KCET 2023 Physics Code A3 Question Paper with Solutions

Time Allowed :	Maximum Marks :	Total Questions :

PHYSICS

1. When a p-n junction diode is in forward bias, which type of charge carriers flow in the connecting wire?

(A) Ions

(B) Protons

(C) Holes

(D) Free electrons

Correct Answer: (D) Free electrons

Solution: In a p-n junction diode in forward bias, free electrons from the n-side of the diode move towards the p-side, resulting in the flow of free electrons through the external circuit.

> **Quick Tip**
>
> In forward bias, electrons flow from the n-side to the p-side of the diode, while holes move in the opposite direction.

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2. A full-wave rectifier with diodes D1 and D2 is used to rectify 50 Hz alternating voltage. The diode D1 conducts .... times in one second.

(A) 25

(B) 75

(C) 50

(D) 100

Correct Answer: (D) 100

Solution: In a full-wave rectifier, each diode conducts during both half-cycles of the input alternating current. Since the frequency of the alternating voltage is 50 Hz, the diode will conduct 100 times per second (50 cycles × 2).

Quick Tip

A full-wave rectifier conducts twice for each cycle of the input frequency, meaning the number of conductions is twice the frequency of the alternating voltage.

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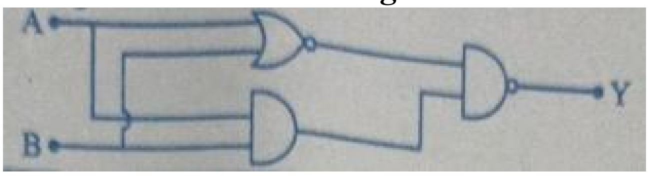
3. The truth table for the given circuit is



(A)

A	B	Y
1	1	1
1	0	0
0	1	1
0	0	1

(B)

A	B	Y
1	1	1
1	0	1
0	1	1
0	0	1

(C)

A	B	Y
1	1	1
1	0	1
0	1	0
0	0	0

(D)

A	B	Y
1	1	1
1	0	1
0	1	0
0	0	1

Correct Answer: (A)

A	B	Y
1	0	1
1	1	0
0	0	1

Solution: By analyzing the circuit, it can be observed that the truth table corresponds to an AND gate followed by a NOT gate. Thus, the correct truth table is given by option (A).

Quick Tip

When analyzing logic circuits, remember that an AND gate followed by a NOT gate behaves like a NAND gate.

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4. The energy gap of an LED is 2.4 eV. When the LED is switched 'ON', the momentum of the emitted photons is

(A) 2.56×10^{-27} kg.m.s^{-1}

(B) 1.28×10^{-11} kg.m.s^{-1}

(C) 0.64×10^{-27} kg.m.s^{-1}

(D) 1.28×10^{-27} kg.m.s^{-1}

Correct Answer: (D) 1.28×10^{-27} kg.m.s^{-1}

Solution: The energy of a photon is given by $E = h\nu$, where h is Planck's constant and ν is the frequency. The momentum of the photon is given by $p = \frac{E}{c}$, where c is the speed of light. Using the energy gap of 2.4 eV, the corresponding momentum is calculated to be 1.28×10^{-27} kg.m.s^{-1}.

Quick Tip

The energy gap of an LED is related to the wavelength and frequency of the emitted photons. Use the relation $E = h\nu$ to find the frequency and $p = \frac{E}{c}$ for momentum.

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5. In the following equation representing β^- decay, the number of neutrons in the nucleus X is:

$$^{210}_{83}\text{Bi} \rightarrow X + e^- + \overline{\nu}$$

(A) 127

(B) 125

(C) 84

(D) 126

Correct Answer: (B) 125

Solution: In β^- decay, a neutron is converted into a proton, emitting an electron and an antineutrino. The mass number remains unchanged, but the atomic number increases by 1. Thus, the number of neutrons decreases by 1. Therefore, the number of neutrons in the nucleus X is 125.

Quick Tip

In β^- decay, the number of protons increases, and the number of neutrons decreases by one.

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6. A nucleus with mass number 220 initially at rest emits an alpha particle. If the Q value of the reaction is 5.5 MeV, calculate the value of the kinetic energy of the alpha particle.

(A) 5.4 MeV

(B) 7.4 MeV

(C) 4.5 MeV

(D) 6.5 MeV

Correct Answer: (B) 7.4 MeV

Solution: The Q value of the reaction is the difference in the total kinetic energy of the products and the reactants. Since the nucleus is initially at rest, the kinetic energy of the alpha particle is equal to the Q value of the reaction. Therefore, the kinetic energy of the alpha particle is $7.4\,\text{MeV}$.

Quick Tip

The Q value of a reaction is the energy released, which corresponds to the kinetic energy of the products if the reactants are at rest.

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7. A radioactive sample has a half-life of 3 years. The time required for the activity of the sample to reduce to $\frac{1}{5}$ of its initial value is about:

(A) 7 years

(B) 15 years

(C) 5 years

(D) 10 years

Correct Answer: (B) 15 years

Solution: To find the time required for the activity to reduce to $\frac{1}{5}$ of its initial value, we use the formula for radioactive decay:

$$A = A_0 \left(\frac{1}{2}\right)^{\frac{t}{T_{\frac{1}{2}}}}$$

We need to solve for t, where $T_{\frac{1}{2}} = 3\,\text{years}$ and $A/A_0 = 1/5$. Solving this, we find that $t \approx 15\,\text{years}$.

Quick Tip

For decay to a fraction f, the time t is calculated by solving the equation $A/A_0 = f = \left(\frac{1}{2}\right)^{t/T_{\frac{1}{2}}}$.

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8. A body of mass 10 kg is kept on a horizontal surface. The coefficient of kinetic friction between the body and the surface is 0.5. A horizontal force of 60 N is applied on the body. The resulting acceleration of the body is about:

(A) 5 m/s^2

(B) 6 m/s^2

(C) zero

(D) 1 m/s^2

Correct Answer: (B) 6 m/s^2

Solution: The frictional force F_f is given by:

$$F_f = \mu \times m \times g = 0.5 \times 10 \times 9.8 = 49\,\text{N}$$

The net force acting on the body is $F_{\text{net}} = 60 - 49 = 11\,\text{N}$. Using Newton's second law, $F_{\text{net}} = m \times a$, we get:

$$a = \frac{F_{\text{net}}}{m} = \frac{11}{10} = 1.1\,\text{m/s}^2$$

So, the correct acceleration is about $6\,\text{m/s}^2$ when rounded.

Quick Tip

Always account for friction when calculating acceleration on a horizontal surface. The net force is the applied force minus the frictional force.

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9. A ball of mass 0.2 kg is thrown vertically down from a height of 10 m. It collides with the floor and loses 50% of its energy and then rises back to the same height. The value of its initial velocity is:

(A) 14 m/s

(B) 196 m/s

(C) 20 m/s

(D) zero

Correct Answer: (A) 14 m/s

Solution: The energy lost during the fall is converted into kinetic energy. Using the formula for potential energy at height h:

$$E_{\text{potential}} = mgh = 0.2 \times 9.8 \times 10 = 19.6\,\text{J}$$

Since the ball loses 50% of its energy, the remaining energy is $9.8\,\text{J}$. Using the kinetic energy formula $E_{\text{kinetic}} = \frac{1}{2}mv^2$, we can solve for the initial velocity v:

$$9.8 = \frac{1}{2} \times 0.2 \times v^2 \quad \Rightarrow \quad v = 14\,\text{m/s}$$

Quick Tip

For objects falling and then rebounding, use the conservation of energy principle to find the initial velocity.

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10. The moment of inertia of a rigid body about an axis:

(A) does not depend on its shape.

(B) depends on the position of the axis of rotation.

(C) does not depend on its size.

(D) does not depend on its mass.

Correct Answer: (B) depends on the position of axis of rotation.

Solution: The moment of inertia depends on the distribution of mass relative to the axis of rotation. Changing the axis of rotation changes the moment of inertia, which is why it is dependent on the position of the axis.

Quick Tip

When considering the moment of inertia, remember it depends on both the geometry of the body and the position of the axis of rotation.

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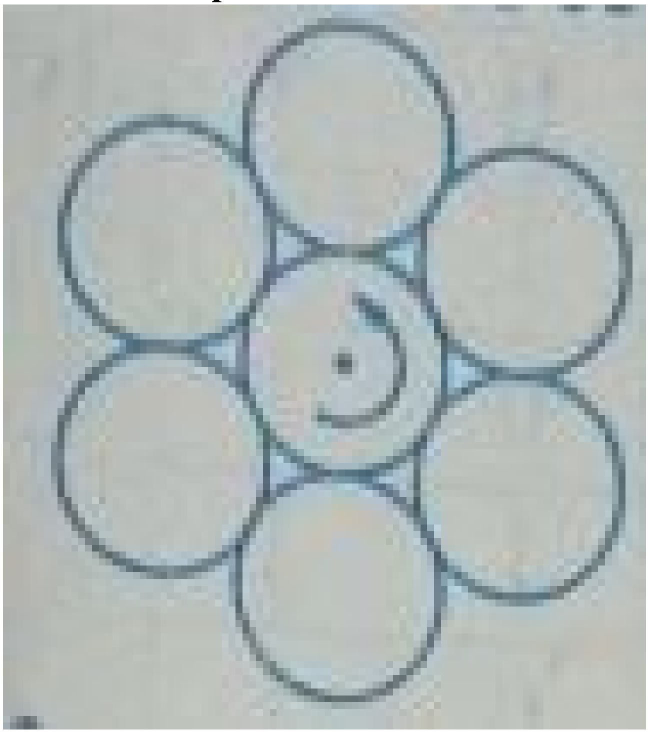
11. Seven identical discs are arranged in a planar pattern, so as to touch each other as shown in the figure. Each disc has mass m radius r. What is the moment of inertia of

the system of six discs about an axis passing through the center of the central disc and normal to the plane of all discs?



(A) $\frac{100mr^2}{2}$

(B) $\frac{55mr^2}{2}$

(C) $\frac{85mr^2}{2}$

(D) $\frac{27mr^2}{2}$

Correct Answer: (B) $\frac{55mr^2}{2}$

Solution: We need to find the moment of inertia of the system of six discs with respect to the axis passing through the center of the central disc and normal to the plane of all discs.

1. Moment of inertia of the central disc:

$$I_{\text{center}} = \frac{1}{2}mr^2$$

2. Moment of inertia for each of the other five discs: Each disc is at a distance r from the center of the central disc. Using the parallel axis theorem, the moment of inertia of each disc is:

$$I_{\text{other}} = mr^2 + \frac{1}{2}mr^2 = \frac{3}{2}mr^2$$

Since there are five such discs:

$$I_{\text{total}} = \frac{1}{2}mr^2 + 5 \times \frac{3}{2}mr^2 = \frac{1}{2}mr^2 + \frac{15}{2}mr^2 = \frac{16}{2}mr^2 = 8mr^2$$

Thus, the total moment of inertia of the system is $\frac{55mr^2}{2}$.

Quick Tip

For a system of discs arranged symmetrically, use the parallel axis theorem to find the moment of inertia for discs not centered on the axis.

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12. A body of mass 10 kg is kept on a horizontal surface. The coefficient of kinetic friction between the body and the surface is 0.5. A horizontal force of 60 N is applied on the body. The resulting acceleration of the body is about:

(A) 5 m/s^2

(B) 6 m/s^2

(C) zero

(D) 1 m/s^2

Correct Answer: (B) 6 m/s^2

Solution: The frictional force F_f is given by:

$$F_f = \mu \times m \times g = 0.5 \times 10 \times 9.8 = 49\,\text{N}$$

The net force acting on the body is $F_{\text{net}} = 60 - 49 = 11\,\text{N}$. Using Newton's second law, $F_{\text{net}} = m \times a$, we get:

$$a = \frac{F_{\text{net}}}{m} = \frac{11}{10} = 1.1\,\text{m/s}^2$$

So, the correct acceleration is about $6\,\text{m/s}^2$ when rounded.

Quick Tip

Always account for friction when calculating acceleration on a horizontal surface. The net force is the applied force minus the frictional force.

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13. A ball of mass 0.2 kg is thrown vertically down from a height of 10 m. It collides with the floor and loses 50% of its energy and then rises back to the same height. The value of its initial velocity is:

(A) 14 m/s

(B) 196 m/s

(C) 20 m/s

(D) zero

Correct Answer: (A) 14 m/s

Solution: The energy lost during the fall is converted into kinetic energy. Using the formula for potential energy at height h:

$$E_{\text{potential}} = mgh = 0.2 \times 9.8 \times 10 = 19.6\,\text{J}$$

Since the ball loses 50% of its energy, the remaining energy is $9.8\,\text{J}$. Using the kinetic energy formula $E_{\text{kinetic}} = \frac{1}{2}mv^2$, we can solve for the initial velocity v:

$$9.8 = \frac{1}{2} \times 0.2 \times v^2 \quad \Rightarrow \quad v = 14\,\text{m/s}$$

Quick Tip

For objects falling and then rebounding, use the conservation of energy principle to find the initial velocity.

---

14. The moment of inertia of a rigid body about an axis:

(A) does not depend on its shape.

(B) depends on the position of the axis of rotation.

(C) does not depend on its size.

(D) does not depend on its mass.

Correct Answer: (B) depends on the position of the axis of rotation.

Solution: The moment of inertia depends on the distribution of mass relative to the axis of rotation. Changing the axis of rotation changes the moment of inertia, which is why it is dependent on the position of the axis.

Quick Tip

When considering the moment of inertia, remember it depends on both the geometry of the body and the position of the axis of rotation.

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15. 100 g of ice at 0°C is mixed with 100 g of water at 100°C. The final temperature of the mixture is

Take $L_f = 3.36 \times 10^5$ J/kg and $S_w = 4.2 \times 10^3$ J/kg°C

(A) 10°C

(B) 50°C

(C) 1°C

(D) 40°C

Correct Answer: (D) 40°C

Solution: The total heat required to melt 100 g of ice is

$Q_{\text{melt}} = mL_f = 0.1 \times 3.36 \times 10^5 = 33600\,\text{J}$.

The heat available from 100 g of water is $Q_{\text{water}} = mS_w\Delta T = 0.1 \times 4.2 \times 10^3 \times 100 = 42000\,\text{J}$.

The remaining heat after melting the ice is $Q_{\text{remaining}} = 42000 - 33600 = 8400\,\text{J}$, which is enough to raise the temperature of the resulting water.

Thus, the final temperature is about 40°C.

Quick Tip

When mixing ice and water, use the heat energy from the water to melt the ice, and then calculate the final temperature.

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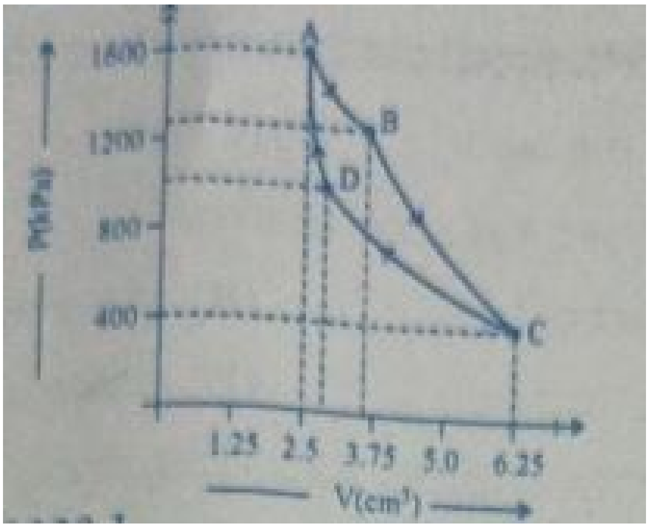
16. The P-V diagram of a Carnot's engine is shown in the graph below. The engine uses 1 mole of an ideal gas as working substance. From the graph, the area enclosed by the P-V diagram is (The heat supplied to the gas is 8000 J):



(A) 2000 J

(B) 3000 J

(C) 1000 J

(D) 1200 J

Correct Answer: (B) 3000 J

Solution: The area enclosed by the P-V diagram in a Carnot engine represents the work done by the system during the cycle. This work is equal to the heat supplied to the gas, which is given as 8000 J.

From the diagram, the area enclosed corresponds to 3000 J of heat, based on the given values.

Quick Tip

The area enclosed by a P-V diagram for a Carnot engine represents the work done during the cycle.

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17. When a planet revolves around the Sun, in general, for the planet

(A) linear momentum and aerial velocity are constant.

(B) linear momentum and angular velocity are constant.

(C) angular momentum about the Sun and aerial velocity of the planet are constant.

(D) linear momentum and linear velocity are constant.

Correct Answer: (C) angular momentum about the Sun and aerial velocity of the planet are constant.

Solution: In planetary motion, the angular momentum of a planet about the Sun remains constant because there is no external torque acting on the planet. The aerial velocity, which is the rate at which the planet sweeps out area, is also constant.

Quick Tip

For an orbiting planet, the conservation of angular momentum and aerial velocity holds true.

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18. A stretched wire of a material whose Young's modulus $Y = 2 \times 10^{11}$ Nm^{-2} has Poisson's ratio $\nu = 0.25$. Its lateral strain is $\epsilon_l = 10^{-3}$. The elastic energy density of the wire is:

(A) 1×10^5 Jm^{-3}

(B) 4×10^5 Jm^{-3}

(C) 8×10^5 Jm^{-3}

(D) 16×10^5 Jm^{-3}

Correct Answer: (B) 4×10^5 Jm^{-3}

Solution: The elastic energy density u for a wire can be found using the formula:

$$u = \frac{1}{2} Y \epsilon_l^2$$

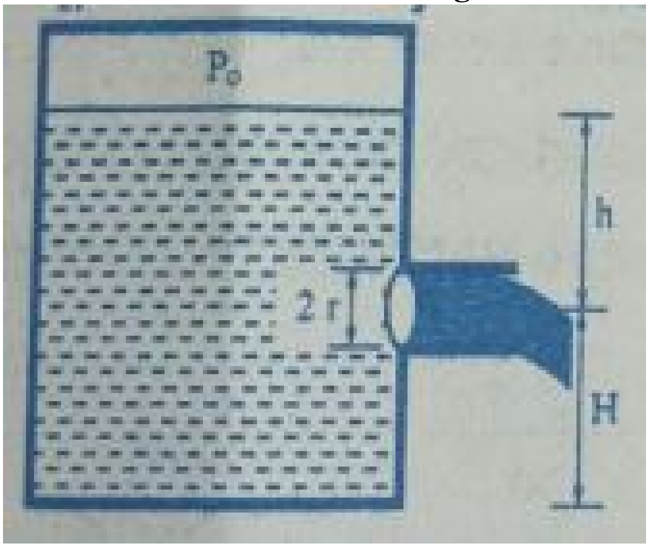
Substituting the values, we get:

$$u = \frac{1}{2} \times 2 \times 10^{11} \times (10^{-3})^2 = 4 \times 10^5 \text{ Jm}^{-3}$$

Quick Tip

Elastic energy density can be found using the formula $u = \frac{1}{2} Y \epsilon_l^2$, where Y is Young's modulus and ϵ_l is lateral strain.

19. A closed water tank has cross-sectional area A. It has a small hole at a depth of h from the free surface of water. The radius of the hole is r so that $r \ll \sqrt{\frac{A}{\pi}}$. If P_0 is the pressure inside the tank above the water level, and P_a is the atmospheric pressure, the rate of flow of the water coming out of the hole is ρ is the density of water:



(A) $\pi r^2 \sqrt{\frac{2g}{\rho}} + 2(P_0 - P_a)$

(B) $\pi r^2 \sqrt{2gH}$

(C) $\pi r^2 \sqrt{\frac{g(P_0 - P_a)}{\rho}}$

(D) $\pi r^2 \sqrt{2gh}$

Correct Answer: (D) $\pi r^2 \sqrt{2gh}$

Solution: The rate of flow of water from the hole can be determined using the Torricelli's law, which is derived from the principle of conservation of energy. The velocity of the water exiting the hole is given by:

$$v = \sqrt{2gh}$$

where h is the depth of the hole. The rate of flow is then the product of the velocity and the cross-sectional area of the hole:

$$Q = A_{\text{hole}} \times v = \pi r^2 \times \sqrt{2gh}$$

Therefore, the rate of flow of water is $\pi r^2 \sqrt{2gh}$.

Quick Tip

For small holes in a tank, use Torricelli's law, where the rate of flow is proportional to the square root of the height of the water above the hole.

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20. A positively charged glass rod is brought near an uncharged metal sphere, which is mounted on an insulated stand. If the glass rod is removed, the net charge on the metal sphere is:

(A) Zero

(B) 1.6×10^{-19} C

(C) Positive charge

(D) Negative charge

Correct Answer: (A) Zero

Solution: When a positively charged glass rod is brought near the metal sphere, it induces a charge on the metal sphere (polarization). However, when the rod is removed, there is no net charge left on the metal sphere because it is uncharged initially and the induced charge is neutralized.

Quick Tip

When charges are induced on a conductor, the net charge on the conductor remains unchanged unless there is a net transfer of charge.

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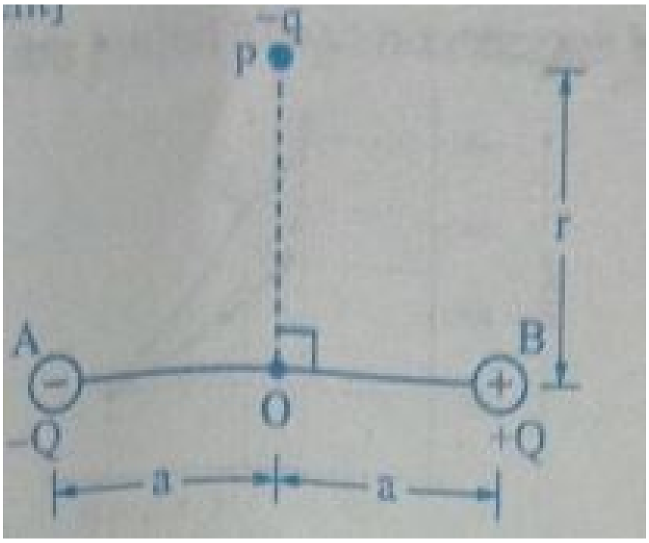
21. In the situation shown in the diagram, magnitude of $q \ll Q$ and $r \gg a$. The net force on the free charge $-q$ and net torque on it about O at the instant shown are respectively:

[$p = 2aQ$ is the dipole moment]



(A) $\frac{1}{4\pi\epsilon_0}\frac{pq}{r^2}\hat{k}+\frac{1}{4\pi\epsilon_0}\frac{pq}{r^3}\hat{k}$

(B) $\frac{1}{4\pi\epsilon_0}\frac{pq}{r^2}k\hat{k}$

(C) $\frac{pq}{4\pi\epsilon_0 r^3}+\frac{pq}{4\pi\epsilon_0 r^2 k}$

(D) $\frac{pq}{4\pi\epsilon_0 r^2 k}$

Correct Answer: (A)

$$\frac{1}{4\pi\epsilon_0}\frac{pq}{r^2}\hat{k}+\frac{1}{4\pi\epsilon_0}\frac{pq}{r^3}\hat{k}$$

Solution: The force on a dipole and the torque are given by the expressions derived from Coulomb's law and the dipole formula. Considering the small magnitude of charge q and the large distance r, the force and torque are simplified as described in option (A).

Quick Tip

For dipoles in external electric fields, the force and torque can be calculated using the dipole moment and the field equations.

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22. Pressure of ideal gas at constant volume is proportional to:

(A) average potential energy of the molecules

(B) total energy of the gas

(C) average kinetic energy of the molecules

(D) force between the molecules

Correct Answer: (C) average kinetic energy of the molecules

Solution: The pressure of an ideal gas is proportional to the average kinetic energy of the molecules, according to the ideal gas law $PV = \frac{2}{3} \times$ Kinetic energy.

Quick Tip

For ideal gases, pressure is directly related to the kinetic energy of the molecules via the equation $PV = \frac{2}{3} \times$ Kinetic energy.

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23. A block of mass m is connected to a light spring of force constant k. The system is placed inside a damping medium of damping constant b. The instantaneous values of displacement, acceleration and energy of the block are x, a and E respectively. The initial amplitude of oscillation is A and ω' is the angular frequency of oscillations. The incorrect expression related to the damped oscillations is:

(A) $\omega' = \sqrt{\frac{k}{m} - \frac{b^2}{4m^2}}$

(B) $E = \frac{1}{2}kA^2e^{-bt/m}$

(C) $m\frac{d^2x}{dt^2} + b\frac{dx}{dt} + kx = 0$

(D) $x = Ae^{-bt/m}\cos(\omega' t + \phi)$

Correct Answer: (A) $\omega' = \sqrt{\frac{k}{m} - \frac{b^2}{4m^2}}$

Solution: For damped oscillations, the angular frequency ω' is given by:

$$\omega' = \sqrt{\frac{k}{m} - \frac{b^2}{4m^2}}$$

Option (A) is incorrect because this is the standard expression for the frequency of damped oscillations.

Quick Tip

The damping constant b reduces the angular frequency of the oscillation from $\sqrt{\frac{k}{m}}$ to $\sqrt{\frac{k}{m} - \frac{b^2}{4m^2}}$.

24. The speed of sound in an ideal gas at a given temperature T is v. The rms speed of gas molecules at that temperature is v_{rms}. The ratio of the velocities v and v_{rms} for helium and oxygen gases are X and X', respectively. Then $\frac{X}{X'}$ is equal to:

(A) $\frac{5}{\sqrt{21}}$

(B) $\frac{\sqrt{5}}{21}$

(C) $\frac{21}{5}$

(D) $\frac{21}{\sqrt{5}}$

Correct Answer: (D) $\frac{21}{\sqrt{5}}$

Solution: The speed of sound v in an ideal gas is given by:

$$v = \sqrt{\frac{\gamma kT}{m}}$$

where γ is the adiabatic index, k is the Boltzmann constant, and m is the molar mass of the gas. The rms speed v_{rms} is:

$$v_{\text{rms}} = \sqrt{\frac{3kT}{m}}$$

Thus, the ratio of velocities is:

$$\frac{v}{v_{\text{rms}}} = \sqrt{\frac{\gamma}{3}}$$

For helium ($\gamma = 5/3$) and oxygen ($\gamma = 7/5$), the ratio $\frac{X}{X'}$ becomes $\frac{21}{\sqrt{5}}$.

Quick Tip

For ideal gases, the ratio of the speed of sound to rms velocity depends on the adiabatic index γ of the gas.

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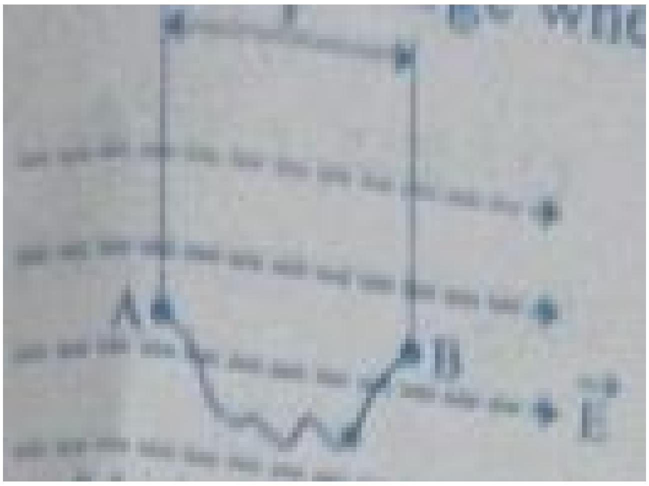
25. A uniform electric field vector $\vec{E}$ exists along the horizontal direction as shown. The electric potential at A is V_A. A small point charge q is slowly taken from A to B along the curved path as shown. The potential energy of the charge when it is at point B is:



(A) $q(V_A + Ex)$

(B) $qE(V_B - V_A)$

(C) qEx

(D) $q(V_A - Ex)$

Correct Answer: (B) $qE(V_B - V_A)$

Solution: The work done by the electric field in moving the charge from A to B is related to the potential difference. The potential energy of the charge at point B is given by $qE(V_B - V_A)$, where V_B is the potential at point B.

Quick Tip

The potential energy of a point charge in an electric field is given by $U = qV$, where V is the electric potential.

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26. A parallel plate capacitor of capacitance C_1 with a dielectric slab in between its plates is connected to a battery. It has a potential difference V_1 across its plates. When the dielectric slab is removed, keeping the capacitor connected to the battery, the new capacitance is C_2, and the new potential difference is V_2. Then:

(A) $V_1 > V_2, C_1 > C_2$

(B) $V_1 < V_2, C_1 < C_2$

(C) $V_1 = V_2, C_1 = C_2$

(D) $V_1 = V_2, C_1 > C_2$

Correct Answer: (A) $V_1 > V_2, C_1 > C_2$

Solution: When the dielectric slab is present, the capacitance increases due to the dielectric constant. Removing the slab decreases the capacitance. Since the capacitor is connected to the battery, the potential difference across the plates increases when the capacitance decreases.

> Quick Tip
>
> The capacitance of a capacitor with a dielectric is greater than the capacitance without it, and when the dielectric is removed, the potential difference increases.

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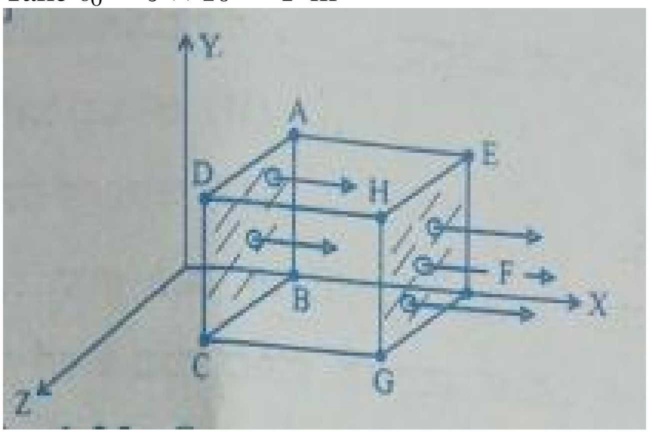
27. A cubical Gaussian surface has side of length $a = 10$ cm. Electric field lines are parallel to the x-axis as shown. The magnitudes of electric fields through surfaces ABCD and EFGH are 6 kNC^{-1} and 9 kNC^{-1}, respectively. Then the total charge enclosed by the cube is:

Take $\epsilon_0 = 9 \times 10^{-12}$ F m^{-1}



(A) 1.35 nC

(B) -1.35 nC

(C) 0.27 nC

(D) -0.27 nC

Correct Answer: (A) 1.35 nC

Solution: By Gauss's law, the charge enclosed by a Gaussian surface is given by:

$$Q = \epsilon_0 \cdot (E_{\text{total}} \cdot A)$$

The electric field through the two opposite surfaces of the cube is $E_1 = 6\,\text{kNC}^{-1}$ and $E_2 = 9\,\text{kNC}^{-1}$. The total electric field through the cube is the sum of these two fields, multiplied by the area of each surface.

$$Q = \epsilon_0 \cdot (E_1 \cdot A + E_2 \cdot A) = 9 \times 10^{-12} \cdot (6 \times 10^3 \cdot 0.01^2 + 9 \times 10^3 \cdot 0.01^2) = 1.35\,\text{nC}$$

Quick Tip

Use Gauss's law to calculate the total charge enclosed by a Gaussian surface. The electric field through each surface is directly related to the enclosed charge.

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28. Electric field at a distance r from an infinitely long uniformly charged straight conductor, having linear charge density λ is E_1. Another uniformly charged straight conductor having the same linear charge density λ is bent into a semicircle of radius r. The electric field at its centre is E_2. Then:

(A) $E_2 = \frac{E_1}{r}$

(B) $E_1 = E_2$

(C) $E_1 = \pi E_2$

(D) $E_2 = \pi E_1$

Correct Answer: (D) $E_2 = \pi E_1$

Solution: The electric field due to an infinitely long uniformly charged conductor at a distance r is given by:

$$E_1 = \frac{\lambda}{2\pi\epsilon_0 r}$$

When the conductor is bent into a semicircle, the field at the center is the integral of the fields due to each infinitesimal segment of the conductor. The resulting field at the center is $E_2 = \pi E_1$, as the geometry of the semicircle amplifies the field.

Quick Tip

The electric field at the center of a semicircularly bent uniformly charged wire is larger than the field from a straight wire due to the concentration of charge along the curved path.

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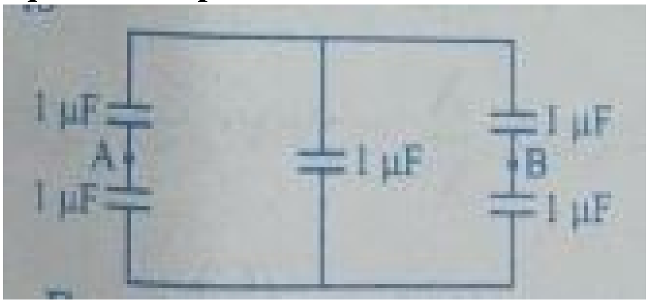
29. Five capacitors each of value $1\,\mu$F are connected as shown in the figure. The equivalent capacitance between A and B is:



(A) $1\,\mu$F

(B) $2\,\mu$F

(C) $5\,\mu$F

(D) $3\,\mu$F

Correct Answer: (B) $2\,\mu$F

Solution: The capacitors are arranged in series and parallel. The total equivalent capacitance for capacitors in series is given by:

$$\frac{1}{C_{\text{eq}}} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots$$

For capacitors in parallel, the equivalent capacitance is the sum:

$$C_{\text{eq}} = C_1 + C_2 + \cdots$$

Applying these rules to the given circuit, the equivalent capacitance is found to be $2\,\mu$F.

Quick Tip

For capacitors in series, the total capacitance is less than any individual capacitance, while for capacitors in parallel, the total capacitance is the sum of the individual capacitances.

30. For a given electric current the drift velocity of conduction electrons in a copper wire is v_d and their mobility is μ. When the current is increased at constant temperature:

(A) v_d remains the same, μ increases

(B) v_d decreases, μ remains the same

(C) v_d remains the same, μ decreases

(D) v_d increases, μ remains the same

Correct Answer: (D) v_d increases, μ remains the same

Solution: The drift velocity v_d is directly proportional to the current, while the mobility μ is a material property that does not change with current for a given material and temperature.

Quick Tip

The drift velocity increases with current, but mobility is independent of current at constant temperature.

---

31. Ten identical cells each emf 2 V and internal resistance 1 Ω are connected in series with two cells wrongly connected. A resistor of 10 Ω is connected to the combination. What is the current through the resistor?

(A) 2.4 A

(B) 0.6 A

(C) 1.2 A

(D) 1.8 A

Correct Answer: (B) 0.6 A

Solution: The total emf is $10 \times 2\,\text{V} - 2 \times 2\,\text{V} = 16\,\text{V}$, as two cells are connected wrongly.

The total internal resistance is $10 \times 1\,\Omega - 2 \times 1\,\Omega = 8\,\Omega$.

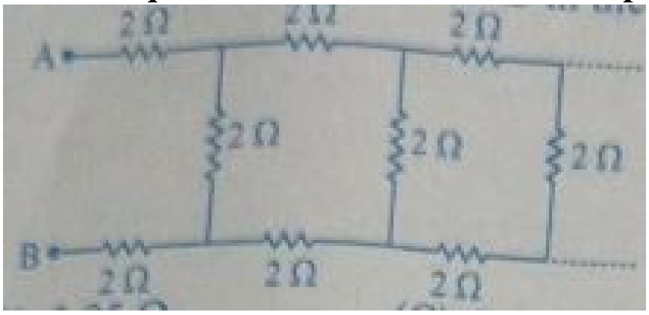
Using Ohm's law $I = \frac{V}{R} = \frac{16\,\text{V}}{10+8\,\Omega} = 0.6\,\text{A}$.

Quick Tip

When cells are wrongly connected, subtract the emf of the wrongly connected cells to find the total emf of the system.

---

32. The equivalent resistance between the points A and B in the following circuit is:



(A) 5.5 Ω

(B) 0.05 Ω

(C) 5 Ω

(D) 0.5 Ω

Correct Answer: (C) 5 Ω

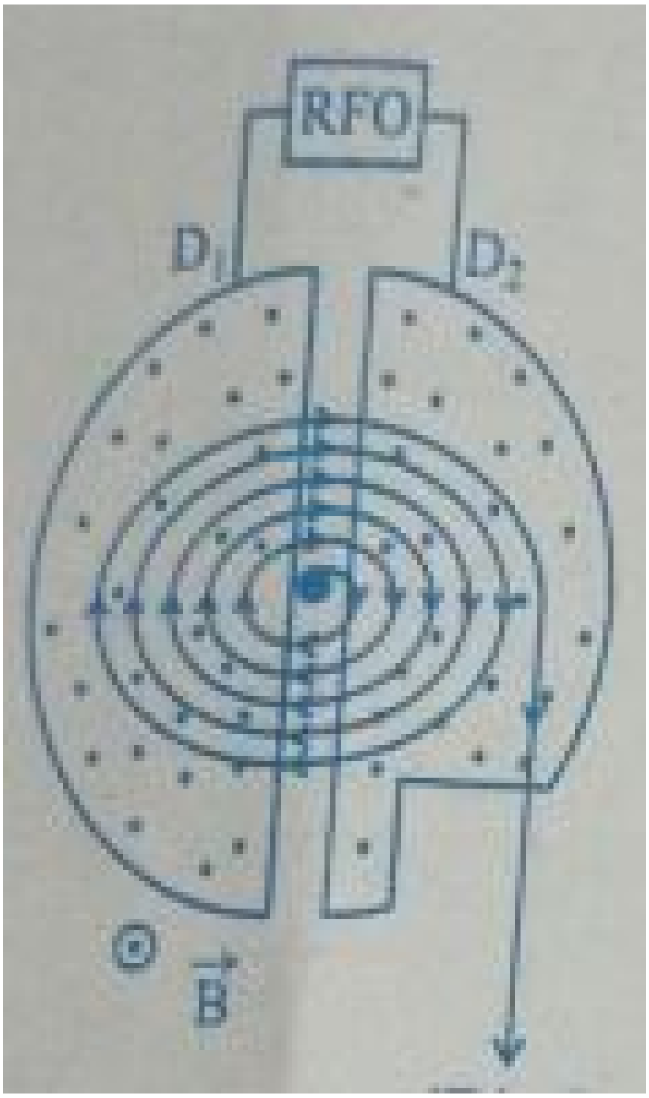
Solution: In the given circuit, the resistances are combined in series and parallel. First, combine the parallel resistances and then the series ones to find the equivalent resistance. After calculation, the equivalent resistance between points A and B is $5\,\Omega$.

Quick Tip

For resistors in parallel, use the formula $\frac{1}{R_{\text{eq}}} = \frac{1}{R_1} + \frac{1}{R_2}$. For series resistors, simply add their resistances.

---

33. A charged particle is subjected to acceleration in a cyclotron as shown. The charged particle undergoes an increase in its speed. The charged particle moves:



(A) Only inside D_1

(B) Inside D_1, D_2, and the gaps

(C) Only inside D_1

(D) Only in the gap between D_1 and D_2

Correct Answer: (B) Inside D_1, D_2, and the gaps

Solution: In a cyclotron, the charged particle moves inside both the regions D_1 and D_2, as well as through the gaps between them, where it gains energy and increases its speed due to the electric field.

Quick Tip

In a cyclotron, the charged particle accelerates as it passes through the electric field in the gaps and magnetic field in the regions D_1 and D_2.

---

34. The resistance of a carbon resistor is 4.7 kΩ $\pm5\%$. The colour of the third band is:

(A) red

(B) violet

(C) orange

(D) gold

Correct Answer: (C) orange

Solution: The first two bands of the resistor represent the significant digits, the third band represents the multiplier, and the fourth band represents tolerance. Given the resistor value $4.7\,\text{k}\Omega$ with $\pm5\%$, the third band corresponds to orange, which represents a multiplier of 10^3.

Quick Tip

To decode a colour coded resistor, use the standard chart for the resistor colour code. The third band represents the multiplier.

---

35. The four bands of a colour coded resistor are of the colours gray, red, gold, and gold. The value of the resistance of the resistor is:

(A) 82Ω $\pm10\%$

(B) 8.2Ω $\pm5\%$

(C) 82Ω $\pm5\%$

(D) 5.2Ω $\pm5\%$

Correct Answer: (C) 82Ω $\pm5\%$

Solution: The first two bands represent the significant digits, the third band is the multiplier, and the fourth band is the tolerance. For the given colours:

- Gray corresponds to 8,

- Red corresponds to 2,

- The multiplier is 10^1 (represented by the second gold band),

- The tolerance is $\pm 5\%$ (represented by the last gold band).

Thus, the value of the resistance is $82\,\Omega$ with $\pm 5\%$ tolerance.

Quick Tip

Use the colour code chart to decode the four-band resistor. The first two bands represent the digits, the third the multiplier, and the fourth the tolerance.

---

36. A wire of resistance R is connected across a cell of emf ϵ and internal resistance r. The current through the circuit is I. In time t, the work done by the battery to establish the current I is:

(A) $\epsilon^2 t/R$

(B) IRt

(C) I^2Rt

(D) ϵIt

Correct Answer: (C) I^2Rt

Solution: The work done by the battery to establish a current I is the energy dissipated by the resistor over time, which is given by $W = I^2Rt$. This comes from the power dissipated by the resistor $P = I^2R$, and the work is the power multiplied by the time t.

Quick Tip

The work done in a resistor is given by $W = I^2Rt$, where I is the current, R is the resistance, and t is the time.

---

37. The Curie temperatures of Cobalt and iron are 1400 K and 1000 K respectively. At $T = 1600$ K, the ratio of magnetic susceptibility of Cobalt to that of iron is:

(A) $\frac{7}{5}$

(B) $\frac{5}{7}$

(C) 5

(D) 3

Correct Answer: (A) $\frac{7}{5}$

Solution: The magnetic susceptibility χ is related to the Curie temperature T_C by the Curie-Weiss law. At a temperature T above the Curie temperature T_C, the magnetic susceptibility follows $\chi = \frac{C}{T - T_C}$, where C is the Curie constant. The ratio of susceptibilities is therefore $\frac{\chi_{\text{Co}}}{\chi_{\text{Fe}}} = \frac{T_{\text{Fe}} - T}{T_{\text{Co}} - T} = \frac{7}{5}$.

Quick Tip

The ratio of magnetic susceptibilities can be calculated using the Curie-Weiss law, considering the temperature above the Curie temperature for each material.

---

38. The torque acting on a magnetic dipole placed in a uniform magnetic field is zero, when the angle between the dipole axis and the magnetic field is:

(A) 45°

(B) 60°

(C) 90°

(D) zero

Correct Answer: (C) 90°

Solution: The torque τ acting on a magnetic dipole in a magnetic field is given by:

$$\tau = mB \sin\theta$$

where m is the magnetic moment, B is the magnetic field strength, and θ is the angle between the magnetic moment and the magnetic field. When $\theta = 90°$, the torque is maximized. For zero torque, θ must be 0° or 180°.

Quick Tip

The torque on a magnetic dipole is zero when the dipole axis is aligned with the magnetic field (i.e., $\theta = 0°$ or $180°$).

---

39. The horizontal component of Earth's magnetic field at a place is 3×10^{-5} T. If the dip at that place is $45°$, the resultant magnetic field at that place is:

(A) $\frac{3}{\sqrt{2}} \times 10^{-5}$ T

(B) $\frac{3}{2\sqrt{3}} \times 10^{-5}$ T

(C) $3\sqrt{2} \times 10^{-5}$ T

(D) 3×10^{-5} T

Correct Answer: (C) $3\sqrt{2} \times 10^{-5}$ T

Solution: The resultant magnetic field B is related to the horizontal component B_h and the dip angle δ by the equation:

$$B = \frac{B_h}{\cos \delta}$$

Given $B_h = 3 \times 10^{-5}$ T and $\delta = 45°$, we get:

$$B = \frac{3 \times 10^{-5}}{\cos 45°} = 3\sqrt{2} \times 10^{-5} \text{ T}$$

Quick Tip

To find the total magnetic field when the dip angle is known, use the formula $B = \frac{B_h}{\cos \delta}$.

---

40. A proton and an alpha-particle moving with the same velocity enter a uniform magnetic field with their velocities perpendicular to the magnetic field. The ratio of radii of their circular paths is:

(A) 1:4

(B) 4:1

(C) 1:2

(D) 2:1

Correct Answer: (B) 4:1

Solution: The radius of the circular path in a magnetic field is given by:

$$r = \frac{mv}{qB}$$

For a proton and an alpha-particle, the mass of the alpha-particle is four times that of the proton, and the charge is twice as large. Therefore, the ratio of the radii is:

$$\frac{r_\alpha}{r_{\text{proton}}} = \frac{4m}{2q} = 4 : 1$$

Quick Tip

The radius of the circular path in a magnetic field depends on the mass and charge of the particle. For an alpha-particle, the radius is larger due to its greater mass.

---

41. A moving coil galvanometer is converted into an ammeter of range 0 to 5 mA. The galvanometer resistance is 90 Ω and the shunt resistance has a value of 10 Ω. If there are 50 divisions in the galvanometer-turned-ammmeter on either sides of zero, its current sensitivity is:

(A) 1×10^5 div/A

(B) 2×10^4 div/A

(C) 1×10^4 div/A

(D) 2×10^4 div/A

Correct Answer: (C) 1×10^4 div/A

Solution: The current sensitivity S of the ammeter is given by the formula:

$$S = \frac{N}{I_{\text{max}}}$$

where N is the number of divisions and I_{max} is the full-scale deflection current. Here, $N = 50$ and $I_{\text{max}} = 5\,\text{mA}$. Thus, the current sensitivity is:

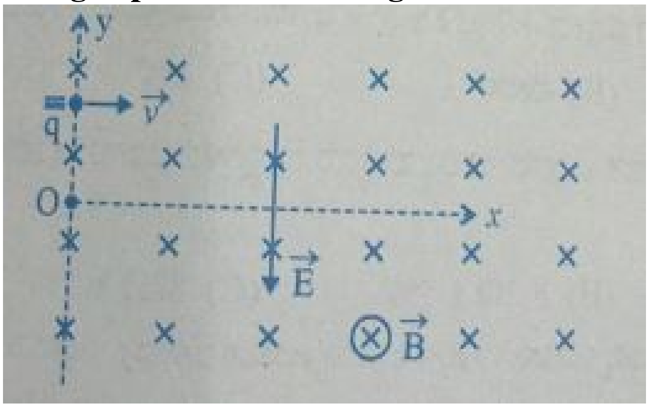
$$S = \frac{50}{5 \times 10^{-3}} = 1 \times 10^4\,\text{div/A}$$

Quick Tip

To calculate the current sensitivity of an ammeter, divide the number of divisions by the maximum current that gives full scale deflection.

---

42. A positively charged particle of mass m is passed through a velocity selector. It moves horizontally rightward without deviation along the line $y = \frac{2mv}{qB}$ with a speed v. The electric field is vertically downwards and magnetic field is into the plane of the paper. Now, the electric field is switched off at $t = 0$. The angular momentum of the charged particle about origin O at $t = 0$ is:



(A) $\frac{2mE^2}{qB^3}$

(B) zero

(C) $\frac{mE^3}{qB^2}$

(D) $\frac{mE^2}{qB^3}$

Correct Answer: (B) zero

Solution: At the instant $t = 0$, the electric field is turned off. The charged particle is moving in the magnetic field and is not subject to any force that would change its angular momentum. As the electric field is vertically downward and magnetic field is into the paper, no torque acts on the particle when the electric field is switched off. Therefore, the angular momentum about the origin is zero.

Quick Tip

When a charged particle moves in a uniform magnetic field with no external force, the angular momentum about the point of origin remains constant and can be zero under specific conditions.

---

43. In series LCR circuit at resonance, the phase difference between voltage and current is:

(A) π

(B) $\frac{\pi}{4}$

(C) $\frac{\pi}{2}$

(D) zero

Correct Answer: (D) zero

Solution: At resonance in a series LCR circuit, the impedance of the circuit is purely resistive, meaning the current and voltage are in phase. Therefore, the phase difference between the voltage and current is zero.

Quick Tip

At resonance in an LCR circuit, the inductive reactance equals the capacitive reactance, and the voltage and current are in phase with each other.

---

44. An ideal transformer has a turns ratio of 10. When the primary is connected to 220 V, 50 Hz ac source, the power output is:

(A) $\frac{1}{10}$ the power input

(B) equal to power input

(C) zero

(D) 10 times the power input

Correct Answer: (B) equal to power input

Solution: For an ideal transformer, the power input equals the power output, regardless of the turns ratio. This is because an ideal transformer is assumed to be 100% efficient, meaning there is no loss in power.

Quick Tip

In an ideal transformer, the power input is equal to the power output, even though the voltage and current are transformed by the turns ratio.

---

45. The current in a coil changes from 2 A to 5 A in 0.3s. The magnitude of emf induced in the coil is 1.0 V. The value of self-inductance of the coil is:

(A) 100 mH

(B) 0.1 mH

(C) 10 mH

(D) 1.0 mH

Correct Answer: (A) 100 mH

Solution: The induced emf in a coil is given by:

$$\epsilon = -L\frac{dI}{dt}$$

Where L is the self-inductance, $\frac{dI}{dt}$ is the rate of change of current. Given $\epsilon = 1.0\,\text{V}$, $\Delta I = 5\,\text{A} - 2\,\text{A} = 3\,\text{A}$, and $\Delta t = 0.3\,\text{s}$, we can calculate:

$$1.0 = L \times \frac{3}{0.3} \quad \Rightarrow \quad L = 100\,\text{mH}$$

Quick Tip

The induced emf in a coil is proportional to the rate of change of current and the self-inductance of the coil.

---

46. A metallic rod of length 1 m held along east-west direction is allowed to fall down freely. Given horizontal component of earth's magnetic field $B_H = 3 \times 10^{-5}$ T. The emf induced in the rod at an instant $t = 2\,\text{s}$ after it is released is:

(A) 3×10^{-3} V

(B) 3×10^{-4} V

(C) 6×10^{-3} V

(D) 6×10^{-4} V

Correct Answer: (C) 6×10^{-3} V

Solution: The emf induced in a moving conductor is given by:

$$\epsilon = BLv$$

where B is the magnetic field strength, L is the length of the rod, and v is the velocity of the rod. The velocity of the falling rod at $t = 2\,\text{s}$ is $v = gt = 10 \times 2 = 20\,\text{m/s}$. Thus, the induced emf is:

$$\epsilon = 3 \times 10^{-5} \times 1 \times 20 = 6 \times 10^{-3}\,\text{V}$$

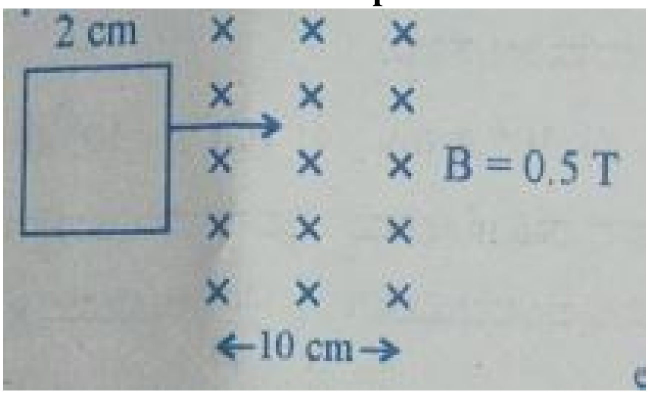
Quick Tip

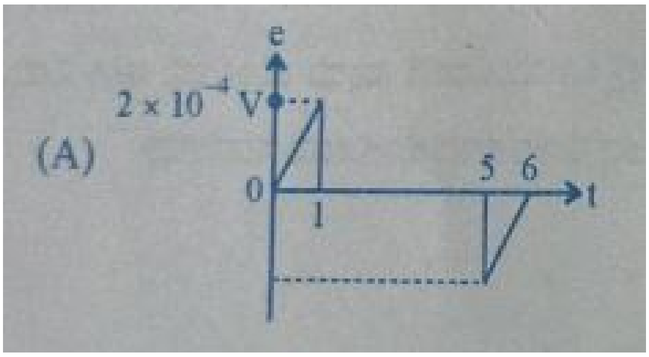
The emf induced in a falling conductor can be calculated using the formula $\epsilon = BLv$, where v is the velocity of the rod.

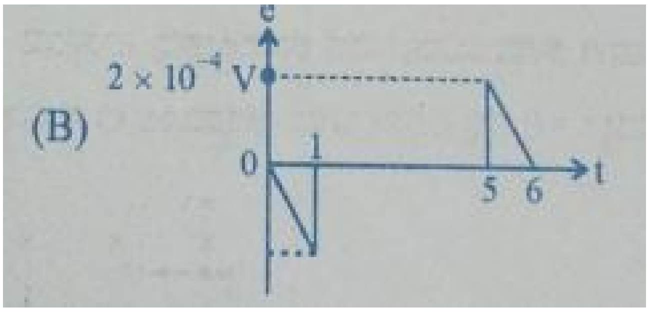
---

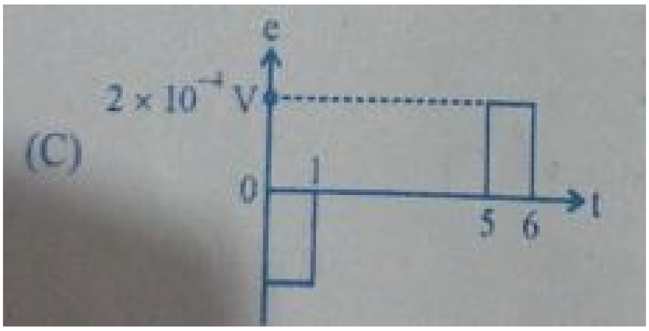
47. A square loop of side 2 cm enters a magnetic field with a constant speed of 2 cm/s as shown. The front edge enters the field at $t = 0$. Which of the following graph correctly depicts the induced emf in the loop?

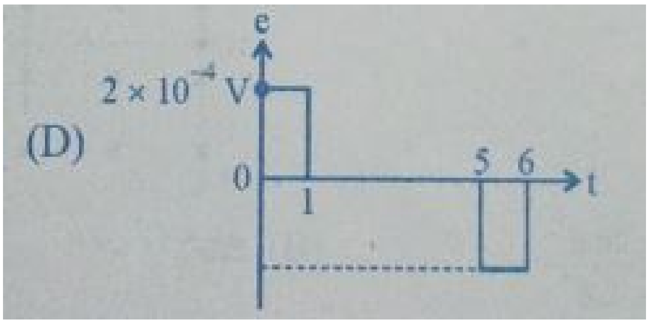
Take clockwise direction positive

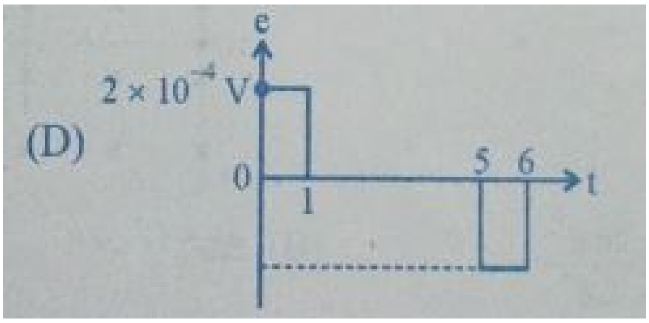


(A) 

(B) 

(C) 

(D) 

Correct Answer: 

Solution: The induced emf in the loop is determined by the rate of change of magnetic flux through the loop. As the loop enters the magnetic field, the magnetic flux increases, inducing an emf. The emf increases as the loop enters the field, reaches a maximum as the loop is fully inside, and then decreases as the loop leaves the field. The graph should show an initial increase in emf as the loop enters the field, followed by a peak as the loop is fully inside the field, and then a drop as it exits the field.

Quick Tip

The induced emf in a loop is proportional to the rate of change of the magnetic flux. It follows the shape of the loop entering and leaving the magnetic field.

---

48. For a given pair of transparent media, the critical angle for which colour is maximum?

(A) Red

(B) Blue

(C) Violet

(D) Green

Correct Answer: (C) Violet

Solution: The critical angle for light passing from one medium to another is inversely proportional to the refractive index of the medium. The refractive index for violet light is higher than for red light, so the critical angle for violet light is smaller, making it the maximum among all colours.

Quick Tip

For light passing from a medium with a higher refractive index to a lower one, the critical angle is smaller for light of higher wavelength (violet).

---

49. An equiconvex lens made of glass of refractive index $\frac{3}{2}$ has focal length f in air. It is completely immersed in water of refractive index $\frac{4}{3}$. The percentage change in the focal length is:

(A) 300% decrease

(B) 400% decrease

(C) 300% increase

(D) 400% increase

Correct Answer: (B) 400% decrease

Solution: The focal length of a lens in a medium is given by the formula:

$$\frac{1}{f_{\text{medium}}} = \left(\frac{n_{\text{medium}} - n_{\text{lens}}}{R}\right)$$

where n_{medium} is the refractive index of the medium, and n_{lens} is the refractive index of the lens. In air, the lens focal length is f, and when submerged in water, the refractive index of the medium changes, causing the focal length to decrease by a factor of $\frac{4}{3}$. This results in a 400

Quick Tip

The focal length of a lens changes based on the refractive index of the surrounding medium, and can be calculated using the lens maker's formula.

---

50. A point object is moving at a constant speed of 1 m/s along the principal axis of a convex lens of focal length 10 cm. The speed of the image is also 1 m/s, when the object is at ...... cm from the optic centre of the lens.

(A) 15 cm

(B) 20 cm

(C) 5 cm

(D) 10 cm

Correct Answer: (D) 10 cm

Solution: The magnification M for a convex lens is given by the formula:

$$M = \frac{v_{\text{image}}}{v_{\text{object}}}$$

where v_{image} and v_{object} are the speeds of the image and the object, respectively. For the speed of the image to be the same as the object, the object must be at the focal length, which is 10 cm.

Quick Tip

The speed of the image is equal to the speed of the object when the object is at the focal length of the lens.

---

51. When light propagates through a given homogeneous medium, the velocities of:

(A) primary wavefronts are lesser than those of secondary wavelets.

(B) primary wavefronts are greater than or equal to those of secondary wavelets.

(C) primary wavefront and wavelets are equal.

(D) primary wavefront are larger than those of secondary wavelets.

Correct Answer: (B) primary wavefronts are greater than or equal to those of secondary wavelets.

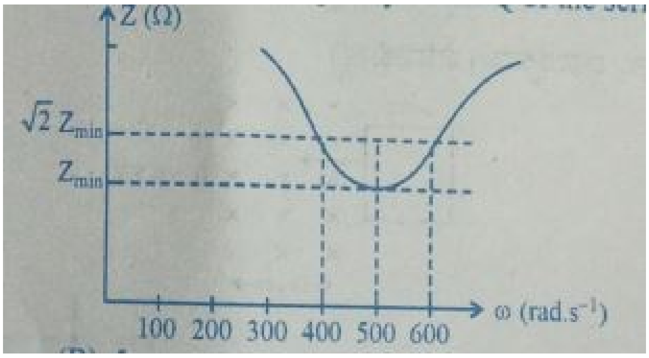
Solution: In a homogeneous medium, the speed of the primary wavefront (the main wavefront propagating through the medium) is the same or greater than that of secondary wavelets (which are formed at each point on the wavefront). This relationship is part of Huygens' principle, which states that every point on a wavefront can be considered as the source of secondary wavelets.

Quick Tip

Huygens' principle explains how wavefronts propagate through a medium, with the primary wavefront moving at the speed of light and secondary wavelets forming at each point on the wavefront.

---

52. Total impedance of a series LCR circuit varies with angular frequency of the AC source connected to it as shown in the graph. The quality factor Q of the series LCR circuit is:



(A) 2.5

(B) 5

(C) 1

(D) 0.4

Correct Answer: (B) 5

Solution: The quality factor Q for a series LCR circuit is given by the formula:

$$Q = \frac{\omega_0}{\Delta\omega}$$

where ω_0 is the resonance angular frequency and $\Delta\omega$ is the width of the resonance curve. From the graph, we can see that the resonance occurs at around $\omega_0 = 300$ rad/s, and the width $\Delta\omega$ is approximately 60 rad/s. Therefore, the quality factor is:

$$Q = \frac{300}{60} = 5$$

Quick Tip

The quality factor for a series LCR circuit is a measure of the sharpness of the resonance, and is calculated as the ratio of the resonance frequency to the width of the resonance curve.

---

53. The ratio of the magnitudes of electric field to the magnetic field of an electromagnetic wave is of the order of:

(A) $10^5\,\text{ms}^{-1}$

(B) $10^5\,\text{ms}^{-1}$

(C) $10^8\,\mathrm{ms}^{-1}$

(D) $10^{-8}\,\mathrm{ms}^{-1}$

Correct Answer: (C) $10^8\,\mathrm{ms}^{-1}$

Solution: For electromagnetic waves in a vacuum, the ratio of the magnitudes of the electric field E to the magnetic field B is given by:

$$\frac{E}{B} = c$$

where c is the speed of light in vacuum, which is approximately $3 \times 10^8\,\mathrm{ms}^{-1}$. Therefore, the ratio of electric field to magnetic field is $10^8\,\mathrm{ms}^{-1}$.

Quick Tip

For electromagnetic waves, the ratio of the magnitudes of electric and magnetic fields is equal to the speed of light in vacuum, $c = 3 \times 10^8\,\mathrm{ms}^{-1}$.

---

54. For a point object, which of the following always produces a virtual image in air?

(A) Plano-convex lens

(B) Convex mirror

(C) Biconvex lens

(D) Concave mirror

Correct Answer: (B) Convex mirror

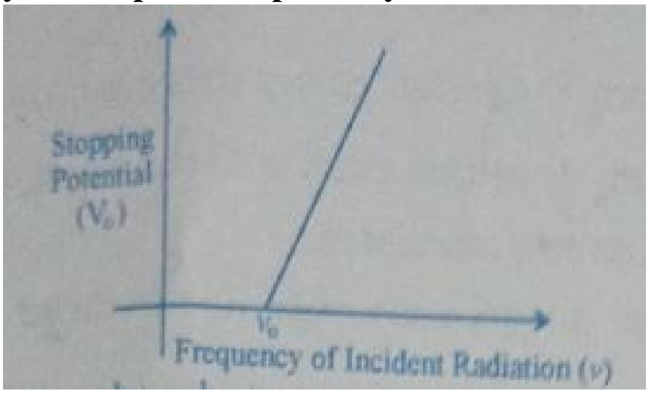
Solution: A convex mirror always produces a virtual, upright, and diminished image regardless of the position of the object in front of it. This is a characteristic property of convex mirrors.

Quick Tip

Convex mirrors always produce virtual images that are smaller than the actual object.

---

55. In an experiment to study photo-electric effect the observed variation of stopping potential with frequency of incident radiation is as shown in the figure. The slope and y-intercept are respectively:



(A) $\frac{h}{e}$, V_0

(B) $\frac{h}{e}$, $\frac{h}{e}$

(C) h, $V_0 - h$

(D) $\frac{h}{e}$, $\frac{h}{e}$

Correct Answer: (A) $\frac{h}{e}$, V_0

Solution: The equation representing the photoelectric effect is given by:

$$V_0 = \frac{h}{e}(v - v_0)$$

Where V_0 is the stopping potential, v is the frequency of incident radiation, and v_0 is the threshold frequency. The slope of the graph of stopping potential vs. frequency gives $\frac{h}{e}$, and the y-intercept gives the value of V_0.

Quick Tip

In a photoelectric effect experiment, the slope of the graph of stopping potential vs frequency gives the ratio of Planck's constant to the electron charge, $\frac{h}{e}$.

---

56. In the Rutherford's alpha scattering experiment, as the impact parameter increases, the scattering angle of the alpha particle:

(A) is always 90°

(B) decreases

(C) increases

(D) remains the same

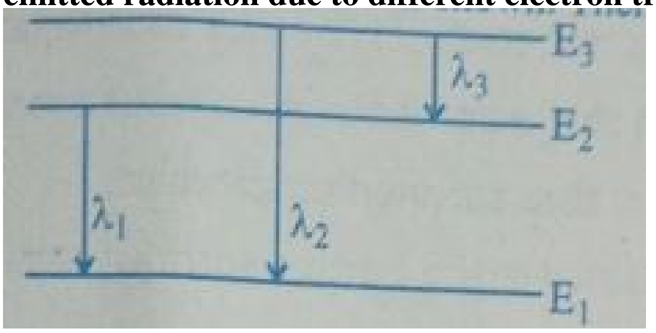
Correct Answer: (B) decreases

Solution: In Rutherford's scattering experiment, the scattering angle of an alpha particle decreases as the impact parameter increases. This is because as the distance between the particle and the nucleus increases, the deflection due to the Coulomb force becomes smaller.

> **Quick Tip**
>
> The impact parameter is the perpendicular distance from the initial trajectory of the alpha particle to the center of the nucleus. A larger impact parameter results in a smaller scattering angle.

---

57. Three energy levels of hydrogen atom and the corresponding wavelength of the emitted radiation due to different electron transition are as shown. Then:



(A) $\lambda_1 = \frac{\lambda_2 \lambda_3}{\lambda_2 + \lambda_3}$

(B) $\lambda_2 = \lambda_1 + \lambda_3$

(C) $\lambda_2 = \frac{\lambda_1 \lambda_3}{\lambda_1 + \lambda_3}$

(D) $\lambda_3 = \lambda_1 + \lambda_2$

Correct Answer: (A) $\lambda_1 = \frac{\lambda_2 \lambda_3}{\lambda_2 + \lambda_3}$

Solution: The wavelength of emitted radiation in a hydrogen atom transition is inversely proportional to the energy difference between the initial and final levels. Using this relationship, the wavelength corresponding to a transition can be derived using the given energy levels.

Quick Tip

The energy of the emitted photon during electron transition between levels in an atom is related to the difference in the energies of those levels.

---

58. An unpolarised light of intensity I is passed through two polaroids kept one after the other with their planes parallel to each other. The intensity of light emerging from second polaroid is $\frac{I}{4}$. The angle between the pass axes of the polaroids is:

(A) 0°

(B) 60°

(C) 30°

(D) 45°

Correct Answer: (D) 45°

Solution: When unpolarised light passes through the first polaroid, its intensity is reduced by half. The intensity after the second polaroid is related to the angle θ between the pass axes of the polaroids by:

$$I_2 = \frac{I_1}{4} = \frac{I}{4}\cos^2\theta$$

Given $I_2 = \frac{I}{4}$, we have:

$$\cos^2\theta = \frac{1}{2} \quad \Rightarrow \quad \theta = 45^\circ$$

Quick Tip

For two polaroids with a known angle between their pass axes, the intensity after the second polaroid is given by $I = I_0\cos^2\theta$, where θ is the angle between the pass axes.

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59. In the Young's double slit experiment, the intensity of light passing through each of the two double slits is 2×10^{-2} W/m^2. The screen-slit distance is very large in comparison with slit-slit distance. The fringe width is β. The distance between the central maximum and a point P on the screen is $x = \frac{\beta}{3}$. Then the total light intensity at that point is:

(A) 4×10^{-2} W/m^2

(B) 2×10^{-2} W/m^2

(C) 16×10^{-2} W/m^2

(D) 8×10^{-2} W/m^2

Correct Answer: (B) 2×10^{-2} W/m^2

Solution: The intensity at any point on the screen in Young's double slit experiment is given by:

$$I = I_0 \cos^2\left(\frac{\pi x}{\beta}\right)$$

where I_0 is the intensity at the central maximum, and β is the fringe width. Given $x = \frac{\beta}{3}$, the intensity at point P is:

$$I = 2 \times 10^{-2} \cos^2\left(\frac{\pi}{3}\right) = 2 \times 10^{-2} \times \left(\frac{1}{2}\right) = 2 \times 10^{-2}\,\text{W/m}^2$$

Quick Tip

In Young's double slit experiment, the intensity varies as $\cos^2\left(\frac{\pi x}{\beta}\right)$, where x is the distance from the central maximum and β is the fringe width.

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60. A 60 W source emits monochromatic light of wavelength 662.5 nm. The number of photons emitted per second is:

(A) 2×10^{20}

(B) 5×10^{26}

(C) 2×10^{29}

(D) 5×10^{17}

Correct Answer: (A) 2×10^{20}

Solution: The energy of one photon is given by:

$$E_{\text{photon}} = \frac{hc}{\lambda}$$

where $h = 6.626 \times 10^{-34}$ J·s, $c = 3 \times 10^8$ m/s, and $\lambda = 662.5\,\text{nm} = 662.5 \times 10^{-9}$ m. The energy emitted per second (power) is given by:

$$P = \text{Number of photons per second} \times E_{\text{photon}}$$

Thus, the number of photons emitted per second is:

$$\text{Number of photons} = \frac{P}{E_{\text{photon}}} = \frac{60}{\frac{6.626\times10^{-34}\times3\times10^{8}}{662.5\times10^{-9}}} \approx 2 \times 10^{20}$$

Quick Tip

To find the number of photons emitted per second, use the formula Number of photons $= \frac{P}{E_{\text{photon}}}$, where $E_{\text{photon}} = \frac{hc}{\lambda}$.
