against gravity and it is (mgh) where h is the vertical distance travelled by the body.
3. Work output is $E \times l$, where l is the length of the slope or plane

14B $W_2 = mgh = 500 \times 1.5 = 750J$ $W_1 = 1000J$

$\epsilon = \frac{W_2}{W_1} \times 100\% = \frac{750}{1000} = 75\%$

15D $VR = \frac{1}{\sin\theta} \rightarrow \sin\theta = \frac{1}{VR}$; But $VR = \frac{10}{1} \therefore \sin = \frac{1}{10}$

16D Applying the principle of moment:
 $F(200 - 20) = 1800 \times 20 \rightarrow F = 200N$

17D $VR = \frac{2\pi r}{p}$ where $r = 21\text{cm}$ $p = 0.3\text{cm}$

$\therefore VR = \frac{2\pi \times 21}{0.3} = 140\pi$

19C Let a = distance of Load from fulcrum
 b = distance of Effort from fulcrum

From the principle of moment

$$L \times a = E \times b \rightarrow \frac{L}{E} = \frac{b}{a} \text{ or } MA = \frac{b}{a}$$

In (C) the ratio is 3 and also the highest

NOTE: The ratio $\frac{b}{a} = VR$; \therefore For a Lever $MA = VR$

10C $W_1 = Pt = 1\,500 \times 10 = 15\,000\text{J}$

$W_2 = mgh = 200 \times 10 \times 6 = 12\,000\text{J}$

$$\epsilon = \frac{W_2}{W_1} \times 100\% = \frac{12\,000}{15\,000} \times 100\% = 80\%$$

21B $VR = \frac{40}{8} = 5 \rightarrow MA = \epsilon \times VR = \frac{80 \times 5}{100} = 4$

$$MA = \frac{L}{E} \rightarrow E = 25\text{N}$$

22C In the absence of friction: $L = E$ and $MA = 1$

23B $MA = \frac{75 \times 5}{100} = 3.75 \rightarrow 3.75 = \frac{150}{E} \rightarrow E = 40\text{N}$

24B $MA = \frac{L}{E} = \frac{240}{80} = 3$; $VR = \text{No of pulleys} = 6$

$$\epsilon = \frac{MA}{VR} \times 100\% = \frac{3}{6} \times 100\% = 50\%$$

25D When $VR > MA$, the ratio $\frac{MA}{VR} < 1$ and $\epsilon < 100\%$

26B $MA = \frac{500}{250} = 2$; $VR = \frac{0.4}{0.1} = 4$

$$\epsilon = \frac{MA}{VR} \times 100\% = \frac{2}{4} \times 100\% = 50\%$$

27D $MA = \frac{L}{E} = \epsilon \times VR$; $\therefore \frac{P}{500} = \frac{60 \times 5}{100} = 1\,500\text{N}$

28A An ideal wheel and axle is 100% efficient i.e. in the absence of friction such that $MA = VR = \frac{R}{r}$

- 29C I \rightarrow hence no machine is 100% efficient.
 II \rightarrow inclined plane, wheel/axle and wedge are also machine
 III \rightarrow L = fish E = Pull on the pole
 IV \rightarrow A machine is one only if a small effort overcomes a larger load

30C $MA = \frac{1\,600}{800} = 2$; $VR = 4 \rightarrow \epsilon = \frac{2}{4} \times 100\% = 50\%$

31C $MA = \frac{80 \times 4}{100} = 3.2 \rightarrow \frac{1\,200}{E} = 3.2 \rightarrow E = 375\text{N}$

32D See Q2, 5 and 11

33C $MA = \frac{800}{400} = 2$; $VR = 6 \rightarrow \epsilon = \frac{2}{6} \times 100\% = 33.33\%$

34D Work output = $20 \times 10 = 200\text{J}$

But efficiency = $\frac{\text{work output}}{\text{work input}} \times 100\%$

$$40 = \frac{200}{W_2} \times 100\% \rightarrow W_2 = 500\text{N}$$

35C Work input = work to overcome load + work to overcome friction

But efficiency = $\frac{\text{work output}}{\text{work input}} \times 100\%$

$$= \frac{(250 \times 30)}{(250 \times 30) + (1\,500)} \times 100\% = 83.3\%$$

36C $VR = \frac{\text{Effort arm}}{\text{Load arm}}$ (See Q19) $\therefore VR = 2$

$$MA = \epsilon \times VR \rightarrow \frac{180}{E} = \frac{90 \times 2}{100} \rightarrow E = 100\text{N}$$

37A $MA = \epsilon \times VR = \frac{75 \times 4}{100} = 3 \rightarrow \frac{1\,000}{E} = 3 \rightarrow E = 333.33\text{N}$

38D $MA = \frac{800}{250} = 3.2$; $VR = \frac{800}{200} = 4$

$$\epsilon = \frac{MA}{VR} \times 100\% = \frac{3.2}{4} \times 100\% = 80\%$$

39A. The work done = $mgh = 100 \times 10 \times 2 = 2\,000\text{J}$

40C Velocity ratio depends on the geometry of the machine, it is independent of friction

41D $MA = \frac{50}{10} = 5$

42C Only an ideal machine is 100% efficient where in ($MA = VR$). Machines practically have efficiency less than 100% because it is not possible to totally eliminate friction

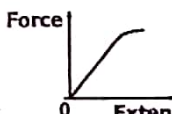
43C V.R. of 6 pulley system = $6 \epsilon = 60\%$

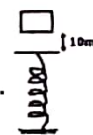
But $\epsilon = \frac{MA}{VR} \times 100\% \rightarrow \frac{60}{100} = \frac{MA}{6}$ and $MA = 3.6$

44B See Q23

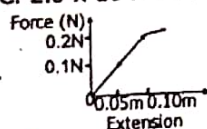
CHAPTER 10

ELASTICITY. HOOKE'S LAW. YOUNG'S MODULUS

- A piece of rubber 10cm long stretches 6mm when a load of 100N is hung from it. What is the strain? A. 60 B. 6 C. 6×10^{-2} D. 6×10^{-3} E. 0.6. (1978:Q5)
 - The extension in a spring when 5g wt was hung from it was 0.56cm. If Hooke's law is obeyed, what is the extension caused by a load of 20g wt? A. 1.12cm B. 2.14cm C. 2.52cm D. 2.80cm E. 2.24cm (1981:Q43)
 - The point beyond which a stretched spring does not return to its original length is called the A. breaking point B. elastic limit C. spring constant D. elasticity point E. release point. (1982:Q49)
 - A 10g mass placed on the pan of a spring balance causes an extension of 5cm. If a 15g mass is placed on the pan of the same spring balance the extension is A. 3.3cm B. 6.5cm C. 7.5cm D. 10.8cm E. 15.0cm (1982:Q50)
 - The total length of a spring when a mass of 20g is hung from its end is 14cm, while its total length is 16cm when a mass of 30g is hung from the same end. Calculate the unstretched length of the spring assuming Hooke's law is obeyed. A. 9.33 cm B. 10.00cm C. 10.66cm D. 12.00cm E. 15.00cm (1983:Q32)
 - A force of 100N stretches an elastic string to a total length of 20cm. If an additional force of 100N stretches the string 5cm further, find the natural length of the string. A. 15cm B. 12cm C. 10cm D. 8cm E. 5cm (1985:Q13)
- Force  Extension
7. The figure is a graph of force against extension for a spiral spring. The force constant of the spring is given by the.
- Slope of the linear portion of the graph.
 - Length of the linear portion of the graph.
 - Area under the linear portion of the graph.
 - Area under the entire graph (1986:Q2)

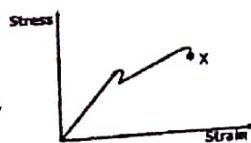
8.  A 50.0kg block is dropped on a spring from a point 10m above (Fig. 2). If the force constant of the spring is $4.0 \times 10^4 \text{Nm}^{-1}$, find the maximum compression of the spring. A. 1.25m B. 0.50m C. 0.25m D. 0.05m ($g=10\text{ms}^{-2}$) (1987:Q7)
- A load of 5N gives an extension of 0.56cm in a wire which obeys Hooke's law. What is the extension caused by a load of 20N? A. 1.12cm B. 2.14cm C. 2.24cm D. 2.52cm. (1987:Q14)
 - In the figure above, $W_1 = 200\text{g}$ and $W_2 = 450\text{g}$. Calculate the extension of the spring per unit load. [$g = 10\text{ms}^{-2}$] A. $6.0 \times 10^{-5} \text{mN}^{-1}$ B. $2.5 \times 10^{-4} \text{mN}^{-1}$ C. $6.0 \times 10^{-3} \text{mN}^{-1}$ D. $2.5 \times 10^{-2} \text{mN}^{-1}$ (1989:Q10)
 - A spring of force constant 1500Nm^{-1} is acted upon by a constant force of 75N. Calculate the potential energy stored in the spring. A. 1.9J B. 3.2J C. 3.8J D. 5.0J (1991:Q7)

12. The spiral spring of a spring balance is 25.0cm long when 5N hangs on it and 30.0cm long, when the weight is 10N. What is the length of the spring if the weight is 3N, assuming Hooke's Law is obeyed? A. 15.0cm B. 17.0cm C. 20.0cm D. 23.0cm (1991:Q11)
13. In an experiment to determine Young's Modulus for a wire, several loads are attached to the wire and the corresponding extensions measured. The tensile stress in each case depends on the A. Load and the extension B. Load and the radius of the wire C. Radius of the wire and the extension D. Extension and the original length of the wire. (1992:Q10)
14. A spring of length 25 cm is extended to 30 cm by a load of 150N attached to one of its ends. What is the energy stored in the spring? A. 3750 J B. 2500 J C. 3.75 J D. 2.50 J (1994:Q14)
15. A force of 15N stretches a spring to a total length of 30cm. An additional force of 10N stretches the spring 5cm further. Find the natural length of the spring. A. 25.0cm B. 22.5cm C. 20.0cm D. 15.0cm (1994:Q16)
16. The energy contained in a wire when it is extended by 0.02m by a force of 500 N is A. 5J B. 10J C. 10³J D. 10⁴J (1995:Q14)
17. A load of 20N on a wire of cross-sectional area $8 \times 10^{-7} \text{m}^2$, produces an extension of 10^{-4}m . Calculate Young's modulus for the material of the wire if its length is 3 m. A. $7.0 \times 10^{11} \text{Nm}^{-2}$ B. $7.5 \times 10^{14} \text{Nm}^{-2}$ C. $8.5 \times 10^{11} \text{Nm}^{-2}$ D. $9.0 \times 10^{11} \text{Nm}^{-2}$ (1997:Q15)
18. The tendon in a man's leg is 0.01m long. If a force of 5N stretches the tendon by $2.0 \times 10^{-5} \text{m}$, calculate the strain on the muscle. A. 5×10^6 B. 5×10^3 C. 2×10^{-3} D. 2×10^{-7} (1998:Q13)
19. If the stress on a wire is 107 Nm² and the wire is stretched from its original length of 10.00cm to 10.05cm. The young's modulus of the wire is A. $5.0 \times 10^4 \text{Nm}^{-2}$ B. $5.0 \times 10^6 \text{Nm}^{-2}$ C. $2.0 \times 10^8 \text{Nm}^{-2}$ D. $2.0 \times 10^9 \text{Nm}^{-2}$ (1999:Q14)
20. A catapult used to hold a stone of mass 500g is extended by 20cm with an applied force f . If the stone leaves with a velocity of 40ms^{-1} , the value of F is A. $4.0 \times 10^4 \text{N}$ B. $4.0 \times 10^3 \text{N}$ C. $2.0 \times 10^3 \text{N}$ D. $4.0 \times 10^2 \text{N}$ (2000:Q1)



The diagram above shows the force-extension curve of a piece of wire. The energy stored when the wire is stretched 0.10m is A. 0.10J B. 0.20J C. $7.5 \times 10^{-3} \text{J}$ D. $2.5 \times 10^{-3} \text{J}$ (2001:Q1)

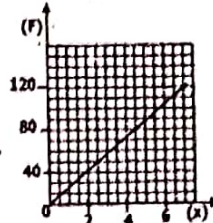
22. On top of a spiral spring of force constant 500Nm^{-1} is placed a mass of $5 \times 10^{-3} \text{kg}$. If the spring is compressed downwards by a length of 0.02m and then released, calculate the height to which the mass is projected. A. 8m B. 4m C. 2m D. 1m [$g = 10 \text{ms}^{-2}$] (2003:Q2)
23. If a force of 50N stretches a wire from 20m to 20.01m, what is the amount of force required to stretch the same material from 20m to 20.05m? A. 100N B. 50N C. 250N D. 200N (2004:Q35)
24. An elastic material has a length of 36cm when a load of 40 N is hung on it and a length of 45cm when a load of 60 N is hung on it. The original length of the string is A. 18cm. B. 12cm. C. 20cm. D. 15cm. (2005:Q42)



The diagram above represents the stress-strain graph for a typical metal rod. What does X represent? A. Yield point B. Breaking point C. Elastic limit D. Proportional limit (2006:Q40)

26. A string of length 4 m is extended by 0.02 m when a load of 0.4kg is suspended at its end. What will be the length of the string when the applied forces is 15 N? A. 5.05 m B. 6.08 m C. 4.05 m D. 4.08 m [$g = 10 \text{ms}^{-2}$] (2007:Q30)

27. A spring of force constant 500Nm^{-1} is compressed such that its length shortens by 5cm. The energy stored in the spring is A. 0.625 J. B. 6.250 J. C. 62.500 J. D. 625.000 J. (2008:Q15)



The diagram above represents the graph of the force (F) applied in stretching a spiral spring against the corresponding extension (X). The force constant of the spring is A. 20Nm^{-1} , B. 40Nm^{-1} , C. 30Nm^{-1} , D. 10Nm^{-1} . (2009:Q15)

28.

29. If a load of mass 10N stretches a cord by 1.2cm, what is the total work done? A. $7.6 \times 10^{-2} \text{J}$ B. $1.8 \times 10^{-2} \text{J}$ C. $1.8 \times 10^{-3} \text{J}$ D. $6.6 \times 10^{-2} \text{J}$ (2009:Q16)

30. If a wire 30cm long is extended to 30.5cm by a force 300N. Find the strain energy of the wire. A. 7.50 J. B. 750.00 J. C. 75.00 J. D. 0.75 J. (2010:Q11)

31. A copper wire was subjected to a tensile stress of $7.7 \times 10^7 \text{Nm}^{-2}$. Calculate the tensile strain of the wire. A. 7.0×10^{-4} B. 2.2×10^{-4} C. 2.0×10^{-5} D. 7.0×10^{-3} [Young modulus = $1.1 \times 10^{11} \text{Nm}^{-2}$] (2011:Q14)

32. If a load of 1 kg stretches a cord by 1.2cm, what is the force constant of the cord? A. 866Nm^{-1} B. 833Nm^{-1} C. 769Nm^{-1} D. 667Nm^{-1} . [$g = 10 \text{ms}^{-2}$] (2012:Q15)

33. Calculate the work done when a force of 20N stretches a spring by 50mm. A. 0.5J B. 1.5J C. 2.0J D. 2.5J (2013:Q13)

34. A force of 500N is applied to a steel wire of cross-sectional area 0.2m^2 , the tensile stress is A. $2.5 \times 10^4 \text{Nm}^{-2}$ B. $1.0 \times 10^2 \text{Nm}^{-2}$ C. $1.0 \times 10^3 \text{Nm}^{-2}$ D. $2.5 \times 10^3 \text{Nm}^{-2}$ (2014: Q16)

35. A metal wire extends by 5cm under a load of 60N, when the load is replaced by a steel block, the new extensions is 7cm. The weight of the steel block is A. 12N B. 84N C. 43N D. 96N (2016:Q15)

36. Calculate the energy stored in a stretched spring constant $1.0 \times 10^4 \text{Nm}^{-1}$ when a force of 200N is applied to its end (a) 2000.0J B. 200.0J C. 0.2J D. 2.0J (2017:Q34)

CHAPTER 10 ANSWERS

1. Strain = $\frac{\text{Extension}}{\text{Original length}} = \frac{e}{l}$ where $e = 6 \text{mm} = 0.6 \text{cm}$

$l_0 = 10 \text{cm} \therefore \text{strain} = \frac{0.6}{10} = 0.06$

NOTE

- Strain, a ratio of two lengths, has no unit.
- The two length must be converted to same unit e.g. diagram or diagram

3. Stress = $\frac{\text{Force Applied}}{\text{Area of elastic material}} = \frac{F}{A}$ (in Nm^{-2})

4. Stress \propto strain or stress = $E \times \text{strain}$

$\therefore E = \frac{\text{Stress}}{\text{Strain}}$ Where $E = \text{Young's modulus of elasticity}$

2E $F \propto e$ or $F = ke \therefore \frac{F}{e} = k$ or $\frac{F_1}{e_1} = \frac{F_2}{e_2} = \frac{F_3}{e_3} \dots$

Therefore, finding k is completely circumvented

$\frac{20}{e_2} = \frac{5}{0.56} \rightarrow e_2 = 2.24 \text{cm}$

NOTE: i. Conversion to S.I. units not necessary
ii. Masses are assumed to be forces

- 3B Hooke's Law is obeyed as long as elastic limit is not exceeded

NOTE:

1. Yield point is a point where a very small increase in load begins to produce a very large extension not proportional to the applied force.
2. Breaking point is the point of maximum extension beyond which the material snaps or breaks

4C $\frac{F_2}{e_2} = \frac{F_1}{e_1}; \frac{15}{e_2} = \frac{10}{5} \rightarrow e_2 = 7.5\text{cm}$

5B Unstretched length = original length = l_0
 20g mass produces extension $e_1 = (14 - l_0)\text{cm}$
 30g mass produces extension $e_2 = (16 - l_0)\text{cm}$

But $\frac{F_2}{e_2} = \frac{F_1}{e_1}; \frac{30}{16 - l_0} = \frac{20}{14 - l_0} \rightarrow 30(14 - l_0) = 20(16 - l_0)$
 $l_0 = 10\text{cm}$

6A Let natural length = l_0
 $F_1 = 100\text{N}$ $e_1 = 20 - l_0$ $F_2 = 100 + 100 = 200\text{N}$
 $e_2 = 20 - l_0 + 5 \therefore \frac{100}{20 - l_0} = \frac{200}{25 - l_0}; l_0 = 15\text{cm}$

7A The force constant $K = \frac{F}{e} = \text{slope}$
 Force constant = elastic constant = stiffness of the material

8B Gravitational PE from $h = 10\text{m}$ is converted to elastic PE in the spring Gravitational PE = mgh
 $E = \frac{1}{2} k e^2 \therefore \frac{1}{2} \times 4 \times 10^4 \times e_2 = 50 \times 10 \times 10$
 $e_2 = \frac{2 \times 50 \times 10 \times 10}{4 \times 10^4} = \sqrt{0.25} = 0.5\text{m}$

9C $\frac{20}{e_2} = \frac{5}{0.56} \therefore e_2 = 2.24$

10C $\Delta l = (6.5 - 5.0) \times 10^{-2} = 1.5 \times 10^{-2}\text{m}$
 $\Delta F = (450 - 200) \times 10^{-3} \times 10 = 2.5\text{N}$
 $x = \frac{\Delta l}{\Delta F} = \frac{1.5 \times 10^{-2}}{2.5} = 6.0 \times 10^{-3}$

NOTE: x calculated above is actually diagram i.e. the reciprocal of the elastic constant

11A PE = average force x extension = $\frac{1}{2} Fe$

But $K = \frac{F}{e}$ or $e = \frac{F}{K} \therefore PE = \frac{1}{2} F^2 \frac{1}{K} = \frac{F^2}{2K} \rightarrow PE = 1.875\text{J}$

NOTE: The PE is calculated by any of these 3 equations

$PE = \frac{1}{2} Ke^2$ (if F is unknown); $PE = \frac{F^2}{2K}$ (if e is unknown)

$PE = \frac{1}{2} Fe$ (if k is unknown)

12D Let the length at $3\text{N} = l_0$
 Between 3N and 5N forces: $\Delta F_1 = 5 - 3 = 2\text{N}$ and $\Delta e_1 = 25 - l_0$
 Between 5N and 10N forces: $\Delta F_2 = 10 - 5 = 5\text{N}$ and $\Delta e_2 = 30 - 25 = 5$

Using $\frac{\Delta F_1}{\Delta e_1} = \frac{\Delta F_2}{\Delta e_2} \rightarrow \frac{2}{25 - l_0} = \frac{5}{5} \rightarrow l_0 = 23\text{cm}$

13D See Q1

14C Energy stored = $\frac{1}{2} Fe = \frac{1}{2} \times 150 (30 - 25) \times 10^{-2} = 3.75\text{J}$

15B $F_1 = 15\text{N}$ $e_1 = 30 - l_0$ $F_2 = 15 + 10 = 25\text{N}$

$e_2 = (30 - l_0) + 5 = 35 - l_0 \rightarrow \frac{15}{30 - l_0} = \frac{25}{35 - l_0} \rightarrow l_0 = 22.5\text{cm}$

16A Energy = $\frac{1}{2} Fe = \frac{1}{2} \times 500 \times 0.02 = 5\text{J}$

17B Stress = $\frac{F}{A} = \frac{20}{8 \times 10^{-7}} = 2.5 \times 10^7 \text{Nm}^{-2}$

Strain = $\frac{e}{l_0} = \frac{10^{-1}}{3} = 3.33 \times 10^{-5}$

But young's modulus $E = \frac{\text{Stress}}{\text{Strain}} \therefore E = \frac{2.5 \times 10^7}{3.33 \times 10^{-5}} = 7.5 \times 10^{11} \text{Nm}^{-2}$

18C Strain = $\frac{e}{l_0} = \frac{2.5 \times 10^{-1}}{0.01} = 2 \times 10^{-1}$

19D $e = 10.05 - 10.00 = 0.05\text{cm} = 0.0005\text{m}$

Strain = $\frac{e}{l_0} = \frac{0.0005}{0.1} = 0.005$

$E = \frac{\text{Stress}}{\text{Strain}} = \frac{10^7}{0.005} = 2.0 \times 10^9 \text{NM}^{-2}$

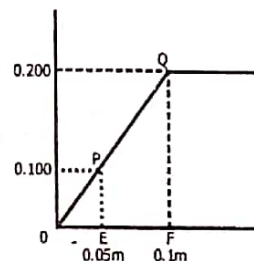
20B Elastic PE in catapult is converted to KE of stone

$\therefore \frac{1}{2} Fe = \frac{1}{2} mv^2; F = \frac{mv^2}{e} = \frac{500 \times 10^{-3} \times 40^2}{20 \times 10^{-2}} = 4000\text{N}$

21C Energy = Average force x extension

$= \left(\frac{0.1 + 0.2}{2} \right) \times (0.1 - 0.05) = \frac{0.3}{2} \times 0.05 = 7.5 \times 10^{-3}$

1. Note average force = $\frac{F_1 + F_2}{2}$ not $\left(\frac{F_2 - F_1}{2} \right)$
2. If in doubt, do you know that the energy stored is also the work done when the spring is released?
3. Do you also know that energy stored or work done is the area under the $F - e$ graph?



Now consider the area of ΔOPQ
 Work = $\frac{1}{2} OF \times QF$
 This is consistent with the earlier submission that Energy stored = Average force x extension
 Also consider the area of trapezium EPQR

Energy = $\frac{EP + FQ}{2} \times EF = \frac{0.1 + 0.2}{2} \times 0.05 = 7.5 \times 10^{-3}$

22C By the time the mass reaches the maximum height h , all the energy stored in the spring must have been converted to potential energy (mgh) at the max height
 $\therefore mgh = \frac{1}{2} Ke^2 \rightarrow 5 \times 10^{-1} \times 10 \times h = \frac{1}{2} \times 500 \times 0.02^2$

$h = \frac{500 \times 0.02^2}{2 \times 5 \times 10^{-1}} = 2\text{m}$

23C $F_1 = 50$ $e_1 = 20.01 - 20.00 = 0.01\text{m}$

$e_2 = 20.05 - 20 = 0.05\text{m}$ $F_2 = ? \rightarrow \frac{F_2}{0.05} = \frac{50}{0.01} \Rightarrow F_2 = 250\text{N}$

24A $\frac{40}{36 - l_0} = \frac{60}{45 - l_0} \therefore l_0 = 18\text{cm}$

25B See Q3

26D $\frac{4.0}{0.02} = \frac{15}{e_2} \rightarrow e^2 = 0.075\text{m}$

New length = original length + extension = $4.00 + 0.075 = 4.075\text{m}$

27A $E = \frac{1}{2} Ke^2 = \frac{500 \times 0.05^2}{2} = 0.625\text{J}$

28A Force constant = slope of graph = $\frac{40 - 0}{2 - 0} = 20\text{Nm}^{-1}$

29A $Fe = \frac{1}{2} \times 10 \times 1.2 \times 10^{-2} = 0.06\text{J} = 6.0 \times 10^{-2}\text{J}$

30D $E = \frac{1}{2} Fe = \frac{1}{2} \times 300 \times 0.5 \times 10^{-2} = 0.75\text{J}$

31A $E = \frac{\text{Stress}}{\text{Strain}} \cdot 1.1 \times 10^{11} = \frac{7.7 \times 10^7}{s} \rightarrow s = 0.0007$

32B Load = $mg = 1 \times 10 = 10\text{N}$
 Extension = $1.2\text{cm} = 1.2 \times 10^{-2}\text{m}$

$K = \frac{F}{e} = \frac{10}{1.2 \times 10^{-2}} \rightarrow K = 833.3\text{Nm}^{-1}$

33A $W = \frac{1}{2}Fe = \frac{1}{2} \times 20 \times 50 \times 10^3 = 5 \times 10^4 \text{ J}$

34B $\text{Stress} = \frac{F}{A} = \frac{500}{0.2} = 2500 \text{ Nm}^{-2}$

35B $K \frac{F_1}{e_1} = \frac{F_2}{e_2} \rightarrow \frac{60}{5} = \frac{F_2}{7} \rightarrow F_2 = 84 \text{ N}$

36D $E = \frac{F^2}{2k} \text{ (Q11)} = \frac{200 \times 200}{2 \times 1.0 \times 10^4} = 2.0 \text{ J}$

CHAPTER 11

DENSITY AND UPTHRUST ARCHIMEDE'S PRINCIPLE. FLOATATION

- The density of a solid is defined as the A. mass of the solid compared to the mass of an equal volume of water B. amount of water displaced when a unit mass of the solid is immersed in it C. weight per unit volume of the solid D. volume per unit mass of the solid E. mass per unit volume of the solid **(1978:Q12)**
- A solid suspended by a piece of string is completely immersed in water. On attempting to lift the solid out of the water, the string breaks when the solid is partly out of the water. This is because A. the tension in the string decreases as the solid is lifted B. the mass of the solid has increased C. the solid apparently weighs less when completely immersed in water than when partially immersed D. part of the solid still in water is exerting more force on the string E. the solid is no longer in equilibrium with water. **(1978:Q14)**
- The density of 400cm³ of palm oil was 0.9 g cm⁻³ before frying. if the density of the oil was 0.6 g m⁻³ after frying, assuming no loss of oil due to spilling, its new volume was A. 360cm³ B. 600cm³ C. 240cm³ D. 800cm³ E. 450cm³. **(1979:Q1)**
- An object of mass m and volume v is totally immersed in a liquid of density p. The tension of a string holding it is A. mg B. (m + pv)g C. (m-pv)g D. pvg E. [m/ m-pv]g. **(1980:Q29)**
- A solid weighs 4.8g in air, 2.8g in water and 3.2g in kerosine. The ratio of density of the solid to that of the kerosine is A. 12 B. 3 C. 2 D. 3/2 E. 5/4 **(1981:Q50)**
- The accurate measurement of the relative density of substances in powder or granular form can be done using a beam balance and a A. pipette B. burette C. measuring cylinder D. density E. eureka can **(1982:Q15)**
- Why does a piece of cork float on water? A. There is no upthrust on it when completely immersed in water B. The upthrust on it when completely immersed in water is greater than its weight in air C. The upthrust on it when completely immersed in water is less than its weight in air D. Its specific gravity is greater than that of water E. Its specific gravity is the same as that of water **(1982:Q20)**
- A hydrometer is an instrument for measuring the A. depth of water in a vessel B. relative density of a liquid by the method of flotation C. relative density of a liquid by finding the apparent loss in weight D. relative humidity of the air E. atmospheric pressure when the air is humid. **(1982:Q45)**
- If the relative density of a metal is 19, what will be the mass of 20cm³ of the metal when immersed in water? A. 380g B. 400g C. 360g D. 39g E. 180g **(1983:Q8)**
- A piece of wood is floating on water. The forces acting on the wood are A. Upthrust and reaction. B. Weight and reaction. C. Weight and upthrust D. Upthrust and viscosity E. Weight and viscosity. **(1983:Q28)**
- 1,000 identical drops of oil of density 500kg/m³ have a total mass of 5 x 10⁻⁴kg. One of the drops forms a thin film of area 0.5m² on water. The thickness of the film is A. 2 x 10⁻⁸m B. 2 x 10⁻⁹m C. 2 x 10⁻⁷m D. 3 x 10⁻⁸m E. 2.8x10⁻⁸m. **(1983:Q31)**
- What volume of alcohol with a density of 8.4 x 10²kgm⁻³ will have the same mass as 4.2m³ of petrol whose density is 7.2 x 10²kgm⁻³? A. 1.4m³ B. 3.6m³ C. 4.9m³ D. 5.0m³ E. 5.8m³ **(1984:Q4)**
- A metal cube of volume 10³mm³ is lowered into a measuring cylinder containing water. If the internal cross-sectional area of the cylinder is 1.5 x 10²mm², by how much does the water level rise in the cylinder? A. 6.67 x 100mm B. 8.50 x 10²mm C. 1.15 x 10³mm D. 2.50 x 10³mm E. 1.50 x 10⁵mm **(1985:Q16)**
- A uniform cylindrical block of wood floats in water with one third of its height above the water level. In a liquid of relative density 0.8, What fraction of its height will be above the liquid level? A. 1/6 B. 1/5 C. 1/3 D. 4/5 E. 5/6 **(1985:Q17)**
- A heavy object is suspended from a string and lowered into water so that it is completely submerged. The object appears lighter because A. The density of water is less than that of the object. B. The pressure is low just below the water surface C. It experiences an upthrust. D. The tension in the string neutralizes part of the weight. **(1986:Q3)**
- A cube of side 10cm and mass 0.5kg floats in a liquid with only 1/5 of its height above the liquid surface. What is the relative density of the liquid? A. 0.125 B. 0.250 C. 0.625 D. 2.500. **(1987:Q15)**
- A body whose mass is 2kg and has a volume of 500cm³ just floats when completely immersed in a liquid. Calculate the density of the liquid. A. 4.0 x 10²kgm⁻³ B. 4.0 x 10³kgm⁻³ C. 1.0 x 10³kgm⁻³ D. 1.0 x 10⁴kgm⁻³ **(1988:Q14)**
- A piece of wood of mass 40g and uniform cross-sectional area of 2cm² floats upright in water. The length of the wood immersed is A. 80cm B. 40cm C. 20cm D. 2cm **(1989:Q12)**
- 40cm³ of liquid is mixed with 60m³ of another liquid Q. If the density of P and Q are 1.00kgm⁻³ and 1.6kgm⁻³ respectively, what is the density of the mixture? A. 0.05 kgm⁻³ B. 1.25kgm⁻³ C. 1.30kgm⁻³ D. 1.36kgm⁻³ **(1990:Q14)**
- The mass of a stone is 15.0g when completely immersed in water and 10.0g when completely immersed in a liquid of relative density 2.0. The mass of the stone in air is A. 5.0g B. 12.0g C. 20.0g D. 25.0g **(1991:Q12)**
- If a plastic sphere floats in water (density = 1000kgm⁻³) with 0.5 of its volume submerged and floats in oil with 0.4 volume submerged, the density of the oil is A. 800kgm⁻³ B. 1 200kgm⁻³ C. 1 250kgm⁻³ D. 2 000kgm⁻³ **(1992:Q12)**
- An object of mass 400g and density 600kgm⁻³ is suspended with a string so that half of it is immersed in paraffin of density 900kgm⁻³. The tension in the string is A. 1.0 N B. 3.0 N C. 4.0 N D. 5.0 N **(1993:Q13)**
- The mass of a specific gravity bottle is 15.2g when it is empty. It is 24.8g when filled with kerosene and 27.2g when filled with distilled water. Calculate the relative density of kerosene. A. 1.25 B. 1.10 C. 0.90 D. 0.80 **(1994:Q18)**
- If a solid X floats in liquid P of relative density 2.0 and in liquid Q of relative density 1.5, it can be inferred that the

- A. Weight of P displaced is greater than that of Q
 B. Weight of P displaced is less than that of Q
 C. Volume of P displaced is greater than that of Q
 D. Volume of P displaced is less than that of Q. (1994:Q19)
25. A piece of wood floats inside water at room temperature with a fraction of it above the liquid surface. As the temperature of the water is raised, the part of the wood above the density of liquid will
 A. Decrease because the density of water decreases with temperature.
 B. Increase because the density of water decreases with temperature.
 C. Decrease because the density of water increases with temperature.
 D. Increase because the density of water increases with temperature (1995:Q20)
26. A cube of sides 0.1 m hangs freely from a string. What is the up thrust on the cube when totally immersed in water?
 A. 1000N B. 700N C. 110N D. 10N [Density of water is 1000 kgm^{-3} , $g = 10 \text{ ms}^{-2}$] (1997:Q16)
27. An empty 60 litre petrol tank has a mass of 10kg. Its mass when full of fuel of relative density 0.72 is
 A. 7.2 k B. 33.2kg C. 43.2 k D. 53.2kg (1997:Q19)
28. A solid of weight 0.600N is totally immersed in oil and water respectively. If the upthrust in oil is 0.210N and the relative density of oil is 0.875 find the upthrust in water.
 A. 0.600N B. 0.360N C. 0.240N D. 0.180N (1998:Q16)
29. A solid weighs 10.0N in air, 6.0 N when fully immersed in water and 7.0 N when fully immersed in a certain liquid X. Calculate the relative density of the liquid.
 A. $\frac{5}{3}$ B. $\frac{4}{3}$ C. $\frac{3}{4}$ D. $\frac{7}{10}$ (1999:Q15)
30. When a ship sails from salt water into fresh water, the fraction of its volume above the water surface will
 A. Remain the same B. Increase C. Decrease D. Increase then decrease. (2000:Q4)
31. If a spherical metal bob of radius 3cm is fully immersed in a cylinder containing water and the water level rises by 1cm, what is the radius of the cylinder?
 A. 12cm B. 1cm C. 3cm D. 6cm (2001:Q5)
32. A copper cube weighs 0.25N in air, 0.17N when completely immersed in paraffin oil and 0.15N when completely immersed in water. The ratio of upthrust in oil to upthrust in water is
 A. 4:5 B. 3:5 C. 13:10 D. 7:10 (2002:Q10)
33. A test tube of radius 1.0cm is loaded to 8.8g. If it is placed upright in water, find the depth to which it would sink.
 A. 2.8cm B. 5.2cm C. 25.5cm D. 28.0cm [$g = 10 \text{ ms}^{-2}$, density of water = 1000 kgm^{-3}] (2003:Q3)
34. The change in volume when 450kg of ice is completely melted is
 A. 0.05 m^3 B. 0.45 m^3 C. 4.50 m^3 D. 0.50 m^3 . [density of ice = 900 kgm^{-3} density of water = 1000 kgm^{-3}] (2004:Q34)
35. A 3 m^3 volume of liquid W of density 200 kgm^{-3} is mixed with another liquid L of volume 7 m^3 and density 150 kgm^{-3} . The density of the mixture is
 A. 265 kgm^{-3} B. 165 kgm^{-3} C. 100 kgm^{-3} D. 350 kgm^{-3} . (2005:Q46)
36. A body of mass 36 kg falls through a viscous liquid which offers a drag force of 260 N on the body. The upthrust on the body at terminal velocity is
 A. 310 N B. 50 N C. 620 N D. 100 N. [$g = 10 \text{ ms}^{-2}$] (2005:Q49)
37. If the relative density of gold is 19.2 the volume of 2.4kg of gold is
 A. $1.92 \times 10^{-4} \text{ m}^3$ B. $4.61 \times 10^{-3} \text{ m}^3$ C. $8.00 \times 10^{-3} \text{ m}^3$ D. $1.25 \times 10^{-4} \text{ m}^3$. (2006:Q41)
38. A uniform solid cube material 10 cm on each side of mass 700 g is submerged in water. Which of the following best describes the behaviour of the cube in water?
 A. The cube will rest at an equilibrium position in water
 B. The cube will melt after a period of time
 C. The cube will sink in water
 D. The cube will float (2006:Q46)
39. A piece of iron weighs 250 N in air and 200 N in a liquid of density 1000 kgm^{-3} . The volume of the iron is
 A. $2.0 \times 10^{-3} \text{ m}^3$ B. $2.5 \times 10^{-3} \text{ m}^3$ C. $4.5 \times 10^{-3} \text{ m}^3$ D. $5.0 \times 10^{-3} \text{ m}^3$. (2007:Q34)
40. An empty density bottle weighs 2 N. If it weighs 5 N when filled with water and 4 N when filled with olive oil, the relative density of olive oil is
 A. $\frac{1}{3}$ B. $\frac{2}{3}$ C. $\frac{1}{5}$ D. $\frac{2}{5}$ (2008:Q18)
41. A plastic sphere floats in water with 50% of its volume submerged. If it floats in glycerine with 40% of its volume submerged, the density of the glycerine is
 A. 1400 kgm^{-3} B. 1250 kgm^{-3} C. 500 kgm^{-3} D. 1000 kgm^{-3} . [density of water = 1000 kgm^{-3}] (2009:Q17)
42. The accurate measurement of the relative density of a substance in its powdered form is done with a beam balance and
 A. an eureka can B. a burette C. a pipette D. a density bottle. (2010:Q13)
43. A hydrometer is an instrument used in measuring
 A. density of liquid B. relative density of a liquid C. relative humidity of a liquid D. vapour pressure of a fluid. (2010:Q14)
44. The density of a certain oil on frying becomes 0.4 kgm^{-3} with a volume of 20 m^3 . What will be its initial volume when its initial density is 0.8 kgm^{-3} assuming no loss of oil due to spillage?
 A. 10 kgm^{-3} B. 5 kgm^{-3} C. 8 kgm^{-3} D. 12 kgm^{-3} (2010:Q17)
45. An object weighs 22kg in water and 30kg in air. What is the upthrust exerted by the liquid on the object?
 A. 220 N B. 80 N C. 50 N D. 520 N [$g = 10 \text{ ms}^{-2}$] (2011:Q15)
46. An object of volume 1 m^3 and mass 2kg is totally immersed in a liquid of density 1 kgm^{-3} . Calculate its apparent weight.
 A. 20 N B. 10 N C. 2 N D. 1 N. [$g = 10 \text{ ms}^{-2}$] (2012:Q16)
47. A balloon whose volume is 300 m^3 is filled with hydrogen. If the density of air is 1.3 kgm^{-3} , find the upthrust on the balloon.
 A. 3000N B. 3800N C. 3900N D. 4200N. [$g = 10 \text{ ms}^{-2}$] (2012:Q18)
48. A piece of cork floats in a liquid. What fraction of its volume will be immersed in the liquid?
 A. 0.8 B. 0.5 C. 0.2 D. 0.1. [density of the cork = $0.25 \times 10^3 \text{ kgm}^{-3}$, density of the liquid = $1.25 \times 10^3 \text{ kgm}^{-3}$] (2013:Q8)
49. What volume of alcohol will have same mass as 4.2 m^3 of petrol?
 A. 0.8 m^3 B. 1.4 m^3 C. 3.6 m^3 D. 4.9 m^3 . [density of alcohol = $8.4 \times 10^2 \text{ kgm}^{-3}$, density of petrol = $7.2 \times 10^2 \text{ kgm}^{-3}$] (2013:Q15)
50. The relative densities of zinc, brass, copper, gold and silver are respectively 7.1, 8.5, 8.9, 19.3, 10.5. A metal ornament which weighs 0.425kg and can displace $50 \times 10^{-6} \text{ m}^3$ of water is made of
 A. zinc B. brass C. copper D. gold E. silver (1980:Q30)
51. A piece of cork floats in water because
 A. the upthrust on it when completely immersed in water is greater than its weight in air
 B. the surface of the water acts like an elastic skin
 C. the upthrust on it when completely immersed in water is equal to its weight in air
 D. there is no upthrust on it when it is completely immersed in water (2015:Q13)
52. An empty relative density bottle has a mass of 30g. When filled with paraffin, its mass is 70g. Calculate the mass of the bottle when it is filled with water. [Relative density of paraffin = 0.8]
 A. 40g B. 20g C. 60g D. 80g. (2015:Q27)
53. A solid weighs 45N and 15N respectively in air and water. Determine the relative density of the solid.
 A. 0.33 B. 0.50 C. 1.50 D. 3.00 (2018: Q8)

CHAPTER 11

DENSITY AND UPTHRUST, ARCHIMEDES PRINCIPLE.
PRINCIPLE OF FLOATATION UPTHRUST

1E. Density = $\frac{\text{mass}}{\text{volume}}$; $\rho = \frac{m}{V}$ in kgm^{-3}

NOTE: option (A) defines relative density

r.d. = $\frac{\text{mass of given volume of solid}}{\text{mass of equal volume of water}}$

= $\frac{\text{weight of given volume of solid}}{\text{weight of equal volume of water}}$

r.d. has no unit as a ratio of two masses or weights

2C. The apparent weight loss is due to the upthrust (U) of water on the solid which apparently reduces the weight (W) of the solid to the tension (T) recorded in the rope when the solid is under water: $U = W - T$

NOTE: Upthrust is also equal to the weight of the water displaced by the immersed solid.

3B. $m = \rho \times v$ and since mass does not change:

$\rho_1 \times v_1 = \rho_2 \times v_2 \rightarrow 0.9 \times 400 = 0.6 \times v_2 \rightarrow v_2 = 600\text{cm}^3$

NOTES:

1. The method above circumvents finding the mass of the palm oil

2. For the consistency of the parameters involved:

a. $m(\text{kg}), v(\text{m}^3)$ and $\rho(\text{kgm}^{-3})$

b. $m(\text{g}), v(\text{cm}^3)$ and $\rho(\text{gcm}^{-3})$

3. $1\text{gcm}^{-3} = \frac{1\text{g}}{1\text{cm}^3} = \frac{1 \times 10^{-3}\text{kg}}{1\text{cm} \times 1\text{cm} \times 1\text{cm}}$

= $\frac{1 \times 10^{-3}\text{kg}}{\frac{1}{100}\text{m} \times \frac{1}{100}\text{m} \times \frac{1}{100}\text{m}} = \frac{1 \times 10^{-3}\text{kg}}{10^{-6}\text{m}^3} = 1000\text{kgm}^{-3}$

$\therefore 5\text{gcm}^{-3} = 5000\text{kgm}^{-3}$ e.t.c

4C. Volume of liquid displaced = V; Density of liquid = ρ
 \therefore mass of liquid displaced = ρv also weight of liquid displaced = $\rho v g$
But upthrust = weight of liquid displaced $\therefore U = \rho v g$
also $U = W - T$ (See Q2) $\therefore \rho v g = mg - T$

$\therefore T = mg - \rho v g = (m - \rho v)g$

5B. Weight of solid = 48N Weight of solid in water = 28N

Weight of water displaced = upthrust = weight loss

Weight of water displaced = 48 - 28 = 20N

But volume of water displaced = volume of solid immersed

and $r.d. = \frac{\text{weight of solid}}{\text{weight of equal volume of displaced water}} = \frac{48}{20} = 2.4$

also weight of water displaced = 20N

weight of kerosine displaced = 48 - 32 = 16N

\therefore r.d of kerosine = $\frac{\text{weight of kerosine displaced}}{\text{weight of equal volume of water}} = \frac{16}{20} = 0.8$

$\therefore \frac{\text{Density of solid}}{\text{Density of kerosine}} = \frac{2.4}{0.8} = 3$

NOTE

1. For a solid of mass m in air and n in water r.d of solid = $\frac{m}{m - n}$

2. If the above solid has mass p in another liquid r.d of liquid = $\frac{m - p}{m - n}$

3. In this question r.d of solid = $\frac{4.8}{4.8 - 2.8} = 2.4$ (as before)

r.d of kerosine = $\frac{4.8 - 7.2}{4.8 - 2.8} = 1.6$ (as before)

6D. Mass of empty bottle = m_1
mass of bottle + sand = m_2
Mass of bottle + sand + water = m_3
Mass of bottle + water = m_4
Mass of sand only = $m_2 - m_1$
Mass of water only (when filled with sand) = $m_3 - m_2$

Mass of water only (in the absence of sand) = $m_4 - m_1$
Mass of water of equal volume of sand = $(m_4 - m_1) - (m_2 - m_1)$

r.d of sand = $\frac{\text{mass of sand}}{\text{mass equal volume of water}}$

= $\frac{m_2 - m_1}{(m_4 - m_1) - (m_2 - m_1)}$

7. No option is right

1. The upthrust on a floating objects is equal to its own weight

2. A body floats on a liquid if its relative density is less than the density of the fluid.

3. Ships that float on water despite their higher density do so because they are specially constructed to displace amount of water equal to their own weights.

8B. The denser the liquid, the lesser the hydrometer sinks in it and the lesser the volume displaced.

NOTES:

1. The hydrometer is calibrated in such a way that the lowest values are above and highest values are below

2. The calibration is non-linear

9C. $V = 20\text{cm}^3$ $\rho = 19\text{gcm}^{-3}$

Mass of the metal in air = $p v = 20 \times 19 = 380\text{g}$

But r.d = $\frac{m}{m - n}$ (See Q5) $\therefore 1\text{g} = \frac{380}{380 - n}$ $n = 360\text{g}$

NOTE:

1. Density of a substance is its r.d expressed in gcm^{-3} e.g: 19 $\rightarrow 19\text{gcm}^{-3} \rightarrow 19000\text{kgm}^{-3}$

2. Alternatively, the above can be worked out as follows:

mass of metal in air = $19 \times 20 = 380\text{g}$

volume of water displaced = 20cm^3

density of water = 1gcm^{-3}

\therefore mass of water displaced = $20 \times 1 = 20\text{g}$

But $T = W - U$ $T = 380 - 20 = 360\text{g}$

The masses are deliberately not converted to weights to save time.

10C. ...and their difference is zero i.e the tension in a rope attached to the wood is zero $T = W - U = 0$

11B. $V = \frac{m}{\rho} = \frac{5 \times 10^{-4}}{500} = 10^{-6}\text{m}^3$

Volume of 1 drop = $\frac{10^{-6}}{1000} = 10^{-9}\text{m}^3$

But volume = Area x thickness $\rightarrow 10^9 = 0.5t$; $t = 2 \times 10^9\text{m}$

12B. $m_{\text{alcohol}} = m_{\text{petrol}}$ $\therefore \rho_{\text{ak}} \times v_{\text{ak}} = \rho_{\text{pa}} \times v_{\text{pa}}$
 $8.4 \times 10^2 \times v = 7.2 \times 10^2 \times 4.2$ $v = 3.6\text{m}^3$

13A. Volume of water displaced = volume of cube = 10^3mm^3
But this is the volume of the cylindrical section of the risen water

\therefore Area x height = volume $1.5 \times 10^2 h = 10^3 h = 6.67\text{m}$

14A. A floating body displaces its own weight of the liquid in which it floats

\therefore mass of block = mass of water = mass of liquid
Let the fraction of the volume of block in liquid = x

$\therefore \frac{2}{3} V \times 1 = xV \times 0.8 \times 2V = 2.4xV$

$\therefore x = \frac{2V}{2.4V} = \frac{2}{2.4} = \frac{20}{24}$ $x = \frac{5}{6}$

\therefore Fraction of volume/height above water = $\frac{1}{6}$

15C. Archimedes principle

16C. Volume of cube = 10^3 and mass = 500g

Volume of liquid displaced = $\frac{4}{5} \times 10^3 = 800\text{cm}^3$

Mass of liquid displaced = mass of cube = 500g

Density of liquid = $\frac{500}{800} = 0.625\text{gcm}^{-3}$

hence relative density = 0.625

17B. Mass of liquid displaced = mass of object = 2kg
Volume of liquid displaced = 500cm³

$$\therefore \text{density of liquid} = \frac{2}{500 \times 10^{-6}} = 4000 \text{kgm}^{-3}$$

NOTE:

$$1\text{cm}^3 = 1\text{cm} \times 1\text{cm} \times 1\text{cm} = \frac{1}{100}\text{m} \times \frac{1}{100}\text{m} \times \frac{1}{100}\text{m} = 10^{-6}\text{m}^3$$

18C. Let the length = L

$$\therefore \text{Volume of water displaced} = AL = 2L$$

$$\text{Mass of water displaced} = 40\text{g}$$

$$\text{But density of water} = 1\text{gcm}^{-3} \text{ and}$$

$$v = \frac{m}{\rho} \rightarrow 2L = \frac{40}{1} \rightarrow L = 20\text{cm}$$

19D. $m_p = 1 \times 40 = 40\text{kg} \rightarrow m_o = 1.6 \times 60 = 96\text{kg}$

$$\text{Total mass of mixture} = 136\text{kg}$$

$$\text{Total volume of mixture} = 100\text{m}^3$$

$$\therefore \text{Density of mixture} = \frac{136}{100} = 1.36\text{kgm}^{-3}$$

20C. r.d of liquid = $\frac{m-p}{m-n}$ (Q5) $\therefore 2 = \frac{m-10}{m-15}$ $m = 20\text{g}$

21C. Since the sphere floats in both liquids, it displaces amount of liquid equal to its own mass in each case

$$\therefore \text{mass of oil displaced} = \text{mass of water displaced}$$

$$\rho \times 0.4v = 1000 \times 0.5v \rightarrow \rho = 1250\text{kgm}^{-3}$$

22A. Volume of object = $\frac{0.4}{600} = 6.67 \times 10^{-4}\text{m}^3$

$$\text{Volume submerged} = \frac{1}{2} \times 6.67 \times 10^{-4} = 3.33 \times 10^{-4}\text{m}^3$$

$$\therefore \text{Volume of paraffin displaced} = 3.33 \times 10^{-4}\text{m}^3$$

$$\text{Mass of paraffin displaced} = 900 \times 3.33 \times 10^{-4} = 0.3\text{kg}$$

$$\text{Weight of paraffin displaced} = 3\text{N} \therefore \text{Upthrust } U = 3\text{N}$$

$$\text{But } T = W - U \text{ (See Q2)} \quad T = (0.4 \times 10) - (3) = 1\text{N}$$

NOTE: Do not confuse upthrust with the tension in the string

$$U = \text{Apparent weight loss} = 3\text{N}$$

$$T = \text{Apparent weight} = 1\text{N} \quad W = \text{Real weight} = 4\text{N}$$

23D. Since same bottle is used, volume of water and kerosine

$$\text{are the same r.d of kerosine} = \frac{\text{mass of kerosine}}{\text{mass equal volume of water}}$$

$$\text{r.d} = \frac{24.8 - 15.2}{27.2 - 15.2} = \frac{9.6}{12} = 0.8$$

24D. Weight displaced or upthrust are the same in both cases or $m_p = m_o$ or $\rho_p \times v_p = \rho_o \times v_o \rightarrow 2v_p = 1.5v_o$

$$\rightarrow \frac{v_p}{v_o} = \frac{1.5}{2.0} \rightarrow \therefore v_p < v_o$$

25A. This is consistent with the working of a hydrometer in Q8
Water when heated between 4°C to 100°C, expands like any other liquid hence its density reduces since

$$\rho = \frac{m}{v} \left(\rho \propto \frac{1}{v} \right)$$

The lesser the density, the more the would sinks hence fraction above the liquid surface decreases.

26D. Volume of cube = $0.1 \times 0.1 \times 0.1 = 0.001\text{m}^3$

$$\text{Volume of water displaced} = 0.001\text{m}^3$$

$$\text{Mass of water displaced} = 1000 \times 0.001 = 1\text{kg}$$

$$\text{Weight of water displaced} = 10\text{N} \therefore \text{upthrust} = 10\text{N}$$

27D. Volume of tank = 60litre = $60 \times 10^{-3}\text{m}^3$

$$\text{Volume of fuel} = 60 \times 10^{-3}\text{m}^3$$

$$\text{Density of fuel} = 720\text{kgm}^{-3}$$

$$\therefore \text{mass of fuel} = 720 \times 60 \times 10^{-3} = 43.2\text{kg}$$

$$\text{Total mass of tank and fuel} = 10 + 43.2 = 53.2\text{kg}$$

NOTE: 1litre = $1000\text{cm}^3 = \frac{1000}{10^6}\text{m}^3 \therefore 1\text{litre} = 10^{-3}\text{m}^3$

28C. Upthrust = weight of oil displaced = 0.210N

$$\therefore \text{Mass of oil displaced} = 0.021\text{kg}$$

$$\text{Density of oil} = 875\text{kgm}^{-3}$$

$$\therefore \text{Volume of oil displaced} = \frac{0.021}{875} = 0.000024\text{m}^3$$

This is the volume of the solid immersed.

$$\text{Hence volume of water displaced} = 2.4 \times 10^{-4}\text{m}^3$$

$$\therefore \text{mass of water displaced} = 1000 \times 2.4 \times 10^{-4} = 0.24\text{kg}$$

$$\text{Weight of water displaced} = 0.24\text{N}$$

NOTES:

1. The above steps are necessary only for academic or didactic reasons

2. Next time, you remember that:

$$\text{r.d of liquid} = \frac{\text{Upthrust in liquid}}{\text{Upthrust in water}} \rightarrow 0.875 = \frac{0.210}{U_{\text{water}}}$$

$$U_{\text{water}} = \frac{0.210}{0.875} = 0.24\text{N}$$

This is when you immerse the same solid in the liquid in turn and one of the liquids must be water whose relative density is 1. Also the mass or weight of the solid does not come into reckoning here.

29C. $\text{r.d}_x = \frac{\text{Upthrust in X}}{\text{Upthrust in water}} = \frac{10 - 7}{10 - 6} = \frac{3}{4}$

30C. Seawater is about 3.5% denser than fresh water hence the floating ship sinks further in fresh water thereby reducing the fraction above the surface.

31D. Volume of cylinder = volume of sphere: $\pi r_1^2 h = \frac{4}{3}\pi r_2^3$

$$r_1^2 h = \frac{4r_2^3}{3} \rightarrow r^2 \times 1 = \frac{4 \times 3 \times 3 \times 3}{3} \rightarrow r = \sqrt{36} = 6\text{cm}$$

32A. $\frac{\text{Upthrust in oil}}{\text{Upthrust in water}} = \frac{0.25 - 0.17}{0.25 - 0.15} = \frac{0.08}{0.10} = \frac{8}{10} = \frac{4}{5}$

33A. Mass of water displaced = 8.8g

$$\therefore \text{Volume of water displaced} = 8.8\text{cm}^3$$

The test tube is more or less a cylinder

$$\therefore \pi r^2 h = 8.8 \frac{22}{7} \times 12 \times h = 8.8 \Rightarrow h = 2.8\text{cm}$$

34A. The mass remains unaltered volume of ice = $\frac{450}{900} = 0.5\text{m}^3$

$$\text{Volume of water} = \frac{450}{1000} = 0.45\text{m}^3$$

$$\Delta \text{volume} = 0.5 - 0.45 = 0.05\text{m}^3$$

35B. Mass of W = $200 \times 3 = 600\text{kg}$

$$\text{Mass of L} = 150 \times 7 = 1050\text{kg}$$

$$\text{Total mass of mixture} = 1650\text{kg}$$

$$\text{Total volume of mixture} = 3 + 7 = 10\text{m}^3$$

$$\text{Density of mixture} = \frac{1650}{10} = 165\text{kgm}^{-3}$$

36D. $W - V - U = ma$

Where W = weight of body acting downwards

V = Viscous drag acting upwards

U = Upthrust acting downward

At terminal velocity, speed is constant hence $a = 0$

$$\therefore U = W - V = (36 \times 10) - 260 = 100\text{N}$$

37D. Density of gold = 19200kgm⁻³

$$\therefore \text{Volume of gold} = \frac{2.4}{19200} = 1.25 \times 10^{-4}\text{m}^3$$

38D. Volume of cube = $10 \times 10 \times 10 = 1000\text{cm}^3$

$$\text{Density of cube} = \frac{700}{1000} = 0.7\text{gcm}^{-3}$$

This is less than the density of water (1gcm⁻³), hence it floats

39D. Upthrust = 250 - 200 = 50N \therefore mass of liquid displaced = 5kg

$$\therefore \text{volume of liquid displaced} = \frac{5}{1000} = 0.005\text{m}^3$$

This is the volume of the iron which causes the displacement

40B. $\text{r.d} = \frac{4 - 2}{5 - 2} = \frac{2}{3}$

41B. In each case, mass of liquid displaced is the same and it has mass equal to the mass of the plastic sphere

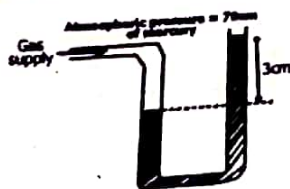
$$\therefore \rho_p \times v_p = \rho_w \times v_w \rightarrow \rho \times \frac{40v}{100} = 1000 \times \frac{50v}{100}$$

Where v = volume of sphere itself $\rho = 1250\text{kgm}^{-3}$

- 42D. See Q6
- 43B. Relative density not density, please
- 44A. Mass before frying = mass after frying $\rightarrow 0.8 \times v = 0.4 \times 20 \text{ V} = 10\text{m}^3$
- 45B. Mass of water displaced = $30 - 22 = 8\text{kg}$
 \therefore upthrust = $8 \times 10 = 80\text{N}$
- 46B. Volume displaced = volume of object = 1m^3
 \therefore mass of liquid displaced = $1 \times 1 = 1\text{kg}$
 \therefore upthrust on object = $1 \times 10 = 10\text{N}$
 This is apparent weight loss
 \therefore Apparent weight = $W - U = (2 \times 10) - 10 = 10\text{N}$
- 47C. Volume of air displaced = 300m^3
 \therefore mass of air displaced = $1.3 \times 300 = 390\text{kg}$
 \therefore upthrust = $390 \times 10 = 3900\text{N}$
48. Let the fraction = x
 Mass of liquid displaced $\rho x v = 1250xv$
 Mass of cork itself = $250v$
 But a body floats when mass of liquid displaced = mass of body itself $\therefore 1250xv = 250v \quad x = \frac{250v}{1250v} = 0.2$
- 49C. $\rho_{\text{ak}} \times v_{\text{ak}} = \rho_{\text{pet}} \times p_{\text{pet}} \rightarrow 8.4 \times 10^2 \times v = 7.2 \times 10^2 \times 4.2$
 $v = 3.6$
51. Density of ornament = $\frac{0.425}{50 \times 10^{-5}} = 8500\text{kgm}^{-3}$
 \therefore Relative Density = $\frac{8500}{1000} = 8.5$
 It is a brass ornament
- 52D. r.d. of paraffin = $\frac{\text{Mass of Paraffin}}{\text{Mass of equal volume of Water}}$
 $\rightarrow 0.8 = \frac{70 - 30}{x - 30}$ and $x = 80\text{g}$
- 53C. r.d. = $\frac{\text{weight in air}}{\text{upthrust in water}} = \frac{45}{45 - 15} = \frac{45}{30} = 1.50$

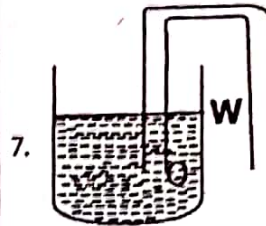
CHAPTER 12: PRESSURE. PASCAL'S PRINCIPLE

1. Which of the following statements is correct? The reading of pressure on a mercury barometer is independent of A. the cross-sectional area of the tube B. the atmospheric pressure C. the density of mercury D. the temperature of mercury E. the acceleration due to gravity. (1979:Q22)
2. The principle of the transmissibility of pressure in a fluid at rest in all directions is known as A. Archimedes Principle B. Flotation Principle C. Newton's Law D. Pascal's Law E. Boyle's Law (1981:Q5)
3. The hatch door of a submarine has an area of 0.5m^2 . The specific gravity of sea water is 1.03. Assume that $g = 10\text{ms}^{-2}$, and neglect the atmospheric pressure. The force exerted by the sea water on the hatch door at a depth of 200m is A. $1.0^3 \times 10^5 \text{N}$ B. $1.0^3 \times 10^4 \text{Nm}^2$ C. $1.0^4 \times 10^5 \text{Nm}^2$ D. $2.0^4 \times 10^4 \text{N}$ E. $1.0^3 \times 10^3 \text{N}$ (1982:Q1)

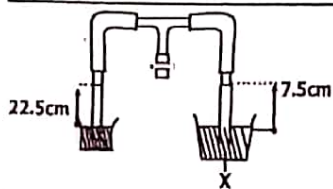


4. The water manometer in the figure is measuring the pressure of the gas supply. If the specific gravity of mercury is 13.6 and the atmospheric pressure is 70cm of mercury, what is the total pressure of the gas supply in cm of water? A. 67cm B. 73cm C. 949cm D. 952cm E. 955cm (1982:Q21)
5. Which of the following statements about liquid pressure is NOT correct? The pressure A. At a point in a liquid is proportional to the depth. B. At any point in a liquid is the same at the same level. C. Is exerted equally in all directions at any point. D. Of a liquid at any point on the wall of its container acts in a direction perpendicular to the wall. E. At a particular depth depends on the shape of the vessel (1983:Q9)
6. If the normal atmospheric pressure in a laboratory supports a column of mercury 0.76m high and the relative density of mercury is 13.8, then the height of water column which

atmospheric pressure will support in the same laboratory at the same time is A. 0 m B. 10 m C. 13 m D. 14 m E. 18 m. (1983:Q37)

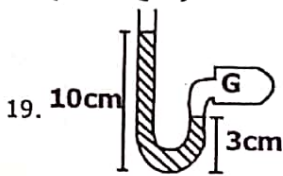


7. The figure above shows an inverted U-tube with the open end, O of one limb below the level, W, of the water in a tank. In order that water should begin to flow from the tank it is necessary that A. The U-tube is completely filled with water and P should be higher than W. B. P should be lower than O and W C. P should be lower than W and O should reach to the bottom of the vessel. D. The U-tube is completely filled with water and P should be lower than W. E. The U-tube is completely filled with water and O should reach the bottom of the vessel (1983:Q50)
8. Normal atmospheric pressure at sea-level is 105Nm^{-2} and the acceleration due to gravity is approximately 10ms^{-2} . If the atmosphere has a uniform density of 1kgm^{-3} , its height is A. 100 m B. 1000 m C. 10 000 m D. 100 000 m E. 1000000 m (1984:Q37)
9. Two divers G and H are at depths 20m and 40m respectively below the water surface in a lake. The pressure on G is P_1 while the pressure on H is P_2 . If the atmospheric pressure is equivalent to 10m of water, then the value of P_2/P_1 is A. 0.50 B. 0.60 C. 1.67 D. 2.00 E. 3.00 (1985:Q14)
10. The areas of the effort and load pistons of a hydraulic press are 0.5m^2 and 5m^2 respectively. If a force F of 100N is applied on the effort piston, the force F on the load is A. 10 N B. 100 N C. 500 N D. 1 000 N E. 5 000 N (1985:Q15)
11. A 1 000kg elevator is descending vertically with an acceleration of 1.0ms^{-2} , if the acceleration due to gravity is 10.0ms^{-2} , the tension in the suspending cable is A. 1.0 N B. 10.0 N C. 9 000.0 N D. 11 000.0 N (1986:Q15)
12. When one arm of a U-tube manometer is connected to a gas supply, the levels of mercury in the two arms of the U-tube are as shown in the diagram above. If the atmospheric pressure is 76.0cm Hg, the gas pressure is A. 62.6cmHg B. 72.5cmHg C. 79.5cmHg D. 85.9cm hg (1988:Q15)
13. Which of the following devices are used to measure pressure? I. Aneroid barometer II. Hydrometer III. Hygrometer IV. Manometer. A. I and III B. II and III C. III and IV D. I and IV. (1989:Q11)
14. What is the length of the liquid column in a barometer tube that would support an atmospheric pressure of $102\ 000\text{Nm}^{-2}$ if the density of the liquid is $2\ 600\text{kgm}^{-3}$? [$g = 10\text{ms}^{-2}$]. A. 0.75m B. 0.76m C. 3.92m D. 39.23m. (1990:Q13)
15. Which of the following is the most suitable for use as an altimeter? A. A mercury barometer B. A fortin barometer C. A mercury manometer D. An aneroid barometer. (1991:Q1)
16. A pilot records the atmospheric pressure outside his plane as 63cm of Hg while a ground observer records a reading of 75cm of Hg for the atmospheric pressure on the ground. Assuming that the density of the atmosphere is constant, calculate the height of the plane above the ground. (Relative density of Hg = 13.0 and that of air = 0.00013) A. 1 200 m B. 6 300 m C. 7 500 m D. 13800 m (1991:Q13)
17. The figure below shows the height of two liquids X and Y when some air is sucked out of the apparatus through



the pump P. the diameter of the tube in X is twice that of the Y. What is the relative density of the liquid X with respect to liquid Y? A. 1/3 B. 2/3 C. 3 D. 6 (1992:Q11)

18. A weightless vessel of dimensions 4m x 3m x 2m is filled with a liquid of density 1 000 kgm⁻³ and sealed. What is the maximum pressure this contain can exert on a flat surface? [g = 10ms⁻²] A. 9 x 10⁴Nm⁻² B. 4 x 10⁴Nm⁻² C. 3 x 10⁴Nm⁻² D. 2 x 10⁴Nm⁻² (1993:Q10)



In the diagram above, if the atmospheric pressure is 760mm, the pressure in the chamber G is A. 660mm B. 690mm C. 830mm D. 860mm (1994:Q15)

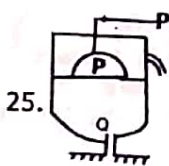
20. Which of these statements are TRUE of pressure in liquids? I. Pressure acts equally in all directions. II. Pressure decreases with depth. III. Pressure at the same level of a liquid is the same. IV. Pressure is dependent on the cross-sectional area of the barometer tube. A. I and III only. B. I, II and III only. C. I, II and IV only. D. I, II, III and IV. (1994:Q17)

21. A hydraulic press has a large circular piston of radius 0.8m and a circular plunger of radius 0.2m. A force of 500N is exerted by the plunger. Find the force exerted on the piston. A. 8 000 N B. 4 000 N C. 2 000 N D. 31 N (1995:Q16)

22. A liquid of mass 1.0 x 10³ kg fills rectangular tank of length 2.5 m and width 2.0 m. If the tank is 4 m high, what is the pressure at the middle of the tank? A. 1.0 x 10⁴Nm⁻² B. 2.0 x 10³Nm⁻² C. 1.5 x 10³Nm⁻² D. 1.0 x 10³Nm⁻² (g = 10m/s²) (1997:Q18)

23. Which of these statements are correct for the pressures in liquids? I Pressure in a liquid at a point acts equally in all directions II Pressure increases with depth III Pressure at a depth depends on the shape of the container. IV Pressures at the same depth in different liquids are proportional to the densities of the liquids. A. I, II and III only B. I, II and IV only C. I, III and IV only D. II, III and IV only. (1998:Q14)

24. The atmospheric pressure due to water is 1.3 x 10⁶Nm⁻². What is the total pressure at the bottom of an ocean 10m deep? A. 1.3x 10⁷Nm⁻² B. 1.4x 10⁶Nm⁻² C. 1.4x 10⁵Nm⁻² D. 1.0 x 10⁵Nm⁻² Density of water = 1000kgm³ [g=10ms⁻²] (1998:Q15)



The diagram above shows a lift pump with valves at P and Q during a downward stroke of the piston, A. Both valves are open B. P is open while Q is closed C. P is closed while Q is open D. Both valves are closed. (1999:Q12)

26. At a fixed point below liquid surface, the pressure downward is P₁ and the pressure upward is P₂. It can be deduced that A. P₁ = P₂ B. P₁ > P₂ C. P₁ < P₂ D. P₁ > P₂ (2000:Q6)

27. The height at which the atmosphere ceases to exist is about 80km. If the atmospheric pressure on the ground level is 760 mmHg, the pressure at a height of 20km above the ground level is A. 380 mmHg B. 580mmHg C. 190mmHg D. 480mmHg (2001:Q2)

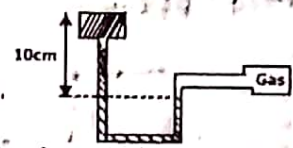
28. The hydrostatic blood pressure difference between the head and feet of a boy standing straight is 1.65 x 10⁴Nm⁻². Find the height of the boy. A. 0.6m B. 0.5m C. 2.0m D. 1.5m Density of blood 1.1 x 10³kgm³ [g = 10ms⁻²] (2002:Q8)

29. The stylus of a phonograph record exerts a force of 7.7 x 10⁻²N on a groove of radius 10⁻⁵m. Compute the pressure exerted by the stylus on the groove. A. 2.45 x 10⁴Nm⁻² B. 3.45 x 10⁴Nm⁻² C. 4.90 x 10⁴Nm⁻² D. 2.42 x 10⁴Nm⁻² (2003:Q9)

30. In a hydraulic press, a force of 40N is applied on the effort piston of area 0.4m². If the force exerted on the load piston is

400N, the area of the large piston is A. 8m². B. 4m². C. 2m². D. 1m². (2004:Q15)

31. Two liquids L₁ and L₂ are contained in a U-tube. The height and the density of L₁ are 8cm and 10₃kgm⁻³ respectively. If the density of L₂ is 800kgm⁻³, its height measured from the same level is A. 8cm. B. 16cm. C. 12cm. D. 10cm. (2005:Q40)



In the diagram above, the pressure of the gas is A. 96cm of mercury. B. 86cm of mercury. C. 66cm of mercury. D. 76cm of m (2006:Q50)

33. A reservoir 500 m deep is filled with a fluid of density 850 kgm⁻³. If the atmospheric pressure is 1.05 x 10⁵Nm⁻², the pressure at the bottom of the reservoir is A. 4.46 x 10⁴Nm⁻² B. 4.25 x 10⁶ Nm⁻² C. 4.72 x 10⁶ Nm⁻² D. 4.28 x 10⁴Nm⁻² [g=10ms⁻²] (2007:Q38)

34. In the Hare's apparatus, water rises to a height of 26.5cm in one limb. If a liquid rises to a height of 20.4cm in the other limb, what is the relative density of the liquid? A. 0.8 B. 1.1 C. 1.2 D. 1.3 (2008:Q16)

35. When cold water is poured on a can containing hot water, the can collapses because the A. steam condenses and occupies the partial vacuum in the can. B. external air pressure counterbalances the pressure within the can C. steam expands to occupy the vacuum remaining in the can. D. external pressure becomes greater than the pressure within the can. (2008:Q17)

36. I. Density of the liquid II. Acceleration due to gravity III. Type of container of the liquid IV. The constituents of the liquid. Which of the above conditions will NOT affect the pressure of fluids? A. I and III only B. II and III only C. III and IV only D. I and II only (2009:Q14)

37. In a hydraulic press, the pump piston exerts a pressure of 100 Pa on the liquid. What force is exerted in the second piston of cross-sectional area 3m²? A. 200N B. 100N C. 150N D. 300N (2010:Q12)

38. I. Density of the Liquid II. Depth below the surface of the liquid. III. Surface area of the liquid. In which of the statements above will pressure be dependent? A. I, II and III B. I and III only C. I and II only D. II and III only (2011:Q10)

39. The pressure at any point in a liquid at rest depends only on the A. depth and the density B. mass and the volume C. quantity and the surface area D. surface area and the viscosity. (2012:Q17)

40. At what depth below the sea-level would one experience a change of pressure equal to one atmosphere? A. 0.1m. B. 1.0m. C. 10.0m. D. 100.0m. [density of sea water = 1 0³ kgm⁻³ one atmosphere = 0.01 x 10⁵Nm⁻²g = 10ms⁻²] (2013:Q14)

41. Mercury is suitable as a barometer fluid because it A. expands uniformly B. is opaque C. is several times denser than water D. is a good conductor of heat. (1986:Q22)

42. A man exerts a pressure of 2.8 x 10³Nm⁻² on the ground and has 4 x 10⁻²m² of his feet in contact with the ground. The weight of the man is A. 112N B. 140N C. 102N D. 70N (2004:32)

43. Mercury is a better barometric fluid than water because I. It needs no colouring II. Its density many times greater than that of water III. It does not wet glass IV. It has a high vapour pressure V. It has a high boiling point. Which of the above statements are true? A. I and II only B. I, II and III only C. III and IV only D. IV and V only E. III, IV and V only (1978:Q8)

44. Which of the following statements is correct? A. pressure exerted is higher with a narrow heel shoe than a flat heel shoe B. no pressure is exerted in both narrow and

flat heel shoes C. pressure exerted is lower with a narrow heel shoes than a flat heel shoe D. pressure exerted is the same in both narrow and flat heel shoes (2017: Q36)

CHAPTER 12 ANSWER

1A. The pressure is given by $p = h\rho g$ where h = height of mercury column
 ρ = density of mercury g = acceleration due to gravity
 Also, since temperature affects volume (expansion or contraction), it also effect density

2D. It states that the pressure applied to an enclosed fluid is transmitted unaltered throughout the entire fluid and the walls of its container

3A. Pressure due to h column of sea water
 $p = h\rho g = 200 \times 1030 \times 10 = 2060000 \text{ Nm}^{-2}$
 But pressure on hatch door
 $p = \frac{F}{A} \rightarrow \therefore 2060000 = \frac{F}{0.5} \rightarrow F = 1.03 \times 10^6 \text{ Nm}^{-2}$

Option (A) was the closest and note that specific gravity = relative density hence density = $(1.03 \times 1000) \text{ kgm}^{-3}$
 4E. Atmospheric pressure = $h\rho g = 70 \times 13.6 \times 10 = 9520 \text{ Pa}$
 What column of water would this pressure support?
 $H \times 1 \times 10 = 9520 \rightarrow H = 952 \text{ cm}$
 But pressure of the gas = $H + h = 952 + 3 = 955 \text{ cm}$

NOTES

- The need to convert 'cm' to 'm' is not necessary here
- Next time just use the relation $h_1\rho_1g = h_2\rho_2g$
 $h_{\text{water}} \times \rho_{\text{water}} \times g = h_{\text{mercury}} \times \rho_{\text{mercury}} \times g$
 or simply $h_{\text{water}} \times \rho_{\text{water}} = h_{\text{mercury}} \times \rho_{\text{mercury}}$
- The result above shows that the prevailing atmospheric pressure of 9520Pa supports 70cm Hg or 952cmH₂O
- In a manometer, the pressure of a gas is
 - ($H + h$) if the arm exposed to atmosphere is higher than the arm exposed to gas
 - ($H - h$) if the arm exposed to the atmosphere is lower where H is liquid column due to atmospheric pressure and h is the differenc between the two arms
- If vessels of different shapes are linked by a pipe, a liquid poured into the vessels has the same level in them and this follows from the fact that pressure is independent of cross-sectional area (see Q1A) Also remember the saying: "water always finds its own level"
- $h_1\rho_1 = h_2\rho_2 \rightarrow 0.76 \times 13.8 = 1.0 \times \rho_2$ ($\rho_{\text{H}_2\text{O}} = 1 \text{ gcm}^{-3}$)
 $\rho_2 = 10.336$
- This is a siphon and it only works under the following conditions:
 - U-tube is completely filled with the liquid to be siphoned
 - P in the above must be lower than W and the end O just below the level of W .
 - The length of the arm above the water level in the tank must be less than the barometric height of the liquid used e.g water's is $\leq 10.3 \text{ m}$ in a practical siphon.

8C. $h\rho g = P \rightarrow \therefore h \times 1 = 10 = 10^5 \rightarrow h = 10^4 \text{ m}$
 9C. Total pressure on G = $20 + 10 = 30 \text{ m}$
 Total pressure on H = $40 + 10 = 50 \text{ m}$
 But ρ_1 (in Pa) = $30 \times 1 \times 10 = 300$
 Also ρ_2 (in Pa) = $50 \times 1 \times 10 = 500 \therefore \frac{\rho_2}{\rho_1} = \frac{500}{300} = 1.67$

NOTE:

- For a diver, pressure is given by $p = H + d$
- For a climber, the pressure is $p = H - h$ where H = atmospheric pressure in metre
 d = depth blow water in metre
 h = height above ground level (metre)
- In other words, pressure increases with depth but decreases with height.

10D. Using Pascal's principle of undiminished transmissibility of pressure
 $p_1 = p_2: \frac{F_1}{A_1} = \frac{F_2}{A_2} \rightarrow \frac{100}{0.5} = \frac{F_2}{5} \rightarrow F_2 = 1000 \text{ N}$

Note that a hydraulic press in truly a machine such that

$$MA = \frac{L}{E} = \frac{1000}{100} > 1$$

11A. $P = \frac{F}{A} = h\rho g \rightarrow \therefore F = Ah\rho g = 4 \times 3 \times 2 \times 10^3 \times 10$

$$F = 2.4 \times 10^5 \text{ N}$$

12D. Consulting Q4: $P = H + h = 76 + (13.4 - 3.5) = 85.9 \text{ cmHg}$

13D. Aneroid barometer particularly useful for measuring altitude and manometer for gas pressure in the laboratory

14C. $h\rho g = h \times 2600 \times 10 = 102000 \rightarrow h = \frac{102000}{26000} = 3.92 \text{ m}$

15D. Altimeter \rightarrow altitude (see Q13)

16A. Pressure differences = $75 - 63 = 12 \text{ cm} = 0.12 \text{ mHg}$
 Convert pressure in Hg to pressure in air

$$(h\rho g)_{\text{air}} = (h\rho g)_{\text{mercury}}$$

$$h \times 0.13 \times 10 = 0.12 \times 13000 \times 10 \rightarrow h = 12000 \text{ m}$$

(A) is the closest

17C. Pressure is independent of cross-sectional area in liquid pressure (see Qs 1 and 5) $\rightarrow \therefore h_1\rho_1g = h_2\rho_2g$

$$\therefore \frac{\rho_1}{\rho_2} = \frac{h_2}{h_1} \left(\rho \propto \frac{1}{h} \right)$$

This follows from the fact that the denser a liquid, the smaller the column of it supported by the prevailing pressure

$$\frac{\rho_x}{\rho_y} = \frac{22.5}{7.5} = 3 \text{ (Liquid X is 3times denser than liquid Y)}$$

18D. Dimension = Length x breadth x height
 Dimension = Area x height
 But area is inconsequential here (Qs 1, 5 and 16)

$$\therefore P = h\rho g = 2 \times 1000 \times 10 = 20000 \text{ Nm}^{-2}$$

19C. $P_G > P_{\text{atm}}$ (see Q4) $\rightarrow \therefore P_G = H + h$
 $\rightarrow P_G = 760 \text{ mm} + (10 - 3) \text{ cm}$
 $= 760 + 7 \times 10 = 760 + 70 = 830 \text{ mm}$

20C. Pressure increases with depth

21C. $P = \frac{F_2}{A_2} = \frac{F_1}{A_1} \Rightarrow \frac{F}{0.8} = \frac{500}{0.2} \rightarrow F = 2000 \text{ N}$

22D. Volume of tank = $Lbh = 2.5 \times 2.0 \times 4.0 = 20 \text{ m}^3$

$$\text{But } \rho = \frac{m}{V} = \frac{1 \times 10^3}{20} = 50 \text{ kgm}^{-3}$$

$$P = \frac{4}{2} \times 50 \times 10 \text{ (middle of tank)} \rightarrow P = 1000 \text{ Nm}^{-2}$$

23B. Compare Q20

24B. Pressure due to ocean water only
 $\rightarrow P = h\rho g = 10 \times 100 \times 10 = 10^5$
 \therefore Total pressure = $10^5 +$ atmospheric pressure
 $= 10^5 + 1.3 \times 10^4 = 1.4 \times 10^4 \text{ Nm}^{-2}$

25B. This is reversed in upward stroke. Also compare a force pump.

26A. Pressure is the same in all directions.

27C. $p \propto h \therefore P_{20} = \frac{20}{80} \times 760 = 190 \text{ mmHg}$.

28D. $h\rho g = P \rightarrow h \times 1.1 \times 10^3 \times 10 = 1.65 \times 10^4 \rightarrow h = 1.49 \text{ m}$.

29A. $A = \pi r^2 \rightarrow \text{But } P = \frac{F}{A} = \frac{F}{\pi r^2}$

$$P = \frac{7.7 \times 10^2 \times 7}{22 \times (10^{-2})^2} = 2.45 \times 10^4$$

30B. $\frac{F_2}{A_2} = \frac{F_1}{A_1} \rightarrow \frac{400}{A} = \frac{40}{0.4} \rightarrow \therefore A = 4 \text{ m}^2$

31D. Pressure is the same at the level of reference

$$\therefore h_1\rho_1g = h_2\rho_2g \rightarrow \therefore h_2 = \frac{8 \times 10^2 \times 10^3}{800}$$

$$h_2 = 0.1 \text{ m} = 10 \text{ cm}$$

32B. $P_G > P_{\text{atm}} \rightarrow \therefore P_G = H + h \rightarrow P_G = 76 + 10 = 86 \text{ cm Hg}$

33A. Just add the pressure due to fluid and pressure due to the atmosphere

$$\text{Pressure of fluid} = h\rho g = 500 \times 850 \times 100 \\ = 4.25 \times 10^6 \text{Nm}^{-2}$$

$$\therefore \text{Total pressure} = 1.05 \times 10^5 + 4.25 \times 10^6 \\ = 4.36 \times 10^6 \text{Nm}^{-2}$$

$$34D. \frac{\rho}{\rho_w} = \frac{h_2}{h_1} \text{ (Hare's)} \rightarrow \frac{\rho}{\rho_w} = \frac{26.5\text{cm}}{20.4\text{cm}} = 1.29$$

$$\text{But r.d} = \frac{\text{Density of liquid}}{\text{Density of water}} = 1.3$$

35D. The water vapour above the hot water condenses thereby reducing the vapour pressure below the atmospheric pressure hence the collapse

36D. See Q1

$$37D. \text{Pressure is equal in both piston} \rightarrow \therefore \frac{F}{A} = p \rightarrow F = 100 \times 3 = 300\text{N}$$

38C. See Q33

39A. See Qs 33 and 38

$$40. h\rho g = p \rightarrow \therefore h = \frac{1.01 \times 10^5}{1013 \times 10} \rightarrow h = 9.97 \approx 10\text{m}$$

41C. A barometer that employs water would be too tall to allow any room for convenience since the less dense a liquid, the taller the column of the liquid supported by a given pressure. For instance, if atmospheric pressure is 760mmHg or 0.76mHg, the pressure in terms of water is $h_w \times \rho_w \times g = h_{Hg} \times \rho_{Hg} \times g$

$$\therefore h_w = \frac{0.76 \times 13600}{1000 \times 10} \rightarrow h_w = 10.3\text{m}$$

$$\rightarrow 0.76\text{m Hg} \equiv 10.3\text{m H}_2\text{O!}$$

NOTE: Options (A), (B) and (D) are thermometric properties (see chapter 13)

$$42A. P = \frac{F}{A} = \frac{W}{A} \rightarrow \therefore \frac{W}{4 \times 10^{-2}} = 2.8 \times 10^3 = W = 112\text{N}$$

43A. Density is the single most important barometric property but the dark color of mercury makes its height in the column easy to read off. Compare Q43

44A. Pressure is inversely proportional to area.

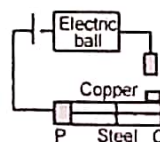
CHAPTER 13

TEMPERATURE AND HEAT. THERMAL EXPANSION

1. A temperature of 20°C is the same as A. 36° F B. 68° F C. 11.1° F D. 43.1° F E. 25° F. (1978:Q17)
2. A steel plug has a diameter of 5cm at 30°C. At what temperature will it fit exactly into a hole of constant diameter 4.997cm? (coefficient of linear expansion of steel is $11 \times 10^{-6} \text{°C}^{-1}$) A. 27.3°C B. -27.3°C C. -2.7°C D. 7.32°C E. 2.7°C (1978:Q22)
3. In what range of temperature is the expansion of water anomalous? A. +208°C to +212°C B. -80°C to -76°C C. 40°C to 0°C D. +96°C to 100°C E. 0°C to +4°C (1979:Q9)
4. The heights of the mercury thread in a mercury-in-glass thermometer when in melting ice and then in steam are 3cm and 18cm respectively. At a temperature of 60°C the height would be A. 7.5cm B. 9cm C. 10.8cm D. 12cm E. 12.6cm (1979:Q14)
5. Consider a thick glass tumbler and a thin glass tumbler which are made of the same kind of glass. Some hot liquid is poured into them. Which of the following statements is correct? A. The thick tumbler is less likely to crack because it is stronger B. The thick tumbler is less likely to crack because it insulates the heat better, glass being a poor conductor of heat. C. Both tumblers are equally likely to crack because they are made of the same kind of glass. D. The thick tumbler is more likely to crack because uneven expansion persists for a longer time within the thicker glass E. The thick tumbler is more likely to crack because it is heavier (1979:Q34)
6. In the study of Physics, temperature and heat are often confused with each other. Which of the following statements correctly defines these two elements? A. Temperature

is a measure of the average kinetic energy of the molecules of a substance B. Heat is a measure of the total kinetic energy of the molecules in a system C. Different materials require different amounts of heat to cause a given change in temperature D. all of the above E. A and B only (1980:Q7)

7. The ratio of the linear expansivity of copper to that of iron is approximately 1.5. A specimen of iron and a specimen of copper expand by the same amount per unit rise in temperature. The ratio of their lengths is A. 3 B. 1.5 C. 1.32 D. 1 E. 0.67 (1980:Q44)
8. The ice and steam points of a mercury-in-glass thermometer of centigrade scale and of uniform bore correspond respectively to 3cm and 19cm lengths of the mercury thread. When the length is 12cm, the temperature is A. 32°C B. 48°C C. 56°C D. 65°C E. 75°C (1981:Q1)
9. A liquid-in-glass thermometer should quickly register temperature changes. This is achieved by choosing a liquid that A. is opaque B. has high density C. has regular expansion D. has a high thermal conductivity E. can wet glass (1981:Q42)
10. Which of the following statements is NOT true? Thermostats are used to control the temperature of A. pressure cookers B. laundry irons C. hot water storage tanks D. aquaria for tropical fish E. heated apartments. (1982:Q16)
11. A rod of length 10cm is heated through 100°C and its final length is 10.26cm. What is the co-efficient of linear expansion of the rod? A. 0.026 per degree centigrade B. 0.00026 per degree centigrade C. 0.26 per degree centigrade D. 1.0026 per degree centigrade E. 0.0026 per degree centigrade (1982:Q22)
12. The linear expansivity of brass is $2 \times 10^{-5} \text{°C}^{-1}$. If the volume of a piece of brass is 10cm³ at 0°C, what will be its volume at 100°C? A. 10.02cm³ B. 10.04cm³ C. 10.06cm³ D. 10.20cm³ E. 102.00cm³ (1983:Q22)
13. A short response time is obtained in a liquid-in-glass thermometer when the A. bulb is large and thick-walled. B. stem is long and thin. C. bulb is small and thick-walled. D. bulb is of high density and the bore is large. E. bulb is thin-walled and the liquid is a good conductor of heat. (1983:Q35)
14. Which of the following statements clearly describes the



that the linear expansivities of copper and steel are $2.0 \times 10^{-5} \text{°C}^{-1}$ and $1.2 \times 10^{-5} \text{°C}^{-1}$ respectively?

The bimetallic strip will not be able to close the circuit when there is fire II. The bimetallic strip will close the circuit when there is no fire III. If the copper and steel are interchanged, the circuit will close when there is fire. A. I only B. II only C. III only D. I and III E. II and III (1983:Q42)

15. The lower and upper fixed points marked on a mercury-in-glass thermometer are 210mm apart. The end of the mercury column in the tube is 49mm above the lower fixed point in a room. What is the temperature of the room in degrees Celsius? A. 55.3°C B. 23.3°C C. 49.0°C D. 16.1°C E. 76.7°C (1984:Q18)
16. Which of the following properties of matter CANNOT be utilized for temperature measurement? The A. Length of a liquid column B. Volume of a gas at constant pressure. C. Pressure of a gas at constant volume D. Resistance of a metallic wire E. Current produced in a photoelectric effect. (1984:Q29)
17. A thin aluminum plate has a surface area of 1,500m² at 20°C. What will be its surface area when it is cooled to -20°C? (Take the linear expansivity of aluminium to be $2.5 \times 10^{-5} \text{K}^{-1}$) A. 1,503m² B. 1,500m² C. 1,498m²

- D. 1.497m³ E. 1.490m³ (1985:Q18)
18. Water shows anomalous behaviour A. Below 0°C B. Between 0°C and 4°C C. At exactly 4°C D. Between 4°C and 100°C E. Above 100°C (1985:Q22)
19. The expansion of solids can be considered a disadvantages in the A. Balance wheel of a watch B. Fitting of wheels on rims C. Fire alarm D. Thermostat. (1986:Q18)
20. The distance between the fixed points of centigrade thermometer is 20cm. What is the temperature when the mercury level is 4.5cm above the lower mark? A. 22.5°C B. 29.0°C C. 90.0°C D. 100.0°C (1987:Q16)
21. A metallic strip of iron and brass was heated. Which of the following diagrams accurately illustrates the shape of the strip after heating?
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- (1987:Q17)
22. The length of a side of a metallic cube at 200°C is 5.0cm. Given that the linear expansivity of the metal is $4.0 \times 10^{-5} \text{K}^{-1}$. Find the volume of the cube at 120°C. A. 126.50cm³ B. 126.25cm³ C. 126.00cm³ D. 125.00cm³ (1987:Q18)
23. The pressure on the gas of constant gas thermometer at the ice point is 325mm of mercury and at the steam point 875mm of mercury. Find the temperature when the pressure of the gas is 190mm of mercury. A. 30k B. 243k C. 300k D. 303k (1989:Q13)
24. The resistance of a platinum wire at the ice and steam points are 0.75 ohm and 1.05 ohm respectively. Determine the temperature at which the resistance of the wire is 0.90 ohm A. 43.0°C B. 50.0°C C. 69.9°C D. 87.0°C (1990:Q15)
25. A bar of initial length l_0 is heated through a temperature change Δt to a new length l . The linear expansivity, α , of the bar is A. $\frac{l-l_0}{l\Delta t}$ B. $\frac{l-l_0}{l_0\Delta t}$ C. $l_0(1+\Delta t)$ D. $\frac{l-l_0}{l_0(1+\Delta t)}$ (1990:Q16)
26. A thermometer with an arbitrary scale, S, of equal divisions registers -30°S at the ice point and $+900\text{S}$ at the steam point. Calculate the Celsius temperature corresponding to 60°S . A. 25.0°C B. 50.0°C C. 66.7°C D. 75.0°C (1991:Q15)
27. A brass rod is 2m long at a certain temperature. What is the length for a temperature rise of 100K, if the expansivity of brass is $18 \times 10^{-6} \text{K}^{-1}$? A. 2.0036m B. 2.0018m C. 2.1800m D. 2.0360m (1991:Q16)
28. A platinum resistance thermometer wire has a resistance of 5 ohms at 0°C and 5.5 ohms at 10°C. Calculate the temperature of the wire when the resistance is 5.2 ohms A. 80°C B. 60°C C. 40°C D. 100°C (1992:Q13)
29. A bridge made of steel is 60m long. What is the daily variation in its length if the night-time and day-time temperatures are 10°C and 35°C respectively. The linear expansivity of steel is 0.000012C^{-1} . A. 0.18cm B. 1.80cm C. 18.00cm D. 1800cm (1992:Q14)
30. One of the most important applications of bimetallic strip is found in the construction of A. A thermostat B. An altimeter C. A thermocouple D. A hygrometer (1992:Q15)
31. The thermometric property of the thermocouple is that its A. e.m.f. changes with temperature B. Resistance changes with temperature C. Volume changes with temperature D. Pressure changes with resistance. (1993:Q14)
32. A metal rod 800mm long is heated from 10°C to 95°C. If it expands by 1.36mm, the linear expansivity of the metal is A. $2.0 \times 10^2 \text{K}^{-1}$ B. $2.0 \times 10^3 \text{K}^{-1}$ C. $5.0 \times 10^3 \text{K}^{-1}$ D. $2.0 \times 10^5 \text{K}^{-1}$ (1993:Q15)
33. The melting point of naphthalene is 78°C. What is this temperature in Kelvin? A. 100 K B. 8.351K C. 378K D. 444K (1994:Q20)

34. Temperature is a measure of the A. Quantity of heat transferred into the molecules of an object B. Mean kinetic energy of any molecules of the object C. Kinetic energy of any individual molecules of the substance. D. Amount of work done by the molecule of the object. (1995:Q18)
35. A rectangular metal block of volume 10^{-6}m^3 at 273K is heated to 573K. If its coefficient of linear expansion is $1.2 \times 10^{-5} \text{K}^{-1}$, the percentage change of its volume is A. 1.5% B. 1.1% C. 0.4% D. 0.1% (1995:Q19)
36. A temperature scale has a lower fixed point of 40mm and an upper fixed point of 200mm. What is the reading on this scale when a thermometer read 60°C? A. 33.3mm B. 36.0mm C. 96.0mm D. 136.0mm (1995:Q23)
37. The length of mercury thread when it is at 0°C, 100°C and at an unknown temperature q is 25mm, 225mm and 175mm respectively. The value of q is A. 85.0°C B. 80.0°C C. 75.0°C D. 70.0°C (1997:Q20)
38. A platinum resistance thermometer records 3.0W at 0°C and 8.0W at 100°C. If it records 6.0W in a certain environment, the temperature of the medium is A. 80°C B. 60°C C. 50°C D. 30°C (1998:Q17)
39. The linear expansivity of brass is $2 \times 10^{-5} \text{C}^{-1}$. If the volume of a piece of brass is 15.00cm³ at 0°C, what is the volume at 100°C? A. 16.03cm³ B. 16.00cm³ C. 15.09cm³ D. 15.03cm³ (1998:Q18)
40. The temperature gradient across a copper rod of thickness 0.02m, maintained at two temperature junctions of 20°C and 80°C respectively is A. $3.0 \times 10^2 \text{K}^{-1}$ B. $3.0 \times 10^3 \text{K}^{-1}$ C. $5.0 \times 10^3 \text{K}^{-1}$ D. $3.0 \times 10^4 \text{K}^{-1}$. (1999:Q26)
41. The diagram below shows a maximum and minimum thermometer divided into three portions P, Q and R. Which of the following is true about the respective contents of P, Q and R?
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- A. Alcohol, mercury and alcohol B. Air, alcohol and mercury C. Mercury, alcohol and mercury D. Air, mercury and alcohol. (2000:Q21)
42. A quantity of water at 0°C is heated to about 30°C. At each degree rise in temperature, its density will A. rise steadily B. rise then fall C. fall steadily D. fall then rise (2000:Q25)
43. A thin wire with heavy weights attached to both ends is hung over a block of ice resting on two supports. If the wire cuts through the ice block while the block remains solid behind the wire, the process is called A. fusion B. sublimation C. condensation D. regelation (2000:26)
44. Water is a poor thermometric liquid because it A. has low vapour pressure B. is opaque C. is a poor conductor D. wets glass. (2002:Q21)
45. Thermal equilibrium between two objects exists when A. the temperature of both objects are equal B. the quantity of heat in both objects are the same C. the heat capacities of both objects are the same D. one object loses heat continuously to the other. (2003:Q17)
46. On a fairly cool rainy day when the temperature is 20°C, the length of a steel railroad track is 20m. What will be its length on a hot dry day when the temperature is 40°C? A. 20.013m B. 20.009m C. 20.004m D. 20.002m [coefficient of linear expansion of steel = $11 \times 10^{-6} \text{K}^{-1}$] (2003:Q20)
47. When left in a freezer, a bottle full of water cracks on freezing into ice because of the A. decrease in the volume of water. B. contraction of the bottle. C. expansion of the bottle. D. increase the volume of water (2004:Q33)
48. Metal rods of length 20m each are laid end to end on a bridge at 25°C. What gap will be provided between consecutive rails for the bridge to withstand 75°C? A. 0.22m B. 0.25m C. 0.02m D. 0.20m (2004:Q38)
49. I. Reproducibility II. Sensitivity III. High thermal

- capacity IV. High accuracy. The qualities of a good thermometer include A. I, III and IV only. B. I, II and IV only. C. II, III and IV only. D. I, II and III only. (2005:Q43)
50. When very hot water is poured into two identical thin glass tumblers in equal volumes, the thick one cracks because A. of the even expansion of glass. B. glass is a good conductor of heat. C. of the uneven expansion of glass. D. glass is a crystal. (2005:Q48)
51. What is likely to happen if the glass of a thermometer expands more upon heating than the liquid inside? A. The glass will shrink B. The liquid will go down in the stem C. The liquid will rise up in the stem D. The glass will break (2006:Q44)
52. The thermometric property of a constant volume thermometer is A. change in pressure. B. change in length. C. differential expansion. D. change in volume. (2006:Q48)
53. The ratio of the coefficient of linear expansion of two metals is 3:5. If, when heated through the same temperature change, the ratio of the increase in lengths of the two metals, is 1:2, the ratio of the original lengths is A. 2/3 B. 8/3 C. 3/8 D. 3/2 (2007:Q28)
54. I. Use a liquid with a high melting point. II. Use a liquid of high volume expansivity. III. Use a capillary tube of large diameter. Which of the above best describes how the sensitivity of a liquid-in-glass thermometer can be enhanced? A. II only B. II and III only C. I only D. I and III only. (2007:Q31)
55. A blacksmith heated a metal whose cubic expansivity is $6:3 \times 10^{-6} \text{K}^{-1}$. The real expansivity is A. $6.3 \times 10^{-6} \text{K}^{-1}$. B. $4.2 \times 10^{-6} \text{K}^{-1}$. C. $2.1 \times 10^{-6} \text{K}^{-1}$. D. $2.0 \times 10^{-6} \text{K}^{-1}$ (2007:Q36)
56. A clinical thermometer is different from other mercury in glass thermometers owing to A. its long stem. B. the constriction on its stem. C. its wide range of temperatures. D. the grade of mercury use in it (2007:Q39)
57. The thermometric property of a thermocouple is the change in A. equivalent resistance B. electromotive force. C. colour D. pressure. (2008:Q19)
58. During summer, the balance wheel of a clock expands. What effect does this have on the accuracy of the clock? A. The clock gains time B. The accuracy of the clock is not affected C. The clock loses time D. The clock stops working (2008:Q19)
59. The thermometer whose reading is indicated by a change in colour of its thermometric property is the A. bi-metallic strip thermometer. B. thermocouple. C. platinum resistance thermometer. D. optical pyrometer. (2009:Q18)
60. At 4°C , the volume of a fixed mass of water is A. constant B. minimum. C. maximum. D. zero (2009:Q19)
61. One special advantage of alcohol over mercury as a thermometric liquid is its A. low freezing point. B. low boiling point. C. high specific heat capacity. D. low density (2010:Q15)
62. Two metals P and Q of lengths l_1 and l_2 are heated through the same temperature difference. If the ratio of the linear expansivities of P to Q 2:3 and the ratio of their length is 3:4. What is the ratio of increase in lengths of P to Q? A. 5:7 B. 2:1 C. 1:2 D. 7:5 (2010:Q16)
63. **I. High thermal capacity. II. High sensitivity. III. Easy readability. IV. Accuracy over a wide range of temperatures.** From the statements above, the qualities of a good thermometer are A. I, III and IV B. II, III and IV C. I and II D. I, II, III and IV (2011:Q11)
64. A metal of volume 40cm^3 is heated from 30°C to 90°C , the increase in volume is A. 1.20cm^3 B. 0.40cm^3 C. 0.12cm^3 D. 4.00cm^3 (2011:Q23)
65. Clinical thermometers are examples of A. pressure gas thermometer B. resistance thermometer C. alcohol thermometer D. mercury-in-glass thermometer (2012:Q19)
66. Calculate the length which corresponds to a temperature of 20°C if the ice and steam points of an ungraduated thermometer are 400mm apart. A. 20mm . B. 30mm . C. 60mm .

D. 80mm . (2013:Q16)

67. A wire of length 100.0m at 30°C has linear expansivity of $2 \times 10^{-5} \text{K}^{-1}$. Calculate the length of the wire at a temperature of -10°C . A. 100.08m . B. 100.04m . C. 99.96m . D. 99.92m . (2013:Q17)
68. What is the equivalent of 20K in Celsius scale? A. 293°C . B. 68°C . C. 36°C . D. 20°C . (2014:Q19)
69. A glass bottle of initial volume $2 \times 10^{-4} \text{cm}^3$ is heated from 20°C to 50°C . If the linear expansivity of glass is $9 \times 10^{-6} \text{K}^{-1}$, the volume of the bottle at 50°C is A. 20005.4cm^3 B. 20008.1cm^3 . C. 20013.5cm^3 . D. 20016.2cm^3 . (2014:Q20)
70. Which of the following is NOT an application of expansion in metals? A. Bimetallic strip thermometer B. Temperature control in an electric iron. C. Compensated balance wheel of a watch. D. Sagging of telegraph wires. (2015:Q46)
71. A platinum resistance thermometer has a resistance of 4Ω at 0°C and 10Ω at 100°C . Assuming the resistance changes uniformly with temperature, calculate the resistance of the thermometer when the temperature is 45°C A. 14.0Ω B. 6.7Ω C. 3.4Ω D. 2.7Ω (2018:Q5)

CHAPTER 13 ANSWERS

- 1B.
$$\frac{x - 32}{20 - 0} = \frac{212 - 32}{100 - 0}$$

$$x = \left(\frac{180}{100} \times 20\right) + 32 \rightarrow x = 68^\circ\text{F}$$
- NOTE: Between $^\circ\text{C}$ and $^\circ\text{F}$, you may care to remember the following relations: $F = \frac{9C}{5} + 32$ and $C = \frac{5}{9}(F - 32)$
2. The plug is expected to contract so as to fit into a hole of smaller diameter hence a lower temperature is required
- But $\alpha = \frac{\Delta L}{L_1 \Delta \theta} = \frac{L_2 - L_1}{L_1 \Delta \theta}$
 $\therefore L_2 - L_1 = L_1 \alpha \Delta \theta \rightarrow 4.997 - 5 = 5 \times 11 \times 10^{-4} \times \Delta \theta$
 $\Delta \theta = \frac{-0.003}{5 \times 11 \times 10^{-4}} \rightarrow \theta_2 - \theta_1 = -54.55^\circ\text{C}$
 $\theta_2 = -54.55 + 30 \rightarrow \theta_2 = -24.5^\circ\text{C}$
 No option was close enough
- NOTE: Using = is not necessary it will only waste your time as you will arrive at the same answers on above.
- 3E. Water contracts from 0°C to 4°C with its maximum density at 4°C and it then expands like a normal liquid from 4°C to 100°C
- 4D.
$$\frac{x - 3}{18 - 3} = \frac{60 - 0}{100 - 0} \rightarrow x = \frac{15 \times 60}{100} + 3$$

 $x = 12\text{cm}$
- 5D. The uneven distribution of heat passes more quickly through the thinner tumbler
- 6D. (C) is just a statement of fact not a definition
- 7E. $\Delta L = L_1 \alpha \Delta \theta \rightarrow$ But $\Delta L_1 = \Delta L_2$; $\Delta \theta = \Delta \theta$
 $\therefore L_1 \alpha_1 = L_2 \alpha_2 \rightarrow \frac{L_1}{L_2} = \frac{\alpha_2}{\alpha_1} = \frac{1}{1.5} = \frac{1}{2}$
 $\frac{L_1}{L_2} = \frac{2}{3} = 0.67$
- NOTE: With the framing of the question, $\frac{L_1}{L_2}$ is required not $\frac{L_2}{L_1}$, beware!
- 8C. Taking a cue from Qs 1 and 4

$$\frac{x - 0}{100 - 0} = \frac{12 - 3}{19 - 3} \quad x = 56.25^\circ\text{C}$$
- 9D. This means that the liquid allows heat to pass through

itself quickly hence a shorter time to respond.

NOTE: Mercury has a higher conductivity but a lower expansivity than alcohol

10A. The pressure cookers work on the principle of the higher the pressure, the higher the temperature at which a liquid boils (see chapter 16)

11B. $\alpha = \frac{\Delta L}{L_0 \Delta \theta} \rightarrow \alpha = \frac{10.26 - 10.00}{10 \times 100} \alpha = 0.00026^\circ\text{C}^{-1}$

12C. $V_2 = V_1 + \gamma V_1 \Delta \theta$ But $\gamma = 3\alpha$
 $V_2 = 10 + 10(3 \times 2 \times 10^{-5})100 \quad V_2 = 10.06\text{cm}^3$

13E. Heat passes through the thin wall and the liquid quickly

14D. The strip as constituted would rather bend away from the contact thereby preventing the establishment of a complete circuit since copper expands longer than steel ($\alpha_c > \alpha_s$) for equal lengths of the metals unless they are inter-changed.

15B. $\frac{x}{100} = \frac{49}{210}$ (see Qs 1, 4 and 8) $x = 23.3^\circ\text{C}$

16E. Photoelectricity measures light intensity rather than temperature

17A. $A^2 = A_1 + A_1 \beta \Delta \theta = 1.5 + 1.5 \times 2 \times 2.5 \times 10^{-5} \times [20 - (-20)]$
 $= 1.5 + 0.003 = 1.503\text{m}^2$

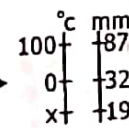
18B. See Q3

19A. In hot weather, the diameter of the balance wheel may increase (expand and the watch loses time unless a bimetallic strip is used).

20A. $\frac{x - 0}{100 - 0} = \frac{4.5}{20} \rightarrow x = 22.5^\circ\text{C}$

21B. Brass expands longer than iron hence the convex side is brass. **NOTE:** If the strip is cooled brass also contracts more and it is on the concave side of the strip (as in option C)

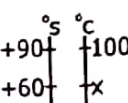
22A. $V_2 = V_1 + V_1 \gamma \Delta \theta$ but $V_1 = 5 \times 5 \times 5 = 125\text{cm}^3$
 $V_2 = 125 + 125 \times 3(4 \times 10^{-5}) \times (120 - 20) \rightarrow V_2 = 126.5\text{cm}^3$
 Alternatively: $L_2 = L_1 + L_1 \alpha \Delta \theta = 5 + 5 \times 4 \times 10^{-5} \times 100 = 5.02\text{cm}$
 But $V = L^3 = 5.02^3 = 126.5\text{cm}^3$

23B. $\frac{x - 0}{100 - 0} = \frac{190 - 325}{875 - 325} \rightarrow$  $x = \frac{100(-137)}{548} x = -25^\circ\text{C}$

But $\pi = c + 273 \rightarrow \pi = -25 + 273 \rightarrow \pi = 248\text{K}$
 (B), probably a mistake, was the closest.

24B. $\frac{x - 0}{100 - 0} = \frac{0.90 - 0.75}{1.05 - 0.75} \rightarrow x = \frac{100 \times 0.15}{0.3} = 50^\circ\text{C}$

25B. By definition: Linear expansivity = $\frac{\text{change in length}}{\text{original length} \times \text{temperature change}}$

26D.  $\rightarrow \frac{x - 0}{100 - 0} = \frac{60 - (-30)}{90 - (-30)} \rightarrow x = \frac{100 \times 90}{120} = 75^\circ\text{C}$

27A. $L_2 = L_1 + L_1 \alpha \Delta \theta \rightarrow L_2 = 2 + 2 \times 18 \times 10^{-6} \times 100 \rightarrow L_2 = 3.0036\text{m}$

28C. $\frac{x - 0}{100 - 0} = \frac{5.2 - 5}{5.5 - 5} \rightarrow x = \frac{100 \times 0.2}{0.5} = 40^\circ\text{C}$

29C. $\Delta L = L_1 \alpha \Delta \theta = 600 \times 0.000012 \times 25 = 0.18\text{m} = 18\text{cm}$

NOTES:

- $0.000012^\circ\text{C} = 0.000012\text{k}^{-1}$
- This arises from the fact that 1°C rise in temperature is 1k rise in temperature.
- Besides, the formula above is about temperature charge ($\Delta \theta$) rather than θ_1 or θ_2 separately
- Therefore the need to convert $^\circ\text{C}$ to k does not arise.

30A. As in electric laundry iron.

31A. Change in p.d between two metallic junctions with temperature change.

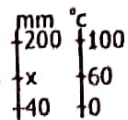
32D. $\alpha = \frac{\Delta L}{L_1 \Delta \theta} = \frac{1.36}{800 \times 85} \rightarrow \alpha = 2.0 \times 10^{-5}\text{k}^{-1}$

33B. $T = C + 273$

34B. See Q6

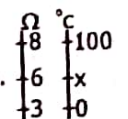
35B. $\Delta V = V_1 \beta \Delta \theta = 10^6 \times 3(1.2 \times 10^{-5}) \times 300$
 $= 1.08 \times 10^8\text{m}^3$

$\therefore \% \Delta V = \frac{\Delta V}{V_1} \times 100\% = \frac{1.08 \times 10^8}{10^4} \times 100\% = 1.08\%$

36D.  $\rightarrow \frac{x - 40}{100 - 40} = \frac{60 - 0}{100 - 0}$

$x = \frac{160 \times 60}{100} + 40 \rightarrow x = 136\text{mm}$

37C. $\frac{0 - 0}{100 - 0} = \frac{175 - 25}{225 - 25} \rightarrow \theta = 75^\circ\text{C}$

38B.  $\rightarrow \frac{x - 0}{100 - 0} = \frac{6 - 3}{8 - 3} \rightarrow x = 60^\circ\text{C}$

Alternatively but more clumsily: $\frac{100 - 0}{x - 0} = \frac{8 - 6}{6 - 3}$

$2x = 300 - 3x \rightarrow 5x = 300 \rightarrow x = 60^\circ\text{C}$

39C. $V_2 = V_1 + V_1 \gamma \Delta \theta = 15 + 15 \times 3(2 \times 10^{-5}) \times 100 = 15.09\text{cm}^3$

40B. Temperature gradient = $\frac{\Delta \theta}{t} = \frac{80 - 20}{0.02} = 3.0 \times 10^3\text{km}^{-1}$

No option is correct

41A. In the Six's combined maximum and minimum thermometer, the bulb P is completely filled with alcohol while the bulb R has a space left above the alcohol (P = minimum arm, R = maximum arm)

42B. Water contracts between 0°C and 4°C ~~hence~~ its density reaches a maximum at 4°C ($\rho \propto \frac{1}{V}$) and it expands between 4°C and 30°C hence its density drops (same reason)

43D. Regelation suggests that pressure lowers the melting point of a solid

44C. Heat slowly passes through water, a poor conductor of heat. Hence water-in-glass thermometer responds slowly

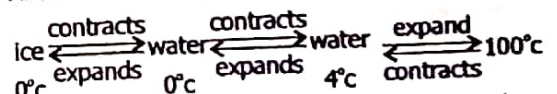
45A. Temperature is a measure of a body's thermal equilibrium with another body.

46C. $L_2 = L_1 + L_1 \alpha \Delta \theta = 20 + 20 \times 11 \times 10^{-6} \times 20 = 20.0044\text{m}$

47D. Water expands when it forms ice instead of contracting as in other liquids.

NOTES:

- Anomalous expansion of water



- The anomalous expansion of water explains the floating of an iceberg and it also prevents a pond from freezing completely to save aquatic life.

48C. $\Delta L = L_1 \alpha \Delta \theta = 20 \times 2 \times 10^{-5} \times 50 = 0.02$

Applying common sense:

Each gap = $\frac{1}{2} \Delta L + \frac{1}{2} \Delta L \quad \Delta L = 0.02\text{m}$

If you are not sure, consider this as each rail expands from both ends



49B. I \rightarrow Ability of the thermometer to produce the same reading over and over again when used to take the temperature of the same body.

II \rightarrow Ability to detect a very slight temperature change or difference.

IV \rightarrow Ability to produce a result as close as possible to the one taken by a standard thermometer.

- 50C. See Q5
- 51B. Applying common sense here, it follows that the volume of the liquid is assumed constant and when the diameter of bulb increases, height of liquid in stem goes down to fill the extra volume of the bulb
- 52A. The thermometer works on the principle of the fact that the pressure of a gas at a constant volume varies linearly with temperature (pressure law - chapter 14)
- 53A. $\Delta L = L_1 \alpha \Delta \theta \rightarrow \therefore \Delta \theta = \frac{\Delta L}{L_1 \alpha}$
 For metals 1 and 2, $\Delta \theta$ is the same
 $\therefore \frac{e_1}{L_1 \alpha_1} = \frac{e_2}{L_2 \alpha_2}$ or $e_1 L_2 \alpha_2 = e_2 L_1 \alpha_1 \rightarrow \therefore \frac{L_1}{L_2} = \frac{e_1 \alpha_2}{e_2 \alpha_1}$
 $\frac{L_1}{L_2} = \frac{e_1}{e_2} \times \frac{\alpha_2}{\alpha_1} \rightarrow \frac{L_1}{L_2} = \frac{1}{2} \times \frac{4}{3} = \frac{4}{6} = \frac{2}{3}$
54. I \rightarrow A liquid with low melting point is ideal, but as desirable as this is, it is unconnected with the sensitivity of a thermometer (see Q50)
 II \rightarrow Any slight temperature change, the liquid expands appreciably

III \rightarrow For a constant volume: Area $\propto \frac{1}{\text{height}}$ ($V = Ah$)

Therefore, a large diameter of bulb means large area but very small height of liquid column which cannot be easily read off or detected. (see Q52)

- 55C. Take "real expansivity" here to mean linear expansivity as the terms "real" and "apparent" expansivities do not apply to a solid.

But $3\alpha = \gamma \rightarrow \alpha = \frac{\gamma}{3} = \frac{6.3 \times 10^{-6}}{3} \rightarrow \alpha = 2.1 \times 10^{-6} \text{K}^{-1}$

- 56B. This constriction or kink allows the clinician to read off the result even long after as only the mercury column below the kink contracts into the bulb.
- 57B. See Q32 58C. See Q20

- 59D. Using educated guess: optical \rightarrow vision \rightarrow colour
 pyro \rightarrow fire \rightarrow heat \rightarrow temperature.
 You might even apply elimination method if you have never come across "optical", "pyro-" or "optical pyrometer".

NOTE:

| Thermometer | Thermetric properties |
|----------------------------------|---|
| 1. Bi-metallic strip thermometer | 1. Differential expansion of the two metals in the strip. |
| 2. Thermocouple | 2. See Qs 31 and 57 |
| 3. Resistance thermometer | 3. Change in electrical resistance with temp |
| 4. Gas volume thermometer | 4. See Q53 |
| 5. Liquid-in-glass thermometer | 5. Change in volume of liquid with temp. |

- 60B. Maximum contraction at 4°C (Qs 3 and 42) hence minimum volume maximum density
- 61A. Alcohol at melting point -115°C can be used to measure very low temperature while mercury must have frozen at its melting point of -39°C

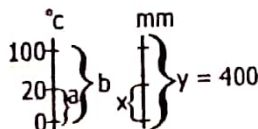
62C. Taking a cue from Q53: $\frac{e_0}{L_0 \alpha_0} = \frac{e_q}{L_q \alpha_q}$
 Rearranging: $\frac{e_r}{e_q} = \frac{L_q \alpha_q}{L_0 \alpha_0} = \frac{L_q}{L_0} \times \frac{e_r}{e_q} \rightarrow \therefore \frac{e_r}{e_q} = \frac{3}{4} \times \frac{2}{3} = \frac{1}{2}$

NOTE: Qs 53 and 62 have many in common and this fact verifies our earlier answer in Q53

- 63B. See Q49
64. $\Delta V = V_1 \times 3\alpha \times \Delta \theta = 40 \times 3 \times 2 \times 10^{-5} \times 60 = 0.144$
 No option was right

- 65D. See Q57

66D. $\frac{a}{b} = \frac{c}{d} \rightarrow \therefore \frac{20}{100} = \frac{x}{400}$
 $x = 80 \text{mm}$



67D. $L_2 = L_1 + L_1 \alpha \Delta \theta = 100 + 100 \times 2 \times 10^{-5} \times (-10 - 30)$
 $= 100 - 0.08 = 99.92 \text{m}$

NOTES:

- $\Delta \theta = \theta_1 - \theta_2$ (not $\theta_1 - \theta_1$)
- Don't be tempted to use $= [30 - (-10)]$ just because $30^\circ > -10^\circ \text{C}$ as this would give you $+40^\circ \text{C}$ instead of -40°C
- This error would be extended to your final answer as $(100 + 0.08 = 100.08$ in option A) instead of $(100 - 0.08$ in option D)

68. $T = C + 273 \rightarrow \therefore C = T - 273 = 20 - 273 = -253^\circ \text{C}$
 This was a human error on the part of JAMB that year because it is only 20°C that is 293K on Kelvin scale. No option is right.

69C. $V_2 = V_1 + V \times 3\alpha \times \Delta \theta$
 $= 2 \times 10^4 + 2 \times 10^4 \times 3(9 \times 10^{-6}) \times (58 - 20)$
 $= 2 \times 10^4 + 16.2 = 20016.2 \text{cm}^3$

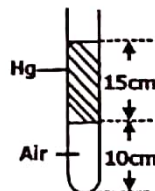
70. The sagging of telegraph wires is an undesirable event.

71. $\frac{R-4}{10-4} = \frac{45-0}{100-0} \rightarrow R = 6.7 \Omega$

CHAPTER 14

STRUCTURE OF MATTER. KINETIC THEORY. GAS LAWS

- A few grains of table salt were put in a cup of cold water, kept at constant temperature and left undisturbed. Eventually all the water tasted salty. This action is due to
 A. convection B. osmosis C. capillarity D. diffusion E. conductivity. (1978:Q16)
- A gas at pressure $P \text{Nm}^{-2}$ and temperature 27°C is heated to 77°C at constant volume. The new pressure is
 A. $0.85P \text{Nm}^{-2}$ B. $0.86P \text{Nm}^{-2}$ C. $1.16P \text{Nm}^{-2}$ D. $1.18P \text{Nm}^{-2}$ E. $2.85P \text{Nm}^{-2}$ (1978:Q20)
- If a given mass of gas at constant pressure obeys the relation...volume is proportional to the absolute temperature the gas is said to obey
 A. Hooke's law B. Boyle's law C. Dalton's law D. Charles' law E. Newton's law (1979:Q17)



end of a capillary tube by a 15cm column of mercury with the tube held vertically as shown in figure. On inverting the tube, the air column becomes 15cm long. The atmospheric pressure during the experiment is
 A. 90cm B. 76cm C. 75cm D. 60cm E. 50cm (1979:Q21)

- An air bubble rises from the bottom to the top of a water dam which is 40m deep. The volume of the bubble just below the surface is 2.5cm^3 . Find its volume at the bottom of the dam, if atmospheric pressure is equivalent to 10m of water.
 A. 10.0cm^3 B. 2.0cm^3 C. 1.6cm^3 D. 0.625cm^3 E. 0.5cm^3 (1979:Q38)
- A quantity of Sugas at -133°C occupies $1/3 \text{m}^3$ under a pressure $1.4 \times 10^5 \text{Nm}^{-2}$. If the gas occupies 31m^3 at 37°C , its pressure will be
 A. $1.26 \times 10^3 \text{Nm}^{-2}$ B. 10^4Nm^{-2} C. $1.35 \times 10^4 \text{Nm}^{-2}$ D. $2.2 \times 10^4 \text{Nm}^{-2}$ E. 10^5Nm^{-2} (1980:Q24)
- If the volume of a fixed mass of a gas is kept constant, the pressure of the gas
 A. is inversely proportional to its centigrade temperature
 B. is inversely proportional to its absolute temperature
 C. is directly proportional to its centigrade temperature
 D. is directly proportional to its absolute temperature
 E. remains constant also. (1980:Q33)
- When a fixed mass of an Ideal gas expands at constant temperature, which property of the gas molecules increases?
 A. Average number per unit volume
 B. Average kinetic energy
 C. Average speed
 D. Average separation
 E. Average number of collisions per unit time. (1981:Q6)
- A balloon inflated with helium gas at ground level is released. As it rises through a constant temperature atmosphere.

- A. its pressure reduces but volume remains constant
 B. the product of pressure and volume remains constant
 C. both pressure and volume increase D. its pressure remains constant but volume decreases E. both pressure and volume remain constant. (1981:Q36)

10. The tyre pressure of a car was found to be 150cmHg in the morning at a temperature of 27°C. Hard driving in the afternoon raised the temperature of the tyres to 57°C. The tyre pressure had by the afternoon A. increased by 15.0 Hg B. decreased by 15.0cm Hg C. increased by 22.50cm Hg D. decreased by 22.50cm Hg E. remained constant. (1982:Q5)

11. The equation $P^x V^y T^z = \text{constant}$ A. $x = 0, y = 0, z = 1$
 B. $x = 1, y = 0, z = 0$ C. $x = 1, y = 1, z = 0$ D. $x = 1, y = 1, z = 1$
 E. $x = 1, y = 1, z = -1$. (1982:Q41)

12. If the pressure on 100cm³ of an ideal gas is doubled while its Kelvin temperature is halved, then the new volume of the gas will become A. 25cm³ B. 50cm³ C. 100cm³ D. 200cm³ E. 400cm³ (1983:Q14)

13. A given mass of an ideal gas occupies a volume V at a temperature T and under a pressure P. If the pressure is increased to 2P and the temperature reduced to 1/2T, then the percentage change in the volume of the gas is A. 0% B. 25% C. 75% D. 300% E. 400% (1984:Q28)

14. A quantity of gas occupies a certain volume when the temperature is -73°C and the pressure is 1.5 atmospheres. If the pressure is increased to 4.5 atmospheres and the volume is halved at the same time, what will be the new temperature of the gas? A. 573°C B. 327°C C. 300°C D. 110°C E. 27°C (1985:Q20)

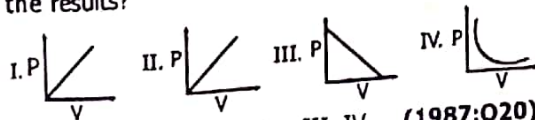
15. In a gas experiment, the pressure of the gas is plotted against the reciprocal of the volume of the gas at a constant temperature. The unit of the slope of the resulting curve is A. Force B. Force/m C. Work D. Force/m³ E. Energy/m². (1985:Q21)

16. Which of the following phenomena CANNOT be explained by the molecular theory of matter? A. Expansion B. Conduction C. Convection D. Radiation E. Evaporation. (1985:Q26)

17. A gas occupies a volume of 300cm³ at a temperature of 27°C. What is its volume at 54°C, when the pressure is constant? A. 150cm³ B. 273cm³ C. 327cm³ D. 600cm³ (1986:Q24)

18. As a result of air at the top of a barometer, the height of the mercury column is 73.5cm when it should be 75.0cm; the volume of the space above the mercury is 8.0cm³. Calculate the correct barometric height when the barometer reads 74.0cm and the volume of the space above the mercury is 6.0cm³. A. 72.0cm B. 74.5cm C. 75.1cm D. 76.0cm (1987:Q19)

19. A fixed quantity of gas is subjected to various pressures P and the corresponding volumes V measured at a constant temperature. Which of the following graphs best represent the results?



- A. I, II B. II, III C. II, IV D. III, IV (1987:Q20)

20. The product PV where P is pressure and V is volume has the same unit as A. Force B. Power C. Energy D. Acceleration (1988:Q16)

21. A column of air 10.0cm long is trapped in a tube at 27°C. What is the length of the volume at 100°C? A. 12.4cm B. 13.7cm C. 18.5cm D. 37.0cm (1989:Q14)

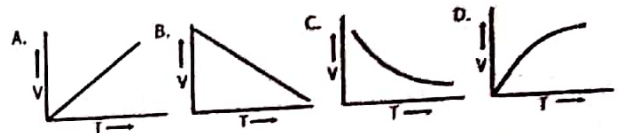
22. A mass of gas at 7°C and 70cm of mercury has a volume of 1200cm³. Determine its volume at 27°C and pressure of 75cm of mercury. A. 1 200cm³ B. 1 378cm³ C. 4 320cm³ D. 4 629cm³ (1989:Q15)

23. From the kinetic theory of gases, temperature is a A. Form of energy and is proportional to the total kinetic energy of the molecules. B. Form of energy and is proportional to the average

kinetic energy of the molecules. C. Physical property and is proportional to the total kinetic energy of the molecules. D. Physical property and is proportional to the average energy of the molecules (1989:Q17)

24. The pressure of a gas when cooled at constant volume will decrease because the molecules A. Collide less frequently with the walls of the container. B. Have the same average kinetic energy C. Break up into smaller molecules D. Decrease in number (1990:Q17)

25. The graphs below show the variation of volume (V) against temperature (T) in Kelvin for a given mass of gas at constant pressure. Which of the graphs depicts the behaviour of an ideal gas?



(1991:Q18)

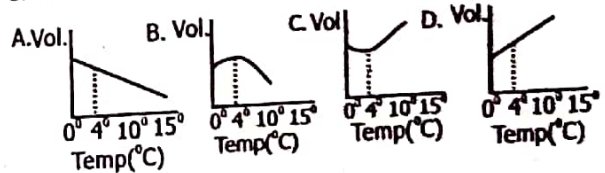
26. The absolute temperature of a perfect gas is proportional to the average A. Potential energy of the molecules B. Separation between the molecules C. Kinetic energy of the molecules D. Velocity of the molecules (1991:Q21)

27. At constant pressure, the density of a fixed mass of gas is A. Constant with temperature B. Proportional to its volume C. Inversely proportional to its temperature D. Independent of its volume (1992:Q16)

28. When the volume of a given mass of gas is halved and its temperature doubled, the pressure A. Remains constant B. Increases by a factor of 4 C. Increases by a factor of 3 D. Decreases by a factor of 4 (1993:Q16)

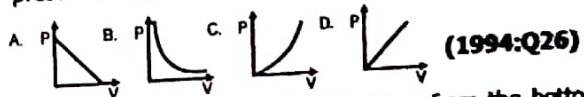
29. A motor tyre is inflated to pressure of $2.0 \times 10^5 \text{Nm}^{-2}$ when the temperature of air is 27°C. What will be the pressure in it at 87°C assuming that the volume of the tyre does not change? A. $2.6 \times 10^5 \text{Nm}^{-2}$ B. $2.4 \times 10^5 \text{Nm}^{-2}$ C. $2.2 \times 10^5 \text{Nm}^{-2}$ D. $1.3 \times 10^5 \text{Nm}^{-2}$ (1994:Q21)

30. A volume of water is heated from 0°C to 15°C. Which of the following diagrams correctly represents the variation of the volume with temperature?



(1994:Q23)

31. Which of the following graphs represents the variation of pressure P against volume V at constant temperature?



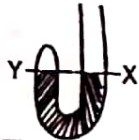
32. The volume of an air bubble increases from the bottom to the top of a lake at constant temperature because A. Atmospheric pressure acts on the surface of the lake. B. Pressure increases with depth of the lake. C. Density remains constant with pressure D. The bubble experiences an upthrust. (1995:Q17)

33. The equation $P^x V^y T^z = \text{constant}$ is Charles' law when A. $x = 1, y = -1, z = 1$ B. $x = 0, y = 1, z = -1$ C. $x = 1, y = 0, z = -1$ D. $x = 0, y = 1, z = 1$. (1995:Q21)

34. Before starting a journey, the tyre pressure of a car was $3 \times 10^5 \text{Nm}^{-2}$ at 27°C. At the end of the journey, the pressure rose to $4 \times 10^5 \text{Nm}^{-2}$. Calculate the temperature of the tyre after the journey assuming the volume is constant. A. 400°C B. 300°C C. 273°C D. 127°C (1997:Q22)

35. What happens when a gas expands at a constant temperature? A. Its pressure decreases. B. The total momentum of its molecules remains constant. C. Its pressure decreases and

the total momentum of its molecules remains constant. D. Its pressure decreases and the total kinetic energy of its molecules decreases (1997:Q27)

36. A gas has a volume of 100cm^3 at 27°C . If it is heated to temperature T until a final volume of 120cm^3 is attained, calculate T . A. 33°C B. 60°C C. 87°C D. 114°C (1998:Q19)
37. One valid assumption of the kinetic theory of gases is that
A. the molecules of a gas are constantly in state of motion and the number of collisions remain constant. B. The number of molecules of gas increases with increasing pressure C. As the temperature increases, the number of collisions made by the gas molecules remain constant. D. The molecules of gas are all identical and are very small in size. (1998:Q23)
38. A gas at a volume V_0 in a container at pressure P_0 , is compressed to one fifth of its volume. What will be its pressure if it maintains its original temperature T ?
A. $\frac{P_0}{5}$ B. $\frac{4}{5}P_0$ C. P_0 D. $5P_0$ (1999:Q10)
39. In the J-tube below, Y and X are on the same horizontal level and 30cm^3 of air is trapped above Y when the atmospheric pressure is 75cm Hg . Calculate the volume of air trapped above Y when 15cm Hg is now poured into the limb above X. A. 15cm^3 B. 25cm^3 C. 35cm^3 D. 45cm^3 (1999:Q13)
- 
40. The pressure of a mass of a gas changes from 300Nm^{-2} to 120Nm^{-2} while the temperature drops from 127°C to -73°C . The ratio of the final volume to the initial volume is A. 2:5 B. 5:4 C. 5:2 D. 4:5 (2001:Q16)
41. A gas with initial volume of $2 \times 10^{-6}\text{m}^3$ is allowed to expand to six times its initial volume at constant pressure of $2 \times 10^5\text{Nm}^{-2}$. The work done is A. 2.0J B. 4.0J C. 12.0J D. 1.2J (2001:Q19)
42. The pressure of 3 moles of an ideal gas at a temperature of 27°C having a volume of 10^{-3}m^3 is A. $2.49 \times 10^6\text{Nm}^{-2}$ B. $7.47 \times 10^6\text{Nm}^{-2}$ C. $2.49 \times 10^5\text{Nm}^{-2}$ D. $7.47 \times 10^5\text{Nm}^{-2}$ [$R = 8.3\text{Jmol}^{-1}\text{K}^{-1}$] (2002:Q18)
43. The process whereby the molecules of different substances move randomly is called A. surface tension. B. diffusion. C. capillarity. D. osmosis. (2005:Q44)
44. I. Melting II. Boiling III. Refraction IV. Conduction. Which combination of the above is evident of the molecular nature of matter? A. I, II and IV only B. I, III and IV only C. I, II and III only D. II, III and IV only (2005:Q47)
45. In a gas experiment, if the volume of the gas is plotted against the reciprocal of the pressure, the unit of the slope of the resulting curve is A. power. B. work. C. temperature. D. force. (2006:Q47)
46. I. Mass II. Density III. Temperature IV. Nature of substance. Which of the above affect diffusion? A. I, II and IV only. B. II, III and IV only. C. I, II, III and IV. D. I and II only. (2007:Q29)
47. Which of the following gas laws is equivalent to the work done? A. Pressure law B. Van der Waal's law C. Boyle's law D. Charles' law (2007:Q33)
48. The differences observed in solids, liquids and gases may be accounted for by A. their relative masses. B. their melting points. C. the different molecules in each of them. D. the spacing and forces acting between the molecules (2007:Q37)
49. A sealed flask contains 600cm^3 of air at 27°C and is heated to 35°C at constant pressure. The new volume is A. 508cm^3 . B. 516cm^3 . C. 608cm^3 . D. 616cm^3 (2008:Q21)
50. The pressure of one mole of an ideal gas of volume 10^{-2}m^3 at a temperature of 27°C is A. $2.24 \times 10^4\text{Nm}^{-2}$. B. $2.24 \times 10^5\text{Nm}^{-1}$. C. $2.49 \times 10^5\text{Nm}^{-1}$. D. $2.49 \times 10^4\text{Nm}^{-2}$. [Molar gas constant = $8.3\text{Jmol}^{-1}\text{K}^{-1}$] (2010:Q22)
51. If a tube of small radius opened at both ends is placed in a liquid, the liquid will A. fall below the liquid level if the liquid does not wet the glass B. rise above the liquid level if the liquid does not wet the glass C. remain at the same level irrespective of whether the liquid wets the glass or not

D. fall below the liquid level if the liquid wets the glass. (2011:Q9)

52. If the volume of a gas increases steadily as the temperature decreases at constant pressure, the gas obeys A. pressure law. B. Charles' law C. Graham's law D. Boyle's law. (2011:Q19)
53. i. Change of state ii. Diffusion iii. Radiation iv. Osmosis
Which of the processes above can be explained using the kinetic theory? A. I, III and IV B. I, II and IV C. I, II, III and IV D. I, II and III (2011:Q24)
54. 2000cm^3 of a gas is collected at 27°C and 700mmHg . What is the volume of the gas at standard temperature and pressure? A. 1896.5cm^3 B. 1767.3cm^3 C. 1676.3cm^3 D. 1456.5cm^3 (2012:Q21)
55. I. It is a rapid, constant and irregular motion of tiny particles. II. It gives evidence that tiny particles of matter called molecules exist. III. It takes place only in gases. IV. It gives evidence that molecules are in a constant state of random motion. Which of the combinations above is correct about Brownian motion? A. I, II and III only B. II, III and IV only C. I, III and IV only D. I, II and IV only. (2012:Q25)
56. A gas at a pressure of 10^5Nm^{-2} expands from 0.6m^3 to 1.2m^3 at constant temperature, the work done is A. $7.0 \times 10^6\text{J}$. B. $6.0 \times 10^6\text{J}$. C. $6.0 \times 10^5\text{J}$. D. $6.0 \times 10^7\text{J}$. (2013:Q18)
57. The rise or fall of a liquid in a narrow tube is because of the A. viscosity of the liquid B. surface tension of the liquid. C. friction between the walls of the tube and the liquid D. osmotic pressure of the liquid. (2013:Q23)
58. The equation $P^aV^bT^c = \text{constant}$ reduces to Charles Law if A. $a = 1, b = 0$ and $c = -1$. B. $a = 0, b = 1$ and $c = 1$. C. $a = 0, b = 1$ and $c = 1$. D. $a = 1, b = 1$ and $c = 0$. (2014:Q21)
59. Calculate the temperature of 6 moles of an ideal gas at a pressure of $7.6 \times 10^6\text{Nm}^{-2}$ with a volume of 10^{-3}m^3 [$R = 8.3\text{Jmol}^{-1}\text{K}^{-1}$] A. 185°C B. 120°C C. 153°C D. 126°C (2015:Q12)
60. According to the kinetic theory, the kelvin temperature of an ideal gas is proportional to A. momentum B. kinetic energy C. velocity d. potential energy (2016:Q11)
61. Calculate the number of moles of an ideal gas of volume 12.0m^3 at a pressure of $6 \times 10^3\text{Nm}^{-2}$ and 27°C [$R = 8.0\text{Jmol}^{-1}\text{K}^{-1}$] A. 3.0 B. 1.5 C. 15.0 D. 30.0 (2017:Q15)

CHAPTER 14 ANSWER

- 1D. Particles of table salt diffuse from an area of higher concentration to that of lower concentration.
- 2C. $P \propto T$ (Gay-Lussac's pressure law)

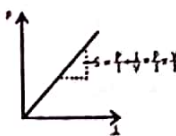
$$\rightarrow \frac{P}{T} = K \therefore \frac{P_1}{T_1} = \frac{P_2}{T_2} \rightarrow \frac{P}{27 + 273} = \frac{P_2}{77 + 273}$$

$$\therefore P_2 = \frac{350P}{300} = 1.166P$$

NOTE: For any problem involving gas laws, always use absolute temperature (K) rather than ($^\circ\text{C}$)

- 3D. Charles $\rightarrow V \propto T$ or $\frac{V}{T} = K$
Boyle's $\rightarrow P \propto \frac{1}{V}$ or $PV = K$
Gay-Lussac's $\rightarrow P \propto T$ or $\frac{P}{T} = K$

- 4C. When tube is upright $P_1 = \text{atm. } P + \text{pressure due to Hg column}$
 $P_1 = (H + 15)\text{cm}$ and $V_1 = 10A$ ($A = \text{cross-sectional area}$)
When tube is inverted: $P_2 = \text{Atm. } P - \text{Pressure due to Hg column}$
 $P_2 = (H - 15)\text{cm}$ and $V_2 = 15A$ But $P_1V_1 = P_2V_2$
 $\rightarrow (H + 15)10A = (H - 15)15A \rightarrow H = 75\text{cm}$
NOTE: If the tube is held horizontally then
 $P_2 = H$ (as Pressure due to mercury is negligible)
5E. $P_1 = 10 + 40 = 50\text{m}$ $V_1 = ?$ $P_2 = 10\text{m}$ $V_2 = 2.5\text{cm}^3$

- $P_1 V_1 = P_2 V_2 \rightarrow V_1 = \frac{10 \times 2.5}{50} \rightarrow V_1 = 0.5 \text{ cm}^3$
6. $T_1 = -133 + 273 = 140 \text{ K}$ $V_1 = 0.8 \text{ cm}^3$ $P_1 = 1.4 \times 10^5 \text{ Nm}^{-2}$
 $V_2 = 31 \text{ m}^3$ $T_2 = 273 + 37 = 310 \text{ K}$ $P_2 = ?$
- $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \Rightarrow P_2 = \frac{P_1 V_1 T_2}{V_2 T_1} \rightarrow P_2 = \frac{1.4 \times 10^5 \times 0.33 \times 310}{31 \times 140}$
 $P_2 = 3.3 \times 10^5 \text{ Nm}^{-2}$ No option is right
- 7D. See Qs 2 and 3
- 8D. Expansion connotes more available space for the molecules hence average intermolecular separation increases.
NOTE: The above also leads to reduced number of collisions of molecules with one another and with the wall of the container i.e reduced pressure - kinetic theory explains Boyle's law.
- 9B. Pressure reduces with height hence volume of balloon increases (Boyle's) such that PV is a constant (see Q3)
- 10A. $\frac{P}{T} = K$ (Gay Lussac's) $\rightarrow \frac{P_1}{T_1} = \frac{P_2}{T_2} \Rightarrow P_2 = \frac{150 \times 330}{300}$
 $P_2 = 165 \text{ cm Hg}$ $\therefore \Delta P = 165 - 150 = 15 \text{ cmHg}$
- 11E. Compare: $\frac{PV}{T} = P^x V^y T^z \rightarrow P^x V^y T^z = P^x V^y T^z \therefore x = 1$ $y = 1$ $z = -1$
- 12A. $P_2 = 2P_1$ $T_2 = T_1$ Using $\frac{P_2 V_2}{T_2} = \frac{P_1 V_1}{T_1}$ (General Gas Equation)
 or $V_2 = \frac{P_1 V_1 T_2}{P_2 T_1} \rightarrow \therefore V_2 = \frac{P_1 \times 100 \times \frac{1}{2} T_1}{2P_1 \times T_1}$ $V_2 = \frac{100}{4} = 25 \text{ cm}^3$
- 13C. Taking a cue from Q12
 $V_2 = \frac{V_1}{4} \rightarrow \therefore \% \text{ change in volume} = \frac{V_1 - V_2}{V_1} \times 100\%$
 $= \frac{V_1 - \frac{V_1}{4}}{V_1} \times 100\% = \frac{3V_1}{4V_1} \times 100\% = \frac{75}{100} = 75\%$
NOTE: From Q12, change is $100 - 25 = 75 \text{ cm}^3$
 $\therefore \% \text{ change} = \frac{75}{100} \times 100 = 75\%$
- 14E. $T_1 = 200 \text{ K}$ $P_1 = 1.5 \text{ atm}$ $P_2 = 4.5 \text{ atm}$ $V_2 = \frac{1}{2} V_1$ $T_2 = ?$
 $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \rightarrow \frac{1.5 \times V}{200} = \frac{4.5 \times \frac{1}{2} V_1}{T_2}$
 $T_2 = \frac{200 \times 4.5 \times \frac{1}{2} V_1}{1.5 \times V} = 300 \text{ K}$
 Now $C = T - 273$ $C = 300 - 273$ $C = 27^\circ \text{C}$
- 15C.  $\therefore \text{Slope} = PV = \text{Work done.}$
 To verify: $W = F \times S$ (Nm)
 Also $PV = \frac{F}{A} \times V = F \times h$ (Nm)
- 16D. Radiation is more or less a wave motion and cannot be explained away in particulate terms i.e radiant heat requires no intervening molecules for transfer (see chapter 7)
- 17C. $\frac{V_1}{T_1} = \frac{V_2}{T_2}$ (Charles's) $\rightarrow \frac{300}{273 + 27} = \frac{V_2}{273 + 54}$
 $V_2 = 327 \text{ cm}^3$
- 18D. $P_1 = P$ due to air $= 75 - 73.5 = 1.5 \text{ cm} = 8 \text{ cm}^3$ $V_2 = 6 \text{ cm}^3$
 $P_2 = ?$ $P_1 V_1 = P_2 V_2$ Boyle's $\rightarrow P_2 = \frac{1.5 \times 8}{6} = 2 \text{ cm}$
 Correct height $= 74 + 2 = 76 \text{ cm}$
NOTE: The air above the normal 75cm or 76cm offers a pressure that depresses the height to 73.5cm or 74cm respectively.
- 19C. P directly proportion to $\frac{1}{V}$ or P inversely proportional to V
- 20C. Work \rightarrow Energy (see Q15)
- 21A. $\frac{V_2}{T_2} = \frac{V_1}{T_1}$ (Charles's Law) $\frac{L_2}{273 + 100} = \frac{10}{273 + 27}$ ($V \propto L$)
 $L_2 = 12.43 \text{ cm}$
- 22A. $\frac{70 \times 1200}{280} = \frac{75 V_2}{300} \rightarrow V_2 = 1200 \text{ cm}^3$
- 23D. See chapter 13
- 24A. Their average kinetic energy declines i.e they move less energetically and collide with the walls of the container less frequently.

- 25A. $V \propto T$ (Charles's)
- 26C. See chapter 13
- 27C. When temperature increases volume of gas increases (Charles's law) hence its density decreases (from $P = \frac{m}{V}$)
 In other words: $P \propto \frac{1}{V}$
- 28B. $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \rightarrow \frac{P_1 \times 2}{1} = \frac{P_2 \times 1}{2} \rightarrow \therefore \frac{P_2}{P_1} = 4$
NOTE: This is a quicker way to work Q12 and some others like it i.e $V_1 = 1$ unit then $V_2 = 2$ units
 $T_1 = 2$ units then $T_2 = 1$ unit.
 You get the gist?
- 29B. $\frac{2 \times 10^5}{300} = \frac{P_2}{360}$ (Pressure law) $P_2 = 2.4 \times 10^5 \text{ Nm}^{-2}$
- 30C. Water contracts (reduces in volume) from 0°C to 4°C and then expands from 4°C onwards see chapter 13
- 31B. See Q19
- 32B. In other words, pressure reduces as the bubble approaches the top of the lake hence volume increases (according to Boyle's)
- 33B. Charles law $\rightarrow VT^{-1} = K$
 Now by comparison: $VT^{-1} = P^x V^y T^z$
 $P^x V^y T^z = VT^{-1}$ ($P^0 = 1$) $\rightarrow x = 0$ $y = 1$ and $z = -1$
- 34D. $\frac{3 \times 10^5}{27 + 273} = \frac{4 \times 10^5}{T_2}$ (Pressure law) $\rightarrow T_2 = 400 \text{ K}$
 But $C = T - 273$ $C = 400 - 273 = 127^\circ \text{C}$
NOTE: As equally applied in Q14, don't be tempted to pick (A) as your answer, it is not in Kelvin
- 35C. Since temperature is constant, the average kinetic energy is conserved and so also is the momentum (mv) while the decrease in pressure arises from the fact that it takes the molecules in the expanded container a longer time to collide with the walls of the container.
- 36C. $\frac{120}{T} = \frac{100}{300} \rightarrow T = 360 \text{ K} \rightarrow C = 360 - 273 = 87^\circ \text{C}$
- 37D. ...and are so small that the volume they occupy compared to the actual volume of the containing vessel is negligible.

OTHER ASSUMPTIONS OF THE THEORY

1. A gas has a large number of molecules which behave like elastic spheres.
 2. The molecules are in constant motion colliding with one another and with the walls of the container and the collision with the walls constitutes the gas pressure.
 3. Collisions of the gas molecules are perfectly elastic such that both kinetic energy and momentum are conserved.
 4. The particles possess kinetic energy due to their motion.
 5. The particles attract one another with a force which is very negligible.
 6. The temperature of the gas is a measure of its average kinetic energy.
- 38D. $P_1 V_1 = P_2 V_2$ Boyle's
 $P_0 \times 6 = P_2 \times 1$ (The alternative method in Q28) $P_2 = 5P_0$
- 39B. $V_1 = 30 \text{ cm}^3$ $P_1 = 75 \text{ cmHg}$
 $P_2 = 75 + 15 = 90$ (The arm exposed is higher - chapter 12)
 $P_2 V_2 = P_1 V_1 \rightarrow 90 V_2 = 75(30) \rightarrow V_2 = 25 \text{ cm}^3$
- 40B. $\frac{P_2 V_2}{T_2} = \frac{P_1 V_1}{T_1} \rightarrow \frac{120 V_2}{200} = \frac{300 V_1}{400}$
 Re-arranging $\frac{V_2}{V_1} = \frac{200 \times 300}{120 \times 400} \rightarrow V_2 : V_1 = 5:4$
- 41A. Work done = Pressure x Volume change: $W = P \Delta V$
 $W = 2 \times 10^6 (2 \times 10^6 - 2 \times 10^5) = 2 \times 10^6 \times 0.00001 = 2 \text{ J}$
- 42B. $PV = nRT$ (ideal gas equation) $\rightarrow P = \frac{nRT}{V}$

$$p = \frac{3 \times 8.3 \times 300}{10^1} = 7.47 \times 10^6 \text{Nm}^2$$

- 43B. Diffusion is the tendency of molecules of substances to fill an empty space owing to their random thermal motions. Osmosis is a special form of diffusion specifically applied to water only.
- 44A. I → In melting, the heat applied overcomes the intermolecular forces so that molecules are free to move about.
 II → In boiling, the intermolecular forces are further weakened and they become highly negligible.
 IV → Heat is transferred from one molecules to another as vibrations of these molecules from one end of a conductor to another during conduction.
 III → Refraction is wave property.
- 45B. $\text{Slope} = \frac{V}{I} \div \frac{1}{P} = \frac{V}{I} \times \frac{P}{1} \rightarrow \therefore \text{slope} = PV = \text{work (compare Q15)}$
- 46B. II → It follows that the lighter the gas, the slower it diffuses
 $r \propto \frac{1}{d^2}$ (Graham's law - Chemistry class)
 III → The higher the temperature, the higher its kinetic energy and hence its rate of diffusion.
 IV → By nature we mean the physical state of the substance as diffusion is fastest in gases, slowest in solids and intermediate in liquids. Besides different substances have different densities
 I → The mass of the gas we start with is inconsequential. The impetus for diffusion is simply the concentration gradient between two locations of reference.
- 47C. See Qs 15 and 45
- 48D. Solids → Molecules are most crowded together and the intermolecular forces are enormous.
 Gases → Molecules are enormously spaced out and intermolecular forces are negligible.
 Liquids → Intermediate between solids and gas.
- 49D. $\frac{V_2}{T_2} = \frac{V_1}{T_1} \rightarrow \frac{V_2}{308} = \frac{600}{300} \rightarrow V_2 = 616 \text{cm}^3$
- 50C. $PV = nRT$ where $n = \text{no of mole and } R = \text{Molar gas constant}$
 $10^2 P = 1 \times 8.3 \times (273 + 27) \rightarrow P = 2.49 \times 10^5$
- 51A. In such liquid Cohesion → Adhesion
- 52B. See Q3
- 53B. See Qs 16, 43 and 44
- 54C. $V_1 = 2000 \text{cm}^3$ $P_1 = 700 \text{mmHg}$ $T_1 = 300\text{K}$ $P_2 = \text{s.p.} = 760 \text{mmHg}$
 $T_2 = \text{s.t} = 273\text{K}$
 $\frac{P_2 V_2}{T_2} = \frac{P_1 V_1}{T_1} \rightarrow \frac{960 \times V_2}{273} = \frac{700 \times 2000}{300} \rightarrow V_2 = 1676.3 \text{cm}^3$
- 55D. Robert Brown, after whom the motion is named, even discovered the motion originally in liquid as his classical observation of bombardment of pollen grains by water molecules under a microscope.
- 56D. $W = P\Delta V = 10^5(1.2 - 0.6) = 6.0 \times 10^4$
- 57B. Capillarity is a function of the surface tension of the liquid. Note that capillarity is less with soap water than ordinary water i.e the lower the surface tension, the lesser the capillarity.
- 58B. Compare Q33
- 59A. $T = \frac{PV}{nR}$ (See Q50) → $T = \frac{7.6 \times 10^6 \times 10^{-3}}{6 \times 8.3} = 153\text{K} = 120$
- 60B See Q37
- 61D Compare Qs 50 and 59

CHAPTER 15

QUANTITY OF HEAT: HEAT CAPACITY AND LATENT HEAT

- The latent heat of fusion of ice is 80calg^{-1} . How much heat is required to change 10g of ice at 0°C into water at the same temperature? A. 80 cal B. 10 cal C. 8 cal D. 800 cal E. 400 cal. (1978:Q18)
- A blacksmith dropped a 2kg iron rod at 257°C into some quantity of water, raising its temperature from 20°C to 30°C .

- If the specific heat of iron is $0.11 \text{calkg}^{-1}^\circ\text{C}^{-1}$, the mass of the iron rod is A. 2.27kg B. 6.34kg C. 9.16kg D. 5.45kg E. 4.54kg (1978:Q19)
- The following are some units I. NS II. Nm III. Nm^{-2} IV. $^\circ\text{K}^{-1}$ V. Jkg^{-1} . What are the units of latent heat? A. 1 B. II C. III D. IV E. V (1978:Q21)
- The amount of heat required to raise the temperature of a body is A. thermal energy B. thermal condition C. heat lost D. specific heat capacity E. thermal capacity. (1978:Q24)
- All the heat generated in a 5 ohm resistor by 2A flowing for 30 seconds is used to evaporate 5g of a liquid at its boiling point. Which of the following is the correct value of the specific latent heat of the liquid? A. 120J B. 60Jg^{-1} C. 120Jg^{-1} D. 1500J E. 1500Jg^{-1} (1979:Q42)
- A given quantity of heat increases the temperature of 150grams of water from 9°C to 15°C and increases the temperature of an equal volume of oil weighing 100grams from 9°C to 25°C . The ratio of the specific heat of oil to that of water is A. 0.36 B. 0.46 C. 0.56 D. 0.76 E. 0.86 (1980:Q10)
- The latent heat of fusion of a substance is the heat required to A. raise the temperature of unit mass of the substance by 1°C B. maintain unit mass of the substance at constant temperature C. change unit mass of substance from solid to liquid at constant temperature D. change unit mass of liquid to vapour at constant temperature E. raise the temperature of unit mass by 100°C . (1981:Q3)
- When equal weights of iron and water are subjected to an equal supply of heat, it is found that the piece of iron becomes much hotter than water after a shorter time because A. the specific heat of iron is higher than that of water B. iron is in solid form C. water is in liquid form D. the specific heat of water is higher than that of iron E. the specific heat of iron is infinite. (1982:Q4)
- 250g of lead at 170°C is dropped into 100g of water at 0°C . If the final temperature is 12°C , the specific heat of lead is (specific heat capacity of water is $4,200\text{J/kg}^\circ\text{C}$) A. $39.5\text{J/kg}^\circ\text{C}$ B. $50.4\text{J/kg}^\circ\text{C}$ C. $127.6\text{J/kg}^\circ\text{C}$ D. $154.6\text{J/kg}^\circ\text{C}$ E. $173.4\text{J/kg}^\circ\text{C}$. (1982:Q17)
- A heater marked 50W will evaporate 0.005kg of boiling water in 50 seconds. The specific latent heat of vaporization of water in J/kg is A. 5.0×10^6 B. 1.0×10^6 C. 2.5×10^6 D. 2.5×10^5 E. 5.0×10^5 (1982:Q37)
- An electric current of 3A flowing through an electric heating element of resistance 20 embedded in 1 000g of an oil raises the temperature of the oil by 10°C in 10 seconds, then the specific heat capacity of the oil is A. 1.8J/g B. 0.6J/g C. $0.18\text{J/g}^\circ\text{C}$ D. $1.8\text{J/g}^\circ\text{C}$ E. $0.06\text{J/g}^\circ\text{C}$ (1983:Q38)
- All the heat generated in a 5-ohm resistor by 2A flowing for 30 seconds is used to evaporate 5g of liquid at its boiling point. Which of the following is the correct value of the specific latent heat of the liquid? A. 120J B. 60Jg^{-1} C. 120Jg^{-1} D. 1 500J E. $1 500\text{Jg}^{-1}$ (1984:Q13)
- Heat is supplied uniformly at the rate of 100W to $1.0 \times 10^{-2}\text{kg}$ of a liquid for 20seconds. If the temperature of the liquid rises by 5°C , then the specific heat capacity of the liquid is A. $2.0 \times 10^2\text{JK}^{-1}\text{K}^{-1}$ B. $2.0 \times 10^3\text{JK}^{-1}$ C. $4.0 \times 10^4\text{J Kg}^{-1}\text{K}^{-1}$ D. $4.0 \times 10^4\text{JKg}^{-1}\text{K}^{-1}$ E. $8.4 \times 10^3\text{JKg}^{-1}\text{K}^{-1}$ (1984:Q27)
- Two liquids, P at a temperature of 20°C and Q at a temperature of 80°C have specific heat capacities of $1.0\text{Jkg}^{-1}^\circ\text{C}^{-1}$ and $1.5\text{Jkg}^{-1}^\circ\text{C}^{-1}$ respectively. If equal masses of P and Q are mixed in a lagged calorimeter, then the equilibrium temperature is A. 44°C B. 50°C C. 56°C D. 60°C E. 70°C (1985:Q19)
- Two thermos flasks of volume V_1 and V_2 are filled with liquid water at an initial temperature of 0°C . After some time the temperatures were found to 0_1 , 0_2 respectively.

- Given that $V_1/V_2 = 2$ and $\theta_1/\theta_2 = 1/2$. The ratio of the heat flow into the flasks is A. $1/4$ B. $1/2$ C. 4 D. 1 E. 2 (1985:Q23)
16. The specific latent heat of fusion of lead is the amount of heat required to A. Melt lead at its melting point B. Heat a unit mass of lead through 1°C . C. Change the state of a unit mass lead at its melting point. D. Change the state of a unit mass of lead at its boiling point. (1986:Q20)
17. When two objects P and Q are supplied with the same quantity of heat, the temperature change in P is observed to be twice that of Q. The mass of P is half that of Q the ratio of the specific heat capacity of P to Q is A. 1: 4 B. 4: 1 C. 1: 1 D. 2: 1 (1986:Q25)
18. Hot water is added to three times its mass of water at 10°C and the resulting temperature is 20°C . What is the initial temperature of the hot water? A. 100°C B. 80°C C. 50°C D. 40°C (1987:Q21)
19. 22,000J of heat is required to raise the temperature of 1.5kg of paraffin from 20°C to 30°C . Calculate the specific heat capacity of paraffin A. $1466\text{Jkg}^{-1}\text{C}^{-1}$ B. $2933\text{Jkg}^{-1}\text{C}^{-1}$ C. $4400\text{Jkg}^{-1}\text{C}^{-1}$ D. $5866\text{Jkg}^{-1}\text{C}^{-1}$ (1987:Q22)
20. Calculate the amount of heat required to convert 2kg of ice at -2°C to water at 0°C . (Specific heat capacity of ice = $2090\text{Jkg}^{-1}\text{C}^{-1}$, specific latent heat of fusion = 333kJkg^{-1}). A. 666J B. 360J C. 666 000J D. 674 360J. (1987:Q23)
21. The amount of heat needed to raise the temperature of 10kg of copper by 1K is its A. Specific heat capacity B. Heat capacity C. Latent heat D. Internal energy. (1988:Q17)
22. A tap supplies water at 25°C while another supplies water at 75°C . If a man wishes to bathe with water at 40°C , the ratio of the mass of cold water to the mass of hot water required is A. 1:3 B. 15:8 C. 7:3 D. 3:1 (1988:Q18)
23. An electric heater is used to melt a block of ice, mass 1.5kg. If the heater is powered by a 12V battery and a current of 20A flows through the coil, calculate the time taken to melt the block of ice at 0°C . (Specific latent heat of fusion of ice = $336 \times 10^3\text{Jkg}^{-1}$). A. 76.0min B. 35.0min C. 21.0min D. 2.9 min. (1989:Q16)
24. 1kg of copper is transferred quickly from boiling water to a block of ice. Calculate the mass of ice melted, neglecting heat loss. [Specific heat capacity of copper = $400\text{Jkg}^{-1}\text{K}^{-1}$ and latent heat of fusion of ice = $333 \times 10^3\text{Jkg}^{-1}$]. A. 60g B. 67g C. 120g D. 133g (1990:Q18)
25. What is the difference in the amount of heat given out by 4kg of steam and 4kg of water when both are cooled from 100°C to 80°C ? [The specific latent heat of steam is 2260000Jkg^{-1} , specific heat capacity of water is $4200\text{Jkg}^{-1}\text{K}^{-1}$] A. 4 200J B. 2 260 000J C. 9 040 000J D. 9 380 000J (1991:Q17)
26. How long does it take a 750-W heater to rise the temperature of 1kg to water from 20°C to 50°C ? [Specific heat capacity of water = $4200\text{Jkg}^{-1}\text{K}^{-1}$] A. 84s B. 112s C. 168s D. 280s (1991:Q18)
27. How much heat is absorbed when a block of copper of mass 0.05kg and specific heat capacity $390\text{Jkg}^{-1}\text{K}^{-1}$ is heated from 20°C to 70°C ? A. $3.98 \times 10^4\text{J}$ B. $9.75 \times 10^2\text{J}$ C. $3.98 \times 10^3\text{J}$ D. $9.75 \times 10^3\text{J}$ (1992:Q17)
28. 200g of water at 90°C is mixed with 100g of water at 30°C . What is the final temperature? A. 50°C B. 60°C C. 70°C D. 80°C (1993:Q17)
29. The melting point of a solid is given at 80°C . If 10^5J of heat energy is required at this temperature to melt 10g of the solid, the specific latent heat of fusion of the solid is A. $1.00 \times 10^3\text{Jkg}^{-1}$ B. $1.25 \times 10^3\text{Jkg}^{-1}$ C. $1.00 \times 10^7\text{Jkg}^{-1}$ D. $8.00 \times 10^3\text{Jkg}^{-1}$ (1993:Q19)
30. When 100g of liquid L_1 at 78°C was mixed with Xg of liquid L_2 at 50°C , the final temperature was 66°C . Given that the specific heat capacity of L_2 is half that of L_1 , find X. A. 50g B. 100g C. 150g D. 200g (1994:Q22)
31. Heat is supplied to a test tube containing 100g of ice at its melting point. The ice melts completely in 1 min. what is the power rating of the source of heat? A. 336W B. 450W C. 560W D. 600 W (Latent heat of fusion of ice = 336Jg^{-1}) (1994:Q24)
32. An electric kettle with negligible heat capacity is rated at 2 000W. If 2.0kg of water is put in it, how long will it take the temperature of water to rise from 20°C to 100°C ? A. 420s B. 336s C. 168s D. 84s. [specific heat capacity of water = $4200\text{Jkg}^{-1}\text{K}^{-1}$]. (1995:Q22)
33. A quantity of ice at -10°C is heated until the temperature of the heating vessel is 90°C . Which of the following constant is NOT required to the vessel? A. Specific heat capacity of ice B. Specific heat capacity of water C. Specific latent heat of fusion D. Specific latent heat of vaporization. (1995:Q24)
34. Equal masses of copper and rubber are raised to the same temperature. After sometimes, the copper was observed to be at a lower temperature because A. the specific heat capacity of copper is lower than that of rubber B. copper expands more than rubber C. the specific heat capacity of rubber is lower than that of copper D. rubber expands more than copper (1997:Q21)
35. A mass of a liquid at 30°C is mixed with a mass of the same liquid at 70°C and the temperature of the mixture is 45°C . Find the ratio of the mass of the cold liquid to the mass of the other liquid. A. 3:5 B. 5:3 C. 3:7 D. 7:3 (1997:Q23)
36. A heating coil rated at 1000W is used to boil off 0.5 kg of boiling water. The time taken to boil off the water is A. $1.15 \times 10^3\text{s}$ B. $1.15 \times 10^7\text{s}$ C. $1.15 \times 10^6\text{s}$ D. $1.15 \times 10^5\text{s}$ [Specific latent heat of vaporization of water = $2.3 \times 10^6\text{Jkg}^{-1}$] (1997:Q24)
37. What happens when a certain quantity of pure ice is completely changed to water at 0°C ? A. Latent heat is absorbed, the mass remains constant and the volume decreases. B. Latent heat is given out, the mass remains constant and the volume decreases. C. Latent heat is given out, the mass increases and the volume remains constant. D. Latent heat is absorbed, the mass decreases and the volume increases. (1997:Q25)
38. A 500W heater is used to heat 0.6kg of water from 25°C to 100°C in t_1 seconds. If another 1000W heater is used to heat 0.2kg of water from 10°C to 100°C in t_2 seconds, find t_1/t_2 A. 50 B. 5 C. $5/4$ D. $1/5$ (1998:Q20)
39. How many grams of water at 17°C must be added to 42g of ice at 0°C to melt the ice completely? A. 200g B. 300g C. 320g D. 400g [Specific latent heat of fusion of ice = $3.4 \times 10^5\text{Jkg}^{-1}$, Specific heat capacity of water = $4200\text{Jkg}^{-1}\text{K}^{-1}$] (1998:Q21)
40. A piece of substance of specific heat capacity $450\text{Jkg}^{-1}\text{K}^{-1}$ falls through a vertical distance of 20m from rest. Calculate the rise in temperature of the substance on hitting the ground when all its energies are converted into heat. A. $2/9^\circ\text{C}$ B. $4/9^\circ\text{C}$ C. $9/4^\circ\text{C}$ D. $9/2^\circ\text{C}$ (1999:Q11)
41. Calculate the mass of ice that would melt when 2kg of copper is quickly transferred from boiling water to a block of ice without heat loss A. $8/33\text{kg}$ B. $33/80\text{kg}$ C. $80/33\text{kg}$ D. $33/8\text{kg}$ [Specific heat capacity of copper = $400\text{Jkg}^{-1}\text{K}^{-1}$; Latent heat of fusion of ice = $3.3 \times 10^5\text{Jkg}^{-1}$] (1999:Q24)
42. A 2 000W electric heater is used to heat a metal object of mass 5kg initially at 10°C . If a temperature rise of 30°C is obtained after 10min, the heat capacity of the material is A. $6.0 \times 10^4\text{J}^\circ\text{C}^{-1}$ B. $4.0 \times 10^4\text{J}^\circ\text{C}^{-1}$ C. $1.2 \times 10^4\text{J}^\circ\text{C}^{-1}$ D. $8.0 \times 10^4\text{J}^\circ\text{C}^{-1}$ (2003:Q25)
43. A 50W electric heater is used to heat a metal block of mass 5kg. If in 10 minutes a temperature rise of 12°C is achieved, the specific heat capacity of the metal is A. $500\text{Jkg}^{-1}\text{K}^{-1}$ B. $130\text{Jkg}^{-1}\text{K}^{-1}$ C. $390\text{Jkg}^{-1}\text{K}^{-1}$ D. $400\text{Jkg}^{-1}\text{K}^{-1}$ (2004:Q39)
44. 10^5J of heat is required to boil off completely 2kg of a

- certain liquid. Neglecting heat lost to the surroundings, the latent heat of vaporization of the liquid is A. $5.0 \times 10^5 \text{Jkg}^{-1}$. B. $2.0 \times 10^5 \text{Jkg}^{-1}$. C. $5.0 \times 10^6 \text{Jkg}^{-1}$. D. $2.0 \times 10^6 \text{Jkg}^{-1}$. (2005:Q45)
45. An immersion heater rated 2.0A, 240V is used to boil water from temperature 52°C to 100°C . If the mass of the water is 2.5kg, determine the time taken to boil the water. A. 1.05 x 10^4 s. B. 1.05×10^5 s. C. 1.05×10^6 s. D. 1.05×10^7 s. (2006:Q43)
46. A drop of petrol makes a finger colder than a drop of water would because A. petrol take its latent heat of fusion from the finger B. petrol takes its latent heat of vaporization from the finger. C. water has higher surface tension D. water is more viscous than petrol. (2006:Q45)
47. 2kg of water is heated with a heating coil which draws 3.5 A from a 200V mains for 2 minutes. What is the increase in temperature of the water? A. 25°C B. 15°C C. 10°C D. 30°C [Specific heat capacity of water = $4200 \text{Jkg}^{-1}\text{K}^{-1}$] (2007:Q40)
48. A block of aluminium is heated electrically by a 25 W heater. If the temperature rises by 10°C in 5 minutes, the heat capacity of the aluminium is A. 850JK^{-1} B. 750JK^{-1} C. 650JK^{-1} D. 500JK^{-1} (2008:Q22)
49. An electric heater 220V, 1000W is immersed into a bucket full of water. Calculate the mass of water if the temperature changes from 30°C to 100°C and the current flows for 300 seconds. A. 428kg. B. 42.86kg. C. 1.02kg. D. 7.14kg. [specific heat capacity of water = $4200 \text{Jkg}^{-1}\text{K}^{-1}$] (2009:Q21)
50. A heating coil rated 1000 W is used to boil off completely 2kg of boiling water. The time required to boil off the water is A. 1.15×10^4 s. B. 1.15×10^3 s. C. 4.6×10^4 s. D. 4.6×10^3 s. [specific latent heat of vaporization of water = $2.4 \times 10^6 \text{Jkg}^{-1}$] (2009:Q23)
51. A block of aluminium is heated electrically by a 30W heater. If the temperature rises by 10°C in 5 minutes, the heat capacity of the aluminium is A. 100JK^{-1} B. 200JK^{-1} C. 900JK^{-1} D. 90JK^{-1} (2011:Q16)
52. Calculate the temperature change when 500J of heat is supplied to 100g of water. A. 12.1°C B. 2.1°C C. 1.2°C D. 0.1°C [specific heat capacity of water = $4200 \text{Jkg}^{-1}\text{K}^{-1}$] (2012:Q22)
53. The quantity of heat energy required to melt completely 1kg of ice at -30°C is A. $4.13 \times 10^6 \text{J}$ B. $4.13 \times 10^5 \text{J}$ C. $3.56 \times 10^4 \text{J}$ D. $3.56 \times 10^3 \text{J}$ [latent heat of fusion = $3.5 \times 10^5 \text{Jkg}^{-1}$ specific heat capacity of ice = $2.1 \times 10^3 \text{Jkg}^{-1}\text{K}^{-1}$] (2012:Q24)
54. Two liquids X and Y having the same mass are supplied with the same quantity of heat. If the temperature rise in X is twice that of Y, the ratio of specific heat capacity of X to that of Y is A. 2:1. B. 1:2. C. 4:1 D. 1:4 (2013:Q19)
55. The quantity of heat needed to raise the temperature of a body by 1K is the body's A. internal energy. B. specific heat. C. latent heat of fusion. D. heat capacity. (2014:Q22)
56. A block of aluminium of mass m is heated electrically by 25W heater. If the temperature rises by 10°C in 5 minutes. Calculate the heat capacity of the aluminium A. 750JK^{-1} B. 1250JK^{-1} C. 125JK^{-1} D. 50JK^{-1} (2015:Q14)
57. Calculate the energy required to raise the temperature of a liquid of mass 15kg from 50°C to 100°C [specific heat capacity of the liquid = $960 \text{Jkg}^{-1}\text{K}^{-1}$] (2016: Q8)
58. The quantity of heat required to raise the temperature of unit mass of a substance through unit temperature is A. specific heat capacity B. specific heat of fusion C. specific heat of fission D. specific heat of sublimation (2017:Q3)
59. Water of mass 120g at 50°C is added to 200g of water at 0°C and the mixture is well stirred. Calculate the temperature of the mixture. [Neglect heat losses to the surroundings] a. 60°C B. 40°C C. 25°C D. 10°C (2018:Q11)
60. A 500W heater is used to heat 0.6kg of water from 25°C to 100°C in t_1 seconds. If another 1000W heater is used to heat 0.2kg of water from 10°C to 100°C in t_2 seconds, find $\frac{t_1}{t_2}$ A. 50 B. 5 C. $\frac{4}{5}$ D. $\frac{1}{5}$ (2018:Q37)

61. Calculate the mass of ice that would melt when 2kg of copper is quickly transferred from boiling water to a block of ice without heat loss [Specific heat capacity of copper $400 \text{Jkg}^{-1}\text{K}^{-1}$, latent heat of fusion of ice $3.3 \times 10^5 \text{Jkg}^{-1}$]
A. $\frac{8}{33} \text{kg}$ B. $\frac{33}{80}$ C. $\frac{80}{33}$ D. $\frac{33}{8}$ (2018: Q39)

CHAPTER 15 ANSWERS

- 1D. $Q = m\ell = 10 \times 80 = 800 \text{cal}$
2. A poorly framed question hence this problem is insoluble.
3E. Latent Heat = $\frac{\text{Quantity of heat}}{\text{Mass of substitution}} \rightarrow \frac{\text{J}}{\text{Kg}} \rightarrow \text{Jkg}^{-1}$
4E. The thermal or heat capacity is the amount of heat (Q) required to elevate the temperature of the entire mass of a body through 1K or 1°C
 $C = \frac{Q}{\theta} \dots \dots$ (i) where $\theta = \theta_2 - \theta_1$ unit $\rightarrow \frac{\text{J}}{\text{K}}$ or Jk^{-1}
The specific thermal or heat capacity raises the temperature of only a unit mass (1kg) of the same body through a unit temperature (1K or 1°C)
 $C = \frac{Q}{m\theta} \dots \dots$ (ii) unit $\rightarrow \frac{\text{J}}{\text{Kkg}} \rightarrow \text{Jkg}^{-1}\text{K}^{-1}$
Combining (i) and (ii): $C = cm \dots \dots$ (iii)
5C. $Q = m\ell = I^2Rt \rightarrow 0.005 \times \ell = 22 \times 5 \times 30$
 $\ell = 120000 \text{Jkg}^{-1} = 120 \text{Jg}^{-1}$
NOTE:
1. Electrical energy is converted to heat energy that vapourizes the liquid.
2. Electrical energy and power (chapter 27) are given by
I. $E = IVt$; $P = IV$
II. $E = I^2Rt$; $P = I^2R$
III. $E = \frac{V^2t}{R}$; $P = \frac{V^2}{R}$
IV. $E = Pt$
6C. $c = \frac{Q}{m\theta} \rightarrow \therefore \frac{c_0}{c_w} = \frac{Q}{m\theta} \times \frac{m_0}{Q}$
 $\frac{c_0}{c_w} = \frac{150 \times (15 - 9)}{100 \times (25 - 9)} \rightarrow \frac{c_0}{c_w} = 0.5625$
7C. Latent heat of fusion \rightarrow Solid to liquid
Latent heat of vapourization \rightarrow Liquid to gas
NOTES:
1. The term "latent" means "hidden" because temperature remains constant while melting or vapourization lasts and temperature rise is the best evidence of application of heat
2. The two major effects of heat namely "change in temperature" and "change of state" do not occur simultaneously unless the substance is impure.
8D. This means that higher quantity of heat is required in water to cause the same temperature rise in iron hence longer time in water than iron.
9C. Heat lost by hot body = Heat gained by cold body
Or $Q = m_{pb} \times c_{pb} \times \theta_{pb} = m_w \times c_w \times \theta_w$
 $\therefore 0.25 \times c \times (170 - 12) = 0.1 \times 4200 \times (12 - 0)$
 $c = 127.6 \text{Jkg}^{-1}\text{K}^{-1}$
NOTES:
1. Don't convert $^\circ\text{C}$ to k and vice versa, it is not necessary
 $1 \text{Jkg}^{-1}\text{K}^{-1} = 1 \text{Jkg}^{-1}\text{K}^{-1}$
2. $\frac{\text{hot body}}{170^\circ\text{C}} \xrightarrow{c_1 = 1500} \text{mixture } 12^\circ\text{C} \xrightarrow{c_2 = 17^\circ\text{C}} \text{cold body}$
Hence hot and cold bodies have a common temperature
10E. $Q = m\ell = Pt \rightarrow 0.005\ell = 50 \times 50 \rightarrow \ell = 5 \times 10^5 \text{Jkg}^{-1}$
11C. $mc\theta = I^2Rt \rightarrow 1000 \times c \times 10 = 32 \times 20 \times 10$
 $c = 0.18 \text{Jg}^{-1}\text{K}^{-1}$

12C. $ml = Jt \rightarrow 5 \times l = 22 \times 5 \times 30 \rightarrow l = 120Jg^{-1}$
 NOTE: This is Q6 repeated and you can achieve the same result by using 5g directly in the calculation instead of 0.005kg so as to obtain your answer in Jg^{-1} directly.

13C. $mc\theta = Pt \rightarrow c = \frac{100 \times 20}{1.0 \times 10^{-3} \times 5} \rightarrow c = 4.0 \times 10^4 Jkg^{-1}K^{-1}$

14C. Let the equilibrium temperature = t
 $Q = m_p c_p \theta_p = m_q c_q \theta_q \rightarrow m_p \times 1 \times (t - 20) = m_q \times 1.5 \times (80 - t)$
 $t - 20 = 1.5(80 - t)$ and $t = 56^\circ C$ (Recall: $m_p = m_q$)

15D. $Q_x = V_x c_x \theta_x$ (V m) $\rightarrow Q_x = V_x c_x \theta_x \therefore Q_x : Q_y = \frac{V_x c_x \theta_x}{V_y c_y \theta_y}$

But $C_x = C_y$ (since both are water)

$\therefore \frac{Q_x}{Q_y} = \frac{V_x}{V_y} \times \frac{\theta_x}{\theta_y} = 2 \times \frac{1}{2} = 1$

16C. See Q8

17C. $Q_p = Q_q \rightarrow m_p c_p \theta_p = m_q c_q \theta_q \rightarrow 1 \times c_p \times 2 = 2 \times c_q \times 1 \rightarrow c_p = c_q$
 Remember chapter 14 Q28?

18C. Let the initial temperature of hot water = x
 Heat lost by hot water: $Q_1 = mc(x - 20) \dots (i)$
 Heat gained by cold water: $Q_2 = 3mc(20 - 10) \dots (ii)$
 But $Q_1 = Q_2 \rightarrow mc(x - 20) = 30mc \rightarrow x = 50^\circ C$

19A. $c = \frac{Q}{m\theta} = \frac{22000}{1.5 \times 10^{-3} \times 10} = 1466.6 Jkg^{-1}C^{-1}$

20D. $\text{ice} \xrightarrow{-2^\circ C} \text{ice} \xrightarrow{0^\circ C} \text{ice} \xrightarrow{0^\circ C} \text{ml} \xrightarrow{0^\circ C} \text{water}$
 To raise temperature from -2 to $0^\circ C$:
 $Q_1 = mc\theta = 2 \times 2090 \times [0 - (-2)] = 8360J$
 To melt ice at its melting point $0^\circ C$:
 $Q_2 = m_l = 2 \times 333000 = 666000J$
 Total = $Q_1 + Q_2 = 8360 + 666000 = 674360J$

21B. Raising the temperature of the entire mass through $1K$ - See Q4

22C. $m_1 c_1 \theta_1 = m_2 c_2 \theta_2 \rightarrow m_1(40 - 25) = m_2(75 - 40) [(c_1 = c_2)]$
 $\therefore \frac{m_1}{m_2} = \frac{35}{15} \rightarrow m_1 : m_2 = 7 : 3$

23B. $Q = m_l = 1Vt \rightarrow 1.5 \times 336 \times 10^3 = 12 \times 20 \times t$
 $\therefore t = 2081.255 = 34.7min$

24C. $m_c c_c \theta_c = m_l l_f \rightarrow 1 \times 400 \times (100 - 0) = m \times 333000$
 $\therefore m = 0.12kg = 120g$

- NOTES:
 1. Temperature of boiling water = $100^\circ C$
 2. Temperature of ice just melted = $0^\circ C$

25C. Heat loss by steam:
 $Q_1 = m_l + mc\theta = 4 \times 2260000 + 4 \times 4200 \times 20 = 9376000J$
 Heat loss by hot water: $Q_2 = mc\theta = 4 \times 4200 \times 20 = 336000J$
 Heat difference = $Q_1 - Q_2 = 9040000J$

- NOTES:
 1. The steam is first converted to water at $100^\circ C$ by losing heat equal to (m_l) and then cooled from $100^\circ C$ to 80° by heat loss equal to $mc\theta$
 2. The results above explain the reason why the burning effect of steam at $100^\circ C$ on the body is far greater than that of hot water at $100^\circ C$

26C. $Pt = mc\theta \rightarrow 750t = 1 \times 4200(50 - 20) \rightarrow t = 108s$

27B. $Q = mc\theta = 0.05 \times 390 \times (70 - 20) = 975J$

28C. $m_1 c_1 \theta_1 = m_2 c_2 \theta_2 \rightarrow 0.2 \times (90 - \theta) = 0.1(\theta - 30) \rightarrow \theta = 70^\circ C$

29C. $m_l = Q \rightarrow 0.01 \times l = 10^5 \rightarrow l = 10^7 Jkg^{-1}$

NOTE: The temperature $80^\circ C$ is not part of the equation.

30C. $m_1 c_1 \theta_1 = m_2 c_2 \theta_2 \rightarrow 100 \times 2 \times (78 - 66) = X \times 1 \times (66 - 50)$
 $16x = 200 \times 12 \rightarrow x = 150$

31C. $Pt = m_l \rightarrow P \times 1 \times 60 = 100 \times 336 \rightarrow P = 560W$

NOTE: Jg^{-1} is compliant with g

32B. $Pt = mc\theta \rightarrow 2000t = 2 \times 4200 \times 80 \rightarrow t = 336s$

33D. $\text{ice} \xrightarrow{-10^\circ C} \text{ice} \xrightarrow{0^\circ C} \text{ice} \xrightarrow{0^\circ C} \text{ml} \xrightarrow{0^\circ C} \text{water} \xrightarrow{90^\circ C} \text{water}$

c_i = specific heat capacity of ice
 l = specific latent heat of fusion of ice
 c_w = specific heat capacity of water

34A. To raise them to the same temperature, rubber requires more heat ($C_r > C_c$); it takes rubber longer time to lose this larger amount of heat than would copper:
 $C_{rubber} = 2010 Jkg^{-1}K^{-1} \rightarrow C_{copper} = 390 Jkg^{-1}K^{-1}$

35B. $m_c(45 - 30) = m_h(70 - 45)$ [c is the same]: $\frac{m_c}{m_h} = \frac{25}{15} = \frac{5}{3}$

36D. $Pt = m_l \rightarrow 100t = 0.5 \times 2.3 \times 10^6 \rightarrow t = 1150s$

37A. A solid melts by absorbing its latent heat but its liquid freezes by giving off the same latent heat; mass is always a constant if there is no loss of substance e.g spilling; water, for one, contracts on melting but expands on freezing - anomalous behaviour of water.

38B. Using $Pt = mc\theta \rightarrow 500t_1 = 0.6 \times c \times (100 - 25)$
 $500t_1 = 45c \dots (i)$ Similarly, $1000t_2 = 18c \dots (ii)$

Dividing (i) by (ii): $\frac{500t_1}{1000t_2} = \frac{45c}{18c} \rightarrow \frac{t_1}{t_2} = 2 \times \frac{5}{2} = 5$

39A. $m_1 c \theta_1 = m_2 l \rightarrow m_1 \times 4200 \times (17 - 0) = 42 \times 3.4 \times 10^5$
 $\rightarrow m = 200g$

40B. PE = Heat energy $\rightarrow mgh = mc\theta$
 $10 \times 20 = 450\theta$ (m is constant) $\theta = \frac{200}{450} = \frac{4}{9}$

41A. $(m_l)_{water} = (mc\theta)_{copper} \rightarrow 3.3 \times 10^5 m = 2 \times 400 \times (100 - 0)$
 $m = \frac{80000}{330000} = \frac{8}{33}$

42D. $mc\theta = Pt \rightarrow 5 \times c \times 30 = 200 \times 10 \times 60 \rightarrow c = 8000 Jkg^{-1}K^{-1}$

43A. $5 \times c \times 12 = 50 \times 10 \times 60 \rightarrow c = 500 Jkg^{-1}K^{-1}$

44A. $m_l = Q \rightarrow 2l = 10^6 \rightarrow l = 500000 Jkg^{-1}$

45C. $lVt = mc\theta \rightarrow 2 \times 240 \times t = 2.5 \times 42 \times 10^3 \times (100 - 52); t = 1050s$

46B. As low as the temperature of the finger is, it is enough to be equal or greater than the low latent heat of vapourization of petrol and this accounts for the higher volatility of petrol... recall that evaporation causes cooling

47C. $mc\theta = lVt \rightarrow 2 \times 4200 \times \theta = 3.5 \times 200 \times 2(60); \theta = 10^\circ C$

48B. $mc\theta = Pt \rightarrow mc \times 10 = 25 \times 5(60) \rightarrow cm = 750$
 But $C = cm$ (see Q4) $\therefore C = 750 Jk^{-1}$

49C. $mc\theta = Pt \rightarrow m \times 4200 \times 70 = 1000 \times 300 \rightarrow m = 1.02kg$

50D. $Pt = m_l \rightarrow 1000t = 2 \times 2.3 \times 10^6 \rightarrow t = 4.6 \times 10^3 s$

51C. Taking a cue from Q48:
 $C\theta = Pt \rightarrow C \times 10 = 30 \times 5 \times 60 = 900 Jk^{-1}$

52C. $mc\theta = Q \rightarrow 0.1 \times 4200 \times \theta = 50^\circ \rightarrow \theta = 1.19^\circ C$

53B. $Q = mc\theta + m_l = 1 \times 2.1 \times 10^3 \times 30 + 1 \times 3.5 \times 10^5 = 4.13 \times 10^5$

54B. $m_x c_x \theta_x = m_y c_y \theta_y \rightarrow$ But $m_x = m_y \theta_x = 2 \theta_y = 1$
 $2c_x = c_y \rightarrow \therefore \frac{c_x}{c_y} = \frac{1}{2}$

55D. See Q4

56. $mc\theta = Pt \rightarrow mc = \frac{Pt}{\theta} = \frac{25 \times (5 \times 60)}{10} = 750 Jk^{-1}$
 But $C = cm \therefore C = 750 Jk^{-1}$

57A. $mc\theta = 15 \times 960 \times (100 - 50) = 720000J$

58A. See Q4

59. Let the temperature of mixture = t
 But heat lost = Heat gained
 $m_h c_h \theta_h = m_c c_c \theta_c$ (where the subscripts "h" and "c" stand for "hot" and "cold" respectively)
 But $m_h \theta_h = m_c \theta_c$ (As $c_h = c_c = c_{water}$)
 $120(50 - t) = 200(t - 0)$ and $t = 18.75^\circ C$ (No correct option)

60. For the first heater: $P_1 t_1 = m_1 c_1 \theta_1 \rightarrow 500 t_1 = 0.6 \times c_1 \times (100 - 25)$
 $\rightarrow t_1 = 0.09 c_1$
 For the second heater: $t_2 = 0.018 c_2$
 $\therefore \frac{t_1}{t_2} = \frac{0.090 c_1}{0.018 c_2} \rightarrow \frac{t_1}{t_2} = 5 [c_1 = c_2 = c_{\text{water}}]$
- 61A. See Q41

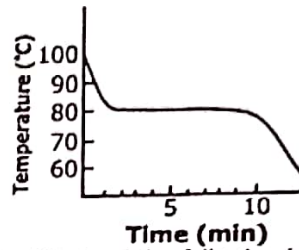
CHAPTER 16

CHANGE OF STATE. VAPOURS

- The statements below were made by some students describing what happened during the determination of the melting point of solids. 1. The temperature of the solid was constant until melting started. 2. The temperature of the solid rose until melting started. 3. During melting, the temperature was rising. 4. During melting, the temperature was constant. 5. The temperature continued to rise after all solid had melted. 6. The temperature stopped rising after all the solid had melted. Which of the following gives correct statements in the right order? A. 2, 4 and 5 B. 2, 3 and 6 C. 1, 3 and 6 D. 1, 3 and 5 E. 1, 4 and 5 (1978:Q15)
- The temperature at which the water vapour present in the air saturates the air and begins to condense is known as A. boiling point B. melting point C. triple point D. dew point E. critical temperature. (1979:Q5)
- When the vapour of a substance is in equilibrium with its own liquid, it is said to be A. gaseous B. unsaturated C. liquefied D. diffused E. saturated (1979:Q10)
- A pressure cooker saves both time and fuel in cooking because inside the cooker, the A. boiling point of water is raised B. pressure is constant C. heat is completely trapped D. temperature is evenly distributed E. volume of steam varies (1980:Q16)
- Heat is supplied to a block of ice at 0°C until half of it has melted. Which of the following statement is true? A. The temperature rises and the ice expands B. The temperature remains constant and the volume of ice decreases C. The ice gives out heat as it melts D. The mass remains constant and the temperature increases E. The mass decreases because some heat is lost to the atmosphere. (1980:Q32)
- A vapour is said to be saturated when A. more molecules return to the liquid than leave it B. a dynamic equilibrium exists between the liquid molecules and the vapour molecules at a given temperature C. the vapour pressure is atmospheric D. the temperature of the vapour varies E. all molecules are moving with the same speed. (1981:Q2)
- Heat was supplied to a block of ice at 0°C until half of it melted. Which of the following statements is true? A. The temperature rises and the ice expands B. The temperature remains constant and the volume of the ice decreases. C. The ice gives out heat as it melts and the temperature decreases D. The mass remains constant and the temperature increases E. The temperature decreases because some heat is lost. (1981:Q16)
- Change of state is accompanied by change of A. temperature B. volume C. heat content D. temperature and volume E. volume and heat content (1981:Q37)
- Which of the following may be used to determine relative humidity in a physics laboratory? I. Manometer II. Wet-and-dry bulb hygrometer III. Hair hygrometer IV. A hydrometer A. I only B. II and III only C. II only D. III only E. II, III and IV only (1983:Q44)
- Dew point is the temperature at which water vapour in the atmosphere A. Turns into steam B. Solidifies into ice pellets C. First condenses into liquid form D. Is just sufficient to cause cooling E. Has a relative of fifty percent. (1984:Q17)
- If a solid changes directly into a gas when heat is applied the process is called A. Vaporization B. Evaporation C. Sublimation D. Ionization E. Conversion. (1984:Q19)
- Which of the following statements is NOT correct? A. Boiling

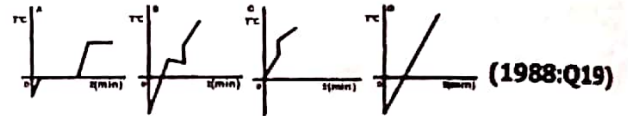
occurs when the saturated vapour pressure of the liquid involved equals the external pressure. B. Both the boiling point and the saturated vapour pressure of a given liquid depend on the external pressure. C. The saturated vapour pressure rises with increase in temperature. D. The saturated vapour pressure is independent of the volume available for the vapour. E. It is possible to boil water at a lower temperature than 100°C at high altitude. (1985:Q25)

13. In an experiment in which molten naphthalene is allowed

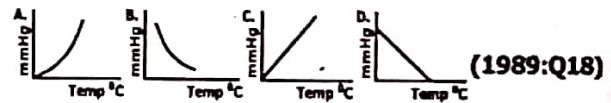


to cool. The cooling curve in the figure 5 was obtained. The temperature 80°C is known as the A. Cooling temperature B. Boiling point C. Melting point D. Vaporization point (1986:Q19)

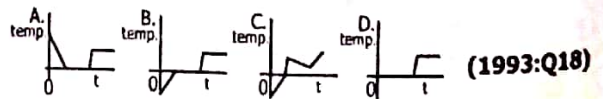
- Which of the following is common to evaporation and boiling? They A. Take place at any temperature. B. Are surface phenomena. C. Involve change of state D. Take place at a definite pressure. (1986:Q21)
- Which of the following graphs clearly illustrates the temperature change which takes place as a piece of ice at -10°C is heated slowly?



- Which of the following correctly represents the variation of the saturated vapour pressure of water with temperature?



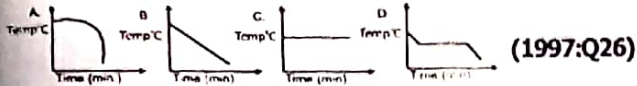
- Which of the following conditions will make water boil at a temperature of 100°C when the atmospheric pressure is 750mm Hg? A. Increase the external pressure B. Reduce the external pressure C. Heat more rapidly at the same pressure. D. Reduce the external pressure by a quarter. (1990:Q19)
- The saturated vapour pressure of a liquid increases as the A. Volume of the liquid increases B. Volume of the liquid decreases C. Temperature of the liquid increases D. Temperature of the liquid decreases (1991:Q20)
- A block of ice floats on water inside a container. If the block of ice gets completely melted, the level of water in the container will A. Increase B. Remain the same C. Decrease D. First decrease and then increase (1992:Q18)
- A block of ice at 0°C is put in an open vessel and heated uniformly until half the water boils off. Which of the following graphs best illustrates the change in temperature during the process?



- If a room is saturated with water vapour, the temperature of the room must be A. at 0°C B. above the dew point C. at 100°C D. below or at the dew point (1994:Q25)
- Which of the following statements give the TRUE differences between evaporation and boiling I. Evaporation occurs at all temperatures while boiling occurs at a fixed temperature for a given pressure. II. Evaporation is a surface phenomenon while boiling is an interior phenomenon. III. Evaporation is affected by surface areas which boiling is not. A. I and II only B. I and III only C. II

and III only D. I, II and III. (1995:Q25)

23. The correct cooling curve for a molten substance such as naphthalene is represented by



24. A vapour is said to be saturated when A. More molecules return to the liquid than the amount that left it. B. A dynamic equilibrium exist between the molecules of the liquid and the vapour molecules at a given temperature. C. The vapour pressure is equal to the atmospheric pressure D. All molecules are moving with the same speed in all directions at a given temperature. (1998:Q22)
25. I. A liquid boils when its saturated vapour pressure is equal to the external pressure. II. Dissolved substances in pure water lead to increase in the boiling point. III. When the external pressure is increased, the boiling point increases. IV Dissolved substances in pure water decrease the boiling point. Which combination of the above are peculiarities of the boiling point of a liquid? A. I, II and III B. I, II, III and IV C. I, II and IV D. II, III and IV. (1999:Q16)
26. The readings above are for three consecutive days from a wet

| | Day 1 | Day 2 | Day 3 |
|-----|-------|-------|-------|
| Dry | 30°C | 29°C | 25°C |
| Wet | 22°C | 22°C | 21°C |

and dry bulb hygrometer. It can be concluded that the relative humidity for the three days A. Increased steadily B. Remained unchanged C. Was least on day 1 D. Decrease steadily (2000:Q15)

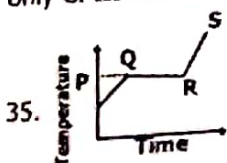
27. A thin wire with heavy weights attached to both ends is hung over a block of ice resting on two supports. If the wire cuts through the ice block while the block remains solid behind the wire, the process is called A. Fusion B. Sublimation C. Condensation D. Regelation. (2000:Q26)
28. Blowing air over a liquid aids evaporation by A. increasing its temperature B. increasing its surface area C. decreasing its density D. decreasing its vapour pressure (2002:Q20)

29.

| T°C | 0 | 5 | 10 | 15 | 20 | 40 | 60 |
|--------------|------|------|------|-------|-------|-------|--------|
| S.V.P.(mmHg) | 4.58 | 6.51 | 8.94 | 12.67 | 17.50 | 55.10 | 149.00 |

The table above shows the situation vapour pressure against temperature in a certain town. If the vapour pressure in this town at 20°C is 10mmHg, what is the relative humidity? A. 170.0% B. 57.0% C. 17.5% D. 10.0% (2003:Q14)

30. The phenomenon where by the water droplets in the atmosphere combine with dust particles in the air to reduce visibility is A. cloud B. mist C. hail D. fog. (2003:Q22)
31. When the temperature difference between the wet and dry bulbs of a hydrometer is high, this indicates that A. it is about to rain. B. there is plenty of sunshine. C. the relative humidity is low. D. the relative humidity is high. (2005:Q41)
32. The process whereby a liquid turns spontaneously into vapour is called A. evaporation. B. regelation. C. boiling. D. sublimation. (2005:Q50)
33. At low humidity in an environment, the human skin is usually A. dry and smooth. B. damp and smooth. C. damp and rough. D. dry and rough. (2006:Q49)
34. I. Increase the melting point of the liquid. II. Increase the boiling point of the liquid. III. Decrease the melting point of the liquid. IV. Decrease the boiling point of the liquid. Which of the statements above about the effects of increase in pressure in a liquid are correct? A. II and III only B. I and II only C. III and IV only D. I and III only. (2007:Q35)

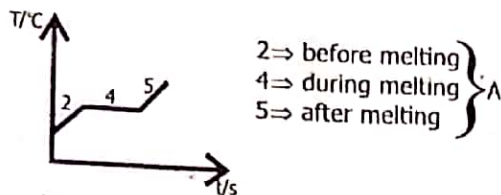


The diagram above is the heating curve for a solid. QR is the A. melting region B. boiling region. C. sublimation region. D. evaporating process. (2008:Q23)

36. If the partial pressure of water vapour at 27°C is 18mm Hg and the saturated vapour pressure of the atmosphere at the same temperature is 24 mm Hg, the relative humidity at this temperature is A. 25%. B. 33%. C. 75%. D. 82% (2008:Q24)
37. If a container is filled with ice to the brim, what happens to the level of water when the ice completely melts? A. The water in the glass outflows B. The level of water drops C. The level of water remains unchanged D. The level of water goes up. (2010:Q19)
38. The small droplet of water that forms on the grass in the early hours of the morning is A. dew. B. mist. C. fog. D. hail. (2010:Q20)
39. A vapour is said to be saturated when A. a dynamic equilibrium exists such that more molecules return to the liquid than are leaving it. B. the vapour pressure is atmospheric C. the temperature of the vapour varies D. a dynamic equilibrium exists between liquid. (2010:Q21)
40. The phenomenon that shows that increase in pressure lowers the melting point can be observed in A. coagulation. B. regelation C. sublimation D. condensation (2011:Q18)
41. Steam burn is more severe than that of boiling water because A. water boils at a higher temperature B. steam burn is dependent on relative humidity C. steam burn is independent of relative humidity D. steam possesses greater heat energy per unit mass. (2011:Q20)
42. Which of the following is NOT a factor that can increase the rate of evaporation of water in a lake? A. Increase in the pressure of the atmosphere B. Rise in temperature C. Increase in the average speed of the molecules of water D. Increase in the kinetic energy of the molecules of water. (2012:Q23)
43. Two liquids X and Y having the same mass are supplied with the same quantity of heat. If the temperature rise in X is twice that of Y, the ratio of specific heat capacity of X to that of Y is A. 2:1 B. 1:2 C. 4:1 D. 1:4 (2013:Q20)
44. Foods cook quicker in salt water than in pure water because of the effect of A. dissolved substances on the boiling point. B. atmospheric pressure on the boiling point. C. food nutrients on the thermal energy. D. salts on the thermal conductivity of water. (2013:Q21)
45. Steam from boiling water causes more damage on the skin than does boiling water because A. water has a high specific heat. B. steam has latent heat of fusion C. the steam is at a higher temperature than the water D. steam brings heat more easily by convection (2013:Q22)
46. The small droplets of water that form on the grass in early hours of the morning is A. hail. B. mist. C. dew. D. fog. (2014:Q18)
47. The melting point of a substance is equivalent to its A. solidification temperature. B. liquidification temperature C. solidification pressures. D. vapour pressure (2014:Q23)
48. The temperature at which the water vapour present in air just sufficient to saturate the air is A. ice point. B. saturation point. C. dew point. D. boiling point (2014:Q24)
49. Vapour is said to be saturated on top of an enclosed liquid if A. the rate of condensation is equal to that of vaporization B. there is neither condensation nor vaporization of the liquid C. the rate of condensation is less than that of vaporization D. the rate of condensation is greater than that of vaporization (2015:Q47)
50. A vapour is said to be saturated when A. more molecules return to the liquid than leave it B. molecules leaving the liquid for the vapour are equal in number to those leaving the vapour for the liquid C. higher number of molecules return to the vapour than the molecules leaving it for the liquid D. the vapour pressure is equal to the atmospheric pressure (2016:Q45)

CHAPTER 16 ANSWERS

1A. Consider the heating curve



2D. The water vapour present in air is just enough to saturate the air at dew point.

NOTES:

1. Dew point is a condition of the atmosphere.
2. Boiling and melting points are the properties of a substance which are temperature at which its liquid form vaporises or its solid form melts.
3. The triple point of water is that temperature where it exists simultaneously as liquid, solid and gas and it is numerically equal to -273.16°C or 273.16k
- 3E. And if the saturated vapour pressure is now equal to the prevailing atmosphere pressure, the liquid boils.
- 4A. The water boils at a higher temperature than normal since a higher pressure environment is created with the cooker.
- 5B. Generally, during change of state, temperature remains constant and water in particular contracts on melting (instead of expanding) and its contraction continues till 4°C and beyond which it begins to expand.
- 6B. The equilibrium here is dynamic because there is actually movement of molecules between the liquid and gaseous phases i.e the number of molecules evaporatory from the liquid is equal to the number of molecules condensing into it (see also Q3)

NOTE: The equilibrium in chapter 6 is static equilibrium since there is no movement of the body being acted upon by a number of forces.

7B. See Q5

8E. See Q5

NOTE: Since heat is the total internal energy of a body then heat content improves even without the outward manifestation of temperature rise (latent)

9B. Hygrometer measures relative humidity; manometer measures pressure; hydrometer measures relative density

10D. "...just sufficient to saturate it" - see Q2

11C. Solid to gas without passing through the liquid phase.

12A. (A) \rightarrow see Q3

(C) \rightarrow The saturated vapour pressure (s.v.p) increases with temperature until a temperature is reached when s.v.p is equal to the prevailing external atmospheric pressure and liquid boils.

(D) \rightarrow Unlike the unsaturated vapour pressure, saturated vapour pressure does not obey Charles's and Boyles law.

(E) \rightarrow The term boiling point is a relative term and it depends largely on the prevailing atmospheric pressure. Water, or any liquid, boils at any temperature as long as its s.v.p is equal to atmospheric pressure.

(B) \rightarrow s.v.p only increases until it is equal to the external pressure for the liquid to boil but it does not depend on this external pressure.

13C. This is the temperature at which molten naphthalene freezes (solidifies) or solid naphthalene melts.

Melting point = "freezing point".

Boiling point = "condensation point".

14C. Differences between evaporation and boiling:

| Evaporation | Boiling |
|-------------------------------|---|
| 1. Occurs at any temperature. | 1. Occurs at a specific temperature. |
| 2. A surface phenomenon | 2. Occurs throughout the entire body of liquid. |
| 3. Independent of any | 3. The definite pressure under |

pressure.

which it occurs is the prevailing atmospheric pressure.

4. A slow process.

4. It is rapid.

5. Temperature need the not be constant while it lasts.

5. Temperature is constant if liquid is pure.

6. It is change of state below boiling point.

6. Change of state at boiling point of liquid to vapour

7. Wind enhances evaporation

7. Boiling is independent of wind.

15A. This is the heating curve of water (compare cooling curve of naphthalene in Q13) - See also Q1

NOTES:

- i. Between -10°C and 0°C : The heat applied causes temperature rise but no change of state.
- ii. At 0°C : The heat applied causes change of state (melting) but no change of temperature (hence curve in parallel to time axis)
- iii. Between 0°C and 100°C : The heat applied causes increase in temperature but no change of state for the liquid water.
- iv. At 100°C : The heat applied cause change of state but no change of temperature.

16A. Although s.v.p increases with temperature, its graph is a curve (A) instead of a straight line (C) i.e it does not obey pressure law or either gas laws.

17A. Water normally boils at 100°C when atmospheric pressure is 760mmHg and below this pressure, it boils below 100°C hence external pressure must be elevated to elevate boiling point to 100°C

18C. See Qs 12 and 16

19C. since water contracts on melting

20B. See Q15

21D. Dew point can be considered the saturation point of the room and the room becomes unsaturated at higher temperature than the dew point hence at dew point, a temperature below it, the room is saturated although if the room is cooled below dew point, excess vapour condenses as dew.

22B. From Q14, it is wrong for the use of the word "interior" as boiling involves the entire bulk of liquid including its surface.

23D. See Q13

24B. See Q6

25A. I \rightarrow See Q3

II \rightarrow Dissolved substances (impurities) elevate boiling point but lower melting point

III \rightarrow Thus a liquid boils at a higher temperature than normal when external pressure is increased and vice versa.

26A. The difference in the temperatures of the dry and wet thermometer is a measure of the relative humidity

Day 1 $\rightarrow 30 - 22 = 8^{\circ}\text{C}$ (least Relative Humidity)

Day 2 $\rightarrow 29 - 22 = 7^{\circ}\text{C}$ (Intermediate Relative Humidity)

Day 3 $\rightarrow 25 - 21 = 4^{\circ}\text{C}$ (highest Relative Humidity)

If steady the temperatures would be as follows:

$8^{\circ}\text{C} \rightarrow 6^{\circ}\text{C} \rightarrow 4^{\circ}\text{C} \rightarrow$ not as above.

NOTES: The hygrometer works on the following principles

- i. Evaporation causes cooling.
- ii. Less humid the air, the more rapid the rate of evaporation and hence the cooler the bulb of the wet thermometer and the lower the temperature it records.

iii. The smaller the temperature differences between the two thermometer, the higher the relative humidity or big temperature difference connotes

very low humidity. $\Delta T \propto \frac{1}{R.H}$

- the A. temperature of its surroundings B. temperature of the body C. difference in temperature between the body and its surroundings D. ratio of the temperature of the body to that of its surroundings. (2002:Q25)
20. If 1.2×10^6 J of heat energy is given off in 1 sec. from a vessel maintained at a temperature gradient of 30K^{-1} , the surface area of the vessel is A. $1.0 \times 10^2\text{m}^2$ B. $9.0 \times 10^2\text{m}^2$ C. $1.0 \times 10^3\text{m}^2$ D. $9.0 \times 10^3\text{m}^2$ [thermal conductivity of the vessel = $400\text{Wm}^{-1}\text{K}^{-1}$] (2003:Q26)
21. Tea pots are often silver-coated to prevent heat loss by A. convection and conduction. B. radiation only. C. conduction only. D. convection only. (2004:Q36)
22. The thermos flask is designed to A. prevent heat gain by conduction, convection and radiation. B. prevent heat loss by conduction, convection and radiation. C. prevent heat loss or gain by conduction, convection and radiation D. store hot tea or water. (2006:Q42)
23. The blade of a hoe feels colder to touch in the morning than the wooden handle because the A. handle contains store energy in form of heat B. blade is placed at a lower temperature than the handle C. handle is a better conductor of heat than the blade D. blade is a better conductor of heat than the handle. (2007:Q32)
24. In a good thermos flask, the main cause of heat loss is A. conduction through the cork. B. the plastic base of the thermos flask. C. the silvered walls and shiny metals. D. the outer cover or jacket. (2008:Q25)
25. A man standing 2 m from a charcoal fire is warmed mainly by A. convection. B. radiation C. refraction D. conduction. (2009:Q25)
26. Heat is radiated by all hot objects in the form of A. light energy. B. solar energy. C. infrared rays. D. x-rays (2010:Q18)
27. Which of the following has no effect on radiation? A. density B. temperature C. surface area D. nature of the surface. (2010:Q23)
28. A perfect emitter or absorber of radiant energy is a A. white body B. red body C. conductor D. black body. (2011:Q17)
29. The ground is always cold at night because the A. sun no longer shine at night B. atmosphere reflects the sun's energy at night C. atmosphere absorbs the sun's energy at night D. earth radiates heat to the atmosphere at night. (2011:Q22)
30. The mechanism of heat transfer from one point to another through the vibration of the molecules of the medium is A. convection. B. conduction. C. radiation. D. diffusion (2013:Q24)
31. Heat transfer by convection in a liquid is due to the A. increased vibration of the molecules of the liquid about their mean position. B. variation of density of the liquid. C. expansion of the liquid as it is heated. D. latent heat of vaporization of the liquid. (2014:Q25).
32. Ice wrapped in gauze placed at the bottom of a tube filled with water remains unmelted when heat is applied to the top of the tube. This experiment A. ice cannot sink in water B. water is a bad conductor of heat C. water is a good medium to show convection D. ice is a solid that conducts heat (2017: Q13)
33. A room is heated by means of a charcoal fire, an occupant of the room standing away from the fire is warmed mainly by A. convection B. radiation C. conduction D. reflection (2018: Q27)

CHAPTER 17 ANSWERS

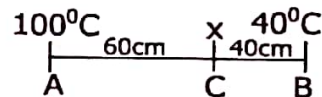
- 1E. Heat in the presence or absence of intervening medium travels by radiation as radiant heat.
- 2E. A black surface is a better radiator (or emitter) of heat than a polished surface.
Note: A black surface is also a better absorber of heat
- 3D. Silvered walls are polished surfaces hence radiate heat poorly
- 4C. See Q1
- 5B. See Q2
- 6C. One can feel the radiant heat short distance away

NOTES:

1. Conduction is heat transfer across the ball itself if heated from one side.
2. Convection only occurs in fluid (liquid or gas) and not in solid.
- 7B. See Q1
- 8B. Conduction occurs in solids especially metals (Steel and Copper). Do you know that copper is the best conductor of heat after silver? Now, you know!
- 9B. Since both cannot travel through a vacuum unlike radiation
- 10D. A white surface would rather reflect the radiant heat than absorb (or conduct) it.
- 11C. Molecular explanation of conduction using kinetic theory.
- 12A. I \rightarrow The cool breeze which blows inland from the sea during the day is sea breeze and this is reversed as land freeze in the night.
 II \rightarrow See Q6 III \rightarrow See Q10
- 13B. See Q6
- 14C. Heat loss due to convection, conduction and radiation no longer possible through the walls.
- 15C. See Q2
- 16C. The temperature gradient across any section of the bar is always the same where temperature gradient is given

$$\text{by: } G = \frac{\Delta T}{\Delta L} = \frac{T_2 - T_1}{L_2 - L_1}$$

where G = temperature change per unit length



In section AC \rightarrow Gradient = $\frac{100-x}{60}$

In section AB \rightarrow Gradient = $\frac{100-40}{100}$

$$\therefore \frac{100-x}{60} = \frac{60}{100} \rightarrow x = \frac{-6400}{-100} \rightarrow = 64^\circ\text{C}$$

Alternatively, try sections: AC vs. CB; BC vs. AB

- 17D. Convectional current can only be set up if air is present to act as an intervening medium.
- 18B. The fan blade blows air into the radiator to set up the conventional current
- 19C. It is over this difference that determines the direction of heat flow $\theta_{\text{body}} > \theta_{\text{surroundings}}$ [Hence heat flows outwards]
- 20A. Thermal conductivity σ is given by

$$\sigma = \frac{Q}{GA\Delta t} \rightarrow Q = \text{Quantity of heat} \quad A = \text{Area}$$

G = temperature gradient t = time

$$400 = \frac{1.2 \times 10^6}{30 \times A \times 1} \rightarrow A = 100\text{m}^2$$

Check the veracity of the equation above from the unit of σ

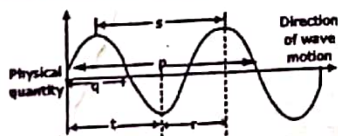
$$\text{Wm}^{-1}\text{k}^{-1} \rightarrow \frac{\frac{\text{J}}{\text{m}}}{\text{m}} \times \text{s} \rightarrow \left(\frac{\text{J}}{\text{s}}\right) \times \frac{1}{\text{km}} = \text{Wk}^{-1}\text{m}^{-1}$$

- 21B. Polisher surface radiates poorly
- 22C. Hence hot water in flask stays hot, cold water stays cold.
- 23D. The blade conducts heat quickly away from the skin.
- 24A. Although this loss is minimal
- 25B. See Q6
- 26C. Heat travels through vacuum majorly as infrared rays, an electromagnetic wave. The heat of the sun we feel is predominantly the infrared portion of its electromagnetic spectrum.
- 27A. The higher the temperature of a body above its surroundings, the faster the rate of radiance; a larger surface area, radiates better; polished and blackened surfaces radiate differently.
- 28D. See Q2
- 29D. The earth is a good heat absorber in the day, a good radiator or emitter of heat at night and this even explains the phenomena of land and sea breezes

- 30D. Conduction only occurs in solids and since particles of solids are fixed about their mean positions, heat is only transferred by vibration of these particles.
Note:
 1. In convection, the molecules actually move transferring heat energy from one location to another in the fluid involved.
 2. Radiation involves heat travelling over a distance even if a vacuum intervenes.
- 31C. Heated molecules at the rock bottom of the vessel expands (volume increases) and hence become less dense. These molecules then rise (float) only to be replaced by denser, colder molecules above and this continues until the entire liquid is warmed.
- 32B Heat transfer in water or any other liquid is by convection rather than conduction. The water molecules heated at the top of the test tube remain afloat being lighter than the colder molecules below. However, if heated as in Q31, a conventional current is set up
- 33B See Q6

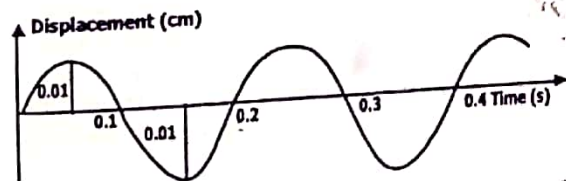
**CHAPTER 18
 WAVES: TYPES. PRODUCTION. PROPAGATION.
 PROPERTIES**

- A string is sustaining a stationary wave when A. the frequency of the wave is not proportional to the wavelength of the wave B. the amplitude of vibration is always zero C. two equal waves are travelling in opposite directions D. the waves are longitudinal E. the frequency is directly proportional to the length of the string. (1978:Q47)
- Which of the following types of waves cannot travel through a vacuum? A. sound waves B. light waves C. infra-red waves D. x-radiation E. radio waves. (1979:Q6)
- If the wavelength of a wave travelling with a velocity of 360ms^{-1} is 60m, the period of the wave is A. 6s B. 3.6s C. 0.17s D. 0.61s E. 3s (1979:Q13)
- For the wave motion represented in the figure the wavelength



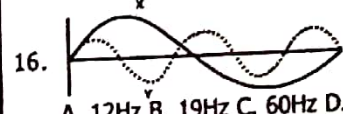
given by A. p B. q C. r
 D. s E. t (1979:Q36)

- Any line or section through an advancing wave in which all the particles are in the same phase is called the A. light waves B. radio waves C. sound waves D. surface waves on water E. x-rays (1981:Q4)
- The following types of waves are all transverse EXCEPT A. raise the temperature of unit mass of the substance by 1°C B. maintain unit mass of the substance at constant temperature C. change unit mass of substance from solid to liquid at constant temperature D. change unit mass of liquid to vapour at constant temperature E. raise the temperature of unit mass by 100°C . (1981:Q4)



7. The wave motion shown (Fig. 3) has a frequency of A. 0.1Hz B. 0.2Hz C. 5Hz D. 10Hz E. 100Hz (1981:Q22)
- The combination of sound waves with different frequencies is known as A. interference B. diffraction C. superposition D. forced vibrations E. resonance (1982:Q19)
 - Ripples on water are similar to light waves in that they both A. have the same wavelength B. are longitudinal C. cannot be reflected D. travel at the same speed E. can be refracted and diffracted. (1983:Q27)
 - Longitudinal waves do not exhibit A. Refraction B. Reflection C. Diffraction D. Polarization E. Rarefaction (1983:Q49)

- Radio waves have a velocity of $3 \times 10^8\text{ms}^{-1}$. A radio station sends out a broadcast on a frequency of 800 kHz. The wavelength of the broadcast is A. 375.0m B. 267m C. 375.0m D. 267m (1984:Q15)
- A wave of frequency 10Hz forms a stationary wave pattern in a medium where the velocity is 20ms^{-1} . The distance between adjacent nodes is A. 1.0cm B. 1.5cm C. 2.0cm D. 5.0cm (1986:Q34)
- The wavelength of ultraviolet radiation is 400nm. If the speed of light in air is $3 \times 10^8\text{ms}^{-1}$, then the frequency of the ultraviolet radiation is A. $1.3 \times 10^{14}\text{Hz}$ B. $7.5 \times 10^{15}\text{Hz}$ C. $1.2 \times 10^{14}\text{Hz}$ D. $7.5 \times 10^{14}\text{Hz}$. (1986:Q49)
- A wave has a frequency of 2Hz and a wavelength of 30cm. The velocity of the wave is A. 60.0ms^{-1} B. 6.0ms^{-1} C. 1.5ms^{-1} D. 0.6ms^{-1} (1987:Q27)
- A boat at anchor is rocked by waves whose crests are 100m apart and whose velocity is 25ms^{-1} . At what interval does the wave crest reach the boat? A. 2,500.00s B. 75.00s C. 4.00s D. 0.25s (1987:Q28)



The diagram above shows two waveforms X and Y. If the frequency is 30 Hz, what is the frequency of Y?

- A. 12Hz B. 19Hz C. 60Hz D. 75Hz (1988:Q22)
- Which of the following properties is/are common to all waves? I Diffraction II refraction III Interference A. I only B. III only C. I and III only D. I, II and III. (1988:Q23)
- A vibrator of frequency 60Hz is used in generating transverse stationary waves in a long thin wire. If the average distance between successive nodes on the wire is 45cm, find the speed of the transverse waves in the wire. A. 27ms^{-1} B. 54ms^{-1} C. 90ms^{-1} D. 108ms^{-1} (1989:Q19)
- In a sound wave in air, the adjacent rarefactions and compressions are separated by a distance of 17cm. If the velocity of the sound wave is 340ms^{-1} , determine the frequency. A. 10Hz B. 20Hz C. 1 000Hz D. 5 780Hz (1989:Q22)
- Light of wavelength $5000 \times 10^{-4}\text{cm}$ travels in free space with a velocity of $3 \times 10^8\text{ms}^{-1}$. What is its wavelength in glass of refractive index 1.5? A. $3.333 \times 10^{-4}\text{cm}$ B. $5.000 \times 10^{-4}\text{cm}$ C. $2.666 \times 10^{-4}\text{cm}$ D. $7.500 \times 10^{-4}\text{cm}$ (1989:Q24)
- A wave disturbance traveling in air enters a medium in which its velocity is less than that in air. Which of the following statements is true about the wave in the medium? A. Both the frequency of the wave and the wavelength are decreased. B. The frequency of the wave is decreased while the wavelength is increased. C. The frequency of the wave is unaltered while the wavelength is decreased. D. The frequency of the wave is decreased while the wavelength is unaltered.
- Which of the following is TRUE of light and sound waves? A. They both transmit energy B. They both need a medium for propagation C. They are both transverse waves D. Their velocities in air are equal. (1991:Q24)
- The equation of wave is $y = 0.005 \sin \pi [x(0.5x - 200t)]$ where x and y are in metres and t is in seconds. What is the velocity of the wave? A. $4 000\text{ms}^{-1}$ B. 400ms^{-1} C. 250ms^{-1} D. 40ms^{-1} (1992:Q20)
- Which of the following characteristics of a wave is used in the measurement of the depth of the sea? A. Diffraction B. Interference C. Refraction D. Reflection (1992:Q21)
- Which of the following waves can propagate through a vacuum? A. High velocity sound waves B. Ultrasonic waves C. Acoustic waves D. Infra-red waves (1993:Q22)
- Radio waves emitted from an antenna are picked up by a radar after reflection from an aircraft in $4 \times 10^{-5}\text{s}$. How far is the aircraft from the antenna? [$c = 3 \times 10^8\text{ms}^{-1}$] A. $6.0 \times 10^3\text{km}$ B. $1.2 \times 10^3\text{km}$ C. $3.0 \times 10^3\text{km}$ D. $6.0 \times 10^3\text{km}$ (1993:Q23)
- The equation of a transverse wave traveling along a string is given by $y = 0.3 \sin (0.5x - 50t)$ where y and x are in

cm and t is in seconds. Find the maximum displacement of the particles from the equilibrium position. A. 50.0cm B. 2.5cm C. 0.5cm D. 0.3cm (1994:Q28)

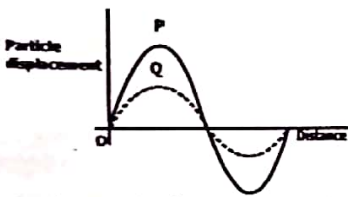
28. Which of the following is the exclusive property of a transverse wave? A. Diffraction B. Refraction C. Compression D. Polarization (1995:Q27)

29. The wavelength of signal from a radio transmitter is 1500m and the frequency is 200kHz. What is the wavelength for a transmitter operating at 1000kHz? A. 7500m B. 300m C. 75m D. 15m (1995:Q28)

30. The difference between sound waves and light waves is that sound waves A. Are transverse while light waves are longitudinal. B. Require a medium to travel while light waves do not. C. Can be diffracted but light waves cannot D. Cannot be reflected but light waves can. (1995:Q29)

31. Ripples on water and light waves are similar because both A. have the same frequency B. can be refracted and diffracted C. are longitudinal waves D. have the same velocity. (1997:Q28)

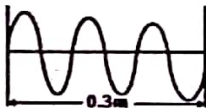
32. The diagram below shows two waveforms P and Q at a particular instant of time. The two waves will interfere A. destructively to produce a wave of a larger amplitude B. destructively to produce a wave of a



smaller amplitude C. constructively to produce a wave of a larger amplitude D. constructively to produce a wave of a smaller amplitude. (1997:Q31)

33. The equation of a wave traveling along the positive x-direction is given by $y = 0.25 \times 10^{-3} \sin(500t - 0.025x)$. Determine the angular frequency of the wave motion, A. $0.25 \times 10^3 \text{ rad s}^{-1}$ B. $0.25 \times 10^{-4} \text{ rad s}^{-1}$ C. $5.00 \times 10^2 \text{ rad s}^{-1}$ D. $2.50 \times 10^3 \text{ rad s}^{-1}$ (1999:Q23)

34. The diagram below represents a transverse electromagnetic wave traveling with speed $3.0 \times 10^8 \text{ ms}^{-1}$. What is the frequency of the wave? A. $3.0 \times 10^7 \text{ Hz}$ B. $9.0 \times 10^7 \text{ Hz}$ C. $1.0 \times 10^8 \text{ Hz}$ D. $3.0 \times 10^8 \text{ Hz}$ (1999:Q22)



35. I. Coherence II Same frequency III Same wavelength IV Same intensity. Which of the conditions above are necessary to produce interference fringes? A. I, II and III B. I and III C. I, II and IV D. II and III. (2000:Q13)

36. One end of a long wire is fixed while vibrator is attached to the other end. When the vibrator is energized, the types of waves generated in the wire are A. Stationary and transverse B. Progressive and transverse C. Stationary and longitudinal D. Progressive and longitudinal. (2000:Q17)

37. A travelling wave moving from left to right has an amplitude of 0.15m, a frequency of 550Hz and a wavelength of 0.01m. The equation describing the wave is A. $y = 0.15 \sin 200\pi(x - 5.5t)$ B. $y = 0.15 \sin \pi(0.01x - 5.5t)$ C. $y = 0.15 \sin 5.5\pi(x - 200t)$ D. $y = 0.15 \sin \pi(550x - 0.01t)$ (2000:Q23)

38. A plane sound wave of frequency 85.5Hz and velocity 342 ms^{-1} is reflected from a vertical wall. At what distance from the wall does the wave have an antinode? A. 2m B. 4m C. 1m D. 3m (2001:Q17)

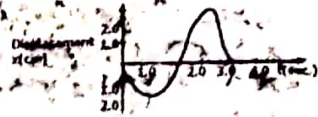
39. Vibration in a stretched spring cannot be polarized because they are A. transverse waves B. mechanical waves C. stationary waves D. longitudinal waves. (2002:Q24)

40. The property that is propagated in a travelling wave is A. amplitude B. energy C. wavelength D. frequency (2002:Q26)

41. Which of the following is a characteristic of stationary waves? A. The antinode is a point of minimum displacement. B. The distance between two successive nodes is one wavelength. C. They are formed by two identical waves travelling in opposite directions. D. They can be transverse or longitudinal (2002:Q27)

42. Transverse waves can be distinguished from longitudinal waves using the characteristics of A. diffraction. B. polarization. C. reflection. D. refraction (2004:Q31)

43. I. Wavelength II. Medium of propagation III. Wave velocity IV. Frequency V. Energy. Which of the above are used for characterizing waves? A. I, II and V B. III, IV and V C. I and IV D. I, III and IV (2004:Q40)



The frequency of the wave in the diagram above is

A. 1.05Hz B. 0.17Hz C. 1.57Hz D. 0.25Hz (2006:Q34)

45. A progressive wave equation is represented by $y = a \sin(150\pi t - \pi x/4)$. If the phase difference of a progressive wave is 45° , the value of x in the equation is A. 3cm. B. 4cm C. 5cm D. 6cm (2006:Q36)

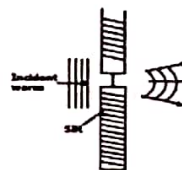
46. I. They should be identical II. They should originate from the same source. III. They should be coherent. IV. They should be monochromatic. From the statements above, the conditions for two waves to interfere are A. I, III and IV only. B. I, II, III and IV. C. I, II and III only. D. II, III and IV only. (2007:Q4)

47. The phenomenon of light bending round an obstacle is A. reflection B. polarization C. refraction D. diffraction (2007:Q8)

48. Given the progressive wave equation $y = 5\sin(2000\pi t - 0.4x)$, calculate the wavelength A. 12.4m. B. 15.7m C. 17.5m D. 18.6m. (2008:Q26)

49. The above figure shows the motion of a progressive wave along a string. The particle motion of the medium is in the direction A. parallel to OX. B. parallel to OY. C. 60° to OX D. 60° to OY. (2008:Q27)

50. The fundamental property of a propagating wave which depends only on the source and not the medium of propagation is the A. wavelength B. harmonics C. frequency D. velocity (2008:Q28)



The wave phenomenon demonstrated in the diagram is A. reflection.

B. deflection. C. diffraction.

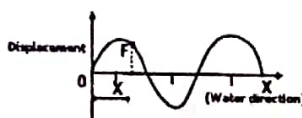
D. refraction. (2009:Q26)

52. If a light wave has a wavelength of 500nm in air, what is the frequency? A. $6.0 \times 10^{14} \text{ Hz}$ B. $6.0 \times 10^{15} \text{ Hz}$ C. $6.0 \times 10^{16} \text{ Hz}$ D. $2.5 \times 10^{14} \text{ Hz}$ [$c = 3 \times 10^8 \text{ ms}^{-1}$] (2009:Q30)

53. The wavelength of a wave travelling with a velocity of 420 ms^{-1} is 42m. What is its period? A. 1.0s B. 0.1s C. 0.5s D. 1.2s (2010:Q24)

54. Which of the following types of waves need a medium for preparation? A. Radio waves. B. X-rays C. Sound waves. D. Light waves. (2011:Q21)

55. The equation of a wave travelling in a horizontal direction is expressed as $y = 15\sin 2/5(60t - x)$. What is its wavelength? A. 60m B. 15m C. 5m D. 2m (2012:Q26)



From the diagram below, if the particle F is at a distance X from O to the right, the phase of the vibration will be different from that at O by

A. $\frac{2\pi X}{\lambda}$ B. $\frac{2\pi X}{\lambda}$ C. $\frac{\lambda}{2\pi}$ D. $\frac{\lambda}{\pi X}$ (2012:Q27)

57. A wave that travels through stretched strings is known as A. electromagnetic wave. B. micro wave C. mechanical wave. D. seismic wave (2013:Q25)

58. A transverse wave and a longitudinal wave travelling in the same direction in a medium differ essentially in their A. frequency. B. amplitude C. direction of vibration of the particles of the medium. D. period of vibration of the particles of the medium. (2013:Q26)

59. The distance between two successive crests of a wave is 15cm and the velocity 300 ms^{-1} . Calculate the frequency. A. $4.5 \times 10^4 \text{ Hz}$ B. $2.0 \times 10^4 \text{ Hz}$ C. $4.5 \times 10^3 \text{ Hz}$ D. $2.0 \times 10^3 \text{ Hz}$ (2014:Q26)

60. Which of the following waves is both transverse and

- mechanical? A. Sound waves. B. Radio waves. C. Water waves. D. X-rays. (2015:Q37)
61. Which of the following is not a phenomenon of a longitudinal wave? A. Polarization B. Refraction C. Diffraction D. Interference (2016:Q24)
62. What is the wavelength of a stationary wave of frequency 170Hz and velocity 34ms⁻¹? A. 0.5m B. 0.2m C. 5.0m D. 2.0m (2016:Q42)
63. If the speed of light is $3 \times 10^8 \text{ms}^{-1}$, calculate the frequency of the light if the wavelength is $7.80 \times 10^{-7} \text{m}$ A. $3.444 \times 10^{14} \text{Hz}$ B. $3.846 \times 10^{14} \text{Hz}$ C. $2.889 \times 10^{14} \text{Hz}$ D. $3.526 \times 10^{14} \text{Hz}$ (2018:Q37)

CHAPTER 18 ANSWERS

- 1C. Conditions for forming stationary wave
- Two progressive waves and involved
 - The waves are in opposite directions
 - Waves of equal amplitude and frequency and wavelength - identical waves

NOTE: Stationary wave = standing wave


- 2A. Sound waves and others of its type are thus referred to as mechanical waves as they require a material medium for propagation.

NOTE:

- Electromagnetic waves on the other hand require no medium and there include the components of the entire electromagnetic spectrum.
- The infra red portion of the sun's electromagnetic spectrum gives us heat radiant heat is an electromagnetic wave.
- Sound waves, water waves, waves in strings are all mechanical waves.

3C. $V = f\lambda \rightarrow 360 = 60f \rightarrow f = 6\text{Hz} \rightarrow T = \frac{1}{f} = \frac{1}{6} = 0.166\dots$

- 4D. One wavelength as the distance between two successive crests or troughs.

- 5E.  Point A, B, C and D form a wavefront because they are in the same state of disturbance.

- 6C. A transverse wave travels perpendicularly to the direction of its own vibration while the direction of propagation of a longitudinal is parallel to the direction of vibration of the medium in which it travels.

7C. $T = 0.25 \rightarrow \text{But } f = \frac{1}{T} = \frac{1}{0.2} = 5\text{Hz}$

NOTES:

- Period T, is the time taken to make one complete cycle or

$T = \frac{t}{n} \rightarrow$ (in seconds) where t = time taken n = no of cycles

- Frequency f, is the no of cycle made in a unit time

$f = \frac{n}{t}$ (cycle/s or Hz); Hence $f = \frac{1}{T}$ or $T = \frac{1}{f}$

- 8C. Interference is a super position of 2 identical waves travelling in same direction

- 9E. In fact, both are transverse waves hence exhibit all the properties of a wave (i) reflection (ii) refraction (iii) diffraction (iv) interference and (v) plane polarization.

NOTE: A longitudinal wave cannot be plane polarized.

- 10D See Q9

11A. $V = f\lambda \rightarrow \lambda = \frac{V}{f} = \frac{3 \times 10^3}{800 \times 10^3} = 375\text{m}$

12A. $\lambda = \frac{V}{f} = \frac{20 \times 10^3}{10} = 2 \times 10^3 \text{m} = 2\text{cm}$

But $\lambda = 2 \times$ distance between 2 adjacent nodes

Distance between adjacent nodes = $\frac{\lambda}{2} = 1\text{cm}$

NOTES:

- For a progressive wave, two crests or troughs make one wavelength.

2. For a stationary wave, 3 nodes make one wavelength or distance between 2 adjacent nodes is one half the wavelength.

13D. $f = \frac{v}{\lambda} \rightarrow f = \frac{3 \times 10^3}{400 \times 10^{-3}} = 7.5 \times 10^4 \text{Hz}$

14D. $v = f\lambda = 2 \times 3 \times 10^3 = 0.6\text{m}$

15C. $\lambda = 100\text{m} \rightarrow v = 25\text{ms}^{-1} \rightarrow f = \frac{v}{\lambda} = \frac{25}{100} = 0.25\text{Hz}$

$T = \frac{1}{f} = \frac{1}{0.25} = 4\text{s}$

Since two crests make one wavelength the time interval between their arrivals is the period.

- 16A. Do you know that the distance between two successive crests or troughs only gives the magnitude of the wavelength but not the number of wavelength travelled? Do you know how to count the number of wavelength from the origin?

Now, distance by x: $S_x = 1 \times \lambda_x$; by y: $S_y = 2\frac{1}{2} \times \lambda_y$

$S_x = S_y \therefore \lambda_x = \frac{5}{2}$ but the two waves travel same distance

$S_x = S_y$ at equal time interval t.

$\therefore v_x = v_y = f_x \lambda_x = f_y \lambda_y$

Substituting for λ_x from $\lambda_x = \frac{5}{2} \lambda_y$; $f_y \lambda_y = f_x \times \frac{5}{2} \lambda_y$

$f_y = \frac{5}{2} f_x = \frac{5}{2} \times 30 = 75\text{Hz}$

NOTE: You can work faster by noting that since it has shorter wavelength, it will definitely have higher frequency

$f \propto \frac{1}{\lambda}$ or $f = \frac{k}{\lambda}$ where k = velocity

If $\lambda_y : \lambda_x = 2:5$ then $f_y : f_x = 5:2 \rightarrow f_y = \frac{5}{2} \times 30 = 75\text{Hz}$

- 17D. See Q9

- 18B. $\lambda = 2 \times$ distance between nodes

$\lambda = 2 \times 0.45 = 0.9\text{m} \rightarrow v = f\lambda = 60 \times 0.9$
 $v = 54\text{ms}^{-1}$

- 19C. Note that in a longitudinal wave compressions and rarefactions correspond respectively to the crests and troughs of a transverse wave. Therefore, adjacent rarefaction and compression have a distance of $\frac{1}{2} \lambda$ between them: $\lambda = 2 \times 0.17 = 0.34\text{m}$

But $f = \frac{v}{\lambda} = \frac{340}{0.34} = 1000\text{Hz}$

20D. $n_g = \frac{\text{Velocity in space}}{\text{Velocity in glass}}$ But $v = f\lambda$

$n_g = \frac{f \lambda_s}{f \lambda_g}$ or $n_g = \frac{\lambda_s}{\lambda_g}$ (as $f_s = f_g$) $\rightarrow 1.5 = \frac{5000 \times 10^{-4}}{\lambda_g}$

$\lambda_g = 3.333 \times 10^{-8} \text{cm}$

NOTES:

- When a wave travels from one medium to another, its velocity changes because it experiences a change in wavelength (λ) while its frequency (f) remains constant.

- n_g means refractive index of glass with respect to free space while n_s means... $n_g = \frac{1}{n_s}$

- 21C. Now see Q20

- 22A. (A) \rightarrow All waves are disturbances transferring energy from one point to another.

(B) \rightarrow Sound needs a medium, light doesn't.

(C) \rightarrow Light is transverse, sound is longitudinal.

(D) $\rightarrow v_{light} = 3 \times 10^8 \text{ms}^{-1}$; $v_{sound} = 330\text{ms}^{-1}$

- 23D. $y = 0.005 \sin[\pi(0.5x - 200t)] = 0.005 \sin(0.5\pi x - 200\pi t) \dots (i)$
But standard wave equation is

$$y = A \sin\left[\frac{2\pi x}{\lambda} - \omega t\right] \text{ or } y = A \sin\left[\frac{2\pi x}{\lambda} - 2\pi ft\right] \dots(ii)$$

as $\omega = 2\pi f$ Comparing (i) and (ii) $= 0.5\pi x \rightarrow \frac{\lambda}{2} = 0.5$

$$\lambda = \frac{2}{0.5} = 4m \text{ Also } 2\pi ft = 200\pi t \text{ and } f = 100\text{Hz}$$

But $V = f\lambda \rightarrow V = 100 \times 4 = 400\text{ms}^{-1}$

24D. See chapter 19

25D. Infrared waves are part of the electromagnetic spectrum- no medium necessary for propagation.

26A. Distance travelled by wave is twice the distance between the antenna and craft.

$$2x = vt \rightarrow 2x = 3 \times 10^8 \times 4 \times 10^{-3} \rightarrow x = 6 \times 10^5\text{m} = 6 \times 10^2\text{km}$$

27D. The amplitude A is the maximum displacement of particles from equilibrium position. Compare with wave equation:

$$y = A \sin\left[\frac{2\pi x}{\lambda} - \omega t\right] = 0.3 \sin[0.5x - \omega t] \rightarrow A = 0.3\text{cm}$$

28D. See Q9

29B. All radio signals (electromagnetic) have the same speed

$$V = F_2\lambda_2 = F_1\lambda_1 \rightarrow 1000 \times 10^3 \times 2 = 200 \times 10^3 \times 1500 \rightarrow \lambda_2 = 300\text{m}$$

30B. See Q22

31B. Properties of all waves

32C. Interference is constructive if crest meets crest, trough meet trough as seen here to produce a higher disturbance of higher amplitude.

NOTE: If crests meets troughs, the waves interfere destructively, producing zero resultant disturbances of lower amplitude.

33C. Compare with wave equation:

$$y = A \sin\left[\frac{2\pi x}{\lambda} - \omega t\right] = 0.25 \times 10^{-3} \sin(500t - 0.025x)$$

$$\omega t = 500t = 500\text{rads}^{-1}$$

34D. $3\lambda = 0.3 \rightarrow \lambda = 0.1\text{m}$ but $f = \frac{V}{\lambda} = \frac{3 \times 10^8}{0.1} = 3 \times 10^9\text{ms}^{-1}$

35D. Conditions for interference:

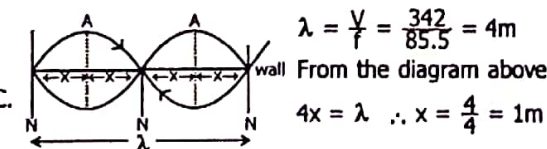
- i. same frequency
- ii. same amplitude
- iii. same wavelength
- iv. same direction

36A. Waves in wire (string) is mechanical and transverse wave and its fixed end is an obstacle that produces waves in opposite direction to the ones produced by the vibrator to generate a standing wave.

37A. If $y = A \sin\left[\frac{2\pi x}{\lambda} - \omega t\right]$ $\therefore y = A \sin 2\pi\left[\frac{x}{\lambda} - ft\right]$

$$y = 0.05 \sin 2\pi\left[\frac{x}{0.01} - 550t\right] \quad y = 0.05 \sin 2\pi[100x - 550t]$$

$$y = 0.05 \sin 200\pi[x - 5.5t]$$



38C. **NOTES:** 1. $\lambda = 3\text{nodes}$, 2. A = Antinode; N = node

39C. Since a string can only be stretched by attaching it to an obstacle, it always generates stationery waves which cannot be polarised

NOTE: Vibrations in stretched string are transverse waves but cannot be polarised for the reason adduced above

40B. See Q22

41C. See Q1

NOTES:

1. A stationary waves arises from reflection of a wave and all waves can be reflected.
2. Option (D) is a fact but it is not the expected answer here.
3. The antinode (A) is a point of maximum displacement

while the node is a point of no displacement.

4. Two nodes are $\frac{1}{2}\lambda$ apart

42B. See Qs 9 and 28

43D. Others are amplitude and period.

44D. One cycle takes 4s

$$\therefore T = 4\text{s and } f = \frac{1}{T} = \frac{1}{4} = 0.25\text{Hz}$$

45D. Comparing wave equation:

$$\frac{\pi x}{4} = \frac{2\pi x}{\lambda} \rightarrow \lambda \pi x = 8\pi x \rightarrow \lambda = 8\text{cm}$$

But phase difference is $\sin 45^\circ = \frac{2\pi x}{\lambda} \quad x = 0.89 \approx 1\text{cm}$

Alternatively: Phase difference $= \frac{\pi x}{\lambda}$

If $180^\circ = \pi\text{rad}$ then $45^\circ = \frac{\pi}{4}\text{rad}$

$$\frac{\pi x}{4} = \frac{\pi}{4} \rightarrow x = \frac{\pi}{4} \times \frac{4}{\pi} \rightarrow x = 1\text{cm (as before)}$$

46A. I \rightarrow Identical waves: same wavelength, amplitude and frequency

II \rightarrow Different sources

III \rightarrow The waves generated by the two sources must be identical and in phase or have constant phase difference

IV \rightarrow **Monochromatic** means the waves are of a single wavelength

47D. Diffraction, a property of all waves, occurs when the wavelength of the wave itself is longer than the gap between the obstacles and the wave spreads out with circular wavefront after escaping from the gap.

48B. $\frac{2\pi x}{\lambda} = 0.4x \rightarrow \lambda = \frac{2\pi}{0.4} = \frac{2 \times 3.142}{0.4} \rightarrow \lambda = 15.71\text{cm}$

49B. Direction of propagation is parallel to OX which in term is perpendicular to the parallels of OY - a transverse wave.

50C. A vibrating source has a fundamental frequency (f) but when it moves from one medium to another, its wavelength changes hence its velocity since $V = f\lambda$

NOTE: The harmonics of this frequency are a function of the frequency itself and they are $f, 2f, 3f$, e.t.c see chapter 19 for details.

51C. Now see Q47

52. $f = \frac{V}{\lambda} = \frac{3 \times 10^8}{500 \times 10^{-3}} = 6 \times 10^5\text{Hz}$ (No option was right)

53B. $f = \frac{V}{\lambda} = \frac{420}{42} = 10\text{Hz}$ But $T = \frac{1}{f} = \frac{1}{10} = 0.1\text{s}$

54C. Sound is a mechanical wave.

55. Rewrite as $y = 15\sin$
Comparing with wave equation:

$$\frac{2\pi x}{\lambda} = \frac{2\pi x}{5} \rightarrow \lambda = 5\text{m}$$

56A. Culled from the wave equation: $y = A \sin[\omega t - \frac{2\pi x}{\lambda}]$

57C. See Qs 2 and 36

58C. See Q6

59. $\lambda = 2 \times \text{distance between 2 crests}$

$$\lambda = 2 \times 15 = 30\text{cm} = 0.3\text{m}$$

But $f = \frac{V}{\lambda} = \frac{300}{0.3} = 1000\text{Hz}$ (No option was right)

60C. See Q2

61A. Only transverse wave can be plane-polarized

62B. $\lambda = \frac{V}{f} = \frac{34}{170} = 0.2\text{m}$

63B $f = \frac{V}{\lambda} = \frac{3 \times 10^8}{7.8 \times 10^7}$

CHAPTER 19

SOUND WAVES: PROPAGATION AND CHARACTERISTICS

1. A guitar string is 75cm long. The wavelength of its fundamental note is A. 75cm B. 150cm C. 37.5cm D. 112.5cm E. 50cm. (1978:Q39)
2. Two boys are communicating with each other by stretching a string passing through a hole punched in the bottom of

each of two tin cans. The physical principle employed is that sound travels A. mainly through air B. fainter in stretched string C. faster through gases than in solids and liquids D. with greater ease through a string than in air E. none of the above (1978:Q40)

- A herdsman yelling out to fellow herdsman heard his voice of reflected by a cliff 4s later. What is the velocity of sound in air if the cliff is 680m away? A. 170ms⁻¹ B. 136ms⁻¹ C. 340ms⁻¹ D. 680ms⁻¹ E. 510ms⁻¹ (1978:Q41)
- In a resonance tube experiment which is illustrated in the

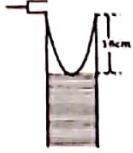
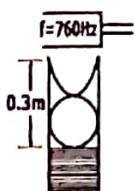


figure velocity of sound in air is 327.68m/s, the frequency of the tuning fork used in therefore A. 128Hz B. 256Hz C. 512Hz D. 768Hz E. 1024Hz (1979:Q23)

- Which of the following statements is true? The frequency of a vibrating string is A. proportional to its length B. inversely proportional to the tension within it C. proportional to the amplitude of vibration D. inversely proportional to its cross-section E. proportional to the square root of the tension within it. (1979:Q37)
- Suppose a car travelling at a uniform speed, sounds its horn at point Y while moving towards X in the above figure. Assuming there is no wind, which of the following observations is correct? A. The man at point X will receive a lower pitch B. The driver at point Y will receive a lower pitch C. The man at point Z will receive a lower pitch D. The pitch will be the same at points X and Z E. None of the above (1980:Q5)
- Which of the following statements about sound is NOT true? A. Sound is a longitudinal wave B. Sound can be reflected and refracted like light C. Sound travels through a vacuum D. Sound moves faster in a steel wire than in air E. Sound can only be produced by vibrating objects. (1980:Q34)
- If a source of sound is moving, a stationary listener will hear a sound of different frequency. This is called A. Doppler effect B. resonance C. ultra sound D. diffraction of sound E. rarefaction (1981:Q8)
- All of the following frequencies are overtones of 320Hz EXCEPT A. 960Hz B. 640Hz C. 520Hz D. 1280Hz E. 1600Hz (1981:Q24)
- The quality (timbre) of sound depends on A. amplitude B. frequency C. harmonics D. velocity E. wavelength (1981:Q38)
- The echo of a sounder from the bottom of an ocean is heard 2.5 seconds later. If the speed of sound in water 1 400ms⁻¹, the depth of the ocean is A. 1 750m B. 3 500m C. 1 400m D. 2 800m E. 2 100m (1982:Q6)
- In a resonance tube experiment in the figure below the


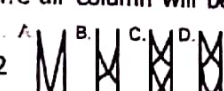



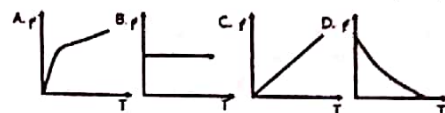

frequency of the tuning fork is 750Hz and the resonating length of the air column is 0.3m as shown. A. 225ms⁻¹ B. 300ms⁻¹ C. 53 x 10⁻⁵ms⁻¹ D. 2 500ms⁻¹ E. 2 500ms⁻¹ (1982:Q47)

- In a resonance tube experiment, a tube of fixed length is closed at one end and several tuning forks of increasing frequency used to obtain resonance at the open end. If the tuning fork with the lowest frequency which gave resonance had a frequency f_1 and the next tuning fork to give resonance had a frequency f_2 , find the ratio f_2/f_1 . A. 8 B. 3 C. 2 D. 1/2 E. 1/3 (1983:Q1)
- A ship traveling towards a cliff receives the echo of its whistle after 3.5 seconds. A short while later, it receives the echo after 2.5 seconds. If the speed of sound in air under the prevailing conditions is 250ms⁻¹, how much closer is the ship to the cliff? A. 10m B. 125m C. 175m D. 350m E. 1,000m (1983:Q10)
- Which of the following is NOT correct? I. The pitch of a sound note depends on the frequency of vibrations. II. The intensity of a sound note is proportional to the amplitude of vibrations. III. Beats are produced by two sources of sound because one

wave is travelling faster than the other. IV. When two sources of sound of frequencies 500Hz and 502Hz are sounded together, a beat frequency of 2Hz is observed. V. The first harmonic of a note has double the frequency of the fundamental note. A. I and II B. II and III C. I and III D. III and IV E. IV and V. (1983:Q11)

- When vibration occurs in an air column, the distance between a node and an antinode is equal to A. One-quarter of the wavelength B. One-half of the wavelength C. The wavelength D. Twice the wavelength E. Four-times the wavelength. (1984:Q14)
- Which of the following statements is (are) NOT correct? I. Pressure changes do not affect the speed of sound in air II. The velocity of sound increases with temperature III. The quantity of a note depends only on its frequency. A. I only B. II only C. III only D. I and III only E. II and III only. (1984:Q15)
- Of two identical turning forks with natural frequency 256 Hz, one is loaded so that 4 beats per second are heard when they are sounded together. What is the frequency of the loaded turning fork? A. 260Hz B. 252Hz C. 248Hz D. 264Hz E. 258Hz (1984:Q16)
- In order to find the depth of the sea. A ship sends out a sound wave and receives an echo after one second. If the velocity of sound in water is 1500m/s, what is the depth of the sea? A. 0.75km B. 1.50km C. 2.20km D. 3.00km E. 3.75km (1985:Q27)
- When a sound wave passes from air into water its A. Speed and frequency increase but its wavelength remains the same. B. Speed and wavelength increase but its frequency remains the same C. Speed decreases. D. Speed remains the same but its frequency and wavelength change. E. Speed increases but its frequency and wavelength decrease. (1985:Q28)
- If the fundamental frequency of a closed pipe organ on a day when the speed of sound is 340ms⁻¹ is 170Hz, then the length of the pipe is A. 50cm B. 70cm C. 100cm D. 150cm E. 200cm (1985:Q29)
- Which of the following is true of sound? A. Sound travels faster in air at 20°C than at 30°C. B. The frequency of a given sound wave changes when it crosses the boundary separating two media. C. The wavelength of a given sound wave in air decreases as the temperature increases. D. Sound waves cannot be reflected. (1986:Q26)
- A wave of frequency 10Hz forms a stationary wave pattern in a medium where the velocity is 20cms⁻¹. the distance between adjacent nodes is A. 1.0cm B. 1.5cm C. 2.0cm D. 5.0cm (1986:Q34)
- In the figure below a resonance tube experiment is performed using one tuning fork. As the water level is lowered the first resonance is obtained when the length of the air column $l = \lambda/4$. The second resonance is obtained when l equals A. $\lambda/2$ B. $3\lambda/4$ C. λ D. $3\lambda/2$. (1986:Q35)
- Which of the following is true of the loudness of sound? It A. Depends on the square of the amplitude of the vibrating body. B. Is proportional to the distance of the observer from the source of the sound. C. Is greatest in vacuum D. (1986:Q36)
- A man clapping his hands at regular intervals observes that the echo of a clap coincides with the next clap. If the reflecting cliff is 160m away and the speed of sound is 320ms⁻¹, what is the frequency of the clapping? A. 1Hz B. 2Hz C. 4Hz D. 8Hz. (1986:Q37)
- The vibration of an air column produces the sound in the A. Piano B. Guitar C. Flute D. School hand bell (1986:Q38)
- Which of the following instruments has a pure tone? A. Guitar B. Vibrating string C. Turning fork D. Siren. (1987:Q29)

29. The lowest note emitted by a stretched string has a frequency of 40Hz. How many overtones are there between 40Hz and 150Hz? A. 1 B. 2 C. 3 D. 4. (1987:Q30)
30. When the length l of a piece of wire under constant tension is varied, the relationship of the frequency of vibration f with l is A. $f \propto l$ B. $f \propto \frac{1}{l}$ C. $f \propto \sqrt{l}$ D. $f \propto \frac{1}{\sqrt{l}}$ (1987:Q31)
31. Which of the following media allow the transmission of sound waves through them? I. Air II. Liquids III. Solids A. I and II only B. I and III only C. II and III only D. I, II and III. (1988:Q21)
32. A piano wire 0.5m long has a total mass of 0.01kg and is stretched with a tension of 800N. Calculate the frequency of the wire when it sounds its fundamental note. A. 200Hz B. 100Hz C. 4Hz D. 2Hz. (1988:Q24)
33. A note is called an octave of another note when A. Its frequency is twice that of the first note B. Its frequency is half that of the first note C. The notes have the same fundamental frequency D. Its periodic time is twice that of the first note. (1988:Q25)
34. Which of the following factors affects the speed of sound in air? I Temperature II Pressure III Frequency. A. I only B. II only C. I and II only D. II and III only. (1988:Q26)
35. The speed of sound in air at sea-level is 340ms^{-1} while that of light is $300,000\text{kms}^{-1}$. How far (to the nearest metre) from the center of thunderstorm is an observer who hears a thunder 2s after a lightning flash? A. 170m B. 340m C. 600m D. 680m. (1988:Q27)
36. A slight loading of a tuning fork has the effect of A. Decreasing its amplitude B. Increasing its amplitude C. Decreasing its frequency D. Increasing its frequency (1988:Q28)
37. Two strings of the same length and under the same tension give notes of frequencies in the ratio 4:1. The masses of the strings are in the corresponding ratio of A. 2:1 B. 1:2 C. 1:4 D. 1:16 (1988:Q29)
38. The air column as shown in the figure above is set into vibration by the tuning fork. In this state of resonance, the waves in the air column will be A. Stationary and transverse B. Stationary and longitudinal C. Progressive and transverse D. Progressive and longitudinal. (1989:Q20)
- 
39. When the tension in a sonometer wire is doubled, the waves in the air column will be A. $1/\sqrt{2}$ B. $\frac{1}{2}$ C. $\sqrt{2}$ D. 2 (1989:Q21)
40. In which of the following diagrams is the length of the tube equal to one wavelength? The air column will be A. $1/\sqrt{2}$ B. $\frac{1}{2}$ C. $\sqrt{2}$ D. 2 (1989:Q21)
- 
41. In a resonance tube experiment, the effective length of the air column for the first resonance is 20cm when set into vibration by a tuning fork of frequency 480Hz. Neglecting end effect, the velocity of sound in air is A. 96Hz B. 255Hz C. 340Hz D. 384Hz (1990:Q31)
42. An organ pipe closed at one end is 80cm long. Determine the frequency of the fundamental note assuming that the speed of sound in air is 340ms^{-1} . A. 106Hz B. 213Hz C. 318Hz D. 425Hz (1990:Q32)
43. Two tuning forks of frequencies 256Hz and 260Hz are sounded close to each other. What is the frequency of the beats produced? A. 2Hz B. 4Hz C. 8Hz D. 258Hz (1991:Q30)
44. A man hears his echo from a nearby hill 2s after he shouted. If the frequency of his voice is 260 Hz and the wavelength is 1.29m, how far away is the hill? A. 330.0m B. 335.4m C. 660.0m D. 670.8m (1991:Q31)
45. When the bottom tip of a vibrating tuning fork held in contact with a wooden box, a louder sound is heard. This phenomena is known as A. Beats B. Echoing C. Resonance D. Reverberation (1991:Q32)
46. A note is the octave of another note if it has A. A frequency twice that of the first note B. Frequency half that of the first

- note C. The same frequency as the first one D. A frequency eight times that of the first note. (1992:Q22)
47. What is the frequency of the sound made by a siren having a disc with 32 holes and making 25 revolutions per second? A. 80Hz B. 600Hz C. 800Hz D. 1600Hz (1992:Q23)
- Use the figure below which shows a stationary wave in a closed tube to answer question 48 and 49
- 
48. The relationship between l and the wavelength λ of the stationary wave is A. $2l = \lambda$ B. $l = \lambda$ C. $l = \lambda/3$ D. $4l = 3\lambda$ (1993:Q20)
49. Determine the distance between the consecutive antinodes XX if the wavelength is 66cm. A. 15cm B. 30cm C. 60cm D. 120cm (1993:Q21)
50. The fundamental frequency of vibration (f) of a wire is measured as a function of the tension (T) in the wire. Which of the following curves adequately represents the data? (1993:Q24)
- 
51. The sound from a source traveled to the bottom of the sea and the echo was heard 4s later. If the speed of sound in seawater is 1500ms^{-1} , the depth of the sea is A. 6000m B. 3000m C. 1500m D. 375m (1994:Q29)
52. The fundamental frequency of vibration of a sonometer wire may be halved by A. Doubling the length of the wire B. Doubling the mass of the wire C. Reducing the tension by half D. Reducing the absolute temperature by half. (1994:Q30)
53. A pipe of length 45cm is closed at one end. Calculate the fundamental frequency of the sound wave generated in the pipe if the velocity of sound in air is 360ms^{-1} (Neglect end corrections). A. 5.5Hz B. 148.5 Hz C. 200.0Hz D. 550.0Hz (1994:Q31)
54. The note produced by a stretched string has a fundamental frequency of 400Hz. If the length of the string is doubled while the tension in the string is increased by a factor of 4, the frequency is A. 200Hz B. 400Hz C. 800Hz D. 1600Hz (1994:Q32)
55. Which of the diagrams below represents the second overtone of a vibrating string fixed at both ends? (1995:Q30)
- 
56. The pitch of an acoustic device can be increased by A. Increasing the frequency B. Increasing the amplitude C. Decreasing the loudness D. Decreasing the intensity (1995:Q31)
57. Under constant tension and constant mass per unit length, the note produced by a plucked string is 500Hz when the length of the string is 0.90m. At what length is the frequency 150Hz? A. 3m B. 4m C. 5m D. 6m (1997:Q29)
58. If the load at the end of a sonometer wire is immersed in a bucket of water, the original fundamental frequency of the wire could be restored by A. decreasing the length of the wire B. increasing the length of the wire C. increasing the mass per unit of the wire D. changing the temperature of the water. (1997:Q32)
59. The physical properties of sound waves can best be described by A. Reflection and diffraction B. Polarization and reflection C. Polarization and diffraction D. Polarization and refraction (1998:Q24)
60. The velocity of a sound wave at 27°C is 360ms^{-1} . Its velocity at 127°C is A. $120\sqrt{3}\text{ms}^{-1}$ B. 240ms^{-1} C. $240\sqrt{3}\text{ms}^{-1}$ D. $720\sqrt{3}\text{ms}^{-1}$ (1998:Q25)
61. In a closed organ pipe producing a musical note, an antinode will always be produced at A. the closed end B. the open end C. the middle D. All the parts of the pipe. (1998:Q26)

62. A steel wire of length 0.50m is stretched between two fixed points and its fundamental frequency is 200Hz. The speed of the wave in the wire is A. 100ms⁻¹ B. 120ms⁻¹ C. 200ms⁻¹ D. 250ms⁻¹ (1998:Q27)
63. In a resonance tube experiment, if the fundamental frequency of the vibrating air column is 280Hz, the frequency of the third overtones is A. 70Hz B. 840Hz C. 1120Hz D. 1960Hz (1998:Q28)
64. The lowest note emitted by a stretched string has a frequency of 40Hz. How many overtones are their between 40Hz and 180Hz? A. 4 B. 3 C. 2 D. 1 (1999:Q19)
65. If a sound wave goes from a cold-air region to a hot-air region, its wavelength A. Increase B. Decrease C. Decrease then increase D. Remain constant (1999:Q21)
66. A sonometer wire is vibrating at frequency f_0 . If the tension in the wire is doubled while the length and the mass per unit length are kept constant, the new frequency of vibration is A. $f_0/2$ B. $2f_0$ C. $f_0/\sqrt{2}$ D. $f_0\sqrt{2}$ (2000:Q18)
67. A transverse wave is applied to a string whose mass per unit is $3 \times 10^{-3}\text{kgm}^{-1}$. If the string is under a tension of 12N, the speed of propagation of the wave is A. 40ms⁻¹ B. 30ms⁻¹ C. 20ms⁻¹ D. 5ms⁻¹ (2000:Q24)
68. Find the frequencies of the first three harmonics of a piano string of length 1.5m, if the velocity of the waves on the string is 120ms⁻¹. A. 40Hz, 80Hz, 120Hz B. 80Hz, 160Hz, 240Hz C. 180Hz, 360Hz, 540Hz D. 360Hz, 180Hz, 90Hz (2001:Q12)
69. A string is fastened tightly between two walls 24cm apart. The wavelength of the second overtone is A. 24cm B. 16cm C. 12cm D. 8cm (2001:Q18)
70. **I. Temperature. II. Density of air molecules. III. Pressure. IV. Pitch.** Which of the above will affect the velocity of sound in air? A. I, II, III and IV. B. I, II and IV only. C. II and IV only. D. I and II only. (2002:Q13)
71. The phenomenon that makes sound persist when its source has been removed is known as A. rarefaction B. acoustic vibration C. reverberation - D. echo. (2002:Q15)
72. If tension is maintained on a stretched string of length 0.6m, such that its fundamental frequency of 220Hz is excited, determine the velocity of the transverse wave in the string. A. 66ms⁻¹ B. 132ms⁻¹ C. 264ms⁻¹ D. 528ms⁻¹ (2002:Q29)
73. A tuning fork of frequency 340Hz is vibrated just above a cylindrical tube of height 1.2m. If water is slowly poured into the tube, at what maximum height will resonance occur? A. 0.95m B. 0.60m C. 0.50m D. 0.45m [speed of sound in air = 340ms⁻¹] (2003:Q15)
74. An open pipe closed at one end produces its first fundamental note. If the velocity of sound in air is v and l the length of the pipe, the frequency of the note is A. $2v/l$ B. $v/5l$ C. $v/4l$ D. $v/2l$ (2003:Q18)
75. Given that Young's modulus for aluminium is $7.0 \times 10^{10}\text{Nm}^{-2}$ and density is $2.7 \times 10^3\text{kgm}^{-3}$, find the speed of the sound produced if a solid bar is struck at one end with a hammer. A. $5.1 \times 10^3\text{ms}^{-1}$ B. $4.2 \times 10^3\text{ms}^{-1}$ C. $3.6 \times 10^3\text{ms}^{-1}$ D. $2.8 \times 10^3\text{ms}^{-1}$ (2003:Q19)
76. If the distance from a point source of sound is doubled, by what factor does the intensity decrease? A. 4.00 B. 2.00 C. 0.50 D. 0.25 (2003:Q24)
77. In which of the following material media would sound travel fastest? A. water B. oil C. metal D. gas (2004:Q4)
78. The pitch of a sound note depends on A. timbre. B. harmonics. C. quality. D. frequency. (2004:Q9)
79. Marching soldiers crossing a suspension bridge are usually advised to break their steps to avoid damaging the bridge owing to A. swinging. B. vibration. C. oscillation. D. resonance. (2005:Q35)
80. The velocity of sound in air will be doubled if its absolute temperature is A. doubled. B. halved. C. constant. D. quadrupled. (2005:Q38)
81. The wavelength of the first overtone of a note in a closed pipe of length 33cm is A. 44cm B. 33cm C. 22cm. D. 17cm (2006:Q30)
82. The fundamental frequency of a plucked wire under a tension of 400N is 250Hz. When the frequency is changed to 500Hz at constant length, the tension is A. 40N. B. 160N. C. 400N. D. 1600N. (2007:Q2)
83. In a large telecommunications auditorium, perforated absorbent materials are used to line the ceiling so as to A. reduce the reverberation of sound in the hall B. reduce the height of the ceiling from the floor. C. increase the reverberation of sound in the hall. D. increase the amount of echo in the hall. (2007:Q7)
84. When the length of a vibrating string is reduced by one-third, its frequency becomes A. three times its former value. B. twice its former value C. one-third of its former value. D. one-sixth of its former value. (2008:Q29)
85. Metal cables are used as telephone wires because A. they are cheap. B. they are sourced locally C. the speed of sound in them is very low D. the speed of sound in them is very high (2009:Q28)
86. Musical instruments playing the same note can be distinguished from one another owing to the differences in their A. quality. B. pitch. C. intensity. D. loudness. Musical instruments playing the same note can be distinguished from one another owing to the differences in their A. quality. B. pitch. C. intensity. D. loudness. (2009:Q29)
87. The sound of an electric bell dies down slowly when air is slowly pumped out from a bottle because A sound cannot pass through the bottle B. sound can pass through a vacuum C. sound needs a material medium. D. the wavelength of sound becomes greater in the bottle. (2010:Q25)
88. During a thunderstorm, the sound is heard over a long time. This phenomenon is referred to as A. refraction of sound B. reverberation C. superposition D. diffraction of sound. (2010:Q26)
89. The velocity of sound in air at 16°C is 340ms⁻¹. What will it be when the pressure is doubled and its temperature raised to 127°C? A. 4 000ms⁻¹ B. 160 000ms⁻¹ C. 8 000ms⁻¹ D. 400ms⁻¹ (2010:Q27)
90. A length of wire has a frequency of 255Hz when stretched by a force of 225N. If the force increases to 324N, what is the new frequency of vibration? (2011:Q26)
91. A cannon is fired from town X. After how long is the sound heard at a town Y 4.95 km away? A. 12s B. 15s C. 30s D. 10s [velocity of sound in air = 330ms⁻¹] (2011:Q31)
92. Which of the following factors will affect the velocity of sound? A. An increase in the pitch of the sound. B. An increase in the loudness of the sound C. Wind travelling in the same direction of the sound the D. A change in the atmospheric pressure constant temperature (2012:Q28)
93. The characteristic of a vibration that determines its intensity is the A. frequent B. overtone C. wavelength D. amplitude. (2012:Q29)
94. What is the velocity of sound at 100°C if the velocity of sound at 0°C is 340ms⁻¹? A. 497m⁻¹ B. 440m⁻¹ C. 397m⁻¹ D. 240m⁻¹ (2013:Q27)
95. If a sonometer has fundamental frequency of 450Hz, what is the frequency of the fifth overtone? A. 2700Hz. B. 456Hz. C. 444Hz. D. 75Hz. (2013:Q28)
96. A boy receives the echo of his clap reflected by a nearby hill 0.8s later. How far is he from the hill? A. 528m B. 66m C. 36m D. 264m [speed of sound in air = 340ms⁻¹] (2014:Q27)



The diagram above shows a stationary wave of wavelength 40cm in a closed tube. The length L of the resonating air column is A. 40cm B. 10cm C. 20cm D. 30cm (2014:Q28)

98. A man hears his echo from a nearby hill 2s after he shouted. If the frequency of his voice is 260Hz and the wavelength is 1.29m, how far away is the hill? A. 330.0m B. 335.4m C. 670.8m (2018:28)

CHAPTER 19

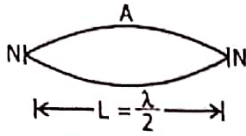
SOUND WAVES: PROPAGATION AND CHARACTERISTICS

- 1B. At fundamental frequency, the two ends are two adjacent nodes

$$\therefore \lambda = 2 \times 75 = 150\text{cm}$$

NOTES:

1. Two nodes or two antinodes are $\frac{\lambda}{2}$ apart



2. A node and an adjacent antinode are $\frac{\lambda}{4}$ apart
 3. The fixed ends of a string are always nodes.
 4. At fundamental frequency, two nodes are recorded (above) but at the subsequent overtones we record 3, 4, 5... nodes



- 2D. Generally for sound waves $V_{\text{solid}} > V_{\text{liquid}} > V_{\text{gas}}$

- 3C. For a distance x, the sound wave travels twice of x hence

$$v = \frac{2x}{t} \quad (v = \frac{s}{t}) \quad \rightarrow \quad v = \frac{2 \times 680}{4} = 340\text{ms}^{-1}$$

- 4C. The distance shown is the distance between two adjacent nodes and antinode which is $\frac{\lambda}{4}$ (see Q1) $\therefore \frac{\lambda}{4} = 16 \rightarrow \lambda = 64\text{cm}$

$$\text{But } f = \frac{v}{\lambda} = \frac{327.68}{0.64} \quad f = 512\text{Hz}$$

5E. From $f_0 = \frac{1}{2} \sqrt{\frac{T}{M}}$

- $f_0 \propto \sqrt{T}$ [L and M are constant]
- $f_0 \propto \frac{1}{L}$ [T and M are constant]
- $f_0 \propto \frac{1}{\sqrt{M}}$ [T and L are constant]

where f_0 = fundamental frequency; T = tension in spring (N)
 L = Natural length of string (M); M = Mass per unit length (Kg m^{-1})
NOTE: M here is not the absolute mass of string such that if the absolute (real) mass of string is m then M is $M = \frac{m}{L}$ (Kg m^{-1})

6. Doppler's effect or principle states that an apparent change in frequency of the wave motion should be observed when a source of sound or light is moving. It follows that frequency increases when one source of sound moves towards an individual but decreases as it moves away. In all these, pitch is a function of frequency and it changes proportionally. But the diagram was not available here.

- 7C. See chapter 18

- 8A. See Q6

- 9C. Overtones are integral multiples of the fundamental frequency f_0 such $2f_0, 3f_0, 4f_0, \dots$ $320 \rightarrow 640, 960, 1280, 160\text{Hz}, \dots$

NOTES:

- The frequencies produced above are called harmonics.
 - The fundamental frequency f_0 is itself a harmonic and the first harmonic, of course.
 - Therefore $2f_0, 3f_0, 5f_0, \dots$ are 2nd, 3rd, 5th... harmonics respectively.
 - However, overtones begin with $2f_0$ hence $2f_0, 3f_0, 4f_0, \dots$ are 1st, 2nd, 3rd... overtones respectively.
- 10C. Quality is a characteristic note produced by a musical instrument as opposed to another note of the same pitch and loudness because the note is a blend of the fundamental frequency and the overtones present (harmonics)

11A. $x = \frac{vt}{2} = \frac{1400 \times 2.5}{2} = 1750\text{m}$

12C. $L = \frac{\lambda}{4} + \frac{\lambda}{2}$ (You get the gist?); $L = \frac{3}{4}\lambda$ (compare Q4)

$$\therefore \lambda = \frac{4l}{3} = 4 \times \frac{0.3}{3} \rightarrow \lambda = 0.4\text{m}$$

$$\text{But } v = f\lambda = 750 \times 0.4 \quad v = 300\text{ms}^{-1}$$

- 13B. In a close pipe, only odd harmonics are possible i.e $f_0,$

$$3f_0, 5f_0, 7f_0, \dots \quad \therefore \frac{f_2}{f_1} = \frac{3f_0}{f_0} = 3$$

NOTES:

- In the above the 3rd harmonic $3f_0$ is the first overtone etc.
- In an open pipe, all harmonics (even and odd) are present.

- 14B. "How much closer" is the distance between its original and final positions.

$$\text{Initial distance from cliff: } x_1 = \frac{vt}{2} = \frac{250 \times 3.5}{2} = 437.5\text{m}$$

$$\text{Final distance from cliff: } x_2 = \frac{250 \times 2.5}{2} = 312.5\text{m}$$

$$\text{The ship is closer to cliff by: } x_1 - x_2 = 125\text{m}$$

- 15.

I \rightarrow see Q6

II \rightarrow Intensity (loudness) is proportional to the square of amplitude as $I \propto \frac{1}{d^2}$ and $A \propto \frac{1}{d}$ or $A^2 \propto \frac{1}{d^2} \therefore I \propto A^2$

Where I \rightarrow Intensity d = distance from sound source and A = amplitude

III \rightarrow Beats are produced because one wave interferes with another of nearly equal frequency.

IV \rightarrow Beat frequency = $f_2 - f_1$ (if $f_2 > f_1$)

V \rightarrow The first harmonic is the fundamental frequency itself. Therefore III and V are wrong. No option was correct

- 16A. Now see Qs 1 and 4

- 17C. I \rightarrow Pitch, loudness and pressure of the surrounding air have no effect on velocity of sound.

II \rightarrow In fact, the velocity of sound is proportional to the square root of the absolute temperature (i.e in kelvin not $^{\circ}\text{C}$) $\rightarrow v \propto \sqrt{T}$

III \rightarrow The quality of sound depends on the frequency and the background overtones present.

NOTES:

- The velocity of sound also depends on the density of the medium in which it travels - greatest in solids and lowest in gases $V_{\text{solid}} > V_{\text{liquid}} > V_{\text{gas}}$
- Wind also affects velocity of sound in air - velocity is higher if wind travels in the same direction and lower in opposite direction.

- 18B. Loading decreases the frequency of the tuning fork to 252Hz such that frequency = unloaded - loaded = $256 - 254 = 4\text{Hz}$

19A. $x = \frac{vt}{2} = \frac{1500 \times 1}{2} = 750\text{m} = 0.75\text{km}$

- 20B. Sound travels faster in water than air (liquid versus gas) because its wavelength increases while its frequency remains constant.

$$V_{\text{water}} > V_{\text{air}} \text{ (see Q17)} \rightarrow f\lambda_{\text{water}} > f\lambda_{\text{air}} \text{ as } \lambda_{\text{water}} > \lambda_{\text{air}}$$

21A. $\lambda = \frac{v}{f} = \frac{340}{170} = 2\text{m}$

$$\text{At fundamental frequency } f_0: L = \frac{\lambda}{4} = \frac{2}{4} = 0.5\text{m} = 50\text{cm}$$

$$f_0 \rightarrow L_1 = \frac{\lambda}{4} \quad 3f_0 \rightarrow L_2 = \frac{3\lambda}{4} \text{ (1st overtone)}$$

$$5f_0 \rightarrow L_3 = \frac{5\lambda}{4} \text{ (2nd overtone) etc.}$$

- 22A. A $\rightarrow V \propto \sqrt{T}$ (see Q17) B \rightarrow See Q20

C $\rightarrow \lambda$ increases since V increases with T.

D \rightarrow All waves can be reflected.

23A. $V = 200\text{ms}^{-1} = 0.2\text{ms}^{-1}$ but $\lambda = \frac{v}{f} = \frac{0.2}{10} = 0.02\text{m}$

$$\lambda = 2\text{cm} \quad \text{Two adjacent nodes are } \frac{\lambda}{2} \text{ apart (Q1)}$$

\therefore The nodes are 1cm apart.

- 24B. See Q1 25A. See Q15

- 26A. Time between two successive claps is equal to the time taken for a sound wave to travel back and forth.

But $T = \frac{2x}{v} = \frac{2 \times 160}{320} = 1 \rightarrow F = \frac{1}{T} = \frac{1}{1} = 1\text{Hz}$

Note that 2claps makes one cycle here hence period is 1s and frequency is 1Hz.

27C. Flute is a wind instrument

NOTES:

1. Wind instrument \rightarrow flutes, trumpets, pipe organ, saxophones, clarinet etc.
2. Percussion instruments \rightarrow bell, drum, xylophone, gongs, tuning fork, cymbal e.t.c.
3. Stringed instruments \rightarrow guitar, sonometer, piano, violin etc.

28C. While the others produce a blend of the fundamental frequency and the overtones, a tuning fork when struck produces its fundamental only.

29B. $f_0 \rightarrow 2f_0 \rightarrow 3f_0$
 $40\text{Hz} \rightarrow 80\text{Hz} \rightarrow 120\text{Hz} \rightarrow 150\text{Hz}$

30D. See Q5

31D. Sound travels in them all but at different speeds - See Q17

32A. $f = \frac{1}{2L} \sqrt{\frac{T}{M}}$ (see Q5) $L = 0.5\text{m}$ $T = 800\text{N}$ $M = 0.01\text{kg}$

$M = \frac{m}{L} = \frac{0.01}{0.5} = 0.02\text{Kg m}^{-1} \therefore f_0 = \frac{1}{2 \times 0.5} \sqrt{\frac{800}{0.02}}$

$f_0 = \sqrt{40000} = 200\text{Hz}$

33A. A note of frequency f_1 is an upper octave of another of frequency f_2 such that their musical interval is given by

$I = \frac{f_1}{f_2} = 2 \rightarrow \therefore f_1 = 2f_2$ or $f_1:f_2 = 2:1$

34A. See Q17

35D. Since light travels at this very high speed, the time taken for the flash to reach us is negligible hence it signifies the beginning of the travel of the thunder clap (sound) $s = vt = 340 \times 2 = 680\text{m}$

36C. See Q18

37D. $f = \frac{1}{2L} \sqrt{\frac{T}{M}} \rightarrow \therefore f \propto \frac{1}{\sqrt{M}}$ where $M = \frac{m}{L}$

$f \propto \frac{1}{\sqrt{M}}$ (since L is equal to both) $\frac{f_1}{f_2} = \sqrt{\frac{m_2}{m_1}}$

$\frac{4}{1} = \sqrt{\frac{m_2}{m_1}} \rightarrow \frac{m_2}{m_1} = \left(\frac{4}{1}\right)^2 \therefore m_1:m_2 = 1:16$

38B. Sound wave is longitudinal and the close end is an obstacle that causes sound wave to be reflected and from stationary wave in the column.

39C. $f \propto \sqrt{T} \rightarrow \frac{f_2}{f_1} = \sqrt{\frac{T_2}{T_1}} \rightarrow \frac{f_2}{f_1} = \sqrt{\frac{2}{1}} = \sqrt{2}$

40C. $L = \frac{\lambda}{4} + \frac{\lambda}{2} + \frac{\lambda}{4} = \frac{\lambda + 2\lambda + \lambda}{4} = \frac{4\lambda}{4} = \lambda$

41D. At first resonance: $L = \frac{\lambda}{4} \rightarrow \lambda = 4 \times 0.2 = 0.8\text{m}$

But $v = f\lambda = 480 \times 0.8 = 384\text{Hz}$

42A At $f_0: L = \frac{x}{4} \therefore \lambda = 4L = 4 \times 0.8 = 3.2\text{m}$

$\therefore f_0 = \frac{v}{\lambda} = \frac{340}{3.2} = 105.25\text{Hz}$

43B Beat frequency = $260 - 256 = 4\text{Hz}$

44B $v = f\lambda = 260 \times 1.29 = 335.4\text{ms}^{-1}$

But $x = \frac{vt}{2} = \frac{335.4 \times 2}{2} = 335.4\text{m}$

45C The wooden box is in forced vibration and the louder sound (higher amplitude) heard arises from the fact that the forcing frequency of the fork coincides with the natural frequency of the box

46B The statement of this question is ambiguously worded unlike in Q33. The "it" in the question refers to the first note, please, hence B but not A is our answer

47C $f = \frac{\text{No of Revolution} \times \text{No of Discs}}{\text{Time of Revolution}} = \frac{\text{No of Revolution} \times \text{No of Discs}}{\text{Time of Revolution}}$
 $= \frac{25}{1} \times 32 = 800\text{Hz}$

48D. $L = \frac{3}{4}\lambda \rightarrow 4L = 3\lambda$

49B Distance between 2 antinodes = $\frac{1}{2}\lambda = \frac{1}{2} \times 60 = 30\text{cm}$

50C $f = \frac{1}{2L} \sqrt{\frac{T}{M}} \therefore f \propto \sqrt{T}$ or $f_2 \propto T$

51B $x = \frac{vt}{2} = \frac{1500 \times 4}{2} = 3000\text{m}$

52A $f \propto \frac{1}{L} \rightarrow \frac{f_1}{f_2} = \frac{L_2}{L_1} \rightarrow \frac{f_1}{f_2} = \frac{L_1}{2L_1} = \frac{1}{2}$

This when L_2 is $2L_1$, f_2 is $\frac{1}{2}f_1$

53A. $f \propto \frac{1}{L} \therefore$ If L is doubled, f is halved If L is halved, f is doubled.

54C. At f_0 $L = \frac{\lambda}{4} \therefore 4L = 4 \times 0.45 = 1.8\text{m}$

But $f_0 = \frac{v}{\lambda} = \frac{360}{1.8} \rightarrow f_0 = 200\text{Hz}$

55B. $f = \frac{1}{2L} \sqrt{\frac{T}{M}} \therefore \sqrt{\frac{2f_1 L_1}{2f_2 L_2}} = \sqrt{\frac{T_1}{T_2}}$

Note that if L is doubled, m is also doubled hence m remains unchanged.

Let $L_1 = 1\text{unit}$; $L_2 = 2\text{units}$; $T_1 = 1$ and $T_2 = 4$

$\frac{2 \times f_1 \times 1}{2 \times f_2 \times 2} = \sqrt{\frac{1}{4}} \rightarrow \frac{f_1}{2f_2} = \frac{1}{2} \rightarrow 2f_2 = 2f_1$

$\therefore f_2 = f_1 = 400\text{Hz}$

56C. (A) is the fundamental frequency and 1st harmonic. (B) is 2nd harmonic, 1st overtone e.t.c. - See Q9

57A. Low frequency has low pitch; high frequency has high pitch.

58A. $f \propto \frac{1}{L} \rightarrow \therefore f_2 L_2 = f_1 L_1 \rightarrow 150 L_2 = 500 \times 0.90 \rightarrow L_2 = 3\text{m}$

59B. Immersion of load causes apparent weight loss registered as reduced tension(T) in the sonometer wire (Archimede's Principle - see chapter 11) since $f \propto \sqrt{T}$ then reduced (T) means reduced (f). In order to restore (f), the length (L) of the wire must be decreased since $f \propto \frac{1}{L}$

60A. Sound is a longitudinal wave hence cannot be polarised.

61C. $V \propto \sqrt{T}$ (see Q17) $\therefore V_1 = 360\text{ms}^{-1}$ $T_1 = 27 + 273 = 300\text{K}$

$T_2 = 127 + 273 = 400\text{K} \therefore \frac{300}{V_2} = \sqrt{\frac{300}{400}}$

$V_2 = \sqrt{\frac{360 \times 360 \times 400}{300}} = 240\sqrt{3}\text{ms}^{-1}$

62B. Antinode always at open end, node always at close end.

63C. At $f_0: L = \frac{\lambda}{2} \therefore \lambda = 2L \rightarrow \lambda = 2 \times 0.5 = 1\text{m}$

But $V = f\lambda = 200 \times 1 = 200\text{ms}^{-1}$

64D. Third overtone is the 7th harmonic in a resonance tube as you remember that only odd harmonics are possible

$f_0, 3f_0, 5f_0, 7f_0, 9f_0$
 overtones \therefore 3rd overtone = $7 \times 280 = 1960\text{Hz}$

65B. Compare Q29 $f_0 \rightarrow 2f_0 \rightarrow 3f_0 \rightarrow 4f_0$
 40Hz 80Hz 120Hz 160Hz

66A. It velocity increases ($V \propto \sqrt{T}$) as its wavelength increases ($V \propto f\lambda$) where f is unaltered - see Q20.

67D. $\frac{f_1}{f_0} = \sqrt{\frac{T_1}{T_0}} \quad f_1 = f_0 \sqrt{\frac{2}{1}} = f_0 \sqrt{2}$

68C. $f_0 = \frac{v}{\lambda} = \frac{1}{2L} \sqrt{\frac{T}{M}}$ But at f_0 $L = \frac{\lambda}{2} \therefore \lambda = 2L$

$\therefore \frac{v}{2L} = \frac{1}{2L} \sqrt{\frac{T}{M}} \quad v = \sqrt{\frac{T}{M}} = \sqrt{\frac{12}{3 \times 10^{-3}}} = 20\text{ms}^{-1}$

68A. The first harmonic is the fundamental frequency.

At $f_0 L = \frac{\lambda}{2} \therefore \lambda = 2L$ using $f_0 = \frac{v}{\lambda} = \frac{120}{2 \times 1.5} = 40\text{Hz}$
 since all harmonics are possible than the 1st 3 harmonics are 40, 80 and 120Hz.

69B. $L = \frac{3\lambda}{2}$ (see Q1) $\therefore \lambda = \frac{2L}{3} = \frac{2 \times 24}{3} = 16\text{cm}$

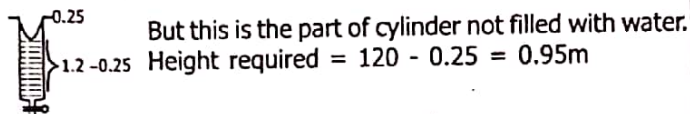
70D. See Q17

71C. Reverberation is multiple echos a listener hears long after the source ceases to produce sound while an echo is a single reflection of sound which dies off as soon as it returns to the listener.

72C. $L = \frac{\lambda}{2}$ (at f_0) $\lambda = 2 \times 0.6 \quad \lambda = 1.2\text{m}$
 $v = f \times \lambda = 220 \times 1.2 \quad v = 264\text{ms}^{-1}$

73A. This is at fundamental frequency f_0 when $L = \frac{\lambda}{4}$

But $\lambda = \frac{v}{f} = \frac{340}{340} = 1\text{m} \quad L = \frac{1}{4} = 0.25\text{m}$



74C. $L = \frac{\lambda}{4}$ or $\lambda = 4L$ But $f = \frac{v}{\lambda} = \frac{v}{4L}$

75A. $v = \sqrt{\frac{\text{Young's Modulus}}{\text{Density}}} = \sqrt{\frac{7.0 \times 10^{10}}{2.7 \times 10^3}} = \sqrt{2.59 \times 10^7}$

$v = 5.1 \times 10^3\text{ms}^{-1}$

NOTE: Confirm the equation above using dimensions:

$v = \sqrt{\frac{\text{Young's}}{\text{Density}}} \rightarrow \frac{\text{m}}{\text{s}} = \sqrt{\frac{\text{N}}{\text{m}^2} \times \frac{\text{m}^3}{\text{kg}}}$

$\rightarrow \frac{\text{m}}{\text{s}} \sqrt{\text{kgms}^{-2}\text{m}^3\text{m}^{-2}\text{kg}^{-1}} = \sqrt{\text{m}^2\text{s}^{-2}} = \text{ms}^{-1}$

76A. $I \propto \frac{1}{d^2}$ (see Q15) $\rightarrow \therefore \frac{I_1}{I_2} = \left(\frac{d_2}{d_1}\right)^2$

If $d_1 = 1\text{unit}$, $d_2 = 2\text{unit} \rightarrow \therefore \frac{I_1}{I_2} = \left(\frac{1}{2}\right)^2 = \frac{1}{4}$

77C. Fastest in solid (Q2)

78D. See Q6

79D. Otherwise, uniform steps would create a vibration with frequency equal in magnitude to the natural frequency of the bridge.

80D. $v \propto \sqrt{T} \rightarrow \frac{T_2}{T_1} = \left(\frac{v_2}{v_1}\right)^2 = \left(\frac{2}{1}\right)^2 \rightarrow \frac{T_2}{T_1} = 4$

81A. At first overtone: $L = \frac{3\lambda}{4} \therefore \lambda = \frac{4L}{3} = \frac{4 \times 33}{3} = 44\text{cm}$

82D. $\frac{T_2}{T_1} = \left(\frac{f_2}{f_1}\right)^2$ ($f \propto \sqrt{T}$) $\rightarrow \frac{T_2}{400} = \left(\frac{500}{250}\right)^2 \rightarrow T_2 = 400 \times 22 = 1600\text{N}$

83A. See Q72

84A. $f \propto \frac{1}{L}$

85D. See Q78

86A. While pitch distinguishes a high note from a low note, quality distinguishes notes of same pitch emanating from different musical instruments. In other words, pitch involves two or more notes, one instrument; quality involves one note, two or more instruments.

87B. Sound is a mechanical wave.

88B. Persistence of echos (Q72)

89D. Velocity is independent of air pressure: $v \propto \sqrt{T}$

$\therefore \frac{v_2}{v_1} = \sqrt{\frac{T_2}{T_1}} \rightarrow v = 340 \sqrt{\frac{273 + 127}{273 + 16}} \quad v = 399.988\text{ms}^{-1}$

90C. $\frac{f_2}{f_1} = \sqrt{\frac{T_2}{T_1}} \rightarrow f_2 = 255 \sqrt{\frac{324}{225}} = 306\text{Hz}$

91B. $t = \frac{x}{v}$ (Q3) $\rightarrow t = \frac{4.95 \times 10^3}{330} = 15\text{s}$

94C. $T_1 = 0^\circ\text{C} = 0 + 273 = 273\text{K}$; $T_2 = 100^\circ\text{C} = 373\text{K}$;

$v_1 = 340\text{ms}^{-1} \rightarrow v \propto \sqrt{T} \rightarrow \therefore \frac{v_2}{v_1} = \sqrt{\frac{T_2}{T_1}}$

$v_2 = 340 \sqrt{\frac{373}{273}} = 397\text{ms}^{-1}$

95A. For a sonometer, all harmonics are possible

$f_0, 2f_0, 3f_0, 4f_0, 5f_0, 6f_0$
 overtones
 5th overtone = $6 \times 450 = 2700\text{Hz}$

96A. $x = \frac{vt}{2} \rightarrow x = \frac{340 \times 0.8}{2} = 136\text{m}$

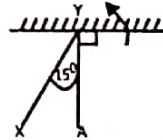
97B. $L = \frac{3\lambda}{4}$ (Q12); $L = \frac{3 \times 40}{4} = 30\text{m}$

98B. $x = \frac{vt}{2} = \frac{f\lambda t}{2} = \frac{260 \times 1.29 \times 2}{2} = 335.4\text{m}$

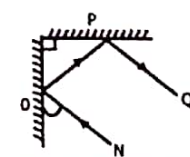
CHAPTER 20

LIGHT ENERGY. REFLECTIONS FROM PLANE SURFACES

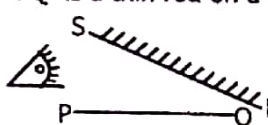
- An object is positioned between two plane mirrors inclined at right angles to each other. The object is 1 unit distance from each mirror. The number of images formed is A. 1 B. 2 C. 3 D. 4 E. 5 (1978:Q44)
- A man standing between two parallel mirrors in a barber's shop will see the following number of his own image A. Eight B. Two C. Four D. One E. Infinite. (1979:Q18)
- Which of the following statements is NOT true of the image in a plane mirror? The image is A. the same size as the object B. laterally inverted C. virtual D. magnified E. the same distance (1980:Q17)
- Which of the following does NOT describe the image formed by a plane mirror? A. Erect B. Laterally C. Same distance from mirror as object D. Magnified E. Virtual (1981:Q7)
- An object 15cm high is 30cm from a pin-hole camera. If the height of the image formed at the back of the camera is 10cm, the image distance is A. 20cm B. 45cm C. 54cm D. 63cm E. 70cm (1982:Q18)
- In the figure below an incident ray XY makes an angle of 15° with a fixed line AY which is normal to the surface of a plane mirror. If the mirror is turned as indicated by the arrow, through 40° , what angle will the reflected ray make with AY? A. 25° B. 40° C. 15° D. 55° E. 95° (1982:Q23)

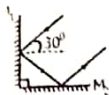


- Two mirrors of the same length are arranged as shown in the diagram. A ray of light NO strikes the system at O and emerges along PQ. The emergent ray has been deviated through A. 220° B. 200° C. 210° D. 180° E. 230° (1982:Q36)



- PQ is a thin rod on a horizontal table, RS is a plane mirror inclined at 45° to the horizontal as shown in figure above. The image of PQ as seen in the mirror by the eye, T is A. Horizontal B. Parallel to the mirror C. At infinity D. Vertical E. Highly magnified. (1983:Q45)
- What is the effect of the increase in the size of the hole of a pin-hole camera on the image? It A. Gives a blurred image. B. Corrects for chromatic aberration C. Magnifies the image D. Brings the image into the sharper focus. (1986:Q32)
- Which of the following statements supports the assumption that light travels in straight lines? A. Light can be diffracted B. A source of light produces distinct shadows of opaque objects C. A source of light produces interference patterns on a suitably placed screens. D. Light can be reflected. (1987:Q32)

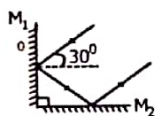




In the figure above, what is the angle of reflection of the ray of light at mirror M_1 ?

- A. 0° B. 60° C. 45° D. 30° (1988:Q31)

13. The plane mirrors in a kaleidoscope are usually placed A. At an angle of 60° B. Parallel to one another C. Perpendicular to one another D. At an angle of 45° (1989:Q27)
14. Shadows and eclipse result from the A. Refraction of light B. Rectilinear propagation of light C. Diffraction of light D. Reflection of light (1990:Q23)
15. A boy looks at the image of an object in a plane mirror. He observes two images, a main bright one and the other faint. The observed images result from A. Reflection only B. Refraction only C. Diffraction and interference D. Reflection and refraction. (1990:Q25)
16. The image in pin-hole camera is A. Erect and formed by refraction through a lens B. Virtual and formed by dispersion C. Erect and gets sharper as the hole becomes larger D. Inverted and formed by the light from each point traveling in a straight line. (1991:Q25)
17. When a plane mirror at which a ray is incident is rotated through an angle Q , the reflected ray will be rotated through A. $\frac{1}{2}Q$ B. Q C. $2Q$ D. $3Q$ (1991:Q26)
18. Two mirrors, M_1 , M_2 are inclined at right angles as shown



above. Calculate the angle of reflection of the ray of light at mirror M_2 . A. 30° B. 45° C. 60° D. 90° (1993:Q25)

19. Total eclipse of the sun occurs when the A. Earth is between the moon and the sun B. Sun is between the moon and the earth C. Moon is between the sun and the earth D. Ozone layer (1995:Q32)

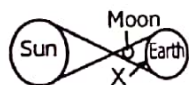


diagram above, an observer standing at X is in A. penumbra and sees a partial eclipse B. penumbra and sees a total eclipse C. umbra and sees a partial eclipse D. umbra and sees a total eclipse. (1997:Q33)

20. When the sun, the moon and the earth are as shown in the diagram above, an observer standing at X is in A. penumbra and sees a partial eclipse B. penumbra and sees a total eclipse C. umbra and sees a partial eclipse D. umbra and sees a total eclipse. (1997:Q33)
21. An object is placed in front of two plane mirrors inclined at an angle θ° . If the total number of images formed is 7, find the value of θ° ? A. 30° B. 45° C. 51° D. 90° (1998:Q30)
22. A man stands 4m in front of a plane mirror. If the mirror is moved 1m towards the man, the distance between him and his image is A. 3m B. 5m C. 6m D. 10m (1999:Q20)
23. An engineer intends to deviate a light ray from its path 120° through reflection from plane mirror. Calculate the angle of incidence. A. 20° B. 30° C. 40° D. 60° (2000:Q14)
24. A ray of light strikes a plane mirror at an angle of incidence of 35° . If the mirror is rotated through 10° , through what angle is the reflected ray rotated? A. 70° B. 45° C. 25° D. 20° (2001:Q11)
25. If an object is placed between two parallel plane mirrors with their reflecting surfaces facing each other, how many images of the object will be formed? A. Four B. Two C. Eight D. infinite (2003:Q21)
26. What happens to the rays in a parallel beam of light? A. they diverge as they travel B. they meet at infinity C. they intersect D. they converge as they travel (2004:Q6)
27. A ray of light makes an angle of 35° with a plane mirror. What is the angle of reflection? A. 55° B. 35° C. 70° D. 65° (2004:Q8)
28. The sharpness of the boundary of the shadow of an object is determined by the A. rays of light passing through the object. B. intensity of light striking the object. C. opacity of the object. D. nature of the object. (2005:Q37)
29. Non-luminous objects can be seen because they A. are polished. B. are near. C. reflect light. D. emit light. (2006:Q37)
30. The instrument used by designers to obtain different colour patterns is called A. periscope B. periscope C. kaleidoscope

IV. Rectilinear propagation of light Which of the above is a phenomenon of total solar eclipse? A. I and IV only B. II and IV only C. I and III only D. III and IV only (2008:Q30)


32. An object of height 4cm is placed in front of a cuboid pinhole camera of size 6cm. If the image formed is 2cm high, how far is the object from the pinhole? A. 3.0 cm B. 8.0 cm C. 12.0 cm D. 16.0 cm (2008:Q31)
33. I. Moon II. Sun III. Street light IV. Stars Which of the above is a natural source of light? A. II, III and IV only B. I, II and III only C. III and IV only D. II and IV only (2009:Q31)
34. The eclipse of the sun occurs when the A. moon is not completely hidden in the earth's shadow B. moon's umbra falls on some part of the earth C. moon is between the sun and the earth D. earth is between the sun and the moon. (2011:Q30)
35. A pinhole camera is placed 300m in front of a building so that the image is formed on a screen 5cm from the pinhole. If the image is 2.5cm high, the height of the building will be A. 2.5m B. 50m C. 100m D. 150m (2012:Q31)
36. The magnification of an object 2cm tall when placed 10cm in front of a plane mirror is A. 6.0 B. 1.0 C. 0.7 D. 0.6 (2012:Q32)
37. A man 1.5m tall is standing 3m in front of a pinhole camera whose distance between the hole and the screen is 0.1m. What is the height of the image of the man on the screen? A. 0.05m. B. 0.15m. C. 0.30m D. 1.00m. (2013:Q29)
38. If the distance between the object the pinhole camera is reduced by half, the size of the image of the object A. is doubled B. is quadrupled C. remains the same D. is halved (2015:Q49)

CHAPTER 20 ANSWERS

- 1C The number of images n formed by two plane mirrors inclined at angle θ to each other is given by
- $$n = \frac{360}{\theta} - 1 \rightarrow n = \frac{360}{90} - 1 = 4 - 1 \rightarrow n = 3 \text{ images}$$
- 2E The angle between two parallel mirrors is 0°
- $$\therefore n = \frac{360}{\theta} - 1 \rightarrow n = \infty - 1 \rightarrow n = \infty$$
- Infinite number of images formed
- NOTE: When $\theta = 180^\circ$, it means that the mirrors now form a single but longer mirror producing expectedly one image according to
- $$n = \frac{360}{180} - 1 = 2 - 1 = 1 \rightarrow$$
-
- 3D A \rightarrow Magnification of a plane mirror is always unity (i.e. 1)
- $$m = \frac{\text{image size}}{\text{object size}} = \frac{\text{image distance}}{\text{object distance}} = 1$$
- B \rightarrow The image is the object rotated through 180°
- C \rightarrow Image is always erect and virtual. Recall that all vertically upright images in optics are optical illusion.
- D \rightarrow Compare to (A) and (E)
- E \rightarrow As in (A)
- NOTE: Any image that is inverted is real
- See Q3
- 4D
- 5A $m = \frac{v}{u} = \frac{h_{\text{image}}}{h_{\text{object}}}$ (see Q3) $\rightarrow \therefore \frac{v}{30} = \frac{10}{15} \rightarrow v_o = 20\text{cm}$
- 6E The reflected ray is rotated through 2θ if the mirror is rotated through θ . The initial angle between the normal AY and the reflected ray is 15° as $(i = r)$
- $$\therefore \text{The new angle} = 15 + 2(40) = 95^\circ$$
- 7D Using common sense of geometry, the emergent ray is parallel to the incident ray: angle of deviation = 180°

CHAPTER 21

REFLECTION OF LIGHT FROM SPHERICAL SURFACES

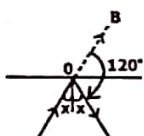
- If not sure, try this at home
- 9A Small hole produces sharp but dull image, large hole produces bright but blurred images.
NOTE: Blurring means a number of overlapping images are produced as the large hole can be taken as an agglomerate of many small holes each producing its own image.
- 10B Shadow and eclipse are evidence of rectilinear propagation of light
- 11C See Q1
- 12B (Using Geometry only) 
- 13A Kaleidoscope at 60°; Periscope at 45°
- 14B See Q10
- 15A This phenomenon arises from multiple reflection
- 16D The image is inverted (hence real) and light from each part of object travels through the pin-hole in straight line to form each part of the image
- 17C See Q6
- 18C See Q12
- 19C In eclipse of the moon, the earth is between the moon and the sun
- 20A Partial eclipse at the edges (penumbra area) and total eclipse at the centre (umbra area)
- 21B From Q1: $n = \frac{360}{\theta} - 1 \rightarrow \theta = \frac{360}{n+1} = \frac{360}{7+1} = 45^\circ$

NOTE: Any two mirrors inclined at forms images between themselves but two of these overlap to form a single image

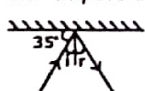
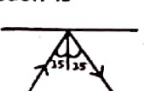
hence: $n = \frac{360}{\theta} - 1$

- 22C He is now 3m in front of the mirror and image is 3m behind the mirror hence distance between man and his image is $2(3\text{m}) = 6\text{m}$. (as $v_o = u_o$)

NOTE: The initial distance between man and image is $2(4) = 8\text{m}$
 Hence image displacement is $(8 - 5)\text{m} = 2\text{m}$

23B.  $\angle BOC = \text{angle of deviation. Using Geometry}$
 $\angle AOC + \angle BOC = 180$ (AB as line)
 $\therefore 2x + 120 = 180 \rightarrow x = \frac{60}{2} = 30^\circ$

- 24D See Q6 and 17
- 25D See Q2
- 26B The rays are continues forever
- 27A The import of this question is

 and not  $\therefore i = 90 - 35 = 55$
 $\therefore r = 35^\circ$

- 28B Diffuse light produces less sharp image. Also the smaller the size of light source, the sharper the image
- 29C Non-luminous objects e.g. moon do not produce light of their own but only reflect light falling on them from luminous objects e.g. sun
- 30C Kaleidoscope is a toy which produces colourful spectacle
- 31D Rectilinear propagation of light is evidenced by the phenomenon of eclipse and it occurs when the sun, the earth and the moon are aligned in such a way as to produce eclipses of the moon or the sun

32C $m = \frac{v}{u} = \frac{h_i}{h_o} \rightarrow \therefore \frac{6}{2} = \frac{2}{4} \rightarrow \therefore u = 12\text{cm}$

NOTE: The image distance in a pin-hole camera is fixed and it is equal to the length of the box of which the camera is made

- 33D The moon produces no light of its own, street light is not natural
- 34C See Q19

35D $\frac{v}{u} = \frac{h_i}{h_o} \rightarrow \frac{5}{300} = \frac{2.5}{h_o} \rightarrow h_o = 150\text{m}$

- 36B See Q3

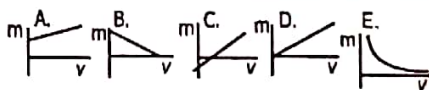
37A $\frac{v}{u} = \frac{h_i}{h_o} \rightarrow \frac{0.1}{3} = \frac{h_i}{1.5} \rightarrow h_i = 0.05\text{m}$

38B $u_1 = u$ but $u_2 = \frac{1}{2}u$ and $v_1 = v_2 = v$ ($v = \text{size of box}$)

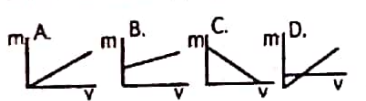
$m_1 = \frac{v}{u}$ and $m_2 = \frac{v}{\frac{1}{2}u} = \frac{2v}{u}$; $\frac{m_2}{m_1} = \frac{2v}{u} \times \frac{u}{v} = 2$

The size of the image doubles

1. Which of the following is true for the image formed by a convex mirror? I. The image is always virtual II. The image is always erect III. The image is never magnified V. The focal length is negative A. I only B. I and II only C. II and III only D. I, II, III and IV only E. All five. (1978:Q45)
2. An object is placed 30cm from a concave mirror of focal length 15cm. The linear magnification of the image produced is A. 0 B. 2/3 C. 1 D. 2 E. 3 (1979:Q16)
3. A concave lens of focal length 20cm forms an image 1/2 the size of the object. The object distance is A. 100cm B. 100/9cm C. 60cm D. 60/7cm E. none of these value. (1979:Q32)
4. Which of the following statements is applicable to a real image formed by a concave mirror? (I) It can be observed on a screen (ii) It is always inverted be observed on a screen (iii) It only seems to exist (iv) It is formed by the actual converging of rays of light. A. (I), (ii) and (iii) only B. (I), (ii) and (iv) only C. (I) and (iii) only D. (I) only (ii) only E. All four statements. (1981:Q12)
5. In order to produce a parallel beam of light, a lamp is placed at a distance from the concave mirror equal to A. the radius of curvature B. half the radius of curvature C. half the focal length D. twice the focal length E. twice the radius of curvature. (1982:Q7)
6. For a concave mirror to form a real diminished image, the object must be placed A. Behind the mirror B. Between the mirror and in focus C. Between the focus and the center of curvature D. At the center of curvature E. At a distance greater than the radius of curvature. (1984:Q6)
7. The image and object distances of a converging mirror are related by the equation $1/f = 1/v + 1/u$ and the magnification of the image is $m = v/u$. Which of the graphs below represents the relation between m and v ?

 (1984:Q30)

8. An object is placed 15cm in front of a concave mirror of radius 40cm. The image formed is A. Virtual and 60cm behind the mirror B. Real and 60cm in front of the mirror C. Virtual and at infinity D. Real and at infinity E. Virtual and 40cm from the mirror. (1985:Q30)
9. A convex mirror is used as a driving mirror because I. Its image is erect II. It has a large field of view III. It has a long focal length Identify the CORRECT statement(s). A. I and III only B. I and II only C. II and III only D. I, II and III only E. I only (1985:Q32)
10. A dentist obtains a linear magnification of 4 of a hole in a tooth by placing a concave mirror at a distance of 2.0cm from the tooth. The radius of curvature of the mirror is A. 5.3cm B. 3.2cm C. 2.7cm D. 1.6cm. (1986:Q31)
11. A pencil is placed vertically between a concave mirror and its focal point. The image of the pencil in the mirror will be A. Real inverted and diminished B. Virtual, inverted and enlarged C. Real, erect and enlarged. D. Virtual, erect and enlarged. (1986:Q33)
12. An object is place 10 cm in front of a concave mirror of focal length 15cm. What is the position and nature of the image formed? A. 30cm and virtual B. 6cm and real C. 6cm and virtual D. 30cm and real. (1988:Q32)
13. The magnification of the image of an object placed in front of a convex mirror is 1/3. If the radius of curvature of

- the mirror is 24cm, what is the distance between the object and its image? A. 8 cm B. 16cm C. 24cm D. 32cm (1989:Q26)
14. An object which is 3cm high is placed vertically 10cm in front of a concave mirror. If this object produces an image 40cm from the mirror, the height of the image is A. 0.75cm B. 4.00cm C. 8.00 cm D. 12.00cm (1990:Q24)
15. Which of the following properties make the convex mirror useful as a driving mirror? I. The image is real II. The image is erect III. It has a wide field of view IV. The image is magnified A. I, II and IV B. I, II and III C. II and III D. I and III. (1992:Q24)
16. When an object is placed very close to the pole of a concave mirror, the virtual image obtained is A. Diminished and upright B. Diminished and inverted C. Enlarged and inverted D. Enlarged and upright. (1992:Q25)
17. A concave mirror has a radius of curvature of 36cm. At what distance from the mirror should an object be placed to give a real image three times the size of the object? A. 12cm B. 24cm C. 48cm D. 108cm (1992:Q26)
18. Which of the following expressions gives the linear magnification produced by a concave mirror of radius of curvature r , if u and v are the object and image distances respectively?
A. $\frac{V}{r-1}$ B. $\frac{2V}{r-1}$ C. $\frac{u}{r-1}$ D. $\frac{2u}{r-1}$ (1993:Q26)
19. To produce a parallel beam of light from a concave mirror, the distance at which the lamp should be placed from the mirror is equal to A. the focal length B. two times the focal length C. the distance of the image D. two times the radius of curvature. (1994:Q33)
20. Which of the graphs represents the relationship between m and v for a converging mirror?
 (1995:Q34)
21. An object is placed at a distance u cm in front of a curved mirror of focal length f cm. If the image is upright and magnified, then the mirror is A. Convex and $u = 2f$ B. Concave and $u = 2f$ C. Convex and $u/2 = f$ D. Concave and $u/2 = f$ (1995:Q35)
22. A boy on looking into a mirror observed that his face appeared to have grown bigger. The boy must have been looking at a A. convex mirror with his face at the focus B. concave mirror with his face between the focus and the mirror. C. concave mirror with his face at the focus D. convex mirror with his face between the focus and the mirror. (1997:Q34)
23. An object O lies at a distance m in front of a concave mirror of the focal length f . If $m < f$, then the final image obtained will be A. Virtual and diminished B. Magnified and erect C. Real and inverted D. Diminished and erect. (1998:Q29)
24. The most suitable type of mirror used for the construction of a searchlight is the A. Concave mirror B. Convex mirror C. Spherical mirror D. Parabolic mirror. (1998:Q31)
25. The inside portion of part of a hollow metal sphere of diameter 20cm is polished. The portion will therefore form A. Concave mirror of focal length 5cm B. Concave mirror of focal length 5cm C. Convex mirror of focal length 5cm D. Convex mirror of focal length 20cm. (1999:Q22)
26. The driving mirror of a car has a radius of curvature of 1m A. vehicle behind the car is 4m from the mirror. Find the image distance behind the mirror A. 8/7 B. 4/9 C. 9/2 D. 4/7 (2001:Q14)
27. To produce an enlarged and erect image with a concave mirror, the object must be positioned A. Between the principal focus and the pole B. Between the principal focus and the centre of curvature C. Beyond the centre of curvature D. At the principal focus. (2002:Q19)
- A concave mirror of radius of curvature 40 cm forms a real image twice as large as the object. The object distance is A. 60cm B. 40cm C. 30cm D. 10cm (2002:Q28)
29. At what position will an object be placed in front of a concave mirror in order to obtain an image at infinity? A. At centre of curvature B. Between the principal focus and the centre of curvature C. At the pole of the mirror D. At the principal focus (2003:Q23)
30. What types of mirrors are capable of producing parallel beams of light such as those arising from the headlamps of a car? A. Cylindrical mirrors B. Parabolic mirrors. C. spherical mirrors D. Plane mirrors. (2004:Q2)
31. A real image three times the size of an object is formed 24cm from a converging mirror. What is the focal length of the mirror? A. 8cm B. 16cm C. 6cm D. 12cm (2005:Q34)
32. An object placed 10 cm from a concave mirror of focal length 5cm would have its image A. at infinity. B. 10cm from the focus. C. at the center of curvature. D. at the radius of curvature. (2006:Q35)
33. An object of height 5cm is placed at 20cm from a concave mirror of focal length 10cm. The image height is A. 20cm. B. 15cm. C. 10cm. D. 5cm. (2008:Q32)
34. Convex mirrors are used as driving mirrors because images formed are A. erect, virtual and diminished. B. erect, real and diminished. C. erect, virtual and magnified. D. inverted, virtual and diminished. (2008:Q33)
35. An object is placed 5cm from the pole of a concave mirror. If the focal length of the mirror is 10cm, what is the image distance? A. 10cm in front of the mirror B. 5cm in front of the mirror C. 10cm behind the mirror D. 5cm behind the mirror (2009:Q32)
36. Calculate the position of an object placed in front of a convex mirror having focal length of 12cm such that an image is formed 6cm away from the mirror. A. 4.0cm. B. 3.0cm. C. 12.0cm. D. 9.0cm. (2009:Q33)
37. An object 4cm high is placed 15cm from a concave mirror of focal length 5cm. The size of the image is A. 3cm. B. 5cm. C. 4cm. D. 2cm (2010:Q29)
38. Where can a man place his face to get an enlarged image when using a concave mirror to shave? A. Between the center of curvature and the principal focus. B. At the principal focus C. Between the principal focus and the pole. D. At the center of curvature. (2012:Q30)
39. After the reflection from the concave mirror, rays of light from the sun converges A. at the radius of curvature B. at the focus C. beyond the radius of curvature D. between the focus and radius of curvature. (2012:Q33)
40. A ray of light passing through the center of curvature of a concave mirror is reflected by the mirror at A. 0° B. 45° C. 90° D. 180° (2013:Q30)
41. The focal length of a concave mirror is 2.0cm. If an object is placed 8.0cm from it, the image is at A. 2.7m B. 2.0m C. 2.3m D. 2.5m (2014:Q30)
42. Convex mirror is used as a driving mirror because it A. magnifies images of objects B. makes image closer to view C. has wide field of view D. gives better and sharper images (2017:Q14)
43. The image of an object is located 6cm behind a convex mirror. If its magnification is 0.6, calculate the focal length of the mirror? A. 3.75cm B. 6.60cm C. 10.00cm D. 15.00cm (2018: Q15)

CHAPTER 21 ANSWERS

- 1E A convex mirror always produces diminished, erect images and ALL erect images are virtual. The focus of a convex

mirror is behind the mirror hence both image and focus are virtual and a virtual focus is negative.

Concave mirror **Convex mirror**

- u: +ve +ve
- v: ±ve -ve
- f: +ve -ve
- m: Depends on u < 1

NOTES: u = object distance v = Image distance
f = focal length m = magnification

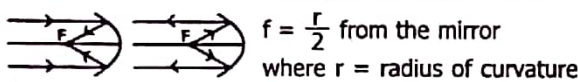
2C. $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ (Mirror formula)

u = + 30cm; f = + 15cm (See Q1) $\rightarrow \frac{1}{v} = \frac{1}{15} - \frac{1}{30}$
 $\frac{1}{v} = \frac{2-1}{30} \rightarrow v = 30\text{cm}$ but $m = \frac{v}{u} = \frac{30}{30} = 1$

3C $v = \frac{u}{2}$ f = 20cm $\rightarrow \frac{1}{f} = \frac{1}{u} + \frac{1}{v} \rightarrow \frac{1}{20} = \frac{1}{u} + \frac{2}{u}$
 $\frac{1}{20} = \frac{3}{u} \rightarrow u = 60\text{cm}$

4B A real image is always inverted and can be captured on a screen. Besides, it is formed in front of a mirror. A concave mirror is a converging mirror.

5B Since parallel beam of light converges the principal focus, it follows from the principle of reversibility of light that a beam of light at the focus produces parallel beam after reflection from the mirror. The focus is at a distance



6E For images in a concave mirror

1. Object beyond C image is diminished, inverted, real and formed in front of mirror and between C and F.
2. Object at C image is inverted, real, same size as object, formed at C, in front of mirror
3. Object between C and F image is enlarged, inverted, real and formed in front of mirror beyond C
4. Object at F image is magnified, inverted, real but formed at infinity
5. Object between F and P image is magnified, virtual, erect and formed behind mirror

NOTE: C = Centre of Curvature; F = Principal Focus
P = Pole of Mirror

7C. $\frac{1}{u} + \frac{1}{v} = \frac{1}{f} \rightarrow \frac{1}{u} = \frac{1}{f} - \frac{1}{v} \rightarrow \frac{1}{u} = \frac{v-f}{fv}$

$\therefore u = \frac{fv}{v-f}$; but $m = \frac{v}{u} \rightarrow \therefore m = \frac{v}{\frac{fv}{v-f}} = \frac{v}{1} \times \frac{v-f}{fv} = \frac{v-f}{f}$

$\therefore m = \frac{1}{f}(v) - 1$

Remember the general equation $y = mx + c$

$y = m, m = \frac{1}{f}$ and $c = -1$

When $v = 0$ then $m = \frac{1}{f}(0) - 1 \rightarrow m = -1$

Hence the intercept on the m - axis is negative i.e. (-1) and slope is $\frac{1}{f}$

NOTES:

1. If it is v versus m, the graph takes the shape of option (A) since $v = fm + f$
Where intercept is f and slope is f.
2. We can arrive at the same conclusion if we multiply mirror formula all through by v

$\frac{1}{u} \times v + \frac{1}{v} \times v = \frac{1}{f} \times v \rightarrow \frac{v}{u} + \frac{v}{v} = \frac{v}{f} \rightarrow m + 1 = \frac{v}{f}$

$m = \frac{v}{f} - 1$ (as before)

8A. $u = +15\text{cm}$ $f = \frac{r}{2} = + 20\text{cm} \rightarrow \therefore \frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{20} - \frac{1}{15}$

$\frac{1}{v} = \frac{3-4}{60} \rightarrow v = 60\text{cm}$

The -ve sign suggests that image is virtual and formed

behind mirror and it is magnified ($\frac{v}{u} = \frac{60}{15} = 3$)

NOTE: the object is placed between F and P since $u < f$. Does our result agree with the explanation in Q 6

9B But it is disadvantageous in that the image is diminished and is apparently farther away than normal behind the mirror. Experienced drivers, however, correct the optical illusion as appropriate.

10B The magnification of 4 means: $\frac{v}{u} = 4$ or $v = 4u = 4(2) = 8$

But $\frac{1}{f} = \frac{1}{u} + \frac{1}{v} \rightarrow \frac{1}{f} = \frac{1}{2} + \frac{1}{8} \rightarrow f = \frac{8}{4+1} = \frac{8}{5}$

But $r = 2f = 2(\frac{8}{5}) \rightarrow r = \frac{16}{5} = 3.2\text{cm}$

11D See Q6

12A. $\frac{1}{v} = \frac{1}{15} - \frac{1}{10} \rightarrow \frac{1}{v} = \frac{2-3}{30} \rightarrow v = -30\text{cm}$

13D $u = u$; $v = -\frac{u}{3}$; $f = -12\text{cm}$

$\frac{1}{u} + \frac{1}{v} = \frac{1}{f} \rightarrow \frac{1}{u} + \left(\frac{1}{-\frac{u}{3}}\right) = -\frac{1}{12} \rightarrow \frac{1}{u} - \frac{3}{u} = -\frac{1}{12}$

$\frac{1-3}{u} = -\frac{1}{12} \rightarrow -\frac{2}{u} = -\frac{1}{12} \rightarrow -u = -2 \times 12$

$u = 24\text{cm}$ $v = -\frac{24}{3} = -8\text{cm}$

The object is 24cm in front of mirror and image is 8cm behind the mirror. Distance between object and images $u - v = 24 - (-8) = 32\text{cm}$

14D $m = \frac{v}{u} = \frac{h_i}{h_o} \rightarrow \frac{40}{10} = \frac{h_i}{3} \rightarrow h_i = 12\text{cm}$

15C See Q9 16D See Q6

17B $u = u$ $v = 3u$ $f = 18\text{cm}$

$\frac{1}{u} + \frac{1}{v} = \frac{1}{f} \rightarrow \frac{1}{u} + \frac{1}{3u} = \frac{1}{18} \rightarrow \frac{4}{3u} = \frac{1}{18} \rightarrow u = 24\text{cm}$

18B. $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$

Multiply all through by v: $\frac{1}{u} \times v + \frac{1}{v} \times v = \frac{1}{f} \times v$

$\rightarrow \frac{v}{u} + \frac{v}{v} = \frac{v}{f} \rightarrow m + 1 = \frac{v}{f}$ ($m = \frac{v}{u}$)

$m = \frac{v}{f} - 1 \rightarrow m = \frac{2v}{f} - 1$

19B See Q5

20D This must be a concave mirror because a convex mirror always produces diminished images. Since image is upright then it must be virtual hence object is between F and P (See Q6) at a distance less than F.

NOTE: $\frac{f}{2} < f$ while $2f > f$

21D See Q7

22B See Q6

23B See Q6

24D Parabolic mirror produces strong parallel beam

25C The centre of curvature of the mirror formed coincides with the centre of the original sphere hence radius of curvature is one-half the diameter of sphere.

$r = \frac{20}{2} = 10\text{cm} \rightarrow$ but $f = \frac{r}{2} = 5\text{cm}$

The polished surface is concave while the reflecting surface is convex.

26B. $\frac{1}{v} = -\frac{1}{f} - \frac{1}{u} \rightarrow \frac{1}{v} = -\frac{1}{0.5} - \frac{1}{4} \rightarrow \frac{1}{v} = -2 - \frac{1}{4}$

$\frac{1}{v} = \frac{-8-1}{4} = \frac{-9}{4} \rightarrow v = -\frac{4}{9}$

-ve sign suggests virtual image.

NOTE (1) You must apply real is - positive rule or else your answer would become $v = +\frac{4}{9}$

2. Our result above agrees with Q1 where a convex mirror has f and $-v$

3. This same principle applies in Q13

27C. See Q6

28A. $u = +u$ $f = +f$ $v = +2u \rightarrow \therefore \frac{1}{u} + \frac{1}{v} = \frac{1}{f}$

$\rightarrow \frac{1}{u} + \frac{1}{2u} = \frac{1}{20} \rightarrow u = 30\text{cm}$

This the object is between C and F and image beyond C (at 60cm) in conformity with Q6

29B See Q6

30B See Q24

31C $m = 3$; If $v = 21$; $u = \frac{21}{3} = 7\text{cm} \rightarrow \frac{1}{f} = \frac{1}{7} + \frac{1}{21} = f = 6\text{cm}$

NOTES:

1. a. Concave mirror = Converging mirror
b. Convex mirror - Diverging Mirror
2. But this is reversed in lenses
a. Concave lens = diverging lens
b. Convex lens = converging lens (See chapter 22)

32C The object is hereby placed at the centre of curvature - See Q6

33D This object is at centre of curvature hence:
 $u = 2\text{cm}$; $v = 20\text{cm}$ (See Q6)

But $\frac{h_i}{h_o} = \frac{v}{u} \rightarrow \frac{h_i}{5} = \frac{20}{2} \rightarrow h_i = 5\text{cm}$

34A See Q9

35C See Q6

36C Using real is positive rule: $f = -12\text{cm}$; $v = -6\text{cm}$

And $\frac{1}{u} = \frac{1}{f} - \frac{1}{v} \rightarrow \frac{1}{u} = -\frac{1}{12} - (-\frac{1}{6}) = -\frac{1}{12} + \frac{1}{6}$

$\frac{1}{u} = \frac{-1+2}{12} \rightarrow u = 12\text{cm}$

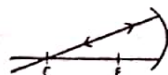
37D. $f = +5\text{cm}$ $u = +15\text{cm} \rightarrow \frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{5} - \frac{1}{15}$

$\frac{1}{v} = \frac{3-1}{15} \rightarrow v = \frac{15}{2} \rightarrow \text{But } \frac{h_i}{h_o} = \frac{v}{u}$

$\therefore \frac{h_i}{4} = \frac{15}{2} = \frac{1}{2} \rightarrow h_i = 2\text{cm}$

38C See Q6

39B Rays from the same are taken to be coming from infinity to converge at focus since rays from focus produces parallel beam to converge at infinity - the principle of reversibility of light. **NOTE:** The principle of reversibility of light states that when light is reversed, it traces its original path

40A  A ray through the centre of curvature is reflected along its original path

41C $f = +2\text{cm}$; $u = +8\text{cm} \rightarrow \frac{1}{v} = \frac{1}{2} - \frac{1}{8} \rightarrow \frac{1}{v} = \frac{4-1}{8}$

$v = \frac{8}{3} = 2.666\text{cm}$

42C See Q9

43D $v = 6\text{cm}$ but $m = \frac{v}{u} \rightarrow \therefore 0.6 = \frac{6}{u}$ and $u = 10\text{cm}$

Now: $\frac{1}{f} = \frac{1}{v} + \frac{1}{u} = \frac{1}{6} + \frac{1}{10} \rightarrow \frac{-10+6}{60}$ and $f = -15\text{cm}$

NOTE:

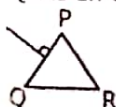
1. A convex mirror has negative v and predictably, negative focus ($-f$)
2. In magnification, the negative sign of v is irrelevant

CHAPTER 22

REFRACTION OF LIGHT FROM PLANE AND SPHERICAL SURFACES

1. An object 1cm high placed on the axis 15cm from a converging lens forms an image 30cm from the lens. The size of the image is A. 0.5cm B. 1.5cm C. 3cm D. 2.5cm E. 2cm. (1978:Q42)

PQR is an equilateral glass prism of refractive index 1.5. Light incident normally on face PQ as shown in the figure will A. undergo total internal reflection at face PR and then emerge normal to the face QR



B. emerge on face PR C. undergo total internal reflection at face PR and emerge deflected away from the normal on face QR D. undergo two successive total internal reflections and emerge at face PQ E. be completely reflected back along its path. (1979:Q8)

3. The speed of light in air is $3 \times 10^8 \text{ms}^{-1}$. If the refractive index of light from air to water is $4/3$, then which of the following is the correct value of the speed of light in water? A. $4 \times 10^8 \text{ms}^{-1}$ B. $2.25 \times 10^8 \text{ms}^{-1}$ C. $4/9 \times 10^8 \text{ms}^{-1}$ D. $2.25 \times 10^8 \text{ms}^{-1}$ E. $4.33 \times 10^8 \text{ms}^{-1}$. (1979:Q42)

4. The diagram in the above figure shows the prism

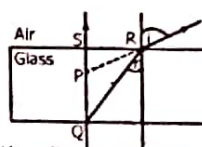


arrangement in a A. microscope B. stereoscope C. projector D. periscope E. gyroscope (1980:Q14)

5. If the magnification of a virtual image formed of an object 10cm from a convex lens is 3, then the focal length of the lens is

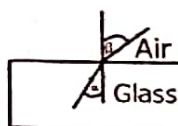
A. 10cm B. 15cm C. 20cm D. 30cm E. 40cm (1980:Q22)

6. Given that $SQ = 10\text{cm}$ and $SP = 6\text{cm}$, the refractive index



of the block of glass shown in the above figure is A. 0.30 B. 0.60 C. 1.67 D. 2.33 E. 2.36 (1980:Q25)

7. In the diagram below, a ray of light passes from glass into



air. If the angle of incidence in glass is α and the angle of refraction in air is β , which of the following statements is true? A. $\alpha = \beta$ B. The refractive index

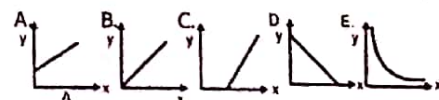
of glass is $\frac{\sin \beta}{\sin \alpha}$ C. The ray suffers total internal reflection if α is greater than the critical angle D. The ray will suffer total internal reflection if α is less than the critical angle.

E. The refractive index of glass is $\frac{\sin \alpha}{\sin \beta}$ (1980:Q35)

8. When a ray of light passes from water to glass, it is A. bent away from the normal B. bent towards the normal C. totally internally reflected D. absorbed by the glass E. broken into a pure spectrum. (1981:Q17)

9. The absolute refractive indices of glass and water are $3/2$ and $4/3$ respectively. The refractive index at the interface when a ray travels from water to glass is A. $1/2$ B. $8/9$ C. $9/8$ D. $17/12$ E. 2 (1981:Q26)

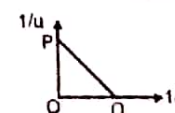
10. When a lamp is placed on the axis and at various distance u from a converging lens, real images are formed at various distances v from the lens. Which of the graphs below will be obtained by plotting the values of quantity y ($y = 1/v$) against another quantity x ($x = 1/u$)?



(1981:Q32)

11. An object placed on the principle axis of a convex lens of focal length 10cm, produces a real image of double magnification. The image distance from the lens is A. 30cm B. 25cm C. 20cm D. 15cm E. 10cm (1981:Q40)

12. In a light experiment with a convex lens a student plotted a graph, shown above (Fig. 6), of the reciprocal of object distance ($1/u$) against the reciprocal of the image distance ($1/v$). The focal length of the lens is given by A. slope of the line PQ B. reciprocal

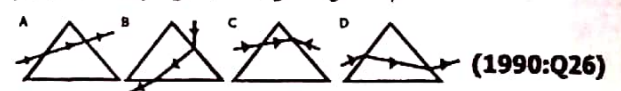


- of either OP or OQ C. length OP or OQ D. area under the graph E. ratio OP/OQ (1981:Q44)
13. The speed of light in air is $3.00 \times 10^8 \text{ms}^{-1}$. Its speed in glass having a refractive index of 1.65 is A. $1.65 \times 10^8 \text{ms}^{-1}$ B. $3.00 \times 10^8 \text{ms}^{-1}$ C. $4.95 \times 10^8 \text{ms}^{-1}$ D. $1.82 \times 10^8 \text{ms}^{-1}$ E. $6.00 \times 10^8 \text{ms}^{-1}$ (1982:Q8)
14. If the refractive index of a medium is $\sqrt{2}$, what is the critical angle? A. 45° B. $50^\circ 12'$ C. $56^\circ 25'$ D. 75° E. 90° (1982:Q24)
15. The arrow represents an object in front of a convex lens whose focal points are X and Y (Fig. 4). The image formed is A. between X and P B. between P and Y C. between Y and Z D. outside W E. outside Z (1982:Q25)
16. The refractive index of a liquid is 1.5. If the velocity of light in vacuum is $3.0 \times 10^8 \text{ms}^{-1}$, the velocity of light in the liquid is A. $1.5 \times 10^8 \text{ms}^{-1}$ B. $2.0 \times 10^8 \text{ms}^{-1}$ C. $3.0 \times 10^8 \text{ms}^{-1}$ D. $4.5 \times 10^8 \text{ms}^{-1}$ E. $9.0 \times 10^8 \text{ms}^{-1}$ (1983:Q7)
17. Which of the following conditions are necessary and sufficient for total internal reflection to take place at the boundary between two optical media? I. Light is passing from optically denser medium to optically less dense medium. II. Light is passing from optically less dense medium to optically dense medium. III. Angle of incidence is greater. IV. Angle of incidence is lesser. A. I and II only B. II and III only C. III and IV only D. I and III only E. II and IV only (1983:Q16)
18. The speed of light in vacuum is $3.0 \times 10^8 \text{ms}^{-1}$. If the refractive index of a transparent liquid is $4/3$ then the speed of light in the liquid is A. $0.44 \times 10^8 \text{ms}^{-1}$ B. $2.25 \times 10^8 \text{ms}^{-1}$ C. $3.0 \times 10^8 \text{ms}^{-1}$ D. $4.0 \times 10^8 \text{ms}^{-1}$ E. $4.33 \times 10^8 \text{ms}^{-1}$ (1983:Q46)
19. A coin is placed at the bottom of a cube of glass t cm thick. If the refraction index of the glass is μ , how high does the coin appear to be raised to an observer looking perpendicularly into the glass?
A. $\frac{1}{t-\mu}$ B. $\frac{t(\mu-1)}{\mu}$ C. $t\left(\frac{1+\mu}{\mu}\right)$ D. $\frac{1}{\mu}$ E. μt (1984:Q32)
20. A 45° triangular glass prism can be used as a reflector of light because A. Refraction never takes place in such a prism B. The angle of reflection equals the angle of incidence. C. The refractive index of glass is less than 1 D. It is transparent E. The critical angle for glass is less than 45° (1985:Q31)
21. Two rays of light from a point below the surface of water are equally inclined to the vertical and are inclined to each other at 60° in water. What is the angle between the rays when they emerge into air? (Take the refractive index of water to be $4/3$) A. 41.80 B. 44.10 C. 60.00 D. 83.60 E. 120.00 (1985:Q33)
22. In Fig. 6, a ray of light in air strikes a glass plate at an angle of incidence of 60° . The reflected ray is observed to be perpendicular to the refracted ray. What is the refractive index of the glass? A. 1.73 B. 1.50 C. 0.87 D. 0.57 (1986:Q27)

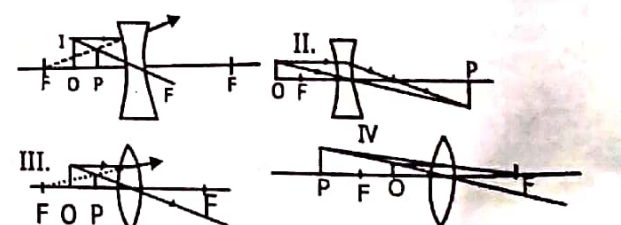


23. A lens of focal length 12.0cm forms an upright image three times the size of a real object. The distance between the object and the image is A. 8.0cm B. 16.0cm C. 24.0cm D. 32.0cm (1986:Q28)
24. If the refractive index of glass is 1.5, what is the critical angle a t t h e a t $1/2$ B. $\sin^{-1} \frac{2}{3}$ C. $\sin^{-1} \frac{3}{4}$ D. $\sin^{-1} \frac{8}{9}$ (1986:Q30)
25. An object 3.0cm high is placed 60.0cm from a converging lens whose focal length is 20.0cm. Calculate the size of the image formed. A. 0.5cm B. 1.5cm C. 2.0cm D. 6.0cm (1987:Q34)
26. A pool of water appears to be 1.0m deep when viewed vertically from above. If the refractive index of water is

- 1.33. What is the actual depth of the pool? A. 0.75m B. 1.0m C. 1.33m (1987:Q35)
27. A ray of light is incident at an angle of 30° on one top surface of a parallel-sided glass block of refractive index 1.5. The ray finally emerges from the lower surface. What is the angular deviation of the emergent ray? A. 60° B. 39° C. 28° D. 0° (1987:Q35)
28. To obtain a magnification of 2.5, how far should an object be placed from the pole of a thin converging lens of focal length 10.20m? A. 0.13m B. 0.25m C. 0.28m D. 0.50m (1988:Q30)
29. Which of the following phenomena explain the formation of a mirage I. Reflection II. Refraction III. Diffraction A. I and II only B. II and III only C. I and III only D. I, II and III. (1988:Q33)
30. An object is placed 5.6×10^{-4} m in front of a converging lens of focal length 1.0×10^{-4} m. The image formed is A. Real, erect and magnified B. Virtual, erect and magnified C. Real, inverted and magnified D. Virtual, erect and diminished (1989:Q25)
31. A light wave of frequency 5×10^{14} Hz moves through water which has a refractive index of $4/3$. Calculate the wavelength in water if the velocity of light in air is $3 \times 10^8 \text{ms}^{-1}$ A. 4.5×10^{-7} m B. 6.0×10^{-7} m C. 1.7×10^{-6} m D. 2.2×10^{-6} m (1990:Q21)
32. Which of the following diagrams correctly illustrates the path of a ray light through a glass prism?

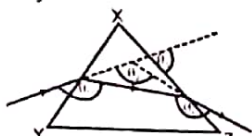


33. What must be the distance between an object and a converging lens of focal length 20cm to produce an erect image two times the object height? A. 20cm B. 15cm C. 10cm D. 5cm (1990:Q27)



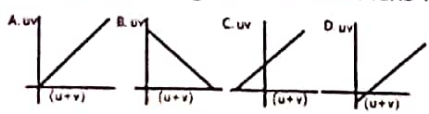
34. Which of the following correctly represents the diagram for locating the image P of an object O in a lens if F is the focal point of the lens? A. I and II only B. II and III only C. III and IV only D. I and IV only (1990:Q28)
35. A trough 12.0cm deep is filled with water of refractive index $4/3$. By how much would a coin at the bottom of the trough appear to be displaced when viewed vertically from above the water surface? A. 3.0cm B. 6.0cm C. 9.0cm D. 16.0cm (1991:Q27)
36. In a ray diagram for a thin converging lens, a ray that is not parallel to the optic axis but passes through the optic center will A. Pass through undeviated B. Pass through the center of curvature after refraction C. Emerge parallel to the principal axis D. Pass through the principal focus after refraction. (1991:Q28)
37. Which of the following correctly describes the image of an object, 4cm from a diverging lens of focal length -12cm? A. The image is virtual, 3cm in front of the lens B. The image is real, 6cm behind the lens C. The image is virtual, 6cm in front of the lens D. The image is real, 3cm in front of the lens. (1991:Q29)
38. If the refractive index of a medium in air is 2.0, what is the critical angle for this medium? A. 30° B. 42° C. 45°

- D. 50° (1992:Q29)
39. If the focal length of a camera lens is 20cm, the distance from the film at which the lens must be set to produce a sharp image of an object 100cm away is A. 17cm B. 20cm C. 25cm D. 100cm (1993:Q27)
40. Which of the following may be used to explain a mirage? I. Layers of air near the road surface have varying refractive indices in hot weather II. Road surfaces sometimes becomes good reflectors in hot weather. III. Light from the sky can be reflected upwards after coming close to the road surface. A. II only B. II and III only C. I and III only D. I, II and III. (1993:Q28)
41. A beam of light is incident from air to, water at an angle 30° , Find the angle of refraction if the refractive index of water is $4/3$. A. 15° B. 18° C. 22° D. 24° (1993:Q29)
42. Light of frequency 6.0×10^{14} Hz traveling in air is transmitted through glass of refractive index 1.5. Calculate the frequency of the light in the glass. A. 4.0×10^{14} Hz B. 6.0×10^{14} Hz C. 7.5×10^{14} Hz D. 9.0×10^{14} Hz (1994:Q34)
43. An object is placed in front of a converging lens of focal length 20cm. The image is virtual and has a magnification of 2. what is the distance of the object from the lens? A. 5cm B. 10cm C. 30cm D. 40cm (1994:Q36)
44. An object is placed directly below a glass block of thickness 3.0 cm. Calculate the lateral displacement of the object if the refractive index of the glass is 1.5 A. 1.0cm B. 1.5cm C. 2.0cm D. 2.5cm (1994:Q26)
45. What is the approximate critical angle for total internal reflection for diamond if the refractive index of diamond is 2.42? A. 21° B. 22° C. 23° D. 24° (1995:Q33)
46. Light of velocity 3.0×10^8 ms⁻¹ is incident on a material of refractive index n. If the velocity of light is reduced to 2.4×10^8 ms⁻¹ in the material, what is n? A. 2.33 B. 2.25 C. 1.33 D. 1.25 (1997:Q35)



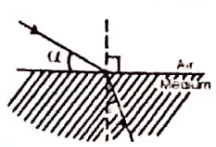
In the diagram above which of the angles $\theta_1, \theta_2, \theta_3,$ and θ_4 is the angle of deviation of a ray of light through the glass prism, XYZ? A. θ_1 B. θ_2 C. θ_3 D. θ_4 (1997:Q38)

47. The displacement d, produced in a glass block of thickness t, and refractive index n when an object is viewed through it is A. $t - n$ B. $t(1 + 1/n)$ C. $t(1 - 1/n)$ D. $t(1/n - 1)$ (1998:Q32)
49. The correct shape of the graph of uv against (u + v) for an object distance u and image distance v in an experiment to find the focal length of a convex lens is given as



(1998:Q33)

50. The velocities of flight air and glass are 3.0×10^8 ms⁻¹ and 2.0×10^8 ms⁻¹ respectively. If the angle of refraction is 30° , the sine of the angle of incidence is A. 0.33 B. 0.50 C. 0.67 D. 0.75 (1999:Q34)
51. Total internal reflection occurs when light moves from A. Air to water B. Water to glass C. A dense medium to a less dense medium D. A less dense medium to a dense medium (2000:Q16)
52. A boy observes a piece of stone at the bottom of a river 6.0m deep. If he looks from the surface of the river, what is the apparent distance of the stone from him. A. 4.5m B. 5.0m C. 5.5m D. 8.0m (2000:Q19)

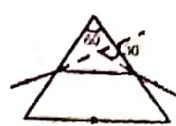


A. $\frac{\cos \alpha}{\sin \beta}$ B. $\frac{\sin \alpha}{\sin \beta}$ C. $\frac{\cos \beta}{\sin \alpha}$ D. $\frac{\sin \beta}{\sin \alpha}$ (2001:Q15)

4. A coin placed below a rectangular glass block of thickness 9cm and refractive index 1.5 is viewed vertically above the

- block. The apparent displacement of the coin is A. 5cm B. 3cm C. 8cm D. 6cm (2002:Q14)

55. A ray of light which strikes a glass slab from air at normal incidence passes through the slab A. Undeviated and displaced at a faster speed B. Undeviated and undisplaced at a lower speed C. Deviated and undisplaced at a lower speed D. Deviated and displaced at a lower speed. (2002:Q16)

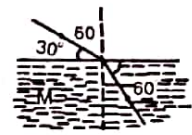


Calculate the refractive index of the material for the glass prism in the diagram above. A. $\sqrt{2}$ B. $3/2$ C. $\sqrt{2}/2$ D. $4/3$ (2002:Q35)

56. By what factor will the size of an object placed 10cm from a convex lens be increased if the image is seen on a screen placed 25cm from the lens? A. 2.5 B. 1.5 C. 0.4 D. 15.0 (2003:Q16)

58. A ray of light is incident on an equilateral triangular glass prism of refractive index $3/2$. Calculate the angle through which the ray is minimally deviated in the prism. A. 30.0° B. 37.2° C. 42.0° D. 48.6° (2003:Q31)

59. A ray incident on a glass prism undergoes minimum deviation when the A. Refraction angle equals 90° B. Incident angle is equal to the angle of refraction C. Incident angle is equal to the angle of emergence D. Incident angle equals 90° (2003:Q38)



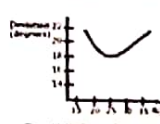
The refractive index of the medium M in the diagram above is A. $2/\sqrt{3}$ B. $1/\sqrt{3}$ C. $2\sqrt{3}$ D. $\sqrt{3}$ (2004:Q1)

60. Calculate the angle of minimum deviation for a ray which is refracted through an equiangular prism of refractive index n. A. 60° B. 60° C. 99° D. 90° (2004:Q5)

62. If u is the object distance and v the image distance, which of the following expressions gives the linear magnification produced by a convex lens of focal length f? A. $\frac{u}{v} + f$ B. $\frac{u}{f} - f$ C. $\frac{v}{f} - 1$ D. $\frac{v}{f} + 1$ (2004:Q7)

63. A thin converging lens has a power of 4.0 diopters. Determine its focal length. A. 0.25m. B. 0.03m. C. 5.00m D. 2.50m. (2005:Q36)

64. The figure above shows a plot of angles of deviation through a glass prism when light is incident at degrees on the prism. The incident angle that produces the minimum deviation is A. 25° . B. 18° . C. 35° . D. 20° (2005:Q39)



65. A submarine is observed to rise from a real depth of 80m to 60m in water. Calculate the change in apparent depth. A. 60m. B. 15m. C. 80m. D. 45m. [Refractive index of water = $4/3$] (2006:Q38)

66. A glass plate 0.9 cm thick has a refractive index of 1.50. How long does it take for a pulse of light to pass through the plate? A. 3.0×10^{-11} s B. 4.5×10^{-11} s C. 3.0×10^{-10} s D. 4.5×10^{-10} s [c = 3.0×10^8 ms⁻¹] (2007:Q1)

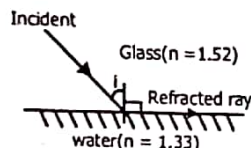
67. When an object is placed between the principal focus and the optical center of a convex lens, it could be used as a A. reflecting lens. B. compound microscope C. projector D. simple microscope. (2007:Q6)

68. If a convex lens of focal length 12 cm is used to produce real image four times the size of the object, how far from the lens must the object be placed? A. 10cm B. 15cm C. 20cm D. 25cm (2008:Q34)

69. An object placed at the bottom of a well full of clear water appears closer to the surface due to A. diffraction B. reflection C. refraction D. polarization (2008:Q35)

70. If the refractive index of crown glass is 1.51, its critical

- angle is A. 48.6° B. 22.5° C. 41.5° D. 45° (2009:Q34)
71. When light passes through two media x and y of refractive indices 1.51 and 1.33 respectively, the speed of light in A. x is same as in y. B. x and y is same in vacuum. C. x is higher than in y. D. y is higher than in x. (2009:Q35)
72. An object is embedded in a block of ice, 10 cm below the plane surface. If the refractive index of the ice is 1.50, the apparent depth of the object below the surface is A. 6.77cm. B. 7.63cm. C. 7.50cm. D. 2.50cm (2010:Q30)
73. An image in a convex lens is upright and magnified 3 times. If the focal length of the lens is 15 cm, what is the object distance? A. 16cm B. 14cm C. 10cm D. 25cm (2011:Q32)
74. A glass block of thickness 10cm is placed on an object. If an observer views the object vertically, the displacement of the object is A. 3.33cm B. 5.00cm C. 6.67cm D. 8.50cm [glass = 1.5] (2012:Q34)
75. I. Rays of light travel from a less dense medium to a denser medium. II. The angle of incidence is greater than critical angle. III. Rays of light travel from a denser medium to a less dense medium. Which of the statements above are conditions for total internal reflection to occur? A. I & II only B. I & III only C. II & III only D. II only. (2012:Q35)



From the diagram above, calculate the incident angle. A. 41° B. 49° C. 55° D. 61° (2013:Q31)

76. Total internal reflection will not occur when light travels from A. water to air. B. water into glass. C. glass to air. D. glass into water. (2013:Q32)
78. If a document is to be produced using a duplicating camera, where should the camera be placed in order to obtain an exact copy? A. at the point which is twice the focal length of the lens of the camera C. between the principal and a point twice the focal lens of the lens of the camera D. beyond a point twice the focal length of the lens of the camera (2015:Q7)
79. If the speed of light in water is $2.26 \times 10^8 \text{ms}^{-1}$ and the velocity of light in air is $3.0 \times 10^8 \text{ms}^{-1}$. Calculate the refractive index of water A. 1.33 B. 1.23 C. 1.45 D. 1.56 (2015:Q16)
80. Which of these occurs when a diverging lens is in use? A. images of real object may sometimes be magnified B. the rays of the sun can be brought to a focus C. a virtual diminished image is formed D. images are always real (2016:Q40)
81. A beam of light is incident from air to water at an angle of 30°. Find the angle of refraction if the refractive index of water is $\frac{4}{3}$ A. 15° B. 18° C. 22° D. 24° (2018:29)

CHAPTER 22 ANSWERS

- 1E. $\frac{h_i}{h_o} = \frac{v}{u} \rightarrow \frac{h_i}{1} = \frac{30}{15} \rightarrow h_i = 2\text{cm}$
- 2A. The ray enters the prism undeviated as it strikes PQ at 90° hence total internal reflection occurs at PR and the reflected ray meets QR at 90°.



Note: If the ray is adjusted to meet QR, the diagram below also applies:



- 3D. ${}_a n_g = \frac{\text{speed in air}}{\text{speed in glass}} \rightarrow \frac{4}{3} = \frac{3 \times 10^8}{v_g} \rightarrow v_g = 2.25 \times 10^8$
- Note:
- ${}_a n_g$ means refractive index of glass (g) with respect to air (a) hence ${}_g n_a$ means....
 - ${}_a n_g = \frac{1}{{}_g n_a}$
 - The refractive index given belongs to the 2nd medium

rather than the first hence $\frac{4}{3}$ is ${}_a n_g$ not ${}_g n_a$. In order

words ${}_1 n_2 = \frac{v_1}{v_2}$

- 4D Used to see above obstacles
- 5B If $m = 3$ then $v = -3u = -30\text{cm}$
 $\rightarrow \frac{1}{f} = \frac{1}{10} - \frac{1}{30} = \frac{3-1}{30}$
- NOTE: Unlike mirrors, convex lenses have +f (as computed above) while concave lenses have -f (i.e. virtual focus, F)
- 6C An object at Q would appear to be at P
- Refractive index = $\frac{\text{Real depth}}{\text{Apparent depth}} \rightarrow n_g = \frac{SQ}{SP} = \frac{10}{6}$
 $n_g = 1.666'$
- 7B (A) \rightarrow Air/glass have different densities hence $\alpha \neq \beta$
 (B) $\rightarrow n = \frac{\sin i}{\sin r}$ But $i = \alpha$ and $r = \beta$ hence $\frac{\sin \alpha}{\sin \beta} = {}_g n_a$
 To obtain ${}_g n_a$, the ray must be reversed so that $\beta = i$ and $\alpha = r$
 $n_g = \frac{\sin \beta}{\sin \alpha}$
 (C) and (D) \rightarrow the angle of incidence β must be greater than the critical angle for total internal reflection to occur
 (E) This is refractive index of air with respect to glass
- 8B Since glass is denser than water, the ray is bent towards the normal as it slows down.
 NOTE: The ray is bent away when it moves from denser to less dense medium because it moves faster in the less dense medium

- 9B With respect to the direction of travel of ray, take glass as the second medium and the refractive index at interface is therefore: ${}_g n_a = \frac{n_2}{n_1} = \frac{4/3}{2} = \frac{4}{3} \times \frac{2}{3} \rightarrow n_g = \frac{8}{9}$
 NOTE: The absolute refractive index of a medium is with respect to vacuum: $n_g = \frac{\text{speed in vacuum}}{\text{speed in glass}}$

- 10D Lens formula = mirror formula
 Now: $\frac{1}{v} = \frac{1}{f} - \frac{1}{u}$; when $\frac{1}{u} = 0 \rightarrow \frac{1}{v} = \frac{1}{f}$
 \therefore Intercept on y-axis is $\frac{1}{f}$; also when $\frac{1}{v} = 0 \rightarrow \frac{1}{u} = \frac{1}{f}$
 \therefore Intercept on x-axis is $\frac{1}{f}$
 Joining the two intercepts we obtain the graph in (D)

- 11A $f = +10\text{cm}$ $\frac{v}{u} = 2 \therefore v = 2u \rightarrow u = \frac{v}{2}$
 $\frac{1}{u} + \frac{1}{v} = \frac{1}{f} \rightarrow \frac{2}{v} + \frac{1}{v} = \frac{1}{10} \rightarrow \frac{3}{v} = \frac{1}{10} \rightarrow v = 30\text{cm}$
- 12B. $\frac{1}{f} = OP = OQ$ (see Q10) $\therefore f = OP = OQ$
- 13D. ${}_a n_g = \frac{v_g}{v_a} \cdot 1.65 = \frac{3 \times 10^8}{v_g} \rightarrow v_g = 1.82 \times 10^8 \text{ms}^{-1}$
- 14A $n = \frac{1}{\sin c}$ or $\sin c = \frac{1}{n}$
 Where c = Critical angle and n = refractive index
 $\sin c = \frac{1}{\sqrt{2}} \rightarrow C = \sin^{-1} = 45^\circ$ (Trig.)

15.
 If drawn to scale, the image might/might not go beyond 2F but it is sure that the image is erect, virtual, magnified, on same side as object and formed beyond object and F.

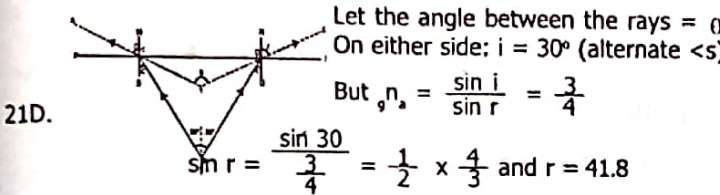
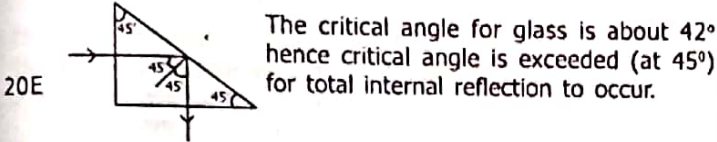
- NOTE:
- It is not indicated that $PW = 2F$ hence image is taken to be outside W.
 - Unlike mirrors, real image is on the opposite side of the object and virtual image on the same side in lenses
 - A concave lens always produces virtual, erect, diminished images on the same side as object.

16B $n = \frac{\text{Velocity in vacuum}}{\text{Velocity in liquid}} \rightarrow 1.5 = \frac{3 \times 10^8}{v} \rightarrow v = 2 \times 10^8 \text{ms}^{-1}$

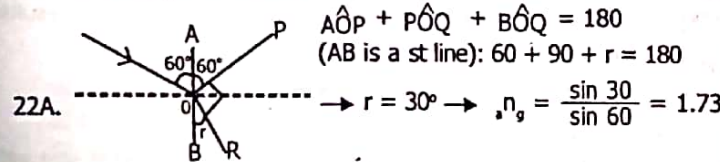
17D I \rightarrow e.g. glass to air but not air to glass
 II \rightarrow the angle of incidence must exceed the critical angle

18B $\frac{3}{4} = \frac{3 \times 10^8}{v} \rightarrow v = 2.25 \times 10^8 \text{ms}^{-1}$

19B Let the apparent depth = $d \rightarrow \mu = \frac{t}{d}$ or $d = \frac{t}{\mu}$
 But apparent displacement: $s = \text{real depth} - \text{Apparent depth}$
 $s = t - d = t - \frac{t}{\mu} \rightarrow s = \frac{\mu t - t}{\mu} \rightarrow s = \frac{t(\mu - 1)}{\mu}$



But $r = \text{SCO} + \text{TDO}$ (vertically opp $<s>$)
 $\therefore \text{TDO} = \text{TDO} = 42 - 30 = 11.8$
 Joining O and T and extending beyond T; from $\triangle \text{OTC}$
 $\frac{1}{2} \theta = 30 + 11.8$ (1 exterior $<= 2$ Opp. Interior $<s>$)
 $\therefore T = 2 \times 41.8^\circ = 83.6^\circ$



23B An upright image is automatically a virtual image and it is expected to be on the same side as object for a lens (but not for a mirror) - See Q 15

$M = \frac{v}{u} = 3 \rightarrow v = 3u$ and $f = 12\text{cm}$

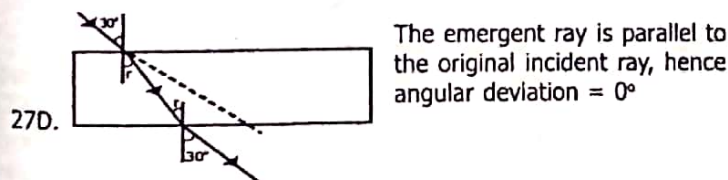
Using mirror formular: $\frac{1}{u} + \frac{1}{v} = \frac{1}{f} \rightarrow \frac{1}{u} + \frac{1}{3u} = \frac{1}{12}$
 (image is virtual $v = -ve$): $u = 8\text{cm}$ and $v = 24\text{cm}$
 Distance between them: $\rightarrow v - u = 16\text{cm}$
 (on the same side)

24B $\sin c = (\text{Q14}) \rightarrow \sin c = \frac{1}{2} \rightarrow c = \sin^{-1} \frac{2}{3}$

25B $\frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{20} - \frac{1}{60} \rightarrow v = 30\text{cm}$

$m = \frac{h_i}{h_o} = \frac{v}{u} \rightarrow h_i = 3 \times \frac{30}{60} \rightarrow h_i = 1.5\text{cm}$

26C $n = \frac{\text{Real depth}}{\text{Apparent depth}} \rightarrow \text{Real depth} = 1.33 \times 1 = 1.33\text{m}$



28C $\frac{v}{u} = 2.5 \therefore v = \frac{5u}{2}$ $f = 0.20\text{m} \rightarrow \frac{1}{u} + \frac{1}{v} = \frac{1}{f}$

$\frac{1}{u} + \frac{2}{5u} = \frac{1}{f} \rightarrow \frac{7}{5u} = \frac{1}{\frac{1}{5}} \rightarrow u = \frac{7}{25} = 0.28\text{m}$

If the maths above confuses you then try this:

$\frac{1}{u} + \frac{1}{2.5u} = \frac{1}{0.2} \rightarrow \frac{2.5 + 1}{2.5u} = \frac{1}{0.2} \rightarrow u = \frac{3.5 \times 0.2}{2.5}$
 $u = 0.28\text{m}$ (as before)

29A Mirage is by itself total internal REFLECTION in nature and this arises from gradual bending away (REFRACTION) of light ray from the normal as it moves from the optically denser, colder, upper air layers to the optically less dense, hotter, lower layers until critical angle is exceeded.

30B Assuming $n < 4$ or $-n > -4$, then $u < f$ hence object is between F and P to produce virtual, erect and magnified image.

31A ${}_a n_w = \frac{\text{Velocity in air}}{\text{Velocity in water}} \rightarrow \frac{4}{3} = \frac{3 \times 10^8}{v_w}$
 $v_w = 2.25 \times 10^8 \text{ms}^{-1}$
 But frequency remains constant from air to water
 $f_w = f_a \rightarrow f_w \lambda_w = v_w \rightarrow 5 \times 10^{14} \times \lambda = 2.25 \times 10^8$
 $\lambda = 4.5 \times 10^{-7}\text{m}$

32D The ray bends towards normal on entering glass and bends away from normal on exiting it and remember that glass is denser than air

33C Image is erect hence it is virtual.

$\therefore v = 2u$ $f = 20\text{cm} \rightarrow \frac{1}{u} - \frac{1}{2u} = \frac{1}{20} \rightarrow \frac{1}{2u} = \frac{1}{20}$
 $u = 10\text{cm}$

Note that $u < f$ and this agrees with ray diagrams.

34D Ray diagram II is meant for convex lens (not concave) while diagram III is for concave lens not convex.

35A. Apparent depth = $\frac{12}{3}$ (see Q6) = 9cm

Apparent displacement = Real depth - Apparent depth
 $\therefore s = 12 - 9 = 3\text{cm}$

36A. Study the diagrams in Q34

NOTES:

1. Rays parallel to optic axis will converge at the focus on the opposite side for convex lens but will appear to diverge from the focus on the same side after refraction for concave lens.
2. Rays from focus will be parallel to optic axis after refraction (law of reversibility of light)
3. Parallel rays from an object at infinity form an image at the focus.

37A. $\frac{1}{v} = \frac{1}{f} - \frac{1}{u} \rightarrow \frac{1}{v} = -\frac{1}{12} - \frac{1}{4} \rightarrow v = -3\text{cm}$

The image is virtual ($V = -ve$) and 3cm on the same side as object.

NOTE: Don't always expect JAMB's pampering as it added the $-ve$ sign to the focal length ($f = -12\text{cm}$) directly from source, always remember that for converging lens/convex lens $f = +ve$ and for diverging/concave lens $f = -ve$

38A $\sin c = \frac{1}{n} \rightarrow c = \sin^{-1} C = 30^\circ$

39C $\frac{1}{v} = \frac{1}{f} - \frac{1}{u} \rightarrow \frac{1}{v} = \frac{1}{20} - \frac{1}{100} \rightarrow v = 25\text{cm}$

40C See Q29

41C $n = \frac{\sin i}{\sin r} \rightarrow \sin r = \frac{\sin 30}{\frac{4}{3}} = \frac{1/2}{4/3}$

$r = \sin^{-1} \frac{3}{8} \rightarrow r = 22^\circ$

42B Frequency is unaltered; the change in speed experienced is owing to change in wavelength. i.e.

${}_a n_g = \frac{v_a}{v_g} = \frac{f \lambda_a}{f \lambda_g} = \frac{\lambda_a}{\lambda_g}$

43B Compare Q33

44A $1.5 = \frac{s}{\text{Apparent}} \rightarrow \text{Apparent depth} = 2\text{cm}$
 Displacement = $3 - 2 = 1\text{cm}$

NOTE: The displacement is upward not lateral.

45D $\sin c = \frac{1}{2.42} \rightarrow c = \sin^{-1} 0.4132 \rightarrow c = 24.4^\circ$

46D $n = \frac{3 \times 10^8}{2.4 \times 10^8} = 1.2$

- 47A Angular deviation is the angle between the old pathway and the new.
- 48C Taking a cue from Q19:
 $S = t \left(\frac{n-1}{n} \right) = t \left(\frac{n-1}{n} \right) \rightarrow S = t \left(1 - \frac{1}{n} \right)$
- 49A $\frac{1}{f} = \frac{1}{v} + \frac{1}{u} \rightarrow \frac{1}{f} = \frac{u+v}{uv} \rightarrow f = \frac{uv}{u+v} \rightarrow uv = f(u+v)$
 Compare to the general equation: $y = mx + c$
 Where $m = f$ and $c = 0$
 \therefore There is no intercept on either axes and the graph starts from the origin.
- 50D $n_g = \frac{\sin i}{\sin r} = \frac{v_1}{v_2} \rightarrow \frac{\sin i}{\sin 30} = \frac{3 \times 10^8}{2 \times 10^8}$
 $\sin i = 0.5 \times 1.5 \rightarrow \sin i = 0.75$
- 51C. See Q17

52A. Apparent depth = $\frac{6}{\frac{4}{3}} = 4.5$

53A. $n = \frac{\sin(90-\alpha)}{\sin \beta} = \frac{\cos \alpha}{\sin \beta}$

NOTE:

1. Sine of an angle = Cosine of its complement
2. Cosine of an angle = Sine of its complement
3. Two complementary angles add up to 90°

54B Apparent depth = $9/1.5 = 6\text{cm}$
 Displacement = $9 - 6 = 3\text{cm}$



In (i) $i = 90^\circ$, no angular nor lateral displacement although the lightwave slows down. In (ii) $i < 90^\circ$, no angular displacement (Q27) but there is lateral displacement, d .

56A. The angle of minimum deviation (Q47) is $D = 30^\circ$ and the refracting angle is $A = 60^\circ$

But $n = \frac{\sin \frac{1}{2}(A+D)}{\sin \frac{1}{2}A} \rightarrow n = \frac{\sin \frac{1}{2}(60+D)}{\sin \frac{1}{2}(60)}$

$n = \frac{\sin 45}{\sin 30} = \frac{1}{\sqrt{2}} \times \frac{2}{1} \rightarrow n = \frac{2}{\sqrt{2}} = \sqrt{2}$

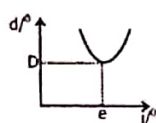
57A $m = \frac{v}{u} = \frac{25}{10} = 2.5$

58B $\frac{\sin \frac{1}{2}(A+D)}{\sin \frac{1}{2}A} = n \rightarrow A = 60^\circ$ for equilateral Prism = $\frac{3}{2}$

$\sin \frac{1}{2}(60+D) = \frac{3}{2} \times \frac{1}{2} \rightarrow \frac{1}{2}(60+D) = \sin^{-1}$

$\frac{1}{2}(60+D) = 2 \times 48.6 \rightarrow D = 97.2 - 60 = 37.2^\circ$

59C At minimum deviation, the ray passes symmetrically through



the prism and the angle of incidence (i) is equal to the angle of emergence: $i = e$
 The equation in Q58 also applies at minimum deviation

60D $n = \frac{\sin 60}{\sin 30} = \frac{\sqrt{3}}{2} \times \frac{2}{1} \rightarrow n = \sqrt{3}$

61A. $\frac{\sin \frac{1}{2}(A+D)}{\sin \frac{1}{2}A} = n \rightarrow \frac{\sin \frac{1}{2}(60+D)}{\sin 30} = 1.4$

$\sin(60+D) = 1.4 \times 0.5 \rightarrow (60+D) = \sin^{-1} 0.7 = 44.43^\circ$
 $D = 28.86^\circ$

62C $\frac{1}{u} + \frac{1}{v} = \frac{1}{f} \rightarrow$ Multiply all through by $v: \frac{v}{u} + 1 = \frac{v}{f}$

$m + 1 = \frac{v}{f} \rightarrow m = \frac{v}{f} - 1$

63A Power = $\frac{1}{\text{focal length}} \rightarrow P = \frac{1}{f} \rightarrow f = \frac{1}{P} = \frac{1}{4} = 0.25\text{m}$

NOTES:

1. From the above, the unit of power of a lens is m^{-1} where $1\text{m}^{-1} = 1$ dioptre

2. This to express power in $\text{cm}^{-1} \rightarrow P = \frac{100}{f} \text{cm}^{-1}$

64A See Q59

65B At 80m depth: Apparent depth = $\frac{80}{4} = 20\text{m}$

At 60m depth: Apparent depth = $\frac{60}{\frac{4}{3}} = 45\text{m}$

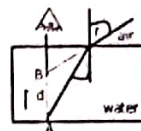
Change in apparent depth = $60 - 45 = 15\text{cm}$

66B $n_g = \frac{v_1}{v_2} \rightarrow 1.5 = \frac{3 \times 10^8}{v_2} \rightarrow v_2 = 2 \times 10^8 \text{ms}^{-1}$

But $s = vt$ (See chapter 2): $t = \frac{0.9 \times 10^8}{2 \times 10^8} = 4.5 \times 10^{-8}\text{s}$

67D Object between F and C produces a virtual, erect and MAGNIFIED image

68B $v = 4u; f = 12\text{cm} \rightarrow \frac{1}{u} + \frac{1}{4u} = \frac{1}{12} \rightarrow \frac{5}{4u} = \frac{1}{12}; u = 15\text{cm}$



The object at A is apparently displaced to B through d because refraction occurs at O as ray AO bends away from the normal at the water air interface.

70C $\sin c = \frac{1}{1.51} \rightarrow c = \sin^{-1} 0.6623 \rightarrow c = 41.5^\circ$

71D $n \propto \frac{1}{v}$; Also $n \propto \text{density}$

72A Apparent = $\frac{10}{1.5} = 6.67\text{cm}$

73C $v = -3u; f = 15; \frac{1}{u} + \frac{1}{v} = \frac{1}{f} \rightarrow \frac{1}{u} - \frac{1}{3u} = \frac{1}{15}$
 $\rightarrow \frac{2}{3u} = \frac{1}{15} \rightarrow u = 10\text{cm}$

74C Compare Q72 75C See Q17

76A Since light travels from optically denser (glass) to optically less dense medium (water), the angle of incidence (i) here is the critical angle c and anything above c results in total internal reflection

$\sin c = \frac{1}{1.52} \rightarrow c = 41^\circ$

77B Water is less dense than glass

78A At 2F the object produces an image the same size as itself at a distance 2F on the opposite side

79A $n_{\text{water}} = \frac{3.0 \times 10^8}{2.260 \times 10^8} = 1.33$

80C A diverging mirror produces similar images

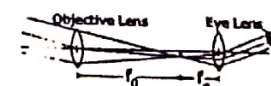
81C $\frac{\sin i}{\sin r} = n \rightarrow \frac{\sin 30}{\sin r} = \frac{4}{3} \rightarrow \sin r = \frac{3 \times 0.5}{4} = 0.375$
 $r = \sin^{-1} 0.375 = 22^\circ$

CHAPTER 23

OPTICAL INSTRUMENT. VISION

1. For the correction of myopic defects in the human eye we require A. a convex lens B. a concave lens C. a combination of concave and convex lenses D. a prism E. a concave mirror (1978:Q48)

2. The diagram below shows the lens arrangement in
 - A. a compound microscope
 - B. an astronomical telescope
 - C. a binocular D. a periscope



E. a projection lantern (1979:Q11)

3. In a compound microscope A. there is only one lens B. the objective lens has a shorter focal length than the eyepiece which is convex C. the objective lens has a longer focal length than the eyepiece which is convex D. the objective lens has a shorter focal length than the eyepiece which is concave E. the objective and the eyepiece are both convex and have the same focal lengths (1980:Q36)

4. The lack of power of accommodation which is mainly due to the hardening of the eye lens and is usual with the onset of old age is called A. myopia B. hypermetropia C. presbyopia D. astigmatism E. eye ring. (1981:Q31)

5. Which of the following statements about defects of vision is/are CORRECT I. For a long sighted person, close objects appear blurred. II. For a short sighted person, distant objects appear blurred. III. Short sight is corrected by using a pair of converging lenses. A. I only B. II only C. I and II only D. II and III only E. I, II and III. (1983:Q12)
6. For correcting long sight defects in the human eye we require a A. Converging lens B. Diverging lens C. Microscope D. Periscope E. Plain glass sheet. (1984:Q5)
7. Which of the following statements about the compound microscope and astronomical telescope is (are) correct? I. The final image of a compound microscope is located at infinity. II. The final image of the astronomical telescope is always erect. III. The objective lens of a compound microscope has a very short focal length. A. I only B. II only C. III only D. I and III E. II and III (1984:Q31)
8. Which of the following statements is NOT correct? A. The average range of distinct vision for a normal eye is from the far distance (infinity) up to about 25cm in front of the eye. B. Longsighted people have difficulty in making the eye lens sufficiently powerful to the focus on nearby objects. C. Shortsighted people cannot accommodate distant objects. D. Longsighted people need diverging spectacles lenses. E. A person with long sight has his eye-ball too short and the image of an object is therefore formed behind the retina. (1985:Q48)
9. Four lenses are being considered for use as a microscope objective. Which of the following focal lengths is most suitable? A. -5mm B. +5mm C. -5cm D. +5cm (1987:Q37)
10. A far sighted person cannot see objects that are less than 100cm away. If this person wants to read a book at 25cm, what type and focal length of lens does he need? A. Convex, 20cm B. Concave, 20cm C. Convex, 33cm D. Concave, 33cm (1989:Q28)
11. For a short sighted person, light rays from a point on a very distant object is focused A. In front of the retina B. On the retina by a converging lens C. Behind the retina by a diverging lens D. In front of the retina a distance 2F from the lens. (1990:Q29)
12. Which of the following statements is CORRECT about a long-sighted boy who does not put on glasses? A. He cannot see distance objects clearly B. Rays of light from a close objects are focused in front of his retina C. His eyeball is too long D. Parallel rays of light are focused behind his retina. (1992:Q27)
13. The property of the eye known as its power of accommodation is controlled by the A. Pupil B. Vitreous humour C. Iris D. Ciliary muscles (1993:Q30)
14. In a projection lantern of focal length f , the object distance u , is such that A. $u > 2f > f$ B. $u < f < 2f$ C. $u = f < 2f$ D. $f < u < 2f$ (1994:Q37)
15. A patient with a sight defect has a least distance of distinct vision of 150 cm. For him to be able to read a material placed at a distance of 25 cm, what is the focal length of the glasses he should wear? A. 15.0cm B. 17.6cm C. 21.4cm D. 30.0cm (1997:Q36)
16. A man wears convex lens glasses of focal length 30cm in order to correct his eye defect. Instead of the optimum 25cm, his least distance of distinct vision is A. 14cm B. 28cm C. 75cm D. 150cm (1998:Q34)
17. An astronomical telescope is said to be in normal adjustment when the A. Eye is accommodated B. Focal length of objective lens is longer than that of eye piece C. Final image is at the near point of eye D. Final image is at infinity. (1999:Q31)



The diagram below shows the prism arrangement is a A. Binocular B. Spectrometer C. Periscope D. Projector (1999:Q33)

18. What optical instrument can best be constructed with converging lenses of focal lengths 50cm and 5cm? A. Compound microscope

- B. Terrestrial telescope C. Astronomical telescope D. Galileo's telescope (2000:Q31)
20. A projection lantern is used to give the image of a slide on a screen. If the image is 24 times as large as the slide and the screen is 72.0m from the projecting lens, what is the position of the slide from the lens? A. 4.0m B. 3.5m C. 3.0m D. 0.3m (2000:Q34)
21. The terrestrial telescope has one extra lens more than the astronomical telescope. The extra lens is for A. Improving the sharpness B. Creating an inverted image C. Magnification of the image D. Erection of the image (2001:Q13)
22. Which of the following eye defects can be corrected using a cylindrical lens? A. Presbyopia B. Chromatic aberration C. Myopia D. Astigmatism (2002:Q22)
23. The eye controls the amount of light reaching the retina by adjusting the A. Iris B. Optic nerve C. Cornea D. Retina (2002:Q37)
24. The operation of an optical fibre is based on the principle of A. dispersion of light B. interference of light C. refraction of light D. polarization of light. (2003:Q29)
25. A person can focus an object only when it lies within 200cm from him. Which spectacles should be used to increase his maximum distance of distinct vision to infinity? A. Concave lens B. Plane glasses C. Binoculars. D. Convex lens (2004:Q3)
26. A person can focus objects when they lie beyond 75cm from his eyes. The focal length of the lens required to reduce his least distance of distinct vision to 25cm is A. 25.00cm B. 37.50cm C. 75.00cm. D. 18.75cm. (2006:Q33)
27. In the microscope, the eyepiece lens merely acts as A. an inverter B. a refiner C. a diminisher D. a magnifier (2008:Q36)
28. An observer with normal eyes views an object with a magnifying glass of focal length 5cm. The angular magnification is A. -6. B. -5. C. 5. D. 6. [least distance of distinct vision $D = 25\text{cm}$] (2008:Q37)
29. The ability of the human eye to focus objects on the retina is referred to as the power of A. interference B. diffraction C. accommodation D. superposition. (2009:Q37)
30. In comparing the camera and the human eye, the film of the camera functions as the A. iris. B. pupil. C. cornea. D. retina. (2010:Q28)
31. Which of the following is used for the correction of short-sightedness? A. Concave lens B. Concave mirror C. Convex mirror D. Convex lens (2010:Q31)
32. When the human eye loses its power of accommodation, the effect is known as A. astigmatism B. long-sightedness C. short-sightedness D. presbyopia (2011:Q25)
33. A certain far-sighted person cannot see objects that are closer to the eye than 50 cm clearly. Determine the power of the converging lens which will enable him to see at 25cm. A. 0.03D B. 0.04D C. 0.06D D. 0.02D (2011:Q27)
34. The use of lenses is NOT applicable in the A. projector B. human eye C. periscope D. telescope (2012:Q36)



35. What does the diagram above represents? A. telescope in normal use. B. microscope in normal use. C. telescope in abnormal use. D. microscope in abnormal use (2013:Q33)
36. If the linear magnification of the objective and eyepiece convex lenses of a compound microscope are 4 and 7 respectively, calculate the angular magnification of the microscope. A. 2. B. 3. C. 11. D. 28. (2013:Q34)
37. In a compound microscope, the objective and the eyepiece focal lengths are A. long. B. short. C. the same. D. at infinity. (2014:Q31)

38. When a telescope is in normal use, the final image is at A. the focus B. the radius of curvature. C. the near point. D. infinity. (2014:Q32)
39. An object 20cm from a convex lens has an image 25cm away from the lens. Calculate the power of the lens A. 45B B. 9D C. 20D D. 5D (2016: Q7)
40. An astronomical telescope in normal use has an angular magnification of 4 and the lenses are at a distance of 25cm, calculate the focal length of the eye-piece (2016:Q46)
41. A stigmatism is corrected by the use of a A. diverging lens spectacle B. cylindrical lens spectacle C. converging lens spectacle D. plano glass spectacle (2017:Q9)
42. If the focal length of a camera lens is 20cm, the distance from the film at which the lens must be set to produce a sharp image of an object 100cm away is A. 17cm B. 20cm C. 25cm D. 100cm (2018: Q32)

CHAPTER 23 ANSWERS

1B. Myopic defect = short sightedness

NOTES:

- In myopia, the sufferer sees only near object clearly as the eye lenses are too converging hence corrected by using concave/diverging laws.
- In hypermetropia or long sightedness, sufferer sees distant objects clearly as the eye lenses are too diverging hence a convex or converging laws required.

2B. This is astronomical telescope in normal adjustment whereby the final image is at infinity.

NOTES:

- At normal adjustment, focal point of objective lens f_o coincides with the focal point of the eye - piece f_e such that the distance between the two lenses is $d = f_o + f_e$
- A telescope is used to view distant objects while a microscope views a near but tiny object.
- You might confuse the telescope above with a compound microscope as both use two convex lenses hence master these differences:

| Astronomical Telescope | Compound Microscope |
|---|---|
| 1. Long objective: $f_o > f_e$ | Long eye-piece: $f_e > f_o$ |
| 2. Objective receives parallel rays from a distance | Objective receives non parallel rays from an object just beyond f_o |
| 3. Can be set in normal adjustment | Normal adjustment is not necessary. |

4. In Galilean telescope: $d = f_o - f_e$ and $f_o > f_e$
 objective \rightarrow convex lens; eye-piece \rightarrow concave lens.

3B. See Q2

4C. This accounts for why many elderly people are long-sighted.

5C. See Q1

6A. See Q1

7C. See Q2

8D. A \rightarrow Near point = 25cm Far point = infinity B and C/D \rightarrow See Q1
 E \rightarrow Image behind retina in long sight and in front of retina in short sight because eye balls are too short and too long respectively.

9B. A converging lens ($f = +ve$) of very small focal length ($5mm < 5cm$) is required (see Q2)

10C. $u = 25cm; v = -100cm; \frac{1}{f} = \frac{1}{u} + \frac{1}{v} \rightarrow \frac{1}{f} = \frac{4-1}{100} = \frac{3}{100}$
 $f = \frac{100}{3} = 33.33cm$

The far-sighted person requires a convex lens of focal length 33cm

NOTE:

- The required lens would produce a virtual image that appears to be at 100cm, the person's least distance of distinct vision i.e object is taken from 25cm to 100cm.
- This image is now the object for the individual hence, the "image of the image" falls on the retina.
- In normal eye, near point is 25cm but in this person, it is 100cm.
- In short sight, a lens that would bring the far point of the individual from infinity to his least distance of distinct

vision is required such that $u = \infty$ and $v =$ person's far point

5. In general, take $u =$ normal far/near point;

$v =$ person's given distance of distinct vision.

6. In case it is not stated that the individual is far/near sighted look for expression like "cannot see beyond..." for short-sight and "cannot see less than..." for far sight

11A. See Q8 12D. See Qs 1 and 8

13D. When viewing near object, the ciliary muscles contract and the lens shortens and thickens such that its focal length reduces; and the reverse is true for viewing far object.

14D. The object is placed at a point between F and 2F so as to produce a real, enlarged, upright image of the inverted object.

15D. This patient is clearly long sighted since his near point 150cm is of larger than the normal near point = 25cm.
 $u = 25cm \quad v = -150cm$

$$\frac{1}{f} = \frac{1}{u} - \frac{1}{v} = \frac{1}{25} - \frac{1}{-150} \rightarrow \frac{1}{f} = \frac{6-1}{150} \rightarrow f = +30cm$$

A convex lens of focal length 30cm.

16D. This is the reversal of Q15, data for data:

$$\frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{30} - \frac{1}{25} \text{ error} \rightarrow \frac{1}{v} = -\frac{1}{150} \rightarrow -150cm$$

Thus the convex lens ($f = +ve$) forms a virtual image ($v = -ve$) of the object ($u = 25cm$) at the near point of the man and this image is now used as object by the eyes for clear vision.

17D. See Q2

18C. A periscope made with plane mirrors produce multiple images from multiple reflections unlike a prismatic periscope.

19C. Since $m =$ for an astronomical telescope, f_o must be far greater than f_e to produce a reasonable magnification and in this $m = \frac{50}{5} = 10$

20C. $m = 24 = \frac{v}{u} \rightarrow u = \frac{v}{24} \rightarrow u = \frac{72}{24} = 3m$

21D. The inverted image produced by astronomical telescope is tolerable in astronomy but not when viewing objects on earth hence the extra lens for eventual erection of image.

22D. Astigmatism arises from uneven surface of the cornea and the patient has difficulty seeing horizontal lines.

23A. This in turn controls the size of the pupil which is the aperture of the iris.

24C. The various wavelengths of the light are refracted in different directions when the light signal enters the glow fibre but a graded index fibre allows this to reach the other end of fibre simultaneously.

25A. This is clearly short sight hence a concave lens is needed (See Q10).

26B. This is a long-sighted individual (see Q10)

$u = 25cm \quad v = -75cm$

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v} \rightarrow \frac{1}{f} = -\frac{1}{75} + \frac{1}{25} \rightarrow \frac{1}{f} = \frac{-1+3}{75} = \frac{2}{75}$$

$$f = \frac{75}{2} = 37.5cm$$

27D. The magnification (m_1) produced by the objective lens is negligible unlike the appreciable one (m_2) by the eye-piece. The eyepiece acts as a simple magnifying

NOTE: Glass overall magnification: $m = m_1 \times m_2 \rightarrow m = m_2$

28. $M_A = \frac{25}{f} = \frac{25}{5} = 5$

29C. See Q13

30D.

| Camera | Eye |
|-----------|--------|
| Film | retina |
| Lens | Lens |
| Diaphragm | Iris |
| Aperture | Pupil |

31A. See Q1 32D. See Q4

33D. $u = 25cm \quad v = -50cm \rightarrow \frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

$$\frac{1}{f} = \frac{1}{25} - \frac{1}{50} = \frac{2-1}{50} \rightarrow f = 50cm$$

But $p = \frac{1}{f} = \frac{1}{50} = 0.02 \text{ cm}^{-1}$

NOTES: The answers in the option are expressed in cm^{-1} not in dioptre because $1 \text{ Dioptre} = 1 \text{ m}^{-1}$

The normal answer is 2D not 0.02D because $p = \frac{100}{f}$ in metre

- 34C. A periscope either uses a plane mirror or a triangular prism.
- 35C. At normal adjustment, f_o coincides with f_e and final image I_2 is formed at infinity.
- 36D. $m = m_1 \times m_2 = 4 \times 7 \rightarrow m = 28$
- 37. Eyepiece is of longer focal length than the objective; question is ambiguous
- 38C. See Q2

39B $\frac{1}{f} = \frac{1}{20} + \frac{1}{25} \rightarrow f = \frac{100}{9}$ But power = $\frac{100}{f} = \frac{100}{\frac{100}{9}} \rightarrow P = 9\text{D}$

40C For an astronomical telescope at normal adjustment:
 $d = f_o + f_e$ (see Q2) $\therefore f_o = d - f_e = 25 - f_e$

Angular Magnification is given by: $m = \frac{f_o}{f_e}$ (See Q19)

$m = \frac{25 - f_e}{f_e} \rightarrow 4 = \frac{25 - f_e}{f_e}$ and $f_e = 5\text{cm}$

41B See Q22

42C $\frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{20} - \frac{1}{100} \rightarrow \frac{1}{v} = \frac{4}{100}$ and $v = 25\text{cm}$

CHAPTER 24

DISPERSION OF LIGHT. ELECTROMAGNETIC SPECTRUM

1. The visible part of light consists of the following colours: A. red, indigo, infra-red, violet, yellow, green and blue B. red, green, blue, violet, indigo, orange and yellow C. blue, ultra-violet, infra-red, red, yellow, indigo, violet, green and orange D. infra-red and ultra-violet E. red, orange, yellow, green, blue, indigo and infra-red. (1978:Q43)
2. The angular dispersion of a prism depends on A. the index of refraction only B. the angle of incidence as well as the index of refraction C. the angle of incidence only D. the thickness of the prism E. the prism angle (1978:Q46)
3. Of the following which is different from the others? A. x-rays B. gamma-rays C. cathode rays D. ultra violet rays E. infrared rays (1978:Q49)
4. Which of the following electromagnetic waves has the shortest wavelength? A. Radio waves B. X-rays C. Infra-red D. Blue light E. Ultraviolet (1979:Q40)
5. In sunlight, a blue flower looks blue because we see the flower by the light it A. receives from our eye B. disperses C. absorbs D. refracts E. reflects. (1980:Q37)
6. The range of wavelengths of the visible spectrum is 400nm–700nm. The wavelength of gamma rays is A. Longer than 700nm B. Shorter than 700nm but longer than 400nm C. 550nm D. Shorter than 400nm E. Infinite (1983:Q13)
7. Which of the following arrangements in the sequence shown can be used to obtain a pure spectrum of white light? A. Source, slit, converging lens, prism, converging lens, screen. B. Source, slit, diverging lens, screen. C. Source, converging lens, prism, diverging lens, screen. D. Source, slit, prism, diverging lens, screen (1983:Q18)
8. What is the apparent colour of a RED SHIRT when viewed in PURE green light? A. Red B. Green C. Yellow D. Black E. Blue (1984:Q40)
9. The spectrum of white light consists of coloured lights arranged in the following order A. Blue, red, green, Yellow, indigo, violet, orange. B. Red, orange, yellow, green, blue, indigo, violet. C. Red, orange, yellow, indigo, green, blue, violet. D. Indigo, green, blue, violet, yellow, red, orange. E. Yellow, blue, green,


violet, orange, indigo, red. (1984:Q41)

10. A narrow beam of white light can be split up into different colours by a glass prism. The correct explanation is that A. White light is an electromagnetic wave B. The prism has all the colours of the white light C. White light has undergone total internal reflection in the prism D. Different colours of white light travel with different speeds in glass. E. White light consists of yellow, green and red colours. (1985:Q34)

11. In which of the following arrangements is the wavelength in an increasing order? A. Gamma rays, infra-red rays, X-rays, Radio waves. B. Gamma rays, X-rays, infra-red rays, Radio waves. C. Radio waves, X-rays, gamma rays, infra-red rays. D. Infra-red rays, radio waves, X-rays, gamma rays. (1986:Q29)

12. When white light is dispersed by a spectrometer, the component having the shortest wavelength is A. Orange B. Green C. Violet D. Red. (1988:Q34)

13. Which of the following statements is TRUE of ultraviolet, visible and infra-red rays? A. They are all electromagnetic waves with the same wavelength. B. Ultra-violet rays have shorter wavelengths than infra-red rays and produce fluorescence. C. Infra-red rays have shorter wavelength than visible light and produce the sensation of heat. D. The wavelengths increase in the sequence: visible, ultra-violet, infra-red. (1988:Q35)

14.  E, F and G are yellow, red and cyan transparent light filters respectively. The colour of a white opaque object when viewed through the arrangement of the filters above is A. Yellow B. Red C. Black D. Blue (1988:Q36)

15. A spectrum of sunlight is said to be impure when A. It is made of only three colours B. It has no red colour in it C. The different colours in it overlap D. It does not contain white light. (1988:Q38)

16. When a yellow card is observed through a blues glass, the card would appear A. Black B. Green C. Red D. White (1989:Q29)

17. Dispersion of light by a glass prism is due to the A. Different hidden colours of the glass B. Different speeds of the various colours in glass C. Defects in the glass D. High density of glass. (1989:Q30)

18. Which of the following pairs is NOT part of the electromagnetic spectrum? I. Radio waves II. Beta rays III. Gamma rays IV. Alpha rays A. I and II B. III and IV C. I and III D. II and IV. (1989:Q31)





19. When light is incident on an object which is magenta in colour, which of the following colours be absorbed? A. Red and blue B. Green only C. Red and green D. Red only. (1990:Q30)

20. Which of the following arrangements of the components of electromagnetic spectrum is in ascending order of wavelengths? A. Gamma rays, ultraviolet rays, x-rays, infra-red rays. B. Gamma rays, x-rays, ultraviolet rays, infra-red rays C. Infra-red rays, ultraviolet rays, x-rays, gamma rays. D. Gamma rays, ultraviolet rays, infra-red rays, x-rays. (1992:Q30)

21. Which of the following correctly explains(s) why a green leaf appears green in bright daylight? I. It absorbs only the green component of sunlight. II. It absorbs all colours in sunlight except green. III. It reflects only the green component of sunlight. A. I only B. II only C. I and III

CHAPTER 24

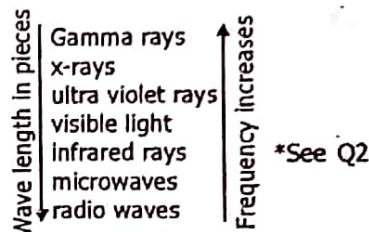
DISPERSION OF LIGHT. ELECTROMAGNETIC SPECTRUM

- only D. II and III only. (1993:Q31)
22. If the Nigerian flag (green, white, green) is viewed in pure yellow light, which of the following set of colours would be observed on the flag? A. Green, yellow, green B. Red, yellow, red. C. Black, yellow, black. D. Green, white, green (1994:Q38)
23. Which of the figures below illustrates the dispersion of white light through a triangular glass prism?
- A  B  C  D  (1994:Q39)
24. Which of the following pairs of colours gives the widest separation in the spectrum of white light? A. Red and violet B. Green and yellow C. Red and indigo D. Yellow and violet. (1995:Q36)
25. The colours seen in thin films of oil on the road and in soap bubbles are due to A. Reflection B. Interference C. Diffraction D. Polarization. (1997:Q30)
26. The electromagnetic waves that are sensitive to temperature changes are A. X-rays B. gamma-rays C. ultra-violet rays D. infra-red rays. (1997:Q37)
27. Which of the following are true about infra-red radiation? I. It is invisible II. It is called heat ray III. Its frequency is higher than that of blue light IV. It travels as a transverse wave. A. I, II, III and IV B. I, II and IV only C. I, III and IV only D. II, III and IV only. (1998:Q35)
28. Which of the following electromagnetic waves is least energetic? A. infra-red rays B. X-rays C. Ultra-violet D. Gamma rays (1999: Q30)
29. The colours seen in soap bubbles are due to A. Interference B. dispersion C. diffraction D. refraction (2002: Q17).
30. Which of the following pairs of light rays shows the widest separation in the spectrum of white light? A. Green and yellow B. Indigo and violet C. Orange and red D. Blue and red (2003: Q36)
31. The production of pure spectrum could easily be achieved using a A. triangular prism only. B. triangular prism with two concave lenses. C. triangular prism with two convex lenses. D. glass prism with a pin. (2007:Q3)
32. Which of the following is a secondary colour? A. Blue B. Orange C. Red D. Green (2009: Q38)
33. Dispersion occurs when white light passes through a glass prism because of the A. different speeds of the colours in the glass. B. high density of the glass. C. defects in the glass. D. different hidden colours in the glass (2010: Q32)
34. Which of the following electromagnetic waves has the highest frequency? A. Infrared-rays. B. X-rays. C. Ultra-violet rays. D. Radio waves. (2011: Q28)
35. When a red rose flower is observed in blue light, what colour does the observer see? A. Magenta. B. Yellow. C. Red. D. Blue. (2011: Q29)
36. Dispersion of white light is the ability of white light to A. penetrate air, water and glass B. move in a straight line C. move around corners D. separate to its component colours. (2012: Q37)
37. The angle of deviation of light of various colours passing through a triangular prism increases in the order A. red → green → blue B. green → violet → blue. C. blue → red → green. D. blue → green → red. (2013: Q28)
38. A pure spectrum can be produced by using a A. triangular prism B. triangular glass prism with two convex lenses C. glass prism D. glass prism with two concave lenses (2016: Q10)
39. What happens when a beam of white light is passed through a triangular glass prism? A. Dispersion occurs B. Polarization occurs C. Interference occurs D. Photoelectric effect occurs (2016:Q35)
40. The optical phenomenon responsible for rainbow is A. refraction B. diffusion C. reflection D. dispersion(2018: Q10)

- 1B. Infrared  ultraviolet

You must be familiar with the correct order.

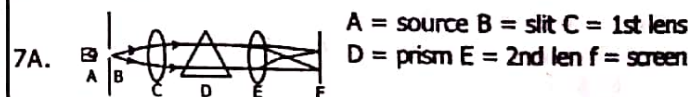
- 2B. The angular dispersion or dispersive power of a prism depends on the following
- The angle of incidence of incoming light
 - Refractive index of the material prism
 - Refracting angle of prism
 - Refraction index of the surroundings
- 3C. Cathode ray is not part of the electromagnetic spectrum



NOTE:

- All the electromagnetic waves have the same speed as visible light such that $v = f\lambda = 3 \times 10^8 \text{ms}^{-1}$ i.e if a wave has a very small f , it has a very large λ and vice versa.
- Thus gamma rays have shortest wavelength but highest frequency; radio waves have longest wavelength but lowest frequency.

- 4B. See Q3
- 5E. When white visible light falls on the flower, all the colour components of white light except blue (ROYG*IV) are absorbed while blue is reflected into our eyes.
- 6D. See Q3



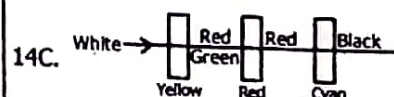
NOTE:

- The slit illuminated by the light source acts as objects producing fairly separate images of different colours.
- The slit is at the focal length of the 1st converging lens.
- The screen is also placed at the focus of the 2nd lens.
- If 2nd lens is remove, a fairly pure spectrum can still be obtained.

- 8D. The green light is completely absorbed and nothing is reflected.

NOTE: Black means no light.

- 9B. ROYGBIV (Q1)
- 10D. The splitting is called dispersion and it follows from the different angular refractions of these colours because they are slowed down by varying degrees on entering the prism.
- 11B. See Q3 12C. See Q3 13B. See Q3



Yellow filter absorbs Blue; Red absorbs Green and Cyan (B-G) absorbs red hence the eye sees black colour.

- 15C. The diagram in Q7 produces a pure (non-overlapping) spectrum.
- 16A. See Q8 17B. See Q10 18D. See Q3
- 19B. Magenta = Red + Blue
Hence green is absorbed while red and blue are reflected.

NOTE:

- Also consider: Cyan = Blue + Green; Yellow = Red + Green
- Biology students should remember that Blue-green algae are called Cyanor bacteria (cyan = blue-green)

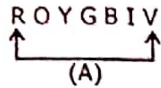
20B. See Q3 21D. See Q5

22C. The green portions absorb the yellow light hence they appear black; the white portion reflects the yellow light and produces a yellow sensation in the eye.

NOTES:

- A white surface reflects all the colour falling on it.
- A black surface absorbs all colours falling on it.

23C. The splitting of the ray into its coloured components occurs at the (first) air-glass interface not the (second) glass air interface in (D).



25B. Thin film interference of white light coming from the sky.
26A. The heat generated in X-ray production is quietly transferred away by some cooling fans

27A. Infra-red is not part of the visible light spectrum but like all electromagnetic waves, it is propagated as a transverse wave with the speed of light. Heat energy reaching us from the sun (called radiant heat) for example is infra-red radiation. It is of higher frequency but lower wavelength than blue light (see Q3)

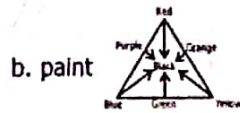
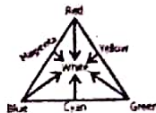
NOTE: Do you know that the so-called global warming arises from the retention of the infra-red portion of the sunlight by excess atmospheric carbon dioxide?

28D. 29A. See Q24 30A. See Q23 31C. See Q7

32B. Red, blue and green are primary colours (in light) and take orange as yellow here.

NOTES:

- A primary colour cannot be obtained by adding two or more colours.
 - In light → Red/Blue/Green
 - In paint → Red/Blue/Yellow
- A secondary colour is obtained by adding two primary colours
 - In light colour: Magenta = Red + Blue
Cyan = Blue + Green; Yellow = Red + Green
 - In paint colour: Purple = Red + Blue
Green = Blue + Yellow; Orange = Red + Yellow
- Addition of three primary colours produces white-coloured light.
- Addition of three secondary colours produces white-coloured light.
- Addition of three primary or three secondary coloured paints produces black paint.
- Two light colours are complementary if their addition produces white light
Green + Magenta = White; Blue + Yellow = White
Red + Cyan = White
- A complementary pair contains a primary and a secondary light colours.



- a. light b. paint
- Light uses additive colour mixing while paint uses subtractive colour mixing.

33A. See Q10 34B. See Q3
35. The red flower would absorb the blue light to produce black appearance of the flower. No option was correct!
NOTE: Additive colour mixing does not apply here hence magenta is wrong.

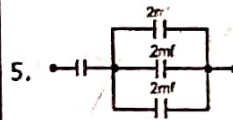
36D. See Q10
A. Red deviates least (ROY-) while violet deviates most (-GBIV).
NOTE: The above also means that red travels fastest while violet travels least speedily.

- 38B See Q7 39A See Q10
40D When white light from the sun passes through rain droplets hanging in the air, it is dispersed to form the visible rainbow

CHAPTER 25

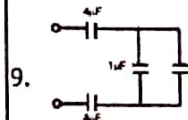
ELECTROSTATICS. ELECTRIC FIELD. CAPACITORS

- The equivalent capacitance for the circuit drawn below is A. 18mf B. 4mf C. 2mf D. 12mf E. 13mf (1978: Q29)
- Why is it impossible for the lines of force of an electric field to cross one another? A. like charges repel each other B. a charged particle is deflected C. like charges are arranged on the same lines of force D. a positively charged particle can travel in only one direction at any time E. none of these is correct. (1978: Q34)
- An electric charge could be transmitted through A. wood, rubber and stone B. paper, clay and plastic C. glass, acid and cloth D. the human body, water and metals E. all of the above. (1978: Q38)
- Which of the following is true of an electrical charge? A. Positive charge means deficit electrons B. Negative charge means excess of electrons C. Electric current means movement of electrons D. All of the above E. A and B only. (1980: Q2)



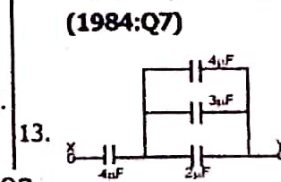
The total capacitance of the circuit above is A. 0.25mf B. 0.50mf C. 0.75mf D. 1.25mf E. 1.50mf (1980: Q9)

- What is the relative permittivity of a capacitor if its capacitance with a medium as dielectric is 16 farads and its capacitance with vacuum as dielectric is 2 farads? A. 0 B. 1/2 C. 2 D. 8 E. 32 (1980: Q21)
- In the process of electrification by induction, the amount of induced charge in relation to the inducing charge is the A. same in sign and quantity B. same in sign but greater C. opposite in sign but greater D. opposite in sign but less E. opposite in sign and equal (1980: Q48)
- Which of the following statements is CORRECT? A. Charges generated on glass rubbed with silk are called negative B. Charges in various media can be carried by protons detached from their atoms. C. The magnitude of any charge is a multiple of the charge of an electron D. The intensity of an electric field is a scalar quantity E. If 500 joules of work are required to move a 2-coulomb charge between two points, the potential difference between the two points is 100V. (1981: Q27)



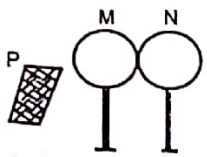
What is the resultant capacity of the circuit (Fig.5) given above? A. 1.5mf B. 18.0mf C. 6.0mf D. 6.8mf E. 8.83mf (1982: Q26)

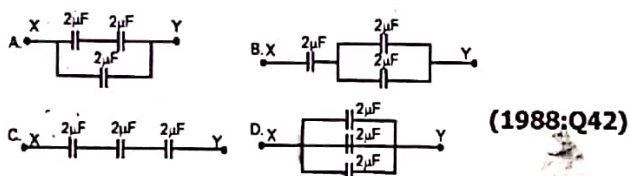
- As a positively charged rod is brought nearer to the top cap of a positively charged gold leaf electroscope, the divergence of the leaves will A. decrease to zero B. steadily increase C. decrease to zero and then increase D. remain constant E. increase to maximum and then decrease. (1982: Q32)
- If the force on a charge of 0.2 coulomb in an electric field is 4N, then the electric field intensity of the field is A. 0.8 B. 0.8N/C C. 20.0N/C D. 4.2N/C E. 20.0C/N (1983: Q47)
- The unit quantity of electricity is called A. The ampere B. The volt C. The coulomb D. The ammeter E. Electromotive force. (1984: Q7)



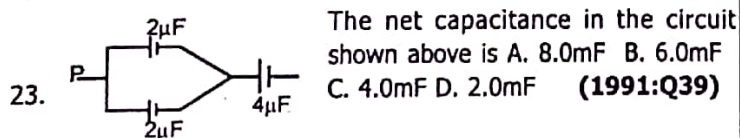
In the circuit shown in the figure below calculate the effective capacitance between X and Y. A. 3/4mf B. 210/13mf C. 12mf D. 412/13mf E. 13mf (1984: Q35)

14. If the distance between two stationary charged particles is doubled, the magnitude of the electrostatic force between them will be A. doubled B. halved C. a quarter of its former value D. unchanged E. four times the original value (1985:Q36)
15. The sign of the charge on a charged glass rod may be determined with A. A charged electroscope B. An uncharged electroscope C. A galvanometer D. An electrometer. (1986:Q46)
16. Two capacitances of 6mF and 8mF are connected in series. What additional capacitance must be connected in series with this combination to give a total of 3mF? A. 3mF B. 16mF C. 24mF D. 30mF. (1987:Q40)

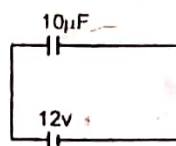
17.  In the figure above, M and N are insulated metal spheres in contact. A negatively charged ebonite rod P is brought near M. When M and N are separated and the rod is taken away, which of the following statements is CORRECT? A. Both M and N have acquired negative charges B. Both M and N have acquired positive charges C. M has acquired negative charge and N positive charge D. M has acquired positive charge and N negative charge. (1987:Q41)
18. Which of the following combinations of 2mF capacitors will give an effective capacitance of 3mF across terminal XY?



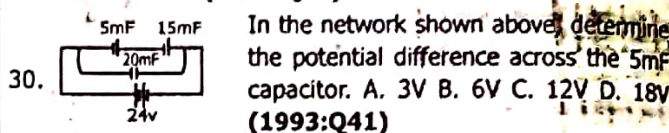
19. Two insulated charged spheres of different sizes and carrying opposite charges are connected together by a metallic conductor. Current will flow from one sphere to the other until both spheres A. Carry the same magnitude and sign of charge. B. Are at the same potential. C. Are at the same temperature. D. Are of the same size. (1989:Q32)
20. Which of the following statements are true of an insulated charged body carrying a positive charge? I. It contains excess positive charges II. It creates an electric field III. It possesses potential energy IV. It carries electric current. A. I and IV only B. I and II only C. I, II and III only D. I, II, III and IV. (1990:Q35)
21. Which of the following is a vector? A. Electric charge B. Electric field C. Electric potential difference D. Electric capacitance. (1990:Q36)
22. An insulated rod when rubbed with a material acquires A. A negative charge if it is made of glass and rubbed with silk B. No charge if it is made of glass and rubbed with fur C. No charge if it is made of copper and rubbed with silk D. A positive charge if it is made of copper and rubbed with fur. (1991:Q34)



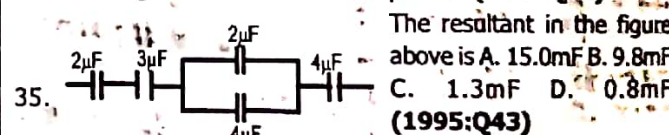
24. Calculate the force acting on an electron of charge 1.6×10^{-19} C placed in an electric field of intensity 10^9Vm^{-1} A. 1.6×10^{-11} N B. 1.6×10^{-14} N C. 1.6×10^{-15} N D. 1.0×10^{-16} N (1992:Q33)
25. When an ebonite rod is rubbed with fur, it has A. No charge at all B. A negative charge C. A positive charge D. Negative and positive charges. (1992:Q34)
26. A 5-V battery is connected across the plates of a 2.0mF uncharged parallel plate capacitor. The charge on the capacitor after a long time is A. 2.5mC B. 10.0mC C. 20.0mC D. 50.0mC (1992:Q39)





27.  A capacitor of 10mF is connected across a cell of 12 volts as shown above. Calculate the energy stored in the capacitor. A. 7.2×10^{-3} J B. 1.4×10^{-3} J C. 1.4×10^{-4} J D. 1.2×10^{-4} J (1992:Q41)

28. A field that results from the contact of a positively charged ball with the inner wall of an uncharged hollow conducting sphere is A. Inside the sphere B. On the surface of the ball C. Inside and outside the sphere D. Outside the sphere. (1993:Q32)
29. A parallel plate capacitor of area 10cm^2 in vacuum has a capacitance of 10^{-7}mF . What is the distance between the plates? ($\epsilon_0 = 9 \times 10^{-12} \text{Fm}^{-1}$) A. $9 \times 10^{-13} \text{m}$ B. $9 \times 10^{-7} \text{m}$ C. $9 \times 10^{-3} \text{m}$ D. $9 \times 10^7 \text{m}$ (1993:Q40)



31. When biro pen rubbed on a dry silk cloth is moved very closed to a piece of paper on a dry table, the pen is found to pick up the paper. This is because A. Both the pen and the cloth are magnetized B. The pen is magnetized but the cloth is not C. The pen is charged while the cloth is magnetized D. Both the pen and the cloth are charged. (1994:Q41)
32. A capacitor 8mF, is charged to a potential difference of 100V. The energy stored by the capacitor is A. 1.0×10^3 J B. 8.0×10^3 J C. 1.25×10^3 J D. 4.0×10^3 J (1994:Q43)
33. Two parallel plates at a distance of $8.0 \times 10^{-3} \text{m}$ apart are maintained at p.d. of 600 volts with the negative plate earthed. What is the electric field strength? A. 4.8Vm^{-1} B. 75.0Vm^{-1} C. 4800.0Vm^{-1} D. 75000.0Vm^{-1} (1995:Q37)
34. The purpose of a dielectric material in a parallel plate capacitor is to A. Increase its capacitance B. Decrease its capacitance C. Insulate the plates from each other D. Increase the magnetic field between the plates. (1995:Q42)



36. Which of the figures below showed the correct distribution of charges on an isolated positively charged hollow metal? A.  B.  C.  D.  (1997:Q39)

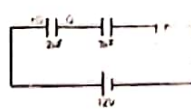
37. Two 50mF parallel plate capacitors are connected in series. The combined capacitor is then connected across a 100-V battery. The charge on each plate of the capacitor is A. $5.00 \times 10^{-6} \text{C}$ B. $2.50 \times 10^{-6} \text{C}$ C. $1.25 \times 10^{-6} \text{C}$ D. $1.00 \times 10^{-6} \text{C}$ (1997:Q44)

38. The force of repulsion between two point positive charges 5mC and 8mC separated at a distance of 0.02m apart is A. $1.8 \times 10^{-10} \text{N}$ B. $9.0 \times 10^{-8} \text{N}$ C. $9.0 \times 10^2 \text{N}$ D. $4.5 \times 10^3 \text{N}$ [$\frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \text{Nm}^2\text{C}^{-2}$] (1998:Q36)

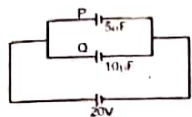
39. An ebonite rod rubbed with fur attracts a glass rod rubbed with silk because A. Ebonite has a negative charge while glass has a positive charge B. Ebonite has a positive charge while glass has a negative charge C. Both have negative charges D. Both have positive charges (1998:Q37)

40. A parallel capacitor has a common plate area of $5 \times 10^{-4} \text{m}^2$ and plate separation of $2 \times 10^{-3} \text{m}$. Assuming free space, what is the capacitance? A. $2.25 \times 10^{-17} \text{F}$ B. $4.50 \times 10^{-17} \text{F}$ C. $2.25 \times 10^{-16} \text{F}$ D. $4.50 \times 10^{-16} \text{F}$ [$\epsilon_0 = 9.0 \times 10^{-12} \text{C}^2 \text{N}^{-1} \text{m}^{-2}$] (1998:Q42)

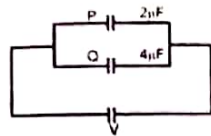
41. In the circuit above, the potential across each capacitor is 100V. The total energy stored in the two capacitors is A. 3.0×10^3 J B. 3.0×10^2 J C. 2.5×10^3 J D. 6.0×10^3 J (1999:Q38)



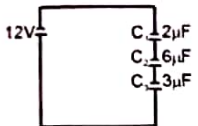
42. The diagram below shows two capacitors P and Q of capacitances $5\mu\text{F}$ and $10\mu\text{F}$. Find the charges stores in P and Q respectively. A. $200\mu\text{C}$ and $100\mu\text{C}$ B. $100\mu\text{C}$ and $200\mu\text{C}$ C. $4\mu\text{C}$ and $2\mu\text{C}$ D. $2\mu\text{C}$ and $4\mu\text{C}$ (2000:Q30)



43. The diagram below shows two capacitors P and Q of capacitances $2\mu\text{F}$ and $4\mu\text{F}$ respectively connected to a d.c. source. The ratio of energy stored in P to Q is A. 4:1 B. 2:1 C. 1:4 D. 1:2 (2001:Q23)

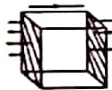


44. The diagram below shows three capacitors C_1 , C_2 and C_3 of capacitances $2\mu\text{F}$, 6mF and $3\mu\text{F}$ respectively. The potential differences across C_1 , C_2 and C_3 respectively are A. 4V, 6V and 2V B. 2V, 6V and 4V C. 6V, 4V and 2V D. 6V, 2V and 4V (2001:Q25)



45. A student is at a height 4m above the ground during a thunderstorm. Given that the potential difference between the thundercloud and the ground is 10^7V , the electric field created by the storm is A. $2.0 \times 10^6\text{NC}^{-1}$ B. $2.5 \times 10^6\text{NC}^{-1}$ C. $1.0 \times 10^7\text{NC}^{-1}$ D. $4.0 \times 10^7\text{NC}^{-1}$ (2001:Q26)

46. The diagram below shows a closed square box of side 0.5m in a uniform electric field E in the direction shown by the arrows. What is the flux for the box? A. 0.5E B. 2.0E C. 0.2E D. 0.0E (2001:Q30)



47. When a piece of rectangular glass block is inserted between two parallel plate capacitor, at constant plate area and distance of separation, the capacitance of the capacitor will A. Increase B. Decrease C. Decrease, then increase D. Remain constant (2001:Q33)

48. The ratio of electrostatic force F_e to gravitational force F_g between two protons each of charge e and mass m, at a distance d is

A. $\frac{e}{4\pi\epsilon_0 Gm}$ B. $\frac{e^2}{Gm^2}$ C. $\frac{Gm^2}{4\pi\epsilon_0 e^2}$ D. $\frac{e^2}{4\pi\epsilon_0 Gm^2}$ (2001:Q34)

49. The energy stored in a capacitor of capacitance $10\mu\text{F}$ carrying a charge $100\mu\text{C}$ is A. $4 \times 10^{-3}\text{J}$ B. $5 \times 10^{-4}\text{J}$ C. $5 \times 10^{-2}\text{J}$ D. $4 \times 10^3\text{J}$ (2002:Q30)

50. The electric field between the two-point charges is shown in the diagram above. What types of charges are at X and Y? A. Both X and Y are positive B. X is positive and Y is negative C. X is negative and Y is positive D. Both X and Y are negative. (2002:Q38)



51. A positively charged rod X is brought near an uncharged metal sphere Y and is then touched by a finger with X still in place. When the finger is removed, the result is that Y has A. A negative charge and a positive potential B. No charge and zero potential C. A negative charge and a negative potential D. A positive charge and a zero potential (2003:Q27)

52. The instrument used for securing a large number of similar charges by induction is called A. Capacitor B. Electrophorus C. Electroscop D. Proof-plane (2004:Q41)

53. Given three capacitors $0.3\mu\text{F}$, $0.5\mu\text{F}$ and $0.2\mu\text{F}$, the joint capacitance when arranged to give minimum capacitance is A. $0.3\mu\text{F}$ B. $1.0\mu\text{F}$ C. $0.1\mu\text{F}$ D. $0.5\mu\text{F}$ (2004:Q50)

54. The electric field intensity in a place where a charge of 10^{-10}C experiences a force of 0.4N is A. $8.0 \times 10^{-12}\text{NC}^{-1}$ B. $8.0 \times 10^9\text{NC}^{-1}$ C. $4.0 \times 10^9\text{NC}^{-1}$ D. $4.0 \times 10^{-11}\text{NC}^{-1}$ (2005:Q17)

55. The figure above shows three capacitors, $2\mu\text{F}$, $3\mu\text{F}$ and $6\mu\text{F}$

connected in series. If the p.d across the system is 12V, the p.d across the $6\mu\text{F}$ capacitor is A. 4V B. 6V C. 12V D. 2V. (2005:Q19)

56. If the distance between two point charges is increased by a factor of four, the magnitude of the electrostatic force between them will be A. 1/2 of its former value. B. 1/16 of its former value C. 1/4 of its former value. D. 4 times its former value (2005:Q23)

57. The production and type of charge of a body can only be accounted for by the A. equilibrium in protons and neutrons. B. deficiency or surplus of electrons. C. deficiency or surplus of protons. D. deficiency or surplus of neutrons. (2006:Q21)

58. If the capacitance of a capacitor is $C = \frac{\epsilon A}{d}$, which of the following parameters is varied when a variable capacitor is used for tuning radio sets? A. Area and distance B. Constant (e) only C. Constant (e) and area. D. Distance only. (2006:Q29)

59. The capacitance of a parallel-plate capacitor when in air is $3\mu\text{F}$ and in the presence of a dielectric material $6\mu\text{F}$. The dielectric constant is A. 3. B. 18. C. 2. D. 9. (2006:Q32)

60. A charge $50\mu\text{C}$ has an electric field strength of 360NC^{-1} at a certain point. The electric field strength due to another charge $120\mu\text{C}$ kept at the same distance apart and in the same medium is A. 18NC^{-1} B. 144NC^{-1} C. 150NC^{-1} D. 864NC^{-1} . (2007:Q23)

61. A short chain is sometimes attached to the back of a petrol tanker to A. generate more friction. B. ensure the balancing of the tanker. C. caution the driver when overspeeding D. conduct excess charges to the earth. (2008:Q38)

62. If negative charges are induced on an electroscope and a positively charged rod is brought near the cap of the electroscope, the leaves will A. close up. B. become positively charged. C. become negatively charged. D. open further. (2009:Q39)

63. When a positively charged rod is brought nearer the cap of a positively charged electroscope, the leaves' divergence will A. converge B. remain constant C. diverge D. be induced. (2010:Q33)

64. Three capacitors of capacitance, $2\mu\text{F}$, $4\mu\text{F}$ and $8\mu\text{F}$ are connected in parallel and a p.d of 6V is maintained across each capacitor, the total energy stored is A. $6.90 \times 10^{-4}\text{J}$ B. $6.90 \times 10^{-1}\text{J}$ C. $2.52 \times 10^{-4}\text{J}$ D. $2.52 \times 10^{-4}\text{J}$. (2010:Q34)

65. The capacitance of a parallel plate capacitor is $20\mu\text{F}$ in air and $60\mu\text{F}$ in the presence of a dielectric. What is the dielectric constant? A. 3.0 B. 2.0 C. 0.3 D. 6.0 (2011:Q33)

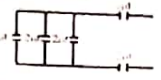
66. The correct expression for the potential at a point, distance r from a charge q, in an electric field is A. $\frac{q^2}{4\pi\epsilon_0 r^2}$ B. $\frac{q^2}{4\pi\epsilon_0 r}$ C. $\frac{q}{4\pi\epsilon_0 r^2}$ D. $\frac{q}{4\pi\epsilon_0 r}$ (2011:Q36)

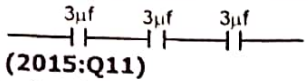
67. Calculate the force acting on an electron of charge $1.5 \times 10^{-19}\text{C}$ placed in an electric field of intensity 10^5Vm^{-1} . A. $1.5 \times 10^{-11}\text{N}$ B. $1.5 \times 10^{-12}\text{N}$ C. $1.5 \times 10^{-13}\text{N}$ D. $1.5 \times 10^{-14}\text{N}$. (2013:Q36)

68. Capacitors are used in the induction coil to A. control circuits. B. dissipate energy. C. prevent electric sparks. D. prevent distortion of electric fields. (2013:Q37)

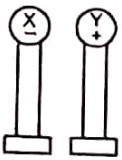
69. When a negatively-charged rod is brought near the cap of a charged gold leaf electroscope which has positive charges, the leaf A. collapses. B. collapses and diverge again. C. diverges. D. remains the same. (2014:Q33)

70. What charge is stored in a 0.1F capacitor when a 10V supply is connected across it? A. 5 C B. 4 C C. 2 C D. 1 C (2014:Q34)

71.  Calculate the effective capacitance of the circuit above. A. 1µf. B. 2µf. C. 3µf. D. 4µf. (2014:Q35)
72. The plates of a 0.5µF uncharged capacitor are connected to a 10V battery. The charge on the capacitor after a long time is A. 20.0µC B. 50.0µC C. 10.0µC D. 5.0µC. (2015:Q6)
73. From the diagram below, the equivalent capacitance of the three capacitors is A. 1/3µF B. 1/9µF C. 1µF D. 3µF. (2015:Q11)



74. In the diagram below, the charges on X and Y are opposite. What happens when they are in contact? A. X and Y become negatively charged. B. X and Y attract each other. C. X and Y become positively charged. D. X and Y repel each other. (2015:Q15)



75. If the voltage applied across the plates of a parallel plate capacitor separated by a distance of 0.02m is 5V, the magnitude of the electric field intensity in the capacity A. 200Vm⁻¹ B. 250Vm⁻¹ C. 300Vm⁻¹ D. 150Vm⁻¹ (2016:Q3)
76. If a charge of 2µC is situated in a field of intensity 400NC⁻¹, the force on the charge is A. 4 x 10³N B. 8 x 10⁴N C. 4 x 10⁶N D. 8 x 10⁹N (2016:Q19)
77. The dielectric of a capacitor is use to A. balance up the energy B. regulate the current flow C. boost the voltage between the plates D. increase the energy stored (2018:Q26)

CHAPTER 25

ELECTROSTATICS. ELECTRIC FIELD. CAPACITORS

- 1B. For 5µf and 7µf capacitors
 $C_r = 5 + 7$ (parallel capacitors)
 $C_r = 12\mu f$
 This is now in series to the 6µf:
 $\frac{1}{C_r} = \frac{1}{12} + \frac{1}{6}$ (series capacitors) $\rightarrow C_r = 4\mu f$

NOTES:

- Resultant capacitance when capacitors are in
 - series $C_r = C_1 + C_2 + \dots$
 - parallel $\rightarrow \frac{1}{C_r} = \frac{1}{C_1} + \frac{1}{C_2} + \dots$
- This is reversed in resistors - see chapter 26
- So also is a negatively charged particles.
- There and others such as damp air, graphite, acids, salt solutions and the earth, are conductors.

NOTE:

- Insulators would not allow electric charge to pass through them.
- Insulators include diamond, plastic, ebonite, polythene bakelite, paper, dry air, silk, diamond, glass, sulphur and wood.
- An immobile electron is called **electric charge** and its constitutes a **current** when it becomes mobile.

- 5E. For the 3 parallel capacitors: $c = 2 + 2 + 2 = 6mf$
 \therefore Total capacitance: $\frac{1}{C_r} = \frac{1}{6} + \frac{1}{2} \rightarrow C_r = \frac{6}{4} = 1.5mf$

- 6D. $\epsilon_r = C_d =$ Capacitance between plates with a dielectric
 $C_v =$ Capacitance between plates without a dielectric
 $\epsilon_r = \frac{16}{2} = 8$. (no unit)

NOTES:

- "with a dielectric" means there is a medium between plates while "without a dielectric" means plate are in a vacuum (C_v)
- If the permittivity of a medium is ϵ and the permittivity of vacuum or free space is ϵ_0 , the relative permittivity of the medium is $\epsilon_r = \frac{\epsilon}{\epsilon_0}$

- 7E The inducing charge impacts an opposite charge on the charged body
- 8BA (A) \rightarrow +ve charge on glass rod rubbed with silk; -ve charge or ebonite rod rubbed with fur.
 (B) \rightarrow Protons unlike electrons are too heavy to be detached
 (C) \rightarrow The charge e on an electron is $1.6 \times 10^{-19}c$ and the magnitude of any charge is a multiple of this fundamental value i.e charge is the quantity of electrcity (or electron)e.g.
 $2c$ generates $\times 10^{19} = 1.25 \times 10^{19}$ electrons
 (D) Electric field is a vector field.
 (E) Work = charge x p.d. $\rightarrow W = \frac{1}{2} qv$
 $\therefore v = \frac{2W}{q} = \frac{2 \times 500}{2} = 500V$

- 9A. For 1µf and 5µf $\rightarrow C = 1+5 = 6\mu f$ parallel capacitor
 All capacitor now in series: $\frac{1}{C_r} = \frac{1}{4} + \frac{1}{6} + \frac{1}{4}$
 $C_r = \frac{12}{3+2+3} = \frac{12}{8} \rightarrow C_r = 5\mu f$

| Body | Electroscope | Effect on leaves |
|-----------|--------------|------------------|
| +ve | +ve | Divergence |
| -ve | +ve | Convergence |
| -ve | -ve | Divergence |
| +ve | -ve | Convergence |
| uncharged | +ve | Convergence |
| uncharged | -ve | Convergence |

10B.

NOTES:

- Increase in divergence of leaves (convergence) is not a reliable result to determine the charge on a body as uncharged body produces the same effect as a body whose charge is different from that of the electroscope.
 - If divergence increases, then it is a sure way of detecting the charge on the body since it must be the same as the known charge on the electroscope.
- 11C. The electric field intensity is the force per unit (positive) charge: $E = \frac{f}{q} = \frac{4}{0.2} = 20N/C$
 This is a measure of the strength of the field.
- 12C. Coulomb \rightarrow Quantity of eletricity
 Ampere \rightarrow Current
 Volt \rightarrow Electromotive force
 Ammeter \rightarrow an instrument for measuring current.
- 13B. Consider the parallel capacitors: $c = 2 + 3 + 4 = 9\mu f$
 For series capacitors: $\frac{1}{C_r} = \frac{1}{4} + \frac{1}{9} \rightarrow C_r = \frac{36}{13} = 2\frac{10}{13}\mu f$

- 14C. $f \propto \frac{1}{d^2} \rightarrow F_1 d_1^2 = F_2 d_2^2$ or $\frac{F_1}{F_2} = \left(\frac{d_1}{d_2}\right)^2$
 Taking $d_1 = 1$ unit $d_2 = 2$ unit ($d_2 = 2d_1$): $\frac{F_1}{F_2} = \left(\frac{1}{2}\right)^2 = \frac{1}{4}$

- 15A. An electroscope of known charge - see Q10
- 16C. Let the 3rd capacitor = x; But $\frac{1}{6} + \frac{1}{8} + \frac{1}{x} = \frac{1}{3}$
 $\frac{1}{x} = \frac{1}{3} - \frac{1}{6} - \frac{1}{8}; \frac{1}{x} = \frac{8-4-3}{24} = \frac{1}{24}$ and $x = 24\mu f$

- 17D. In electromagnetic inductions, the nearer sphere acquires charges opposite to the ones on the rod while the distant one acquires the same charges as the rod.
- 18A. (A) \rightarrow Series: $C = 1$; Parallel: $C_r = 1 + 2 = 3\mu f$
 (B) \rightarrow Parallel: $C = 2 + 2 = 4\mu f$

Series: $\frac{1}{C_r} = \frac{1}{4} + \frac{1}{2} \rightarrow C_r = \frac{4}{3}\mu f$

(C) \rightarrow Series: $\frac{1}{C_r} = \frac{1}{2} + \frac{1}{2} + \frac{1}{2} = \frac{3}{2}\mu f$

(D) \rightarrow Parallel $\rightarrow 2 + 2 + 2 = 6\mu f$

- 19B. No net current flow is observed if two points are at equal potential.

20C. Flow of charge is called current - no flow here, please
21B. See Q8
22B. See Q8

23D. Parallel: $C = 2 + 2 = 4 \mu\text{f}$; Series: $\frac{1}{C_r} = \frac{1}{4} + \frac{1}{4} \rightarrow C_r = 2 \mu\text{f}$

24A. $F = qE$ (See Q11); $F = 1.6 \times 10^{-19} \times 10^8 \rightarrow F = 1.6 \times 10^{-11} \text{N}$

25B. See Q8

26B. $q = CV \rightarrow q = 2 \times 10^{-6} \times 5 = 10 \times 10^{-6} \text{C} \rightarrow q = 10 \mu\text{C}$

27A. $W = \frac{1}{2} CV^2 \rightarrow W = \frac{1}{2} \times 10 \times 10^{-6} \times 12 \times 12 = 7.2 \times 10^{-4} \text{J}$

NOTE: $q = CV$ (Q26) and $W = \frac{1}{2} qV$ (Q8)

$$\therefore W = \frac{1}{2} (CV)V = \frac{1}{2} CV^2 \text{ (Q26)}$$

$$\text{Also } V = \frac{q}{C} \therefore W = \frac{1}{2} q \times \frac{q}{C} \rightarrow W = \frac{q^2}{2C}$$

28D.

29C. $C = \frac{\epsilon_0 A}{d} \therefore 10^2 \times 10^6 = \frac{9 \times 10^{-12} \times 10^4}{d} \rightarrow d = \frac{9 \times 10^{-15}}{10^8} = 9 \times 10^{-23} \text{m}$

30D. Net capacitance for $5 \mu\text{f}$ and $15 \mu\text{f}$ $\frac{1}{C} = \frac{1}{5} + \frac{1}{15} \rightarrow C = 3.75 \mu\text{f}$

$$\text{But } Q = CV = \frac{15}{4} \times 24 = 90 \mu\text{C}$$

$$\text{This p.d. across } 5 \mu\text{f} = \frac{90 \times 10^{-6}}{5 \times 10^{-6}} = 18 \text{V}$$

31D. The charged on the pen attracts the uncharged paper.

32D. $W = \frac{1}{2} CV^2 = \frac{1}{2} \times 8 \times 10^{-6} \times 100^2 \rightarrow W = 4 \times 10^{-2} \text{J}$

33D. $E = \frac{V}{d} = \frac{600}{8 \times 10^{-3}} \rightarrow E = 75 \text{ 000 Vm}^{-1}$

34A. Remember the relation: $C = \frac{\epsilon A}{d}$? (Q29)

It suggests that $C \propto \epsilon$ where

C = capacitance of the parallel plate

ϵ = permittivity of the dielectric But $\epsilon > \epsilon_0$ and is proportional to C hence dielectric increases capacitance.

NOTE: Also $C \propto A$ and $C \propto \frac{1}{d}$

35D. Parallel: $C = 2+4 = 6 \mu\text{f}$; Series: $\frac{1}{C_r} = \frac{1}{2} + \frac{1}{3} + \frac{1}{6} + \frac{1}{4}$

$$C_r = \frac{12}{6+4+2+3} = \frac{12}{15} = 0.8 \mu\text{f}$$

36C. Charges on the surface only

37B. Total capacitance: $C_r = 2+5 = 5 \mu\text{f}$

$$\text{But } W = \frac{1}{2} CV^2 = \frac{1}{2} \times 5 \times 10^{-6} \times 100 \times 100 = 2.5 \times 10^{-2} \text{J}$$

38C. $f = \frac{Q_1 Q_2}{4\pi\epsilon_0 r^2} \rightarrow f = \frac{9 \times 10^9 \times 5 \times 10^{-6} \times 8 \times 10^{-6}}{0.02^2} = 900 \text{N}$

39A. See Q7

40C. $C = \frac{\epsilon_0 A}{d} \rightarrow C = \frac{9 \times 10^{-12} \times 5 \times 10^6}{2 \times 10^{-3}} = 2.25 \times 10^{-16}$

41C. Effective Capacitance $C_r = (2+3) \mu\text{f} = 5 \mu\text{f}$.

$$\text{Energy stored } E = \frac{1}{2} C_r V^2 = \frac{1}{2} \times 5 \times 10^{-6} \times (100)^2 = 2.5 \times 10^{-2} \text{J}$$

42B. Since they are parallel the voltage across each is 20V
 $Q_p = 5 \times 10^{-6} \times 20$ (Q25) $\rightarrow Q_p = 1 \times 10^{-4} \text{C} = 100 \mu\text{C}$
Similarly $Q_q = 200 \mu\text{C}$

43D. $E = \frac{1}{2} CV^2 \rightarrow \frac{E_p}{E_q} = \frac{\frac{1}{2} \times 2 \times 10^{-6} \times V^2}{\frac{1}{2} \times 4 \times 10^{-6} \times V^2} \rightarrow E_p : E_q = 1:2$

NOTE: Same voltage passes across them.

44D. $\frac{1}{C_r} = \frac{1}{2} + \frac{1}{6} + \frac{1}{3} \therefore C_r = 1 \mu\text{f}$ $\frac{E_p}{E_q} = \frac{E_p}{E_q}$

$$Q_r = 1 \times 12 = 12 \mu\text{C}$$

In series combination, voltage across each capacitor are different while charge across each are the same.

$$\therefore V_1 = \frac{Q_r}{C_1} = \frac{12 \mu\text{C}}{2 \mu\text{f}} = 6 \text{V} \rightarrow V_2 = \frac{12}{6} = 2 \text{V but } V_3 = \frac{12}{3} = 4 \text{V}$$

45B. $E = \frac{V}{d} = \frac{10^4}{4} \rightarrow E = 2.5 \times 10^3 \text{Nc}$

NOTE: The units Nc and Vm^{-1} are dimensionally equal.

46D.

47A. $C \propto \epsilon$ (See Q34)

48D. $F_e = \frac{e^2}{4\pi\epsilon_0 d^2}$ and $F_g = \frac{6m^2}{d^2} \therefore \frac{F_e}{F_g} = \frac{e^2}{4\pi\epsilon_0 d^2} \times \frac{d^2}{6m^2}$
 $= \frac{e^2}{4\pi\epsilon_0 6m^2}$

49B. $W = \frac{q^2}{2C} = \frac{(100 \times 10^{-6})^2}{2 \times 10^{-6}} \rightarrow W = 5.0 \times 10^{-4} \text{J}$

50A. The direction of flux is away from +ve charge or to -ve charge. Treat the North and South poles of a magnets similarly.

51C. To charge a sphere by induction, we bring a rod whose charge is opposite to the charge intended for the sphere hence +ve rod produces -ve sphere.

NOTE: Positive charge is at positive potential and negative charge at negative potential (Q50)

52B. A capacitor also stores charges but not by induction.

53C. Minimum capacitance combination occurs when all three are in series (compare Q18)

$$\frac{1}{C_r} = \frac{1}{0.3} + \frac{1}{0.5} + \frac{1}{0.2} \rightarrow \frac{1}{C_r} = \frac{10+6+15}{3}$$

$$C_r = \frac{3}{31} = 0.097 \rightarrow C_r = 0.1 \mu\text{f}$$

NOTES:

1. In series arrangement, the combine capacitance is smaller than the smallest of the capacitors $0.1 < 0.2 \mu\text{f}$.
2. In parallel arrangement, combined resistance is larger than the largest of the capacitors $1.0 \mu\text{f} > 0.5 \mu\text{f}$
3. You might not bother to work out the answer by using he above revelations alone.

54C. $E = \frac{F}{q} = \frac{0.4}{10^{-10}} = 4.0 \times 10^9 \text{Nc}^{-1}$

55D. This is Q44 revisited

56B. $\frac{F_2}{F_1} = \left(\frac{d_1}{d_2}\right)^2$ (Q14) $\rightarrow \frac{F_2}{F_1} = \left(\frac{1}{4}\right)^2 = \frac{1}{16}$

57B. Electron deficit \rightarrow +ve charge
Electron surplus \rightarrow -ve charge

58A. A variable capacitor used in radio sets is the one in which the effective area of the plates can be adjusted for tuning to the different wavelength of radio stations.

59C. $\epsilon = \frac{C_1}{C_0} = \frac{C_1}{C_0} \rightarrow \epsilon = \frac{6}{3} = 2$

60C. Since they are in the same medium, forces on the charges

are the same: $E = \frac{f}{q} \therefore f = qE \rightarrow q_2 E_2 = q_1 E_1$

$$120E_2 = 50 \times 360 \rightarrow E_2 = 150 \text{Nc}^{-1}$$

NOTE: $E = \frac{F}{q} \therefore E \propto \frac{1}{q}$ i.e. the larger the charge, the lower the electric field strength or field intensity

61D. The moving tanker generates static electricity in friction through air and the excess charges are conducted away via the chain.

62A. Divergence of leaves decrease (See Q10) - unlike charges attract.

63C. Divergence increases (See Q10) - like charges repel.

64C. Net capacitance: $C_r = 2 + 4 + 8 = 14 \mu\text{f}$ (parallel)

$$E = \frac{1}{2} CV^2 = \frac{1}{2} \times 14 \times 10^{-6} \times 6 \times 6 \rightarrow E = 2.5 \times 10^{-4} \text{J}$$

65A. $\epsilon = \frac{60}{20} = 3$

66B. Consider the following:

$$1. \text{ Force between two equal charges: } F = \frac{q^2}{4\pi\epsilon_0 r^2}$$

$$2. \text{ Electric field strength or intensity: } E = \frac{q}{4\pi\epsilon_0 r^2}$$

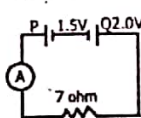
$$3. \text{ Electric potential: } v = \frac{q}{4\pi\epsilon_0 r}$$

NOTES:

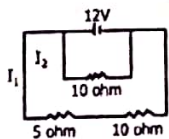
1. If $r = d$ then $V = Ed$ or $E = \frac{V}{d}$
2. F and E are vectors, V is a scalar quantity
- 67D. $F = qE = 1.5 \times 10^{-19} \times 10^5 \rightarrow F = 1.5 \times 10^{-14}N$
- 68C. An induction coil uses a circuit which contains an inductance and if such is suddenly opened, it produces sparks unless we use a capacitors.
- 69A. See Q10
- 70C. $q = CV = 0.1 \times 10 = 1C$
- 71D. For parallel combination: $C = 2 + 2 + 2 = 6\mu f$
All are now in series: $\frac{1}{C_r} = \frac{1}{6} + \frac{1}{2} + \frac{1}{3}$
 $\frac{1}{C_r} = \frac{1+3+2}{6} \rightarrow C_r = 1\mu f$
- 72D. $Q = CV = 0.5 \times 10^{-6} \times 10 = 5.0C$
- 73C. $\frac{1}{C_r} = \frac{1}{3} + \frac{1}{3} + \frac{1}{3}$ and $C_r = 1\mu f$
- 74B. Unlike charges attract
- 75B. $E = \frac{V}{d} = \frac{5}{0.02} = 250Vm^{-1}$
- 76B. $F = qE$ (See Q66) $\rightarrow F = 2 \times 10^{-1} \times 400 = 8 \times 10^{-4}N$
- 77D. Dielectric increases the capacitance C (Q34) hence it increases energy stored in the capacitor (since $E = 1/2 CV^2$)

**CHAPTER 26
CURRENT ELECTRICITY**

1. Two resistors R_1 and R_2 are connected in parallel, R_2 being greater than R_1 . The combined resistance is A. less than R_1 B. greater than R_2 C. the sum of R_1 and R_2 D. the difference of R_2 and R_1 E. greater than R_1 but less than R_2 (1978:Q26)
2. Three 5 ohm resistors connected in parallel have a potential difference of 60V applied across the combination. The current in each resistor is A. 4 A B. 36 A C. 12 A D. 24 A E. 10 A (1978:Q27)
3. In order to convert a galvanometer into an ammeter A. a low resistance shunt is connected in parallel B. a low resistance shunt is connected in series C. a medium resistance shunt is connected in series D. a high resistance shunt is connected in parallel E. a high resistance shunt is connected in series. (1978:Q31)
4. In the given circuit in the figure cell P has an e.m.f 1.5V and an

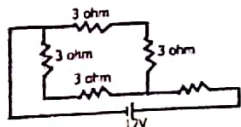


unknown internal resistance r while the cell Q has an e.m.f 2.0V and an internal resistance 1 ohm. If the ammeter reads 50mA, then, r is equal to A. 0.5 ohm B. 0.62 ohm C. 1.0 ohm D. 2.0 ohms E. 3.0 ohms. (1979:Q12)



The sum of the currents I_1 and I_2 in the figure is A. 1.2A B. 0.6A C. 0.8 D. 2A E. 1A (1979:Q15)

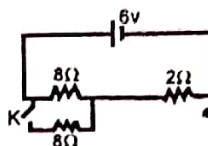
6. An electric cell has an internal resistance of 2 ohms. A current of 0.5A is found to flow when a resistor of 5 ohms resistance is connected across it. What is the electromotive force of the cell? A. 5 volts B. 3.5 volts C. 2.5 volts D. 1 volt E. 10 volts (1979:Q27)
7. An electrical circuit of the figure is connected up as shown; which of the following is the correct value of the current through the 1 ohm resistance? A. 12/13A B. 13/12A C. 1/3A D. 3A E. 12/7A (1979:Q45)
8. What is the total resistance in the above diagram? A. 5 ohms B. 15 ohms C. 25 ohms D. 35 ohms E. 45 ohms. (1980:Q8)
9. A milliammeter of resistance 5W and full scale deflection of 50mA is to be used to measure a potential difference of 50V. The resistance of the multiplier should be A. 95W B. 110W C. 595W D. 995W E. 1005W. (1980:Q28)
10. A cell has an open circuit voltage V_1 , and a closed circuit voltage V_2 when a current I is flowing through it. Therefore, the internal resistance of the cell is



- A. $\frac{V_2}{I}$ B. $\frac{V_1}{I}$ C. $\frac{(V_1 + V_2)}{I}$ D. $\frac{(V_1 - V_2)}{I}$ E. $\frac{(V_2 - V_1)}{I}$

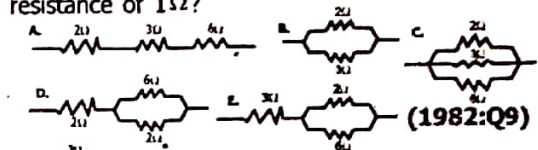
(1980:Q46)

11. According to Ohm's law, the ratio V/I is constant for A. an electrolyte B. a diode C. a transistor D. silver E. all of the above (1980:Q47)
12. Which of the following is NOT an effect that can be produced by an electric current? A. Heat B. Light C. Sound D. Motion E. None of the above. (1981:Q13)
13. A cell of e.m.f 2V and internal resistance 1W supplies a current of 0.5 amp to a resistance whose value is A. 0.5W B. 1W C. 2W D. 2.5W E. 3W (1981:Q14)
14. The effect of closing the key K in the circuit shown in Fig.



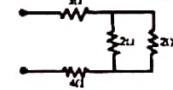
2 would be to A. increase the current by 0.6A B. reduce the current by 0.6A C. reduce the current by 0.4A D. increase the current by 0.4A E. keep the current unchanged (1981:Q21)

15. The resistance of an open series circuit is A. zero B. half the normal resistance of the circuit D. one E. infinite (1981:Q30)
16. Which of the circuits illustrated below will give a total resistance of 1Ω?

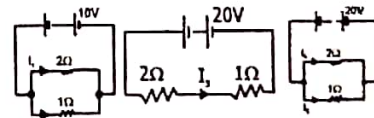


(1982:Q9)

17. What is the resultant resistance of the circuit in the figure given below? A. 11Ω B. 8Ω C. 3Ω D. 3.6Ω E. 4.3Ω (1982:Q27)



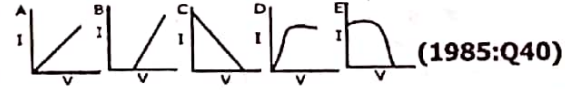
18. The value of the series resistance required to convert the above galvanometer (Fig. 9) into a voltmeter with a full range deflection of 15V is A. 985 ohms B. 990 ohms C. 995 ohms D. 1 000 ohms E. 1 005 ohms (1982:Q30)
19. A high-resistance voltmeter reads 3.0V when connected across the terminals of a battery on open circuit and 2.6V when the battery supplies a current of 0.2A through a lamp. The resistance of lamp is A. 2.00Ω B. 13.00Ω C. 0.52Ω D. 0.13Ω E. 1.50Ω (1982:Q38)



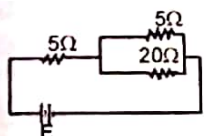
The diagrams in the figure show three circuits. The internal resistance of the

20. batteries are negligible. Which of the currents is the largest? A. I_1 B. I_2 C. I_3 D. I_4 E. I_5 (1983:Q19)
21. A milliammeter with full scale deflection of 100mA has an internal resistance of 5 ohms. It would be converted to an ammeter with a full scale deflection of 1A by connecting a resistance of A. 5/99 ohm in series with it B. 5/99 ohm in parallel with it C. 99/5 ohm in parallel with it . 99/5 ohm in series with it E. 2 ohms in series with it (1983:Q20)
22. A 24V potential difference is applied across a parallel combination of four 6-ohm resistors. The currents in each resistor is A. 1A B. 4A C. 16A D. 18A E. 36A (1983:Q23)
23. In the circuit shown in the figure T is a resistor whose resistance falls as temperature increases. L_1 and L_2 are lamps. Assuming the cell has negligible internal resistance, as the temperature of T increases A. L_1 becomes brighter, L_2 becomes dimmer. B. L_1 and L_2 becomes brighter. C. L_1 becomes dimmer, L_2 becomes brighter. D. L_1 becomes brighter, L_2 does not change. E. L_1 becomes dimmer, L_2 does not change. (1983:Q24)
24. The difference of potential between the terminals of a cell is 2.2 volts. When a 4 ohm resistor is connected across the terminals of this cell, the potential difference is 2 volts. What is the internal resistance of the cell? A. 0.10 ohms B. 0.25 ohms C. 0.40 ohms D. 2.50 ohms E. 4.00 ohms. (1983:Q39)

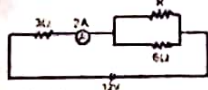
25. Four equal resistors R_1, R_2, R_3 and R_4 are connected in series as shown in Fig 9 below. V_1, V_2 and V_3 are voltmeters connected as indicated. Which of the following relations is CORRECT?
 A. $V_1 = V_3 = V_2/2$ B. $V_1 = 2V_2 = V_3$
 C. $V_1 = 1/2 V_3 = V_2$ D. $V_1 - V_2 = V_3$
 E. $V_3 - V_1 = V_2/2$ (1983:Q43)
26. The resistance of a wire depends on A. The length of the wire B. The diameter of the wire C. The temperature of the wire D. The resistivity (1984:Q8)
27. What is the resistance of the circuit shown in the figure
 A. 4Ω B. 11Ω C. $19/5\Omega$ D. $17/4\Omega$ E. 8Ω (1984:Q9)
28. Two cells, each of e.m.f. $1.5V$ and an internal resistance 2Ω are connected in parallel. Calculate the current flowing when the cells are connected to a 1Ω resistor. A. $0.75A$ B. $1.5A$ C. $0.5A$ D. $1.0A$ E. $0.6A$ (1984:Q10)
29. A galvanometer of resistance 5.0Ω has full-scale deflection for a current of $100mA$. How would its range be extended to $1.0A$ by placing a resistance of A. $5/9\Omega$ in parallel B. $9/5\Omega$ in series C. 45Ω in parallel D. 45Ω in series E. $9/5\Omega$ in parallel. (1984:Q49)
30. A cell gives a current of $0.15A$ through a resistance of 8Ω and $0.3A$. When the resistance is changed to 3Ω the internal resistance of the cell is A. 0.05Ω B. 1.00Ω C. 1.50Ω D. 2.00Ω E. 2.50Ω (1985: Q38)
31. Which of the following will convert a milliammeter to a voltmeter? A. Low series resistance B. Low parallel resistance C. High series resistance D. High parallel resistance E. Parallel resistance equal to milliammeter resistance. (1985:Q39)
32. Which of the graphs A-E in the figure represents the current-voltage ($I - V$) relationship for a cell with internal resistance?



33. A wire P has half the diameter and half the length of a wire Q of similar material. The ratio of the resistance of P to that of Q is A. 8:1 B. 4:1 C. 2:1 D. 1:1 E. 1:4 (1985:Q41)

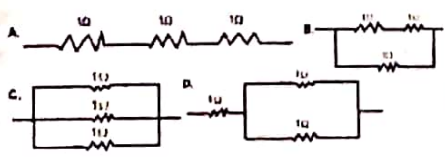


In the figure is an accumulator E with negligible internal resistance. If the e.m.f. is $9.0V$, then the total current is A. $0.3A$ B. $0.8A$ C. $1.0A$ D. $1.8A$ (1986:Q39)



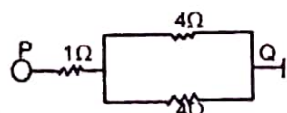
In the figure below the value of R is A. 3Ω B. 4Ω C. 5Ω D. 6Ω (1986:Q40)

36. Which of the following arrangements will produce an equivalent resistance of 1.5Ω from three 1Ω ?



(1986:Q43)

37. In the figure below, a voltage V is applied across the terminals



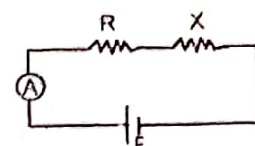
P and Q. the voltage across the 1Ω resistor is A. $V/8$ B. $V/4$ C. $V/3$ D. (1987:Q39)

38. A galvanometer of resistance 20Ω is to be provided with a shunt such that $1/10$ of the whole current in a circuit passes through the galvanometer. The resistance of the shunt is A. 2.00 B. 2.22 C. 18.00 D. 18.22 (1987:Q46)

39. A cell of internal resistance 2Ω supplies current to a 6Ω resistor. The efficiency of the cell is A. 12.0% B. 25.0% C. 33.3% D. 75.0% (1988:Q39)
 When a resistance R is across a cell, the voltage across the terminals of the cell is reduced to two thirds of its nominal value. The internal resistance of the cell is A. $1/3R$ B. $1/2R$

- C. $2/3R$ D. R (1988:Q40)

41. In the circuit above, the ammeter reads a current of $3A$, when R is 5Ω and reads $6A$ when R is 2Ω . The value of the unknown resistance X is A. 1 B. 2 (1988:Q41).



42. The resistance of a $5m$ uniform wire of cross-sectional area $0.2 \times 10^{-4}m^2$ is 0.425 . What is the resistivity of the material of the wire? A. $1.0 \times 10^{-8}\Omega m$ B. $4.25 \times 10^{-6}\Omega m$ C. $2.40 \times 10^{-7}\Omega m$ D. $1.70 \times 10^{-8}\Omega m$ (1989:Q35)

43. Three resistors, with substances 250Ω , 500Ω and $1k\Omega$ are connected in series. A $6V$ battery is connected to either end of the combination. Calculate the potential difference between the ends of the 250Ω resistor. A. $0.20V$ B. $0.86V$ C. $1.71V$ D. $3.43V$. (1989:Q36)

44. A calibrated potentiometer is used to measure the e.m.f. of a cell because the A. Internal resistance of a cell is small compared with that of the potentiometer. B. Potentiometer has a linear scale. C. Potentiometer takes no current from the cell D. Resistance of the potentiometer is less than that of a voltmeter (1989:Q37)

45. In the above circuit diagrams, A is the ammeter and V the voltmeter. Which of the circuits is correct for finding the value of the resistance R ? A. I B. II C. III D. IV (1989:Q38)

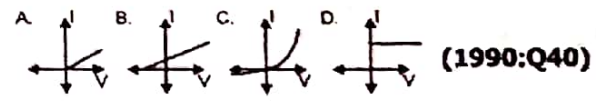
46. An ammeter of resistance 0.1Ω has a full scale deflection of $50mA$. Determine the resultant full-scale deflection of the meter when a shunt of 0.0111Ω is connected across its terminals. A. $400mA$ B. $450mA$ C. $500mA$ D. $550mA$. (1989:Q43)

47. Three cells each of e.m.f. $1.5V$ and an internal resistance of 1.0Ω are connected in parallel across a load resistance at $2.67W$. Calculate the current in the load? A. $0.26A$ B. $0.41A$ C. $0.50A$ D. $0.79A$. (1990:Q37)

48. When a known standard resistor of 2.0Ω is connected to the $0.0cm$ end of a meter bridge the balance point is found to be $55.0cm$. what is the value of the unknown resistor? A. 1.10Ω B. 1.64Ω C. 2.44Ω D. 27.50Ω (1990:Q38)

49. The total energy required to send a unit positive charge round a complete electrical circuit is the A. Kinetic energy B. Potential difference C. Electromotive force D. Electrical energy (1990:Q39)

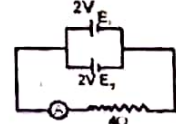
50. Which of the following graphs of current against voltage illustrates Ohm's law?



(1990:Q40)

51. A $0 - 10mA$ galvanometer with a coil resistance of 30Ω can be converted to a $0 - 0A$ ammeter by using A. 0.03Ω series resistor B. 0.03Ω shunt resistor C. 9.99Ω shunt resistor D. 9.99Ω series resistor (1990:Q45)

52. The internal resistance of each of the cells E_1 and E_2



shown in the figure above is 2Ω . Calculate the total current in the circuit A. $0.80A$ B. $0.50A$ C. $0.40A$ D. $0.004A$ (1991:Q35)

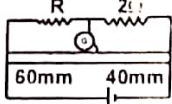
53. A moving coil galvanometer of 300Ω resistance gives full scale deflection for $1.0mA$. The resistance, R_s , of the shunt that is required to convert the galvanometer into a $3.0A$ ammeter is A. 899.70Ω B. 10.00Ω C. 0.10Ω D. 0.01Ω (1991:Q37)

54. Which of the following obeys Ohm's Law? A. Glass B. Diode C. All electrolytes D. All metals. (1991:Q38)

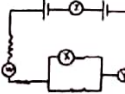
55. A wire of length $15m$ made of a material of resistivity $1.8 \times 10^{-4} ohms-m$ has a resistance of $0.27 ohms$.

Determine the area of the wire A. $1.5 \times 10^{-4} \text{m}^2$ B. $1.0 \times 10^{-4} \text{m}^2$ C. $2.7 \times 10^{-4} \text{m}^2$ D. $7.3 \times 10^{-4} \text{m}^2$ (1992:Q36)

56. The diagram above shows ammeter bridge in which two of the arms contain resistance R and 2Ω . A balance point is obtained at 60cm from the left end. Calculate the value of R. A. 1.2Ω B. 1.3Ω C. 3.0Ω D. 6.0Ω (1992:Q37)



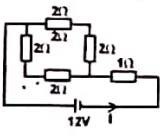
57. The circuit diagram above contains four ammeters W, X, Y and Z. Which of the following statements about the ammeter reading is correct? A. The reading of W is equal to that of Y and twice that of X. B. The reading of Y is greater than that of Z. C. The readings of W and Y are equal and each is greater than that of X. D. The reading of Z is equal to the sum of the readings of W and Y. (1992:Q38)



58. The maximum permissible current through a galvanometer G of internal resistance 10Ω is 0.05A . A resistance R is used to convert G into a voltmeter with a maximum reading of 100V . Find the value of R and how it is connected to G. A. $20\,000\Omega$ in parallel B. $19\,990\Omega$ in series C. $1\,990\Omega$ in series D. 100Ω in series (1992:Q44)

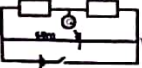
59. The terminal voltage of a battery is 4.0V when supplying a current of 2.0A , and 2.0V when supplying a current of 3.0A . The internal resistance of the battery is A. 0.5Ω B. 1.0Ω C. 2.0Ω D. 4.0Ω (1993:Q37)

60. The current I in the figure above is A. 4.00A B. 1.30A C. 0.80A D. 0.75A (1993:Q38)

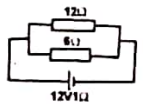


In the figure above, XY is of length 1m . The value of R at balance point Z is

61. A. 3.0Ω B. 13.3Ω C. 15.0Ω D. 30.0Ω (1994:Q42)



62. In the circuit diagram below, calculate the current in the 12Ω resistor if the cell has an e.m.f. of 12V and an internal resistance of 1Ω . A. 0.8A B. 1.0A C. 1.6A D. 2.4A (1994:Q45)



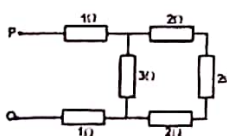
63. If a resistance is halved in value and the potential difference across it is tripled, then the ratio of the new current to the old is A. $1:6$ B. $1:3$ C. $2:1$ D. $6:1$ (1995:Q39)

64. Which of the following is required to convert a milliammeter to an ammeter? A. A high resistance in parallel B. A high resistance in series C. A low resistance in parallel D. A low resistance in series. (1995:Q46)

65. Three electric cells each of e.m.f. 1.5V and internal resistance 1.0Ω are connected in parallel across an external resistance of $2/3\Omega$. Calculate the value of the current in the resistor. A. 0.5A B. 0.9A C. 1.5A D. 4.5A (1997:Q40)

66. A galvanometer of internal resistance 50Ω has a full scale deflection for current of 5mA . What is the resistance required to convert it to a voltmeter with full scale deflection of 10V ? A. $1\,750\Omega$ B. $1\,950\Omega$ C. $2\,000\Omega$ D. $2\,500\Omega$ (1997:Q41)

67. In a metre bridge experiment, two resistors 2Ω and 3Ω occupy the left and right gaps respectively. Find the balance point from the left side of the bridge. A. 20cm B. 40cm C. 60cm D. 80cm (1997:Q43)



The total resistance measured at PQ in the diagram below is A. 18.0Ω B. 11.0Ω C. 4.0Ω D. 2.0Ω (1998:Q40)

68. Four cells each of e.m.f. 1.5V and internal resistance of 4Ω are connected in parallel. What is the effective e.m.f. and internal resistance of the combination? A. 6.0V , 16Ω B. 6.0V , 1Ω C. 1.5V , 4Ω D. 1.5V , 1Ω (1999:Q29)

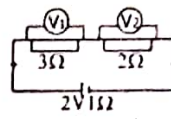
70. In the circuit above, the ammeter reads a current of 5.0A

when $R = 8\Omega$ and reads 7.0A when $R = 5\Omega$. The value of the unknown resistance X is A. 10.0Ω B. 7.5Ω C. 5.0Ω D. 2.5Ω (1999:Q30)

71. A galvanometer has a resistance of 5Ω . By using a shunt wire of resistance 0.05Ω , the galvanometer could be converted to an ammeter capable of reading 2A . What is the current through the galvanometer? A. 2mA B. 10mA C. 20mA D. 25mA (1999:Q41)

72. A cell of internal resistance 0.01Ω can be measured accurately using the A. Ohm-meter B. Potentiometer C. Electroscopes D. Metre bridge (2000:Q27)

73. In the diagram above, the values of V_1 and V_2 are respectively A. 1V and $1/3\text{V}$ B. $1/3\text{V}$ and 1V C. $1/3\text{V}$ and $2/3\text{V}$ D. 1V and $2/3\text{V}$ (2000:Q33)

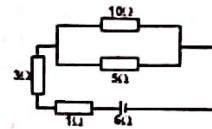


74. A radio is operated by eight cells each of e.m.f. 2.0V connected in series. If two of the cells are wrongly connected, the net e.m.f. of the radio is A. 16V B. 12V C. 10V D. 8V (2000:Q35)

75. A cell of internal resistance 1ohm supplies current to an external resistor of 3ohms . The efficiency of the cell is A. 75% B. 50% C. 33% D. 25% (2000:Q40)

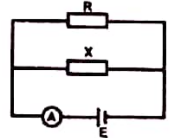
76. A cell of internal resistance r supplies current to a 6.0Ω resistor and its efficiency is 75% . Find the value of r A. 4.5Ω B. 1.0Ω C. 8.0Ω D. 2.0Ω (2001:Q21)

77. In the diagram above, the current I is A. $3/8\text{A}$ B. $9/11\text{A}$ C. $11/9\text{A}$ D. $8/3\text{A}$ (2001:Q22)



78. A resistance R is connected across the terminal of an electric cell of internal resistance 2Ω and the voltage was reduced to $3/5$ of its nominal value. The value of R is A. 3Ω B. 2Ω C. 1Ω D. 6Ω (2001:Q24)

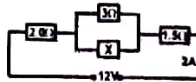
79. In the circuit diagram above, the ammeter reads a current of 3A when R is 5Ω and 6A when R is 2Ω . Determine the value of x A. 8Ω B. 2Ω C. 10Ω D. 4Ω (2001:Q32)



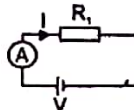
80. A cell can supply currents of 0.4A and 0.2A through a 4.0Ω and 10.0Ω resistors respectively. The internal resistance of the cell is A. 2.0Ω B. 1.0Ω C. 2.5Ω D. 1.5Ω (2001:Q36)

81. An electric cell with nominal voltage E has a resistance of 3Ω connected across it. If the voltage falls to $0.6E$, the internal resistance of the cell is A. 4Ω B. 3Ω C. 2Ω D. 1Ω (2002:Q32)

82. From the diagram above, determine the value of the resistance X A. 9Ω B. 12Ω C. 15Ω D. 6Ω (2002:Q34)



83. In the diagram above, what would happen to the current, I, if another resistor, R_2 , is connected in parallel to R_1 ? A. It will increase because the equivalent resistance will increase B. It will decrease if R_2 is greater than R_1 . C. It will increase because the effective resistance will decrease. D. It will decrease if R_2 is less than R_1 . (2003:Q30)



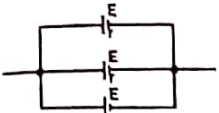
84. A wire of 5Ω resistance is drawn out so that its new length is two times the original length. If the resistivity of the wire remains the same and the cross-sectional area is halved, the new resistance is A. 40Ω B. 20Ω C. 10Ω D. 5Ω (2003:Q32)

85. A moving-coil galvanometer has a full-scale deflection of 3A equivalent to 30° deflection. The sensitivity of the instrument is A. 10.0 B. 33.0 C. 99.0 D. 0.1 (2004:Q20)

86. A cell whose internal resistance is 0.5Ω delivers a current

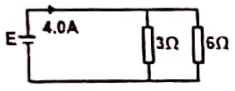
- of 4A to an external resistor. The lost voltage of the cell is
 A. 1.250V B. 8.000V C. 0.125V D. 2.000V (2004:Q20)
87. The resistance of a piece of wire of length 20m and cross-sectional area $8 \times 10^{-6} \text{m}^2$ is A. 1.0Ω B. 10.0Ω C. 0.5Ω D. 5.0Ω (Resistivity of the wire = $4 \times 10^{-7} \Omega \text{m}$) (2005:Q18)

88. An ammeter of resistance 5Ω has a full-scale deflection when a current of 50mA flows in it. The value of the resistor required to adapt it to measure a current of 5A is A. 89.80Ω B. 5.00Ω C. 0.05Ω D. 0.25Ω (2006:Q26)

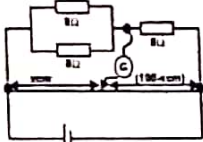
89. Three cells each of e.m.f 1.5V and internal resistance 2.5Ω are connected as shown in the diagram above. Find the net e.m.f and the internal resistance.

 A. 4.5V, 7.50Ω B. 4.5V, 0.83Ω C. 1.5V, 7.50Ω D. 1.5V, 0.83Ω (2007:Q17)

90. A conductor has a diameter 1.00mm and length 2.00m. If the resistance of the material 0.1Ω , its resistivity is A. $3.93 \times 10^{-8} \Omega \text{m}$ B. $3.93 \times 10^{-6} \Omega \text{m}$ C. $2.55 \times 10^2 \Omega \text{m}$ D. $2.55 \times 10^5 \Omega \text{m}$ (2007:Q22)

91. Find the effective resistance in the diagram above A. 6Ω B. 12Ω C. 18Ω D. 24Ω (2008:Q39)

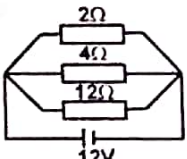
92. Calculate the e.m.f. of the cell in the above circuit if its internal resistance is negligible. A. 12V B. 8V C. 2V D. 36V (2009:Q40)


93. A cell of emf 12V and internal resistance 4Ω is connected to an external resistor of resistance 2Ω . Find the current flow. A. 4A B. 2A C. 3A D. 5A (2010:Q35)

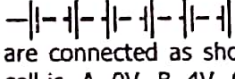
94. The diagram above shows a balanced metre bridge, the value of x is A. 66.7cm B. 25.0cm C. 33 (2010:Q36)


95. Three 4Ω resistors connected in parallel have a potential difference of 16 V applied across them. A. 12 A B. 8A C. 10A D. 14 A (2010:Q37)

96. A galvanometer with full-scale deflection of 10mA is to be converted to a voltmeter with full-scale deflection of 5V. If a series resistance of 498Ω is used for the conversion, the resistance of the galvanometer is A. 2Ω B. 10Ω C. 5Ω D. 1Ω (2010:Q41)

97. In the circuit above, three resistors, 2Ω , 4Ω and 12Ω are connected in parallel and a 12V battery is connected across the combination. The current flowing through the 12Ω resistor is A. 3.2 A B. 9.6A C. 14.4A D. 1.0A (2011:Q34)


98. Three similar cells each of e.m.f 2V and internal resistance of 2Ω are connected in parallel, the total e.m.f and total internal resistance are respectively A. 2V, 6.0Ω B. 6V, 0.7Ω C. 6V, 6.0Ω D. 2V, 0.7Ω (2011:Q37)

99. Six identical cells, each of e.m.f 2V, are connected as shown above. The effective e.m.f of the cell is A. 0V B. 4V C. 6V D. 12V (2012:Q39)


100. A cell of emf 1.5V is connected in series with a 1Ω resistor and a current of 0.3A flows through the resistor. Find the internal resistance of the cell. A. 4.0Ω B. 3.0Ω C. 1.5Ω D. 1.0Ω (2013:Q38)

101. Which of the following obeys ohms laws? A. electrolytes B. metals. C. diode. D. glass. (2013:Q39)

102. When a charge moves through an electric circuit in the direction of an electric force, it A. gains both potential and kinetic energy. B. gains potential energy and loses kinetic energy. C. loses potential energy and gains kinetic energy. D. loses both potential

and kinetic energy. (2013:Q42)

103. To convert a galvanometer to a voltmeter, a A. high resistance is connected to it in series. B. high resistance is connected to it in parallel. C. low resistance is connected to it in series. D. low resistance is connected to it parallel (2013:Q43)

104. If a metal wire 4m long and cross-sectional area 0.8mm^2 has a resistance of 6, find the resistivity of the wire. A. $3.0 \times 10^{-8} \Omega \text{m}$ B. $1.2 \times 10^{-6} \Omega \text{m}$ C. $3.2 \times 10^{-6} \Omega \text{m}$ D. $5.3 \times 10^{-7} \Omega \text{m}$ (2014:Q37)

105. A circuit has a resistance of 200Ω . The resistance of the circuit can be reduced to 120Ω when A. an 80Ω resistor is connected to it in series. B. a 150Ω resistor is connected to it in parallel. C. a 240Ω resistor is connected to it in series. D. a 300Ω resistor is connected to it in parallel (2014:Q38)

106. If a current of 4.6A was passed through a wire of resistance of 6.5Ω , the potential difference across the wire is A. 1.4V B. 0.7V C. 29.9V D. 48.5V (2015:Q43)

107. Four resistors of resistances 2Ω , 3Ω , 4Ω and 6Ω are connected in parallel. What is the value of their combined resistance? A. 0.2Ω B. 0.6Ω C. 0.4Ω D. 0.8Ω (2016:Q6)

108. When resistance is constant in a circuit, the electric current is A. inversely proportional to the resistance B. directly proportion to the potential difference C. same as the resistance D. directly proportional to the resistance (2016:Q41)

109. Calculate the current flowing in a cell of emf 2.5V and an internal resistance of 0.5Ω if it is connected in series with two resistors of resistances 1.5Ω and 3.0 respectively A. 0.25A B. 0.55A C. 0.50A D. 0.75A (2016:Q44)

110. When a galvanometer is connected in series with a multiplier, it function as A. voltmeter B. rectifier C. amplifier D. ammeter (2017:Q12)

111. The resistance of a wire 20m long is 0.5Ω . If the cross sectional area is $1.2 \times 10^{-4} \text{m}^2$, determine the resistivity of the material A. $1.2 \times 10^{-6} \Omega \text{m}$ B. $4.2 \times 10^{-6} \Omega \text{m}$ C. $2.0 \times 10^{-6} \Omega \text{m}$ D. $3.0 \times 10^{-6} \Omega \text{m}$ (2017:Q33)

112. When a known standard resistor of 2.0 is connected to the 0.0cm end of a metre bridge, the balance point is found to be at 55.0cm. What is the value of the unknown resistor? A. 0.10 Ω B. 1.64 Ω C. 2.44 Ω D. 27.50 Ω (2018:Q23)

CHAPTER 26

CURRENT ELECTRICITY

- 1A. For parallel connection, combined resistance R is less than the least of the resistances

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$$

For series connection, combined resistance R is greater than the largest of the resistances $R = R_1 + R_2 + \dots$

Now compare Q53 chapter 25

NOTE: If not sure, take $R_1 = 2 \Omega$ and $R_2 = 3 \Omega$

and work out $\frac{1}{R} = \frac{1}{2} + \frac{1}{3} \rightarrow R = \frac{6}{5} = 1.2 \Omega$ where $1.2 \Omega < 2 \Omega$

- 2C. In parallel connection, same p.d but different current pass through the resistors current in each resistor:

$$I = \frac{V}{R} = \frac{60}{5} = 12 \text{A} \quad \text{Check: Total current in circuit}$$

$$I_T = 3(12) = 36 \text{A. (i.e. } 12 + 12 + 12)$$

It is this current (36A) which splits equally into 3 and passes through each as 12A. Again combined resistance is

$$\frac{1}{R} = \frac{1}{5} + \frac{1}{5} + \frac{1}{5} \text{ (parallel)} \rightarrow R = \frac{5}{3}$$

$$\text{But } I = \frac{V}{R} = \frac{60}{\frac{5}{3}} = \frac{3 \times 60}{5}$$

$I_1 = 36A$ (As before)

NOTE: In series connection, same current but different p.d across resistors.

3A. This low-resistance resistor called shunt diverts most of the current from the galvanometer and passes it through itself.

NOTE: To convert galvanometer to a voltmeter, high-resistance resistor called multiplier is connected in series with the galvanometer.

4D. Net emf in the circuit = $2.0 - 1.5 = 0.5V$
 Net resistance in circuit = $7 + 1 + x$; but $E = I(R + r_1 + r_2)$
 $\rightarrow 0.5 = 5.0 \times 10^{-3}(8 + x)$ and $x = 2\Omega$

NOTE: The cells are connected with +ve terminal of one in contact with the -ve terminal of the other hence net emf is $E = 0.5V$. If connected otherwise $E = 2.0 + 1.5 = 3.5V$

5D. The upper 10ohm resistor is in parallel with the other two resistance hence p.d across the two sets is the same

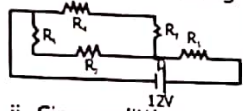
Upper 10-ohm resistor: $I = \frac{V}{R} = \frac{12}{10} = 1.2A$

Lower resistors (in series): $R = 5 + 10 = 15\Omega$

$\therefore I = \frac{12}{15} = 0.8A \rightarrow \therefore I_1 + I_2 = 0.8 + 1.2 = 2A$

6B. $E = I(R+r) \rightarrow R = \text{External resistance}; r = \text{internal resistance}$
 $E = 0.5(5+2) = 3.5V$

7D. Consider the labelling below



Note that:

i. The total current in circuit passes through $R_1(10V \text{ resistor})$

ii. Since splitting occurs at p

- a. R_2 and R_3 are parallel
- b. R_2 and R_3 are in series
- c. R_3 and R_4 are in series

Now series combination R_2 and R_3

$\frac{1}{R_A} = 3 + 3 \rightarrow R_A = 6\Omega \rightarrow R_B \rightarrow 6\Omega$

Similarly for R_3 and R_4 : $R_B = 6\Omega$

But R_A and R_B are parallel: $\therefore \frac{1}{R} = \frac{1}{6} + \frac{1}{6} \rightarrow R = 3\Omega$

But R_1 is in series with this: $R_T = 1 + 3 = 4\Omega$

$\therefore I_T = \frac{12}{4} = 3A$ I_T passes through 1Ω resistor

as well as through the combined resistance of the other four.



Check: i. P.d across 1Ω resistor: $V = 1 \times 3 = 3V$

ii. P.d across combination 3Ω : $V = 3 \times 3 = 9V$

iii. Total voltage = $3V + 9V = 12V$ (as in the diagram)

8C. $\frac{1}{R} = \frac{1}{R_2} + \frac{1}{R_2}$ (Parallel) $\rightarrow R = \frac{10}{2} = 5\Omega$

All now in series: $R_T = 10 + 5 + 10 = 25\Omega$

9D. The multiplier M is connected in series with the milliammeter.

This arrangement causes 50mA of current to pass through both multiplier and galvanometer but p.d across them (V_1 and V_2) are different (Q2) such that total p.d $V = 50V$ or $V = V_1 + V_2$

P.d across galvanometer: $V_2 = Ir = 50 \times 10^{-3} \times 5 \rightarrow V_2 = 0.25V$

But $V_1 = V - V_2 = 50 - 0.25 \rightarrow V_1 = 49.75V$

The resistance R of Multiplier: $R = \frac{V_1}{I} = \frac{49.75}{50 \times 10^{-3}} = 995\Omega$

This is consistent with Q3

10D. Note that by definition:

i. $V_1 = E = \text{electromotive force} = \text{e.m.f.}$

ii. $V_2 = V = \text{terminal p.d.}$

Also note that: $I = \frac{E}{R+r} \therefore I = \frac{V_1}{R+r}$ or $IR + Ir = V_1$

$IR = V_1 - Ir \text{ ---(i)}$

Also $I = \frac{V}{R}$ or $I = \frac{V_2}{R} \therefore IR = V_2 \text{ ---(ii)}$

Compare (i) and (ii) $V = V_1 - Ir$; $Ir = V_1 - V \rightarrow r = \frac{V_1 - V}{I}$

11D. Silver is a metallic conductor hence silver obeys ohm's law - ohmic conductor

NOTE: Not all electrolytes are ohmic conductors.

12E. Conversion of electrical energy to heat, light, sound or mechanical energy is possible.

13E. $I = \frac{E}{R+r} \rightarrow 0.5 = \frac{1}{R+1} \rightarrow R = \frac{2}{0.5} - 1 = 3\Omega$

14D. With k open, total resistance: $R = 8 + 2 = 10\Omega$

$\therefore I = \frac{V}{R} = \frac{6}{10} = 0.6A$

With k close, total resistance for parallel arrangement:

$\frac{1}{C} = \frac{1}{8} + \frac{1}{8} \rightarrow C = 4\Omega$; 4Ω now in series with 2Ω

$R_T = 4 + 2 = 6\Omega \therefore I = \frac{V}{R} = \frac{6}{6} = 1A$

Hence current increases by $(1 - 0.6)$ or $0.4A$

15A. No current flows in an open circuit and resistance is all about opposing current

16C. A $\rightarrow R = 2 + 3 + 6 = 11\Omega$ ✗

B $\rightarrow \frac{1}{R} = \frac{1}{2} + \frac{1}{3} \therefore R = 1.2\Omega$ ✗

C $\rightarrow \frac{1}{R} = \frac{1}{2} + \frac{1}{3} + \frac{1}{6} \therefore R = \frac{6}{6} = 1\Omega$ ✓

D $\rightarrow \frac{1}{R} = \frac{1}{6} + \frac{1}{3} \rightarrow R_1 = 2\Omega \therefore R = 2 + 2 = 4\Omega$ ✗

E $\rightarrow \frac{1}{R} = \frac{1}{6} + \frac{1}{2} \rightarrow \frac{6}{R} \therefore R = \frac{6}{4} + 3 = 4.5\Omega$ ✗

17B. The 2 resistors are in parallel: $\frac{1}{R} = \frac{1}{2} + \frac{1}{2} \therefore R = 1\Omega$

All are now in series: $R_T = 3 + 1 + 4 = 8\Omega$

18C. Calculate the voltage across each and equate their sum with 15V (See Q9): $5(0.015) + 0.015R = 15$

$\rightarrow R = \frac{15 - 0.075}{0.015} = 995\Omega$

19B. e.m.f = $E = 3V$; Terminal p.d = $V = 2.6V$

But $I = \frac{E}{R+r} = \frac{V}{R} \rightarrow I = \frac{V}{R} \rightarrow R = \frac{V}{I} = \frac{2.6}{0.2} = 13\Omega$

NOTES:

1. The e.m.f is the p.d across the terminals of a battery when it is NOT delivering current to an external circuit i.e. open circuit (See Q10)

2. The terminal p.d is the p.d in a circuit when the cell is delivering current to the external circuit i.e the current is close.

20E. $I_1 = \frac{10}{2} = 5\Omega$; $I_2 = \frac{10}{1} = 10\Omega$; $I_3 = \frac{20}{2+1} = 6.7\Omega$

$I_4 = \frac{20}{2} = 10\Omega$; $I_5 = \frac{20}{1} = 20\Omega$

21B. A shunt of low resistance connected in parallel to the galvanometer diverts 0.99A of the 1A allowing only 10mA (0.01A) which is the full scale deflection of the galvanometer to pass through.

Voltage across galvanometer: $V = Ir = 0.01 \times 5 = 0.05V$

Voltage across shunt: $V = IR = 0.99R$

But voltage across both are the same for parallel connection

(see Q2) $\therefore 0.99R = 0.05 \rightarrow R = \frac{0.05}{0.99} = \frac{5}{99}\text{-ohm}$

22B. $\frac{1}{R} = \frac{1}{6} + \frac{1}{6} + \frac{1}{6} + \frac{1}{6} \rightarrow R = \frac{6}{4} = 1.5\Omega$

$I_T = \frac{V}{R_T} = \frac{2.4}{1.5} = 16A$

Since the four resistors have the same resistance just split 16A equally among them current in each = 4A
 Alternatively and much faster: Same voltage across each in parallel arrangement:

Current through each: $I = \frac{V}{R} = \frac{24}{6} = 4A$ (as before)

23A. Since resistance of T decreases with temperature, more current passes through L_1 making it brighter, and less through L_2 making it dimmer

24C. $I = \frac{E}{R+r} = \frac{V}{R} \rightarrow \frac{2.2}{4+r} = \frac{2}{4} \rightarrow r = 0.4\Omega$

25A. The voltage across R_1 and R_4 will be the same: $V_1 = V_4$
Voltage across R_2 and R_3 combined will be twice V_1 and V_4
 $\therefore V = V_1 = \frac{V_2}{2}$

26E. $R \propto L$ and $R \propto \frac{1}{A}$ But $A = \pi r^2 = \pi (\frac{D}{2})^2 \therefore R \propto \frac{1}{D^2}$ ($D = \text{diameter}$)

Combining $R \propto L$ and $R \propto \frac{1}{A}$: $R \propto \frac{L}{A} \rightarrow R = \frac{\rho L}{A}$ or $\rho = \frac{RA}{L}$ (Ωm)

where ρ is a constant (of proportionality) called **Resistivity** hence it does not change for a given material of which the wire is made.

Also $R \propto T$ (metallic conductors)

$R \propto \frac{1}{T}$ (non-metallic conductors) where $T = \text{absolute temperature}$

NOTE: Some materials are little affected by temperature changes such as manganin and constantan alloys are used to make standard resistors.

27E. Combined resistance in parallel: $R = 1\Omega$

Total resistance in circuit: $R_T = 1 + 3 + 4 = 8\Omega$

28A. Combined e.m.f in parallel is the e.m.f of just one of them
 \therefore Combined parallel internal resistance: $r = 1\Omega$

But $I = \frac{E}{R+r} = \frac{1.5}{1+1} \rightarrow I = 0.75A$

29A. Divert $(1 - 0.1)A$ through A shunt parallel to the galvanometer and equate the p.d across them.

$V_{\text{galvanometer}} = 5 \times 0.1 = 0.5V$; $V_{\text{shunt}} = 0.9R$; $\therefore 0.9R = 0.5$

$R = \frac{0.5}{0.9} = \frac{5}{9}\Omega$

30D. The e.m.f of cell is constant: But $E = I(R+r)$

$\therefore 0.15(8+r) = 0.3(3+r)$; $8+r = 2(3+r)$; $r = 8 - 6 = 2\Omega$

31C. See Q3

32C. Let's first consider a (V - I) graph instead of an (I - V) graph

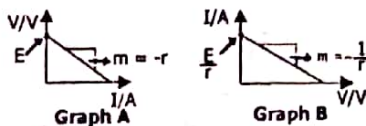
Recall: $I = \frac{E}{R+r}$ and $E = IR + Ir$

But $IR = V \therefore E = V + Ir$

Rearrange ($E = V + Ir$) to match the general equation— ($y = mx + c$) for a straight line: $V = E - Ir$ or $V = -Ir + E$

$\begin{bmatrix} V \\ y \end{bmatrix} = \begin{bmatrix} -r \\ m \end{bmatrix} I + \begin{bmatrix} E \\ c \end{bmatrix}$. Thus $y = V$, $m = -r$ and $c = E$

Now, a graph of V against I is as shown in graph A below where the slope $m = -r$ while the intercept (constant) $c = E$ when $I = 0$



If V and I are interchanged for the x and y axes, the graph is as in graph B from $Ir = E - V \rightarrow Ir = -v + 1E \rightarrow I = \frac{-V}{r} + \frac{E}{r}$

$\rightarrow \begin{bmatrix} I \\ y \end{bmatrix} = \begin{bmatrix} -1/r \\ m \end{bmatrix} V + \begin{bmatrix} E/r \\ c \end{bmatrix}$ thus $y = I$, $m = -\frac{1}{r}$ and $c = \frac{E}{r}$

NOTES:

- In both graphs, the slopes are negative and this is reflected in that the graphs are downward sloping.
- E is the voltage of the cell when not delivering any current to an external circuit and recall that E always is greater than the p.d. or V in the circuit hence E (Intercept is the highest value on the V-axis).

3. The value ($\frac{E}{r}$) is the maximum current the cell can deliver hence it is the highest value on the I-axis. When an external resistance is available, however, current becomes $I = \frac{E}{R+r}$ hence the current is lower than $\frac{E}{r}$

4. The intercepts not indicated on the I-axis in graph A and V-axis on graph B are D and E respectively and they still maintain their maximum values as earlier stated with respect to I and V respectively.

33C. $2D_p = D_q$; $2L_p = L_q$; $P_p = P_q$
But $R = \frac{\rho L}{A}$ and $A = \frac{\pi D^2}{4}$ (Q26)

$\therefore A \propto D^2$ ($\frac{\pi}{4} = \text{constant}$) Hence $R \propto \frac{L}{D^2}$

And $\frac{R_p}{R_q} = \frac{L_p}{D_p^2} \times \frac{D_q^2}{L_q} \rightarrow \frac{R_p}{R_q} = \frac{L_p}{D_p^2} \times \frac{(2D_p)^2}{L_q}$

$\frac{R_p}{R_q} = \frac{L_p}{D_p^2} \times \frac{4D_p^2}{L_q} \rightarrow R_p : R_q = 2:1$

NOTE: Retaining the constant makes your working dumsier, so eliminate it as above.

34C. Parallel combination: $\frac{1}{R} = \frac{1}{5} + \frac{1}{20} \therefore R = \frac{20}{5} = 4\Omega$

Total resistance combination: $R_T = 5 + 4 = 9\Omega$

But $I = \frac{E}{R+r}$ where $r = 0$ (negligible) $\rightarrow I = \frac{9}{9} = 1A$

35D. Parallel combination = $\frac{6R}{R+6}$

Total resistance (series) $\rightarrow R_T = 3 + \frac{6R}{R+6}$

$R_T = \frac{3(R+6)+6R}{R+6} \rightarrow R_T = \frac{9R+18}{R+6}$

But $R_T = \frac{V_T}{I_T} = \frac{12}{2} = 6 \rightarrow \therefore \frac{9R+18}{R+6} = 6$

$9R+18 = 6R+36 \rightarrow 3R = 18 \rightarrow R = 6\Omega$

36B. $1 + 1 = 2\Omega$ series: $\frac{1}{R_T} = \frac{1}{2} + \frac{1}{1} = \frac{3}{2}$ parallel

$R_T = \frac{2}{3} = 1.5\Omega$

37C. Parallel combination: $\frac{1}{R} = \frac{1}{4} + \frac{1}{4} \rightarrow R = 2\Omega$

The 1Ω now in series with $2\Omega \therefore R_T = 1 + 2 = 3\Omega$
Note that same current I_T passes through them but different voltages across their ends.

$I_T = \frac{V_T}{R_T} \rightarrow I_T = \frac{V}{3}$

Voltage across 1Ω : $V_1 = I_T \times R_1 = \frac{V}{3} \times 1 = \frac{V}{3}$

Check: Voltage across parallel combination

$V_2 = I_T R_2 = \frac{V}{3} \times 2 \rightarrow V_2 = \frac{2V}{3}$ But $V = V_1 + V_2$

$V = \frac{V}{3} + \frac{2V}{3} \rightarrow V = \frac{V+2V}{3} = \frac{3V}{3} = V$

38B. Let the whole current = I and resistance of shunt = R
P.d across galvanometer = p.d across shunt.

Current through galvanometer = $\frac{I}{10}$

Voltage across galvanometer = $\frac{I}{10} \times 20 = 2I$ —(1)

Current through shunt = $I - \frac{I}{10} = \frac{9I}{10}$

Voltage across shunt = $\frac{9I}{10} \times R = \frac{9IR}{10}$ —(2)

But $2I = \frac{9IR}{10}$ [(1) = (2)] $\rightarrow R = \frac{20I}{9I} \rightarrow R = 2.22$

39D. $2I = \frac{V}{R} = \frac{E}{R+r} \therefore V = IR = 6I$

Also $E = I(R + r) = I(6 + 2) \rightarrow E = 8I$

But efficiency $\epsilon = \frac{V}{E} \times 100\% \therefore \epsilon = \frac{6I}{8I} \times 100\% \rightarrow \epsilon = 75\%$

NOTE: Since I cancels out in the calculation:

$\epsilon = \frac{R}{R + r} \times 100\%$ (faster)

40B. Let e.m.f = E \therefore Terminal p.d, $V = \frac{2E}{3}$ But $= \frac{V}{R}$

$\therefore \frac{E}{R + r} = \frac{2E}{3R} \rightarrow 3RE = 2E(R + r) \rightarrow 3R = 2R + 2r \rightarrow r = \frac{R}{2}$

41A. When $R = 5$, combined resistance = $5 + x$ (series).

The current in the circuit $I = \frac{E}{5 + x} = 3 \therefore E = 3(5 + x)$

Similarly when $Q = 2\Omega$: $E = 6(2 + x)$

$\therefore 6(2 + x) = 3(5 + x) \rightarrow 12 + 6x = 15 + 3x \rightarrow x = 1\Omega$

42D. $\rho = \frac{RA}{L} \rightarrow \rho = \frac{0.425 \times 0.2 \times 10^{-6}}{5} = 1.7 \times 10^{-8} \Omega m$

43B. $R_T = 250 + 500 + 1\,000 = 1\,750\Omega \therefore I_T = \frac{V_T}{R_T} = \frac{6}{1\,750}$

$\therefore E = 3(5 + x)$

This current passes through each (series arrangement)

$\therefore V_{250} = I_T \times R_{250} = \frac{6}{1\,750} \times 250 \rightarrow V_{250} = 0.86V$

44C. The potentiometer is an advantage over voltmeter in measuring e.m.f of cell

| Potentiometer | Voltmeter |
|--|---|
| 1. Measures e.m.f in open circuit when cell delivers no current to the circuit | 1. Measures e.m.f in close circuit as cell delivers current to the circuit. |
| 2. Takes no current from cell | 2. Takes current from cell |
| 3. Does not use pointer; not prone to parallax error | 3. Uses pointer; prone to reading error usually due to parallax |
| 4. Measures e.m.f with precision | 4. Measure e.m.f inaccurately as it may have zero error |

45A. Ammeter must be connected in series with the resistor while voltmeter must be converted in parallel.

NOTE:

- The arrangement allows the current being measured to pass through ammeter directly since it is a low-resistance instrument.
- The voltmeter is a high-resistance instrument and besides it measures p.d across the ends of the resistor.

46C. Let full scale deflection = x

P.d across shunt = p.d across G

$(x - 0.05) 0.0111 = 0.05 \times 0.1 \rightarrow x = 0.5A \rightarrow x = 500mA$

47C. Effective e.m.f = e.m.f of just one cell: $\therefore E = 1.5$ (for parallel cells):

Effective internal resistance: $\frac{1}{r_T} = \frac{1}{1} + \frac{1}{1} + \frac{1}{1}; r_T = 0.33\Omega$

But $I = \frac{E}{R + r} = \frac{1.5}{2.67 + 0.33} = \frac{1.5}{3} = 0.5A$

NOTE:

- For identical cell of e.m.f., E each and connected in parallel, the effective e.m.f is E (or the e.m.f of just one of them).
- For cells in series, it is the sum of their e.m.f.s (or simply nE, where n is the number of cells involved)
- For parallel cells each of internal resistance r, the effective resistance is $\frac{1}{r_T} = \frac{1}{r} + \frac{1}{r} + \frac{1}{r} + \dots$
(or simply use $r_T = \frac{r}{n}$ where n is the number of such cells)
- For cells in series $r_T = nr$
- If the cells are not identical we use Kirchhoff's laws for E_T and r_T

48B. $\frac{R_1}{R_2} = \frac{L_1}{100 - L_1}$ (Wheatstone Bridge) $\frac{2}{R_2} = \frac{55}{45} \rightarrow R_2 = 1.64\Omega$

NOTE:

- We use Wheatstone bridge principle (practical arrangement: meter bridge) to determine the unknown resistance by

comparing with a standard (or known) resistance.

- We use potentiometer to measure unknown e.m.f or to compare the e.m.f's of two cells.

49C. The e.m.f is said to have done work around the entire circuit.

NOTE: Potential difference is the energy expended or work done across any two points in the circuit as a unit positive charge is transferred between them.

50A. $V \propto I$ hence $I \propto V$

NOTE:

- The graph starts from the origin.
- Temperature must be kept constant for the graph to have this shape.

51B. Voltage across G = Voltage across shunt: $0.01 \times 30 = (10 - 0.01)R$

$R = \frac{0.3}{9.99} = 0.03\Omega$

52C. Effective e.m.f = $E = 2V$;

Effective internal resistance: $\frac{r}{n} = 1\Omega$

But $I = \frac{E}{R + r} = \frac{2}{4 + 1} = 0.40A$

53C. $0.001 \times 300 = (3.000 - 0.001)R \rightarrow R = 0.1\Omega$

Maybe we should derived a generalized equations for conversion galvanometer to

1. Ammeter: $\frac{I_G r_G}{I - I_G}$ Where R = Resistance of shunt

I_G = Full-scale deflection of galvanometer

r_G = Internal resistance of galvanometer

I = Full-scale deflection of intended ammeter

$I - I_G$ = current through shunt

2. Voltmeter: $R_m = \frac{V - I_G r_G}{I_G}$

R = Resistance of multiplier

V = Full-scale voltage of inded voltmeter

$I_G r_G$ = p.d across galvanometer only

$V - I_G r_G$ = p.d across multiplier only

Now apply these formulae to Qs 9, 21 and others to save time.

54D. All metals are ohmic conductors including the liquid mercury see Q11.

55B. $R = \frac{\rho L}{A} \rightarrow A = \frac{\rho L}{R} \rightarrow A = \frac{1.8 \times 10^{-8} \times 15}{0.27} = 1 \times 10^{-6} m^2$

56C. $\frac{r}{2} = \frac{60}{40} \rightarrow R = 3\Omega$

57C. The same current (the total of the circuit) passes through W, Y and Z hence they have same reading;

NOTE:

- Since it is not stated that the two parallel resistors are of equal resistances, concluding that the reading of W or Y (or Z) is twice that of X is an error.
- If the parallel resistors are identical, the total current splits equally between them to produce $\frac{1}{2}W$ or $\frac{1}{2}Y$ or $\frac{1}{2}Z$

58C. Using $R = \frac{V - I_G r_G}{I_G}$ (See Q52)

$R = \frac{100 - 0.05 \times 10}{0.05} = \frac{100 - 0.5}{0.05} \rightarrow R = 1990\Omega$ in series

59C. Terminal p.d, $V = IR$; e.m.f, $E = I(R+r) = IR + Ir$

$\therefore E = V + Ir$; But $E_1 = E_2$; $\therefore 4 + 2r = 2 + 3r \rightarrow r = 2\Omega$

NOTE: The e.m.f and internal resistance of a battery are constant.

60A. For the set of four resistors: $R = 2\Omega$ (see Q7)

$\therefore R_T = 2 + 1 = 3\Omega \rightarrow$ Now $I_T = \frac{V_T}{R_T} = \frac{12}{3} = 4A$

61A. Compare Q48

62D. $\frac{1}{12} = \frac{1}{6} + \frac{1}{12} \rightarrow R = 4\Omega \rightarrow I = \frac{E}{R + r} = \frac{12}{4 + 1} = 2.4A$

63D. If $R_1 = 2$ units; $R_2 = 1$ unit and $V_1 = 1$ units; $V_2 = 3$ units

$\therefore \frac{I_2}{I_1} = \frac{\frac{V_2}{R_2}}{\frac{V_1}{R_1}} = \frac{V_2}{R_2} \times \frac{R_1}{V_1} \rightarrow \frac{I_2}{I_1} = \frac{3}{1} \times \frac{2}{1} = \frac{6}{1}$

$\therefore I_2 : I_1 = 6 : 1$

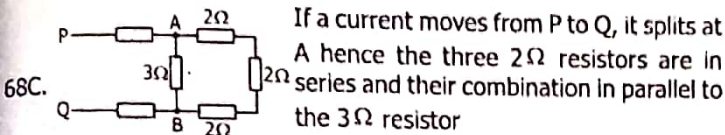
64C See Q3

65C. Effective $E = 1.5V$ (parallel cells); Effective $r = \frac{1}{3} \Omega$ (parallel cells)

But $I = \frac{E}{R+r} = \frac{1.5}{\frac{2}{3} + \frac{1}{3}} = \frac{1.5}{1} \rightarrow I = 1.5A$

66B. $R_M = \frac{V - I_g r_g}{I_g} \rightarrow R_M = \frac{10 - 0.005 \times 50}{0.005} \rightarrow R_M = 1950 \Omega$ (in series)

67B. Let the balance point = $L \rightarrow \frac{R_1}{R_2} = \frac{L}{100-L} \rightarrow \frac{2}{3} = \frac{L}{100-L}$
 $3L = 200 - 2L \rightarrow L = 40cm$



$R_1 = 2 + 2 + 2 = 6\Omega$ series $\rightarrow \frac{1}{R_2} = \frac{1}{6} + \frac{1}{3} \rightarrow R_2 = \frac{6}{3} = 2\Omega$

The overall resistance: $R_T = 1 + 2 + 1$ (All now in series); $R_T = 4\Omega$

NOTE: This arrangement is different from the ones in Qs 7 and 60

69D. $E_T = E = 1.5V$ (of just one of them); $r_T = \frac{r}{n} = \frac{4}{4} = 1\Omega$

70D. $E = I(R+x) \rightarrow \therefore 5(8+x) = 7(5+x) \rightarrow x = 2.5\Omega$

71C. $R = \frac{I_g r_g}{I - I_g} \rightarrow 0.05 = \frac{I_g \times 5}{2 - I_g} \rightarrow 5I_g = 0.1 - 0.05I_g$

$4.95I_g = 0.1 \rightarrow I_g = 0.020A = 20mA$

NOTE:

1. The 20mA is the full-scale deflection of the galvanometer.
2. SSCE students consulting this booklet should only use the formulae in question 53 for their multiple-choice test (obj.)

72B. Potentiometer measures e.m.f most accurately, metre bridge (using the Wheatstone principle) measures unknown resistance

73D. Find the total current in the circuit which passes equally through both resistors

$I_T = \frac{E}{R+r} \rightarrow R = 3+2 = 5\Omega$ (series resistors)

$\therefore I_T = \frac{2}{5+1} \rightarrow I_T = \frac{1}{3}A \rightarrow V_1 = I_T \times R_1 = \frac{1}{3} \times 3 = 1V$

$V_2 = I_T \times R_2 = \frac{1}{3} \times 2 = \frac{2}{3}V$

74D. The two cells wrongly connected are in opposition to the other six hence assign them -ve p.d. (see Q4)

\therefore Net e.m.f = $6(+2) + 2(-2) = 8V$

75A. $\epsilon = \frac{R}{R+r} \times 100\%$ (See Q39) $\rightarrow \epsilon = \frac{3}{3+1} \times 100\% = 75\%$

76D. $\epsilon = \frac{R}{R+r} \rightarrow \frac{75}{100} = \frac{6}{6+r} \rightarrow 450 + 75r = 600$

$r = \frac{600 - 450}{75} = 2\Omega$

NOTE: This is consistent with Q39 where $R = 6$; $r = 2$ and $\epsilon = 75\%$

77B. Parallel combination: $\frac{1}{R} = \frac{1}{10} + \frac{1}{5} \rightarrow R = \frac{10}{3}$

Total resistance in circuit: $R_T = 3 + 1 + \frac{10}{3} = \frac{22}{3}\Omega$

$\therefore I = \frac{6}{\frac{22}{3}} = \frac{18}{22} \rightarrow I = \frac{9}{11}A$

78A. $V = \frac{3E}{5}$ (E reduces to V); But $I = \frac{V}{R} = \frac{E}{R+r} \rightarrow \frac{3E}{5} = \frac{E}{R+2}$

$\rightarrow \frac{3E}{5R} = \frac{E}{R+2} \rightarrow 5RE = 3RE + 6E \rightarrow 2RE = 6E \rightarrow R = \frac{3E}{2E} = 3\Omega$

79C. The resistors are in parallel and combined resistance when $R = 5\Omega$:

$\frac{1}{R_T} = \frac{1}{5} + \frac{1}{x} \rightarrow R_T = \frac{1}{\frac{1}{5} + \frac{1}{x}}$

Similarly, when $R = 2\Omega \rightarrow R_T = \frac{2x}{x+2}$

But $E = IR_T$ (r is assumed negligible)

$\therefore 3 \left(\frac{5x}{x+5} \right) = 6 \left(\frac{2x}{x+2} \right) \rightarrow \frac{15x}{x+5} = \frac{12x}{x+2}$

$15(x+2) = 12(x+5) \rightarrow 3x = 30 \rightarrow x = 10\Omega$

80A. $I_1(R_1+r) = I_2(R_2+r) \rightarrow 0.4(4+r) = 0.2(10+r) \rightarrow r = 2\Omega$

81C. $\frac{E}{R+r} = \frac{V}{R} \rightarrow \frac{E}{3+r} = \frac{0.6E}{3} \rightarrow 3E - 1.8E = 0.6Er$

$6 = \frac{1.2E}{0.6E} = 2\Omega$

NOTE: If the question had been framed "... if the voltage falls by $0.6E$..." our V would have been taken as $0.4E$

82C. For the parallel resistors: $\frac{1}{R} = \frac{1}{3} + \frac{1}{x} \rightarrow R = \frac{3x}{x+3}$

Total resistance in the circuit: $R_T = 2 + \frac{3x}{x+3} + 1.5 = \frac{7}{2} + \frac{3x}{x+3}$

$\therefore R_T = \frac{7(x+3) + 2(3x)}{2(x+3)} = \frac{13x+21}{2(x+3)}$ But $IR = V$

$\therefore 2 \left(\frac{13x+21}{2(x+3)} \right) = 12 \rightarrow 13x+21 = 12x+36 \rightarrow x = 15$

83C. Note that whatever the value of the new resistance added, the effective resistance will be less than R_1 (see Q1) and the lower the total resistance in the circuit the higher the current

$I \propto \frac{1}{R}$

84B. $L_1 = 1$ unit; $L_2 = 2$ units and $A_1 = 2$ units; $A_2 = 1$ unit

But $R = \frac{\rho L}{A} \therefore \frac{R_2}{R_1} = \frac{\rho L_2}{A_2} \times \frac{A_1}{\rho L_1} \rightarrow \frac{R_2}{5} = \frac{2}{1} \times \frac{2}{1}$ ($\rho_1 = \rho_2$)

$R_2 = 5 \times 4 = 20$

85D. Sensitivity is the current recorded per unit degree deflection

Sensitivity = $\frac{\text{Full deflection}}{\text{Total angle of deflection}}$

Sensitivity = $\frac{3}{30} = 0.1A^\circ$ i.e 1° deflection $\equiv 0.1A$

The above result shows that any current lower than $0.1A$ cannot be detected by the galvanometer i.e reading accuracy is $0.1A$

NOTE:

1. A galvanometer is an instrument used to detect very small current.
2. An ammeter is less sensitive and used to detect large current.
3. Galvanometer are therefore sometimes called milliammeter especially when calibrated in mA.

86D. The e.m.f of cell $\rightarrow E = I(R+r)$ or $E = IR + Ir$
 But the p.d across resistor is $V = IR \therefore E = V + Ir$

$\therefore E - V = Ir$ where $E - V =$ lost voltage

\therefore Lost voltage = $4 \times 0.5 = 2V$

NOTE: The voltage loss is why a cell would not be 100% efficient (as in Qs 39 et al)

87A. $R = \frac{\rho L}{A} = \frac{4 \times 10^{-7} \times 20}{8 \times 10^{-6}} \rightarrow R = 1\Omega$

88C. $R_s = \frac{I_g r_g}{I - I_g} = \frac{0.05 \times 5}{5 - 0.05} \rightarrow R_s = 0.05\Omega$

89D. Net e.m.f = $1.5V$ (see Q65)

Net inf resistance = $\frac{r}{n} = \frac{2.5}{3} = 0.83\Omega$

90A. $\rho = \frac{RA}{L}$ But $A = \pi r^2 = \pi \left(\frac{D}{2} \right)^2 = \frac{\pi D^2}{4}$

$\therefore \rho = \frac{R\pi D^2}{4L} = \frac{0.1 \times 22 \times (1 \times 10^{-3})^2}{7 \times 4 \times 2} \rightarrow \rho = 3.93 \times 10^{-4} m$

91D. All are in series: $R_T = 6(4) = 24\Omega$

92B. $E_1 = IR_T$ ($r = 0$) But $\frac{1}{R_T} = \frac{1}{3} + \frac{1}{6}$ (parallel) $\rightarrow R_T = 2\Omega$

$\therefore E = 4 \times 2 = 8V$

93B. $I = \frac{E}{R+r} = \frac{12}{2+4} \rightarrow I = 2.0A$

94C. For the parallel resistors: $R_T = \frac{1}{\frac{1}{8} + \frac{1}{8}} R_T = 4\Omega$

$$\frac{R_1}{R_T} = \frac{x}{100-x} \rightarrow \frac{4}{8} = \frac{x}{100-x} \rightarrow x = 33.3\text{cm}$$

95A. $\frac{1}{R_T} = \frac{1}{4} + \frac{1}{4} + \frac{1}{4} \rightarrow R_T = \frac{4}{3} \rightarrow I_T = \frac{V_T}{R_T} = \frac{16}{\frac{4}{3}} = 12\text{A}$

96A. $R_N = \frac{V - I_0 r_0}{I_0} \rightarrow 498 = \frac{5 - 0.01r}{0.01} \rightarrow r = \frac{5 - 4.98}{0.01} = 2\Omega$

97D. P.d across each is 12V \therefore For 12Ω resistor $\rightarrow I_{12} = \frac{12}{12} = 1.0\text{A}$

Check: Find the total current in the circuit:

$$\frac{1}{R_T} = \frac{1}{2} + \frac{1}{4} + \frac{1}{12} \rightarrow R_T = 1.2 \rightarrow I_T = \frac{V_T}{R_T} = \frac{12}{1.2} = 10\text{A}$$

Find current through 2Ω and $4\Omega \rightarrow I_2 = \frac{12}{2} = 6\text{A}$ $I_4 = \frac{12}{4} = 3$

$\therefore I_{12} + I_2 + I_4 = 1 + 6 + 3 = 10\text{A}$ (as before)

98D. Total e.m.f = 2V; Total inf resistance = 0.67

99. The fourth cell from left is connected in opposition to the others five hence its e.m.f is -ve

\therefore effective e.m.f = $5(2) + 1(-2) = 8\text{V}$. (No option is right)

100A. $I = \frac{E}{R+r} \rightarrow 0.3 = \frac{1.5}{1+r} \rightarrow r = 4\Omega$

101B. See Q11

102C. Its potential energy (p.d) is converted to kinetic energy and the K.E can be converted to other form of energy depending on the type of load involved e.g. light energy in a bulb etc

103A. See Q3

104B. $\rho = \frac{RA}{L} \rightarrow \rho = \frac{6 \times 0.8 \times 10^{-6}}{4} \rightarrow \rho = 1.2 \times 10^{-6}\Omega$

NOTE:

- Linear measure: $1\text{m} = 1000\text{mm} \therefore 1\text{mm} = 10^{-3}\text{m}$
- Area measure: $1\text{m}^2 = 10^6\text{mm}^2 \therefore 1\text{mm}^2 = 10^{-6}\text{m}^2$
- Cubic/Volume measure: $1\text{m}^3 = 10^9\text{mm}^3 \therefore 1\text{mm}^3 = 10^{-9}\text{m}^3$
- Also note that $1000\text{dm}^3 = 1\text{m}^3 \rightarrow 1\text{dm}^3 = 10^{-3}\text{m}^3$
Hence 1 litre = $1\text{dm}^3 = 10^{-3}\text{m}^3$

105D. Series connection will only increase the resistance; forget options A and C. Parallel connection is to produce $R_T = 120\Omega$
Let the resistance required = R

$$\therefore \frac{1}{R_T} = \frac{1}{200} + \frac{1}{R} \rightarrow \therefore \frac{1}{R} = \frac{1}{120} - \frac{1}{200}$$

$$\frac{1}{R} = \frac{5-3}{600} \rightarrow \frac{1}{R} = \frac{2}{600} \rightarrow \frac{600}{2} = 300\Omega$$

106C. $V = IR = 4.6 \times 6.5 = 29.9\text{V}$

107D. $\frac{1}{R} = \frac{1}{2} + \frac{1}{3} + \frac{1}{4} + \frac{1}{6} \rightarrow R = \frac{12}{6+4+3+2} = 0.8\Omega$

108B. $V \propto I$ and $V = kI$ where $k = \text{Resistance}$

109C. $I = \frac{E}{R+r} = \frac{2.5}{1.5+3.0+0.5} = 0.50\text{A}$

110A. ...and when in parallel with a shunt, it functions as ammeter (D)

111D. Compare Q104

112B. $\frac{R}{2.0} = \frac{45}{55} \rightarrow R = 1.64\Omega$

NOTE: If the unknown resistor is connected to 0.00cm end and the balance point is 55, work as: $\frac{R}{2.0} = \frac{55}{45} = 2.44\Omega$ (Option C)

CHAPTER 27

ELECTRICAL ENERGY AND POWER

- Two lamps rated 40W and 220V each are connected in series. The total power dissipated in both lamps is A. 10 W B. 20 W C. 40 W D. 80 W E. None of the above. (1978:Q25)
- If NEPA charges 5k per kWh, what is the cost of operating for 24 hours a lamp requiring 1A on a 200V line? A. 24K B. 55K C. 40K D. 26K E. 32K (1978:Q28)
- A potential difference of 6V is used to produce a current of 5A for 200s through a heating coil. The heat produced is A. 4 800cal B. 6 000cal C. 2 400J D. 240kcal E. 6 000J. (1978:Q35)

4. Every house supplied with electricity is provided with a box of fuses so that A. the consumption of electricity can be recorded B. people residing in the house will not have an electric shock if they touch a live wire C. the total current drawn from the remains can be limited D. the voltage supply can be stabilised E. it serves as a standby supply when there is a power failure. (1978:Q37)

5. A landlord has eight 40W electric light bulbs, four 60W bulbs and two 100W bulbs in his house. If he has all the points on for five hours daily and if N.E.P.A charges 5k per unit, his bill for 30 days is A. N5.70 B. N7.23 C. N3.65 D. N8.05 E. N4.50 (1979:Q20)

6. The bulb of a motorcycle head-lamp is marked 40W, 6V. The resistance of the filament when it is switched on is A. 62/40ohms B. 40/62ohms C. 40/6 ohms D. 6 x 40 ohms E. 62/40 ohms. (1979:Q29)

7. A stand-by generator is connected to fifteen 40 W lamps and a musician's 600 W amplifying system. How much energy is used if the generator runs for 6 hours? A. 3.84 k Wh B. 7.20 k Wh C. 8.40 k Wh D. 12.00 k Wh E. 14.56 k Wh. (1980:Q26)

8. High Tension (H.T.) transmission means A. to transmit a given amount of power, the tension in the conducting wire must be high B. heat is not when current is passed through a conductor C. heat is gained when a given power is transmitted D. a big transformer is required to transmit power E. transmission of power at low current and high voltage. (1980:Q39)

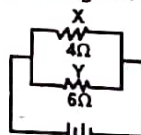
9. The resistance of a 240V, 60watt electric filament bulb is A. 0.25W B. 480W C. 60W D. 240W E. 960W (1981:Q18)

10. An electric iron is rated at 1000 watts, 250V. The corresponding maximum resistance and accompanying current is A. 62.5A 4.0W B. 16.0A 62.5W C. 62.5A 16.0W D. 4.0A 62.5W E. 4.0A 250W. (1982:Q10)

11. It is usual to transmit electric power at high voltage and low current. Which of the following are possible advantages of the method. I. Heat losses are reduced because the currents are small. II. Thin wires can be used because small currents are flowing. III. The power can flow faster because the voltage is high. A. I only B. I and II only C. II and III only D. I and III only E. I, II and III. (1983:Q21)

12. Which of the following can be described as high tension transmission? A. High resistance and low voltage B. Low current and high voltage C. High current and low voltage D. High voltage and zero current E. High current and low resistance. (1984:Q12)

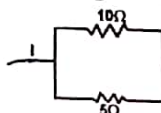
13. In the diagram above (Fig. 7), X and Y are resistance 4W and 6W respectively. If power dissipation in X is 10W, then power dissipation in Y is A. 2.4W B. 4.0W C. 6.0W D. 6.7W E. 15.0W (1984:Q46)



14. What is the cost of running five 50W lamps and four 100W lamps for 10 hours if electrical energy costs 2 kobo per kWh? A. N0.65 B. N0.13 C. N3.90 D. N39.00 E. N34.00 (1984:Q47)

15. An electric kettle, connected to a 240V mains, produces $6.0 \times 10^5\text{J}$ of heat energy to boil a quantity of water in 5 minutes. Find the resistance of the kettle. A. 14.4W B. 28.8W C. 144W D. 288W E. 2880W (1985:Q42)

16. In the figure of current (I) passes through the parallel combination. If the power dissipated in the 5 ohms resistor is 40W, then the power dissipated in the 10W resistor is A. 10 W B. 20 W C. 40 W D. 80 W E. 100 W (1985:Q44)



17. A current of 0.5A flows through a resistor when connected to a 40-V battery. How much energy is dissipated in 2 minutes? A. 1200J B. 1500J C. 2400J D. 96000J. (1987:Q43)

18. A household refrigerator is rated 200 watts. If electricity costs 5k per kWh, what is the cost of operating it for 20 days? A. N4.80 B. N48.00 C. N480.00 D. N4800.00 (1988:Q43)

19. Which of the following instruments consumes the highest current?

| Instrument | Voltage Rating | Power Rating |
|---------------------|----------------|--------------|
| A. Electric Iron | 250V | 1kW |
| B. Television Set | 220V | 110W |
| C. Torch Light | 6V | 30W |
| D. Immersion Heater | 110V | 500W |

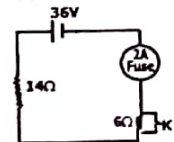
(1988:Q44)

20. The function of a 5-A fuse included in a circuit supplying a household refrigerator with power is to keep the A. Temperature of the refrigerator low and constant. B. Current supplied to the refrigerator below 5A. C. Voltage supply constant D. Current supplies to the refrigerator constant and above 5A. (1989:Q40)
21. The total power drawn from the cell in the circuit diagram above is A. 12W B. 24W C. 32W D. 40W (1989:Q41)
22. Which of the following correctly represents the relationship between the temperature rise θ and the current I in an experiment to illustrate the heating effect of the electric current?



(1989:Q42)

23. Which of the following is an essential physical property of the wires used for making fuses? A. Low density B. High thermal conductivity C. Low electrical resistivity D. Low melting point (1990:Q41)
24. Which of the following is most suitable for protecting the circuit of a 2000W electric iron connected to a 250V mains? A. 13A B. 8A C. 5A D. 3A (1990:Q42)
25. Electrical power is transmitted at a high voltage rather than low voltage because the amount of energy loss is reduced due to A. Heat dissipation B. Production of eddy currents C. Excessive current discharged D. Excessive voltage discharged. (1990:Q43)
26. In the above circuit, the fuse wire melts when A. K is opened

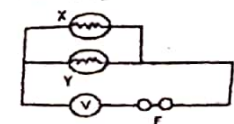


B. K is closed C. The 14-ohm resistor is doubled with K closed D. The 6-ohm resistor is doubled with K closed. (1991:Q40)

27. An equipment whose power is 1500W and resistance is 375 ohm would draw a current of A. 0.10A B. 2.00A C. 4.00A D. 77.5A (1991:Q41)
28. Which of the following apparatus will require the smallest fuse rating for its protection? A. 60W, 240V B. 60W, 40V C. 40W, 12V D. 40W, 5V (1992:Q40)
29. The heat produced in a conductor carrying an electric is A. Inversely proportional to the current and the resistance B. Directly proportional to the current, resistance and the time. C. Inversely proportional to the square of the resistance, current and the time. D. Directly proportional to the square of the current, the resistance and the time. (1992:Q42)

30. A 40-W instrument has a resistance of 90 ohm. On what voltage should it be operated normally? A. 60V B. 150V C. 225V D. 3600V (1993:Q42)
31. Two resistors, $R_1 = 4\Omega$ and $R_2 = 5\Omega$, are connected in parallel across a potential difference. If P_1 and P_2 represent the power dissipated in R_1 and R_2 respectively, the ratio $P_1:P_2$ is A. 4:5 B. 5:4 C. 16:25 D. 25:16 (1994:Q44)

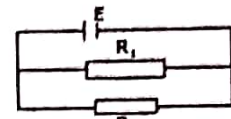
32. The diagram below shows two similar bulbs X and Y connected to a suitable power supply with F as an appropriate fuse rating. If the filament of X breaks, then the A. Brightness of Y will reduce B. Brightness of Y will remain constant C. Brightness of Y will remain constant D. Fuse F will blow. (1995:Q41)



33. An electric current of 2 amperes flows in a heating coil of resistance 50 ohm for 3 minutes 20 seconds. Determine the heat produced. A. 0.5 kJ B. 8.0 kJ C. 20.0 kJ D. 40.0 kJ (1995:Q44)
- If the maximum voltage across a 100-ohm resistor is 20V, then the maximum power it can dissipate is A. 5.00 W B. 4.00 W C. 2.00 W D. 0.25 W (1995:Q45)
34. What is the total electrical energy consumed by using an electric cooker rated 1 000W for 5 hrs? A. 5.3×10^3 J B. 6.5×10^3 J

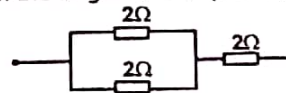
C. 1.8×10^7 J D. 2.3×10^7 J (1997:Q45)

36. Electricity is supplied to a school along a cable of total resistance 0.5 ohm with the maximum current drawn from the mains as 100A. the maximum energy dissipated as heat for 1hr is A. 3.6×10^3 J B. 5.0×10^3 J C. 3.0×10^3 J D. 1.8×10^3 J (1998:Q44)
37. A 3000W electric cooker is to be used on a 200V mains circuit. Which of the fuses below can be used safely with the cooker? A. 2A B. 5A C. 10A D. 20A (1999:Q40)
38. In the diagram below, if the internal resistance of the cell is zero, the ratio of the power P_1 and P_2 dissipated by R_1 and R_2 respectively, is A. $\frac{R_2}{R_1}$ B. $\frac{R_1}{R_2}$ C. $\frac{R_1 + R_2}{R_1}$ D. $\frac{R_1 + R_2}{R_2}$ (1999:Q42)



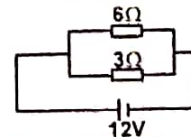
39. The correct position for a fuse in the diagram above is A. S B. Q C. P D. Between P and Q (2000:Q45)
40. An electric generator with a power output of 3.0KW at a voltage of 1.5KV distributes power along cables of total resistance 20.0 ohm. the power loss in the cable is A. 0.1W B. 10.0W C. 40.0W D. 80.0W (2000:Q49)
41. A working electric motor takes a current of 1.5A when the p.d. across it is 250V. If its efficiency is 80%, the power output is A. 300.0W B. 469.0W C. 133.0W D. 4.8W (2001:Q27)
42. The cost of running five 60W lamps and four 100W lamps for 20 hours if electrical energy costs N10.00 per kWh is A. N280.00 B. N160.00 C. N120.00 D. N140.00 (2001:Q28)
43. A bread toaster uses a current of 4A when plugged in a 240 volts line. It takes one minute to toast slices of bread. What is the energy consumed by the toaster? A. 5.76×10^3 J B. 1.60×10^3 J C. 3.60×10^3 J D. 1.60×10^2 J (2001:Q31)
44. An electric iron is rated 1 000W, 230V. What is the resistance of its element? A. 57.6W B. 55.9W C. 52.9W D. 51.9W (2002:Q31)
44. When connected to a mains 250V, the fuse rating in the plug of an electric device of 1kW is A. 4A B. 2A C. 5A D. 3A (2002:Q36)

45. In the diagram above, if each of the resistors can dissipate a maximum of 18W without becoming excessively heated, what is the maximum power the circuit can dissipate? A. 27W B. 18W C. 9W D. 5W (2003:Q28)



46. A steady current 2A flows in a coil of e.m.f. 12V for 0.4s. A back e.m.f. of 3V was induced during this period. The stored energy in the loop that can be utilized is A. 7.2J B. 12.0J C. 2.4J D. 9.6J (2004:Q42)

47. In the diagram below, the ratio of the electric power dissipated in the 6W and 3W resistors respectively is A. 2:3 B. 1:2 C. 1:3 D. 2:1 (2004:Q45)



48. Electrical appliances in homes are normally earthed so that A. both the a.c. and d.c. sources can be used. B. a person touching the appliances are maintained at a higher p.d. than the earth. C. the appliances are maintained at a higher p.d. than the earth. D. the appliances are maintained at a low p.d. (2004:Q48)
49. An electric device is rated 2 000W, 250V. The correct fuse rating of the device is A. 8A B. 9A C. 7A D. 6A. (2005:Q21)
50. A car battery rated 45 AH is charged with a charger whose rating is 2.5 A. How long will it take to charge the battery fully? A. 20 hrs B. 10 hrs C. 25 hrs D. 18 hrs (2005:Q22)
51. An electric heater with a p.d. of 240 V connected across the terminals has a total resistance of 960W. Find the power rating of the heater. A. 4.00 W B. 0.25 W C. 60.00 W D. 38.40 W (2006:Q25)
52. A cell of internal resistance r is connected to an external resistor R . The condition for maximum power transfer is A. $R < r$ B. $R = r$ C. $R = 2r$ D. $R > r$ (2006:Q31)
53. A 40 kW electric cable is used to transmit electricity through

a resistor of resistance 2.0Ω at 800 V. The power loss as internal energy is A. 5.0×10^3 W. B. 4.0×10^3 W. C. 5.0×10^2 W. D. 4.0×10^2 W. (2007:Q26)

54. An electric generator has an e.m.f of 240V and an internal resistance of 1Ω. If the current supplied by the generator is 20A when the terminal voltage is 220 V, find the ratio of the power supplied to the power dissipated. A. 11:1 B. 1:11 C. 12:11 D. 11:12 (2008:Q40)
55. A generator is on daily use and in the process, ten 60W and five 40W tungsten bulbs are on for the same time interval. The energy consumed daily is A. 0.96 kWh. B. 1.92 kWh. C. 9.60 kWh D. 19.20 kWh. (2008:Q41)
56. An electric lamp marked 240V, 60W is left of operate for an hour. How much energy is generated by the filament? A. 3.86×10^5 J B. 3.56×10^5 J C. 1.80×10^5 J D. 2.16×10^5 J (2009:Q41)
57. In the diagram above, a 200W bulb is lighted by a 240 V a.c mains supply. If 1kWh is sold at ₦40, the cost of keeping the bulb lighted for a day is A. ₦192.00. B. ₦1.92. C. ₦19.20. D. ₦ 1.920.00. (2010:Q38)
58. Power supply is transmitted at a very high voltage and low current in order to A. increase the power supply. B. prevent overheating of the coil. C. make it travel fast. D. make it pass through the transformers. (2010:Q39)
59. If the charge of electricity per kWh is ₦4, what is the cost of operating an electrical appliance rated 250 V, 2 A for 6 hours? A. ₦16 B. ₦24 C. ₦28 D. ₦12 (2011:Q35)
60. In homes, electrical appliances and lamps are connected in parallel because A. less current will be used B. less voltage will be used C. parallel connection does not heat up the wires D. series connection uses high voltage (2011:Q38)
61. Two resistors 5 and 10 are arranged first in series and later in parallel to a 24V source. The ratio of total power dissipated in the series and parallel arrangements respectively is A. 50:1 B. 3:5 C. 5:3 D. 1:50 (2011:Q39)
62. The fuse in an electric device is always connected to the A. neutral side of an electric supply B. earth side of an electric supply C. live side of an electric supply D. terminal side of an electric supply. (2012:Q40)
63. A house has ten 40W and five 100W bulbs. How much will it cost the owner of the house to keep them lit for 10 hours if the cost of a unit is ₦5? A. ₦90. B. ₦50. C. ₦45 (2013:Q40)
64. An electric device is rated 2000V, 250V. Calculate the maximum current it can take. A. 9A. B. 8A. C. 7A. D. 6A. (2013:Q41)
65. The maximum power transfer occurs in a cell when the external resistance is A. the same as the internal resistance of the cell. B. greater than the internal resistance of the cell. C. less than the internal resistance of the cell. D. twice the internal resistance of the cell. (2014:Q36)
66. PHCN measures its electrical energy in A. kWh. B. Wh. C. J. D. W. (2014:Q39)
67. A current of 20A flows through a cable whose resistance is 5Ω. Calculate the electric power dissipated. A. 2×10^3 W B. 2×10^4 W C. 1×10^3 W D. 1×10^2 W. (2015:Q10)
68. An electric bulb is labelled 260V, 80W. How much current is taken by the bulb? A. 0.46A B. 0.82A C. 0.40A D. 0.31A (2015:Q29)
69. A current of 15A flows through a cable of resistance 30Ω. Calculate the electric power dissipated in the cable A. 675W B. 225W C. 75W D. 6750W (2016:Q47)
70. An electrical appliance is rated 240V and 45W. Calculate the current drawn from the appliance A. 0.19A B. 0.30A C. 0.12A D. 0.45A (2017:Q20)
71. Which of the following is most suitable for protecting the circuit of 2000W electric iron connected to a 250V mains? A. 13A B. 8A C. 5A D. 3A (2018:Q20)
72. Electrical power is transmitted at a high voltage rather than a low voltage because the amount of energy loss is due to A. heat dissipation B. production of eddy currents C. excessive current discharge D. excessive voltage discharge (2018:Q22)
73. A 40W instrument has a resistance 90Ω. On what voltage should it be operated normally? A. 60V B. 150V C. 225V D. 360V (2018:Q30)
74. What is the total electrical energy consumed by using an electric

cooker rated 1000W for 5hours? A. 5.3×10^3 J B. 6.5×10^3 J C. 1.8×10^3 J D. 2.3×10^3 J (2018:Q36)

CHAPTER 27 ANSWERS

- 1D. $P_T = P_1 + P_2$ (series connection) $\rightarrow P_T = 2(40) = 80W$
- 2A. The energy expanded: $E = IVt = 1 \times 200 \times 24 = 4800Wh = 4.8kWh$ But 1Kwh $\rightarrow 5k \therefore 48kwh = 5 \times 4.8 = 24k$
- 3E. Heat energy produced: $E = IVt = 5 \times 6 \times 20 = 6000J$
NOTE: Avoid calories (cal) here; it is not SI unit of energy 1cal = 4.18J
- 4C. ... so as to protect electrical components from being damaged by excess current.
NOTE:
1. A fuse melts and opens the circuit when a current above a predetermined value passes through it.
2. If for example, a current of 5A is likely to damage the circuit a "fuse rating" of say 6A or just equal to 5A is needed as the safety device for the circuit.
- 5A. Total power generated: $P_T = 8(40) + 4(60) + 2(100) = 760W$
Energy consumed = Power x time
 $E = 760 \times 5 \times 30 = 114000Wh \rightarrow E = 114Kwh$
The bill = $114 \times 5 = ₦570$
- 6E. $P = IV \rightarrow \therefore P = \frac{V^2}{R} (I = \frac{V}{R}) \rightarrow R = \frac{V^2}{P} = \frac{6^2}{40} \text{ohms}$
Also: $P = I^2R (V = IR)$
- 7B. Total power = $15(40) + 1(600) \rightarrow P_T = 1200W$
Energy used = $P_T t \rightarrow E = 1200 \times 6 = 7200Wh = 7.2KWh$
- 8E. Since heat generated in transmission is given by $H = I^2Rt$ and power loss is $P = I^2R$ it follows that excessive heat loss is experienced at high current hence High Tension transmission uses very high voltage but low current.
NOTE: The high voltage is not safe for domestic or industrial consumption hence the need for step-down transformer arises.
- 9E. $P = \frac{V^2}{R}$ (see Q6) $\rightarrow R = \frac{V^2}{P} = \frac{240 \times 240}{60} \rightarrow R = 960\Omega$
- 10A. $R = \frac{V^2}{P}$ (see Q9) $\rightarrow R = \frac{250 \times 250}{1000} \rightarrow R = 62.5\Omega$
Also $P = IV$ (Q6) $\rightarrow \therefore I = \frac{P}{V} = 4A$
We can also find current from: $P = I^2R$ (Q6)
 $I = \sqrt{\frac{P}{R}} = \sqrt{\frac{1000}{62.5}} = \sqrt{16} \rightarrow I = 4A$
- 11A. Using thin wire would have been cheaper to buy, easier to connect but the thinner the wire the higher the resistance it offers as $R \propto \frac{1}{A}$ and the higher the resistance the higher the heat loss $H = I^2R$ Hence II is not an advantage and somewhat thick cables are used for transmission.
- 12B. See Qs 8 and 11
- 13D. P.d across them is the same. But $P = \frac{V^2}{R} \therefore V^2 = PR$
Hence: $P_2 R_2 = P_1 R_1 \rightarrow P_2 \times 6 = 10 \times 4 \rightarrow P_2 = 6.67W$
- 14B. $P_T = 5(50) + 4(100) = 650W$
Electrical Energy = $P_T t = 650 \times 10 = 6500Wh = 6.50KWh$
Cost = $6.5 \times 2 = 13k = ₦0.13$
- 15B. $H = \frac{V^2 t}{R} \rightarrow 6 \times 10^5 = \frac{240 \times 240 \times 5 \times 60}{R} \rightarrow R = 28.8\Omega$
- 16B. For parallel resistors: $V^2 = P_1 R_1 = P_2 R_2$ (see Q13)
 $40 \times 5 = P_2 \times 10 \rightarrow P_2 = 20W$
- 17C. $E = IVt = 0.5 \times 40 \times 2 \times 60 \rightarrow E = 2400J$
- 18A. $E = 200 \times 24 \times 20 = 96KWh \rightarrow \text{Cost} = 5 \times 96 = ₦480$
- 19C. $P = IV \rightarrow I = \frac{P}{V}$
A $\rightarrow \frac{1000}{250} = 4A$ B $\rightarrow \frac{110}{220} = 0.5A$
C $\rightarrow \frac{30}{6} = 5A$ ✓ D $\rightarrow \frac{500}{110} = 4.5A$

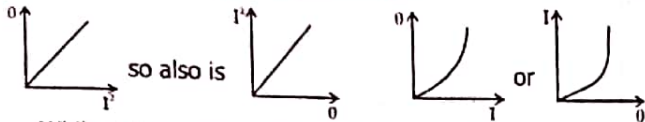
21B. For parallel resistors: $\frac{1}{R} = \frac{1}{4} + \frac{1}{4} \rightarrow R = 2\Omega$

Total resistance in circuit: $R_T = 4 + 2 = 6\Omega$ (series); $V_T = 12V$

But $P_T = \frac{V_T^2}{R_T} = \frac{12 \times 12}{6} \rightarrow P_T = 24W$

22. No option was right

NOTE: Joule's classical experiment in 1841 involves converting electrical energy I^2Rt to heat energy $mc\theta$ by raising the temperature of water such that $mc\theta = I^2Rt$. Thus $\theta \propto I^2$ where m, c, R and t are kept constant by using the same mass m of water, not changing the water of specific heat capacity c to another liquid and not changing the thickness t nor length of the wire. Therefore θ versus I^2 is a straight line from origin



While θ versus I or I versus θ will at best be a curve

23D. See Q4

24B. $D = IV \rightarrow I = \frac{P}{V} \rightarrow I = \frac{2000}{250} = 8A$

The fuse melts if 8A passes through it and circuit is broken.

NOTE: 5A is too low.

25A. See Q8

26A. $R = \frac{V^2}{P} = \frac{240 \times 240}{60} \rightarrow R = 960\Omega$

27B. When key is open, the entire current passes through 6Ω resistor

$R_T = 14 + 6 = 20\Omega \rightarrow I = \frac{V}{R_T} = \frac{30}{20} = 1.8A$

This is not enough to melt a 2-A fuse. Close the key and part of the current passes through K making the R_T to become lesser than 20Ω . As $6 \rightarrow 0$ i.e. $14 \rightarrow 0 \rightarrow I \rightarrow 2.0A$

28B. $I^2R = P \rightarrow I^2 = \frac{1500}{375} = 4 \rightarrow I = 2A$

29A. $I = \frac{P}{V} \rightarrow \therefore A \rightarrow \frac{60}{240} = 0.25A$ B $\rightarrow \frac{60}{40} = 1.25A$

C $\rightarrow \frac{40}{12} = 3.3A$ D $\rightarrow \frac{40}{5} = 8A$

30D. $H = I^2Rt$

31A. $P = \frac{V^2}{R} \Rightarrow V^2 = PR \rightarrow V = \sqrt{40 \times 90} = 60V$

32B. $P_1 = \frac{V^2}{4}$ $P_2 = \frac{V^2}{5} \rightarrow \therefore \frac{P_1}{P_2} = \frac{V^2}{4} \times \frac{5}{V^2} \rightarrow \therefore P_1:P_2 = 5:4$

33C. ... as more current passes through Y

34D. Total time taken = $3(60) + 20 \rightarrow t = 200s$; $I = 2A$; $R = 50\Omega$
 $H = I^2Rt = 22 \times 50 \times 200 = 40KJ$

35B. $P = \frac{V^2}{R} = \frac{20 \times 20}{100} \rightarrow P = 4W$

36C. $E = Pt = 1000 \times 5 \times 60 \times 60 = 18\,000\,000 = 1.8 \times 10^7J$

37D. $H = I^2Rt \rightarrow 4 = 100^2 \times 0.5 \times 60 \times 60 = 1.8 \times 10^7J$

38D. $P = IV \rightarrow I = \frac{P}{V} \rightarrow I = \frac{3000}{200} = 15A$

The predetermined maximum current (Q4) is 15A hence 20A fuse is suitable.

NOTE: However, the 20A quoted above is rather too high, you can use something around 16A

39A. Power in $R_1 = \frac{E^2}{R_1} \rightarrow$ Power in $R_2 = \frac{E^2}{R_2}$

$\therefore \frac{P_1}{P_2} = \frac{E^2}{R_1} \times \frac{R_2}{E^2} = \frac{R_2}{R_1} \rightarrow \frac{P_1}{P_2} = \frac{R_2}{R_1}$

The above suggests that the larger the resistance the lesser the power.

Fuse is connected to the live wire.

39D. $I = \frac{3000}{1500} = 2A \rightarrow P = I^2R = 2^2 \times 20$ (see Q8) $\rightarrow P = 80W$

42A. Power input = $IV = 1.5 \times 200 \rightarrow$ Power input = 375

Efficiency = $\frac{\text{Power output}}{\text{Power input}} \times 100\%$

\therefore Power output = $375 \times \frac{80}{100} = 300W$

43D. Total power = $5(60) + 4(100) = 700W$

Electrical Energy = $Pt = 700 \times 20 = 14\,000 = 14kWh$

Cost = $10 \times 14 = 140k$

The cost is 140k or N1.40k. The JAMB's error in the options notwithstanding, pick D.

44A. $E = IVt = 4 \times 240 \times 60 = 5.76 \times 10^4J$

45C. $R = \frac{V^2}{P} = \frac{230 \times 230}{1000} = 52.9\Omega$

46A. $I = \frac{P}{V} = \frac{1000}{250} = 4A$

47. For each of resistor is parallel: $I^2R = P \rightarrow I^2 = \frac{18}{2} \therefore I = 3A$

48A. The voltage stored = voltage lost by coil = $12 - 3 = 9V$
 But $E = IVt \therefore$ Energy stored in loop = $2 \times 9 \times 0.4 = 7.2J$

49B. $\frac{P_1}{P_2} = \frac{V_1^2}{R_1} + \frac{V_2^2}{R_2} \rightarrow \frac{P_1}{P_2} = \frac{12}{6} \times \frac{3}{12} \rightarrow P_1:P_2 = 1:2$

50B. Electric charges pass quickly into the earth to prevent shock.

51A. $I = \frac{P}{V} = \frac{2000}{250} = 8A$

52B. $t = \frac{45}{2.5} = 10h$

NOTE: The unit Ah means Amperhour i.e the quantity of charge or electricity is 45C or 45AH $\rightarrow \frac{AH}{A} \rightarrow$ hour

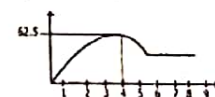
53C. $P = \frac{V^2}{R} = \frac{240 \times 240}{960} = 60W$

54C. Power output of a cell is $P_{out} = I^2R$

But $I = \frac{E}{R+r} \rightarrow P_{out} = \left(\frac{E}{R+r}\right)^2 \times R$. Using fixed values of

E and r , P_{out} is maximum when $R = r$.

Check: Let $E = 10$ and $r = 4$ and use various values of R 1,2,3,4,5,10, you will note that $P_{max} = 6.25$ when $R = 4$



55C. $I = \frac{P}{V} = \frac{40000}{800} = 50A$

But power loss is $P = I^2R = 50 \times 50 \times 2 = 5\,000W$

56C. The resistance of the external load

$I = \frac{E}{R+r} \rightarrow 20 = \frac{240}{R+1} \rightarrow R = 11\Omega$

Energy dissipated (as heat): $H = I^2R = 20 \times 20 \times 11$

Energy supply = $IV = 20 \times 240$

$\frac{\text{Energy supply}}{\text{Energy dissipated}} = \frac{20 \times 240}{20 \times 20 \times 11} \rightarrow \frac{240}{20 \times 11} = \frac{12}{11}$

57D. Total power daily = $10(60) + 5(40) = 800W$

Energy to 24hrs period $E = 800 \times 24 = 19.2KWh$

58D. $E = Pt = 60 \times 60 \times 60 \rightarrow E = 2.16 \times 10^5J$

Using 240V to find I is needless (it only wastes time)

because $I = \frac{60}{240} \rightarrow E = IVt = \frac{60}{240} \times 240 \times 60 \times 60$

59A. Electrical energy = $Pt \rightarrow E = 200 \times 24 \rightarrow E = 4800Wh$
 $E = 4.8Wh \rightarrow$ Cost = $4.8 \times 40 = N192$

60A. The power supplied from the source will be drastically reduced at the points of consumption because high current means very high power loss ($P = I^2R$) in transit.

61D. $E = IVt = 2 \times 250 \times 6 = 3\,000Wh = 3KWh$

Cost = $3 \times 4 = N12$

62A. In series connection, the same current passes through all the appliances. In parallel, the current breaks up into small units as dictated by the resistance of each appliance.

63. For series connecting: $R_T = 5 + 10 = 15$

Check! For parallel connection: $\frac{1}{R_T} = \frac{1}{5} + \frac{1}{10} \rightarrow R_T = \frac{50}{15} = \frac{10}{3}$

Power in series = $\frac{250^2}{15} \rightarrow$ Power in parallel = $\frac{250^2}{15} = \frac{250^2 \times 3}{10}$

$\frac{\text{Power in series}}{\text{Power in parallel}} = \frac{250^2}{15} \times \frac{10}{250^2 \times 3} = \frac{10}{15 \times 3} = \frac{2}{3 \times 3} = \frac{2}{9}$

No option was right

64C. See Q40

65C. $P_T = 10(40) + 5(100) = 900W \rightarrow E = P_T t = 900 \times 10 = 9KWh$
Cost = $9 \times 5 = N45$

66B. $I = \frac{P}{V} = \frac{2000}{250} = 8A$

67D. See Q54

68D. $1KWh = 1\ 000Wh$

The power is consumed on hourly basis not in seconds/minutes

69D $P = I^2 R = 15 \times 15 \times 30 = 6\ 750W$

70A $P = IV \rightarrow 45 = 240I$ and $I = 0.1875A$

71B $P = IV \rightarrow 2\ 000 = 250I \rightarrow I = 8A$

72A See Q8

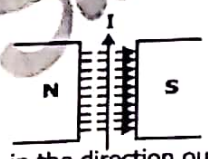
73A $P = \frac{V^2}{R} \rightarrow 40 = \frac{V^2}{90} \rightarrow V^2 = 3\ 600 \rightarrow V = 60V$

74C $E = IVt = Pt = 1\ 000 \times 5 \times 60 \times 60 = 1.8 \times 10^7J$

CHAPTER 28

MAGNETIC FIELD AND ELECTROMAGNETIC INDUCTION

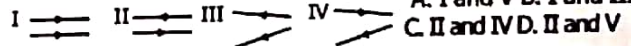
- A magnet is moved through a coil of wire. The e.m.f produced in the wire depends on A. the number of turns in the coil B. the strength of the magnet C. the speed at which the magnet is moved D. all of the above E. none of the above (1978: Q30)
- On an a.c generator, which of the following does not apply? A. field magnet B. commutator C. armature D. slip rings E. carbon brushes (1978: Q33)
- The electric supply from Kainji Dam is transmitted at high voltages of the order hundreds of kilovolts but is converted to domestic use of about 220 volts by A. commutators B. transistors C. valves and diodes D. rectifiers E. transformers (1978: Q36)
- Which of the following statements is incorrect? The sensitivity of a galvanometer which incorporates an optical lever arrangement may be increased by providing: A. a larger number of turns in the coil B. a thinner suspension with a small torsional control C. a special alloy permanent magnet which gives a high magnetic flux D. all of the above E. a light source with a greater intensity (1979: Q19)
- Which of the following statements is correct? The magnetized state of an iron bar can be destroyed completely by A. heating the bar to a high temperature B. breaking the bar C. connecting opposite poles with a small piece of iron D. placing the bar inside a strong magnetic field E. none of the above (1979: Q26)
- The figure shows a current I flowing in a copper wire situated in the magnetic field existing between the pole-pieces of a horse-shoe magnet. Which of the following statements is correct? A. The wire will experience a force in the direction into the paper. B. The wire will experience a force in the direction out of the paper. C. The wire will vibrate in the direction into and out of the paper. D. The wire will move in the direction of the field, i.e. towards the S-pole E. The wire will not move because it is made of copper which is non-magnetic (1979: Q33)
- On which of the following is the operation of a moving coil galvanometer based? A. Magnetic effect of electric current B. Electromagnetic induction C. Chemical reaction produced by electricity D. Force on a current carrying conductor in a magnetic field E. Electrical energy and power. (1979: Q43)
- A magnet is similar to a bipolar charged system in that A. it consists of two opposite poles - the north and south poles B. the earth's magnetic field has a south pole near the geographic north pole and a north pole near the geographic south pole C. the force of attraction and repulsion between opposite and between like poles obeys a law opposite and between like poles obeys a law identical in form to Coulomb's law for electrostatic charges D. A and B only E. A and C only. (1980: Q6)



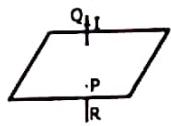
- The name given to the characteristic behaviour of substances which set their length perpendicular to a strong magnetic field instead of in line with it is A. magnetization B. paramagnetism C. diamagnetism D. demagnetization E. ferromagnetism (1980: Q19)
- In the diagram below a straight vertical wire is placed between two opposite magnetic poles which are separated horizontally by a short distance. If a current is passed down the wire, in which direction will the wire move? A. Towards the observer B. Away from the observer C. Toward the North pole D. Towards the South pole E. Upwards (1980: Q38)



- The best material for the core of the primary and secondary coils of an induction coil is A. copper, because it is a good conductor of electricity B. steel, because it becomes magnetic and retains its magnetism for a long time C. rubber, because it is a good insulator and the user is prevented from shock D. soft iron, because it becomes magnetic but easily loses its magnetism E. glass, because it is transparent. (1980: Q40)
- Which of the following elements are real magnetic materials? A. Iron, steel and nickel B. Copper, steel and iron C. Lead, iron and brass D. Glass, lead and steel E. Stone, air and iron. (1981: Q9)
- Which of the following is NOT directly associated with direct current (D.C.)? A. A dry cell B. A moving coil galvanometer C. A transformer D. A lead-acid accumulator E. A commutator (1981: Q45)
- A transformer has 300 turns of wire in the primary coil and 30 turns in the secondary coil. If the input voltage is 100 volts, the output voltage is A. 5 volts B. 10 volts C. 15 volts D. 20 volts E. 25 volts (1981: Q47)
- A closed coil of wire is placed near a magnet. The magnet lies along the axis of the coil. Under which of the following conditions would there be no current in the coil? A. When the coil is moved towards the stationary magnet B. When the coil is moved away from the stationary magnet C. When the coil is held stationary but the magnet is moved towards the coil D. When both the coil and the magnet are held stationary E. When the coil is held stationary but the magnet is moved away from the coil. (1981: Q48)
- A magnetic needle is suspended first at the earth's north magnetic pole and then at a point on the magnetic equator. The respective angles between the needle and the horizontal are A. 0° and 0° B. 60° and 60° C. 90° and 90° E. 0° and 90°. (1982: Q39)
- Each of the diagrams in the figure represents two current carrying conductors situated close to each other. In which two diagrams are the forces between the two wires attractive? A. I and V B. I and III C. II and IV D. II and V E. III and IV (1983: Q33)



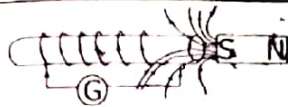
- In the figure above, QR is a vertical conductor and the current I flows from R to Q. P is a point on the horizontal plane and it is to the South of the wire. The direction of the magnetic field at P due to the current is A. Upward B. North C. South D. West E. East (1983: Q40)



- The electromotive force obtained from a simple dynamo may be increased by A. increasing the cross-sectional area of the coil B. winding the coil on a soft-iron armature so as to decrease the magnetic flux through the coil C. increasing the speed of rotation D. making the field magnet longer E. using low-resistance copper coils. (1984: Q33)
- A short bar magnet is placed in the earth's magnetic field as shown in the figure. Which of the points II and III is (are) possible position(s) of a neutral point? A. I only B. II only C. III only D. I and II E. I, II and III. (1984: Q34)



- In the figure below represents an insulated cylindrical coil or copper wire wound round a paper tube. The ends of the coil are connected to a sensitive galvanometer. When a magnet was plunged into the coil it was observed that the



galvanometer needle gave a deflection. Which of the following correctly describes this experiment?

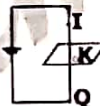
- A. The effect illustrated is induced electromotive force. B. The strength of the current produced is inversely proportional to the speed with which the magnet is plunged into the coil. C. The direction of the current is always such as to enhance the change producing it. D. The galvanometer gave a permanent deflection. E. On removing the magnet from the coil the galvanometer deflected in the same direction. (1984:Q50)
22. Which of the following methods CANNOT be used to produce a steel magnet? The A. passing of an electric current through a solenoid B. repeated stroking of the specimen with a magnet C. repeated stroking of the specimen in opposite D. heating of the specimen E. hammering of the specimen in the earth's magnetic field. (1985:Q37)
23. On which of the following does the operation of a moving coil ammeter depend? I. Electromagnetic induction. II. Force on a current-carrying conductor in a magnetic field. III. Magnetic effect of an electric current. A. I only B. II only C. III only D. II and III E. I, II and III (1985:Q43)
24. Which of the following statements is NOT correct? A. A galvanometer can be converted to an ammeter with a different range by connecting a high resistance in series. B. An electric current always produces a magnetic field C. Maxwell's screw rule states that if a corkscrew moves in the direction of the current, the hand turns in the direction of the lines of force. D. Electromagnets are used in electric bells and telephone receivers. E. The lines of force round a straight current carrying conductor are circular. (1985:Q45)
25. A transformer has a primary coil with 500 turns and secondary coil with 2 500 turns. When the voltage input to the primary coil is 120V, the output is A. 6 000V B. 600V C. 240V D. 60V E. 24V (1985:Q46)
26. Which of the following if NOT a part of the a d.c. electric motor? A. Field-magnet B. Armature C. Commutator D. Transformer (1986:Q41)
27. Which of the following is true of magnetism? A. Iron fillings cling mainly round the ends of a bar magnet. B. The freely suspended bar magnet comes to rest in the geographic north-south direction C. Like poles attract. D. Lodestone is a non-magnetic oxide. (1986:Q44)
28. The angle between the magnetic meridian and the geographic meridian at a locality on the earth is the A. Longitude of the locality B. Angle of inclination at the locality C. Latitude of the locality D. Angle of declination of the locality. (1986:Q45)
29. The diagrams below depict the current induced in a coil as a result of the relative motion between it and a bar magnet. Which of the diagrams illustrates the direction of the induced current?
 A. B. C. D. (1986:Q47)
30. If the inclination at Ibadan is $7^\circ S$, this means that A. The angle between the geographic meridian and the magnetic meridian at Ibadan is 7° B. The earth's resultant magnetic intensity at Ibadan makes angle 7° with the horizontal direction C. A magnetic needle will be inclined at 7° to the vertical at Ibadan. D. The north pole of a magnetic needle dips downwards at Ibadan. (1986:Q48)
31. If the angle of declination in a place is $10^\circ E$, calculate the true geographic bearing if the compass reads $N40^\circ E$. A. $N50^\circ E$ B. $N40^\circ E$ C. $N30^\circ E$ D. $N25^\circ E$ (1987:Q38)
32. When a transformer has more secondary winding than primary winding, it A. Has a smaller secondary current B. Has a greater power output C. Is a step-down transformer D. Increases the total energy output (1987:Q42)
33. The direction of the magnetic field at a point in the vicinity of a bar magnet is A. Always towards the north pole of the magnet B. Always away from the south pole of the magnet C. Along the line joining the point to the neutral point D. In the direction the north pole of a compass needle would point (1987:Q44)
34. When two parallel wires carry currents in opposite directions, the force on either wire is A. Away from the other wire B. Zero, because the currents cancel each other C. Twice as much as when the currents are in the same direction D. Towards the other wire. (1987:Q45)

35. The wire X in the figure above is at right angles to the plane of the paper and carries a current into the paper. At which of the point labeled 1-4 will the magnetic flux density due to this current be in the same direction as that of the horizontal component of the earth's magnetic field? A. 1 B. 2 C. 3 D. 4. (1988:Q37)



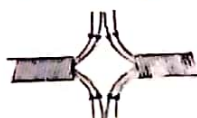
36. Which of the following ammeters may be used to measure alternating current? I. Moving-coil ammeter II. Moving-iron ammeter III. Hot-wire ammeter. A. I and II only B. II and III only C. I and III only D. I, II and III. (1988:Q45)
37. The principle of operation of an induction coil is based on A. Ohm's law B. Ampere's law C. Faraday's law D. Coulomb's law. (1988:Q46)
38. A dynamo primarily converts A. Mechanical energy into electrical energy B. Electrical energy into kinetic energy C. Potential energy into kinetic energy D. Kinetic energy into potential energy. (1988:Q47)
39. When a number of identical small magnets are arranged in a line, the strength of the resultant magnet A. Is largest when they are arranged end to end B. Is greatest when they are arranged parallel with like poles adjacent to each other. C. Depends only on the number of magnets provided they are parallel. D. Is greater when the magnets are arranged on a wooden surface than on a metal surface. (1989:Q32)
40. A bar magnet is most effectively demagnetized by A. Placing it in a N-S position and hitting it with a hammer. B. Subjecting it to an electric current from a battery C. Bringing its north pole in contact with the north pole of a very strong magnet D. Heating the magnet. (1989:Q34)

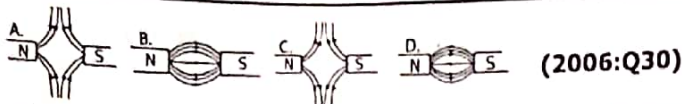
41. The figure above shows a conductor PQ carrying a current I in the direction shown. At a particular position near the conductor is a compass needle K. Neglecting the earth's magnetic field, the



- compass needle will A. Settle in any direction B. Settle in a fixed direction only if conductor PQ is a magnetic material C. Settle in a fixed direction whether conductor PQ is a magnetic material or not D. Be stationary. (1989:Q45)
42. One of the properties of the earth's magnetic field is that the A. North pole lies in the northern hemisphere B. Geographic and magnetic meridians coincide C. Earth's magnetic flux is entirely horizontal at a place where the magnetic vertical dip is zero. D. Earth's magnetic flux is entirely vertical at a place where the magnetic dip is zero. (1990:Q34)
43. What precaution should a manufacturer take to ensure that energy loss in a transformer is minimized? A. The winding of the transformer should be made of high resistance wires. B. The core should be made of thin sheets of metal. C. No magnetic material should be used to make the core. D. The flux linking the primary with the secondary coils should be minimum. (1990:Q47)
44. Which of the following statements is CORRECT about the earth's magnetic field? A. The angle of dip is the angle which a free suspended magnet makes with the vertical B. The angle of declination is the angle between the magnetic meridian and the geographic meridian C. The angle of declination is the angle which a magnetic compass makes with the magnetic meridian. D. The angle of inclination is the difference between the angle of dip and the angle of declination. (1991:Q33)
45. To convert an alternating current dynamo into a direct current dynamo, the A. number of turns in the coil is increased B. strength of the field magnetic is increased C. slip rings are replaced with a split ring commutator D. coil is wound on a soft iron armature. (1991:Q42)
46. If a current carrying coil is mounted on a metal frame, the back e.m.f. induced in the coil causes A. Inductance B. Eddy currents C. Electromagnetism D. Dipole moment (1991:Q43)

47. The diagram below represents the field pattern obtained by bringing the poles of two magnets near each other. The poles must be A. N - N poles B. S - S

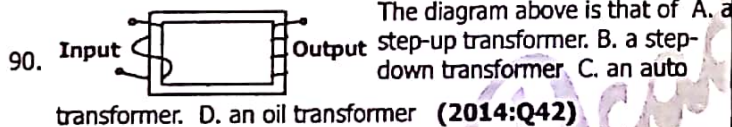




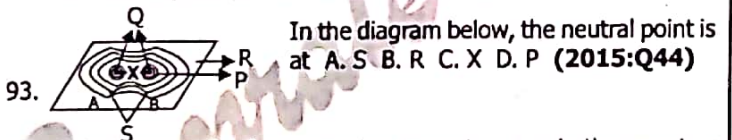
(2006:Q30)

81. The instrument that measures both a.c. and d.c. is A. an inverter. B. a current balance. C. a moving coil ammeter. D. a moving iron ammeter. (2007:Q15)
82. Lenz's law is a law of the conservation of A. energy. B. momentum. C. electric current. D. electric charge (2007:Q16)
83. The d.c. generator has essentially the same components as the a.c. generator except the presence of A. slip-ring B. carbon brushes. C. split-ring D. armature. (2008:Q42)
84. A step-down transformer has a power output of 50W and efficiency of 80%. If the mains supply voltage is 200V, calculate the primary current of the transformer. A. 0.31A. B. 3.20A. C. 3.40A. D. 5.00A (2008:Q43)
85. In measuring high frequency a.c., the instrument used is the A. moving iron ammeter B. hot wire ammeter C. d.c. ammeter D. moving coil ammeter. (2011:Q47)
86. A particle carrying a charge of $1.0 \times 10^{-8} \text{C}$ enters a magnetic field at $3.0 \times 10^2 \text{ms}^{-1}$ at right angles to the field. If the force on this particle is $1.8 \times 10^{-8} \text{N}$, what is the magnitude of the field? A. $6.0 \times 10^{-1} \text{T}$ B. $6.0 \times 10^{-2} \text{T}$ C. $6.0 \times 10^{-3} \text{T}$ D. $6.0 \times 10^{-4} \text{T}$ (2012:Q41)
87. Induced emfs are best explained using A. Ohm's law. B. Faraday's law C. Colomb's law. D. Lenz's law. (2013:Q44)
88. What is the best method of demagnetizing a steel bar magnet? A. Heating it. B. Rough handling it C. Solenoid method D. Hammering. (2014:Q40)
89. The magnitude of the angle of dip at the equator is A. 0° B. 90° C. 180° D. 360° . (2014:Q41)

Use the diagram below to answer questions 90 and 91



90. The diagram above is that of A. a step-up transformer. B. a step-down transformer C. an auto transformer. D. an oil transformer (2014:Q42)
91. The electromotive force in the secondary winding is A. increasing. B. reducing. C. stabilizing. D. varying. (2014:Q43)
92. Which of the following does NOT use magnetic effect of current to function? A. A telephone receiver. B. Lead acid accumulator. C. A moving coil galvanometer. D. An electric bell. (2015:Q18)



93. In the diagram below, the neutral point is at A. S B. R C. X D. P (2015:Q44)
94. Which parts of a d.c. generator convert an a.c. in the armature to a d.c. in the external circuit? A. Slip rings and brushes B. field poles C. armature and core D. commutator and brushes (2016:Q14)
95. Which of the following is associated with alternating current only? A. A transformer B. A lead-acid accumulator C. an induction coil D. a moving coil galvanometer (2016:Q21)
96. Electrical power is transmitted at a high voltage rather than a low voltage because the amount of energy loss is due to A. heat dissipation B. production of eddy currents C. excessive current discharge D. excessive voltage discharge (2018:Q22)

CHAPTER 28 ANSWERS

- 1D. The e.m.f is directly proportional to (A), (B) and (C)
- 2B. In d.c. generator and electric motor, split-ring commutator replaces slip-ring.
- 3E. Step-down transformers.
- 4D. Large torsional control
- 5A. Methods of Demagnetization
 1. **Electrical:** A magnet is placed in an a.c. -carrying solenoid oriented in the E-W direction.
 2. **Mechanical:** The magnet is hammered while held in E-W direction.
 3. **Thermal:** Magnet is heated strongly.
- 6A. Using Fleming's left hand rule, the wire moves into the paper. Direction of magnetic field \rightarrow Left to right of the page.

Direction of current \rightarrow upwards on the page.
 Direction of motion \rightarrow Must be perpendicular to both field and current
 Fore Finger \rightarrow Field
 Second finger \rightarrow current
 Thumb \rightarrow motion
NOTE: Second finger is the middle finger if thumb is counted for a finger.

- 7D. While moving-iron ammeter (or galvanometer) is based on the principle of electromagnetic induction.
- 8E. The north pole corresponds to the positive charge and the south pole to the negative charge.
NOTE: Option B is the behaviour of the earth's imaginary bar magnet.
- 9B. Paramagnetism is a form of magnetism in which certain materials are attracted by an external magnetic field and form internal induced magnetic fields in the direction of the applied external magnetic field. However, a paramagnet does not retain its induced magnetism after external magnetism is removed.
- 10A. Using Fleming's left-hand rule:
 Fore finger \rightarrow Direction of field
 Second finger \rightarrow Direction of current
 Thumb \rightarrow Direction of motion
NOTE:
 1. Use Fleming's lefthand rule to obtain the direction of motion of a current - carrying conductor in an electric field.
 2. If the thumb is counted as a finger, the second finger above is the middle finger i.e. the longest of the five fingers at the middle of the pack.
 3. Fleming's right-hand rule follows the same rule at the left-hand rule but our aim is to obtain the direction of the induced current (electromagnetic induction) having known the directions of field and motion of the conduction.
 4. The three directions in both cases are all perpendicular to one another.

- 11D. Primary coil of insulated copper wire wound on soft iron core.
- 12A. These are ferromagnets including cobalt. Note that alloys of ferromagnetic elements are also ferromagnetic e.g iron and steel. A ferromagnet retains its magnetism after external magnet is removed (see Q9). A diamagnet is not attracted by a magnet or it might even be slightly repelled by it.
- 13C. The current stepped up or down by a transformer is (A.C) not (D.C).

$$14B. \frac{V_s}{V_p} = \frac{N_s}{N_p} \rightarrow V_s = \frac{30 \times 100}{300} = 10V$$

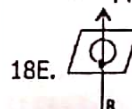
This is a step-down transformer.

- 15D. The coil and the magnet must be in relative motion to one another as in one of the following cases
 1. Stationary coil, moving magnet
 2. Moving coil, stationary magnet
 3. Both moving but one faster than the other.

NOTE:

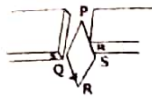
1. The induced current can be increased by
 - i. Increasing the speed of the relative motion.
 - ii. Increasing the strength of the magnet.
 - iii. Increasing the number of turns in the coil.
2. Changing the direction of the relative motion only change the direction of current but the current always flow in such a manner as to oppose the motion inducing the current in the first place.

- 16D. The angle of dip at the Earth's north magnetic pole is 90° but 0° at the equator.
- 17B. This depends on the directions of current in the two wires
 1. Same direction - attraction
 2. Opposite direction - repulsion



- 18E. Using right hand grip rule or clenched fist rule

- poles C. S – N poles D. N – S poles (1992:Q31)
48. The angle between the direction of the earth's magnetic field and the horizontal is called the A. Angle of deviation B. Magnetic declination C. Magnetic meridian D. Angle of dip (1992:Q32)



49. PQRS is a rectangular coil with PQ perpendicular to the magnetic field as shown in the diagram. If a current flows in the direction PQRS, in what direction will the coil move? A. Upwards B. Downwards C. Towards the north pole D. Towards the south pole. (1992:Q43)
50. A horizontal component of the earth's magnetic field and the magnetic field of a straight wire X carries current into the plane of a paper. Which of the following figures correctly illustrates the resultant magnetic field pattern in the horizontal plane?

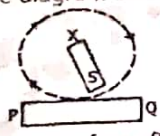


- A. B. C. D. (1993:Q33)
51. Which of the following correctly explain(s) why soft iron is preferred to steel in electromagnets? I. Soft iron is more readily magnetized than steel. II. Soft iron is more readily demagnetized than steel. III. Soft iron retains magnetism more than steel. A. I only B. II and III only C. I and II only D. I, II and III. (1993:Q34)

52. A current-carrying conductor experiences a force when placed in a magnetic field because the A. Conductor is magnetized B. Magnetic field of the current interacts with external magnetic field. C. Force is due to the motor principle D. Electric field of the current interacts with the external magnetic field. (1993:Q35)
53. Which of the following devices may be used to set up the voltage in a d.c. circuit? A. A step-up transformer B. A d.c. generator C. A wattmeter D. An induction coil. (1993:Q43)

54. The primary aim in high tension transmission is to A. Minimize electrical energy losses due to heat production B. Increase the rate of energy transfer by using high voltage C. Increase the current in the wires D. Generate electricity at high current and low voltage. (1993:Q44)
55. At different locations on the earth's surface, the earth's magnetic field is A. The same in magnitude and direction B. The same in magnitude but different in direction C. Different in both magnitude and direction D. Different in magnitude but not in direction. (1995:Q38)

56. The iron core of an induction coil is made from bundles of wires so as to A. Minimize eddy-currents B. Generate eddy-currents C. Prevent sparking at the contact breaker D. Get the greatest possible secondary voltage. (1998:Q43)
57. A transformer which can produce 8V from a 240V a.c. supply, has an efficiency of 80%. If the current in the secondary coil is 15A, calculate the current in the primary coil. A. 0.625A B. 1.600A C. 2.500A D. 6.250A (1998:Q46)

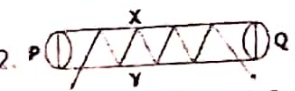


58. The diagram below show a magnet X with its South pole moved along a soft-iron bar PQ in the direction shown. After some time, the poles at P and Q respectively are A. North – North B. North –South C. South – North D. South – South (1999:Q28)

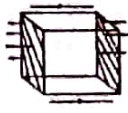
59. The core of an efficient transformer should consist of laminated pieces of metal in order to A. Increase the heat produced by increasing the eddy current B. Increase the heat produced by reducing the eddy current C. Reduce the heat produced by increasing the eddy current D. Reduce the heat produced by reducing the eddy current. (1999:Q36)
60. If a charged ion goes through combined electric and magnetic fields, the resultant emergent velocity of the ion is

- A. $\frac{E}{B}$ B. EB C. $\frac{B}{E}$ D. E - B (2000:Q32)

61. The magnetic flux in a coil having 200 turns changes at the time rate of 0.08 Wb s^{-1} . The induced e.m.f. in the coil is A. 1.6V B. 16.0V C. 25.0V D. 250.0V (2000:Q43)



62. If current flows in the direction of the arrows in the solenoid above, the North pole is at A. P B. X C. Q D. Y (2000:Q47)
- A conductor of length 2m carries a current of 0.8A while kept in a magnetic field of magnetic flux density 0.5T. The maximum force acting on it is



64. The diagram above shows a closed square box of side 0.5m in a uniform electric field E in the direction shown by the arrows. What is the flux Φ for the box? A. 0.5E B. 2.0E C. 0.2E D. 0.0E (2001:Q30)

65. The primary coil of a transformer has N turns and is connected to a 120V a.c. power line. If the secondary coil has 1,000 turns and a terminal voltage of 1 200 volts, what is the value of N? A. 120 B. 100 C. 1 000 D. 1,200 (2001:Q43)

66. The force on a current carrying conductor in a magnetic field is greatest when the A. conductor makes an angle of 60° with the field B. force is independent of the angle between the field and the conductor C. conductor is parallel with the field D. conductor is at right angles with the field (2001:Q46)

67. Energy losses through eddy currents are reduced by using A. low resistance wires B. insulated soft iron wires C. few turns of wire D. high resistance wires (2001:Q48)

68. The magnetic force on a charged particle moving with velocity v is A. proportional to both the magnitude of the charge and the velocity v B. independent of the magnitude of the charge C. proportional to the velocity v only D. proportional to the magnitude of the charge only (2001:Q50)

69. The carbon-granule microphone works on the principle of change in A. voltage B. inductance C. resistance D. capacitance (2002:Q42)

70. From the generating station to each substation, power is transmitted at a very high voltage so as to reduce A. eddy current loss B. hysteresis loss C. heating in the coils D. magnetic flux leakage. (2002:Q44)

71. Which of the following statements is true of the properties of a moving coil galvanometer? A. There are strong hair springs to give a large control couple B. It has a small number of turns of coil. C. The coil has a small area. D. There is a strong permanent magnet to give high magnetic flux. (2002:Q47)

72. A circuit has an area of 0.4 m^2 and consists of 50 loops of wire. If the loops are twisted and allowed to rotate at a constant angular velocity for 10 rads^{-1} in a uniform magnetic field is 0.4T, the amplitude of the induced voltage is A. 8V B. 16V C. 20V D. 80V (2003:Q41)

73. The force on a charge moving with velocity v in a magnetic field B is half of the maximum force when the angle between v and B is A. 90° B. 45° C. 30° D. 0° (2003:Q43)

74. A generator-manufacturing company was contracted to produce an a.c dynamo but inadvertently produced a d.c dynamo. To correct this error, the A. commutator should be replaced with slip rings. B. commutator should be replaced with split rings. C. armature coil should be made of aluminum. D. armature coil should be made of silver. (2004:Q30)

75. To protect a material from the influence of an external magnetic field, the material should be kept in a A. square steel ring. B. loop of copper wire. C. triangular zinc ring. D. soft iron ring. (2004:Q46)

76. A transformer is rated 240V. If the primary coil is 4 000 turns and the secondary voltage 12V, determine the number of turns in the secondary coil A. 250. B. 100. C. 150. D. 200. (2005:Q1)

77. A proton moving with a speed of $1.0 \times 10^6 \text{ ms}^{-1}$ through a magnetic field of 1.0T experiences a magnetic force of magnitude $8.0 \times 10^{-14} \text{ N}$. The angle between the proton's velocity and the field is A. 45° B. 30° C. 60° D. 90° [Proton charge = $1.6 \times 10^{-19} \text{ C}$] (2005:Q6)

78. The north pole of magnet can never be separated from the south pole because of a property known as A. magnetic dipole. B. magnetic octopole. C. magnetic monopole. D. magnetic quadrupole. (2005:Q20)

79. The main purpose of the transformer in an a.c. radio set is to A. increase power to the radio. B. convert energy from a.c to d.c. C. step down the voltage. D. step up the voltage. (2006:Q23)

80. Which of the following diagrams represents the magnetic field of two isolated unlike poles?

19C. See Q15

Point I is too close to the magnet while point II is far enough from the magnet is a neutral point when the poles are interchanged.

- 21A. This is electromagnetic induction which produces induced e.m.f and current which causes the needle to deflect.
- 22D. Hammering like heating destroy magnetism but the hammering is done in E-W direction rather than in the more or less N-S direction of the Earth's magnetic field.
- 23D. See Q7
- 24A. (A) → See chapter 26
(B) → Magnetic effect of current
(C) → Alternative to clenched fist rule (see Q18)
(D) → Electromagnets work on the principle of rapid alternation of magnetization and demagnetization
(E) → See Q18

25B $\frac{V_s}{120} = \frac{2500}{500} \rightarrow V_s = 600V$ (Step-up transformer)

26D. See Qs2 and 13

- 27A. (A) → These ends are called poles of the magnet.
(B) → The magnet comes to rest in the magnetic north-south direction and this is roughly the geographic north-south direction.
(C) → Like poles repel; unlike poles attract.
(D) → Lodestone is also called magnetic because it is the magnetic ore of iron (chemistry class)

28D. This is also called **angle of variation** by mariners.

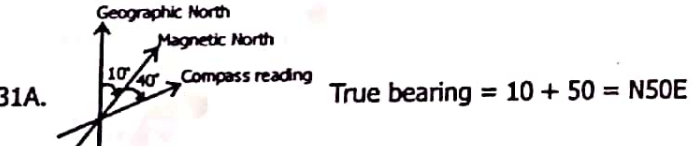
NOTE:

1. **Magnetic meridian** is a plane through the magnetic axis while geographic meridian is a plane through the earth geographic axis (N-S) at the given place.
2. **Angle of dip** also called angle of inclination is the angle between the direction of the earth's resultant magnetic field and the horizontal.
3. **Angle of dip** is measured by a **dip circle**.

29A. The direction of arrow indicates the direction of motion inducing the current in the first place. The polarity of the coil is in such a way as to oppose this motion. Options (A) and (B) require repulsion (if North polarity is produced in coil) while options (C) and (D) require attraction (if the coil polarity is south)

North polarity $\vec{N} \rightarrow$ Anticlockwise
South polarity $\vec{S} \rightarrow$ Anticlockwise
(Option (A) satisfies all the terms)

30B. See Q28. (dip = tilt = incline)



32A. For an ideal transformer, power ($P = IV$) is conserved.

Power output = Power input: $I_s \times E_s = I_p \times E_p$ or $\frac{E_s}{E_p} = \frac{I_p}{I_s}$

Recall: $\frac{E_s}{E_p} = \frac{N_s}{N_p}$ $\frac{E_s}{E_p} = \frac{N_s}{N_p} \rightarrow \frac{N_s}{N_p} = \frac{E_s}{E_p} = \frac{I_p}{I_s}$

$\therefore \frac{N_s}{N_p} = \frac{E_s}{E_p} = \frac{I_p}{I_s}$ (See Q25)

Hence the higher the number of turns, the higher the e.m.f but the smaller the current with respect to primary and secondary coils in the transformer.

NOTE:

1. When power is generated, it is high current, low voltage.
2. To transmit the power, a step-up transformer is employed to elevate the voltage and lower the current so as to minimize energy loss as heat ($H = I^2R$)
3. Before power is distributed to homes, it must be stepped down to low voltage and high, reasonable current.
4. When our home appliances got spoilt as evidenced by brightly glowing electric bulbs, it is high voltage not high current as erroneously believed when a step-down transform fails.

- 33D. Hence the magnetic field lines (or flux) always in the direction from the north, or to south, pole of the magnet.
- 34A. Force is repulsive (option A) if wires carry currents in the opposite direction but attractive (option D) if in the same direction.
- 35C. Apply clenched fist rule.
- 36B. Moving coil ammeter (galvanometer) can only measure D.C. - a disadvantage of the instrument.
- 37C. Faraday's law of electromagnetic induction.
- 38A. And such dynamo is called a **generator**. Loosely speaking, however, a **motor** which converts electrical energy to mechanical energy is also a dynamo.
- 39A. This is the reversal of breaking a single, large magnet into small pieces, each piece becoming a smaller, weaker magnet with N-S polarity.
- 40D. Hammering is only effective if magnet is in E-S (East - West) direction (See Q22)
- 41C. Since magnetic field will exist around the current carrying conductor.
- 42C. Considering the definition of angle of d.p, this occurs at the equator. Dip angle is 90° at the poles.
- 43B. This is the lamination of the core to prevent eddy current
- 44B. See Q28
- 46B. And this results in damping.
- 47B. Direction of flux moves towards a south pole but away from a north pole hence this is a S-S repulsion.



- 48B. See Q28
- 49B. Using Fleming's left-hand rule.

NOTE:

1. Don't use Fleming's right-hand rule here since the direction of to be found motion is not the direction of induced current see Qs and 10
2. In order not to twist your left hand unnecessarily here, reverse the direction of field from S-N to N-S and you will discover that your thumb points upwards hence the right direction of motion is downward.

- 50A. Note the neutral point where the two sets of flux cancel each other out.
- 51C. But used as permanent magnet. In addition, iron is more strongly magnetized than steel. Electromagnets work on the principle of rapidly alternatively magnetized and demagnetized states. Steel which does not magnetize easily retains its magnetization much longer once magnetized hence would not serve our purpose.
- 52B. The interplay of two magnetic fields, one due to the current and the other due to the magnet, produces an electromagnetic force which moves the conductor in a direction perpendicular to those of the current and magnetic field.
- 53D. The induction coil is a make-and-break device which can produce a very high intermittent electromotive force (e.m.f) from a low voltage d.c. source like a car battery. Transformer is only associated with a.c.

54A. See Q32

56A. The Earth's magnetic field is a uniform field strength and direction are constant.

57A. Efficiency = $\frac{\text{Power output}}{\text{Power Input}} \times 100\%$. But $P = IV$
 $\epsilon = \frac{I_s V_s}{I_p V_p} \times 100\% \rightarrow \frac{80}{100} = \frac{15 \times 8}{I_p \times 240} \rightarrow I_p = 0.625A$

NOTE: Only an ideal transformed has 100% efficiency and ideal transformer does not exist.

For ideal transformer: $I_s \times V_s = I_p \times V_p$

- 58B. If you stroke with North pole, you attain South pole at P and North at Q. This is single touch method. Divided touch method produces a stronger magnet.
- 59D. Eddy currents generate heat and heat energy is wasteful.
- 60D. Relative velocities of the magnetic and electric fields.
 $V = E + (-B) \rightarrow V = E - B$

- 61B. Induced e.m.f = Rate of change of flux x no of turns
 $F = RN \rightarrow E = 0.08 \times 200 = 16V$
- 62C. The current flows anticlockwise at the Q end
- 63C. Using the relation: $F = BIL\sin\theta$
 But $F = \text{max}$ when $\sin\theta = \text{max}$ i.e when $\theta = 90^\circ$; $\sin 90 = 1$
 $F = BIL = 0.5 \times 0.8 \times 2 = 0.8N$
- 64D. The flux is given by $\Phi = NAB\cos\theta$, where $N = \text{no of turns} = 1$
 $A = \text{Area of box} = (0.5)^2$ $B = \text{Magnetic field strength} = E$
 $\Phi = 1 \times 0.25 \times E \times \cos 90^\circ = 0.0E$
- 65B. $\frac{N}{1000} = \frac{120}{1200} \rightarrow N = 100 \text{ turns}$
- 66D. The force is zero if the conductor is parallel to the magnetic field.
- 67B. See Qs 59
- 68A. Recall: $F = qvB$
- 69C. Sound wave impinging on the diaphragm causes the vibration of the diaphragm thereby exerting a varying pressure on the granules, which in turn changes the electrical resistance between the plates
- 70C. Heat loss due to ($H = I^2R$)
- 71A. Features of a money-coil Galvanometer
1. A light rectangular vertical coil
 2. The coil is of several turns
 3. Two curved pole pieces of a horse-shoe magnet
 4. A soft iron core or cylinder between the pole pieces
 5. Two non-magnetic spiral springs and these hair springs produce a control couple.
- 72D. Induced voltage is given by $E = NAB\omega\sin\theta$
 The amplitude of the induced voltage is the peak voltage or maximum voltage and it coincides with $\theta = 90$ and $\sin 90 = 1$
 $E_0 = NAB\omega = 50 \times 0.4 \times 0.4 \times 10 = 80V$
- 73C. $F = qvB\sin\theta$ $F_1 = q_1v_1B_1\sin\theta_1$ (max force) and $F_2 = q_2v_2B_2\sin\theta_2$
 But $F_1 = 2F_2$; $v_1 = v_2$; $q_1 = q_2$; $B_1 = B_2$; $\theta_1 = 90^\circ$
 $q_1v_1B_1\sin\theta_1 = 2q_2v_2B_2\sin\theta_2 \rightarrow \sin\theta_2 = \frac{q_1v_1B_1\sin 90^\circ}{q_2v_2B_2} = 1/2$
 $\theta = \sin^{-1} 0.5 = 30^\circ$
- 74A. See Q2
- 75D. This is called magnetic screening
- 76D. $N_s = \frac{4000 \times 12}{240} = 200$
- 77B. $qvB\sin\theta = F \rightarrow 1.6 \times 10^{-19} \times 1 \times 10^6 \times 1.0\sin\theta = 8.0 \times 10^{-14}$
 $\sin\theta = \frac{8 \times 10^{-14}}{1.6 \times 10^{-19} \times 10^6 \times 1.0} \rightarrow \theta = \sin^{-1} 0.5 = 30^\circ$
 To confirm your answer in Q73, use $\sin 90^\circ$ instead of $\sin 30^\circ$
 $F = 1.6 \times 10^{-19} \times 10^6 \times 1.0 \sin 90^\circ = 1.6 \times 10^{-13}$ (maximum force)
 This is twice $8 \times 10^{-14}N$
- 78A. When a magnet is cut into two halves, each half is a magnet with N-S polarity. If the cutting is repeated, the dipole is retained however small each small piece becomes.
- 79C. High voltage is dangerous.
- 80C. See Q47
- 81D. Hot-wire ammeter can also measure a.c and d.c. A moving coil ammeter/galvanometer cannot measure a.c unless a rectifier is attached.
- 82A. If a magnet is push towards a coil, it is repelled because the current flows in such a way as to produce same polarity as the end of the magnet in use. If the same magnet is pulled away, it is attracted as coil polarity is opposite that of the end in use. In both cases, current opposes the motion which induces it into existence. an extra force F applied to resist this repulsion or attraction moves the magnet over a distance s and the work done is converted to electrical energy of the induced e.m.f and current ($F \times s = IVt$). Mechanical energy is conserved but converted to electrical energy.
- 83C. In this type of question, note that **d.c. generator** is mentioned first. Your answer is then about d.c not a.c.

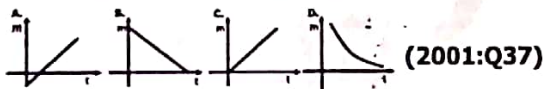
84A. $\frac{\text{Power output}}{\text{Power input}} \times 100 = \text{Efficiency} \rightarrow \frac{50}{I_p \times V_p} = \frac{80}{100}$

- $I_p = 0.313A$
- 85B. Note that hot-wire ammeter uses the principle of heating effect of current and its (97) scale is a square-law scale $H = I^2R$
- 86C. $F = qvB\sin 1.8 \times 10^4 = 1.0 \times 10^{-4} \times 3 \times 10^2 \times B\sin 90^\circ$
 $B = \frac{1.8 \times 10^4}{1.0 \times 10^{-4} \times 3 \times 10^2 \times 1} = 6.0 \times 10^2 T$
- 87D. Faraday's law only state the fact of induced e.m.f while lenz's law offers the (99) explanation for the induced e.m.f
- 88A See Q22
- 89A See Q16
- 90A Secondary coil (output) has more turns than primary coil (input)
- 91A Recall from Q32 that: $\frac{N_s}{N_p} = \frac{E_s}{E_p} = \frac{I_p}{I_s}$
 Thus the higher the number of turns, the higher the emf but the lower the current
- 92B Head acid accumulator works on the principle of converting chemical energy (change) to electrical energy
- 93C Flux has zero density at X.
- 94D Split-ring commutator and brushes (See Q2)
- 95A See Q13
- 96A. See Q

CHAPTER 29
CONDUCTION OF ELECTRICITY THROUGH LIQUIDS AND GASES

1. In an electrolysis experiment, a cathode of mass 5g is found to weigh 5.01g after a current of 5A flows for 50 seconds. What is the electrochemical equivalent of the deposited substance? A. 0.00004g/C B. 0.00002g/C C. 0.02500g/C D. 0.05000g/C E. 0.00001g/C (1979:Q30)
2. In copper plating, a current of 0.5A is allowed for cathode area of 100cm². If this current is maintained constant for 100 minutes, the thickness of the copper deposited will be approximately. (the electrochemical equivalent of copper = 0.0003 g/C, density of copper = 104 g/cm³) A. 10⁻²mm B. 10⁻³mm C. 10⁻⁴mm D. 10⁻⁵mm E. 10⁻⁶mm (1982:Q31)
3. The electrochemical equivalent of a metal is 0.126 x 10⁻⁴kg/C. The mass of the metal that a current of 5A deposit from a suitable bath in 1 hour is A. 0.0378 x 10⁻³kg B. 0.227 x 10⁻³kg C. 0.378 x 10⁻³kg D. 0.595 x 10⁻³kg E. 2.268 x 10⁻³kg (1983:Q26)
4. Which of the following components is NOT contained in a dry cell? A. Carbon rod B. Paste of magnesium dioxide C. Paste of ammonium chloride D. Zinc case E. Copper rod. (1984:Q11)
5. Cathode rays are A. High-energy electromagnetic waves B. Protons C. Streams of electrons D. Neutrons E. Radio waves (1984:Q42)
6. A charge of one coulomb liberates 0.0033g of copper in an electrolytic process. How long will it take a current of 2A to liberate 1.98g of copper in such a process. A. 5minutes B. 30minutes C. 50minutes D. 60minutes E. 120minutes (1985:Q35)
7. Which of the following statements about electrolysis is NOT correct? A. The substances in solution in the electrolyte become ionized. B. Ions are electrically charged and are attracted towards electrodes when a potential difference is applied. C. Ions may be discharged at the electrodes, forming bubbles or deposits. D. The mass deposited depends upon the length of time for which current flows. E. The mass of gas set free or metal deposited is proportional to the square of the current. (1985:Q47)
8. Which of the following is stored by a dry Leclanche cell? A. Electrical power B. Kinetic energy C. Electric current D. Chemical energy. (1986:Q42)
9. The electrochemical equivalent of silver is 0.0012g/C. If 36.0g of silver is to be deposited by electrolysis on a surface by passing a steady current for 5.0 minutes, the current must be A. 6 000A B. 100A C. 10A D. 1A (1989:Q44)
10. The function of the system of granulated carbon mixed with manganese (IV) oxide in a Leclanche cell is to A. Increase the e.m.f. of the cell to 2.0V B. Prevent local action in the cell C. Prevent polarization in the cell D. Make the cell black and hence a good radiator (1991:Q36)

- cell C. Prevent polarization in the cell D. Make the cell black and hence a good radiator (1991:Q36)
- The electrochemical equivalent of platinum is $5.0 \times 10^{-7} \text{kgC}^{-1}$. To plate-out 1.0kg of platinum, a current of 100A must be passed through an appropriate vessel for A. 5.6 hours B. 56 hours C. 1.4×10^4 hours D. 2.0×10^4 hours. (1991:Q44)
 - Which of the following factors has no effect on e.m.f. of a primary cell? A. Temperature B. Size of the cell C. Nature of the plates D. Nature of the electrolyte. (1992:Q35)
 - A simple cell with mercury-amalgamated zinc electrode prevents A. Local action B. Polarization C. Buckling D. Degradation (1993:Q36)
 - Which of the following statements correctly describe(s) cathode rays? I. They consist of tiny particles negative electric charges II. They are deflected in a magnetic field but not in an electric field III. They consist of fast moving neutrons and deflected in an electric field. A. I only B. III only C. I and II only D. II and III only (1993:Q46)
 - Which of the following has the lowest internal resistance when new? A. Leclanche cell. B. Daniel cell. C. Accumulator D. Torch battery. (1994:Q40)
 - Which of the following can be used to reduce local action in a Leclanche cell? A. A carbon rod as the positive pole. B. Pure zinc as the negative pole. C. Potassium permanganate solution in contact with the positive pole. D. Common salt solution. (1998:Q39)
 - The electrochemical equivalent of metal is $1.3 \times 10^{-7} \text{kgC}^{-1}$. The mass of the metal which $2.0 \times 10^4 \text{C}$ of electricity will deposit from a suitable electrolyte is A. $6.5 \times 10^{-2} \text{kg}$ B. $2.6 \times 10^{-2} \text{kg}$ C. $6.5 \times 10^{-3} \text{kg}$ D. $2.6 \times 10^{-3} \text{kg}$ (1998:Q47)
 - A gas would serve as an electrical conductor under A. Reduced pressure and reduced potential B. Reduced pressure and high current C. Increased magnetic field D. Exposure to visible light (2000:Q48)
 - In a Daniel cell, the depolarizer, positive and negative electrodes are respectively A. copper sulphate, copper and zinc B. manganese dioxide, carbon and zinc C. sulphuric acid, lead oxide and lead D. potassium hydroxide, nickel and iron (2001:Q29)
 - Which of the following graphs correctly represents the variation of mass of a given material deposited with time for constant current in Faraday's law of electrolysis?



- (2001:Q37)
- I. Low pressure II. High pressure III. High p.d. IV. Low p.d. Which combination of the above is true of the conduction of electricity through gases? A. I and IV only B. I and III only C. II and IV only D. II and III only (2001:Q41)
 - A current of 0.5A flowing for 3h deposits 2g of a metal during electrolysis. The quantity of the same metal that would be deposited by a current of 1.5A flowing in 1h is A. 10g B. 18g C. 2g D. 6g (2002:Q40)
 - The most suitable cell used for short interval switches in electric bells is a A. lead-acid accumulator B. Daniel cell C. Leclanche cell D. nickel iron accumulator (2003:Q37)
 - In the calibration of an ammeter using Faraday's laws of electrolysis, the ammeter reading is kept constant at 1.20A. If 0.9990g of copper is deposited in 40 minutes, the correction to be applied to the ammeter is A. 0.03A B. 0.04A C. 0.05A D. 0.06A (2003:Q39)
 - Which of the following is an electrolyte? A. grape juice B. sugar solution C. alcohol D. paraffin (2004:Q47)
 - The charge carriers in gases are A. ions only. B. electrons and holes. C. electrons only. D. electrons and ions. (2005:Q3)
 - The ray which causes gas molecules to glow is known as A. molecular ray. B. gamma ray. C. anode ray D. cathode ray (2005:Q5)
 - The electrolyte in the Nickel-iron (NiFe) accumulator is A. ammonium chloride solution. B. dilute tetraoxosulphate(VI) acid. C. copper tetraoxosulphate(VI) solution. D. potassium hydroxide solution (2006:Q22)
 - 118.8cm^2 surface of the copper cathode of a voltameter is to be coated with 10^{-6}m thick copper of density $9 \times 10^3 \text{kgm}^{-3}$. How long will the process run with 10 A constant current? A. 10.8 min

- B. 20.0 min C. 5.4 min D. 15.0 min [e.c.e of copper = $3.3 \times 10^{-7} \text{kgC}^{-1}$] (2007:Q21)
- In Faraday's law of electrolysis, a graph of mass deposited against the quantity of electricity is plotted. The slope of the graph gives A. the electrochemical equivalent B. the charge released. C. the current flowing. D. the energy released. (2010:Q44)
 - In a discharge tube, most of the gas is pumped out so that electricity is conducted at A. steady voltage. B. low pressure. C. high pressure. D. low voltage. (2010:Q45)
 - Which of the following will be applied when a metal Y is used to electroplate another metal X in electrolysis? A. Y is the cathode and X is the anode. B. Y is the anode and very high current is used. C. X is the anode and very high current is used. D. X is the anode and Y is the cathode. (2011:Q40)
 - Under which of the following conditions do gases conduct electricity? A. High pressure and low p.d. B. High pressure and high p.d. C. Low pressure and low p.d. D. Low pressure and high p.d. (2011:Q46)
 - A newly charged 12V accumulator can easily start a car whereas eight new dry cells in series with an effective e.m.f. of 12V cannot start the same car because A. the current capacity is high. B. the current capacity is low C. it cannot be re-charged D. it cannot easily be connected to a car. (2012:Q38)
 - If a current of 2.5A flows through an electrolyte for 3 hours and 1.8g of a substance is deposited, what is the mass of the substance that will be deposited if a current of 4A flows through it for 4.8 hours? A. 2.4g. B. 3.2g. C. 4.6g. D. 4.8g. (2013:Q45)
 - Calculate the mass of the copper deposited during electrolysis when a current of 4A passes through a copper salt for 2 hours. A. $9.5 \times 10^{-7} \text{kg}$ B. $9.5 \times 10^{-3} \text{kg}$ C. $2.9 \times 10^{-4} \text{kg}$ D. $2.9 \times 10^5 \text{kg}$ (e.c.e. of copper $Z = 3.3 \times 10^{-3} \text{kg}$) (2014:Q46)
 - Chemical energy is used to power which of the following? A. Leclanche cell. B. Electric cell. C. A dynamo. D. Solar cell (2015:Q39)

CHAPTER 29 (ANSWERS)

- Mass of deposited substance = $5.01 - 5.00 = 0.01 \text{g}$
Faraday's first law of electrolysis! $m = ZIt$
 $\therefore Z = \frac{m}{It} = \frac{0.01}{5 \times 50} = 0.0004 \text{g/c}$
- Faraday's first law: $m = ZIt \rightarrow m = 0.003 \times 0.5 \times 100 \times 60 = 0.9 \text{g}$
But mass = Density \times volume
 $\therefore \text{Volume} = \frac{0.9}{10^4} = 9 \times 10^{-5} \text{cm}^3$
Also volume = Area \times thickness
 $\therefore \text{Thickness} = \frac{9 \times 10^{-5}}{100} = 9 \times 10^{-7} \text{cm} = 9 \times 10^{-6} \text{mm}$
No correct option
- $m = ZIt = 0.126 \times 10^{-6} \times 5 \times 1 \times 60 \times 60 = 2.268 \times 10^{-3} \text{kg}$
- By dry cell we mean Dry Leclanche cell made of a zinc container (anode) in which ammonium chloride paste is placed. A mushin bay which contains manganese(IV)oxide paste is embedded in the ammonium chloride paste. A carbon rod in form of graphite is inserted in the ammonium chloride paste as cathode.
NOTE:
1. In wet leclanche cell, solutions rather than pastes are used.
2. Daniel cell is never in dry form and has the following components Anode \rightarrow Zinc rod Cathode \rightarrow Copper vessel Electrolytes \rightarrow Zinc sulphate and copper sulphate solutions.
- Cathode rays therefore have the following properties
1. They turn a paddle wheel in their path because of their particulate nature.
2. They move towards the anode because of their negative charge.
3. They are deflected towards the positive plate in an electric field.
4. They are deflected towards the North pole in a magnetic field.
5. They travel in straight lines.
6. They cause certain materials to fluoresce or glow e.g.

glass and zinc sulphide.

7. They ionize a gas in which they travel.
8. They have effect on photographic plates.
9. They produce x-rays from metals which suddenly stop them.
10. They can penetrate through metals such as aluminium, steel and gold.

NOTE: Cathode rays are by all means same particles of electron in the β -rays produced in Radioactivities.

6A. Since it is the same metal, the electrochemical equivalent is constant

$$Z = \frac{m}{Q} = \frac{m}{It} \rightarrow \frac{m_1}{Q_1} = \frac{m_2}{Q_2} = \frac{0.0033}{1} = \frac{1.98}{Q_2} = Q_2 = 60^\circ\text{C}$$

$$It = Q \rightarrow 2t = 600 \rightarrow t = 300\text{s} = 5\text{mins}$$

7E. $m \propto I$; $m \propto t$; $m \propto It$ but not $m \propto I^2$

8D. Stores chemical energy but converts it to electrical energy when electric current flows out of the cell.

$$9B. I = \frac{m}{Zt} = \frac{36}{0.0012 \times 5 \times 60} = 100\text{A}$$

10C. Polarization is one of the two defects of a primary cell i.e **polarization** and **local action**.

NOTE:

1. Polarization arises when hydrogen gas bubbles produced when zinc anode dissolves in sulphuric acid form layers around the carbon rod cathode: $\text{Zn} + \text{H}_2\text{SO}_4 \rightarrow \text{ZnSO}_4 + \text{H}_2$.
2. The manganese(iv)oxide added is a depolariser which oxidizes the hydrogen to water: $\text{MnO}_2 + 2\text{H}_2 \rightarrow \text{Mn}^{2+} + 2\text{H}_2\text{O}$
3. Aside manganese dioxide, potassium dichromate can also be used as depolarizer.
4. Local action arises from using impure zinc plate and this is countered by amalgamating with mercury.

$$11A. t = \frac{m}{ZI} = \frac{1}{15 \times 10^{-7} \times 100}$$

$$t = 20\,000\text{s} = \frac{20\,000}{80 \times 60} = t = 20\,000\text{s} = 5.56\text{hrs}$$

12B. (A): Temperature affects resistance

(C): The e.m.f is dependent on the difference in the electrode potentials of the plates or electrodes used

(D): The electrolyte used is dependent on the electrode used e.g copper in copper sulphate in Daniel cell.

13A. See Q10

14A. See Q5

15C. Daniel cell = 1.1V; Leclanche cell = 1.5V

Lead-acid accumulator = 2.2V

Recall that: $V = I$ and $V = IR$. Since an accumulator produces largest current in practical use, it has the least resistance.

16B. See Q10

$$17D. m = ZQ \rightarrow m = 1.3 \times 10^{-7} \times 2.0 \times 10^4 = 2.6 \times 10^{-3}\text{kg}$$

18B. Pressure as low as 0.01mmHG, p.d as high as 1000V in a discharge it tube connected to a vacuum. Recall that high p.d means high current ($V \propto I$)

19A. Polarization: $\text{H}_2 + \text{CuSO}_4 \rightarrow \text{H}_2\text{SO}_4 + \text{Cu}$.

NOTE:

1. Anode (Zn rod) is the negative electrode.
2. Cathode (copper container) is the positive electrode.
3. Option B \rightarrow Leclanche cell
4. Option C \rightarrow Lead-acid accumulator - a secondary cell
5. Option D \rightarrow NIFE cell or nickel-iron accumulator; another secondary cell.

20C. $m \propto It \rightarrow \frac{m}{It} = \text{constant}$ (A straight line graph pass through the origin)

21B. See Q18

$$22C. \text{Using } Z = \frac{m_1}{I_1 t_1} = \frac{m_2}{I_2 t_2} \rightarrow \frac{2}{0.5 \times 3} = \frac{m_2}{1.5 \times 1} \rightarrow m_2 = 2\text{g}$$

NOTE: Converting hours to seconds is not necessary here.

23B. Low voltage required in electric ball.

$$24C. I = \frac{m}{Zt} = \frac{0.990}{3.3 \times 10^{-4} \times 3 \times 40 \times 60} = 1.25\text{A}$$

$$\text{Adjustment} = 1.25 - 1.20 = 0.05\text{A}$$

A. Grape juice contains acid.

D. In a discharge tube, electrons are knocked out of the gas atoms and the atoms become positively charged ions while the

electrons are negatively charged. The positive ions migrate towards the anode, the electrons towards the cathode hence this stream of electrons constitute the cathode rays. The gas itself begins to glow and the colour depend on the gas used.

27D. See Qs5 and 26

28D. See Q19

29B. The volume of copper deposit required = Area x thickness

$$\frac{118.8 \times 10^{-4}}{10 \times 10^2} \times 10^{-6} = 1.188 \times 10^{-4}\text{m}^3$$

$$\text{Mass of copper deposit} = \text{Density} \times \text{volume} = 9 \times 10^3 \times 1.188 \times 10^{-4} = 1.0692 \times 10^{-4}\text{Kg}$$

$$\text{Now } t = \frac{m}{ZI} (\text{Faraday's}) = \frac{1.0692 \times 10^{-4}}{3.3 \times 10^{-7} \times 10}$$

$$t = 32.4\text{s} = \frac{32.4}{60} \text{min} = 0.54\text{min}$$

Don't leave this type of question unanswered because JAMB had 5.4min as its predetermined answer - pick option B

$$30A. m \propto Q \rightarrow m = ZQ \rightarrow \therefore Z = \frac{m}{Q}$$

The slope Z is called the electrochemical equivalent of the substance involved (See Q20).

31B. Pumped out through a vacuum pump to drastically lower the pressure within the tube (see Q18)

32D. Anode \rightarrow Electroplating metal e.g silver

Cathode \rightarrow Electroplated metal e.g iron (spoon)

Electrolyte \rightarrow A solution of a soluble salt of the electroplating metal e.g silver nitrate (AgNO_3)

NOTE:

1. The silver atoms on the anode lose electrons and go into the electrolyte as silver ions. $\text{Ag} \rightarrow \text{Ag}^+ + e^-$
2. The electrons deposited on the anode travel through external circuit but re-enter the electrolyte via the iron spoon. Hence the silver plate (anode) is +ve while the iron spoon (cathode) is negative.
3. The +ve silver ions in solution therefore migrate towards the -ve iron spoon and take up electrons to become discharged as silver deposit on the spoon thus the surface coating (electroplating) of the spoon.

33D. See Qs 18 and 32

34A. Now revisit Q15 as explained'

35C. Compare Q6 and 22

36B. Compare Q3

37C.

CHAPTER 30

ATOMIC PHYSICS AND RADIO ACTIVITIES

1. The net charge on the atom is zero because A. the electrons and the protons that are charged are in the nucleus B. the total charge on the electrons is equal to the total charge on the neutrons C. the neutrons form a shield around the charged protons. D. the number of electrons in an atom is half the number of protons E. A and B above (1978:Q50)
2. Which of the following is the correct definition of 'half-life'? A. The average life-time of a radioactive material B. The time it takes a radioactive material to decay to half of its original quantity. C. Half the period a radioactive material decays completely D. Half of the decay constant E. The decay constant times life-time. (1979:Q28)
3. Which of the following statements about radioactivity are true? (i) Alpha particle is positively charged (ii) Beta particle is negatively charged (iii) Gamma ray is neutral (iv) Beta particle has the same mass as helium atom (v) Gamma ray is charged. A. i, ii, iii, iv only B. iv and v only C. i, ii and iii only D. i, ii and v only E. All (1979:Q31)
4. It is known that a neutron exists in a light atomic nucleus. Which of the following also exists in the nucleus? A. an electron B. a β -particle C. an α -particle D. a proton E. an atom. (1979:Q46)
5. Which of the following statements are true in the structure of atoms? A. The atoms of the different elements differ only in the number of protons and electrons B. The number

- of protons equals the number of electrons C. Atoms are constructed according to the plan of our solar system D. All of the above E. A and C only (1980:Q3)
- Which of the following are true of atoms? A. Atoms are indestructible B. All atoms of a pure substance, or element, are identical C. Atoms of different substances have different weights D. All of the above E. A and B only (1980:Q4)
 - Which of the following on the use of X-rays is incorrect? X-rays are used A. in hospitals to obtain photographs of tissues and bones in the body B. for the treatment of malignant growths like cancer cells C. in detecting fingerprints D. to reveal hidden flaws in metal castings and welded joints E. to detect alterations which have been made to works of art. (1980:Q20)
 - Which of the following radiations cannot be deflected by a magnetic field? A. α B. β C. γ D. β and γ E. None of them (1980:Q41)
 - Which of the following elements is the best absorber of X-rays? A. Hydrogen B. Oxygen C. Calcium D. Copper E. Lead (1980:Q42)
 - The activity of a radioactive substance depends on A. temperature and purity B. temperature and age C. purity and age D. age, purity and temperature E. none of the above (1980:Q49)
 - Natural radioactivity consists of the emission of A. α -particles and β -rays B. α -particles and X-rays C. γ -rays and X-rays D. α -particles, β -rays and γ -rays E. α -particles, β -rays, γ -rays and X-rays (1980:Q50)
 - Which type of radiation does NOT originate within the nucleus? A. Alpha B. Beta C. Gamma D. Neutron E. X-rays. (1981:Q29)
 - The mass of a proton is approximately equal to that of A. an α -particle B. a β -particle C. a γ -ray D. an electron E. a neutron (1981:Q39)
 - Which of the following statements is NOT true of γ -rays? A. γ -rays do belong to the electromagnetic spectrum B. γ -rays do not carry an electron charge C. γ -rays obey the inverse cube law in air D. The thickness of aluminium which stops β -particles has a negligible effect on γ -radiation E. The difference between γ -rays and X-rays is that γ -rays originate from energy changes in the nuclei of atoms, while X-rays come from energy changes associated with the electron structure of atoms. (1982:Q33)
 - In a radioactive series: ${}_{82}^{214}\text{Pb} \rightarrow {}_{82}^{214}\text{Bi} \rightarrow {}_{82}^{214}\text{Po} \rightarrow {}_{82}^{214}\text{Pb}$ the particles emitted are respectively, A. β, β, α particles B. α, γ, β particles C. γ, α, β particles D. α, α, β particles E. β, α, β particles (1982:Q40)
 - Which of the following statements is CORRECT? I. The mass number is equal to the total number of protons and electrons in an atom. II. The atomic number is equal to the number of protons in an atom III. The number of electrons in an atom is equal to the total number of protons and neutrons in the nucleus. A. I only B. II only C. III only D. I and II only E. II and III only. (1983:Q34)
 - Which of the following statements describes an atom accurately? I. Atoms of all elements are identical II. An atom contains a nucleus and number of electrons. III. Due to the electrons in the atom, an atom is negatively charged. IV. Electrons in the atom move in circular orbits round the nucleus. A. I and II B. II and III C. III and IV D. II and IV E. I, II and III (1984:Q25)
 - Cathode rays are a high A. High-energy electromagnetic waves B. Protons C. Streams of electrons D. Neutrons E. Radio waves (1984:Q42)
 - Which of the following: I. β -particles II. Protons III. Neutrons IV. α -particles may be found in light nuclei? A. I and II B. I and III C. II and IV D. II and III E. I, II, and III. (1984:Q44)
 - Which of the following statements is (are) NOT true about the emission of photoelectrons from metallic surfaces? I. All metallic surfaces emit the same number of photoelectrons in a given light. II. Most metallic surfaces in visible and infrared light. III. A metallic surface emits photoelectric only if frequency of the incident light is higher than its own characteristic threshold frequency. A. I only B. II only C. I and II D. II and III E. III only (1984:Q48)
 - Which of the following features is NOT a characteristic of natural radioactivity? A. Radioactivity is a nuclear phenomenon.

- Radioactivity is exhibited only by elements of mass number greater than 206. C. The radioactivity of an element is affected by electric and magnetic fields in the surroundings. D. The radioactive element is transformed into a new element. (1985:Q49)
- What is the number of neutrons in the Uranium isotope ${}_{92}^{238}\text{U}$? A. 92 B. 146 C. 238 D. 330 E. 119 (1985:Q50)
- Which of the following is most strongly deflected by a magnetic field? A. gamma rays B. alpha particles C. beta-particles D. X-rays. (1986:Q50)
- What type of reaction is represented by the following scheme? ${}^1_1\text{X} + {}^1_1\text{Y} \rightarrow {}^2_2\text{Z} + {}^1_0\text{n} + \text{energy}$. A. Fusion reaction B. Fission reaction C. Chain reaction D. Radioactive decay. (1987:Q47)
- Which of the following statements is TRUE of photoelectric effect? A. It cannot occur in liquids B. The energy of the emitted electron is independent of the work function of the surface C. The energy of the emitted electron depends on the wavelength of the incident light D. The greater the intensity of the incident, the greater the energy of the emitted electron. (1987:Q48)
- Isotopes are nuclei which have A. The same number of neutrons and electrons B. Equal number of electrons and protons C. The same atomic number but different number of neutrons D. The same number of total particles (1987:Q49)
- A radioactive sample initially contains N atoms. After three half-lives the number of atoms that have disintegrated is A. N/8 B. 3N/8 C. 5N/8 D. 7 N/8 (1987:Q50)
- In a certain fusion reaction, a deuteron (${}^2_1\text{H}$) interacts with a triton (${}^3_1\text{H}$) and produces an α particle (${}^4_2\text{He}$) and a second product. The second product is A. A proton B. An electron C. A neutron D. A gamma ray. (1988:Q48)
- Which of the following symbolic representations is correct for an atom X with 22 electrons and 43 neutrons? A. ${}_{22}^{65}\text{X}$ B. ${}_{43}^{22}\text{X}$ C. ${}_{43}^{65}\text{X}$ D. ${}_{22}^{43}\text{X}$ (1988:Q49)



30.

A particle is injected perpendicularly into an electric field. It travels along a curved path as depicted in the figure above. The particle is A. A gamma ray

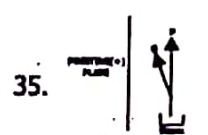
B. An electron C. A neutron D. A proton. (1988:Q50)

- A radioactive substance has a half-life of 2 years. If the initial mass is 40g, which of the following rows correctly gives the mass of substance left at the times stated?

| 2years | 3years | 4years | 5years |
|--------|--------|--------|--------|
| A. 20g | | 10g | |
| B. 20g | 20g | 10g | 0g |
| C. 30g | 20g | 15g | |
| D. 20g | | 10g | 0g |

(1989:Q46)

- When a radiation strikes a metal surface, electrons may be ejected from the metal. The maximum kinetic energy which may be acquired by an ejected electron depends on the A. Intensity of the radiation B. Source of the radiation C. Wavelength of the radiation D. Detection device for the electron. (1989:Q47)
- Which of the following is TRUE of the particles emitted in radioactive disintegration? A. The alpha particle is the helium nucleus B. The alpha particle is lighter than the beta particle C. The alpha particle is deflected more than the beta particle in a magnetic field D. The beta particle is deflected more than alpha particle in a magnetic field. (1989:Q48)
- Eight alpha decays and six beta decays necessary before an atom of ${}_{92}^{238}\text{U}$ achieves stability. The final product in the chain has an atomic number of A. 70 B. 78 C. 82 D. 90 (1989:Q49)



35.

A beam of radiation is passed between a pair of charged plates indicated in the diagram above. Beam P is undeflected while Q is deflected to the left. P and Q

- respectively could be I. α -rays and β -rays II. x-rays and β -rays III. γ -rays and α -rays IV. x-rays and x-rays. A. I only B. III only C. I and II D. III and IV. (1989:Q50)

36. The number of neutrons contained in the nucleus of $^{238}_{92}\text{U}$ is
 A. 92 B. 146 C. 238 D. 330 (1990:Q46)
37. A substance has a half life of 3min. after 6min, the count rate was observed to be 400. What was its count rate at zero time?
 A. 200 B. 1 200 C. 1 600 D. 2 400 (1990:Q48)
38. The photocell works on the principle of the A. Voltaic cell B. Emission of electrons by incident radiation C. Emission of protons by incident electrons, D. photographic plate (1990:Q50)
39. Which of the following statements are TRUE of isotopes? I. Isotopes of an element have the same chemical properties because they have the same number of electrons. II. Isotopes of elements are normally separated using physical properties III. Isotopes of an element have the same number of protons in the nuclei. A. I and II only B. I and III only C. II and III only D. I, II and III. (1991:Q45)
40. When an atom loses or gains a charge, it becomes A. An electron B. An ion C. A neutron D. A proton. (1991:Q46)
41. 4g of a radioactive material of half-life 10 days is spilled on a laboratory floor. How long would it take to disintegrate 3.5g of the material? A. $1\frac{1}{4}$ days B. $8\frac{3}{4}$ days C. 30 days D. 80 days. (1991:Q47)
42. In a nuclear fusion process, four protons each of mass M_p were fused to produce a nucleus X of mass M_x . Which of the following equations is CORRECT? A. $4M_p > M_x$ B. $4M_p = M_x$ C. $4M_p < M_x$ D. $M_p = M_x$ (1991:Q48)
43. Which of the following are TRUE for α -decay I. Mass number decreases by four II. Atomic number decreases by two III. Mass number does not change. A. I and II only B. II and III only C. I and III only D. I, II and III. (1991:Q49)
44. Which of the following phenomena is called photoelectric effect?
 A. High energy electrons impinge on a metallic anode which then emits photons B. A high energy photon emits photons as it is slowed down C. A metal absorbs quanta of light and then emits electrons D. Two electrons are created from quantum of light. (1991:Q50)
45. Which of the following graphs correctly illustrates the number of remaining atoms during a radioactive decay.
-
- (1992:Q47)
46. The threshold frequency for photoelectric effect depends on the
 A. Intensity of incident light B. Frequency of incident light
 C. Material of the photocathode D. Potential difference between the cathode and the anode (1992:Q48)
47. After three half life, the fraction of a radioactive material that has decayed is A. $1/8$ B. $1/3$ C. $2/3$ D. $7/8$ (1992:Q49)
48. $^{27}_{13}\text{Al} + ^1_0\text{n} \rightarrow ^{24}_{11}\text{Na} + X$. In the nuclear reaction above, the product denoted by X is A. A proton B. A gamma ray C. A helium particle D. An alpha particle. (1992:Q50)
49. Natural radioactivity is the random spontaneous disintegration of the nuclei of heavy isotopes of certain elements with the emission of
 A. α , β and X-rays B. α , β and γ -rays C. X, α and γ -rays
 D. β , γ and X-rays. (1993:Q47)
50. Which of the following are produced after a nuclear fusion process?
 I. One heavy nucleus II. Neutrons III. Protons IV. Energy A. I and II B. I and IV C. II and III D. II and IV. (1993:Q48)
51. An element X of atomic number 88 and mass number 226 decays to form an element Z by emitting two beta particles and an alpha particles. Z is represented by A. $^{222}_{86}\text{Z}$ B. $^{222}_{90}\text{Z}$ C. $^{226}_{88}\text{Z}$ D. $^{226}_{90}\text{Z}$ (1993:Q49)
52. The kinetic energy of a photoelectron liberated from a metallic surface depends on the
 A. Intensity of the incident radiation
 B. Time duration of the incident radiation C. Temperature of the incident radiation D. Frequency of the incident radiation (1993:Q50)
53. A certain radioisotope of $^{235}_{92}\text{U}$ emits four alpha particles and three beta particles. The mass number and the atomic number of the resulting element respectively are A. 219 and 87 B. 84 and 223 C. 223 and 87 D. 219 and 81 (1994:Q48)
54. If the light with photon energy 2eV is incident suitably on the surface of a metal with work function 3eV, then
 A. No electron will be emitted
 B. The few electrons emitted will have a maximum kinetic energy of 1eV
 C. The few electrons emitted will have a maximum kinetic energy of 3eV
 D. Many electrons will be emitted. (1994:Q50)
55. The half-life of a radioactive element is 9 days. What fraction of atoms has decayed in 36 days? A. $1/16$ B. $1/4$ C. $1/2$ D. $15/16$ (1995:Q49)
56. A light of energy 5eV falls on a metal and the electrons with a maximum kinetic energy of 2eV are ejected. The work function of the metal is A. 0.4eV B. 2.5eV C. 3.0eV D. 7.0eV (1995:Q50)
57. One of the features of the fission process is that
 A. Its products are not radioactive B. It leads to chain reaction
 C. Neutrons are not released D. The sum of the masses of the reactants equals the sum of the masses of the products. (1997:Q49)
58. The graphite rods surrounding the uranium fuel rods in a nuclear reactor, are used to
 A. Absorb the neutrons and hence halt the nuclear process B. Create the neutrons and hence start up the nuclear process.
 C. Slow down the neutrons and hence slow down the nuclear process. D. Speed up the neutrons and hence speed up the nuclear process. (1997:Q50)
59. A radioactive substance has a half-life of 80 days. If the initial number of atoms in the sample is 6.0×10^{10} , how many atoms would remain at the end of 320 days? A. 3.75×10^9 B. 7.50×10^9 C. 3.00×10^{10} D. 5.63×10^{10} (1998:Q48)
60. In a nuclear fusion experiment, the loss of mass amounts to $1.0 \times 10^{-6}\text{kg}$. The amount of energy obtained from the fusion is
 A. $3.0 \times 10^{-1}\text{J}$ B. $3.0 \times 10^{-1}\text{J}$ C. $9.0 \times 10^1\text{J}$ D. $9.0 \times 10^{11}\text{J}$
 [Speed of light = $3.0 \times 10^8\text{ms}^{-1}$] (1998:Q49)
61. In photoelectric effect, electrons will leave the metal surface when illuminated by light of appropriate frequency if the photon energy is
 A. Greater than the work function. B. Less than the work function
 C. Equal to the work function D. Equal to the maximum kinetic energy of the electrons. (1998:Q50)
62. If Δx is the uncertainty in the measurement of the position of a particle along the x-axis and ΔP_x is the uncertainty in the measurement of the linear momentum along the x-axis, then the uncertainty principle relation is given as
 A. $\Delta x \Delta P_x \geq h$ B. $\Delta x \Delta P_x = 0$
 C. $\Delta x \Delta P_x < h$ D. $\Delta x \Delta P_x = \infty$ (1999:Q43)
63. $^{23}_{11}\text{Na} + \text{Proton} \rightarrow ^p_q\text{X} + \text{alpha particle}$. What are the values of p and q respectively in the equation above? A. 10 and 20 B. 12 and 24 C. 20 and 10 D. 24 and 12. (1999:Q44)
64. What is the speed of a particle of mass 10^{-27}kg . Whose wavelength is 10^{-8}m ? A. 6.63ms^{-1} B. 66.30ms^{-1} C. 663.00ms^{-1} D. 6630.00ms^{-1}
 ($h = 6.63 \times 10^{-34}\text{Js}$) (1999:Q47)
65. Gamma rays are produced when
 A. High velocity electrons are abruptly stopped in metals B. Energy changes occur within the nucleus atoms
 C. Energy changes occur within the electronic structure of atoms D. Electrons are deflected in very strong magnetic fields. (1999:Q49)
66. In the Rutherford scattering experiment, a beam of alpha particles was fired at a thin gold film with some of the particles being considerably deflected. This shows that
 A. A gold nucleus contains protons, neutrons and electrons uniformly distributed in a tiny volume.
 B. The gold nucleus is positively charged and is concentrated in a tiny volume
 C. The gold nucleus emitted alpha particles D. The gold nucleus is concentrated in a tiny volume and contains alpha particles. (1999:Q50)
67. An electron of charge $1.6 \times 10^{-19}\text{C}$ and mass $9.1 \times 10^{-31}\text{kg}$ is accelerated between two metal plates with a velocity of $4 \times 10^7\text{ms}^{-1}$, the potential difference between the plates is
 A. $4.55 \times 10^4\text{V}$ B. $9.10 \times 10^4\text{V}$ C. $4.55 \times 10^5\text{V}$ D. $4.55 \times 10^6\text{V}$ (2000:Q28)
68. If the fraction of the atoms of a radioactive material left after 120 years is $1/64$. What is the half-life of the material?
 A. 2years B. 10years C. 20years D. 24years (2000:Q37)
69. A certain radioactive source emits radiations that were found to be deflected by both magnetic and electric fields. The radiations are
 A. x-rays B. beta rays C. gamma rays D. ultra-violet rays (2000:Q38)
70. Light energy 5eV falls on a metal of work function 3eV and electrons are liberated. The stopping potential is
 A. 15.0V B. 8.0V C. 2.0V D. 1.7V (2000:Q41)
71. In the thermonuclear reaction, the total initial mass is $5.02 \times 10^{-27}\text{kg}$. The energy released in the process is
 A. $9.0 \times 10^{12}\text{J}$ B. $9.0 \times 10^{13}\text{J}$
 C. $9.0 \times 10^{14}\text{J}$ D. $9.0 \times 10^{15}\text{J}$ (2000:Q42)

72. If the frequency ν Hz, the accelerating potential is A. 6.6V B. 66.3V C. 663.0V D. 6630.0V [$e = 1.6 \times 10^{-19}$ C, $h = 6.63 \times 10^{-34}$ Js] (2000:Q44)
73. The particle emitted when $^{39}_{19}\text{K}$ decays to $^{39}_{19}\text{K}$ is A. gamma B. beta C. electron D. alpha (2001:Q39)
74. Which of the following metals will provide the greatest shield against ionizing radiation? A. Iron B. Manganese C. Aluminium D. Lead (2001:Q42)
75. The process of energy production in the sun is A. nuclear fission B. nuclear fusion C. electron collision D. radioactive decay (2001:Q44)
76. The particle that is responsible for nuclear fission in a nuclear reactor is A. electron B. photon C. neutron D. proton (2002:Q41)
77. The energy associated with the photon of a radio transmission at 3×10^5 Hz is A. 1.30×10^{-29} J B. 2.00×10^{-29} J C. 1.30×10^{-28} J D. 2.00×10^{-28} J (2002:Q43)
78. The percentage of the original nuclei of a sample of a radioactive substance left after 5 half-lives is A. 1% B. 8% C. 5% D. 3% (2002:Q45)
79. $^{23}_{11}\text{Na} + X \rightarrow ^{20}_{9}\text{F} + ^4_2\text{He}$. What is the particle is X in the reaction above? A. Beta B. Gamma C. Alpha D. Neutron (2002:Q49)
80. An electron of charge 1.6×10^{-19} C is accelerated between two metal plates. If the kinetic energy of the electron is 4.8×10^{-17} J, the potential difference between the plates is A. 30V B. 40V C. 300V D. 400V (2003:Q33)
81. The count rate of a radioactive material is 800 count/min. If the half-life of the material is 4 days, what would the count rate be 16 days later? A. 200 count/min. B. 100 count/min. C. 50 count/min. D. 25 count/min. (2003:Q40)
82. If the uncertainty in the measurement of the position of a particle is 5×10^{-10} m, the uncertainty in the momentum of the particle is A. 1.32×10^{-24} Ns B. 3.30×10^{-24} Ns C. 1.32×10^{-24} Ns D. 3.30×10^{-24} Ns [$h = 6.6 \times 10^{-34}$ Js] (2003:Q42)
83. The maximum kinetic energy of the photoelectrons emitted from a metal surface is 0.34eV. If the work function of the metal surface is 1.83eV, find the stopping potential. A. 2.17V B. 1.49V C. 1.09V D. 0.34V (2003:Q44)
84. In a fission process, the decrease in mass is 0.01%. How much energy could be obtained from the fission of 1.0g of the material? A. 9.0×10^9 J B. 9.0×10^{10} J C. 6.3×10^{11} J D. 9.0×10^{11} J [$c = 3.0 \times 10^8$ ms $^{-1}$] (2003:Q46)
85. An electron makes a transition from a certain energy level E_k to the ground state E_0 . If the frequency of emission is 8.0×10^{14} Hz, the energy emitted is A. 8.25×10^{-19} J B. 5.28×10^{-19} J C. 5.28×10^{19} J D. 8.25×10^{19} J [$h = 6.6 \times 10^{-34}$ Js] (2003:Q48)
86. When a nucleus is formed by bringing protons and neutrons together, the actual mass of the formed nucleus is less than the sum of the masses of the constituent protons and neutrons. The energy equivalent of this mass difference is the A. lost energy B. work function C. building energy D. stability energy (2003:Q50)
87. A radioisotope has a decay constant of 10^{-7} s $^{-1}$. The average life of the radioisotope is. A. 6.93×10^6 s. B. 1.00×10^{-7} s C. 1.00×10^7 s D. 6.93×10^7 s. (2004:Q19)
88. The binding energy of helium He is A. 2.017U B. 0.033U C. 4.033U. D. 0.330U. [atomic mass of proton = 1.00783U, atomic mass of neutron = 1.00867U] (2004:Q21)
89. The particle and wave nature of matter are demonstrated in the equation. A. $\lambda = \frac{h}{p}$ B. $\lambda = \frac{c}{f}$ C. $\lambda = 2d \sin \theta$ D. $\lambda = \frac{hc}{E}$ (2004:Q23)
90. X-rays can be used in the study of crystal structures because they A. have an extremely short wavelength. B. have a very long-reaching wavelength C. are very fast. D. are invisible (2004:Q28)
91. The difference between x-rays and gamma rays is that A. x-rays arise from energy changes in the electronic structure of atoms while gamma rays come from the nucleus. B. x-rays are electromagnetic radiations. C. x-rays have higher frequencies than gamma rays. D. x-rays are more penetrating than gamma rays. (2004:Q44)
92. The ray which causes gas molecules to glow is unknown as A. molecular ray. B. gamma ray. C. cathode ray. D. cathode ray. (2005:Q5)
93. $^{235}_{92}\text{U} + ^1_0\text{n} \rightarrow ^{144}_{56}\text{Ba} + ^{90}_{36}\text{Kr} + 2X$. In the reaction above, X is A. neutron. B. electron. C. neutrino. D. proton. (2005:Q7)
94. The time it will take a certain radioactive material with a half-time of 50 days to reduce to 1/32 of its original number is A. 300 days. B. 150 days. C. 200 days. D. 250 days. (2005:Q9)
95. The amount of energy released when 0.5kg of uranium is burnt completely is a. 4.5×10^{16} J. B. 1.5×10^{16} J. C. 1.5×10^9 J. D. 4.5×10^9 J. [$c = 3 \times 10^8$ ms $^{-1}$] (2005:Q12)
96. In photoelectric effect, which of the following graphs correctly represents the graph of stopping potential V_0 against frequency f of incident light?
-
- (2005:Q14)
97. One of the properties of gamma rays is that they are A. negatively charged B. massive C. neutral D. positively charged. (2006:Q2)
98. A radioactive element has a half life of 4 days. The fraction that has decayed in 16 days is A. 3/4 B. 1/16 C. 15/16 D. 1/4 (2006:Q4)
99. The energy associated with the emitted photon when a mercury atoms changes from one state to another is 3.3 eV. Calculate the frequency of the photon. A. 8.0×10^{14} Hz. B. 3.1×10^{15} Hz. C. 1.3×10^{15} Hz. D. 3.2×10^{15} Hz. [$e = 1.6 \times 10^{-19}$ C; $h = 6.6 \times 10^{-34}$ Js] (2006:Q8)
100. The energy E of a photon and its wavelength are related by $E = \frac{X}{\lambda}$. The numerical value of X is A. 1.99×10^{-27} B. 6.60×10^{-26} C. 1.99×10^{-25} D. 6.60×10^{-24} [$h = 6.63 \times 10^{-34}$ Js, $c = 3 \times 10^8$ ms $^{-1}$] (2007:Q9)
101. A radioactive substance has a half-life of 20 days. What fraction of the original radioactive nuclei will remain after 80 days? A. 1/16 B. 1/8 C. 1/4 D. 1/32. (2007:Q10)
102. A photon of wavelength 6.0×10^{-7} m behaves like a particle of a certain mass. The value of that mass is A. 1.1×10^{-29} kg. B. 2.2×10^{-27} kg. C. 3.5×10^{-26} kg. D. 2.2×10^{-25} kg. [$h = 6.63 \times 10^{-34}$ Js, $c = 3 \times 10^8$ ms $^{-1}$] (2007:Q12)
103. During the nuclear reactions described by $^{235}_{92}\text{W} \rightarrow ^{235}_{92}\text{X} \rightarrow ^{231}_{91}\text{Y}$, the particles emitted are respectively A. β and β B. β and α C. α and β D. α and α (2007:Q13)
104. If electrons accelerated from rest through a potential difference of 10kV, what is the wavelength of the associated electron? A. 1.22×10^{-11} m B. 3.87×10^{-10} m C. 2.27×10^{11} m D. 2.27×10^{14} m [$m_e = 9.1 \times 10^{-31}$ kg, $e = 1.6 \times 10^{-19}$ C, $h = 6.6 \times 10^{-34}$ Js] (2008:Q45)
105. $^{14}_7\text{N} + ^4_2\text{He} \rightarrow ^{17}_8\text{O} + X$. In the equation above, the particle X is A. a proton B. a neutron. C. an α -particle. D. a β -particle (2008:Q46)
106. Caesium has a work function of 3×10^{-19} J. The maximum energy of liberated electrons when it is illuminated by light of frequency 6.7×10^{14} Hz is A. 1.42×10^{-19} J B. 3.00×10^{-19} J. C. 4.42×10^{-19} J. D. 7.42×10^{-19} J. [$h = 6.6 \times 10^{-34}$ Js] (2008:Q47)
107. Cancerous cells can be destroyed by A. ultraviolet rays. B. alpha particles c. x-rays D. infrared rays. (2009:Q45)
108. If the decay constant of a radioactive substance is 0.231 s $^{-1}$, the half-life is A. 3.00s. B. 0.12s. C. 0.33s. D. 1.50s (2009:Q46)
109. A piece of radioactive material contains 10^{20} atoms. If the half-life of the material is 20 seconds, the number of disintegration in the first second is A. 3.47×10^{18} B. 6.93×10^{20} C. 3.47×10^{20} D. 6.93×10^{18} . (2009:Q47)
110. Thermionic emission is the process whereby A. β -rays are produced. B. holes are produced. C. x-rays are produced. D. electrons leave a hot element. (2009:Q48)
111. The radioisotope $^{235}_{92}\text{U}$ decays by emitting two alpha particles, three beta particles and a gamma ray. What is the mass and atomic numbers of the resulting daughter element? A. 91 and 227 B. 92 and 238 C. 227 and 91 D. 215 and 88. (2010:Q46)
112. The ground state energy for a hydrogen atom is 5.44×10^{-19} J. If an electron drops from zero energy to ground state, calculate the frequency of the emitted radiation. A. 2.0×10^{14} Hz. B. 2.0×10^{15} Hz. C. 5.0×10^{14} Hz. D. 5.0×10^{15} Hz [$h = 6.6 \times 10^{-34}$ Js] (2010:Q47)
113. A radioactive isotope has a decay constant of 10^{-5} s $^{-1}$. Calculate its half life. A. 6.93×10^4 s B. 6.93×10^6 s C. 6.93×10^5 s

- D. 6.93×10^5 s (2011:Q41)
114. If the threshold frequency for tungsten is 1.3×10^{15} Hz, what is the work function? A. 8.5×10^{-17} J B. 8.85×10^{-18} J C. 8.58×10^{-19} J D. 8.58×10^{-15} J [$h = 6.6 \times 10^{-34}$ J s] (2011:Q43)
115. The process of detecting a pin mistakenly swallowed by a child is x-ray A. diagnosis B. therapy C. crystallography D. mammography (2012:Q45)
116. Which of the following particles CANNOT be deflected by both electric and magnetic fields? A. Gamma rays. B. Alpha particles. C. Wave particles. D. Beta particles. (2012:Q46)
117. A piece of radioactive material contains 1 000 atoms. If its half-life is 20seconds, the time taken for 125 atoms to remain is A. 20 seconds B. 40 seconds C. 60 seconds D. 80 seconds. (2012:Q47)
118. Calculate the energy of the third level of an atom if the ground state energy is -24.8eV A. -9.20eV. B. -8.20eV. C. -2.75eV. D. -1.75eV. (2013:Q46)
119. In photo-emission, the number of photoelectrons ejected per second depends on the A. frequency of the beam. B. work function of the metal C. threshold frequency of the metal. D. intensity of the beam. (2013:Q47)
120. The particle nature of light is demonstrated by the A. photoelectric effect. B. speed of light. C. colours of light. D. diffraction of light. (2013:Q48)
121. What type of reaction is represented by the equation ${}^2_1X + {}^2_1X \rightarrow {}^3_1Y + {}^1_0n + \text{energy}$? A. Fusion. B. Fission. C. Chain. D. Ionization. (2014:Q44)
122. When an atom undergoes a beta decay, the atomic number of the nucleus A. decreased by one. B. increases by one. C. becomes zero D. remains unchanged. (2014:Q45)
123. Calculate the mass of the copper deposited during electrolysis when a current of 4A passes through a copper salt for 2 hours. A. 9.5×10^{-7} kg B. 9.5×10^{-3} kg C. 2.9×10^{-4} kg D. 2.9×10^5 kg [e.c.e. of copper $z = 3.3 \times 10^{-7}$ kgC⁻¹] (2014:Q46)
124. Which gas produces a pink coloured light in a discharge tube? A. Argon. B. Air. C. Neon. D. Mercury. (2014:Q47)
125. Which ${}^{210}_{82}\text{Pb}$ decays to ${}^{206}_{80}\text{Pb}$, it emits A. an alpha particle B. one beta particle. C. one alpha and one beta particle. D. two alpha and two beta particles. (2014:Q48)
126. Which of the following statement is NOT true about atoms? A. An atom is made up of a nucleus and a number of electrons B. The mass of an atom is concentrated in the nucleus. C. Atoms of different elements have different atomic weights. D. Atoms of all elements are identical. (2015:Q9)
127. What is the energy with which an incident light of wavelength 10^{-7} m falls on a metal and electrons are emitted? [$c = 3.0 \times 10^8$ ms⁻¹; $h = 6.63 \times 10^{-34}$ J s] A. 1.99×10^{-18} J B. 1.99×10^{-16} J C. 1.99×10^{-19} J D. 1.99×10^{-20} J. (2015:Q21)
128. The photo cell works on the principle of the A. voltaic cell B. emission of electron by incident radiation C. emission of protons by incident electrons D. photographic plate (2018:Q18)
129. The energy needed to separate the nucleons against the forces which hold them together is A. nuclear energy B. mechanical energy C. ionisation energy D. binding energy (2018:Q7)

CHAPTER 30 (ANSWERS)

ATOMIC PHYSICS. RADIOACTIVITIES

1. The number of negatively charged electrons is equal to the number of positively charged protons hence the equal opposite charges cancel out. Thus an atom is electrically neutral. **No option is right.**
- 2B. The time taken for let's say 30g of uranium to decay to 15g is the half life of uranium.
- 3C. α -particle = ${}^4_2\text{He}$ (+ve); β -particle = ${}^0_{-1}\text{e}$ (-ve); γ -ray = nil (neutral)

NOTE:

- γ -ray is just a wave of the electromagnetic variety. It has no particulate properties such as mass and charge.
- α -particle or rays are helium nuclei containing 2protons (+ve) and 2 neutrons (-ve) hence with mass number or nucleon number of 4 unit and atomic number 2 unit.
- β -particle or rays are a stream of fast moving electrons whose masses are vanishingly small with atomic number-1

- 4D. Protons and neutrons are resident in nucleus and the sum total of their numbers constitutes the nucleon number or mass number of the element. Electrons exist in energy levels or shells or orbits which are imaginary regions of very high probability of finding an electron.
- 5D. (A) \rightarrow This no of proton which is invariably the no of electron in a neutral atom is the atomic no of a given element and it is different from those of other elements
(B) \rightarrow See Q1
(C) \rightarrow The planetary model of the atom by Earnest Rutherford in that the mass of the atom is concentrated at a central core equivalent to the sun while the electrons on the orbits correspond to the planets around the sun in our solar system
- 6D. (A), (B) and (C) are raw Dalton's Atomic Theory although now modified by phenomena such as radioactivity and isotopy.
- 7C. X-ray is not used for this purpose.
- 8C. See Q3
- 9E. Hence lead coat is the best protective shield against indiscriminate exposure to X-rays and any other ionizing radiation.
- 10C. The activity of a radioactive element is independent of temperature and of course, pressure.
- NOTE:**
- Pierre and Marie Curie suspected that pitchblende, an ore of uranium, was contaminated with impurities responsible for its inexplicably heightened Radioactivities.
 - The two impurities isolated from pitchblende were polonium and radium.
 - As a radioactive material ages, its activity decline because it disintegrates to produce fewer atoms available for radioactivities.
- 11D. Production of x-rays is an artificial process while a radioactive substance emits α - β - and γ - rays naturally spontaneously from the nuclei of its atoms.
- 12E. X-rays are only produced when fast moving electrons bombard a metal and knock out electrons from the inner shells of its atoms. The electrons are replaced by electrons from outer shells and this is accompanied by radiation of the electromagnetic nature like light but with a shorter wavelength.
- NOTE:**
- Roentgen** who first (accidentally) produced x-rays said "Let the unknown rays be X" and the name x-ray stuck.
 - Protons (positive ray) and neutrons which are resident in the nuclei also produce rays and are used in transmutation of elements they bombard as in artificial radioactivities.
- 13E. Mass of proton = 1.0078 *amu
Mass of neutron = 1.0087 *amu
- NOTE:**
- A neutron is slightly or negligibly weighter than a proton hence their masses are taken as 1amu each.
 - By amu we mean atomic mass unit.
 - An electron is about 1840times less massive as a proton or neutron hence its mass is taken as zero and electrons are therefore, not taken into mathematical reckoning in computing the atomic mass of an element.
 - Atomic mass = mass no= nucleon number = protons +neutrons
*Recall that proton and neutron reside in the nucleus.
- 14D. γ -ray has ionizing effect through gases including air. Also See Qs 3, 9, 11 and 12.
- 15A. ${}^{235}_{92}\text{L} \rightarrow {}^{235}_{93}\text{M} + {}^0_1\text{e}$; ${}^{235}_{93}\text{M} \rightarrow {}^{235}_{94}\text{N} + {}^0_1\text{e}$
 ${}^{235}_{94}\text{N} \rightarrow {}^{227}_{90}\text{P} + 2({}^4_2\text{He})$
- 16B. See Q5 17D. See Q4 18C. See chapter 29
- 19D. Generally, light nuclei show no radioactive property hence their nuclei containing protons(II) and neutrons(III) are stable. Heavy nuclei especially those above lead (${}^{208}_{82}\text{Pb}$) in the periodic table tend to have unstable nuclei emitting α , β and γ - rays
- NOTE:** Notable exceptions of naturally occurring radioisotopes of light-nucleus elements are H-3, K-40 and C-14
- 20C. (I) Different metallic surfaces have different work functions hence different threshold frequency to liberate the minimum

number of electrons from their respective surfaces. (II) Photoelectrons are produced by visible light. (III) Threshold frequency is the minimum frequency (with correspondingly maximum wavelength) required or which must be exceeded to liberate an electron from an illuminated metal surface.

- 21C. (A) Or Nuclear reaction or disintegration
 (B) See Q19
 (C) The radiations but not the production of the radiations are affected (in terms of deflection or otherwise) by magnetic or electric fields.
 (D) See Q3 (E) And the transformation may continued in a decay series.
- 22B. Neutron number is given by: $n(n^0) = A - Z$ where $A =$ Nucleon number
 $Z =$ Atomic number $\rightarrow n(n^0) = 238 - 92 = 146$
 Recall: 1. $A =$ no of protons and neutron
 2. $Z =$ no of protons only
 3. No of electron = no of proton (neutral atom)
- 23C. (A) \rightarrow Not deflected at all for being neutral.
 (B) \rightarrow Slightly reflected for being relatively heavy and towards south pole in a magnetic field or towards plate in an electric field.
 (C) \rightarrow β -particles experience well pronounced deflection for being light (electrons) and towards north pole or +ve plate
 (D) \rightarrow X-rays are mere waves like visible light and γ -rays hence are undeflected.
- 24A. Two small (or light) nuclei fuse together to form a single larger (or heavier) nucleus with the emission of a small nuclear particle and energy.

NOTE:

- In fission reaction, the above is reversed when a larger nucleus is bombard by small particles to produce smaller nuclei.
- While nuclear fission is induced, Radioactive decay is spontaneous.

- 25C. (A) \rightarrow Occurs only when surfaces of metals are illuminated and Hg is a liquid.
 (B) \rightarrow The work function of the surface is given by $W = hf_0$ where $f_0 =$ specific threshold frequency for that surface.
 (C) \rightarrow See Q20
 (D) \rightarrow Increased in intensity only increases the number of photoelectrons emitted but not their energy or velocity.
- 26C. Or the same number of protons (atomic no) but different number of neutrons which accounts for the different masses or nucleon nos.

27D. Three half-lives: $N \xrightarrow{\frac{1st}{2}} \frac{N}{2} \xrightarrow{\frac{2nd}{4}} \frac{N}{4} \xrightarrow{\frac{3rd}{8}} \frac{N}{8}$

After the 3rd half-life, $\frac{1}{8}$ of N remains hence $\frac{7}{8}$ of N has been used up.

NEXT TIME: Let total time involved = T

$$\text{Half-life} = t \quad \therefore \text{No of half-lives} = n = \frac{T}{t}$$

The fraction L of the material of half-life t left after time T is

$$\text{given by } L = \frac{1}{2^n}. \text{ In the above case: } L = \frac{1}{2^3} = \frac{1}{8}$$

Hence fraction disintegrated F is given by $F = 1 - L = 1 - \frac{1}{8} = \frac{7}{8}$

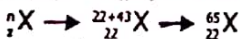
28C. Write a balanced nuclear equation: ${}^2_1\text{H} + {}^3_1\text{H} \rightarrow {}^4_2\text{He} + {}^1_0\text{n}$

$$\text{For mass no: } 2 + 3 = 4 + a \quad \rightarrow a = 1$$

$$\text{For atomic no: } 1 + 1 = 2 + b \quad \rightarrow b = 0$$

$\therefore X$ is a neutron $\rightarrow {}^1_0\text{n}$

29D. $n(e^-) = n(p^+) = \text{Atomic no} = Z \rightarrow n(p^+ + n^0) = \text{mass no} = A$



30B. Since the particle is deflected towards the positive plate of the electric field (see Q23)

NOTE: You will be disappointed if you always expect the ends of an electric field or the polarity of a magnetic field to be labelled for you. The directions of a field is +ve to -ve or North to South (See chapter 28).

31A. Only options (A) and (D) make sense up to 2 years and 4 years.

Even after 6 years, the amount left must be 5g hence (D) is not correct.

32C. See Q20 33. Option (A) and (D) are true

34C. 8α -decays = $8[{}^4_2\text{He}] \rightarrow 6\beta$ -decays = $6[{}^0_{-1}\text{e}]$

$$\text{For atomic number: } 92 - [8(2) + 6(-1)] = 82$$

$$\text{NOTE: If mass number is required: } 238 - [8(4) + 6(0)] = 226$$

35C. See Qs 23 and 30

36B. $238 - 92 = 146$

37C. The mass of the substance left is a measure of the no of its particle remaining and this is proportional to the count rate.

\therefore If initial count rate is N .

$$\text{After 2 half-lives: Count rate} = \frac{N}{2} = \frac{N}{4}, \frac{N}{4} = 400, N = 1600$$

- 38B. An application of photoelectric effect
 39D. In mass spectrometry, isotopes are separated by physical means [mass is a physical property]
 40B. +ve ion when it loses charge, -ve ion when it gains charge

41C. To disintegrate 3.5g then 0.5g is left i.e. $\frac{0.5}{4}$ or $\frac{1}{8}$ of the

original mass is left. But $\frac{1}{2^n} = \frac{1}{8} = \frac{1}{2^3}$ (see Q24)

$$\therefore n = 3 \text{ half-lives} \rightarrow T = 3 \times 10 \text{ days} = 30 \text{ days}$$

$$\text{Alternatively: } 4.0 \xrightarrow{10 \text{ day}} 2.0 \xrightarrow{10 \text{ day}} 1.0 \xrightarrow{10 \text{ day}} 0.5$$

To disintegrate to 0.5g, 30 days is required

42A. This difference is called mass defect (m) and it is converted to energy $E = mc^2$

43A. ${}^A_Z\text{X} \rightarrow {}^A_Z\text{Y} + {}^4_2\text{He}$ is 4 unit by mass less than X ; 2 unit by atomic number

44C. See Q20

45B. The curve touches the y-axis to indicate the starting point (when $t = 0$) but does not touch the x-axis (t -axis) as the atoms are not totally disintegrated.

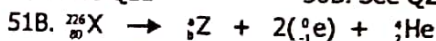
46C. See Q20

$$47D. \frac{1}{2^n} = \frac{1}{2^3} = \frac{1}{8}. \text{ Fraction decayed} = \frac{7}{8}$$

48D. After balancing for mass and atomic numbers

49B. See Q11

50B. See Q24



$$a + 2(0) + 4 = 226; a = 222; b + 2(-1) + 2 = 88 = 88$$

52D. See Qs 20 and 44

53A. Compare Q57

54A. The work function of a metal is the amount of energy just enough to liberate an electron from its surface.

NOTE:

- The work function W is a minimum (e.g 3eV here) and anything below it (e.g 2eV) produces no photoelectron.
- To attain the work function, the frequency of the incident must be increased until it reaches threshold frequency f_0 (since $W_0 = hf_0$) and anything below f_0 produces no photoelectricity.
- Thus for any surface, the incident light must be of high enough frequency (or correspondingly short enough wavelength) to eject an electron.
- If the energy (W) now exceeds the work function (W_0), the extra energy impacts kinetic energy on the electron to have the metal surface. $KE = W - W_0 = \frac{1}{2}mv^2$

$$55D. n = \frac{T}{t} = \frac{36}{9} = 4 \text{ half-lives; } L = \frac{1}{2^n} = \frac{1}{16}$$

$$F = 1 - \frac{1}{16} = \frac{15}{16} \text{ (see Q27)}$$

$$56C. W_0 = W - KE \text{ (see Q54)} \rightarrow W_0 = 5 - 2 = 3\text{eV}$$

57B. Features of Fission

- A heavy nucleus e.g U is bombarded and fragmented into two small nuclei.
- The bombardment is done by using a neutron of moderate speed.
- The fragments are of approximately equal masses and are unstable (or radioactive) (A)
- Two or more high-speed neutrons are also produced (C)
- The neutrons can bombard more uranium atoms to form chain reaction (B)
- Mass defect occurs as the sum of the masses of the fragments and bombarding neutron is less than the sum of the masses of the uranium fragmented and the neutrons released (D).
- It is this mass defect that is converted to the energy harnessed in nuclear reactors.

58C. Graphite as neutron moderator in atomic piles or nuclear reactor

$$59A. n = \frac{T}{t} = \frac{320}{80} = 4 \text{ half-lives; } L = \frac{1}{2^n} = \frac{1}{16}$$

$$\therefore \text{No of atoms which remain is } \frac{1}{16} \times 6.00 \times 10^{20} = 0.375 \times 10^{20}$$

60E. $E = mc^2 = 1.0 \times 10^{-6} \times (3.0 \times 10^8)^2 = 9.0 \times 10^{10} \text{J}$

61A. See Q54

62A. Heisenberg uncertainty principle

63C. ${}_{11}^{\text{Na}} + {}_{15}^{\text{P}} \rightarrow {}_{26}^{\text{Fe}} + {}_2^4\text{He}$; $p + 4 = 23 + 1$; $p = 20$
 $q + 2 = 11 + 1$ $q = 10$

64B. The wavelength is given: $\lambda = \frac{h}{p} = \frac{h}{mv}$ ($h = \text{Planck's constant}$;

$p = mv = \text{momentum}$) $\rightarrow 10^{-10} = \frac{6.63 \times 10^{-34}}{10^{-27} \times v} \rightarrow v = 66.30 \text{ms}^{-1}$

65B. Radioactivity as nuclear disintegration.

66B. The deflection suggests repulsion of the positively charged alpha particles by positively charged nuclear core.

67D. P.d is the work done (W) in moving a unit charge from one point to another in a circuit.

$V = \frac{W}{Q} = \frac{\frac{1}{2}mv^2}{Q} = \frac{\frac{1}{2} \times 9.1 \times 10^{-31} \times (4 \times 10^7)^2}{1.6 \times 10^{-19}} = 4.55 \times 10^6 \text{V}$

68C. $L = \frac{1}{2^n} = \frac{1}{64} = \frac{1}{2^6}$. But $n = \frac{T}{t}$ (see Q27)

$6 = \frac{120}{t} \rightarrow t = 20 \text{years}$.

69B. All are uncharged except beta-rays

70C. The stopping potential is the energy required to stop the motion of the ejected electron and this must be equal to its own kinetic energy ($KE = \frac{1}{2}mv^2$) $KE = W - W_0$ (see Q54) $= 5 - 3 = 2 \text{eV}$

71D. $\Delta m = (5.02 - 5.01) \times 10^{-27} \text{Kg}$

$E = \Delta mc^2 = 0.01 \times 10^{-27} \times (3 \times 10^8)^2 = 9 \times 10^{-13} \text{J}$

72B. $W = hf \rightarrow$ But $V = \frac{W}{Q} \therefore W = QV \rightarrow QV = hf$

$1.6 \times 10^{-19} \times V = 6.63 \times 10^{-34} \times 3 \times 10^{16} \rightarrow V = 66.3 \text{V}$

73A. Gamma ray is no particle hence no change

74D. See Q9

75B. Fusion is a thermonuclear reaction requiring heat in the order of $10^6 - 10^8$ degree celsius and this is possible because the core of the sun indeed provides such high temperature.

76C. See Q57

77D. $W = hf = 6.63 \times 10^{-34} \times 3 \times 10^5 = 1.989 \times 10^{-28} \text{J}$

78D. $L = \frac{1}{2^n} = \frac{1}{2^5} = \frac{1}{32} \therefore \% \text{left} = \frac{1}{32} \times 100\% = 3.125\%$

79D. Particle is ${}^1_0\text{n}$

80C. $W = qV \therefore V = \frac{4.8 \times 10^{-17}}{1.6 \times 10^{-19}} = 300 \text{V}$

81C. $L = \frac{1}{2^n} = \frac{1}{2^4} = \frac{1}{16} = (n = \frac{16}{4})$

Count rate (at $T = 16$): $\frac{1}{16} \times 800 = 50$

82C. $\Delta p \Delta x \geq h \rightarrow \Delta p \times 5 \times 10^{-10} \geq 6.6 \times 10^{-34}$
 $\Delta p \geq 1.32 \times 10^{-24} \text{Ns}$

83D. See Q70

84A. Mass defect $= x \cdot 1.0g = 1 \times 10^{-7} \text{Kg}$

$E = \Delta mc^2 = 1 \times 10^{-7} \times (3 \times 10^8)^2 = 9.0 \times 10^9 \text{J}$

88B. $E_x - E_0 = hf \rightarrow \Delta E = 6.6 \times 10^{-34} \times 8 \times 10^{14} = 5.28 \times 10^{-19} \text{J}$

88B. $E_x - E_0 = hf$ $E = 6.6 \times 10^{-34} \times 8 \times 10^{14} = 5.28 \times 10^{-19} \text{J}$

86C. The energy which holds (or binds) the particles together

87. The half-life t and the decay constant are related by

$t = \frac{0.693}{\lambda} \rightarrow t = \frac{0.693}{10^{-7}} = 6.93 \times 10^6 \text{s}$. **No option is correct**

88B. Helium H of mass number 4.000 has a binding energy E given by:

$E = \text{Total mass of particles} - \text{Mass number}$

$E = [2(1.00783) + 2(1.00867)] - 4.000$ $E = 4.033 - 4.000 = 0.033 \text{u}$

89A. $\lambda = \text{wavelength}$ (indicating wave nature) $m = \text{mass}$ (indicating the particulate nature of matter and mass is a characteristic of all matter)

90A. Short wavelength but high frequency crystal particles are too small to be captured by the large wavelength of ordinary white light and this also explains why electron microscope instead of light microscope is used in virology.

91A. Major difference lies in their productions.

92D. And the colour of the glowing gas depends on the gas in the discharge tube.

93A. See also Qs 57 and 63

94D. $L = \frac{1}{2^n} = \frac{1}{32} = \frac{1}{2^5} \rightarrow n = 5$ and $t = 50 \text{days}$

But $\frac{T}{t} = n \rightarrow T = 5 \times 50 = 250 \text{days}$

95A. $E = \Delta mc^2 = 0.5 \times (3 \times 10^8)^2 = 4.5 \times 10^{16} \text{J}$

95A. $E = mc^2 = 0.5 \times (3 \times 10^8)^2 = 4.5 \times 10^{16} \text{J}$

96D. A straight-line graph cutting the f -axis at an intercept $I = \text{threshold frequency } f_0$. As the frequency of the incident light increases above f_0 , the stopping potential which corresponds to the kinetic energy of the photoelectron increases.

97C. See Q73

98C. This is after 4 half-lives $(\frac{16}{4}) \rightarrow F = 1 - L = 1 - \frac{1}{2^4}$; $F = \frac{15}{16}$

99A. $\Delta E = hf \rightarrow \therefore f = \frac{3.3 \times 1.6 \times 10^{-19}}{6.63 \times 10^{-34}} = 8 \times 10^{14} \text{Hz}$

100C. If $\lambda = x$ then $E = \frac{hc}{\lambda}$ --- (1) Recall that $E = hf$ and $f = \frac{c}{\lambda}$

$\therefore E = \frac{hc}{\lambda}$ --- (2) \rightarrow Comparing (1) and (2):

$x = hc = 6.63 \times 10^{-34} \times 3 \times 10^8 = 1.99 \times 10^{-25}$

101A. After 4 half-lives: $= \frac{1}{2^4} = \frac{1}{16}$

102C. $\lambda = \frac{h}{mv} \rightarrow m = \frac{h}{\lambda v}$; $m = \frac{6.6 \times 10^{-24}}{6 \times 10^7 \times 3 \times 10^4} = 3.67 \times 10^{-36}$

103B. Factor in $({}^0_1\text{e})$ and $({}^4_2\text{He})$ respectively

104A. $E = eV = 1.6 \times 10^{-19} \times 10 \times 10^3 = 1.6 \times 10^{-15} \text{J}$

But $E = KE$ of electron and $KE = \frac{1}{2}mv^2$

$1.6 \times 10^{-15} = \frac{1}{2} \times 9.1 \times 10^{-31} \times v^2 \therefore v = 5.93 \times 10^6 \text{ms}^{-1}$

But $\lambda = \frac{h}{mc} \rightarrow \lambda = \frac{6.6 \times 10^{-34}}{9.1 \times 10^{-31} \times 5.93 \times 10^6}$

$\lambda = 1.22 \times 10^{-11} \text{m}$

105A. This is proton p

106A. $E_{\text{max}} = hf - hf_0$ where $hf_0 = \text{work function}$

$E_{\text{max}} = (6.6 \times 10^{-34} \times 6.7 \times 10^{14}) - 3 \times 10^{-19} = 1.422 \times 10^{-19} \text{J}$

107C. However, prolonged or indiscriminate exposure to x-ray has serious health implications such as:

1. Causing cancer
2. Causing skin burns
3. Killing body cell (this is however, employed in cancer radio therapy above)
4. Causing leukaemia.
5. Causing genetic mutations with deleterious hereditary effect.

108A. $t = \frac{0.693}{\lambda} \rightarrow t = \frac{0.693}{0.231} = 3 \text{g}$

109A. Calculate first the decay constant from half-life

$t = \frac{0.693}{\lambda} \therefore \lambda = \frac{0.693}{t} = \frac{0.693}{20} \rightarrow \lambda = 0.03465$

But $\lambda = \frac{\text{No of atoms disintegrating per second}}{\text{No of atoms in the original source}}$

$\therefore \text{No of atoms disintegrating per second:}$
 $N = 0.03465 \times 10^{20} = 3.465 \times 10^{18}$

NOTE:

1. A student of mine once worked this question and follows: The no of disintegration after first half-live (20s)

$= \frac{10^{20}}{2} = 10^{19}$ No of disintegration in the first second

$= \frac{10^{19}}{20} = 5 \times 10^{17}$

2. He was conceptually and arithmetically wrong:

a. The no of atoms which disintegrate in the first 20 second is not divided exactly into twenty equal parts for each second because the rate of disintegration declines with the fewer and fewer number of atoms left and hence with time.

b. However, the decay constant used above actually factors in the instantaneous rate of decay per unit atom.


3. Even if he were right 10^{19} is one-half of 10^{20} . In case you are not using a calculator, which is discouraged, anyway, one-half of 10^{20} is worked as follows:





- 110D. The electrons now emitted, if allowed to bombard a metal (tungsten) filament, produce x rays.
- 111A. ${}^{235}_{92}\text{U} \rightarrow {}^A_Z\text{X} + 2({}^4_2\text{He}) + 3({}^1_0\text{n}) + 3e^-$
 $A = 235 - [2(4) + 3(0) + 1(0)] = 227$
 $Z = 92 - [2(2) + 3(-1) + 1(0)] = 92 - 1 = 91$
112. $E_0 - E_n = hf$; where $E_n =$ Energy at infinite distance from atom's nucleus = 0 (i.e. $n = \infty$) $\rightarrow E_0 =$ Energy at ground state.
 $\therefore f = \frac{E_0}{h} = \frac{5.44 \times 10^{19}}{6.6 \times 10^{-34}} = 8.24 \times 10^{14}$. **No option is right**
- 113A. See Q87
- 114C. $W = hf_0 = 6.6 \times 10^{-34} \times 1.3 \times 10^{15} = 8.58 \times 10^{-19}$ J
- 115C. Compare mammography
- 116A. Gamma rays are neutral
- 117C. $L = \frac{125}{1000} = \frac{1}{8} = \frac{1}{2^3}$; comparing $\frac{1}{2^n}$ and $\frac{1}{2^3}$; $n = 3$ half-lives
 $\therefore T = 3 \times t = 3 \times 20 = 60$ s
- 118C. The energy of an electron is given by $E = \frac{R}{n^2}$ where $n =$ electron quantum no and $R =$ a constant
 At ground state $n = 1$; At third level $n = 3$
 Comparing: $E_3 = \frac{R}{n_3^2}$ and $E_1 = \frac{R}{n_1^2} \rightarrow \frac{E_3}{E_1} = \left(\frac{n_1}{n_3}\right)^2$
 $\therefore E_3 = \left(\frac{n_1}{n_3}\right)^2 E_1 \rightarrow E_3 = \left(\frac{1}{3}\right)^2 \times 24.8 \rightarrow E_3 = \frac{24.9}{9}$
- 119C. The lower the threshold frequency, the quicker the photo-emission begins and hence the rate of photo-emission.
- 120A. ...while (B), (C) and (D) explain the wave nature of light.
- 121A. 2 small nuclei fusing together to form a larger nucleus
- 122B. The new element is one step to the right of the old element in the periodic table is created
- 123A. A difference of ${}^4_2\text{He}$ between the 2 atoms
- 124D. Elements have characteristically distinct mass numbers
- 125E. $E = hf = \frac{hc}{\lambda} = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{10^{-7}} = 1.99 \times 10^{-18}$ J
- 126C. Molecules of gases are in random motion
- 127D. ${}^1_1\text{H} + {}^2_1\text{H} \rightarrow {}^3_2\text{He} + {}^1_0\text{n}$
- 128B. Photoelectricity
- 129D. Protons and neutrons in the nucleus of an atom are bound together by this binding energy.
 $n(\text{protons} + \text{neutrons}) = \text{nucleon number}$

**CHAPTER 31
 INTRODUCTORY ELECTRONICS**

- Radio carrier waves are generated by causing electrons to oscillate rapidly in A. a microphone B. a television camera C. an antenna D. coaxial cables E. a transmitter. (1979:Q48)
- Which of the following graphs represents a voltage current characteristic curve for a diode? Diagram (1990:Q49)
- A semi-conductor diode is used in rectifying alternating current into direct current mainly because it A. allows current to flow in either direction B. is non-linear C. offers a high input resistance D. allows current to flow only in one direction. (1999:Q45)
- In semi-conductors, the carriers of current at room temperature are A. electrons only B. electrons and holes C. holes only D. electrons and ions. (1999:Q46)
- In a pure semiconductor, the number of electrons in the conduction band is A. equal to the number of holes in the valence band B. greater than the number of holes in the valence band C. less than the number of holes in the valence band D. twice the number of holes in the valence band. (2000:Q39)
- A transistor functions mainly as a A. switch and an amplifier B. rectifier and an amplifier C. charge storer and amplifier D. charge storer and a switch. (2001:Q47)
- A transistor is used in the amplification of signals because it A. allows doping B. contains electron and holes carriers C. consumes a lot of power D. controls the flow of current. (2002:Q39)
- Pure silicon can be converted to a p-type material by adding a controlled amount of A. pentavalent atoms B. hexavalent atoms C. tetravalent atoms D. trivalent atoms (2002:Q48)
- In a semiconductor junction diode, as the depletion or barrier

- layer is forward-biased, the layer A. widens B. narrows C. remains constant D. widens then narrows (2003:Q47)
- The major difference between a pure semiconductor and a pure metal is that A. metals are harder than semiconductors B. while the resistance of metals decreases with temperature, the reverse is the case for semiconductors C. the resistance of metals increases with temperature, while for semiconductors, it is the reverse D. metals have forbidden gaps while semiconductors have not. (2003:Q49)
 - For semiconductors to have negative temperature coefficient of resistance implies that A. they have electrons and holes at high temperatures. B. their resistance is constantly changing with temperature. C. their resistance increases with temperature. D. their resistance decreases with temperature. (2004:Q24)
 - In a reverse biased junction diode, current flows in by A. electrons alone. B. majority carriers. C. minority carriers. D. positive holes alone. (2004:Q26)
 - Which of the following materials is a conductor? A. Plastic B. Sodium C. Wax D. Glass. (2005:Q2)
 - When impurities are added to semi-conductors, the conductivity of the semi-conductor A. remains constant B. increases then decreases. C. increases D. decreases. (2005:Q4)
 - A silicon material is dropped with an element of a certain group and an n-type semi-conductor is formed. The most likely group of the element is A. II. B. I. C. V. D. III (2005:Q8)

16.  In the circuit diagram of a transistor above, the terminals P, Q and R represent. A. Collector, Emitter And Base. B. Emitter, Base And Collector C. Base, Emitter And Collector. D. Base, Collector And Emitter. (2005:Q11)
- The theory of electronic conduction in solids, which satisfactorily explains the properties of conductors, insulators and semiconductors, is A. particle theory. B. band theory. C. group theory. D. string theory (2006:Q3)
 - A certain manufacturer wishes to make an n-type semi-conductor. Which materials would he select for doping? A. Arsenic and antimony B. Aluminium and indium C. Boron and antimony D. Helium and boron (2006:Q5)
 - Which of the following represents correctly an n-p-n transistor

- A.  B.  C.  D.  (2006:Q6)
- An p-n junction diode is used as A. a rectifier in a d.c. circuit. B. an amplifier in an a.c. circuit. C. a rectifier in an a.c. circuit. D. an amplifier in a d.c. circuit. (2006:Q9)
 - The battery connection that permits current to flow across p-n junction is called A. amplification. B. rectification. C. forward biased. D. reverse biased. (2006:Q10)
 - Silicon doped with aluminium and germanium doped with arsenic become A. n-type semiconductors. B. p-type semiconductors. C. n- and p-types respectively D. p- and n-types respectively. (2007:Q11)
 - The bond that forms a semiconductor is A. ionic. B. metallic. C. covalent. D. electrovalent. (2007:Q14)
 - Zener diode is used for A. current amplification. B. power amplification. C. voltage regulation. D. energy conversion. (2008:Q48)
 - When a pure semiconductor is heated, its resistance A. increases. B. decreases. C. remains the same. D. increases and decreases. (2008:Q49)
 - I. For current amplification B. II. For voltage stabilization C. III. For power amplification. IV. As a switch. Which of the above are the uses of a transistor? A. I, II, III and IV B. I, III and IV only C. I, II and III only D. I, II and IV only (2008:Q50)
 - Which of the following can conduct electricity owing to the presence of free mobile electrons? A. Germanium B. Silicon C. Grapefruit D. Copper (2009:Q49)
 - When a pentavalent impurity is added to a pure semiconductor, it becomes A. a p-type semiconductor. B. an n-type semiconductor C. an insulator D. an intrinsic semiconductor (2009:Q50)
 - Transistors are used for the A. conversion of a.c to d.c. B. conversion of d.c to a.c C. amplification of signals.

30. Identification of signals (2010:Q48)
 A typical transistor characteristic is represented as one of the following (2010:Q49)
31. Which of the following is a pure semiconductor? A. Silicon B. Phosphorus C. Transistor D. Carbon (2010:Q50)
32. The bond between silicon and germanium is A. dative B. electrovalent C. covalent D. ionic. (2011:Q48)
33. Which of the following materials has an increase in resistance with temperature? A. Wood. B. Electrolyte. C. Water. D. Metals. (2011:Q49)
34. The electrical properties of germanium can be altered drastically by the addition of impurities. This process is referred to as A. amplification. B. doping. C. saturation. D. bonding. (2011:Q50)
35. The p-n junction diodes can act as rectifiers because they A. conduct current when forward-biased B. conduct current when reverse-biased C. block current when forward-biased D. conduct current in both directions. (2012:Q48)
36. If a reverse-biased voltage is applied across a p-n junction, the depletion layer width is A. increased B. decreased C. constant D. halved. (2012:Q49)
37. I. Small size. II. Low power requirement. III. Not easily damaged by high temperature IV. Highly durable. Which of the above are the advantages of semiconductors? A. I, II and III only B. II, III and IV only C. I, II and IV only D. I, II, III and IV. (2012:Q50)
38. In a common emitter configuration, the output voltage is through the A. base B. collector. C. emitter. D. resistor. (2014:Q49)
39. What are the charge carriers in semiconductors? A. Electrons and holes. B. Holes only. C. Ion and electrons. D. Ion and holes (2015:Q19)
40. Which of the following is a semiconductor material? A. Copper B. Silicon C. Steel D. Iron (2015:Q38)

CHAPTER 31 ANSWERS

- 1E Radio transmitter
 2B This graph does not follow ohm's law i.e. the pin junction diode is non-ohmic conductr just like thermionic diode
 3D A rectifier would allow current to flow only in one direct.
 4B The electrons carry negative charges hence constitute the carriers of current in n-type semi conduction (n-for negative). The holes are positive as in p-type semi conductors (p-for positive)
 5A When certain number of electrons are lost, the equal number of holes are created since it is the electron deficits that constitute holes
 6C See Q7 below
 7B A semi conductor
 8D This process is called doping.

NOTE:

- In doping, a pure semi-conductor is made impure by adding a doping material
- Pure semi conductors ant air atoms with four valence electrons (tetravalent)
- In your chemistry class, they are also called semi-metals or metalloids and they belong to group 4 of the periodic table-silicon and germanium
- To produce a p-type material trivalent atoms (e.g. boron and indium) are used for doping so that electrons leave the tetravalent, atoms of the pure semi conductor for the doping material to create holes (tve) in the semi-conductor itself
- To create n-type materials pentravalent (e.g. ar-semic and antimoney supply extra electrons to the semi-conductors thereby creating negative charges on the semi-conductor.

- 9B. This depletion region or zone thins out because the mobile charge carriers are being diffused away by an electric field while the element left behind are ionized donor or acceptor impurities (or doping materials)

NOTE: The depletion zone widens or thickens in reverse biased diode.

- 10C Hence metals conduct better at low temperature while semi conductors conduct better at high temperature.

11D See Q10

12B Few holes and electrons are involved in the repulsion set up across the diode

13B Sodium is a pure metal

14C Doping enhances conductivity

15C Pentavalent element of group 5 of the periodic table (See Q8)

16B The transistor shown here is of the type PNP. If it were an NPN transistor, the arrow head on the emitter would point outwards.

NOTE:

1 A transistor combines 2 diodes into one as in:

(a) PNP → A P-N diode joined to an N-P diode

(b) NPN → An N-P diode joined to a P-N diode

2. To identify an NPN transmitter circuit diagram, use this mnemonic: NPN → **Not Pointing in**

17B By "band" we mean the energy band formed from the molecular orbitals of atoms of a solid.

18A See Q8 and Q15

19A See Q16

20C To convert a.c. to d.c.

21C In forward biased diode, there is little resistance to flow of current (Compare: Reverse biased diode)

22D See Q8

23B Just as in pure metals, electrons leave the surface of atoms of semi-conductors, thereby creating a positive charge on the atom and negative electron cloud available to cause current flow.

24C Named after Clarence Melvin Zener, the diode prevents over voltage i.e. it stabilizes power supplies

25B See Q10

26D Uses of a transistor

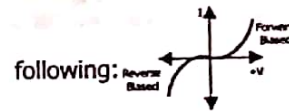
27D Pure metals like copper ...while semi-conductors like Germanium and silicon do by holes and electrons

28B See Q8

29C See Q26

30D This is non-ohmic graph. For an ohmic conductor the graph starts from the origins and it is a straight line.

NOTE: A diode I-V characteristics curves looks like the



following:

31A See Q8

32C Electron sharing

33D Q10 34B See Q8 35A See Q3

36B See Q9

37D Advantages over thermionic diode

38A Output voltage → Collector

Input voltage → Base

NOTE: The emitter is involved in both output and input.

39A See Qs 5, 6, 8

40B See Q8

CHAPTER 32

SIMPLE A.C. CIRCUIT

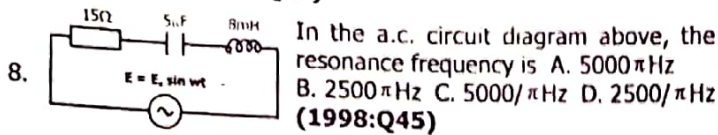
- In alternating current theory, the units of impedance, r.m.s voltage and resonance frequency are respectively equal to A. volt, ampere and hertz B. ohm, volt and hertz C. watt, ohm and radian D. ohm, hertz and joule (1992:Q45)
- In A.C. circuit theory, the root mean square (r.m.s) current, I_{rms} , and the peak (maximum) current I_0 are related by A. $I_0 = I_{rms} \sqrt{2}$ B. $I_{rms} = I_0 \sqrt{2}$ C. $I_{rms} = 1/I_0 \sqrt{2}$ D. $I_0 = 1/I_{rms} \sqrt{2}$ (1992:Q46)
- Determine the inductive reactance when a 30.0mH inductor with a negligible resistance is connected to a 1.30×10^3 Hz oscillator. A. 39.0Ω B. 122.5Ω C. 245.0Ω D. 3900.0Ω (1993:Q45)



In the curve above, PQRST represents an alternating voltage of frequency 50Hz. The time interval

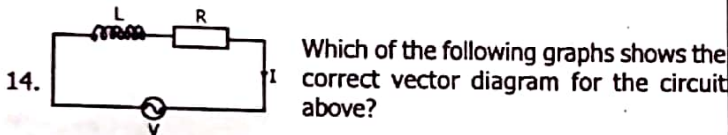
- between points P and R on the graph is A. 25s B. 1/50 s C. 1/100s S D. 1/200s (1994:Q49)
- An alternating source is connected in series to a capacitor of capacity reactance of $10^3 \sqrt{3}$ and a resistor of resistance $10^3 \Omega$. The impedance of the circuit is A. $2000 \sqrt{3} \Omega$ B. 2000Ω C. $1000 \sqrt{3} \Omega$ D. 1000Ω (1995:Q48)
- The power dissipated in an a.c. circuit with an r.m.s current of 5A, r.m.s. voltage of 10V and a phase angle of 60° is

- A. 25 B. 50 C. 120 D. 125 (1997:Q46)
7. The voltage of the domestic electric supply is represented by the equation $V = 311 \sin 314.2t$. Determine the frequency of the a.c. supply. A. 50.0Hz B. 100.0Hz C. 311.0Hz D. 314.2Hz [$p = 3.142$] (1997:Q47)



8. In the a.c. circuit diagram above, the resonance frequency is A. 5000π Hz B. 2500π Hz C. $5000/\pi$ Hz D. $2500/\pi$ Hz (1998:Q45)
9. In the series a.c. circuit shown above, the p.d across the inductor is 8V r.m.s and that across the resistor is 6V r.m.s. The effective voltage is A. 2V B. 10V C. 14V D. 48V (1999:Q35)

10. At what frequency would a 10H inductor have a reactance of 2000Ω? A. $\pi/200$ Hz B. $\pi/100$ Hz C. $100/\pi$ Hz D. 100π Hz (1999:Q39)
11. In a series R-L-C circuit at resonance, the voltages across the resistor and the inductor are 30V and 40V respectively. What is the voltage across the capacitor? A. 30V B. 40V C. 50V D. 70V (1999:Q48)
12. A 2H inductor has negligible resistance and is connected to a 50/Hz a.c supply. The reactance of the inductor is A. 200Ω B. 50Ω C. $100/\pi$ Ω D. $25/\pi$ Ω (2000:Q36)
13. The current through a resistor in an a.c. circuit is given as $2\sin \omega t$. Determine the d.c. equivalent of the current. A. $1/\sqrt{2}$ A B. $2\sqrt{2}$ A C. 2A D. $\sqrt{2}$ A (2001:Q40)



14. Which of the following graphs shows the correct vector diagram for the circuit above?
- A. B. C. D. (2002:Q46)

15. When a alternating current given by $I = 10\sin(120\pi)t$ passes through a 12 resistor, the power dissipated in the resistor is A. 1200 B. 600 C. 120 D. 30 (2003:Q45)
16. In a turned radio receiver R, L, C series circuit for resonance, the inductive reactance and X_c respectively are related as A. $X_L = X_c$ B. $X_L = X_c$ C. $X_L = X_c$ D. $X_L = 2X_c$ (2004:Q22)
17. The energy stored in an inductor of inductance 5mH when a current of 6A flows through it is: A. 1.8×10^{-2} J B. 9.0×10^{-2} J C. 1.4×10^{-2} J D. 9.0×10^{-2} J. (2004:Q27)
18. An A.C. circuit of emf 12V has a resistor of resistance 8 connected in series to an inductor of inductive reactance 16 and a capacitor of capacitive reactance 10. The current flow in the circuit is A. 1.4A B. 14.0A C. 1.2A D. 12.0A (2004:Q29)
19. If two inductors of inductance 3H and 6H are arrangement in series, the total inductance is A. 18.0 H. B. 9.0 H. C. 2.0 H. D. 0.5 H. (2005:Q15)
20. When an A.C. voltage is applied to a capacitor, no power is consumed because the current A. and voltage are 180° out of phase. B. and voltage are in phase. C. lags behind the voltage by 90° . D. leads the voltage by 90° (2006:Q24)
21. When a certain a.c. supply is connected to a lamp, it lights with the same brightness as it does with a 12V d.c. battery. The r.m.s value of the a.c. supply is A. 8.5V B. 17.0V C. 3.5V D. 12.0V. (2006:Q27)
22. The instantaneous value of the induced e.m.f as a function of time $\mathcal{E} = \mathcal{E}_0 \sin \omega t$ where is the peak value of the e.m.f. The instantaneous value of the e.m.f., one quarter of the period is A. \mathcal{E}_0 B. $\mathcal{E}_0/2$ C. $\mathcal{E}_0/4$ D. 0. (2007:Q20)
23. Given three inductors of inductances 5mH, 10mH and 20mH connected in series, the effective inductance is A. 0.35 mH B. 3.50 mH. C. 2.90 mH. D. 35.00 mH. (2008:Q44)
24. From the diagram above, if the potential difference across the resistor, capacitor and inductor are 80V, 110V and 40V respectively, the effective potential difference is A. 116. 3V. B. 50.0V. C. 230.0V D. 106.3V. (2009:Q44)
25. Two inductors of inductances 5mH and 15mH are connected

- in series and a current of 5A flows through them. The total energy stored in the inductors is A. 250.0J B. 50.0J C. 62.5J D. 500.0J. (2010:Q42)
26. In alternating current circuit at resonance, the angle of lead or lag is A. $\frac{\pi}{2}$ B. 0° C. $\frac{\pi}{3}$ D. π° (2010:Q43)

27. In an a.c circuit, the ratio of r.m.s value to peak value of current is A. $1/\sqrt{2}$ B. $\sqrt{2}$ C. 2 D. 1/2 (2011:Q44)
28. Two inductances 4H and 8H are arranged in series and a current of 10A is passed through them. What is the energy stored in them? A. 13J B. 250J C. 500J D. 50J (2011:Q45)
29. The current output form of an a.c. source is given as $I = 10 \sin t$. The d.c. equivalent of the current is A. 5.0A B. 7.1A C. 10.0A D. 14.1A (2012:Q43)
30. The current in an R-L-C series circuit attains its maximum value when the A. inductive reactance is equal to the capacitive reactance B. inductive reactance is greater than the capacitive C. capacitive reactance is less than the resistance D. impedance is greater than the resistance (2016:Q4)
31. The capacitive reactance of an a.c. circuit that contains a capacitor of capacitance $10\mu\text{F}$ and operating at a frequency of 50Hz is A. 2000Ω B. 500Ω C. 200Ω D. 318Ω (2018:Q30)

CHAPTER 32 (ANSWERS)

- 1B. Impedance is the total resistance in ohms in an a.c. circuit containing of at least 2 of a resistor, an inductor and a capacitor.
- 2B The phrase "root mean square" is obtained as follows
1. Square of the peak current = I_0^2
 2. Average of the square = $\frac{I_0^2}{2}$ and this as the means - square current (Average = mean as in Maths class)
 3. Now, the root of the mean - square = $\sqrt{\frac{I_0^2}{2}}$

Thus $I_{r.m.s} = \frac{I_0}{\sqrt{2}}$

- 3C Continuing from Q1, each of the 3 components mentioned offers resistance which is part of the total opposition (or impedance) to current flow

Resistance due to a Resistor: $R = \frac{V}{I}$

Resistance due to a capacitor: $X_c = \frac{1}{2\pi fC}$

Resistance due to an inductor: $X_L = 2\pi fL$

Where C = Capacitance (Farad) and L = Inductance (Henry)

NOTE:

1. Reactance is the resistance offered to the flow of a.c. by a capacitor and/or a an inductor
 2. Resistance by capacity X_c is called capacitive reactance
 3. Resistance by inductor X_L is called inductive reactance
- Now, $X_L = 2\pi fL = 2 \times 3.142 \times 1.30 \times 10^3 \times 30 = 245.04\Omega$

4D $T = \frac{1}{f} = \frac{1}{50} = 0.02s$.

The time period of 0.02s is interpreted as 0.02s per cycle. If 1 cycle is completed in 0.02s then 1/4 cycle is completed in

$s = \frac{0.02}{4} s = 0.005s = \frac{5}{1000} s = \frac{1}{200} s$

NOTE: PR = 1/2 cycle

- 5B The impedance Z is given by:

1. $Z = \sqrt{R^2 + X_L^2}$ for R - L circuit

2. $Z = \sqrt{R^2 + X_C^2}$ for R-C circuit

3. $Z = \sqrt{(X_L - X_C)^2}$ for L-C circuit

4. $Z = \sqrt{R^2 + (X_L - X_C)^2}$. Now, this is an R-C Circuit

$$Z = \sqrt{(10)^2 + (10\sqrt{3})^2} = 2 \times 10^3 = 2000 \Omega$$

6A $P = IV \cos \phi$ where P = power; $I = I_{r.m.s.}$; $V = V_{r.m.s.}$ and ϕ = phase angle $\therefore P = 5 \times 10 \cos 60 = 25W$.

NOTE: $\cos \phi$ = power factor

7A Compare to $V = V_0 \sin 2\pi ft$; $2\pi ft = 314.2t$; $f = 50Hz$

8D $L = 8 \times 10^{-4}H$; $C = 5 \times 10^{-6}F$; But $f_0 = \frac{1}{2\pi\sqrt{LC}}$

Substituting for L and C : $f_0 = \frac{2500}{\pi}$

9B The effective voltage $V = \sqrt{V_R^2 + V_L^2} = \sqrt{6^2 + 8^2} = 10V$

10C $X_L = 2\pi fL \rightarrow 2000 = 2\pi f \times 10 \rightarrow f = \frac{100}{\pi}$

11B At Resonance, I is maximum and $X_L = X_C$

$$\therefore \frac{V_L}{I_L} = \frac{V_C}{I_C} \text{ where } I_L = I_C = I_{max} \text{ (series)}$$

$$\therefore V_L = V_C \rightarrow V_C = 40V$$

12A $X_L = 2\pi fL \rightarrow 200 = 2\pi \times \frac{50}{\pi} \times 2 = 200\Omega$

13D The current given is the instantaneous current I not the peak current I_0 . But $I = I_0 \sin \omega t$ $2 \sin \omega t = I_0 \sin \omega t \rightarrow I_0 = 2A$
But the d.c. equivalent = $I_{r.m.s.}$ (See Q2)

$$\text{And } I_{r.m.s.} = \frac{I_0}{\sqrt{2}} = \frac{2}{\sqrt{2}} = \sqrt{2}A$$

14B In any case, let your V_R be on the horizontal axis

15B If $I = 10 \sin(120\pi)t$ then $I_0 = 10A$

$$\text{and } I_{r.m.s.} = \frac{I_0}{\sqrt{2}} = \frac{10}{\sqrt{2}} = 5\sqrt{2}A$$

Since the circuit contains no L or C

$$P = I^2 R = (5\sqrt{2})^2 \times 12 = 50 \times 12 = 600W$$

NOTE: The I in $(P = I^2 R)$ is, in fact, $I_{r.m.s.}$, don't use I_0

16. See Q11

17D The energy stored $E = LI^2 = \frac{1}{2} \times 5 \times 10^{-3} \times 6^2 = 9 \times 10^{-2}J$

18C $Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{8^2 + (16 - 10)^2} = 10\Omega$

$$\text{But } I = \frac{V}{Z} = \frac{12}{10} = 1.2A$$

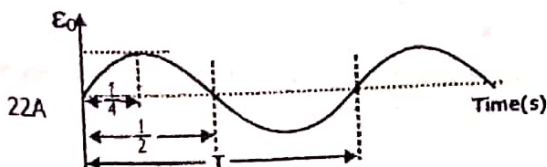
19B $L_{effective} = L_1 + L_2 = 3 + 6 = 9H$

20D A circuit which contains only inductor and/or capacitor but no resistor is of pure reactance - pure inductance and/or capacitance
In a pure capacitance device, the current I_C leads the voltage V_C by $\frac{\pi}{2}$ radians or 90° . Recall from Q6: Power $IV \cos \phi$

Where ϕ is the angle of lag or lead called **phase angle**

$$\text{When } \phi = 90^\circ \cos 90^\circ = 0 \therefore P = IV \times 0 = 0$$

21D The V_{max} is the d.c. equivalent that produces same heating effect - See Q2 and 13



22A

Consider the sinusoidal variation of voltage (emf) with time in the graph below. Starting from the origin, the time taken to make one full cycle is the period T as shown. The voltage peaks at $1/4 T$ and this corresponds to

23D See Q19

$$24D V = \sqrt{V^2 + (V_L - V_C)^2} \text{ (See Q9)} \quad V = \sqrt{80^2 + 70^2} = 106.3V$$

25A Effective inductance = $5 + 15 = 20mH$.

$$E = \frac{1}{2} LI^2 = \frac{1}{2} \times 20 \times 10^{-3} \times 5 \times 5 = 0.25J$$

Pick option a as JAMB must have predetermined it as their answer

26B Note that $\tan \phi = \frac{X}{R}$ where X is the reactance and is the angle of lag or lead

$$\therefore \tan \phi = \frac{X_L - X_C}{R} \text{ But at resonance } X_L = X_C$$

$$\therefore \tan \phi = \frac{0}{R} = 0 \text{ and } \phi = \tan^{-1} 0 = 0^\circ$$

NOTE:

1. A.C. circuit containing Capacitor: I_C leads V_C or V_C lags I_C by 90° .
2. A.C. Circuit containing Inductor: V_L leads I_L or I_L lags V_L by 90° .
3. At resonance: Lead or lag angle is 0°
4. At resonance: $I = I_{max}$ and $X_L = X_C$
5. Resonance has application in the tuning of radio and TV into desired stations

27A Recall from Q2: $I_{rms} = \frac{I_0}{\sqrt{2}} \rightarrow \frac{I_{r.m.s.}}{I_0} = \frac{1}{\sqrt{2}}$

28 Effective inductance = $12H$

$$E = \frac{1}{2} LI^2 = \frac{1}{2} \times 12 \times 10^2 = 600J. \text{ No correct option}$$

29B $I_0 = 10A$ and $I_{rms} = \frac{I_0}{\sqrt{2}} = 7.07A$

30A See Q11

31D $X_C = \frac{1}{2\pi fc} = \frac{1}{2\pi \times 50 \times 10 \times 10^{-6}} = 318.30\Omega$

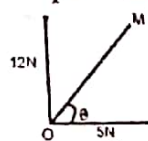
2019 POST UTME STRUCTURED QUESTIONS

1. Which of the following is NOT a vector quantity A. Force B. Altitude C. Weight D. Displacement
2. Which of the following is a set of vectors? A. Force, mass and moment B. Acceleration, velocity and moment C. Mass, weight and density D. Mass, volume and density
3. A train has an initial velocity of $44m/s$ and an acceleration of $-4m/s^2$. Its velocity after 10 seconds is A. $2m/s$ B. $4m/s$ C. $8m/s$ D. $12m/s$
4. A ball is thrown vertically into the air with an initial velocity. A. $\frac{U}{2g}$ B. $\frac{3U^2}{2g}$ C. $\frac{U^2}{g}$ D. $\frac{U^2}{2g}$



5.

From the diagram above, the bob of the pendulum has the fastest speed at A. W. B. Z. C. Y. D. X.

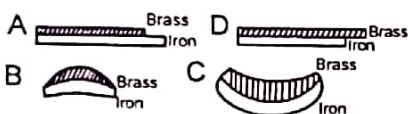


6.

A body of mass $5kg$ initially at rest is acted upon by two mutually perpendicular forces $12N$ and $5N$ as shown in the figure. If the particle moves in the direction OM , calculate the magnitude of the acceleration. A. $0.40ms^{-2}$ B. $1.40ms^{-2}$ C. $0.26ms^{-2}$ D. $2.60ms^{-2}$

7. A cone in an unstable equilibrium has its potential energy A. Decreased B. Increased C. Unchanged D. Oscillating
8. A car travelling at $60ms^{-1}$ produces a force of $400N$. Calculate the power of the engine in kW A. 25 B. 22 C. 24 D. 20
9. Which of the following is NOT a force? A. Friction B. Tension C. Upthrust D. Impulse
10. In elastic collision A. momentum and kinetic energy are conserved B. only momentum is conserved C. only kinetic energy is conserved D. neither momentum nor kinetic energy is conserved
11. The force with which an object is attracted to the earth is called its A. Acceleration B. Mass C. Gravity D. Weight
12. An object of mass $80kg$ is pulled on a horizontal rough ground by a force of $500N$. Find the coefficient of static friction. A. 0.8 B. 0.4 C. 1.0 D. 0.6.

13. No machine is 100% efficient because of the phenomenon of
A. upthrust B. friction C. viscosity D. gravity
14. A block and tackle system has 6 pulleys. If the efficiency of the machine is 60%, determine its mechanical advantage? A. 12.0 B. 10.0 C. 3.6 D. 1.8
15. What is the unit of strain? A. Nm^2 B. Nm^{-1} C. Nm D. no unit
16. According to Archimede's principle. A. upthrust is weight of the fluid displaced B. upthrust is loss in weight experienced by an immersed object C. upthrust is equal to the weight of the body when immersed D. A and B are true
17. The density of a certain oil on frying becomes 0.4kgm^{-3} with a volume of 20m^3 . What will be its initial volume when its initial density is 0.8kgm^{-3} assuming no loss of oil due to spillage? A. 10kgm^{-3} B. 5kgm^{-3} C. 8kgm^{-3} D. 12kgm^{-3}
18. The pressure at any point in a liquid at rest depends only on the A. depth and the density B. mass and the volume C. quantity and the surface area D. surface area and the viscosity.
19. A metallic strip of iron and brass was heated. Which of the following diagrams accurately illustrates the shape of the strip after heating?



20. Which of the following graphs represent(s) Charle's Law



- A. I and II only B. I and III only C. II and III only D. III only
21. The following are some units I. NS II. Nm III. Nm^{-2} IV. $\text{J}^\circ\text{K}^{-1}$ V. Jkg^{-1} . What are the units of latent heat? A. 1 B. II C. III D. V
22. When the vapour of a substance is in equilibrium with its own liquid, it is said to be A. gaseous B. unsaturated C. liquefied D. saturated
23. Which of the following is common to evaporation and boiling? They A. Take place at any temperature. B. Are surface phenomena. C. Involve change of state D. Take place at a definite pressure.
24. The mechanism of heat transfer from one point to another through the vibration of the molecules of the medium is A. convection B. conduction C. radiation D. diffusion
25. Which of the following is conventional current in nature A. mirage B. radiant heat C. sea breeze D. reflection
26. Sound wave is A. mechanical and transverse B. electromagnetic and longitudinal C. electromagnetic and transverse D. mechanical and longitudinal
27. Which of the following is not a phenomenon of a longitudinal wave? A. Polarization B. Refraction C. Diffraction D. Interference
28. A man hears his echo from a nearby hill 2s after he shouted. If the frequency of his voice is 260 Hz and the wavelength is 1.29m, how far away is the hill? A. 330.0m B. 335.4m C. 660.0m D. 670.8m
29. Which of the following statements supports the assumption what light travels in straight lines? A. Light can be diffracted B. A source of light produces distinct shadows of opaque objects C. A source of light produces interference patterns on a suitably placed screens. D. Light can be reflected.
30. A concave mirror has a radius of curvature of 36cm. At what distance from the mirror should an object be placed to give a real image three times the size of the object? A. 12cm B. 24cm C. 48cm D. 108cm
31. An object 20cm from a convex lens has an image 25cm away from the lens. Calculate the power of the lens A. 45B B. 9D C. 20D D. 5D
32. An object 20cm from a convex lens has an image 25cm away from the lens. Calculate the power of the lens A. 45B B. 9D C. 20D D. 5D

33. The resultant in the figure above is A. 15.0mF B. 9.8mF C. 1.3mF D. 0.8mF
34. What is the resultant resistance of the circuit in the figure given below? A. 11Ω B. 8Ω C. 3Ω D. 3.6Ω
35. A current of 15A flows through a cable of resistance 30Ω. Calculate the electric power dissipated in the cable A. 675W B. 225W C. 75W D. 6750W
36. A transformer has 300 turns of wire in the primary coil and 30 turns in the secondary coil. If the input voltage is 100 volts, the output voltage is A. 5 volts B. 10 volts C. 15 volts D. 20 volts
37. Which of the following is stored by a dry Leclanche cell? A. Electrical power B. Kinetic energy C. Electric current D. Chemical energy.
38. The electrochemical equivalent of silver is 0.0012g/C. If 36.0g of silver is to be deposited by electrolysis on a surface by passing a steady current for 5.0 minutes, the current must be A. 6 000A B. 100A C. 10A D. 1A
39. The number of neutrons contained in the nucleus $^{236}_{92}\text{U}$ is A. 92 B. 146 C. 238 D. 330
40. Pure silicon can be converted to a p-type material by adding a controlled amount of A. pentavalent atoms B. hexavalent atoms C. tetravalent atoms D. trivalent atoms

2019 POST UTME ANSWERS

- 1B Altitude is vertical distance measured from the ground level to a specific height.
- 2B See Chapter 1
- 3B $u = 44\text{m/s}$ $a = -4\text{m/s}^2$ $t = 10\text{s}$ $v = ?$.
Using $v = u + at \rightarrow v = 44 - 4 \times 10 = 4\text{m/s}$
- 4D $V = 0$ (at max. height) $u = u$ $a = -g$ (against gravity) and $s = h$
But $v^2 = u^2 + 2as \rightarrow 0 = u^2 - 2gh$
 $\therefore 2gh = u^2 \rightarrow h = \frac{u^2}{2g}$
- 5D The bob accelerate from Z to X; decelerates from X to W; it accelerates from W to X and decelerates from X to Z. Hence $v = \text{Maximum}$ (at X) $v = 0$ (at W and Z)
- 6D The resultant of the 2 forces is given by $R = \sqrt{12^2 + 5^2} = 13\text{N}$
Recall: $F = ma \rightarrow a = \frac{F}{m} = \frac{13}{5} = 2.060\text{ms}^{-2}$
- 7B $mgh_2 > mgh_1$ since $h_2 > h_1$
- 8C The work done on the car = $F \times S$. This power generated by engine = $\frac{F \times S}{t} = F \left(\frac{S}{t}\right)$
 $\therefore P = F \times V = 400 \times 60 = 24\ 000\text{J} = 24\text{KJ}$
- 9D Impulse = Force x time
- 10A While in inelastic collision, only momentum is conserved.
- 11D Gravity is the pull of the earth on any body above it and the magnitude of this pull is a force called the weight of the body expressed in Newton.
- 12D $\mu = \frac{F}{R} = \frac{500}{800} = 0.625$
- 13B Work must be done to overcome friction that comes into play when moving parts of the machine come in contact
- 14C V.R. of 6 pulley system = 6, $\epsilon = 60\%$
But $\epsilon = \frac{MA}{VR} \times 100\% \rightarrow \frac{60}{100} = \frac{MA}{6}$ and $MA = 3.6$

15D Strain = $\frac{\text{Extension (metre)}}{\text{original length (metre)}} \rightarrow$ no unit

16D Archimede's principle states that when a body is partially or wholly immersed in a fluid, it experienced a loss in weight called upthrust which is equal to the weight of fluid it displaces

17A Mass before frying = mass after frying $\rightarrow 0.8 \times v = 0.4 \times 20V = 10m^7$

18A Consider the relation: $p = h\rho g$ where $h =$ depth and $\rho =$ density

19B Brass expands longer than iron hence the convex side is brass.

NOTE: If the strip is cooled, brass also contracts more and it is on the concave side of the strip (as in option C)

20C See Chapter 14

21D Latent Heat = $\frac{\text{Quantity of heat}}{\text{Mass of substitution}} \rightarrow \frac{J}{Kg} \rightarrow Jkg^{-1}$

22D And if the saturated vapour pressure is now equal to the prevailing atmosphere pressure, the liquid boils.

23C See Chapter 16

24B See Chapter 17

25C And also land breeze

26D See Chapter 18

27A See Chapter 18

28B $v = f\lambda = 260 \times 1.29 = 335.4ms^{-1}$

But $x = \frac{vt}{2} = \frac{335.4 \times 2}{2} = 335.4m$

29B Shadow and eclipse are evidence of rectilinear propagation of light

30B $u = u \quad v = 3u \quad f = 18cm$

$\frac{1}{u} + \frac{1}{v} = \frac{1}{f} \rightarrow \frac{1}{u} + \frac{1}{3u} = \frac{1}{18} \rightarrow \frac{4}{3u} = \frac{1}{18} \rightarrow u = 24cm$

31B $\frac{1}{f} = \frac{1}{20} + \frac{1}{25} \rightarrow f = \frac{100}{9}$ But power = $\frac{100}{f} = \frac{100}{\frac{100}{9}} \rightarrow P = 9D$

32D Beta and Alpha rays are produced in radioactivity.

33D Parallel: $C = 2+4 = 6\mu f$; Series: $\frac{1}{C_r} = \frac{1}{2} + \frac{1}{3} + \frac{1}{6} + \frac{1}{4}$

$C_r = \frac{12}{6+4+2+3} = \frac{12}{15} = 0.8\mu f$

34B The 2 resistors are in parallel: $\frac{1}{R} = \frac{1}{5} + \frac{1}{20} \therefore R = \frac{20}{5} = 4\Omega$

Total resistance combination: $R_T = 5 + 4 = 9\Omega$

But $I = \frac{E}{R+r}$ where $r = 0$ (negligible) $\rightarrow I = \frac{9}{9} = 1A$

35D $P = I^2R = 15 \times 15 \times 30 = 6750W$

36B $\frac{V_s}{V_p} = \frac{N_s}{N_p} \rightarrow V_s = \frac{30 \times 100}{300} = 10V.$

This is a step-down transformer

37D It stores chemical energy but converts it to electrical energy when electric current flows out of the cell.

38B $I = \frac{m}{Zt} = \frac{36}{1.0012 \times 5 \times 60} = 100A$

39B Nucleon number = 238....A

Atomic number = 92....Z

Number of neutron = $A - Z = 238 - 92 = 146$

40D See chapter 31

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- Answers are well researched, accurate, detailed and systematically developed
- Lesson notes are added where necessary
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