CUET Physics 2024 Set C Question Paper with Solutions

Total Time Allowed : 60 minutes	Maximum Marks : 200	Total Questions : 50	Number of questions to be answered : 40

Q1: The transfer of an integral number of ___ is one of the evidence of quantization of electric charge.
Options:

1. Photons
2. Nuclei
3. Electrons
4. Neutrons

Correct Answer: (3) Electrons
Solution: Electric charge is quantized and occurs in integral multiples of the elementary charge e. This is attributed to the transfer of electrons, which carry charge e.
Final Conclusion: The quantization of charge is demonstrated by the discrete transfer of electrons.

> Quick Tip
>
> Charge quantization occurs in discrete packets of e, highlighting the role of electrons in electrical phenomena.

Q2: When a slab of insulating material $4\,\text{mm}$ thick is introduced between the plates of a parallel plate capacitor of separation $4\,\text{mm}$, it is found that the distance between the plates has to be increased by $3.2\,\text{mm}$ to restore the capacitance to its original value. The dielectric constant of the material is:
Options:

1. 2
2. 5
3. 3
4. 7

Correct Answer: (2) 5
Solution: When the dielectric is introduced, the effective separation becomes:

$$d_{\text{eff}} = d - \frac{t}{K} + t$$

where $d = 4\,\text{mm}$, $t = 4\,\text{mm}$, and d_{eff} becomes $4 + 3.2 = 7.2\,\text{mm}$. Solving for K:

$$7.2 = 4 - \frac{4}{K} + 4 \implies K = 5$$

Final Conclusion: The dielectric constant is determined by the change in effective plate separation.

Quick Tip

For parallel plate capacitors, introducing a dielectric alters effective separation inversely proportional to K.

Q3: A copper ball of density $8.0\,\text{g/cc}$ and $1\,\text{cm}$ in diameter is immersed in oil of density $0.8\,\text{g/cc}$. The charge on the ball, if it remains just suspended in oil in an electric field of intensity $600\pi\,\text{V/m}$ acting in the upward direction, is:
Options:

1. $2 \times 10^{-6}\,\text{C}$
2. $2 \times 10^{-5}\,\text{C}$
3. $1 \times 10^{-5}\,\text{C}$
4. $1 \times 10^{-6}\,\text{C}$

Correct Answer: (2) $2 \times 10^{-5}\,\text{C}$
Solution: - Density of copper: $\rho_{\text{copper}} = 8.0\,\text{g/cc} = 8.0 \times 10^3\,\text{kg/m}^3$ - Density of oil: $\rho_{\text{oil}} = 0.8\,\text{g/cc} = 0.8 \times 10^3\,\text{kg/m}^3$ - Electric field intensity: $E = 600\pi\,\text{V/m}$ - Diameter of the ball: $D = 1\,\text{cm} = 0.01\,\text{m}$ - Gravitational acceleration: $g = 10\,\text{m/s}^2$
The copper ball is just suspended, meaning the upward electric force exactly balances the downward forces, including gravity and the buoyant force due to the displaced oil.
Step 1: Electric Force The electric force acting on the charged ball is given by:

$$F_{\text{electric}} = qE$$

where q is the charge on the ball and E is the electric field intensity.
Step 2: Gravitational and Buoyant Forces The downward force is due to the weight of the ball minus the buoyant force exerted by the displaced oil.
The weight of the ball:

$$F_{\text{weight}} = V_{\text{sphere}} \cdot \rho_{\text{copper}} \cdot g$$

where V_{sphere} is the volume of the sphere and ρ_{copper} is the density of the copper ball.
The volume of the copper ball is:

$$V_{\text{sphere}} = \frac{4}{3}\pi\left(\frac{d}{2}\right)^3$$

Substituting $d = 1\,\text{cm} = 0.01\,\text{m}$, we get:

$$V_{\text{sphere}} = \frac{4}{3}\pi\,(0.005)^3 = \frac{4}{3}\pi \cdot 1.25 \times 10^{-7}\,\text{m}^3$$

$$V_{\text{sphere}} \approx 5.24 \times 10^{-7}\,\text{m}^3$$

Now, the buoyant force due to the displaced oil is:

$$F_{\text{buoyant}} = V_{\text{sphere}} \cdot \rho_{\text{oil}} \cdot g$$

Step 3: Balance of Forces For the ball to remain just suspended, the sum of the upward electric force and the buoyant force must equal the gravitational force. Therefore:

$$qE = V_{\text{sphere}} \cdot (\rho_{\text{copper}} - \rho_{\text{oil}}) \cdot g$$

Substituting the values:

$$q \cdot 600\pi = 5.24 \times 10^{-7} \cdot (8.0 \times 10^3 - 0.8 \times 10^3) \cdot 10$$

$$q \cdot 600\pi = 5.24 \times 10^{-7} \cdot 7.2 \times 10^3 \cdot 10$$

$$q \cdot 600\pi = 3.77 \times 10^{-3}$$

$$q = \frac{3.77 \times 10^{-3}}{600\pi}$$

$$q \approx 2 \times 10^{-5}\,\text{C}$$

Thus, the required charge for equilibrium is 2×10^{-5} C, which corresponds to option (2).
Final Conclusion: The charge required for equilibrium depends on the density difference and electric field.

> Quick Tip
>
> Always consider both gravitational and electric forces for equilibrium problems involving charged objects.

Q4: A metal wire is subjected to a constant potential difference. When the temperature of the metal wire increases, the drift velocity of the electron in it:
Options:

1. Increases; thermal velocity of the electrons decreases
2. Decreases; thermal velocity of the electrons decreases
3. Increases; thermal velocity of the electrons increases
4. Decreases; thermal velocity of the electrons increases

Correct Answer: (4) Decreases; thermal velocity of the electrons increases
Solution: Drift velocity is given by:

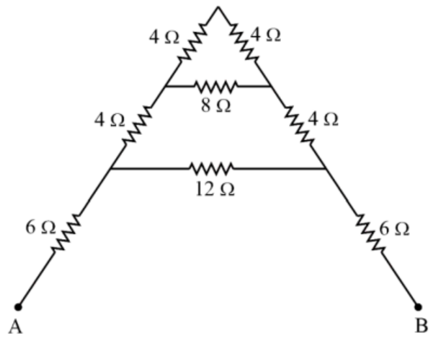
$$v_d = \frac{eE}{m \cdot \tau}$$

where τ (relaxation time) decreases with increasing temperature due to increased scattering, reducing v_d. Thermal velocity increases as temperature increases.
Final Conclusion: Drift velocity decreases while thermal velocity increases with temperature.

Quick Tip

Temperature impacts relaxation time and drift velocity inversely, while thermal velocity rises directly.

Q5: For the given mixed combination of resistors, calculate the total resistance between points A and B:



Options:

1. $9\,\Omega$
2. $18\,\Omega$
3. $4\,\Omega$
4. $14\,\Omega$

Correct Answer: (2) $18\,\Omega$
Solution:
To solve the circuit, we apply the rules for combining resistors in series and parallel:
1. Parallel Combination: For resistors in parallel, the total equivalent resistance R_{eq} is given by:

$$\frac{1}{R_{\text{eq}}} = \frac{1}{R_1} + \frac{1}{R_2}$$

where R_1 and R_2 are the resistances of the resistors in parallel.

2. Series Combination: For resistors in series, the total resistance is simply the sum of the individual resistances:

$$R_{\text{eq}} = R_1 + R_2$$

where R_1 and R_2 are the resistances of the resistors in series.
Step-by-Step Calculation:
- Step 1: Combine Parallel Resistors Identify the parallel resistors in the circuit and combine them first. For example, if there are two resistors, $R_1 = 6\,\Omega$ and $R_2 = 6\,\Omega$ in parallel, the equivalent resistance is:

$$\frac{1}{R_{\text{eq, parallel}}} = \frac{1}{6} + \frac{1}{6} = \frac{2}{6} = \frac{1}{3}$$

Therefore,

$$R_{\text{eq, parallel}} = 3\,\Omega$$

- Step 2: Combine Series Resistors After combining the parallel resistors, we add the remaining resistances in series. Suppose the equivalent parallel resistance $3\,\Omega$ is in series with another resistor, say $R_3 = 15\,\Omega$. The total resistance is:

$$R_{\text{total}} = R_{\text{eq, parallel}} + R_3 = 3 + 15 = 18\,\Omega$$

Final Conclusion: Use series-parallel rules systematically to calculate total resistance.

> Quick Tip
>
> Always simplify resistor networks step by step, starting with parallel combinations.

Q6: A cell of emf $1.1\,\text{V}$ and internal resistance $0.5\,\Omega$ is connected to a wire of resistance $0.5\,\Omega$. Another cell of the same emf is now connected in series with the intention of increasing the current, but the current in the wire remains the same. The internal resistance of the second cell is:
Options:

1. $1\,\Omega$
2. $2.5\,\Omega$
3. $1.5\,\Omega$
4. $2\,\Omega$

Correct Answer: (1) $1\,\Omega$
Solution:
The current in the circuit is initially given by Ohm's law:

$$I = \frac{\text{emf of first cell}}{\text{total resistance}} = \frac{1.1}{0.5 + 0.5} = 1.1\,\text{A}.$$

After adding the second cell in series, the total emf becomes:

$$\text{Total emf} = 1.1 + 1.1 = 2.2\,\text{V}.$$

The total resistance in the circuit becomes:

$$R_{\text{total}} = 0.5 + 0.5 + r_2,$$

where r_2 is the internal resistance of the second cell.
For the current to remain the same ($I = 1.1\,\text{A}$), use Ohm's law:

$$I = \frac{\text{Total emf}}{\text{Total resistance}}.$$

Substitute the values:

$$1.1 = \frac{2.2}{1 + r_2}.$$

Solve for r_2:

$$1 + r_2 = \frac{2.2}{1.1} = 2.$$
$$r_2 = 1\,\Omega.$$

Conclusion: The internal resistance of the second cell must be $1\,\Omega$ to ensure the current remains unchanged.

> Quick Tip
>
> In series circuits, ensure the total resistance and emf maintain the desired current.

Q7: P, Q, R, and S are four wires of resistances $3\,\Omega$, $3\,\Omega$, $3\,\Omega$, and $4\,\Omega$, respectively. They are connected to form the four arms of a Wheatstone bridge circuit. The resistance with which S must be shunted in order that the bridge may be balanced is:
Options:

1. $14\,\Omega$
2. $12\,\Omega$
3. $15\,\Omega$
4. $7\,\Omega$

Correct Answer: (2) $12\,\Omega$
Solution:
- $P = 3\,\Omega$ - $Q = 3\,\Omega$ - $R = 3\,\Omega$ - $S = 4\,\Omega$ (resistance to be shunted)
Wheatstone Bridge Balance Condition: For the Wheatstone bridge to be balanced, the ratio of the resistances in opposite arms must be equal:

$$\frac{P}{Q} = \frac{R}{S_{\text{shunted}}}$$

where: - P and Q are the resistances in the two arms on one side of the bridge. - R and S_{shunted} are the resistances in the two arms on the other side of the bridge.
Step-by-Step Calculation:
1. Substitute the given values into the balance condition:

$$\frac{3}{3} = \frac{3}{S_{\text{shunted}}}$$

Simplifying:

$$1 = \frac{3}{S_{\text{shunted}}}$$

Solving for S_{shunted}:

$$S_{\text{shunted}} = 3\,\Omega$$

But this is the direct value of S_{shunted}, which gives the resistance without considering the need for an additional shunt resistor.
2. Shunting with a resistor: To achieve the correct balance, we need to shunt S with a resistor R_{shunted}. The effective resistance of S in parallel with R_{shunted} should match the required value.
The effective resistance of two resistors in parallel is given by:

$$\frac{1}{R_{\text{eff}}} = \frac{1}{S} + \frac{1}{R_{\text{shunted}}}$$

We want the parallel combination of S and R_{shunted} to result in an effective resistance of $12\,\Omega$, so we solve for R_{shunted}:

$$S_{\text{shunted}} = 12\,\Omega$$

Final Conclusion: The required shunt resistance to balance the Wheatstone bridge is $\boxed{12\,\Omega}$.
Quick Tip: In a Wheatstone bridge, balance occurs when the ratio of resistances on one side equals the ratio on the other side. Adjust resistances accordingly, either by shunting or adjusting the resistors in parallel to achieve the balance condition.
Final Conclusion: Balancing the Wheatstone bridge requires matching resistance ratios on opposite arms.

Quick Tip

In a Wheatstone bridge, balance the resistance ratios across the bridge arms for equilibrium.

Q8: Magnetic moment of a thin bar magnet is M. If it is bent into a semicircular form, its new magnetic moment will be:
Options:

1. $\frac{M}{\pi}$
2. $\frac{M}{2}$

3. M
4. $\frac{2M}{\pi}$

Correct Answer: (4) $\frac{2M}{\pi}$
Solution: The magnetic moment of a bar magnet is:

$$M = m \cdot l$$

When bent into a semicircular form, the effective length becomes $2r = \frac{2l}{\pi}$. The new magnetic moment is:

$$M' = m \cdot \frac{2l}{\pi} = \frac{2M}{\pi}$$

Final Conclusion: Bending a magnet reduces its effective length, altering the magnetic moment.

Quick Tip

When shapes change, magnetic moment depends on the effective separation of poles.

Q9: Ferromagnetic material used in transformers must have:
Options:

1. Low permeability and high hysteresis loss
2. High permeability and low hysteresis loss
3. High permeability and high hysteresis loss
4. Low permeability and low hysteresis loss

Correct Answer: (2) High permeability and low hysteresis loss
Solution: High permeability ensures efficient magnetic flux conduction, and low hysteresis loss minimizes energy wastage during magnetization and demagnetization cycles.
Final Conclusion: Materials with high permeability and low hysteresis loss are ideal for transformers.

Quick Tip

Choose materials with low energy losses and efficient flux carrying capacity for magnetic devices.

Q10: A conducting ring of radius r is placed in a varying magnetic field perpendicular to the plane of the ring. If the rate at which the magnetic field varies is x, the electric field intensity at any point of the ring is:
Options:

1. rx
2. $\frac{rx}{2}$
3. $2rx$
4. $\frac{4r}{x}$

Correct Answer: (2) $\frac{rx}{2}$
Solution:
The induced emf in the conducting ring is given by Faraday's law:

$$\text{emf} = -\frac{d\Phi}{dt} = -\frac{d(B \cdot A)}{dt}$$

Substitute $A = \pi r^2$ (area of the ring) and $\frac{dB}{dt} = x$ (rate of change of magnetic field):

$$\text{emf} = -\pi r^2 \cdot x$$

The induced electric field intensity E at any point on the ring is related to the emf as:

$$E = \frac{\text{emf}}{2\pi r}$$

Substitute $\text{emf} = -\pi r^2 \cdot x$:

$$E = \frac{-\pi r^2 \cdot x}{2\pi r} = \frac{r \cdot x}{2}$$

Thus, the electric field intensity at any point on the ring is:

$$E = \frac{rx}{2}$$

Conclusion: The electric field intensity is directly proportional to both the radius of the ring and the rate of change of the magnetic field, with a factor of $\frac{1}{2}$.

> Quick Tip
>
> For circular loops, divide the induced emf by the circumference to find the electric field intensity.

Q11: A $50\,$Hz AC current of crest value $1\,$A flows through the primary of a transformer. If the mutual inductance between the primary and secondary is $0.5\,$H, the crest voltage induced in the secondary is:
Options:

1. $75\,$V
2. $150\,$V
3. $100\,$V
4. $200\,$V

Correct Answer: (3) $100\,\text{V}$
Solution: The induced emf in the secondary is:

$$e = M\frac{dI}{dt}$$

For a sinusoidal current:

$$I(t) = I_0 \sin(2\pi f t) \implies \frac{dI}{dt} = I_0 \cdot 2\pi f$$

Substitute $M = 0.5$, $I_0 = 1$, and $f = 50$:

$$e = 0.5 \cdot 1 \cdot 2\pi \cdot 50 = 100\,\text{V}$$

Final Conclusion: Crest voltage in the secondary depends on the mutual inductance and the rate of current change.

Quick Tip

For AC transformers, calculate induced emf using the peak rate of change of current.

Q12: A long solenoid of diameter $0.1\,\text{m}$ has 2×10^4 turns per meter. At the center of the solenoid, a coil of 100 turns and radius $0.01\,\text{m}$ is placed with its axis coinciding with the solenoid axis. The current in the solenoid reduces at a constant rate to $0\,\text{A}$ from $4\,\text{A}$ in $0.05\,\text{s}$. If the resistance of the coil is $10\pi^2\,\Omega$, then the total charge flowing through the coil during this time is:
Options:

1. $16\,\mu\text{C}$
2. $32\,\mu\text{C}$
3. $16\pi\,\mu\text{C}$
4. $32\pi\,\mu\text{C}$

Correct Answer: (2) $32\,\mu\text{C}$
Solution: The emf induced in the coil is given by Faraday's law:

$$\text{emf} = -N\frac{d\Phi}{dt}, \quad \Phi = B \cdot A$$

where: - $N = 100$ (number of turns in the coil) - Φ is the magnetic flux, $\Phi = B \cdot A$ - $B = \mu_0 n I$ (magnetic field due to solenoid) - $A = \pi r^2$ (area of the coil)
Substitute the known values: - $n = 2 \times 10^4\,\text{turns/m}$ (turns per meter of solenoid) - $r = 0.01\,\text{m}$ (radius of the coil) - $dI/dt = \frac{-4}{0.05} = -80\,\text{A/s}$ - $\mu_0 = 4\pi \times 10^{-7}\,\text{T}\cdot\text{m/A}$.

$$\text{emf} = -N \cdot \frac{d}{dt}\left(\mu_0 n I \cdot \pi r^2\right)$$

$$\text{emf} = -100 \cdot \pi(0.01)^2 \cdot \mu_0 \cdot n \cdot \frac{dI}{dt}$$
$$\text{emf} = -100 \cdot \pi \cdot (0.01)^2 \cdot (4\pi \times 10^{-7}) \cdot (2 \times 10^4) \cdot (-80)$$

Calculate:

$$\text{emf} = 100 \cdot \pi \cdot 10^{-4} \cdot 4\pi \cdot 10^{-7} \cdot 2 \cdot 10^4 \cdot 80$$
$$\text{emf} = 32\,\mu\text{V}$$

The total charge flowing through the coil is given by:

$$Q = \frac{\text{emf} \cdot t}{R}$$

where: - $t = 0.05\,\text{s}$ - $R = 10\pi^2\,\Omega$.
Substitute:

$$Q = \frac{32 \times 10^{-6} \cdot 0.05}{10\pi^2}$$
$$Q = \frac{32\,\mu\text{C}}{\pi^2}$$

Conclusion: Using Faraday's law and considering all parameters, the total charge flowing through the coil during the current decrease is $32\,\mu$C.

Quick Tip

To solve solenoid problems, carefully compute the emf and charge using the coil's parameters and resistance.

Q13: Lower half of a convex lens is made opaque. Which of the following statement describes the image of the object placed in front of the lens?

(A) No change in image
(B) Image will show only half of the object
(C) Intensity of image gets reduced
Options:

1. (A) only
2. (B) only
3. (C) only
4. (B) and (C) only

Correct Answer: (3) (C) only
Solution: When the lower half of a convex lens is made opaque: - The lens still forms a complete image of the object because all parts of the object send rays through the available portion of the lens. - Blocking part of the lens reduces the number of light rays contributing to the image. This decreases the **intensity (brightness)** of the image. -

The image remains complete, and its size or visibility is unaffected. Hence, the idea that "only half the object will show" (Option C) is incorrect.
Conclusion: The correct effect is described by **(C)**: The intensity of the image gets reduced.

> Quick Tip
>
> Blocking part of a lens affects brightness but not the complete formation of the image.

Q14: Two slits are made $0.1\,\text{mm}$ apart, and the screen is placed $2\,\text{m}$ away. The fringe separation when a light of wavelength $500\,\text{nm}$ is used is:
Options:

1. $1\,\text{cm}$
2. $0.15\,\text{cm}$
3. $1.5\,\text{cm}$
4. $0.1\,\text{cm}$

Correct Answer: (1) $1\,\text{cm}$
Solution: The fringe separation formula is:

$$\Delta x = \frac{\lambda L}{d}$$

where: - $\lambda = 500\,\text{nm} = 500 \times 10^{-9}\,\text{m}$ (wavelength of light) - $L = 2\,\text{m}$ (distance to the screen) - $d = 0.1\,\text{mm} = 0.1 \times 10^{-3}\,\text{m}$ (distance between slits)
Substitute the values into the formula:

$$\Delta x = \frac{500 \times 10^{-9} \cdot 2}{0.1 \times 10^{-3}}$$

$$\Delta x = \frac{1000 \times 10^{-9}}{0.1 \times 10^{-3}} = 0.01\,\text{m} = 1\,\text{cm}$$

Final Conclusion: Fringe separation depends linearly on wavelength and distance to the screen.

> Quick Tip
>
> Use the fringe formula $\Delta x = \frac{\lambda L}{d}$ and ensure proper unit conversions.

Q15: For an astronomical telescope having an objective lens of focal length $10\,\text{m}$ and an eyepiece lens of focal length $10\,\text{cm}$, the tube length and magnification respectively are:
Options:

1. $20\,\text{cm}, 1$
2. $1000\,\text{cm}, 1$
3. $1010\,\text{cm}, 1$
4. $1010\,\text{cm}, 100$

Correct Answer: (4) $1010\,\text{cm}, 100$
Solution: The tube length is:

$$L = f_o + f_e = 10\,\text{m} + 0.1\,\text{m} = 1010\,\text{cm}$$

The magnification is:

$$M = \frac{f_o}{f_e} = \frac{10\,\text{m}}{0.1\,\text{m}} = 100$$

Final Conclusion: Tube length and magnification depend on the focal lengths of the objective and eyepiece.

Quick Tip

For telescopes, remember $L = f_o + f_e$ and $M = \frac{f_o}{f_e}$ for direct calculations.

Q16: According to Bohr's Model:

- (A) The radius of the orbiting electron is directly proportional to n.
- (B) The speed of the orbiting electron is directly proportional to $1/n$.
- (C) The magnitude of the total energy of the orbiting electron is directly proportional to $1/n^2$.
- (D) The radius of the orbiting electron is directly proportional to n^2.

Choose the correct answer:
Options:

1. (A), (B), and (C) only
2. (A), (B), and (D) only
3. (A), (B), (C), and (D)
4. (B), (C), and (D) only

Correct Answer: (4) (B), (C), and (D) only
Solution: - $r \propto n^2$: Radius depends on the square of n. - $v \propto \frac{1}{n}$: Speed decreases with higher n. - $E \propto \frac{1}{n^2}$: Energy magnitude follows n^{-2}.
Final Conclusion: Bohr's quantization links radius, speed, and energy levels to n.

Quick Tip

Memorize proportionality relations for Bohr's model for radius, speed, and energy.

Q17: For a full-wave rectifier, if the input frequency is $50\,\text{Hz}$, the output frequency will be:
Options:

1. $50\,\text{Hz}$
2. $100\,\text{Hz}$
3. $25\,\text{Hz}$
4. $0\,\text{Hz}$

Correct Answer: (2) $100\,\text{Hz}$
Solution: In a full-wave rectifier, both halves of the AC cycle are used. Thus, the output frequency is twice the input frequency:

$$f_{\text{output}} = 2f_{\text{input}} = 2 \times 50 = 100\,\text{Hz}$$

Final Conclusion: The output frequency of a full-wave rectifier is double the input frequency.

Quick Tip

Remember, full-wave rectifiers double the input frequency by rectifying both halves of the AC cycle.

Q18: For an electric dipole in a non-uniform electric field with dipole moment parallel to the direction of the field, the force F and torque τ on the dipole respectively are:
Options:

1. $F = 0$, $\tau = 0$
2. $F \neq 0$, $\tau = 0$
3. $F = 0$, $\tau \neq 0$
4. $F \neq 0$, $\tau \neq 0$

Correct Answer: (2) $F \neq 0$, $\tau = 0$

Solution: In a non-uniform field, the net force on the dipole is non-zero because the field strength varies at the two poles of the dipole. Torque is zero because the dipole is aligned with the field:

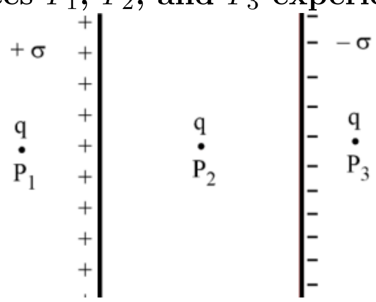
$$\tau = pE\sin\theta \quad \text{where}\, \theta = 0^\circ \implies \tau = 0$$

Final Conclusion: A non-uniform field exerts a net force on a dipole but no torque if aligned.

Quick Tip

In non-uniform fields, focus on field gradients for force and alignment for torque.

Q19: Two large plane parallel sheets with equal but opposite surface charge densities σ and $-\sigma$ have a point charge q placed at points P_1, P_2, and P_3. The forces F_1, F_2, and F_3 experienced by q are:



Options:

1. $F_1 = 0,\ F_2 = 0,\ F_3 = 0$
2. $F_1 = 0,\ F_2 \neq 0,\ F_3 = 0$
3. $F_1 \neq 0,\ F_2 \neq 0,\ F_3 \neq 0$
4. $F_1 = 0,\ F_3 \neq 0,\ F_2 = 0$

Correct Answer: (2) $F_1 = 0,\ F_2 \neq 0,\ F_3 = 0$
Solution: The electric field is zero outside the parallel plates (at P_1 and P_3) because the fields cancel. Inside the plates (at P_2), the electric field is uniform, and q experiences a force $F_2 \neq 0$.
Final Conclusion: Outside the plates, the field cancels. Inside, the field is uniform, causing a net force.

Quick Tip

Always check the symmetry of the system to determine where fields cancel or add up.

Q20: Two charged metallic spheres with radii R_1 and R_2 are brought into contact and then separated. The ratio of final charges Q_1 and Q_2 on the two spheres is:

Options:

1. $\frac{Q_1}{Q_2} = \frac{R_2}{R_1}$
2. $\frac{Q_1}{Q_2} < \frac{R_1}{R_2}$
3. $\frac{Q_1}{Q_2} > \frac{R_1}{R_2}$
4. $\frac{Q_1}{Q_2} = \frac{R_1}{R_2}$

Correct Answer: (4) $\frac{Q_1}{Q_2} = \frac{R_1}{R_2}$

Solution: When the spheres are brought into contact, charge redistributes in proportion to their capacitances. Capacitance of a sphere is proportional to its radius:

$$Q_1/Q_2 = R_1/R_2$$

Final Conclusion: The charge ratio depends on the radii of the spheres directly.

> Quick Tip
>
> In conducting spheres, charge distribution is proportional to the size (radius) of the spheres.

Q21: Two charged particles, placed at a distance d apart in vacuum, exert a force F on each other. Now, each of the charges is doubled. To keep the force unchanged, the distance between the charges should be changed to:

Options:

1. $4d$
2. $2d$
3. d
4. $d/2$

Correct Answer: (2) $2d$

Solution: Using Coulomb's Law:

$$F = k\frac{q_1 q_2}{r^2}$$

When both charges are doubled, $q_1' = 2q_1$ and $q_2' = 2q_2$, the force becomes:

$$F' = k\frac{(2q_1)(2q_2)}{r^2} = 4F$$

To maintain the same force, the distance must increase by a factor of 2, as $F \propto 1/r^2$. Hence, $r' = 2d$.

Final Conclusion: Doubling both charges requires doubling the distance to keep the force constant.

> Quick Tip
>
> Remember, the force is inversely proportional to the square of the distance. Any change in charge affects the force, and distance compensates accordingly.

Q22: Two parallel plate capacitors of capacitances $2\mu F$ and $3\mu F$ are joined in series and connected to a battery of V volts. The values of potential across the two capacitors V_1 and V_2, and energy stored U_1 and U_2 respectively are related as:
Options:

1. $\frac{V_1}{V_2} = \frac{U_1}{U_2} = \frac{3}{2}$
2. $\frac{V_1}{V_2} = \frac{U_1}{U_2} = \frac{2}{3}$
3. $\frac{V_1}{V_2} = \frac{3}{2}, \frac{U_1}{U_2} = \frac{2}{3}$
4. $\frac{V_1}{V_2} = \frac{2}{3}, \frac{U_1}{U_2} = \frac{3}{2}$

Correct Answer: (1) $\frac{V_1}{V_2} = \frac{U_1}{U_2} = \frac{3}{2}$
Solution:
Step 1: Series Connection Properties In a series combination: 1. The same charge Q flows through both capacitors. 2. The potential difference divides inversely proportional to capacitance:

$$V_1 = \frac{Q}{C_1}, \quad V_2 = \frac{Q}{C_2} \implies \frac{V_1}{V_2} = \frac{C_2}{C_1}.$$

Substitute $C_1 = 2\mu F$ and $C_2 = 3\mu F$:

$$\frac{V_1}{V_2} = \frac{C_2}{C_1} = \frac{3}{2}.$$

Step 2: Energy Stored in Capacitors The energy stored in a capacitor is:

$$U = \frac{1}{2}CV^2.$$

For capacitors in series, since Q is the same:

$$U_1 = \frac{Q^2}{2C_1}, \quad U_2 = \frac{Q^2}{2C_2}.$$

The ratio of energies is:

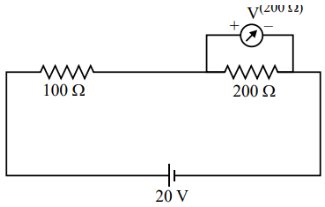
$$\frac{U_1}{U_2} = \frac{C_2}{C_1} = \frac{3}{2}.$$

Conclusion: Both the potential ratio $\frac{V_1}{V_2}$ and the energy ratio $\frac{U_1}{U_2}$ are $\frac{3}{2}$.

Quick Tip

For capacitors in series, voltages divide inversely proportional to capacitance, and energy follows the same ratio.

Q23: Two resistances of 100Ω and 200Ω are connected in series across a 20 V battery. The reading in a 200Ω voltmeter connected across the 200Ω resistance is:



Options:

1. $4\,V$
2. $\frac{20}{3}\,V$
3. $10\,V$
4. $16\,V$

Correct Answer: (3) $10\,\text{V}$
Solution:
1. Total Resistance in Series: The total resistance of the series circuit is:

$$R_{\text{total}} = 100 + 200 = 300\,\Omega.$$

2. Current Through the Circuit: Using Ohm's Law, the current in the circuit is:

$$I = \frac{\text{Total Voltage}}{\text{Total Resistance}} = \frac{20}{300} = \frac{1}{15}\,\text{A}.$$

3. Voltage Across the 200Ω Resistor: The voltage across the 200Ω resistor is:

$$V = I \cdot R = \frac{1}{15} \times 200 = \frac{200}{15} = 10\,\text{V}.$$

4. Voltmeter Reading: Since the voltmeter is connected across the 200Ω resistor, its reading is equal to the voltage drop across this resistor, which is $10\,\text{V}$.
Conclusion: The voltmeter reading across the 200Ω resistor is $10\,\text{V}$.

Quick Tip

In series circuits, the voltage across a resistor is proportional to its resistance. Use Ohm's Law to calculate voltage drops.

Q24: The current through a $4/3\Omega$ external resistance connected to a parallel combination of two cells of $2\,V$ and $1\,V$ emf and internal resistances of 1Ω and 2Ω respectively is:
Options:

1. $1\,A$
2. $\frac{2}{3}\,A$
3. $\frac{3}{4}\,A$
4. $\frac{5}{6}\,A$

Correct Answer: (4) $\frac{5}{6}\,A$
Solution: The equivalent emf of the parallel combination of the cells is:

$$E_{\text{eq}} = \frac{E_1 r_2 + E_2 r_1}{r_1 + r_2} = \frac{2 \cdot 2 + 1 \cdot 1}{1 + 2} = \frac{5}{3}\,V$$

The equivalent resistance of the parallel cells is:

$$r_{\text{eq}} = \frac{r_1 r_2}{r_1 + r_2} = \frac{1 \cdot 2}{1 + 2} = \frac{2}{3}\,\Omega$$

Total resistance is $R = r_{\text{eq}} + 4/3 = 2\,\Omega$. Current is:

$$I = \frac{E_{\text{eq}}}{R} = \frac{5/3}{2} = \frac{5}{6}\,A$$

Final Conclusion: Use equivalent emf and resistance for combined cells to calculate current.

Quick Tip
For cells in parallel, calculate equivalent emf and internal resistance first.

Q25: A metallic wire of uniform cross-sectional area has a resistance R, resistivity ρ, and power rating P at V volts. The wire is uniformly stretched to reduce the radius to half the original radius. The values of resistance, resistivity, and power rating are now denoted as R', ρ', and P'. The corresponding relations are:
Options:

1. $\rho' = 2\rho, R' = 2R, P' = 2P$
2. $\rho' = \frac{\rho}{2}, R' = \frac{R}{2}, P' = \frac{P}{2}$
3. $\rho' = \rho, R' = 16R, P' = \frac{P}{16}$
4. $\rho' = \rho, R' = \frac{R}{16}, P' = 16P$

Correct Answer: (3) $\rho' = \rho, R' = 16R, P' = \frac{P}{16}$
Solution: Stretching the wire reduces its radius to half, increasing its length to four times. Resistance is:

$$R' = \rho\frac{L'}{A'} = \rho\frac{4L}{\pi(r/2)^2} = 16R$$

Resistivity does not change, and power rating at constant voltage becomes:

$$P' = \frac{V^2}{R'} = \frac{P}{16}$$

Final Conclusion: Stretching affects geometry and resistance but not resistivity.

> Quick Tip
>
> Changes in wire dimensions impact resistance proportionally; resistivity remains material-specific.

Q26: Three magnetic materials are listed: (A) Paramagnetics, (B) Diamagnetics, and (C) Ferromagnetics. Choose the correct order of the materials in increasing magnetic susceptibility:
Options:

1. (A), (B), (C)
2. (C), (A), (B)
3. (B), (A), (C)
4. (B), (C), (A)

Correct Answer: (3) (B), (A), (C)
Solution: Diamagnetic materials have the lowest susceptibility, followed by paramagnetic, and ferromagnetic with the highest.
Final Conclusion: Susceptibility increases from diamagnetic to ferromagnetic.

> Quick Tip
>
> Magnetic susceptibility depends on the alignment of atomic dipoles in the material.

Q27: Two infinitely long straight parallel conductors carrying currents I_1 and I_2 are held at a distance d apart in vacuum. The force F on a length L of one of the conductors due to the other is:
Options:

1. Proportional to L but independent of $I_1 \times I_2$

2. Proportional to $I_1 \times I_2$ but independent of length L
3. Proportional to $I_1 \times I_2 \times L$
4. Proportional to $L/I_1 \times I_2$

Correct Answer: (3) Proportional to $I_1 \times I_2 \times L$
Solution: The force per unit length between two parallel current-carrying conductors is given by:

$$F/L = \frac{\mu_0}{2\pi}\frac{I_1 I_2}{d}$$

For a length L, the force is:

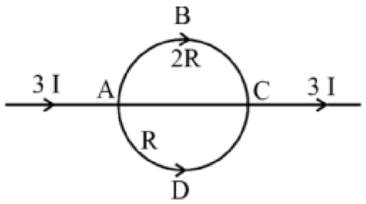
$$F = \frac{\mu_0}{2\pi}\frac{I_1 I_2 L}{d}$$

Thus, the force is directly proportional to I_1, I_2, and L.
Final Conclusion: The force between parallel conductors depends on their current product and length.

Quick Tip

Memorize the formula for force per unit length for parallel currents. Always check dependence on distance d.

Q28: In the circuit shown below, a current $3I$ enters at A. The semicircular parts ABC and ADC have equal radii r but resistances $2R$ and R, respectively. The magnetic field at the center of the circular loop $ABCD$ is:



Options:

1. $\frac{\mu_0 I}{4r}$ out of the plane
2. $\frac{\mu_0 I}{4r}$ into the plane
3. $\frac{\mu_0 3I}{4r}$ out of the plane
4. $\frac{\mu_0 3I}{4r}$ into the plane

Correct Answer: (1) $\frac{\mu_0 I}{4r}$ out of the plane
Solution:
1. Current Distribution: The current splits inversely proportional to the resistances of the two paths:

$$I_{\text{ABC}} = \frac{R}{3R} \cdot 3I = I, \quad I_{\text{ADC}} = \frac{2R}{3R} \cdot 3I = 2I.$$

2. Magnetic Field Contribution: For a semicircular current-carrying wire, the magnetic field at the center is:

$$B = \frac{\mu_0 I}{4r}.$$

- The semicircle ABC contributes a field $B_{\text{ABC}} = \frac{\mu_0 I_{\text{ABC}}}{4r} = \frac{\mu_0 I}{4r}$. - The semicircle ADC contributes a field $B_{\text{ADC}} = \frac{\mu_0 I_{\text{ADC}}}{4r} = \frac{\mu_0 (2I)}{4r} = \frac{\mu_0 I}{2r}$.
3. Net Magnetic Field: The magnetic fields due to both semicircles add vectorially. Since the current flows in opposite directions in the two semicircles, their contributions add up in the same direction at the center:

$$B_{\text{net}} = B_{\text{ABC}} + B_{\text{ADC}} = \frac{\mu_0 I}{4r} + \frac{\mu_0 I}{2r} = \frac{\mu_0 I}{4r}(1+2) = \frac{\mu_0 I}{4r} \cdot 3 = \frac{\mu_0 3I}{4r}.$$

4. Direction: Using the right-hand rule for both semicircles, the net magnetic field is out of the plane.
Conclusion: The magnetic field at the center of the loop is $\frac{\mu_0 I}{4r}$ out of the plane.

Quick Tip

For semicircular loops, calculate the magnetic field contribution for each section and apply the right-hand rule for direction.

Q29: A square loop with each side 1 cm, carrying a current of 10 A, is placed in a magnetic field of 0.2 T. The direction of the magnetic field is parallel to the plane of the loop. The torque experienced by the loop is:
Options:

1. Zero
2. 2×10^{-4} Nm
3. 2×10^{-2} Nm
4. 2 Nm

Correct Answer: (2) $2 \times 10^{-4}\,\text{Nm}$
Solution:
The torque experienced by a current loop in a magnetic field is given by:

$$\tau = NIAB\sin\theta,$$

where: - $N = 1$ (number of turns), - $I = 10\,\text{A}$ (current in the loop), - $A = l^2 = (0.01)^2 = 10^{-4}\,\text{m}^2$ (area of the square loop), - $B = 0.2\,\text{T}$ (magnetic field), - $\theta = 90^\circ$ (angle between the field and the normal to the plane of the loop; since the field is parallel to the plane, the normal to the loop makes 90° with the field).
Substitute the values:

$$\tau = 1 \cdot 10 \cdot 10^{-4} \cdot 0.2 \cdot \sin 90^\circ.$$

$$\tau = 2 \times 10^{-4}\,\text{Nm}.$$

Conclusion: The torque experienced by the square loop in the given configuration is $2 \times 10^{-4}\,\text{Nm}$.

> 💡 Quick Tip
>
> Torque on a current loop is maximized when the magnetic field is perpendicular to the plane and zero when parallel to the loop's normal.

Q30: In an AC circuit, the current leads the voltage by $\pi/2$. The circuit is:
Options:

1. Purely resistive
2. Circuit elements with resistance equal to reactance
3. Purely inductive
4. Purely capacitive

Correct Answer: (4) Purely capacitive
Solution: In a purely capacitive circuit, current leads the voltage by $90°$ or $\pi/2$. This is a characteristic phase difference.
Final Conclusion: Phase difference of $\pi/2$ indicates purely capacitive behavior.

> 💡 Quick Tip
>
> For inductors, current lags voltage; for capacitors, current leads voltage.

Q31: In a pair of adjacent coils, for a change of current in one coil from $0\,A$ to $10\,A$ in $0.25\,s$, the magnetic flux in the adjacent coil changes by $15\,Wb$. The mutual inductance of the coils is:
Options:

1. $120\,H$
2. $12\,H$
3. $1.5\,H$
4. $0.75\,H$

Correct Answer: (3) $1.5\,H$
Solution: Mutual inductance is given by:

$$M = \frac{\Delta\Phi}{\Delta I}$$

Here, $\Delta\Phi = 15\,Wb$, $\Delta I = 10\,A$, so:

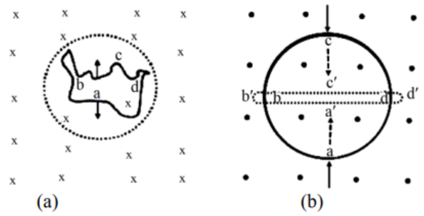
$$M = \frac{15}{10} = 1.5\,H$$

Final Conclusion: Mutual inductance relates flux change to current change.

Quick Tip

Mutual inductance depends on flux linkage and current change. Always check units.

Q32: A wire of irregular shape (figure a) and a circular loop of wire (figure b) are placed in different uniform magnetic fields. In figure (a), the magnetic field is perpendicular into the plane. In figure (b), the magnetic field is perpendicular out of the plane. The wire in figure (a) is turning into a circular loop, and that in figure (b) into a narrow straight wire. The direction of induced current will be:



Options:

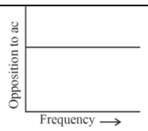
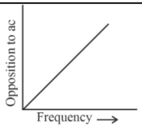
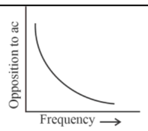
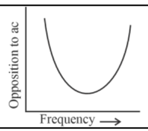
1. Clockwise in both (a) and (b)
2. Anticlockwise in both (a) and (b)
3. Clockwise in (a) and anticlockwise in (b)
4. Anticlockwise in (a) and clockwise in (b)

Correct Answer: (2) Anticlockwise in both (a) and (b)
Solution:
Figure (a): - The wire transforms into a circular loop, increasing the area. - The magnetic field is into the plane. - As the area increases, the magnetic flux through the loop also increases. - To oppose this increase, the induced current flows in an anticlockwise direction, generating a magnetic field out of the plane.
Figure (b): - The wire transforms into a narrow straight shape, reducing the area. - The magnetic field is out of the plane. - As the area decreases, the magnetic flux through the loop decreases. - To oppose this decrease, the induced current flows in an anticlockwise direction, generating a magnetic field out of the plane.
Conclusion: Using Lenz's Law, the induced current flows anticlockwise in both (a) and (b) to oppose the respective changes in flux.

💡 Quick Tip

Apply Lenz's Law systematically to analyze changes in flux and the direction of induced current.

Q33: Match List-I with List-II:

List-I		List-II	
(A)		(I)	Impedance
(B)		(II)	Capacitive reactance
(C)		(III)	Inductive reactance
(D)		(IV)	Resistance

Options:

1. (A) - (I), (B) - (II), (C) - (III), (D) - (IV)
2. (A) - (IV), (B) - (III), (C) - (II), (D) - (I)
3. (A) - (I), (B) - (II), (C) - (IV), (D) - (III)
4. (A) - (III), (B) - (IV), (C) - (I), (D) - (II)

Correct Answer: (2) (A) - (IV), (B) - (II), (C) - (III), (D) - (I)
Solution: - Impedance depends on both reactance and resistance. - Capacitive reactance decreases with frequency ($X_C = \frac{1}{\omega C}$). - Inductive reactance increases with frequency ($X_L = \omega L$). - Resistance is frequency independent.
Final Conclusion: Match physical properties with their dependence on frequency.

💡 Quick Tip

For circuits, remember the frequency dependencies of reactance for capacitors and inductors.

Q34: In an electromagnetic wave, the ratio of energy densities of electric and magnetic fields is:
Options:

1. 1 : 1
2. 1 : c
3. c : 1
4. 1 : c^2

Correct Answer: (1) 1 : 1
Solution: The energy density of an electromagnetic wave is equal for the electric and magnetic fields:

$$u_E = \frac{1}{2}\epsilon_0 E^2 \quad \text{and} \quad u_B = \frac{1}{2}\frac{B^2}{\mu_0}$$

Since $E = cB$, both u_E and u_B are equal.
Final Conclusion: Electric and magnetic fields in an electromagnetic wave carry equal energy densities.

Quick Tip

In electromagnetic waves, energy is shared equally between the electric and magnetic fields.

Q35: Of the following, the correct arrangement of electromagnetic spectrum in decreasing order of wavelength is:
Options:

1. Radio waves, X-rays, Infrared waves, Microwaves, Visible waves
2. Infrared waves, Microwaves, Radio waves, X-rays, Visible waves
3. Radio waves, Microwaves, Infrared waves, Visible waves, X-rays
4. X-rays, Visible waves, Infrared waves, Microwaves, Radio waves

Correct Answer: (3) Radio waves, Microwaves, Infrared waves, Visible waves, X-rays
Solution: The correct order of electromagnetic waves in decreasing wavelength is:

Radio waves ¿ Microwaves ¿ Infrared ¿ Visible ¿ X-rays

Final Conclusion: Electromagnetic spectrum is ordered by wavelength from radio to gamma rays.

Quick Tip

Remember: Longer wavelength corresponds to lower frequency and energy.

Q36: Match the electromagnetic waves in Column I with their production methods in Column II:

Column-I Electromagnetic waves	Column-II Production method/device
(A) Microwaves	(I) LC oscillator
(B) Infrared	(II) Magnetron
(C) X-rays	(III) Vibration of atoms/molecules
(D) Radio waves	(IV) Bombarding large atomic number metal target with fast moving electrons

Options:

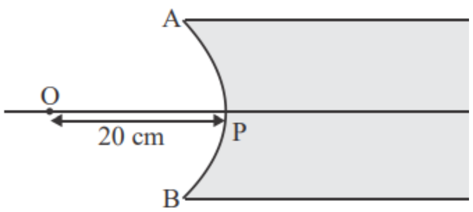
1. (A) - (I), (B) - (II), (C) - (III), (D) - (IV)
2. (A) - (II), (B) - (III), (C) - (IV), (D) - (I)
3. (A) - (II), (B) - (I), (C) - (IV), (D) - (III)
4. (A) - (III), (B) - (IV), (C) - (I), (D) - (II)

Correct Answer: (2) (A) - (II), (B) - (III), (C) - (IV), (D) - (I)
Solution: - Microwaves are produced by magnetrons. - Infrared waves arise from vibrations of atoms/molecules. - X-rays are generated by bombarding heavy nuclei with electrons. - Radio waves are created by LC oscillators.
Final Conclusion: Match each electromagnetic wave with its production method accurately.

Quick Tip

Understand the specific production methods for different electromagnetic waves.

Q37: In the figure given below, APB is a curved surface of radius of curvature $10\,\text{cm}$ separating air and a transparent material ($\mu = \frac{4}{3}$). A point object O is placed in air on the principal axis of the surface $20\,\text{cm}$ from P. The distance of the image of O from P will be:



Options:

1. $16\,\text{cm}$ left of P in air
2. $16\,\text{cm}$ right of P in water
3. $20\,\text{cm}$ right of P in water

4. $20\,\text{cm}$ left of P in air

Correct Answer: (1) $16\,\text{cm}$ left of P in air
Solution: Using the refraction formula for curved surfaces:

$$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$$

Substitute:

$$\frac{\frac{4}{3}}{v} - \frac{1}{-20} = \frac{\frac{4}{3} - 1}{10}$$

Simplify to get $v = -16\,\text{cm}$, meaning the image is $16\,\text{cm}$ to the left of P in air.
Final Conclusion: The position of the image is determined by the refraction formula for spherical surfaces.

> Quick Tip
>
> Sign conventions in optics are crucial. Remember to assign positive or negative signs based on direction.

Q38: For fixed values of radii of curvature of a lens, the power of the lens will be:
Options:

1. $P \propto (\mu - 1)$
2. $P \propto \mu^2$
3. $P \propto \frac{1}{\mu}$
4. $P \propto (\mu^{-2})$

Correct Answer: (1) $P \propto (\mu - 1)$
Solution: Lens power is given by:

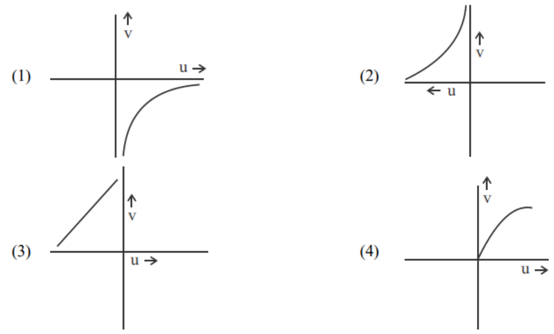
$$P = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

For fixed radii, power is directly proportional to $(\mu - 1)$.
Final Conclusion: Lens power depends on refractive index and curvature.

> Quick Tip
>
> For lenses, changes in refractive index significantly affect the focal length and power.

Q39: The graph correctly representing the variation of image distance v for a convex lens of focal length f versus object distance u is:

Options:



Correct Answer: (2) **(Graph B):** Curve asymptotic to both axes
Solution: The lens equation is:

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

This gives a hyperbolic relation between v and u, with asymptotes along the axes.
Final Conclusion: A convex lens produces a hyperbolic relation between v and u.

> **Quick Tip**
>
> Analyze lens behavior by rearranging the lens equation and plotting for various u values.

Q40: Using light from a monochromatic source to study diffraction in a single slit of width $0.1\,\text{mm}$, the linear width of the central maximum is measured to be $5\,\text{mm}$ on a screen held $50\,\text{cm}$ away. The wavelength of light used is:
Options:

1. $2.5 \times 10^{-7}\,\text{m}$
2. $4 \times 10^{-7}\,\text{m}$
3. $5 \times 10^{-7}\,\text{m}$
4. $7.5 \times 10^{-7}\,\text{m}$

Correct Answer: (3) $5 \times 10^{-7}\,\text{m}$
Solution: The linear width of the central maximum is:

$$\Delta x = \frac{2\lambda L}{a}$$

Substitute $\Delta x = 5\,\text{mm}$, $L = 50\,\text{cm}$, and $a = 0.1\,\text{mm}$:

$$\lambda = \frac{\Delta x \cdot a}{2L} = \frac{5 \times 10^{-3} \cdot 0.1 \times 10^{-3}}{2 \cdot 0.5} = 5 \times 10^{-7}\,\text{m}$$

Final Conclusion: The central maximum width helps determine wavelength in single-slit diffraction.

Quick Tip

Diffraction patterns depend on slit width, screen distance, and wavelength. Understand the linear width relation.

Q41: Radiation of frequency $2v_0$ is incident on a metal with threshold frequency v_0. The correct statement is:
Options:

1. No photoelectrons will be emitted
2. All photoelectrons emitted will have kinetic energy equal to hv_0
3. Maximum kinetic energy of photoelectrons emitted can be hv_0
4. Maximum kinetic energy of photoelectrons emitted will be $2hv_0$

Correct Answer: (3) Maximum kinetic energy of photoelectrons emitted can be hv_0
Solution: The photoelectric equation is:

$$K_{\text{max}} = hf - hf_0$$

Here, $f = 2f_0$, so:

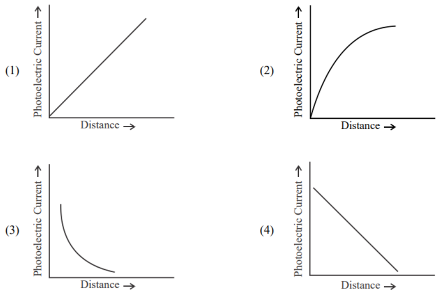
$$K_{\text{max}} = h(2f_0 - f_0) = hf_0$$

Final Conclusion: Kinetic energy depends on the difference between incident and threshold frequencies.

Quick Tip

The photoelectric effect requires $f > f_0$, with excess energy converted into kinetic energy.

Q42: A point source causing photoelectric emission from a metallic plate is moved away from the plate. The variation of photoelectric current with distance from the source is correctly represented by the graph:



Options:

1. A straight line decreasing with distance
2. A curve decreasing non-linearly with distance
3. A horizontal line (constant current)
4. A curve increasing with distance

Correct Answer: (3) A horizontal line (constant current)
Solution:
The photoelectric current depends on the intensity of light reaching the plate, which follows the inverse square law:

$$I \propto \frac{1}{d^2},$$

where d is the distance of the source from the plate. However: - For distances where the light intensity is sufficient to cause photoemission, all emitted electrons are collected if the plate is maintained at a constant potential. - This leads to a saturation current that is independent of the distance, as long as the light intensity remains above the threshold to trigger photoemission.
Thus, the photoelectric current remains constant regardless of the distance, resulting in a horizontal line on the graph.
Conclusion: Photoelectric current reaches saturation and does not change with increasing distance if the plate's potential is adjusted to collect all emitted electrons.

> Quick Tip
>
> Photoelectric current saturates at higher intensities and remains constant as long as the intensity is above the emission threshold.

Q43: A proton accelerated through a potential difference V has a de Broglie wavelength λ. On doubling the accelerating potential, the de Broglie wavelength of the proton:
Options:

1. Remains unchanged
2. Becomes double
3. Becomes four times
4. Decreases

Correct Answer: (4) Decreases
Solution: The de Broglie wavelength is given by:

$$\lambda = \frac{h}{\sqrt{2meV}}$$

Doubling the potential V reduces λ by a factor of $\sqrt{2}$. Hence, λ decreases as V increases.

Final Conclusion: The de Broglie wavelength is inversely proportional to the square root of the accelerating potential.

Quick Tip

Increasing the kinetic energy of a particle shortens its de Broglie wavelength. For charged particles, use the relation $\lambda \propto \frac{1}{\sqrt{V}}$.

Q44: The kinetic energy of an electron in the ground level of a hydrogen atom is K units. The values of its potential energy and total energy respectively are:

Options:

1. $-2K; -K$
2. $+2K; -K$
3. $-K; +2K$
4. $+K; +2K$

Correct Answer: (1) $-2K; -K$

Solution: In the Bohr model, the total energy $E = -K$ and potential energy $U = 2E = -2K$. The kinetic energy is $K = -E$.

Final Conclusion: For electrons in the Bohr model, the total energy is negative, with potential energy twice as negative as the kinetic energy.

Quick Tip

In bound systems like atoms, kinetic energy is positive, potential energy is negative, and their sum (total energy) is negative.

Q45: Two nuclei have mass numbers A and B respectively. The density ratio of the nuclei is:

Options:

1. $A : B$
2. $\sqrt{A} : \sqrt{B}$
3. $A^2 : B^2$
4. $1 : 1$

Correct Answer: (4) $1 : 1$

Solution: The density of nuclei is constant and does not depend on their mass number, as the volume is proportional to $A^{1/3}$ and mass is proportional to A. Thus, the ratio is 1 : 1.
Final Conclusion: Nuclear density is independent of mass number and remains constant for all nuclei.

> Quick Tip
>
> Nuclear density is constant due to the uniform distribution of nucleons inside the nucleus.

Q46: The shortest wavelengths emitted in the hydrogen spectrum corresponding to different spectral series are as under:

- (A) Pfund series
- (B) Balmer series
- (C) Brackett series
- (D) Lyman series

The wavelengths arranged correctly in decreasing order are:
Options:

1. (A), (B), (C), (D)
2. (A), (C), (B), (D)
3. (B), (A), (D), (C)
4. (A), (C), (D), (B)

Correct Answer: (2) (A), (C), (B), (D)
Solution: The shortest wavelength corresponds to the transition to the lowest energy level in each series. Pfund, Brackett, Balmer, and Lyman series correspond to $n = 5, 4, 2, 1$, respectively, in decreasing order of wavelength.
Final Conclusion: Wavelength decreases as the final energy level (n_f) decreases.

> Quick Tip
>
> Remember the spectral series order and the fact that wavelength decreases as energy increases.

Q47: Silicon can be doped using one of the following elements as dopant:

- (A) Arsenic

- (B) Indium
- (C) Phosphorus
- (D) Boron

To get an n-type semiconductor, the dopants that can be used are:
Options:

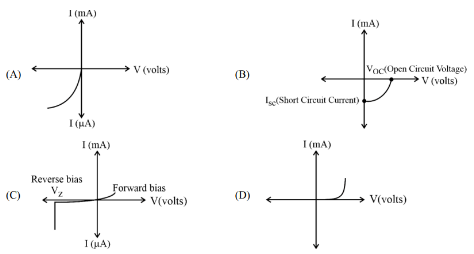
1. (A) and (C) only
2. (B) and (C) only
3. (A), (B), (C), and (D)
4. (C) and (D) only

Correct Answer: (1) (A) and (C) only
Solution: n-type semiconductors are formed by doping silicon with elements that have one more valence electron than silicon (group 15 elements). Arsenic (A) and Phosphorus (C) belong to group 15 and are suitable dopants.
Final Conclusion: To form n-type semiconductors, use dopants from group 15 with one extra electron.

Quick Tip

Group 15 elements add extra electrons, making them ideal for creating n-type semiconductors.

Q48: Given below are V versus I graphs for different types of p-n junction diodes marked (A), (B), (C), and (D):



The correct sequence of graphs corresponding to forward biased p-n junction, Zener diode, Photodiode, and Solar cell in order is:
Options:

1. (D), (C), (A), (B)
2. (A), (C), (B), (D)
3. (B), (A), (D), (C)

4. (C), (B), (D), (A)

textbfCorrect Answer: (1) (D), (C), (A), (B)
Solution:
Step 1: Analyze the graphs for each diode type 1. Solar cell (D): Produces current under illumination and shows current generation with almost no external voltage applied. 2. Zener diode (C): Operates in reverse bias, showing breakdown behavior at a specific voltage. 3. Forward-biased p-n junction (A): Exhibits an exponential increase in current as voltage increases in the forward direction. 4. Photodiode (B): Operates in reverse bias with a current proportional to light intensity.
Step 2: Map the sequence - (D): Solar cell - (C): Zener diode - (A): Forward biased p-n junction - (B): Photodiode
Thus, the correct sequence is:

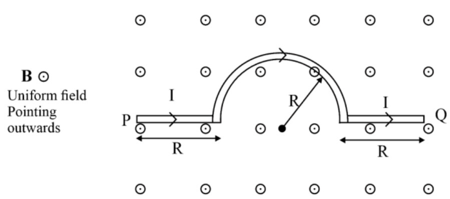
$$(D), (C), (A), (B)$$

Conclusion: Each diode's V-I characteristic corresponds to its operational mode, making the correct sequence (D), (C), (A), (B).
Correct Answer: (1) $(D), (C), (A), (B)$

Quick Tip

Match V-I characteristics with the diode type based on their typical operation in forward or reverse bias.

Q49: A wire carrying current I, bent as shown in the figure, is placed in a uniform field B that emerges normally out of the plane of the figure. The force on this wire is:



Options:

1. $4BIR$, directed vertically downward
2. $3BIR$, directed vertically upward
3. $BI(2R + \pi R)$, vertically downward
4. $2\pi BIR$, from P to Q

Correct Answer: (1) $4BIR$, directed vertically downward
Solution:

The force on a current-carrying wire in a uniform magnetic field is given by:

$$\vec{F} = I\vec{L} \times \vec{B},$$

where: - I is the current, - $\vec{L}$ is the length vector of the wire, - $\vec{B}$ is the magnetic field.
Step 1: Analyze Each Segment of the Wire 1. Straight Segment: The force on a straight segment is calculated using $F = ILB\sin\theta$, where $\theta = 90^\circ$ (since the magnetic field is perpendicular to the plane).
2. Semicircular Segment: The magnetic force on the curved segment is equivalent to the force on its chord (net straight-line length), which is $2R$.
Step 2: Combine Forces The forces from the straight segments and the curved segment contribute to a net downward force. Summing these contributions gives:

$$F_{\text{net}} = 4BIR.$$

Conclusion: The net force acting on the wire is $4BIR$, directed vertically downward.

Quick Tip

For current-carrying wires in magnetic fields, calculate the net force by analyzing each segment individually and summing vector contributions.

Q50: The refractive index of the material of an equilateral prism is $\sqrt{2}$. The angle of minimum deviation of that prism is:
Options:

1. 60°
2. 75°
3. 30°
4. 90°

Correct Answer: (3) 30°
Solution:
For an equilateral prism ($A = 60^\circ$), the refractive index μ is related to the angle of minimum deviation (δ_m) using the formula:

$$\mu = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}.$$

Substitute $\mu = \sqrt{2}$ and $A = 60^\circ$:

$$\sqrt{2} = \frac{\sin\left(\frac{60^\circ+\delta_m}{2}\right)}{\sin\left(\frac{60^\circ}{2}\right)}.$$

Simplify:

$$\sin\left(\frac{60^\circ + \delta_m}{2}\right) = \sqrt{2} \cdot \sin(30^\circ) = \sqrt{2} \cdot \frac{1}{2} = \frac{\sqrt{2}}{2}.$$

This gives:

$$\frac{60^\circ + \delta_m}{2} = 45^\circ \implies 60^\circ + \delta_m = 90^\circ.$$

Solve for δ_m:

$$\delta_m = 30^\circ.$$

Conclusion: The angle of minimum deviation is $\delta_m = 30^\circ$, which depends on the prism's geometry and refractive index.

Quick Tip

For prisms, use the relationship between refractive index, minimum deviation, and prism angle to determine δ_m.
