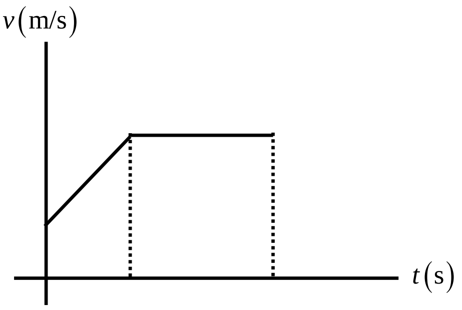
1. For a body moving along a straight line, the following v-t graph is obtained.

According to the graph, the displacement during



(a) Uniform acceleration is greater than that during uniform motion

(b) Uniform acceleration is less than that during uniform motion

(c) Uniform acceleration is equal to that during uniform motion

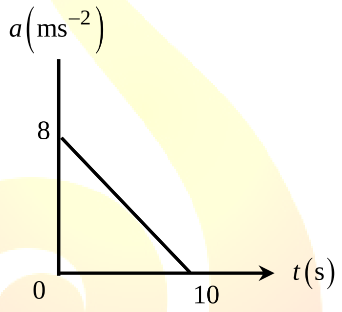
(d) Uniform motion is zero

Ans: (b)

Sol: Displacement = area under $v-t$ graph. For the given, $v-t$ graph the area under uniform acceleration is less than area under uniform motion. Hence, the displacement during uniform acceleration is less than that during uniform motion.

Motion in a straight line

2. A particle starts from rest. Its acceleration 'a' versus time 't' is shown in the figure. The maximum speed of the particle will be



(a) $80\ \text{ms}^{-1}$ (b) $40\ \text{ms}^{-1}$ (c) $18\ \text{ms}^{-1}$ (d) $2\ \text{ms}^{-1}$

Ans: (b)

Sol: Maximum speed = Area of the triangle

$\therefore v_{max} = \frac{1}{2} \times 8 \times 10 = 40\,\text{ms}^{-1}$

Motion in a straight line

3. The maximum range of a gun on horizontal plane is 16 km. If $g = 10\ \text{ms}^{-2}$, then muzzle velocity of a shell is

(a) $160\ \text{ms}^{-1}$ (b) $200\sqrt{2}\ \text{ms}^{-1}$ (c) $400\ \text{ms}^{-1}$ (d) $800\ \text{ms}^{-1}$

Ans: (c)

Sol: $R_{\max} = \frac{u^2}{g} \Rightarrow u^2 = gR$

$u^2 = 10 \times 16 \times 1000$

$\therefore u = 4 \times 10^2 = 400 \text{ ms}^{-1}$

Motion in a plane

4. The trajectory of a projectile is

   (a) Semicircle

   (b) An ellipse

   (c) A parabola always

   (d) A parabola in the absence of air resistance

Ans: (d)

Sol: The trajectory of a projectile is a parabola in the absence of air resistance.

Motion in a plane

5. For a projectile motion, the angle between the velocity and acceleration is minimum and acute at

   (a) only one point (b) two points (c) three points (d) four points

Ans: (a)

Sol: For a projectile motion, the angle between the velocity and acceleration is obtuse in the beginning of the motion, it changes to right angle at the maximum height of the motion and it becomes less acute as it reaches the ground. At the end of the projectile motion, just before it hits the ground the angle is acute and minimum. Hence, the angle between the velocity and acceleration is minimum and acute at only point.

Motion in a plane

6. A particle starts from the origin at $t = 0$ s with a velocity of $10\hat{j}$ ms^{-1} and moves in the x-y plane with a constant acceleration of $(8\hat{i} + 2\hat{j})$ ms^{-1}. At an instant when the x-coordinate of the particle is 16 m, y-coordinate of the particle is

   (a) 16 m (b) 28 m (c) 36 m (d) 24 m

Ans: (d)

Sol: $v = 10\hat{j}$ and $a = 8\hat{i} + 2\hat{j}$

$\vec{s} = \vec{u}t + \frac{1}{2}\vec{a}t^2$

$\Rightarrow x\hat{i} + y\hat{j} = (10\hat{j}) + \frac{1}{2}(8\hat{i} + 2\hat{j})t^2 = 4t^2\hat{i} + (10t + t^2)\hat{j}$

$x = 4t^2$ and $x = 16 \Rightarrow t = 2\text{ s}$

$\therefore y = 10t + t^2 = 20 + 4 = 24$

Motion in a plane

7. A coin placed on a rotating turn table just slips if it is placed at a distance of 4 cm from the centre. If the angular velocity of the turn table is doubled it will just slip at a distance of

(a) 1 cm (b) 2 cm (c) 4 cm (d) 4 cm

Ans: (a)

Sol: When the coin is just on the verge of slipping, it just overcomes the force of static friction (F_s) which acts as centripetal force for being that coin in the circular motion.

$F_s = m\omega^2 r$

If we double the ω then r will also self adjust to a new r', since the static friction will remain same.

$\Rightarrow m\omega^2 r = m(2\omega)^2 r'$

$\therefore r' = \frac{r}{4} = \frac{4}{4} = 1\text{ cm}$

Laws of motion

8. A 1 kg ball moving at 12 ms^{-1} collides with a 2 kg ball moving in opposite direction at 24 ms^{-1}. If the coefficient of restitution is $\frac{2}{3}$, then their velocities after the collision are

(a) $-4\text{ ms}^{-1}, -28\text{ ms}^{-1}$ (b) $-28\text{ ms}^{-1}, -4\text{ ms}^{-1}$ (c) $4\text{ ms}^{-1}, 28\text{ ms}^{-1}$ (d) $28\text{ ms}^{-1}, 4\text{ ms}^{-1}$

Ans: (b)

Sol: Given: $m = 1\text{kg}, u_1 = 12\text{ms}^{-1}, m_2 = 2\text{kg}$ and $u_2 = -24\text{ms}^{-1}$

Using conservation of linear momentum

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

$(1\times 12) + (2\times -24) = (1\times v_1) + (2\times v_2)$

$v_1 + 2v_2 = -36$ ...... (i)

Now, $e = \frac{v_2 - v_1}{u_1 - u_2}$

$\Rightarrow \frac{v_2 - v_1}{u_1 - u_2} = \frac{2}{3}$

$v_2 - v_1 = 24$ ...... (ii)

Solving (i) and (ii), we get

$v_1 = -28\,\text{ms}^{-1}$ and $v_2 = -4\,\text{ms}^{-1}$

Work, Energy and Power

9. A ball hits the floor and rebounds after an inelastic collision. In this case

(a) The momentum of the ball is conserved

(b) The mechanical energy of the ball is conserved

(c) The total momentum of the ball and the earth is conserved

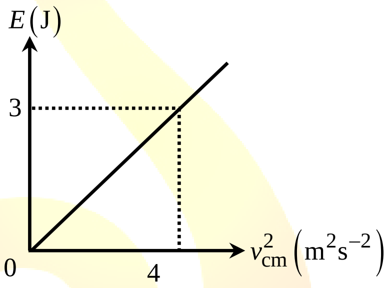
(d) The total mechanical energy of the ball and the earth is conserved

Ans: (c)

Sol: The total momentum of the ball and the earth is conserved

Work, Energy and Power

10. In figure E and v_{cm} represent the total energy and speed of centre of mass of an object of mass $1\,\text{kg}$ in pure rolling. The object is



(a) Sphere (b) Ring (c) Disc (d) Hollow Cylinder

Ans: (c)

Sol: $E = \frac{1}{2}Mv^2 + I\omega^2$

$$E = \frac{1}{2}Mv_{cm}^2\left(1 + \frac{k^2}{R^2}\right)$$

Comparing with equation of straight line passing through origin $y = mx$

Slope, $m = \frac{1}{2}M\left(1 + \frac{K^2}{R^2}\right)$

Now, the slope of E versus v_{cm}^2 from the given figure is $m = \frac{3}{4}$

$$\Rightarrow \frac{3}{4} = \frac{1}{2} \times 1\left[1 + \frac{K^2}{R^2}\right] \qquad (\because M = 1\text{kg})$$

$$1+\frac{K^2}{R^2}=\frac{6}{4}$$

$$\frac{K^2}{R^2}=\frac{6}{4}-1$$

$$\frac{K^2}{R^2}=\frac{6-4}{4}$$

$$\frac{K^2}{R^2}=\frac{1}{2}$$

$$\frac{K}{R}=\frac{1}{\sqrt{2}}$$

Hence, given the object is disc.

System of particles

11. Two bodies of masses 8 kg are placed at the vertices A and B of an equilateral triangle ABC. A third body of mass 2 kg is placed at the centroid G of the triangle. If $AG = BG = CG = 1\text{ m}$, where should a fourth body of mass 4 kg be placed so that the resultant force on the 2 kg body is zero?

(a) at C

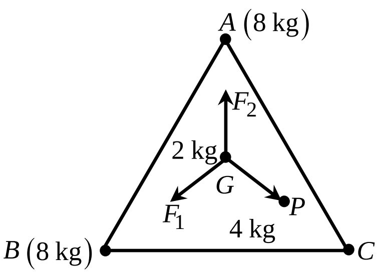
(b) at a point P on the line CG such that $PG=\frac{1}{\sqrt{2}}\text{ m}$

(c) at a point P on the line CG such that $PG = 0.5\text{ m}$

(d) at a point P on the line CG such that $PG = 2\text{ m}$

Ans: (b)

Sol: $F_1 = F_2 = \frac{G(8)(2)}{1^2} = F$ (say) … (i)



Resultant of F_1 and F_2

$$F_{14}=\sqrt{F^2+F^2+2F(F)\cos 120^\circ}=F$$

In order that mass at G is at rest

Force on G due to P is also F

$$F=\frac{G(4)(2)}{(GP)^2} \quad \dots \text{(ii)}$$

From (i) and (ii),

$$\frac{G(8)(2)}{1^2}=\frac{G(4)(2)}{(GP)^2}$$

$$\Rightarrow GP=\frac{1}{\sqrt{2}}\text{ m}$$ Gravitation

12. Two capillary tubes P and Q are dipped vertically in water. The height of water level in capillary tube P is $\frac{2}{3}^{\text{th}}$ of the height in capillary tube Q. The ratio of their diameter is______.

(a) $2:3$ (b) $3:2$ (c) $3:4$ (d) $4:3$

Ans: (b)

Sol: $h = \frac{2T}{r\rho g}$

$h_1 r_1 = \text{Constant}$

$\frac{h_1 d_1}{2} = \text{Constant}$

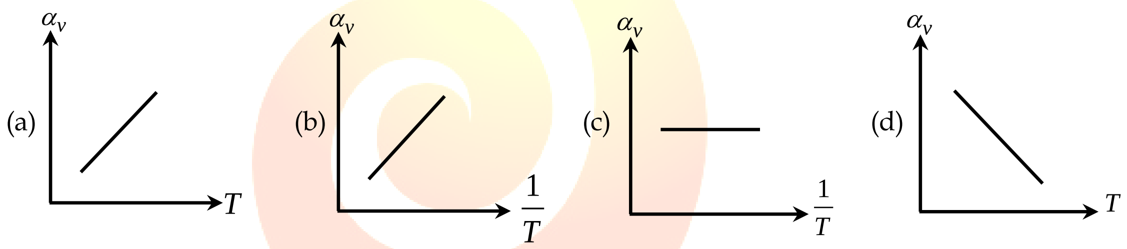
$\Rightarrow h_1 d_1 = h_2 d_2$

$\frac{d_1}{d_2} = \frac{h_2}{h_1}$

$\frac{h_1}{h_2} = \frac{2}{3}$

$\therefore \frac{d_1}{d_2} = \frac{3}{2}$ Mechanical properties of fluids

13. Which of the following curves represent the variation of coefficient of volume expansion of an ideal gas at constant pressure?



Ans: (c)

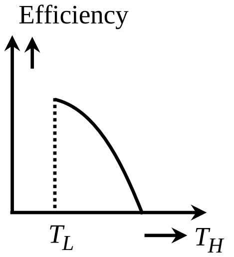
Sol: $\alpha = \frac{1}{T}$

Hence, curve c represents the variation of coefficient of volume expansion of an ideal gas at constant pressure.

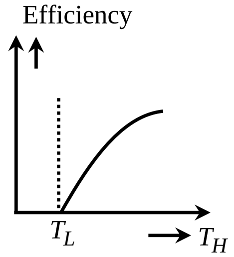
Thermal properties of matter

14. A number of Carnot engines are operated at identical cold reservoir temperatures (T_1). However, their hot reservoir temperatures are kept different. A graph of the efficiency of the engines versus hot reservoir temperature (T_H) is plotted. The correct graphical representation is

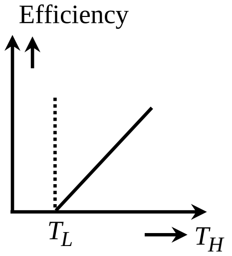
(a)



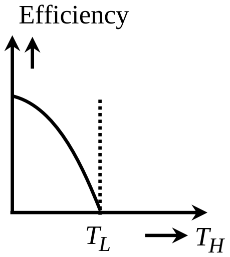
(b)



(c)



(d)



Ans: (b)

Sol: $\eta = 1 - \frac{T_L}{T_H}$

For, $T_L = 50$ and $T_H = 100$, $\eta = 1 - \frac{50}{100} = 1 - \frac{1}{2} = 0.5$

For, $T_L = 50$ and $T_H = 150$, $\eta = 1 - \frac{50}{150} = 1 - \frac{1}{3} = 0.66$

For, $T_L = 50$ and $T_H = 200$, $\eta = 1 - \frac{50}{200} = 1 - \frac{1}{4} = 0.75$

For, $T_L = 50$ and $T_H = 250$, $\eta = 1 - \frac{50}{250} = 1 - \frac{1}{5} = 0.80$

Therefore, the correct graphical representation of efficiency of the engines versus hot reservoir temperature is as shown in option (b)

Thermodynamics

15. A gas mixture contains monoatomic and diatomic molecules of 2 moles each. The mixture has a total internal energy of (symbols have usual meanings)

(a) $3RT$ (b) $5RT$ (c) $8RT$ (d) $9RT$

Ans: (c)

Sol: Internal energy of monoatomic gas, $U_1 = nC_{v_1}T = 2 \times \frac{3}{2}RT = 3RT$

Internal energy of diatomic gas, $U_2 = nC_{v_2}T = 2\times\frac{5}{2}RT = 5RT$

The internal energy of mixture of monoatomic and diatomic gas $U = 3RT + 5RT = 8RT$

Kinetic theory of gases

16. A pendulum oscillates simple harmonically if and only if

(i) the size of the bob of pendulum is negligible in comparison with the length of the pendulum

(ii) the angular amplitude is less than 10°

(a) Both (i) and (ii) are correct (b) Both (i) and (ii) are incorrect

(c) Only (i) is correct (d) Only (ii) is correct

Ans: (a)

Sol: A pendulum oscillates simple harmonically if and only if the size of the bob of pendulum is negligible in comparison with the length of the pendulum and the angular amplitude is less than 10°.

Oscillations

17. To propagate both longitudinal and transverse waves, a material must have

(a) Bulk and shear moduli (b) Only bulk modulus

(c) Only shear modulus (d) Young's and Bulk modulus

Ans: (a)

Sol: To propagate both longitudinal and transverse waves, a material must have Bulk and shear moduli.

Waves and Sound

18. A copper rod AB of length l is rotated about end A with a constant angular velocity ω. The electric field at a distance x from the axis of rotation is

(a) $\frac{m\omega^2 x}{e}$ (b) $\frac{m\omega x}{el}$ (c) $\frac{mx}{\omega^2 l}$ (d) $\frac{me}{\omega^2 x}$

Ans: (a)

Sol: $F = qE = m\omega^2 x$

$\therefore E = \frac{m\omega^2 x}{e}$

Electric charge, field and potential

19. Electric field due to infinite, straight uniformly charged wire varies with distance $'r'$ as

(a) r (b) $\frac{1}{r}$ (c) $\frac{1}{r^2}$ (d) r^2

Ans: (b)

Sol: $E \propto \frac{1}{r}$ Electric charge, field and potential

20. A 2-gram object, located in a region of uniform electric field $\vec{E} = \left(300 \text{ NC}^{-1}\right)\hat{i}$ carries a charge Q. The object released from rest at $x = 0$, has a kinetic energy of 0.12 J at $x = 0.5$ m. Then Q is

(a) $400\ \mu C$ (b) $-400\ \mu C$ (c) $800\ \mu C$ (d) $-800\ \mu C$

Ans: (c)

Sol: $v^2 = u^2 + 2as = 0 + 2as = 2as$

$\Rightarrow v^2 = 2\frac{qE}{m}s \qquad \left(\because a = \frac{qE}{m}\right)$

Now, $KE = \frac{1}{2}mv^2 = \frac{1}{2} \times 2 \times \frac{qE}{m} \times s = qEs$

$0.12 = Q \times 300 \times 0.5$

$\therefore Q = \frac{0.12}{300 \times 0.5} = 800\ \mu C$

Since, the electric field and charge are in positive $x-$direction, the charge Q is positive.

Electric charge, field and potential

21. If a slab of insulating material (conceptual) 4×10^{-3} m thick is introduced between the plates of a parallel plate capacitor, the separation between the plates has to be increased by 3.5×10^{-3} m to restore the capacity to original value. The dielectric constant of the material will be

(a) 6 (b) 8 (c) 10 (d) 12

Ans: (a)

Sol: $t = 4 \times 10^{-3}$ m and $d' = d + \left(3.5 \times 10^{-3}\right)$

Now, $C' = \frac{\varepsilon_0 A}{d' - t + \frac{t}{k}}$ and $C = \frac{\varepsilon_0 A}{d}$

$C = C' \Rightarrow d = d' - t + \frac{t}{k}$

$t - \frac{t}{k} = d' - d$

$1 - \frac{1}{k} = \frac{d' - d}{t}$

$1 - \frac{1}{k} = \frac{3.5 \times 10^{-3}}{4 \times 10^{-3}} \qquad \therefore k = 6$

Capacitor

22. Eight drops of mercury of equal radii combine to form a big drop. The capacitance of a bigger drop as compared to each smaller drop is

(a) 2 times (b) 8 times (c) 4 times (d) 16 times

Ans: (a)

Sol: $C = n^{1/3}C = 8^{1/3}C = \left(2^3\right)^{1/3} = 2C$

Capacitor

23. Which of the statements is false in the case of polar molecules?

(a) Centres of positive and negative charges are separated in the absence of external electric field

(b) Centres of positive and negative charges are separated in the presence of external electric field

(c) Do not possess permanent dipole moments

(d) Ionic molecule HCl is the example of polar molecule

Ans: (c)

Sol: Polar molecules do possess permanent dipole moment.

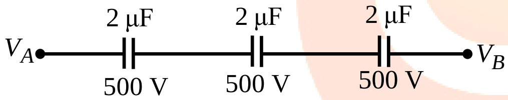
Capacitor

24. An electrician requires a capacitance of $6\ \mu\text{F}$ in a circuit across a potential difference of $1.5\ \text{kV}$. A large number of $2\ \mu\text{F}$ capacitors which can withstand a potential difference of not more than $500\ \text{V}$ are available. The minimum number of capacitors required for the purpose is

(a) 3 (b) 9 (c) 6 (d) 27

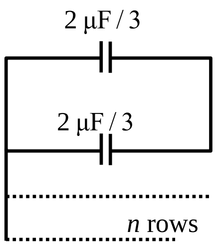
Ans: (d)

Sol:



$V_A - V_B = 1500\ \text{V}$

Effective capacitance of above $= \dfrac{2\ \mu\text{F}}{3}$



Effective capacitance of above

$= n \times \frac{2\ \mu\text{F}}{3}$

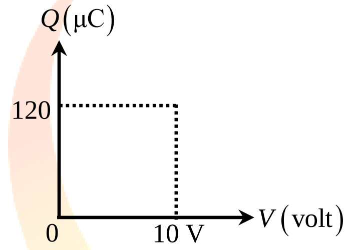
$\Rightarrow\ n\frac{2}{3}\ \mu\text{F} \neq 6\ \mu\text{F}$

$\Rightarrow\ n = 9$

$\therefore$ Total number of capacitors $= n \times 3 = 9 \times 3 = 27$

Capacitor

25. In figure, charge on the capacitor is plotted against potential difference across the capacitor. The capacitance and energy stored in the capacitor are respectively



(a) $12\ \mu\text{F}, 1200\ \mu\text{J}$ (b) $12\ \mu\text{F}, 600\ \mu\text{J}$ (c) $24\ \mu\text{F}, 600\ \mu\text{J}$ (d) $24\ \mu\text{F}, 1200\ \mu\text{J}$

Ans: (b)

Sol: $Q = CV$

From graph, $Q = 120\ \mu\text{C}$ and $V = 10\ \text{V}$

$C = \frac{Q}{V} = \frac{120 \times 10^{-6}}{10} = 12 \times 10^{-6} = 12\ \mu\text{F}$

$U = \frac{1}{2} \times CV^2 = \frac{1}{2} \times 12 \times 10^{-6} \times 10^2 = 600\ \mu\text{J}$

Capacitor

26. A wire of resistance $3\ \Omega$ is stretched to twice its original length. The resistance of the new wire will be

(a) $1.5\ \Omega$ (b) $3\ \Omega$ (c) $6\ \Omega$ (d) $12\ \Omega$

Ans: (d)

Sol: $R = \frac{\rho l}{A} = 3\Omega$

$R' = \frac{\rho l'}{A'}$

Now, Volume of the wire before and after stretching are equal.

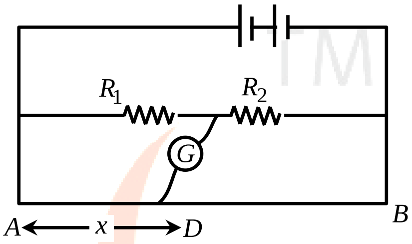
$V = V'$

$\Rightarrow Al = A'l'$

$A' = \frac{Al}{l'} = \frac{Al}{2l} = \frac{A}{2}$

$\therefore R' = \frac{2\rho l}{A/2} = 4R = 12\,\Omega$ Current electricity

27. In the given arrangement of experiment on metre bridge. If AD corresponding to null deflection of the galvanometer is x, what would be its value if radius of the wire AB is doubled?



(a) x (b) $\frac{x}{4}$ (c) $4x$ (d) $2x$

Ans: (a)

Sol: At null condition, $\frac{R_1}{R_2} = \frac{x}{100-x}$ .Thus, null condition is independent of radius of AB wire. So, when radius is doubled, null position will remain same. Current electricity

28. A copper wire of length $1\,\text{m}$ and uniform cross-sectional area $5\times10^{-7}\ \text{m}^2$ carries a current of $1\,\text{A}$. Assuming that there are 8×10^{28} free electrons per m^3 in copper, how long will an electron take to drift from one end of the wire to the other?

(a) 0.8×10^3 s (b) 1.6×10^3 s (c) 3.2×10^2 s (d) 6.4×10^3 s

Ans: (d)

Sol: $v_d = \frac{l}{t}$ and $v_d = I/nAe$

$\Rightarrow t = \frac{l\,nAe}{I} = \frac{1\times8\times10^{28}\times1\times1.6\times10^{-19}}{1}$

$\therefore t = 8\times10^{28}\times5\times10^{-7}\times1.6\times10^{-19} = 40\times1.6\times10^2 = 6.4\times10^3$ s Current electricity

29. Consider an electrical conductor connected across a potential difference V. Let Δq be a small charge moving through it in time Δt. If I is the electric current through it,

(i) the kinetic energy of the charge increases by IV Δt

(ii) the electric potential energy of the charge decreases by IV Δt

(iii) the thermal energy of the conductor increases by IV Δt

Then the correct statement/s is/are

(a) (I) (b) (I), (II) (c) (I) and (III) (d) (II) and (III)

Ans: (d)

Sol: The electric potential energy of the charge decreases by $IV\Delta t$ and the thermal energy of the conductor increases by $IV\Delta t$. Since, the drift velocity of the charge is constant; the kinetic energy of the charge remains constant. Current electricity

30. A strong magnetic field is applied on a stationary electron. Then the electron
    (a) Moves in the direction of the field
    (b) Moves in an opposite direction of the field
    (c) Remains stationary
    (d) Starts spinning

Ans: (c)

Sol: The force acting on stationary electron in magnetic field is zero. Hence, the electron doesn't move and remains stationary. Moving charges and magnetism

31. Two parallel wires in free space are $10\ \text{cm}$ apart and each wire carries a current of $10\ \text{A}$ in the same direction. The force exerted by one wire on the other [per unit length] is
    (a) $2\times10^{-4}\ \text{N m}^{-1}$ [attractive]
    (b) $2\times10^{-2}\ \text{N m}^{-1}$ [attractive]
    (c) $2\times10^{-4}\ \text{N m}^{-1}$ [repulsive]
    (d) $2\times10^{-2}\ \text{N m}^{-1}$ [repulsive]

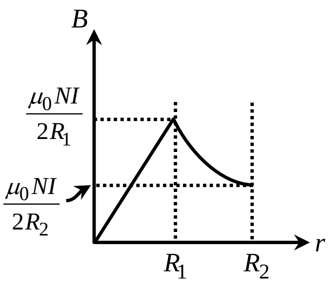
Ans: (a)

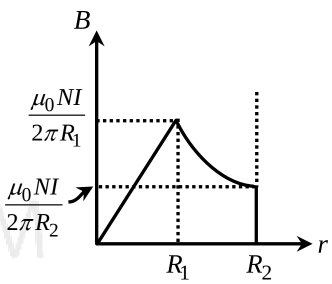
Sol: Force per unit length between them,

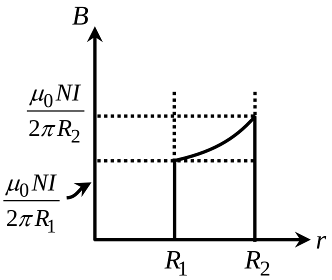
$$F=\frac{\mu_0 I_1 I_2}{2\pi r}=\frac{\left(4\pi\times10^{-7}\right)\times(10)\times(10)}{2\times\pi\times\left(10\times10^{-2}\right)}=2\times10^{-4}$$ (attractive, as currents are in same direction).

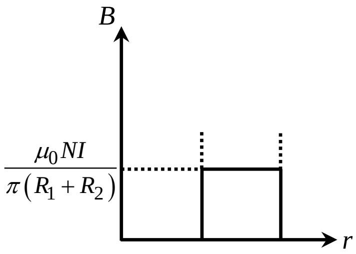
Moving charges and magnetism

32. A toroid with thick windings of N turns has inner and outer radii R_1 and R_2 respectively. If it carries certain steady current i, the variation of the magnetic field due to the toroid with radial distance is correctly graphed in

(a)


(b)


(c)


(d)


Ans: (d)

Sol: Magnetic field inside the body of the toroid is uniform. In the rest of space, magnetic field is zero. Moving charges and magnetism

33. A tightly would long solenoid has $'n'$ turns per unit length, a radius $'r'$ and carries a current I. A particle having charge $'q'$ and mass $'m'$ is projected from a point on the axis in a direction perpendicular to the axis. The maximum speed of the particle for which the particle does not strike the solenoid is

(a) $\frac{\mu_0 nIqr}{m}$ (b) $\frac{\mu_0 nIqr}{2m}$ (c) $\frac{\mu_0 nIqr}{4m}$ (d) $\frac{\mu_0 nIqr}{8m}$

Ans: (b)

Sol: For maximum velocity such that charge does not strike the solenoid, charge moves on a circle whose plane is parallel to the cross-sectional area of the solenoid. Radius of circle $=\frac{r}{2}$. Point of projection lies on the axis of the circle.

$$\text{Radius of circle} = \frac{r}{2} = \frac{mv_{max}}{qB}$$

But $B = \mu_0 nI$

$\frac{r}{2} = \frac{mv_{max}}{q\mu_0 nI} \Rightarrow v_{max} = \frac{rq\mu_0 nI}{2m}$. Moving charges and magnetism

34. Earth's magnetic field always has a horizontal component except at

(a) equator (b) magnetic poles

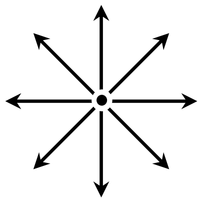
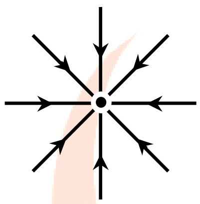
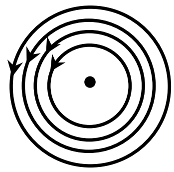
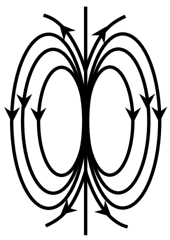
(c) a latitude of $60°$ (d) an altitude of $60°$

Ans: (b)

Sol: $B_H = B\cos\delta$, where δ is angle of dip.

For $B_H = 0$, $\delta = 90°$ (at magnetic poles). Magnetism and Matter

35. Which of the field pattern given below is valid for electric field as well as for magnetic field?

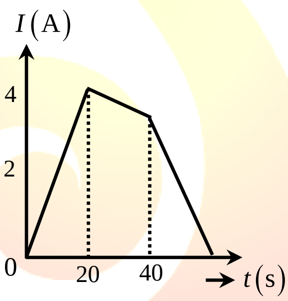
(a)  (b)  (c)  (d) 

Ans: (c)

Sol: Induced electric field lines and magnetic field lines always form closed loop.

Magnetism and Matter

36. The current flowing through an inductance coil of self inductance 6 mH at different time instants is as shown. The emf induced between $t = 20\text{ s}$ and $t = 40\text{ s}$ is nearly



(a) 2×10^{-2} V (b) 3×10^{-2} V (c) 4×10^{-3} V (d) 30×10^{2} V

Ans: (No options are matching)

Sol: $\varepsilon = L\dfrac{dI}{dt} = \left(6\times10^{-3}\right)\times\dfrac{(4-3)}{40-20} = 0.3\text{mV}$ .EMI

37. The physical quantity which is measured in the unit of Wb A^{-1} is

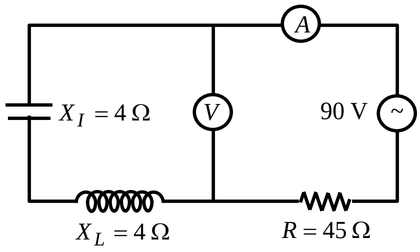
(a) Self-inductance (b) Mutual inductance (c) Magnetic flux (d) Both (a) and (b)

Ans: (d)

Sol: $\phi = LI$ and $\phi = MI$.

EMI

38. What will be the reading in the voltmeter and ammeter of the circuit shown?



(a) 90 V, 2 A (b) 0 V, 2 A (c) 90 V, 1 A (d) 0 V, 1 A

Ans: (b)

Sol: Inductive and capacitive reactance are equal. Hence, they cancel each other. $X = X_C - X_L = 0$

Entire voltage is dropped across resistance.

Current $= \frac{90}{45} = 2\text{ A}$ (ammeter measurement).

AC

39. LC oscillations are similar and analogous to the mechanical oscillations of a block attached to a spring. The electrical equivalent of the force constant of the spring is

(a) reciprocal of capacitive reactance (b) capacitive reactance

(c) reciprocal of capacitance (d) capacitance

Ans: (c)

Sol: $\omega = \sqrt{\frac{k}{m}}$ for spring-mass constant. $\omega = \sqrt{\frac{1}{LC}}$ for electrical oscillations.

L is analogous to mass m, k is analogous to reciprocal of capacitance.

AC

40. In an oscillating LC circuit, $L = 3.00\text{ mH}$ and $C = 2.70\ \mu\text{F}$. At $t = 0$, the charge on the capacitor is zero and the current is 2.00 A. The maximum charge that will appear on the capacitor will be

(a) 1.8×10^{-5} C (b) 18×10^{-5} C (c) 9×10^{-5} C (d) 90×10^{-5} C

Ans: (b)

Sol: By energy conservation, $\frac{1}{2}LI^2 = \frac{1}{2}\frac{Q^2}{C}$

$\Rightarrow Q = \sqrt{CLI^2} = \sqrt{\left(2.7\times10^{-6}\right)\times\left(3\times10^{-3}\right)\times2^2} = 18\times10^{-5}\text{ C}$. AC

41. Suppose that the electric field amplitude of electromagnetic wave is $E_a = 120\ \mathrm{N\,C^{-1}}$ and its frequency is $f = 50$ MHz . Then which of the following value is incorrectly computed?

(a) Magnetic field amplitude is 400 nT

(b) Angular frequency of EM wave is $\pi \times 10^8\ \mathrm{rad\,s^{-1}}$

(c) Propagation constant (angular wave number) is $2.1\ \mathrm{rad\,m^{-1}}$

(d) Wavelength of the EM wave is 6 m

Ans: (c)

Sol: $B_0 = \frac{E_0}{c} = \frac{120}{3\times10^8} = 400\,\mathrm{nT}$.

$\omega = 2\pi f = 2\times\pi\times\left(50\times10^6\right) = \pi\times10^8\ \mathrm{rad\,s^{-1}}$

$\lambda = \frac{c}{f} = \frac{3\times10^8}{50\times10^6} = 6\,\mathrm{m}$

$k = \frac{2\pi}{\lambda} = \frac{2\times3.14}{6} = 1.05\,\mathrm{rad\,m^{-1}}$ .Electromagnetic waves

42. The source of electromagnetic waves can be a charge

(a) Moving with a constant velocity

(b) Moving in a circular orbit

(c) At rest

(d) Moving parallel to the magnetic field

Ans: (b)

Sol: Only accelerated charges emit electromagnetic waves.

Electromagnetic waves

43. In refraction, light waves are bent on passing from one medium to second medium because in the second medium

(a) frequency is different

(b) speed is different

(c) coefficient of elasticity is different

(d) amplitude is smaller

Ans: (b)

Sol: Waves bend because velocities in the two media are different.

Ray Optics

44. If the refractive index from air to glass is $\frac{3}{2}$ and that from air to water is $\frac{4}{3}$, then the ratio of focal lengths of a glass lens in water and in air is

(a) $1:2$

(b) $2:1$

(c) $1:4$

(d) $4:1$

Ans: (d)

Sol: $\frac{1}{f_w} = \left(\frac{\mu_g}{\mu_w} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) = \left(\frac{3/2}{4/3} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

$$\Rightarrow \frac{1}{f_w} = \frac{1}{8}\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \quad \ldots(1)$$

$$\frac{1}{f_a} = (\mu_g - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) = (1.5-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\Rightarrow \frac{1}{f_a} = \frac{1}{2}\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \quad \ldots(2)$$

From (1) and (2),

$\frac{f_w}{f_a} = \frac{1/2}{1/8} = 4 \Rightarrow f_w = 4f_a$. Ray Optics

45. Two thin biconvex lenses have focal lengths f_1 and f_2. A third thin biconcave lens has focal length of f_3. If the first two biconvex lenses are kept in contact, the total power of the lenses is P_1. If the first convex lens is in contact with the third lens, the total power is P_2. If the second lens is kept in contact with the third lens, the total power is P_3, then

(a) $P_1 = \frac{f_1 f_2}{f_1 - f_2}$, $P_2 = \frac{f_1 f_2}{f_2 - f_1}$ and $P_3 = \frac{f_2 f_3}{f_3 - f_2}$
(b) $P_1 = \frac{f_1 - f_2}{f_1 f_2}$, $P_2 = \frac{f_3 - f_1}{f_3 + f_1}$ and $P_3 = \frac{f_3 - f_2}{f_2 f_3}$
(c) $P_1 = \frac{f_1 - f_2}{f_1 f_2}$, $P_2 = \frac{f_3 - f_1}{f_1 f_2}$ and $P_3 = \frac{f_3 - f_2}{f_2 f_3}$
(d) $P_1 = \frac{f_1 + f_2}{f_1 f_2}$, $P_2 = \frac{f_2 - f_1}{f_1 f_3}$ and $P_3 = \frac{f_3 - f_2}{f_2 f_3}$

Ans: (d)

Sol: In general, $P = \frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$

So, $P_1 = \frac{1}{f_1} + \frac{1}{f_2}$; $P_2 = \frac{1}{f_2} - \frac{1}{f_3}$; $P_3 = \frac{1}{f_2} - \frac{1}{f_3}$. Ray Optics

46. The size of the image of an object, which is at infinity, as formed by a convex lens of focal length 30 cm is 2 cm. If a concave lens of focal length 20 cm is placed between the convex lens and the image at a distance of 26 cm from the lens, the new size of the image is

(a) 1.25 cm (b) 2.5 cm (c) 1.05 cm (d) 2 cm

Ans: (b)

Sol: When convex lens alone is used, it forms image at its focal point at a distance of 30 cm from it.

After the introduction of concave lens, for concave lens,

$u = 30 - 26 = 4\text{cm}$, $f = -20\text{cm}$`

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

$$\Rightarrow \frac{1}{v} - \frac{1}{+4} = \frac{1}{-20} \Rightarrow v = 5\text{cm}.$$

$m = \frac{v}{u} = \frac{h_i}{h_o} \Rightarrow \frac{5}{4} = \frac{h_i}{2\,\text{cm}} \Rightarrow h_i = 2.5\,\text{cm}$. Ray Optics

47. A slit of width $'a'$ is illuminated by red light of wavelength 6500 Å. If the first diffraction minimum falls at $30°$, then the value of $'a'$ is

(a) 6.5×10^{-4} mm (b) 1.3 micron (c) 3250 Å (d) 2.6×10^{-4} cm

Ans: (b)

Sol: For first minima,

$$a\sin\theta = \lambda \Rightarrow a = \frac{\lambda}{\sin\theta} = \frac{6500\times10^{-10}}{\sin 30°} = 1.3\,\mu\text{m}$$ Wave Optics

48. Which of the statements are correct with reference to single slit diffraction pattern?

(i) Fringes are of unequal width (ii) Fringes are of equal width

(iii) Light energy is conserved (iv) Intensities of all bright fringes are equal

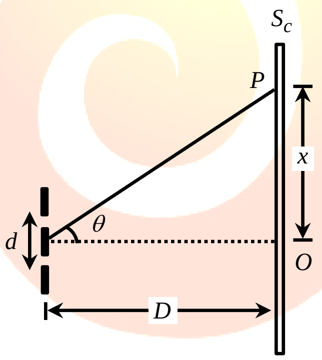
(a) (i) and (iii) (b) (i) and (iv) (c) (ii) and (iv) (d) (ii) and (iii)

Ans: (a)

Sol: Fringes are not of equal width. And since light is energy, it obeys energy conservation principle.

Wave Optics

49. In the YDSE, a monochromatic source of wavelength λ is used. The intensity of light passing through each slit is I_0. The intensity of light reaching the screen S_C at a point P, a distance x from O is given by (Take $d << D$)



(a) $I_0\cos^2\left(\frac{\pi D}{\lambda d}x\right)$ (b) $4I_0\cos^2\left(\frac{\pi d}{\lambda D}x\right)$ (c) $I_0\sin^2\left(\frac{\pi d}{2\lambda D}x\right)$ (d) $4I_0\cos\left(\frac{xd}{2\lambda D}x\right)$

Ans: (b)

Sol: Path difference for waves reaching P,

$$\Delta y = d\sin\theta \approx d\tan\theta \approx \frac{dx}{D}$$

Phase difference, $\phi = \frac{2\pi(\Delta y)}{\lambda} = \frac{2\pi dx}{\lambda D}$ ...(1)

Intensity of light at P,

$$I = 4I_0 \cos^2\left(\frac{\phi}{2}\right) = 4I_0 \cos^2\left(\frac{\pi dx}{\lambda D}\right) \qquad \text{using (1)}$$

Wave Optics

50. The work function of a metal is $1\,\text{eV}$. Light of wavelength $3000\ \text{Å}$ is incident on this metal surface. The maximum velocity of emitted photoelectrons will be about

(a) $10\ \text{m s}^{-1}$ (b) $1\times10^3\ \text{m s}^{-1}$ (c) $1\times10^4\ \text{m s}^{-1}$ (d) $1\times10^6\ \text{m s}^{-1}$

Ans: (d)

Sol: $h\nu = h\nu_0 + \frac{1}{2}mv_{max}^2$

$$\frac{12400}{3000} = 1 + \frac{1}{2}\frac{\left(9.1\times10^{-31}\right)}{1.6\times10^{-19}}v_{max}^2$$

$$4.13 = 1 + 2.84\times10^{-12}v_{max}^2$$

$$\Rightarrow v_{max}^2 = \frac{3.13}{2.84}\times10^{12}$$

$$\Rightarrow v_{max} = 1.05\times10^6\ \text{m s}^{-1}$$

Dual nature of radiation and matter

51. A proton moving with a momentum P_1 has a kinetic energy $\frac{1}{8}^{\text{th}}$ of its rest mass energy. Another light photon having energy equal to the kinetic energy of the proton possesses a momentum P_2. Then the ratio $\frac{P_1 - P_2}{P_1}$ is equal to

(a) 1 (b) $\frac{1}{4}$ (c) $\frac{1}{2}$ (d) $\frac{3}{4}$

Ans: (d)

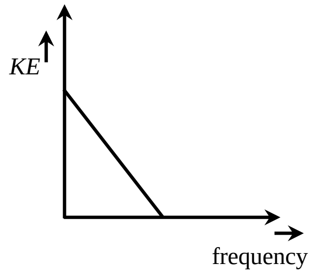
Sol: For proton, $K_1 = \frac{1}{8}m_0c^2$; $P_1 = \sqrt{2m_0K_1} = \sqrt{2m_0\left(\frac{1}{8}m_0c^2\right)} = \frac{m_0c}{2}$

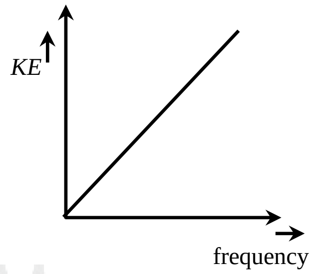
For photon, $E_2 = K_1 = \frac{1}{8}m_0c^2$; $P_2 = \frac{E_2}{c} = \frac{1}{8}m_0c$

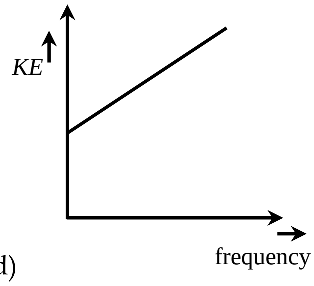
$$\frac{P_1 - P_2}{P_1} = \frac{\left(\frac{m_0c}{2}\right) - \left(\frac{m_0c}{8}\right)}{\left(\frac{m_0c}{2}\right)} = \frac{3}{4}$$

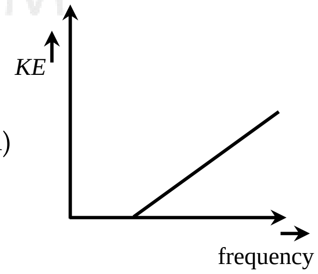
Dual nature of radiation and matter

52. According to Einstein's photoelectric equation, the graph between kinetic energy of photoelectrons ejected and the frequency of incident radiation is

(a) 

(b) 

(c) 

(d) 

Ans: (d)

Sol: $h\nu = h\nu_0 + KE_{max} \Rightarrow KE_{max} = h(\nu - \nu_0)$

Dual nature of radiation and matter

53. Energy of an electron in the second orbit of hydrogen atom is E_2. The energy of electron in the third orbit of He^+ will be

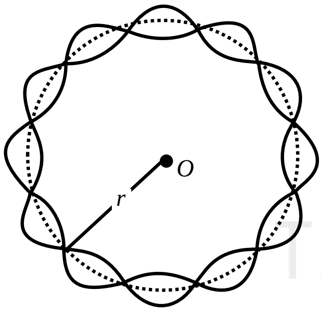
(a) $\frac{9}{16}E_2$ (b) $\frac{16}{9}E_2$ (c) $\frac{3}{16}E_2$ (d) $\frac{16}{3}E_2$

Ans: (b)

Sol: For Hydrogen, $E_2 = \frac{-13.6Z^2}{n^2} = \frac{-13.6}{4}\text{eV}$

For Helium, $E_3 = \frac{-13.6 \times 2^2}{3^2} = \frac{-13.6 \times 2^2 \times 4}{4 \times 3^2} = \frac{E_2 \times 16}{9}$. Atoms

54. The figure shows standing de Broglie waves due to the revolution of electron in a certain orbit of hydrogen atom. Then the expression for the orbit radius is (all notations have their usual meanings)



(a) $\frac{h^2\varepsilon_0}{\pi me^2}$ (b) $\frac{4h^2\varepsilon_0}{\pi me^2}$ (c) $\frac{9h^2\varepsilon_0}{\pi me^2}$ (d) $\frac{16h^2\varepsilon_0}{\pi me^2}$

Ans: (No options are matching)

Sol: $2\pi r_n = 6\lambda_n$ ...(1)

And $\lambda_n = \frac{h}{mv_n}$ ...(2)

$v_n = \frac{e^2}{2n\varepsilon_0 h}$ ...(3)

Using (2) and (3) in (1), we get,

$2\pi r_n = 6\times\frac{h}{m\left(\frac{e^2}{2n\varepsilon_0 h}\right)}$ $\Rightarrow r_n = \frac{6n\varepsilon_0 h^2}{\pi me^2}$

Substituting $n=6$, we get, $\Rightarrow r_n = \frac{36\varepsilon_0 h^2}{\pi me^2}$ Atoms

55. An electron in an excited state of Li^{2+} ion has angular momentum $\frac{3h}{2\pi}$. The de Broglie wavelength of electron in this state is $P\pi a_0$ (where a_0 = Bohr radius). The value of P is

(a) 3 (b) 2 (c) 1 (d) 4

Ans: (b)

Sol: $mv_n r_n = \frac{3h}{2\pi} \Rightarrow mv_n = \frac{3h}{2\pi r_n}$ ...(1) (third orbit)

$r_n = \frac{h^2\varepsilon_0 n^2}{\pi me^2 Z}$ ...(2)

$\lambda = \frac{h}{mv_n} = \frac{h}{\left(\frac{3h}{2\pi r_n}\right)} = \frac{2\pi r_n}{3}$ ...(3) using (1)

Using (2) in (3), we get,

$$\lambda = \frac{2\pi}{3}\frac{h^2\varepsilon_0 n^2}{\pi m e^2 Z}$$

Put $n = 3,\ Z = 3$

$$\lambda = \frac{2h^2\varepsilon_0}{me^2} \qquad \ldots(4)$$

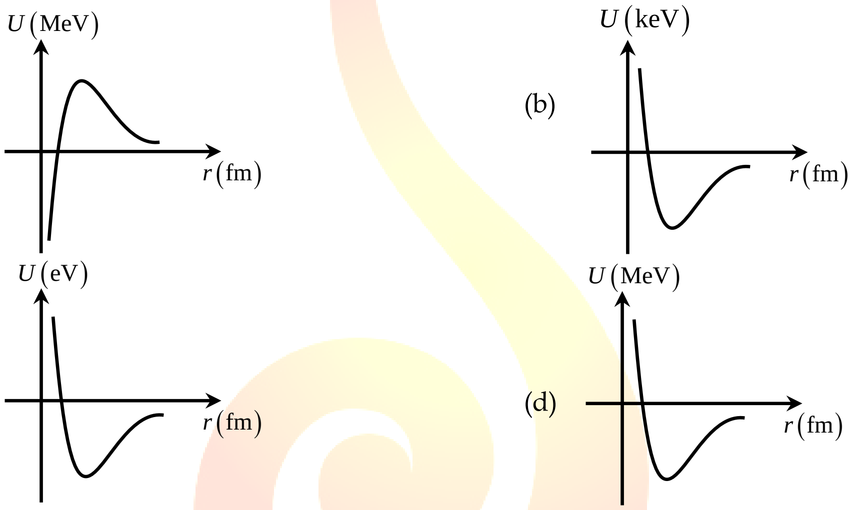
Now, $a_0 = \dfrac{h^2\varepsilon_0}{\pi m e^2}$. $\qquad \ldots(5)$

Using (5) in (4), we get,

$\lambda = 2\pi a_0$. Atoms

56. Which graph in the following diagrams correctly represents the potential energy of a pair of nucleons as a function of their separation?

(a) (b) (c) (d)



Ans: (d)

Sol: Graph in (d) represents correctly. Energy associated with nucleons is of the order of MeV. When nucleons are very close, they repel each other. After the optimum distance, (slope $= 0$ in the graph), they attract each other. Nuclei

57. In a nuclear reactor heavy nuclei is not used as moderators because

(a) They will break up

(b) Elastic collision of neutrons with heavy nuclei will not slow them down

(c) The net weight of the reactor would be unbearably high

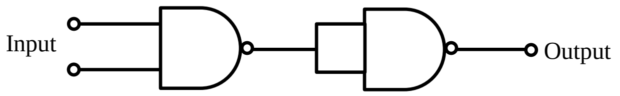
(d) Substances with heavy nuclei do not occur in liquid or gaseous state at room temperature

Ans: (b)

Sol: Moderator must reduce speed drastically, of neutrons generated in fission. Elastic collisions of similar-mass nuclei lead to great amounts of transfer of kinetic energy.

Nuclei

58. The circuit given represents which of the logic operations?



(a) OR (b) AND (c) NOT (d) NOR

Ans: (b)

Sol: Output = $\overline{\overline{A.B}} = A.B$.

Semiconductor

59. Identify the incorrect statement

(a) When a P-N junction diode is forward biased, the width of the depletion region decreases

(b) When a P-N junction diode is reverse biased, the barrier potential increases

(c) A photo diode is operated in the reverse bias

(d) An LED is a lightly doped P-N junction diode which emits spontaneous radiation on forward biasing

Ans: (d)

Sol: An LED is a heavily doped P-N junction diode.

Semiconductor

60. Three photodiodes D_1, D_2 and D_3 are made of semiconductors having band gaps of $2.5\,\text{eV}$, $2\,\text{eV}$ and $3\,\text{eV}$ respectively. Which one will be able to detect light of wavelength $600\,\text{nm}$?

(a) D_1 only (b) Both D_1 and D_3

(c) D_2 only (d) All the three diodes

Ans: (c)

Sol: Energy of light, $E = \frac{12400}{6000}\text{eV} = 2.06\,\text{eV}$

Since, $E > 2.0\,\text{eV}$, hence, D_2 can detect this light.

Since, $E < 2.5\,\text{eV}, 3.0\,\text{eV}$, so D_1 and D_3 cannot detect this light.

Semiconductor

Key Answers:

1. b	2. b	3. c	4. d	5. a	6. d	7. a	8. b	9. c	10. c
11. b	12. b	13. c	14. b	15. c	16. a	17. a	18. a	19. b	20. c
21. a	22. a	23. c	24. d	25. b	26. d	27. a	28. d	29. d	30. c
31. a	32. d	33. b	34. b	35. c	36.	37. d	38. b	39. c	40. b
41. c	42. b	43. b	44. d	45. d	46. b	47. b	48. a	49. b	50. d
51. d	52. d	53. b	54.	55. b	56. d	57. b	58. b	59. d	60. c

36. (No options are matching) 54. (No options are matching)