Be Ahead with Sustained Excellence

CET - 2010

Question paper with Solutions

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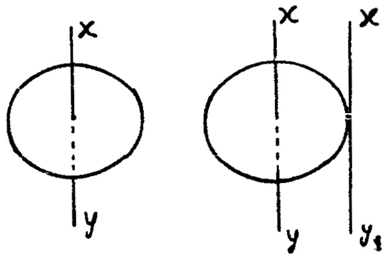
CET - 2010 Physics

(Version – D1)

Question paper with Solution

60 Questions
60 Marks
Duration: 70 Minutes

1. The moment of inertia of a circular disc of radius 2 m and mass 1 kg about an axis passing through the centre of mass but perpendicular to the plane of the disc is 2 kgm^2. Its moment of inertia about an axis parallel to this axis but passing through the edge of the disc is ________ (See the given figure).



(1) 10 kgm^2 (2) 6 kgm^2

(3) 8 kgm^2 (4) 4 kgm^2

Ans (2)

According to the parallel axes theorem, moment of inertia of the circular disc about the axis x_1y_1 is

$$I_{x_1y_1} = I_{xy} + MR^2$$

$$= \frac{MR^2}{2} + MR^2$$

$$= \frac{3}{2}MR^2$$

$$= \frac{3}{2} \times 1 \times z^2 = 6 \text{ kg m}^2$$

2. An astronaut on a strange planet finds that acceleration due to gravity is twice as that on the surface of Earth. Which of the following could explain this?

(1) Both the mass and radius of the planet are twice as that of Earth.

(2) Mass of the planet is half as that of Earth, but radius is same as that of Earth.

(3) Both the mass and radius of the planet are half as that of Earth.

(4) Radius of the planet is half as that of Earth, but the mass is the same as that of Earth.

Ans (3)

Acceleration due to gravity on the surface of earth is $g_E = \frac{GM_E}{R_E^2}$

Acceleration due to gravity on the surface of the planet is $g_P = \frac{GM_P}{R_P^2}$

$$\frac{g_P}{g_E} = \frac{M_P}{M_E} \times \left(\frac{R_E}{R_P}\right)^2$$

Let $M_P = \frac{M_E}{2}$ and $R_P = \frac{R_E}{2}$

Then $\frac{g_P}{g_E} = \frac{1}{2} \times 2^2 = 2 \Rightarrow g_P = 2g_E$

3. Which of the following substances has the highest elasticity?

(1) Rubber (2) Copper (3) Sponge (4) Steel

Ans (4)

Among the given substances, the modulus of elasticity is highest for steel.

4. Three liquids of equal masses are taken in three identical cubical vessels A, B and, C. Their densities are P_A , P_B and P_C respectively. But $P_A < P_B < P_C$. The force exerted by the liquid on the base of the cubical vessel is ________

(1) the same in all the vessels (2) maximum in vessel A

(3) maximum in vessel C (4) minimum in vessel C

Ans (1)

The force exerted by liquid column on the base of the vessel is equal to the height of the liquid.

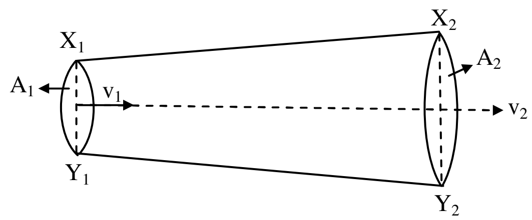
$F_A = M_A g$; $F_B = M_B g$ and $F_C = M_C g$

Since $M_A = M_B = M_C$, $F_A = F_B = F_C$

5. Water is in streamline flow along a horizontal pipe with nonuniform cross-section. At a point in the pipe where the area of cross-section is 10 cm^2, the velocity of water is 1 ms^{-1} and the pressure is 2000 Pa. The pressure at another point where the cross sectional area is 5 cm^2 is

(1) 1000 Pa (2) 500 Pa (3) 4000 Pa (4) 2000 Pa

Ans (2)



According to the equation of continuity, $A_1 v_1 = A_2 v_2$

$$5 \times v_1 \quad 10 \times 1$$

$$\Rightarrow v_1 = 2 \text{ m s}^{-1}$$

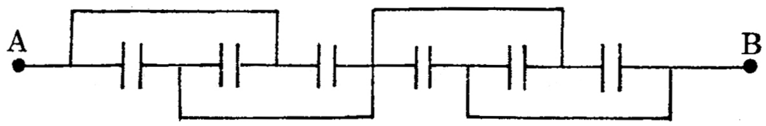
According to Bernoulli's theorem, $P_1 + \frac{\rho v_1^2}{2} = P_2 + \frac{\rho v_2^2}{2}$

$$P_1 + \frac{10^3 \times 2^2}{2} = 2000 + \frac{10^3}{2} \times 1^2$$

$$P_1 + 2000 = 2000 + 500$$

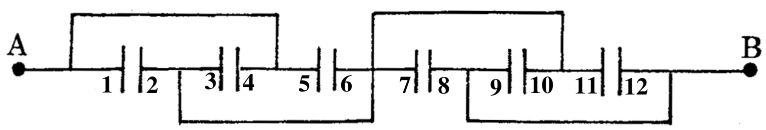
$$P_1 = 500 \text{ Pa}$$

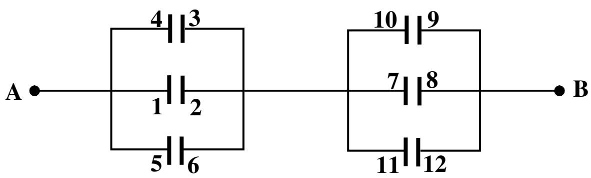
6. All capacitors used in the diagram are identical and each is of capacitance C. Then the effective capacitance between the points A and B is ________



(1) C (2) 3 C (3) 1.5 C (4) 6 C

Ans (3)





Effective capacitance between A and B is $C_{AB} = \frac{3C \times 3C}{6C} = \frac{3C}{2} = 1.5\,C$

7. Two identical conducting balls A and B have positive charges q_1 and q_2 respectively. But $q_1 \neq q_2$. The balls are brought together so that they touch each other and then kept in their original positions. The force between them is ________

(1) same as that before the balls touched

(2) zero

(3) less than that before the balls touched

(4) greater than that before the balls touched

Ans (4)

$F \propto q_1 q_2$; $F' \propto \left(\frac{q_1 + q_2}{2}\right)^2 \Rightarrow F' > F$

8. Red light of wavelength 625 nm is incident normally on an optical diffraction grating with 2×10^5 lines/m. Including central principal maxima, how many maxima may be observed on a screen which is far from the grating?

(1) 8 (2) 16 (3) 15 (4) 17

Ans (3)

Number of lines / m $= N = \frac{1}{(a+b)}$

$\therefore (a+b) = \frac{1}{N} = \frac{1}{2 \times 10^5}\,m$

Angular position of nth order maximum is given by $(a + b)\sin\theta = n\lambda$

$$n = \frac{(a+b)\sin\theta}{\lambda} = \frac{\left(\frac{1}{2\times10^5}\right)\sin 90^\circ}{6.25\times10^{-7}} = \frac{100}{12.5} = 8$$

8^{th} order maximum being at angular position $\theta = 90°$ can not be observed. Hence, total number of maxima observed on the screen (including central maximum is) N = 7 + 1 + 7 = 15.

9. A battery of e.m.f. E has an internal resistance ‘r’. A variable resistance R is connected to the terminals of the battery. A current I is drawn from the battery. V is the terminal PD. If R alone is gradually reduced to zero, which of the following best describes I and V?

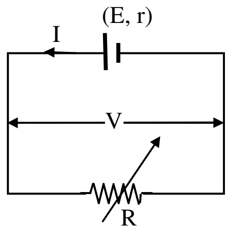
(1) I approaches $\frac{E}{r}$, V approaches E

(2) I approaches infinity, V approaches E

(3) I approaches zero, V approaches E

(4) I approaches $\frac{E}{r}$, V approaches zero

Ans (4)



Current in a simple circuit is given by $I = \frac{E}{R+r}$

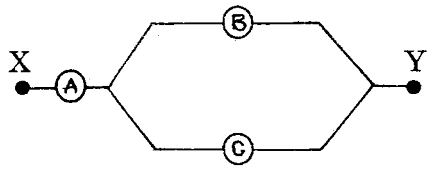
As R is gradually reduced to zero, I increases gradually.

When $R \Rightarrow 0,\ I \Rightarrow \frac{E}{r}$

The terminal P.D. across R is given by $V = \frac{ER}{R+r} = \frac{E}{1+\frac{r}{R}}$

As $R \Rightarrow 0,\ \frac{r}{R} \Rightarrow \infty$ and $v \Rightarrow 0$

10. Three voltmeters A, B and C having resistances R, 1.5 R and 3R respectively are used in a circuit as shown. When a P.D. is applied between X and Y, the reading of the voltmeters are V_1, V_2 and V_3 respectively. Then ________



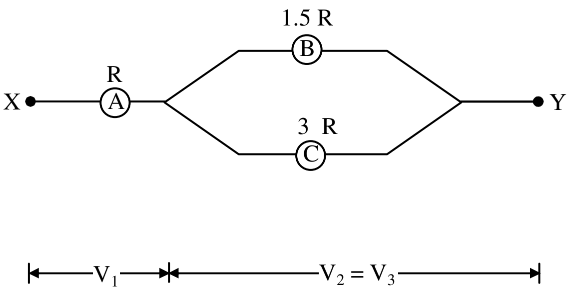
(1) $V_1 > V_2 > V_3$

(2) $V_1 > V_2 = V_3$

(3) $V_1 = V_2 = V_3$

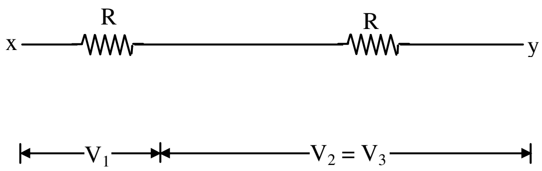
(4) $V_1 < V_2 = V_3$

Ans (3)



1.5 R and 3R are in parallel

Effective resistance $= \dfrac{1.5R \times 2R}{4.5R} = R$



$\therefore$ R and R are in series.

$\therefore V_1 = V_2 = V_3$.

[Note: when R_1 and R_2 are in series across a source of emf, ratio of p.ds across them is given by $V_1 : V_2 = R_1 : R_2$. When $R_1 = R_2$, $V_1 = V_2$]

11. The wavelength of the light used in Young's double slit experiment is λ. The intensity at a point on the screen where the path difference is $\dfrac{\lambda}{6}$ is I. If I_0 denotes the maximum intensity, then the ratio of I and I_0 is ________

(1) 0.707 (2) 0.75 (3) 0.866 (4) 0.5

Ans (2)

Case (1) : Let $I_1 = I_2 = I'$ (say)

At the point of superposition, the resultant intensity is given by

$I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$

$= I' + I' + 2I'\cos\phi$

$= 2I'(1 + \cos\phi)$

$I = 4I'\cos^2\left(\dfrac{\phi}{2}\right)$

Resultant intensity at the point of superposition of waves having a path difference δ is

$$I = 4I'\cos^2\left[\frac{\pi}{\lambda} \times \delta\right]$$

Path difference $\delta = \dfrac{\lambda}{6}$ (given)

We know that $\phi = \dfrac{2\pi}{\lambda} \times \dfrac{\lambda}{6} = \dfrac{\pi}{3}$

$\therefore\ I = 4I'\cos^2\left(\dfrac{\pi}{3}\right) = 3I'$

Case (2) : Maximum intensity at the point of superposition is given by

$I_0 = 4I'$

$\dfrac{I}{I_0} = \dfrac{3I'}{4I'} = 0.75$

12. What is the minimum thickness of a thin film required for constructive interference in the reflected light from it?

Given, the refractive index of the film = 1.5, wavelength of the light incident on the film = 600 nm.

(1) 50 nm (2) 200 nm (3) 100 nm (4) 300 nm

Ans (4)

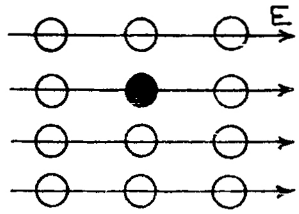
In case of interference of waves reflected from a thin film, for the film to appear bright,

$$2nt = \frac{(2m+1)\ \lambda}{2}$$

$$t = \frac{(2m+1)\ \lambda}{4n} = \frac{[(2\times1)+1]\times 6\times10^{-7}}{4\times1.5} = 3\times10^{-7}\ \text{m}$$

t = 300 nm.

13. There is a uniform electric field of intensity E which is as shown. How many labelled points have the same electric potential as the fully shaded point?



(1) 8 (2) 11
(3) 2 (4) 3

Ans (4)

A plane imagined normal to the electric field lines in a uniform electric field represents equipotential surface. In the figure, 3 white circles are in line with the fully shaded point (along the vertical line) are at the same potential.

14. Critical angle for certain medium is $\sin^{-1}(0.6)$. The polarizing angle of that medium is ________

(1) $\tan^{-1}(1.6667)$ (2) $\tan^{-1}(0.6667)$ (3) $\tan^{-1}(1.5)$ (4) $\sin^{-1}(0.8)$

Ans (1)

$C = \sin^{-1}(0.6) \Rightarrow \sin C = 0.6$

$\Rightarrow$ R.I. of the medium, $n = \frac{1}{\sin C} = \frac{1}{0.6} = 1.6667$

According to Brewster's law, $n = \tan\theta_P$

$\theta_P = \tan^{-1} n = \tan^{-1}(1.6667)$

15. Electromagnetic wave consists of periodically oscillating electric and magnetic vectors ________

(1) in randomly oriented planes but vibrating in phase.

(2) in mutually perpendicular planes but vibrating in phase.

(3) in mutually perpendicular planes but vibrating with a phase difference of π

(4) in mutually perpendicular planes but vibrating with a phase difference of $\frac{\pi}{2}$

Ans (2)

In mutually perpendicular planes but vibrating in phase.

16. The temperature of a gas contained in a closed vessel of constant volume increases by 1 °C when the pressure of the gas is increased by 1%. The initial temperature of the gas is ________

(1) 100 °C (2) 200 K (3) 100 K (4) 273 °C

Ans (3)

Since the gas is contained in a closed vessel, volume is constant.

Hence P α T

$$\frac{T_1}{T_2} = \frac{P_1}{P_2}$$

$$\left(\frac{P_2 - P_1}{P_1}\right) \times 100 = 1 \Rightarrow \left(\frac{P_2}{P_1} - 1\right) \times 100 = 1$$

$$\frac{P_2}{P_1} = \frac{1}{100} + 1 = \frac{101}{100} = 1.01$$

$$\therefore T_2 = (T_1 + 1)$$

$$\frac{T_1}{T_2} = \frac{P_1}{P_2} \Rightarrow T_1 = T_2 \times \frac{P_1}{P_2} = (T_1 + 1) \times \frac{1}{1.01}$$

$$1.01 T_1 = T_1 + 1$$

$$0.01 T_1 = 1$$

$$T_1 = \frac{1}{0.01} = 100\,K$$

17. A motorboat covers a given distance in 6 hours moving downstream on a river. It covers the same distance in 10 hours moving upstream. The time it takes to cover the same distance in still water is ________

(1) 6.5 hours (2) 8 hours (3) 9 hours (4) 7.5 hours

Ans (4)

Let v_b = velocity of motor boat.

v_r = velocity of river.

Let d be the distance covered in 6 hours during down stream motion.

Then, $d = (v_b + v_r)t = (v_b + v_r)b$ …(1)

During upstream motion of motor boat,

$d = (v_b - v_r)\ 10$ …(2)

From (1) and (2), $(v_b + v_r)\ 6 = (v_b - v_r)\ 10$

Solving, we get $v_b = 4v_r \Rightarrow v_r = \frac{v_b}{4}$

Equation (1) $\Rightarrow d = \left(v_b + \frac{v_b}{4}\right) 6 = \frac{15}{2} v_b$

Time taken by the motor boat to cover the same distance d in still water is

$$t = \frac{d}{v_b} = \frac{\frac{15}{2} v_b}{v_b} = 7.5 \text{ hours.}$$

18. Two slabs are of the thicknesses d_1 and d_2. Their thermal conductivities are K_1 and K_2 respectively. They are in series. The free ends of the combination of these two slabs are kept at temperatures θ_1 and θ_2. Assume $\theta_1 > \theta_2$. The temperature θ of their common junction is ________

(1) $\dfrac{K_1\theta_1 d_2 + K_2\theta_2 d_1}{K_1 d_2 + K_2 d_1}$ (2) $\dfrac{K_1\theta_1 + K_2\theta_2}{K_1 + K_2}$ (3) $\dfrac{K_1\theta_1 + K_2\theta_2}{\theta_1 + \theta_2}$ (4) $\dfrac{K_1\theta_1 d_1 + K_2\theta_2 d_2}{K_1 d_2 + K_2 d_1}$

Ans (1)

Let θ be the temperature of the interface.

Since the slabs are in series,

$$\therefore \frac{K_1 A(\theta_1 - \theta)}{d_1} = \frac{K_2 A(\theta - \theta_2)}{d_2}$$

$$K_1 d_2 \theta_1 - K_1 d_2 \theta = K_2 d_1 \theta - K_2 d_1 \theta_2$$

$$\theta(K_1 d_2 + K_2 d_1) = K_1 d_2 \theta_1 + K_2 d_1 \theta_2 \quad \Rightarrow \quad \theta = \frac{K_1 d_2 \theta_1 + K_2 d_1 \theta_2}{K_1 d_2 + K_2 d_1}$$

19. Hot water cools from 60 °C to 50 °C in the first 10 minutes and to 42 °C in the next 10 minutes. Then the temperature of the surroundings is ________

(1) 15 °C (2) 10 °C (3) 20 °C (4) 30 °C

Ans (2)

Let θ_0 be the temperature of the surroundings.

Case (1) Average temperature, $\theta_{av} = \dfrac{\theta_1 + \theta_2}{2} = \dfrac{60 + 50}{2} = 55\ °C$

$$\theta_{excess} = \theta_{av} - \theta_0 = 55 - \theta_0$$

Rate of cooling = $k\,[55 - \theta_0]$

i.e., $\dfrac{60 - 50}{10} = k[55 - \theta_0]$ …(1)

Case (2) Average temperature, $\theta_{av} = \dfrac{50 + 42}{2} = 46\ °C$

$$\theta_{excess} = (46 - \theta_0)$$

Rate of cooling = $k\,(46 - \theta_0)$

$\therefore \dfrac{50 - 42}{10} = k(46 - \theta_0)$ …(2)

From equations (1) and (2), $\dfrac{10}{8} = \dfrac{55 - \theta_0}{46 - \theta_0}$ $\quad \theta_0 = 10\ °C$

20. The efficiency of Carnot's heat engine is 0.5 when the temperature of the source is T_1 and that of sink is T_2. The efficiency of another Carnot's heat engine is also 0.5. The temperature of source and sink of the second engine are respectively ________

(1) $T_1 + 5$, $T_2 - 5$ (2) $T_1 + 10$, $T_2 - 10$ (3) $2T_1$, $2T_2$ (4) $2T_1$, $\dfrac{T_2}{2}$

Ans (3)

For 1st Carnot's engine

$$\eta = 1 - \frac{T_2}{T_1}$$

$$0.5 = 1 - \frac{T_2}{T_1} \quad \text{...(1)}$$

For 2nd Carnot's engine

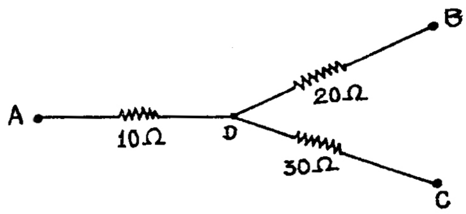
$$\eta = 1 - \frac{T_2'}{T_1'}$$

$$0.5 = 1 - \frac{T_2'}{T_1'} \quad \text{...(2)}$$

From (1) and (2), $\frac{T_2'}{T_1'} = \frac{T_2}{T_1}$

$T_1' = 2T_1$ and $T_2' = 2T_2$

21. In the circuit given here, the points A, B and C are 70 V, zero, 10 V respectively. Then



(1) currents in the paths AD, DB and DC are in the ratio of 1 : 2: 3.

(2) currents in the paths AB, DB and DC are in the ratio of 3: 2: 1.

(3) the point D will be at a potential of 60 V.

(4) the point D will be at a potential of 20 V.

Ans None of the given options is correct

Note: Option (2) should have been "currents in the paths AD, DB and DC are in the ratio 3 : 2 : 1"

By KCL, $I_1 = I_2 + I_3$

$$\left(\frac{V_A - V_D}{10}\right) = \left(\frac{V_D - 0}{20}\right) + \left(\frac{V_D - V_C}{30}\right)$$

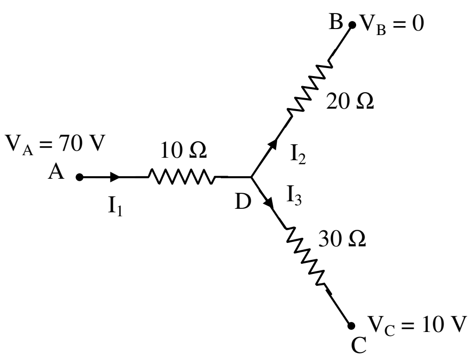
$$70 - V_D = \frac{V_D}{2} + \left(\frac{V_D - 10}{3}\right)$$

$$6(70 - V_D) = 3V_D + 2(V_D - 10)$$

$$420 - 6V_D = 3V_D + 2V_D - 20$$

$$11V_D = 440$$

$$V_D = 40 \text{ V}$$



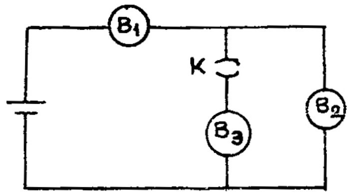
$$\therefore\ I_1 = \frac{(70 - 40)}{10} = 3\text{A}$$

$$I_2 = \frac{40 - 0}{20} = 2 \text{ A}$$

$$I_3 = \frac{40 - 10}{30} = 1 \text{ A}$$

$$\therefore I_{AD} : I_{DB} : I_{DC} = 3 : 2 : 1$$

22. B_1, B_2 and B_3 are the three identical bulbs connected to a battery of steady e.m.f. with key K closed. What happens to the brightness of the bulbs B_1 and B_2 when the key is opened?



(1) Brightness of the bulb B_1 decreases and that of B_2 increases.

(2) Brightness of the bulbs B_1 and B_2 decreases.

(3) Brightness of the bulbs B_1 increases and that of B_2 decreases.

(4) Brightness of the bulbs B_1 and B_2 increases.

Ans (1)

(i) K closed

$$R_{eff} = R + \frac{R}{2} = \frac{3R}{2}$$

$$I = \frac{2V}{3R} = 0.67\left(\frac{V}{R}\right)$$

Brightness of B_1 is more than that of B_2 and B_3.

(ii) K open

$R_{eff} = 2R$

$$I' = \frac{V}{2R} = 0.5\left(\frac{V}{R}\right)$$

$\therefore$ Brightness of B_1 decreases and that of B_2 increases.

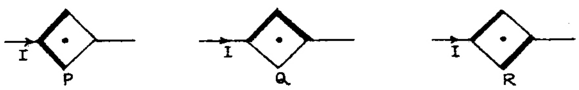
23. Magnetic field at the centre of a circular coil of radius R due to current I flowing through it is B. The magnetic field at a point along the axis at distance R from the centre is ________

(1) $\frac{B}{\sqrt{8}}$ (2) $\sqrt{8}B$ (3) $\frac{B}{2}$ (4) $\frac{B}{4}$

Ans (1)

$$B_x = \frac{\mu_0 NIR^2}{2\left[R^2 + x^2\right]^{\frac{3}{2}}} = \frac{\mu_0 NIR^2}{2\left[R^2 + x^2\right]^{\frac{3}{2}}} = \frac{\mu_0 NI}{\sqrt{8} \times 2R} = \frac{B}{\sqrt{8}}$$

24. Two thick wires and two thin wires, all of same material and same length, form a square in three different ways P, Q and R as shown in the figure. With correct connections shown, the magnetic field due to the current flow, at the centre of the loop will be zero in case of ________



(1) P and Q only (2) P and R only (3) Q and R only (4) P only

Ans (2)

Each branch resistance in P and R is the same. So, the magnetic fields at the centre due to one branch current is equal and opposite to that due to the other. B = 0.

25. There is a uniform magnetic field directed perpendicular and into the plane of the paper. An irregular shaped conducting loop is slowly changing into a circular loop in the plane of the paper. Then ________

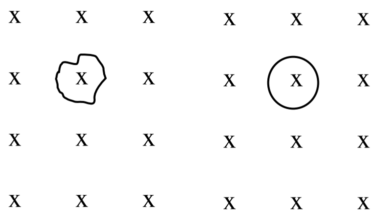
(1) AC is induced in the loop.

(2) no current is induced in the loop.

(3) current is induced in the loop in the anti-clockwise direction.

(4) current is induced in the loop in the clockwise direction.

Ans (3)



As the shape of the loop is changed to circular one, flux linking the loop increases. The Lenz law says that this increases must be opposed by the induced current. Hence, the induced current is anticlockwise.

26. The dimensions of 'resistance' are same as those of ________ where h is the Planck's constant, e is the charge.

(1) $\frac{h}{e^2}$ (2) $\frac{h}{e}$ (3) $\frac{h^2}{e^2}$ (4) $\frac{h^2}{e}$

Ans (1)

$$\left[\frac{h}{e^2}\right] = \left[\frac{J_S}{C^2}\right] = \left[\frac{VCs}{C^2}\right]$$

$$= \left[\frac{V}{C_S^{-1}}\right] = \left[\frac{V}{I}\right] = [R]$$

27. A train is moving slowly on a straight track with a constant speed of 2 ms^{-1}. A passenger in that train starts walking at a steady speed of 2 ms^{-1} to the back of the train in the opposite direction of the motion of the train. So to an observer standing on the platform directly in front of that passenger, the velocity of the passenger appears to be

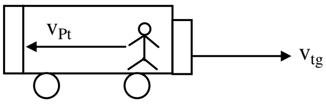
(1) 2 ms^{-1} in the opposite direction of the train (2) zero

(3) 4ms^{-1} (4) 2 ms^{-1}

Ans (2)

$\vec{v}_{pg} - \vec{v}_{tg} = \vec{v}_{pt}$

$\vec{v}_{pg} = \vec{v}_{pt} + \vec{v}_{tg} = 0$



28. A ball rests upon a flat piece of paper on a table top. The paper is pulled horizontally but quickly towards right as shown. Relative to its initial position with respect to the table, the ball

(a) remains stationary if there is no friction between the paper and the ball.

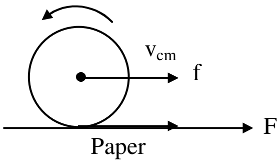
(b) moves to the left and starts rolling backwards, i.e. to the left if there is a friction between the paper and the ball.

(c) moves forward, i.e. in the direction in which the paper is pulled.

Here, the correct statement/s is/are

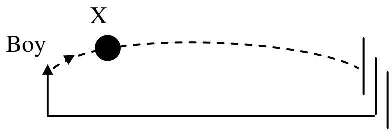
(1) only (a) (2) only (b) (3) both (a) and (b) (4) only (c)

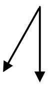
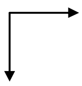
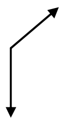
Ans None of the given options is correct



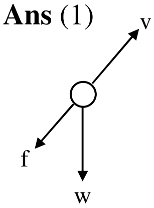
Slipping tendency is against the direction in which the paper is pulled. So, friction f is in the direction of F, the pull on the paper. Hence the linear speed is in the direction of motion of the pull. So, it moves to the right. At the same time, it has the tendency to rotate anticlockwise.

29. A boy throws a cricket ball from the boundary to the wicket-keeper. If the frictional force due to air cannot be ignored, the forces acting on the ball at the position X are represented by ________



(1)  (2)  (3)  (4) 

Ans (1)



30. If the linear momentum of a body is increased by 50%, then the kinetic energy of that body increases by

(1) 225 % (2) 25 % (3) 100 % (4) 125%

Ans (4)

$$K = \frac{p^2}{2m}$$

$$\frac{K_1}{K} = \left(\frac{p_1}{p_2}\right)^2 = \left(\frac{3}{2}\right)^2 = \frac{9}{4}$$

$$\Delta K = (K_1 - K) = \frac{5K}{4}$$

Percentage increase = $\frac{\Delta K}{K} \times 100 = \frac{5 \times 100}{4} = 125\%$

31. Two simple harmonic motions are represented by $y_1 = 5\left[\sin 2\pi t + \sqrt{3}\cos 2\pi t\right]$ and $y_2 = 5\sin\left(2\pi t + \frac{\pi}{4}\right)$

The ratio of their amplitude is

(1) 1 : 3 (2) $\sqrt{3}$: 1 (3) 1 : 1 (4) 2 : 1

Ans (4)

$$y_1 = 5\left[\sin(2\pi t) + \sqrt{3}\cos(2\pi t)\right]$$

$$= 2 \times 5\left[\frac{1}{2}\sin(2\pi t) + \frac{\sqrt{3}}{2}\cos(2\pi t)\right]$$

$$= 10\left[\cos\frac{\pi}{3}\sin(2\pi t) + \sin\frac{\pi}{3}\cos(2\pi t)\right]$$

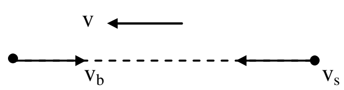
$$= 10\left[\sin\left(2\pi f t + \frac{\pi}{3}\right)\right]$$

$$\therefore \frac{A_1}{A_2} = \frac{10}{5} = \frac{2}{1}$$

32. A bat flies at a steady speed of 4 m s^{-1} emitting a sound of f = 90 × 10^3 Hz. It is flying horizontally towards a vertical wall. The frequency of the reflected sound as detected by the bat will be (Take velocity of sound in air as 330 m s^{-1}).

(1) 92.1 × 10^3 Hz (2) 89.1 × 10^3 Hz (3) 88.1 × 10^3 Hz (4) 87.1 × 10^3 Hz

Ans (1)



$$f' = \left(\frac{v - v_0}{v - v_s}\right) f = \left(\frac{330 + 4}{330 - 4}\right) \times 90 \text{ kHz}$$

= 92.2 kHz

33. A closed organ pipe and an open organ pipe of same length produce 2 beats/second while vibrating in their fundamental modes. The length of the open organ pipe is halved and that of closed pipe is doubled. Then, the number of beats produced per second while vibrating in the fundamental mode is

(1) 8 (2) 7 (3) 2 (4) 6

Ans (2)

$$f_c = \frac{v}{4L}\ ;\ f_0 = \frac{v}{2L}$$

$$f_b = f_0 - f_c = \frac{v}{2L}\left(1-\frac{1}{2}\right) = \frac{v}{4L} \Rightarrow \frac{v}{4L} = 2 \Rightarrow \frac{v}{L} = 8$$

$$f_b' = \left[\frac{v}{2\times\frac{L}{2}} - \frac{v}{4\times 2L}\right] = \left[\frac{v}{L}\left(1-\frac{1}{8}\right)\right]$$

$$= 8\times\frac{7}{8} = 7\ \text{Hz}.$$

34. A uniform wire of length L, diameter D and density P is stretched under a tension T. The correct relation between its fundamental frequency 'f', the length L and the diameter D is

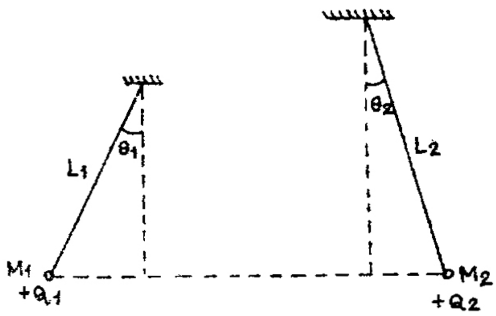
(1) $f\ \alpha\ \frac{L}{D^2}$ (2) $f\ \alpha \frac{1}{LD^2}$ (3) $f\ \alpha \frac{1}{LD}$ (4) $f\ \alpha\ \frac{1}{L\sqrt{D}}$

Ans (3)

$$f = \frac{1}{2L}\sqrt{\frac{T}{\mu}} = \frac{1}{2L}\sqrt{\frac{T}{\frac{\pi D^2 L\rho/L}{4}}}$$

$$= \frac{1}{2L}\sqrt{\frac{2T}{\pi\rho D^2}} = \frac{1}{LD}\sqrt{\frac{T}{\pi\rho}} \Rightarrow f \propto \frac{1}{LD}$$

35. Two small spheres of masses M_1 and M_2 are suspended by weightless insulating threads of lengths L_1 and L_2. The spheres carry charges of Q_1 and Q_2 respectively. The spheres are suspended such that they are in level with one another and the threads are inclined to the vertical at angles of θ_1 and θ_2 as shown. Which one of the following conditions is essential, if $\theta_1 = \theta_2$?



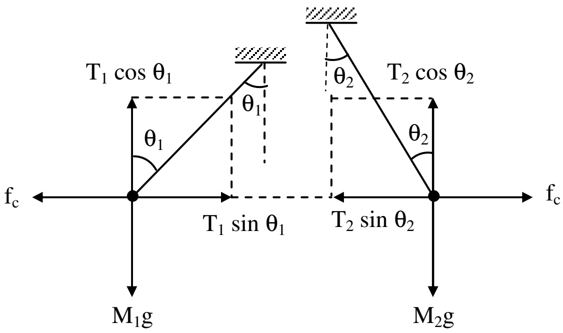
(1) $Q_1 = Q_2$

(2) $L_1 = L_2$

(3) $M_1 \neq M_2$, but $Q_1 = Q_2$

(4) $M_1 = M_2$

Ans (4)



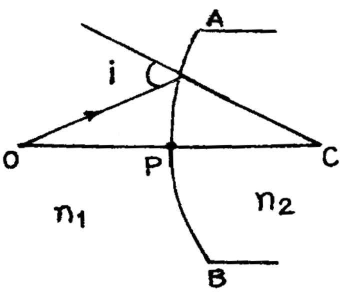
Under equilibrium condition $T_1 \cos \theta_1 = M_1 g$; $T_2 \cos \theta_2 = M_2 g$

$T_1 \sin \theta_1 = T_2 \sin \theta_2 = f_c$

For $\theta_1 = \theta_2$, $T_1 = T_2$ and $M_1 = M_2$

36. A point object O is kept at a distance of OP = u. The radius of curvature of the spherical surface APB is CP = R. The refractive index of the media are n_1 and n_2 which are as shown in the diagram. Then,

(a) if $n_1 > n_2$, image is virtual for all values of 'u'.
(b) if $n_2 = 2n_1$, image is virtual when R> u.
(c) the image is real for all values of u, n_1 and n_2.
Here, the correct statement/s is/are



(1) only (a)

(2) (a), (b) and (c)

(3) only (b)

(4) both (a) and (b)

Ans (4)

$$\frac{n_1}{u} + \frac{n_2}{v} = \frac{n_1 \sim n_2}{R}$$

$$\Rightarrow \frac{n_2}{v} = \frac{n_1 \sim n_2}{R} - \frac{n_1}{u}$$

(a) If $n_1 > n_2$

$$\frac{n_2}{v} = \left(\frac{n_1 - n_2}{-R} - \frac{n_1}{u} \right) < 0$$

So, image is virtual for all values of u

(b) If $n_2 = 2n_1$ and R > u

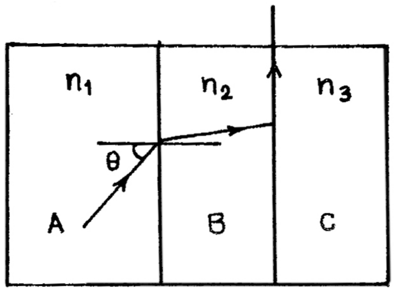
$$\frac{2n_1}{v} = \frac{n_1}{R} - \frac{n_1}{u} < 0 \quad \text{if } R > u$$

So, image is virtual when R > u

37. A, B and C are the parallel sided transparent media of refractive index n_1, n_2 and n_3 respectively. They are arranged as shown in the figure. A ray is incident at an angle θ on the surface of separation of A and B which is as shown in the figure. After the refraction into the medium B, the ray grazes the surface of separation of the media B and C. Then, sin θ =

(1) $\frac{n_2}{n_3}$ (2) $\frac{n_1}{n_2}$

(3) $\frac{n_3}{n_1}$ (4) $\frac{n_1}{n_3}$



Ans (3)

$$\frac{\sin\theta}{\sin r} = \frac{n_2}{n_1};\ \sin r = \sin C = \frac{n_3}{n_2}$$

$$\therefore \sin\theta = \frac{n_2}{n_1} \times \frac{n_3}{n_2} = \frac{n_3}{n_1}$$

38. A boat has green light of wavelength λ = 500 nm on the mast. What wavelength would be measured and what colour would be observed for this light as seen by a diver submerged in water by the side of the boat? Given $n_w = 4/3$.

(1) Green of wavelength 500 nm (2) Blue of wavelength 376 nm

(3) Green of wavelength 376 nm (4) Red of wavelength 665 nm

Ans (3)

$$n_w = \frac{c}{v} = \frac{\lambda_0}{\lambda_w}$$

$$\Rightarrow \lambda_w = \frac{\lambda_0}{n_w} = \frac{500 \times 3}{4} = 375\ \text{nm}$$

Note: option (3) should be "Green of wavelength 375 nm"

39. Two beams of red and violet colours are made to pass separately through a prism of A = 60°. In the minimum deviation position, the angle of refraction inside the prism will be

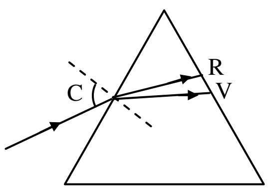
(1) greater for violet colour

(2) 30° for both the colours

(3) greater for red colour

(4) equal but not 30° for both the colours

Ans (2)



$r_v > r_r$

Since red and violet lights are sent separately, when the prism is in minimum deviation position, $r_1 = r_2 = 30°$ for both the rays. If red and violet lights are together incident at the same angle, minimum deviation position can be set for one colour only.

40. The focal length of a plano convex lens is 'f' and its refractive index is 1.5. It is kept over a plane glass plate with its curved surface touching the glass plate. The gap between the lens and the glass plate is filled by a liquid. As a result, the effective focal length of the combination becomes 2f. Then the refractive index of the liquid is

(1) 1.25 (2) 1.33 (3) 1.5 (4) 2

Ans (1)

$$\frac{1}{f_g} = \frac{1}{2R} ; \frac{1}{f_l} = \frac{n-1}{R}$$

$$\frac{1}{f_{eq}} = \frac{1}{2f_g} = \frac{1}{4R}$$

$$\therefore \frac{1}{4R} = \frac{1}{2R} - \frac{(n-1)}{R}$$

$$(n-1) = \frac{1}{2} - \frac{1}{4} = \frac{1}{4}$$

$$\therefore n = 1 + \frac{1}{4} = 1.25$$

41. ν_1 is the frequency of the series limit of Lyman series, ν_2 is the frequency of the first line of Lyman series and ν_3 is the frequency of the series limit of the Balmer series. Then

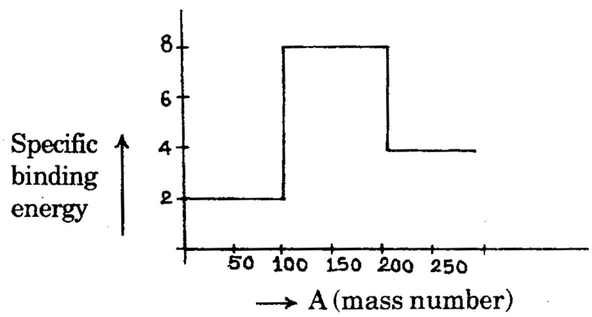
(1) $\frac{1}{\nu_2} = \frac{1}{\nu_1} + \frac{1}{\nu_3}$ (2) $\frac{1}{\nu_1} = \frac{1}{\nu_2} + \frac{1}{\nu_3}$ (3) $\nu_1 - \nu_2 = \nu_3$ (4) $\nu_1 = \nu_2 - \nu_3$

Ans (3)

$$\nu_L^{Limit} = \nu_1 ; \nu_2^L = \nu_2 ; \nu_3 = \nu_{Lim}^B$$

$$\nu_1 - \nu_3 = \nu_2 \Rightarrow \nu_1 - \nu_2 = \nu_3$$

42. Assume the graph of specific binding energy versus mass number is as shown in the figure. Using this graph, select the correct choice from the following:



(1) Fusion of two nuclei of mass number lying in the range of 1 < A < 50 will release energy.
(2) Fission of the nucleus of mass number lying in the range of 100 < A < 200 will release energy when broken into two fragments.
(3) Fusion of two nuclei of mass number lying in the range of 100 < A < 200 will release energy.
(4) Fusion of two nuclei of mass number lying in the range of 51 < A < 100 will release energy

Ans (4)

Specific B.E of the products is greater than the reactants.

43. Pick out the correct statement from the following

(1) Pu^{239} is not suitable for a fission reaction.

(2) For stable nucleus, the specific binding energy is low.

(3) Energy released per unit mass of the reactant is less in case of fusion reaction.

(4) Packing fraction may be positive or may be negative

Ans (4)

Packing fraction is w.r.t ^{12}C. So it can be zero, +ve and −ve.

Option (1) is wrong. Because, Pu^{239} is a nuclear fuel used in a nuclear reactor

Option (2) is wrong. Because, for a stable nucleus, the specific binding energy is high (~ 8 MeV)

Option (3) is wrong. Because energy released per unit mass of the reactants is high in a fusion reaction,

Option (4) is correct. Positive packing fraction ⇒ less stable nucleus; negative packing fraction ⇒ more stable nucleus.

44. A radioactive sample S_1 having the activity A_1 has twice the number of nuclei as another sample S_2 of activity A_2. If $A_2 = 2A_1$, then the ratio of half life of S_1 to the half life of S_2 is

(1) 0.25 (2) 0.75 (3) 4 (4) 2

Ans (3)

$A_1 = N_1\lambda_1$; $A_2 = N_2\lambda_2$

$$\frac{A_1}{A_2} = \left(\frac{N}{N_2}\right)\left(\frac{T_2}{T_1}\right)$$

$$\Rightarrow \frac{T_2}{T_1} = \left(\frac{A_1}{A_2}\right)\left(\frac{N_2}{N_1}\right) = \frac{1}{2}\times\frac{1}{2} = \frac{1}{4}$$

$$\frac{T_1}{T_2} = \frac{4}{1}$$

45. When a neutron is disintegrated to give a β-particle,

(1) a proton alone is emitted.

(2) a proton and an antineutrino are emitted.

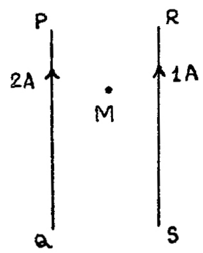
(3) a neutrino alone is emitted.

(4) a proton and neutrino are emitted.

Ans (2)

$$n \rightarrow p + _{-1}e + \overline{v}$$

46. PQ and RS are long parallel conductors separated by certain distance. M is the midpoint between them (see the figure). The net magnetic field at M is B. Now, the current 2A is switched off. The field at M now becomes



(1) $\frac{B}{2}$

(2) 3B

(3) 2B

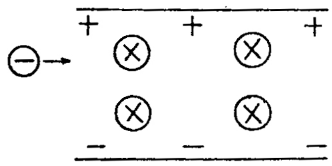
(4) B

Ans (4)

$$B = \frac{\mu_0 I}{2\pi a}$$

$$B_r = \frac{(2I - I)\mu_0}{2\pi a} = \frac{\mu_0 I}{2\pi a} = B$$

47. An electron enters the space between the plates of a charged capacitor as shown. The charge density on the plate is σ. Electric intensity in the space between the plates is E. A uniform magnetic field B also exists in that space perpendicular to the direction of E. The electron moves perpendicular to both $\vec{E}$ and $\vec{B}$ without any change in direction.



The time taken by the electron to travel a distance l in that space is

(1) $\frac{\epsilon_0 lB}{\sigma}$ (2) $\frac{\epsilon_0 l}{\sigma B}$ (3) $\frac{\sigma l}{\epsilon_0 B}$ (4) $\frac{\sigma B}{\epsilon_0 l}$

Ans (1)

$$v = \frac{E}{B} = \frac{6}{\epsilon_0 .B}$$

$$t = \frac{l}{v} = \frac{\epsilon_0 Bl}{\sigma}$$

48. In a series resonant R–L–C circuit, the voltage across R is 100 V and the value of R = 1000 Ω. The capacitance of the capacitor is 2×10^{-6} F; angular frequency of AC is 200 rad s^{-1}. Then the P.D. across the inductance coil is

(1) 250 V (2) 400 V (3) 100 V (4) 40 V

Ans (1)

$$I = \frac{V}{R} = 0.1 \text{ A}$$

$$V_L = 2\pi + LI = \frac{I}{2\pi + C}$$

$$= 200 \times 2 \times 10^{-6}$$

$$= \frac{1000}{4} = 250\text{ V}$$

49. A capacitor and an inductance coil are connected in separate AC circuits with a bulb glowing in both the circuits. The bulb glows more brightly when

(1) separation between the plates of the capacitor is increased.

(2) a dielectric is introduced into the gap between the plates of the capacitor.

(3) an iron rod is introduced into the inductance coil.

(4) the number of turns in the inductance coil is increased.

Ans (2)

$C_{med} = KC_{air}$; $X_C \propto \frac{1}{C}$ $\therefore$ X_C decreases and I increases

50. A horizontal metal wire is carrying an electric current from the north to the south. Using a uniform magnetic field, it is to be prevented from falling under gravity. The direction of this magnetic field should be towards the

(1) east (2) west (3) north (4) south

Ans (1)

By Fleming's left hand rule.

51. The forbidden energy gap in *Ge* is 0.72 eV. Given, *hc* = 12400eV −Å. The maximum wavelength of radiation that will generate an electron hole pair is ………..

(1) 17222 Å (2) 1722 Å

(3) 172220 Å (4) 172.2 Å

Ans (1)

$$\frac{hc}{e\lambda} = 0.72 \text{ eV}$$

$$\lambda \approx \frac{12400}{0.72} \overset{o}{A} = 17222 \overset{o}{A}$$

52. Pick out the statement which is NOT correct.

(1) Width of the depletion region increases as the forward bias voltage increases in case of a N- P junction diode.

(2) In a forward bias condition, the diode heavily conducts.

(3) At a low temperature, the resistance of a semiconductor is very high.

(4) Movement of holes is restricted to the valence band only.

Ans (1)

Width of the depletion region decreases as the forward bias voltage increases in case of a N-P junction diode.

53. In a given direction, the intensities of the scattered light by a scattering substance for two beams of light are in the ratio of 256: 81. The ratio of the frequency of the first beam to the frequency of the second beam is

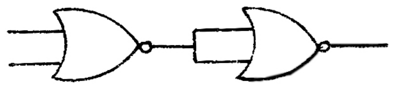
(1) 64:27 (2) 2:1 (3) 64:127 (4) 1:2

Ans None of the given options is correct

$I \propto \nu^4$

$$\therefore \frac{\nu_1}{\nu_2} = \left(\frac{I_1}{I_2}\right)^{\frac{1}{4}} = \left(\frac{256}{81}\right)^{\frac{1}{4}} = \frac{4}{3}$$

54. Identify the logic operation performed by the circuit given here.



(1) NOT (2) NAND (3) OR (4) NOR

Ans (3)

NOR NOT OR

55. The de-Broglie wavelength of the electron in the ground state of the hydrogen atom is ………….. (radius of the first orbit of hydrogen atom = 0.53 Å).

(1) 1.06 Å (2) 0.53 Å (3) 1.67 Å (4) 3.33 Å

Ans (4)

$2\pi r = \lambda$

$\Rightarrow \lambda = 3.33\,\text{Å}$

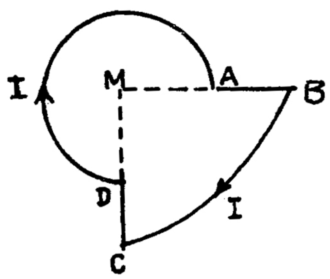
56. A current I is flowing through the loop. The direction of the current and the shape of the loop are as shown in the figure. The magnetic field at the centre of the loop is $\frac{\mu_0 I}{R}$ times …………… (MA = R, MB = 2R, $\underline{|DMA} = 90^\circ$)

(1) $\frac{7}{16}$, but out of the plane of the paper.

(2) $\frac{7}{16}$, but into the plane of the paper.

(3) $\frac{5}{16}$, but out of the plane of the paper.

(4) $\frac{5}{16}$, but into the plane of the paper.



Ans (2)

$$B = \frac{\mu_0 I}{4\pi}\left[\frac{3\times 2\pi R}{4R^2} + \frac{2\pi\times 2R}{4\times 4R^2}\right]$$

$$= \frac{\mu_0 I}{2\times 4}\left[\frac{3}{R} + \frac{2}{4R}\right]$$

$$= \frac{\mu_0 I}{8}\left[\frac{3}{R} + \frac{1}{2R}\right] = \frac{7\mu_0 I}{16R}, \text{ into the plane of the paper.}$$

57. An ideal choke draws a current of 8A when connected to an AC supply of 100 V, 50 Hz. A pure resistor draws a current of 10 A when connected to the same source. The ideal choke and the resistor are connected in series and then connected to the AC source of 150 V, 40 Hz. The current in the circuit becomes

(1) 18 A (2) 10 A (3) $\frac{15}{\sqrt{2}}$ A (4) 8 A

Ans (3)

$R = \frac{100}{10} = 10\ \Omega$

$X_L = \frac{100}{8} = 12.5$

$\therefore\ 2\pi fL = 12.5 \Rightarrow L = 0.04$ H

$X_L' = 2\pi f' L = 10\Omega$

$Z' = \sqrt{R^2 + X'L^2} = 10\sqrt{2}\ \Omega$

$I = \frac{150}{10\sqrt{2}} = \frac{15}{\sqrt{2}}$ A

58. The spectrum of an oil flame is an example for

(1) line absorption spectrum (2) band emission spectrum

(3) line emission spectrum (4) continuous emission spectrum

Ans (4)

Continuous emission spectrum

59. According to Einstein's photoelectric equation, the graph of K.E. of the photoelectron emitted from the metal versus the frequency of the incident radiation gives a straight line graph, whose slope

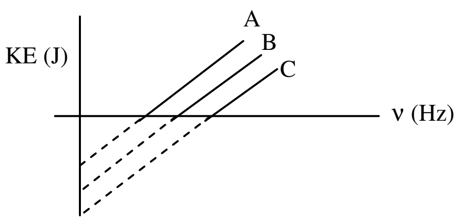
(1) is same for all metals and independent of the intensity of the incident radiation.

(2) depends on the nature of the metal.

(3) depends on the intensity of the incident radiation.

(4) depends on the nature of the metal and also on the intensity of incident radiation.

Ans (1)



$(K.E)_{MAX} = h\nu - h\nu_0$

$(y = mx + c)$

The graph shows three lines drawn with respect to different metals. They are parallel. Slope of each straight line is h, Planck's constant. It is a universal constant.

60. An electron is moving in an orbit of a hydrogen atom from which there can be a maximum of six transitions. An electron is moving in an orbit of another hydrogen atom from which there can be a maximum of three transitions. The ratio of the velocity of the electron in these two orbits is

(1) $\frac{5}{4}$ (2) $\frac{3}{4}$ (3) $\frac{1}{2}$ (4) $\frac{2}{1}$

Ans (2)

Number of possible transitions = $\frac{n(n-1)}{2}$

Case (i) $\frac{n(n-1)}{2} = 6 \Rightarrow n = 4$

Case (ii) $\frac{n(n-1)}{2} = 3 \Rightarrow n = 3$

Velocity of the electron in n^{th} stationary orbit, $v_n \propto \frac{1}{n}$

$\therefore \frac{v_4}{v_3} = \frac{3}{4}$

* * *