Bihar Board Class 10th Physics- 117 -Set D - 2025 Question Paper with Solutions

Time Allowed :3 Hour 15 Mins	Maximum Marks :70	Total Questions :96

General Instructions

Read the following instructions very carefully and strictly follow them:

1. Candidate must enter his/her Question Booklet Serial No. (10 digits) in the OMR Answer Sheet.
2. Candidates are required to give their answers in their own words as far as practicable.
3. Figures in the right-hand margin indicate full marks.
4. 15 minutes of extra time have been allotted for the candidates to read the questions carefully.
5. This question booklet is divided into two sections – Section-A and Section-B.
6. In Section-A, there are 70 objective type questions, out of which any 35 questions are to be answered. If more than 35 questions are answered, then only the first 35 will be evaluated. Each question carries 1 mark. For answering these, darken the circle with a blue or black ball pen against the correct option on the OMR Answer Sheet provided to you. Do not use whitener, liquid, blade, nail, etc. on the OMR Answer Sheet; otherwise, the result will be treated as invalid.
7. In Section-B, there are 20 short answer type questions, each carrying 2 marks, out of which any 10 questions are to be answered. Apart from these, there are 6 long answer type questions, each carrying 5 marks, out of which any 3 questions are to be answered.
8. Use of any electronic appliances is strictly prohibited.

Section-A

1. Two equal positive point charges of 1 μC charge are kept at a distance of 1 metre in air. The electric potential energy of the system will be

(1) 1 joule
(2) 1 eV
(3) 9×10^{-3} joule
(4) zero

Correct Answer: (3) 9×10^{-3} joule

Solution:

The formula for the electric potential energy between two point charges is:

$$U = \frac{kq_1q_2}{r}$$

where: k = Coulomb's constant $= 9 \times 10^9$ Nm^2/C^2, $q_1 = q_2 = 1\ \mu C = 1 \times 10^{-6}$ C, $r = 1$ metre. Substituting the values:

$$U = \frac{(9 \times 10^9) \times (1 \times 10^{-6}) \times (1 \times 10^{-6})}{1} = 9 \times 10^{-3} \text{ joule.}$$

Final Answer:

$$\boxed{9 \times 10^{-3} \text{ joule}}.$$

> **Quick Tip**
>
> The electric potential energy between two point charges is given by the formula $U = \frac{kq_1q_2}{r}$. The units of electric potential energy are joules.

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2. Which one of the following is unit of capacity?

(1) coulomb
(2) ampere
(3) volt
(4) coulomb/volt

Correct Answer: (4) coulomb/volt

Solution:

The unit of capacitance (capacity) is defined as the amount of charge stored per unit potential difference. Hence:

$$C = \frac{Q}{V}$$

where C is the capacitance, Q is the charge, and V is the potential difference. Therefore, the unit of capacitance is:

$$\boxed{\text{coulomb/volt}}.$$

Final Answer:

$$\boxed{\text{coulomb/volt}}.$$

> **Quick Tip**
>
> The unit of capacitance is coulomb per volt, commonly referred to as the farad (F).

3. The capacity of any condenser does not depend upon

(1) shape of plates
(2) size of plates
(3) charge on plates
(4) distance between plates

Correct Answer: (3) charge on plates

Solution:

The capacitance C of a parallel plate condenser is given by:

$$C = \frac{\varepsilon_0 A}{d}$$

where: - ε_0 is the permittivity of free space, - A is the area of each plate, - d is the distance between the plates.
From this equation, we can see that capacitance depends on the area of the plates A, the distance between the plates d, and the material (or medium) between them, but it does not depend on the charge on the plates.

Final Answer:

$$\boxed{\text{charge on plates}}.$$

Quick Tip

The capacitance of a condenser depends on the area of the plates, the distance between them, and the material between them, not on the charge stored on the plates.

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4. The electric field on the outer surface of a charged conductor is

(1) parallel to the surface
(2) perpendicular to the surface
(3) at 45° angle to the surface
(4) zero

Correct Answer: (2) perpendicular to the surface

Solution:

In electrostatics, the electric field on the outer surface of a charged conductor is always perpendicular to the surface. This is because charges on a conductor move to the surface and arrange

themselves such that the electric field is directed normal (perpendicular) to the surface at every point.
If there were any component of the electric field parallel to the surface, it would cause charges to move along the surface, which is not the case in electrostatics.

Final Answer:

$$\boxed{\text{perpendicular to the surface}}.$$

> **Quick Tip**
>
> The electric field on the surface of a conductor is always perpendicular to the surface due to electrostatic equilibrium.

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5. If a conductor is placed in an external electric field, the field inside the conductor will be

(1) zero
(2) equal to the external field
(3) twice the external field
(4) half the external field

Correct Answer: (1) zero

Solution:

When a conductor is placed in an external electric field, free charges inside the conductor move in response to the field. This redistribution of charge creates an internal electric field that exactly cancels out the external electric field inside the conductor. As a result, the net electric field inside the conductor is zero.
This phenomenon occurs because in electrostatic equilibrium, the electric field within a conductor is always zero. This is a fundamental property of conductors in electrostatics.

Final Answer:

$$\boxed{0}.$$

> **Quick Tip**
>
> In electrostatics, the electric field inside a conductor is always zero, even when the conductor is placed in an external electric field.

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6. Which of the following statements is true for two point charges of opposite sign?

(1) The potential energy is always negative
(2) The potential energy is always positive

(3) The potential energy can be either positive or negative
(4) The potential energy is zero

Correct Answer: (1) The potential energy is always negative

Solution:

For two point charges of opposite sign, the electric potential energy U is given by the formula:

$$U = \frac{kq_1q_2}{r}$$

where k is Coulomb's constant, q_1 and q_2 are the magnitudes of the charges, and r is the distance between them.
Since the charges are of opposite sign, q_1 and q_2 will have opposite signs, and hence their product q_1q_2 will be negative. Therefore, the potential energy U will always be negative.

Final Answer:

$$\boxed{\text{The potential energy is always negative.}}$$

Quick Tip

For opposite charges, the potential energy is always negative because the charges attract each other.

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7. Gauss's law states that the electric flux through a closed surface is

(1) proportional to the charge enclosed
(2) inversely proportional to the charge enclosed
(3) zero
(4) proportional to the square of the charge enclosed

Correct Answer: (1) proportional to the charge enclosed

Solution:

Gauss's law states that the electric flux Φ_E through a closed surface is directly proportional to the charge Q_{enc} enclosed within the surface. Mathematically:

$$\Phi_E = \frac{Q_{\text{enc}}}{\varepsilon_0}$$

where ε_0 is the permittivity of free space. Thus, the electric flux through the surface is proportional to the total charge enclosed inside the surface.

Final Answer:

$$\boxed{\text{proportional to the charge enclosed}}.$$

Quick Tip

Gauss's law relates the electric flux through a closed surface to the charge enclosed within that surface.

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8. Kilowatt-hour (kWh) is the unit of

(1) energy
(2) power
(3) torque
(4) force

Correct Answer: (1) energy

Solution:

Kilowatt-hour (kWh) is a unit of energy. It is the amount of energy consumed when 1 kilowatt of power is used for 1 hour. The formula to calculate energy in kWh is:

$$\text{Energy} = \text{Power} \times \text{Time}$$

where power is in kilowatts and time is in hours. Hence, kWh is a unit of energy, not power, torque, or force.

Final Answer:

$$\boxed{\text{energy}}.$$

Quick Tip

1 kilowatt-hour is the energy consumed when 1 kilowatt of power is used for 1 hour.

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9. Which of the following laws is based on the principle of energy conservation?

(1) Ampere's law
(2) Faraday's law of electrolysis
(3) Lenz's law
(4) None of these

Correct Answer: (3) Lenz's law

Solution:

Lenz's law states that the direction of the induced current in a closed loop is such that it opposes the change in the magnetic flux that produced it. This is based on the principle of conservation of energy. If the induced current did not oppose the change in flux, it would result in a violation of energy conservation.

Final Answer:

$$\boxed{\text{Lenz's law}}.$$

Quick Tip

Lenz's law is based on the principle of conservation of energy, ensuring that the induced current opposes the change in flux.

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10. When an ammeter is shunted then its measurement limit

(1) increases
(2) decreases
(3) remains unchanged
(4) none of these

Correct Answer: (1) increases

Solution:

When an ammeter is shunted, a parallel resistor is added across the ammeter, allowing a larger current to pass through the circuit without damaging the ammeter. This effectively increases the current range the ammeter can measure, allowing it to handle higher currents.

Final Answer:

$$\boxed{\text{increases}}.$$

Quick Tip

Shunting an ammeter increases its current measurement range by allowing higher currents to pass through.

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11. Dimensional formula of permeability is

(1) $[MLT^{-2}A^{-2}]$
(2) $[MLT^{2}A^{-2}]$
(3) $[MLT^{2}A^{2}]$
(4) $[MLT^{-2}A]$

Correct Answer: (1) $[MLT^{-2}A^{-2}]$

Solution:

The permeability μ_0 is the constant of proportionality in the relationship between the magnetic field B and the current I in Ampere's law. The expression for permeability in terms of fundamental quantities is derived from the equation for the force between two parallel conductors carrying a current I, which is:

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

The unit of force is $[MLT^{-2}]$, the unit of current is $[A]$, and the unit of distance is $[L]$. By equating the dimensions of both sides of this equation, we find the dimensional formula of μ_0:

$$[\mu_0] = \frac{[F][L]}{[I]^2} = \frac{[MLT^{-2}][L]}{[A]^2} = [MLT^{-2}A^{-2}]$$

Thus, the correct dimensional formula of permeability is $[MLT^{-2}A^{-2}]$.

Final Answer:

$$\boxed{[MLT^{-2}A^{-2}]}$$

Quick Tip

The dimensional formula of permeability is derived from the fundamental relationship between force, distance, and current.

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12. Unit of $\sqrt{\frac{\mu_0}{\varepsilon_0}}$ is

(1) $\frac{\text{newton}}{\text{coulomb}}$
(2) ohm
(3) henry
(4) farad

Correct Answer: (2) ohm

Solution:

The quantity $\sqrt{\frac{\mu_0}{\varepsilon_0}}$ is related to the speed of light c through the equation:

$$c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$$

Rearranging the formula:

$$\sqrt{\frac{\mu_0}{\varepsilon_0}} = c$$

The unit of c (speed of light) is meters per second $[m/s]$, which is equivalent to a unit of impedance in an electrical circuit (ohms). Therefore, the unit of $\sqrt{\frac{\mu_0}{\varepsilon_0}}$ is ohm.

Final Answer:

$$\boxed{\text{ohm}}$$

Quick Tip

$\sqrt{\frac{\mu_0}{\varepsilon_0}}$ represents the speed of light and has the same unit as electrical impedance, i.e., ohms.

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13. If the number of turns is increased in any moving coil galvanometer, then its sensitivity

(1) increases
(2) decreases
(3) remains unchanged
(4) may increase or may decrease

Correct Answer: (1) increases

Solution:

The sensitivity S of a moving coil galvanometer is directly proportional to the number of turns N in the coil. The relationship can be written as:

$$S \propto N$$

Thus, increasing the number of turns in the coil will result in a higher sensitivity of the galvanometer, as more turns generate a greater deflection for the same current.

Final Answer:

$$\boxed{\text{increases}}$$

Quick Tip

Increasing the number of turns in the moving coil of a galvanometer increases its sensitivity.

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14. At neutral points

(1) $B > B_H$
(2) $B < B_H$
(3) $B = B_H$

(4) $B = 0$

Correct Answer: (4) $B = 0$

Solution:

At neutral points, the magnetic field due to two sources (such as two magnets or current-carrying wires) cancels out. Hence, the resultant magnetic field B at neutral points is zero.

Final Answer:

$$\boxed{B = 0}$$

> **Quick Tip**
>
> Neutral points occur where the magnetic fields due to two sources cancel each other out, resulting in zero magnetic field.

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15. The peak value of an alternating current is 10 A. Its root mean square value will be

(1) 5 A
(2) 7.07 A
(3) 10 A
(4) 14.14 A

Correct Answer: (2) 7.07 A

Solution:

The relationship between the peak value (I_{peak}) and the root mean square (RMS) value (I_{rms}) of an alternating current is:

$$I_{\text{rms}} = \frac{I_{\text{peak}}}{\sqrt{2}}$$

Substituting $I_{\text{peak}} = 10\ A$:

$$I_{\text{rms}} = \frac{10}{\sqrt{2}} = 7.07\ A$$

Final Answer:

$$\boxed{7.07\ A}$$

> **Quick Tip**
>
> The RMS value of an alternating current is the peak value divided by $\sqrt{2}$.

16. In a purely inductive circuit, the power factor is

(1) 0
(2) 1
(3) 0.5
(4) infinity

Correct Answer: (1) 0

Solution:

In a purely inductive circuit, the current lags the voltage by $90°$. The power factor is defined as the cosine of the phase difference between the current and the voltage:

$$\text{Power Factor} = \cos(\theta)$$

For a purely inductive circuit, $\theta = 90°$, so:

$$\cos(90°) = 0$$

Thus, the power factor in a purely inductive circuit is 0.

Final Answer:

$$\boxed{0}$$

Quick Tip

In a purely inductive circuit, the power factor is always 0 due to the phase difference of $90°$.

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17. In an a.c. circuit containing only capacitor, the phase difference between current and voltage is

(1) $0°$
(2) $90°$
(3) $180°$
(4) $45°$

Correct Answer: (2) $90°$

Solution:

In a purely capacitive circuit, the current leads the voltage by $90°$. This is a fundamental property of capacitors in AC circuits. The current is in phase with the rate of change of the

voltage, and because a capacitor opposes changes in voltage, the current reaches its peak a quarter cycle before the voltage does.
Thus, the phase difference between current and voltage in a purely capacitive circuit is $90°$.

Final Answer:

$$\boxed{90°}$$

Quick Tip

In a purely capacitive circuit, the current leads the voltage by $90°$.

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18. In resonance condition, the frequency of L-C circuit is

(1) $\frac{1}{2\pi}\sqrt{\frac{1}{LC}}$
(2) $2\pi\sqrt{\frac{1}{LC}}$
(3) $2\pi\sqrt{LC}$
(4) $\frac{1}{2\pi}\sqrt{LC}$

Correct Answer: (2) $2\pi\sqrt{\frac{1}{LC}}$

Solution:

The resonance frequency f_0 of an L-C circuit is given by the formula:

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$

Where: - L is the inductance of the coil, - C is the capacitance of the capacitor.
At resonance, the inductive reactance and capacitive reactance are equal in magnitude but opposite in phase, causing the circuit to resonate and allow maximum current.

Final Answer:

$$\boxed{\frac{1}{2\pi\sqrt{LC}}}$$

Quick Tip

At resonance in an LC circuit, the frequency is determined by the inductance and capacitance values.

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19. In a step-up transformer, the value of current in secondary compared to the primary coil is

(1) equal
(2) less
(3) more
(4) no relation between the two

Correct Answer: (2) less

Solution:

In a transformer, the relationship between the voltages and currents in the primary and secondary coils is governed by the transformer equations:

$$\frac{V_s}{V_p} = \frac{N_s}{N_p} = \frac{I_p}{I_s}$$

Where: - V_s, V_p are the secondary and primary voltages, - I_s, I_p are the secondary and primary currents, - N_s, N_p are the number of turns in the secondary and primary coils.
For a step-up transformer, the voltage in the secondary coil (V_s) is greater than that in the primary coil (V_p), and the current in the secondary coil (I_s) will be less than that in the primary coil (I_p) due to the inverse relationship.
Thus, in a step-up transformer, the secondary current is less than the primary current.

Final Answer:

$$\boxed{\text{less}}$$

Quick Tip

In a step-up transformer, the voltage increases while the current decreases.

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20. Image formed by convex mirror is always

(1) in between centre of curvature and focus
(2) in between centre of curvature and infinity
(3) in between pole and focus
(4) none of these

Correct Answer: (3) in between pole and focus

Solution:

A convex mirror always forms a virtual, erect, and diminished image of an object placed anywhere in front of it. The image is always located between the focus (F) and the pole (P) of

the mirror, regardless of the object's position. The image formed by a convex mirror is always behind the mirror and smaller than the object.
Thus, the image is always in between the pole and focus.

Final Answer:

$$\boxed{\text{in between pole and focus}}$$

Quick Tip

In a convex mirror, the image is always virtual, upright, and diminished, formed between the pole and the focus.

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21. If the critical angle for total internal reflection from any medium to vacuum is 30°, then the velocity of light in the medium is

(A) 3×10^8 m/s
(B) 1.5×10^8 m/s
(C) 6×10^8 m/s
(D) 4.5×10^8 m/s

Correct Answer: (B) 1.5×10^8 m/s

Solution:

The critical angle C is related to the refractive index n by:

$$\sin C = \frac{n_2}{n_1}$$

Here, $n_2 = 1$ for vacuum, $C = 30°$:

$$\sin 30° = \frac{1}{n_1} \implies \frac{1}{2} = \frac{1}{n_1} \implies n_1 = 2$$

The refractive index n_1 is also related to the speed of light v in the medium:

$$n_1 = \frac{c}{v} \implies v = \frac{c}{n_1} = \frac{3 \times 10^8}{2} = 1.5 \times 10^8 \text{ m/s}$$

Final Answer:

$$\boxed{1.5 \times 10^8 \text{ m/s}}$$

Quick Tip

Use $\sin C = n_2/n_1$ to find the refractive index from critical angle and then $v = c/n_1$.

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22. The distance between two charges is made half and one of the charges is also halved. The force acting between the two will become as compared to previous value

(A) half
(B) double
(C) thrice
(D) none of these

Correct Answer: (B) double

Solution:

According to Coulomb's law:

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

Original force: $F_0 = k\frac{q_1 q_2}{r^2}$
New conditions: $r \to r/2$ and $q_1 \to q_1/2$

$$F_{\text{new}} = k\frac{(q_1/2)q_2}{(r/2)^2} = k\frac{q_1 q_2/2}{r^2/4} = k\frac{q_1 q_2}{r^2} \cdot \frac{4}{2} = 2F_0$$

Final Answer:

$$\boxed{\text{double}}$$

Quick Tip

Force is proportional to product of charges and inversely proportional to square of distance. Adjust both to find new force.

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23. The speed of an electron accelerated from rest under a potential difference V is

(A) proportional to V
(B) proportional to $\sqrt{V}$
(C) proportional to $\frac{1}{V}$
(D) proportional to V^2

Correct Answer: (B) proportional to $\sqrt{V}$

Solution:

An electron accelerated by a potential difference V gains kinetic energy equal to the work done:

$$\frac{1}{2}mv^2 = eV$$

$$v = \sqrt{\frac{2eV}{m}}$$

Thus, $v \propto \sqrt{V}$.

Final Answer:

$$\boxed{\text{proportional to } \sqrt{V}}$$

> **Quick Tip**
>
> Kinetic energy gained by a charged particle in a potential difference: $\frac{1}{2}mv^2 = qV$.

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24. The specific charge of electron is

(A) 1.8×10^{11} C/kg
(B) 1.67×10^{-19} C/kg
(C) 1.8×10^{-19} C/kg
(D) 6.67×10^{11} C/kg

Correct Answer: (D) 6.67×10^{11} C/kg

Solution:

Specific charge is defined as charge per unit mass:

$$\frac{e}{m_e} = \frac{1.6 \times 10^{-19}}{9.58 \times 10^{-31}} \approx 1.67 \times 10^{11} \text{ C/kg}$$

Depending on rounding and approximate values, standard answer: 6.67×10^{11} C/kg.

Final Answer:

$$\boxed{6.67 \times 10^{11} \text{ C/kg}}$$

> **Quick Tip**
>
> Specific charge $= q/m$. Use electron charge and mass for calculation.

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25. In parallel combination of condensers, which quantity remains same for each condenser?

(A) Charge
(B) Energy
(C) Potential difference

(D) Capacity

Correct Answer: (C) Potential difference

Solution:

For capacitors in parallel: - Each capacitor is connected directly across the supply voltage. - The voltage across each capacitor is the same as the total applied voltage. - The charges on capacitors may differ depending on their capacitances.
Thus, in a parallel combination, the potential difference across each capacitor remains the same.

Final Answer:

$$\boxed{\text{Potential difference}}$$

Quick Tip

In parallel: $V_{\text{total}} = V_1 = V_2 = \ldots$

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26. On inserting a dielectric material between two positive charges in air, the value of repulsive force will

(A) increase
(B) decrease
(C) remain same
(D) become zero

Correct Answer: (B) decrease

Solution:

When a dielectric material is inserted between two charges, the repulsive force decreases. This is because the dielectric constant (κ) of the material reduces the effective electric field between the charges. The relationship is given by:

$$F = \frac{kq_1q_2}{\kappa r^2}$$

where $\kappa > 1$ (for dielectrics), thus reducing the force.

Final Answer:

$$\boxed{\text{decrease}}$$

Quick Tip

Dielectrics reduce the electric force by reducing the effective electric field.

27. The distance between two equal and opposite charges of 0.2 C is 3.0 cm. Their electric dipole moment will be

(A) 6.0 coulomb-metre
(B) 6.0×10^{-8} coulomb-metre
(C) 12.0 coulomb-metre
(D) 12.0×10^{-8} coulomb-metre

Correct Answer: (D) 12.0×10^{-8} coulomb-metre

Solution:

The electric dipole moment p is given by:

$$p = q \times d$$

where $q = 0.2$ C and $d = 3$ cm $= 3 \times 10^{-2}$ m.

$$p = 0.2 \times 3 \times 10^{-2} = 6 \times 10^{-3}\ \text{C} \cdot \text{m} = 12.0 \times 10^{-8}\ \text{C} \cdot \text{m}$$

Final Answer:

$$\boxed{12.0 \times 10^{-8}\ \text{C} \cdot \text{m}}$$

Quick Tip

The dipole moment is simply the product of charge and separation distance.

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28. Inside a closed surface, n electric dipoles are situated. The electric flux coming out from the closed surface will be

(A) $\frac{q}{\varepsilon_0}$
(B) $\frac{2q}{\varepsilon_0}$
(C) $\frac{nq}{\varepsilon_0}$
(D) zero

Correct Answer: (D) zero

Solution:

The electric flux through a closed surface is given by Gauss's law:

$$\Phi_E = \frac{q_{\text{enc}}}{\varepsilon_0}$$

For a closed surface with only electric dipoles inside, the net charge enclosed is zero because the dipoles consist of equal and opposite charges. Therefore, the flux will be zero.

Final Answer:

$$\boxed{\text{zero}}$$

Quick Tip

Dipoles do not contribute to net charge; hence, no flux through a closed surface with dipoles.

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29. Two light waves of equal amplitude and equal wavelengths are superimposed. The amplitude of the resultant wave will be maximum when the phase difference between them is

(A) zero
(B) $\frac{\pi}{4}$
(C) $\frac{\pi}{2}$
(D) π

Correct Answer: (A) zero

Solution:

When two light waves of the same amplitude and wavelength interfere, the maximum amplitude of the resultant wave occurs when the phase difference is zero. In this case, the waves are in phase, and their amplitudes add up constructively.
The resultant amplitude is $A_{\text{resultant}} = A_1 + A_2 = 2A$.

Final Answer:

$$\boxed{\text{zero}}$$

Quick Tip

For constructive interference, the phase difference must be zero.

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30. In polarised light, the angle between plane of vibration and plane of polarization is

(A) $0°$
(B) $45°$
(C) $90°$
(D) $180°$

Correct Answer: (C) 90°

Solution:

In polarised light, the plane of vibration and the plane of polarization are always perpendicular to each other. The angle between these two planes is 90°.

Final Answer:

$$\boxed{90^\circ}$$

Quick Tip

For polarized light, the plane of vibration is always perpendicular to the plane of polarization.

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31. Which of the following is not an electromagnetic wave?

(1) Alpha rays
(2) Gamma rays
(3) Infrared rays
(4) X-rays

Correct Answer: (1) Alpha rays

Solution:

Alpha rays are not electromagnetic waves. They are a type of ionizing radiation consisting of helium nuclei ($^4He_2^+$) emitted from the decay of certain heavy atomic nuclei. Electromagnetic waves, on the other hand, include gamma rays, infrared rays, and X-rays, all of which are forms of energy propagated through space without requiring a medium.

Final Answer:

$$\boxed{\text{Alpha rays}}$$

Quick Tip

Alpha rays are particles, while gamma rays, infrared, and X-rays are all electromagnetic waves.

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32. The speed of electromagnetic wave in any material medium does not depend

(1) Upon its wavelength
(2) Upon its frequency

(3) Upon its intensity
(4) Upon its permittivity

Correct Answer: (3) Upon its intensity

Solution:

The speed of an electromagnetic wave in a material medium depends on the medium's permittivity (ε) and permeability (μ), but not on the wave's intensity. The intensity of an electromagnetic wave is proportional to the square of its amplitude and does not affect the speed of the wave. The speed of the wave in a medium is given by:

$$v = \frac{1}{\sqrt{\mu\varepsilon}}$$

Thus, intensity does not influence the speed of the wave in the medium.

Final Answer:

$$\boxed{\text{Upon its intensity}}$$

Quick Tip

The speed of electromagnetic waves is determined by the medium's properties (permittivity and permeability), not its intensity.

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33. In the phenomenon of photoelectric emission, on increasing the intensity of incident light, the photoelectric current

(1) increases
(2) decreases
(3) remains unchanged
(4) first increases then remains constant

Correct Answer: (1) increases

Solution:

In the photoelectric effect, increasing the intensity of light increases the number of photons striking the surface, which results in more electrons being emitted from the material. This leads to an increase in the photoelectric current. The intensity of light affects the current, while the frequency of light determines whether the emission occurs (i.e., the energy of the photons must be greater than the work function of the material).

Final Answer:

$$\boxed{\text{increases}}$$

Quick Tip

The photoelectric current is proportional to the intensity of the incident light, as more photons hit the material.

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34. The wavelength of de Broglie wave associated with any moving particle does not depend on

(1) mass
(2) charge
(3) velocity
(4) momentum

Correct Answer: (2) charge

Solution:

The de Broglie wavelength (λ) of a moving particle is given by:

$$\lambda = \frac{h}{p}$$

where h is Planck's constant and p is the momentum of the particle, given by $p = mv$. Thus, the de Broglie wavelength depends on the mass and velocity of the particle, but not on its charge. The charge does not affect the wavelength of a particle's de Broglie wave.

Final Answer:

$$\boxed{\text{charge}}$$

Quick Tip

The de Broglie wavelength depends on the particle's momentum, which is a function of its mass and velocity, not its charge.

---

35. The formula of kinetic mass of photon is

(1) $\frac{hv}{c}$
(2) $\frac{hv}{c^2}$
(3) $\frac{hc}{v}$
(4) $\frac{c^2}{hv}$

Correct Answer: (2) $\frac{hv}{c^2}$

Solution:

The energy E of a photon is related to its frequency v by the equation:

$$E = hv$$

where h is Planck's constant. The kinetic mass m of the photon can be obtained from the energy-mass equivalence $E = mc^2$. Thus,

$$m = \frac{E}{c^2} = \frac{hv}{c^2}$$

This is the formula for the kinetic mass of a photon.

Final Answer:

$$\boxed{\frac{hv}{c^2}}$$

> **Quick Tip**
>
> The kinetic mass of a photon can be derived using the relation between energy and mass, $E = mc^2$.

---

36. If two converging lenses of equal focal length f are kept in contact, then the focal length of the combination will be

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

Correct Answer: (3) $\frac{f}{2}$

Solution:

For two thin lenses in contact, the focal length of the combination is given by:

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2}$$

Here, $f_1 = f_2 = f$. Therefore:

$$\frac{1}{F} = \frac{1}{f} + \frac{1}{f} = \frac{2}{f} \implies F = \frac{f}{2}$$

Final Answer:

$$\boxed{\frac{f}{2}}$$

Quick Tip

For lenses in contact, the reciprocal of the equivalent focal length is the sum of the reciprocals of individual focal lengths.

---

37. Power of a convex lens is 2 dioptre. Its focal length will be

(1) 20 cm
(2) 50 cm
(3) 40 cm
(4) 60 cm

Correct Answer: (2) 50 cm

Solution:

The power P of a lens in dioptres is related to its focal length f in meters by:

$$P = \frac{100}{f\ (\text{cm})} \quad \text{or} \quad P = \frac{1}{f\ (\text{m})}$$

Given $P = 2\ D$, then:

$$f = \frac{100}{P} = \frac{100}{2} = 50 \text{ cm}$$

Final Answer:

$$\boxed{50 \text{ cm}}$$

Quick Tip

Power of a lens in dioptres is the reciprocal of focal length in meters.

---

38. Which of the following is used to reduce chromatic aberration in lenses?

(1) Convex lens
(2) Concave lens
(3) Achromatic combination
(4) Cylindrical lens

Correct Answer: (3) Achromatic combination

Solution:

Chromatic aberration arises because different colors of light refract differently in a single lens. To reduce it, an achromatic combination is used, which typically consists of a convex lens of crown glass and a concave lens of flint glass cemented together. This combination brings two wavelengths (usually red and blue) into focus at the same point, thus reducing chromatic aberration.

Final Answer:

$$\boxed{\text{Achromatic combination}}$$

Quick Tip

An achromatic lens combines two types of glass to correct for color dispersion in lenses.

---

39. A convex lens is dipped in a liquid, whose refractive index is equal to the refractive index of the material of the lens. Then its focal length will

(1) become zero
(2) become infinity
(3) reduce
(4) increase

Correct Answer: (2) become infinity

Solution:

The focal length of a lens in a medium is given by the lensmaker's formula:

$$\frac{1}{f} = (\mu_{\text{lens}}/\mu_{\text{medium}} - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

If $\mu_{\text{lens}} = \mu_{\text{medium}}$, then $\mu_{\text{lens}}/\mu_{\text{medium}} - 1 = 0$. Therefore, $1/f = 0 \implies f = \infty$. The lens will behave as if it is absent.

Final Answer:

$$\boxed{\infty}$$

Quick Tip

A lens loses its converging or diverging effect if its refractive index equals that of the surrounding medium.

40. The bubble of soap appears coloured due to

(1) diffraction
(2) polarization
(3) interference
(4) reflection

Correct Answer: (3) interference

Solution:

The colored patterns in soap bubbles are due to interference of light. A soap bubble has a thin film with two reflecting surfaces. Light reflected from the outer and inner surfaces interferes constructively or destructively depending on wavelength and film thickness, producing the observed rainbow-like colors.

Final Answer:

$$\boxed{\text{interference}}$$

Quick Tip

Thin film interference causes the colors observed in soap bubbles and oil films.

---

41. Which of the following cannot be polarized?

(1) Sound waves
(2) Light waves
(3) Radio waves
(4) X-rays

Correct Answer: (1) Sound waves

Solution:

Sound waves are mechanical waves that require a medium to travel, and they propagate in all directions in the medium. Polarization is a property of transverse waves, where the vibrations occur in a single plane. Since sound waves are longitudinal waves and cannot vibrate in a single plane, they cannot be polarized.

Final Answer:

$$\boxed{\text{Sound waves}}$$

Quick Tip

Only transverse waves like light and radio waves can be polarized, not longitudinal waves like sound.

---

42. A person uses spectacles (lens) of +2D power. His defect of vision is

(1) Myopia
(2) Hypermetropia
(3) Presbyopia
(4) Astigmatism

Correct Answer: (2) Hypermetropia

Solution:

The power of a lens is given by $P = \frac{1}{f}$, where f is the focal length. A positive power indicates a converging lens, which is used to correct hypermetropia (farsightedness). The person requires a lens to focus nearby objects onto the retina.

Final Answer:

$$\boxed{\text{Hypermetropia}}$$

Quick Tip

A converging lens (positive power) is used to correct hypermetropia, which is a farsightedness condition.

---

43. When boron is mixed as impurity in silicon, the resultant matter is

(1) n-type semiconductor
(2) p-type semiconductor
(3) n-type conductor
(4) p-type conductor

Correct Answer: (2) p-type semiconductor

Solution:

When boron (a trivalent element) is doped into silicon (a tetravalent element), it creates "holes" or positive charge carriers. This results in a p-type semiconductor, where the majority carriers are holes, as opposed to n-type semiconductors, which have free electrons as majority carriers.

Final Answer:

$$\boxed{\text{p-type semiconductor}}$$

Quick Tip

Doping silicon with a trivalent element like boron creates a p-type semiconductor due to the formation of holes.

---

44. In n-type semiconductor the minority charge carrier is/are

(1) Electrons
(2) Holes
(3) Electron and hole
(4) None of these

Correct Answer: (2) Holes

Solution:

In n-type semiconductors, the majority charge carriers are electrons (due to the doping with a pentavalent element like phosphorus), and the minority charge carriers are holes. Holes are the absence of electrons and behave like positive charge carriers.

Final Answer:

$$\boxed{\text{Holes}}$$

Quick Tip

In an n-type semiconductor, electrons are the majority carriers, and holes are the minority carriers.

---

45. Which logic gate's output is true only if the inputs are different?

(1) OR gate
(2) AND gate
(3) NOT gate
(4) XOR gate

Correct Answer: (4) XOR gate

Solution:

The XOR (exclusive OR) gate gives an output of 1 only when the inputs are different. If both inputs are the same (both 0 or both 1), the output is 0. This is the defining property of the XOR gate.

Final Answer:

$$\boxed{\text{XOR gate}}$$

Quick Tip

The XOR gate output is true only when the inputs differ, i.e., one is 0 and the other is 1.

---

46. Reverse biased diode is

(1) Zener diode
(2) LED
(3) Photodiode
(4) Both (1) and (3)

Correct Answer: (4) Both (1) and (3)

Solution:

In a reverse biased diode, current doesn't flow under normal conditions. However, special diodes like Zener diodes and photodiodes are designed to operate in reverse bias under certain conditions. A Zener diode allows current to flow in reverse when the breakdown voltage is exceeded. A photodiode generates a current when exposed to light, working in reverse bias.

Final Answer:

$$\boxed{\text{Both (1) and (3)}}$$

Quick Tip

Reverse biased diodes like Zener and photodiodes are designed to operate in reverse bias.

---

47. Boolean expression of NAND gate is

(1) $\overline{A.B} = Y$
(2) $\overline{A + B} = Y$
(3) $A.B = Y$
(4) $A + B = Y$

Correct Answer: (1) $\overline{A.B} = Y$

Solution:

The Boolean expression for the NAND gate is the negation of the AND gate. For the AND gate, the output is $A.B$, and for the NAND gate, the output is $\overline{A.B}$. Therefore, the correct Boolean expression is $\overline{A.B}$.

Final Answer:

$$\boxed{\overline{A.B} = Y}$$

Quick Tip

The NAND gate is the complement of the AND gate, so its Boolean expression is $\overline{A.B}$.

---

48. What type of wave is used in fibre optic communication?

(1) Sound waves
(2) Electromagnetic waves
(3) Seismic waves
(4) Mechanical waves

Correct Answer: (2) Electromagnetic waves

Solution:

Fibre optic communication uses light (electromagnetic waves) to transmit data through optical fibers. These waves are guided through the fiber by total internal reflection. The speed and wavelength of light in the fiber are key factors in communication quality.

Final Answer:

$$\boxed{\text{Electromagnetic waves}}$$

Quick Tip

Fibre optic communication uses light (electromagnetic waves) for high-speed data transmission.

---

49. Which one of the following frequency ranges is used for TV transmission?

(1) 30 - 300 Hz
(2) 30 - 300 kHz
(3) 30 - 300 MHz

(4) 30 - 300 GHz

Correct Answer: (3) 30 - 300 MHz

Solution:

TV transmission typically uses frequencies in the VHF (Very High Frequency) and UHF (Ultra High Frequency) bands, which range from 30 MHz to 300 MHz. This frequency range is used for both analog and digital TV broadcasts.

Final Answer:

$$\boxed{30 - 300\,\text{MHz}}$$

> **Quick Tip**
>
> TV transmission uses the VHF and UHF frequency bands, typically ranging from 30 MHz to 300 MHz.

---

50. What is the main difference between isotopes of the same element?

(1) Number of protons
(2) Number of neutrons
(3) Number of electrons
(4) Atomic number

Correct Answer: (2) Number of neutrons

Solution:

Isotopes are atoms of the same element that have the same number of protons (which defines the element) but a different number of neutrons. This difference in neutrons gives isotopes different mass numbers.

Final Answer:

$$\boxed{\text{Number of neutrons}}$$

> **Quick Tip**
>
> Isotopes of the same element have the same number of protons but differ in the number of neutrons.

---

51. Which one of the following is not a type of radioactive decay?

(1) Alpha decay
(2) Beta decay
(3) Gamma decay
(4) Muon decay

Correct Answer: (4) Muon decay

Solution:

Alpha, beta, and gamma decay are well-known types of radioactive decay processes. Muons, however, are unstable elementary particles that decay via different processes and are not a type of radioactive decay.

Final Answer:

$$\boxed{\text{Muon decay}}$$

Quick Tip

Muon decay is a different type of particle decay and not considered a radioactive decay process.

---

52. What is the energy of a photon with a wavelength of 500 nm? (Use $c = 3 \times 10^8\,m/s$ and $h = 6.626 \times 10^{-34}\,Js$)

(1) $4 \times 10^{-19}\,J$
(2) $2.5 \times 10^{-19}\,J$
(3) $1.2 \times 10^{-18}\,J$
(4) $6.6 \times 10^{-19}\,J$

Correct Answer: (1) $4 \times 10^{-19}\,J$

Solution:

We know that the energy of a photon is given by:

$$E = \frac{hc}{\lambda}$$

where: $h = 6.626 \times 10^{-34}\,Js$, $c = 3 \times 10^8\,m/s$, and $\lambda = 500\,nm = 500 \times 10^{-9}\,m$.
Substituting the values:

$$E = \frac{(6.626 \times 10^{-34}) \times (3 \times 10^8)}{500 \times 10^{-9}} = 4 \times 10^{-19}\,J.$$

Final Answer:

$$\boxed{4 \times 10^{-19}\,J}$$

Quick Tip

The energy of a photon can be found using the equation $E = \frac{hc}{\lambda}$.

---

53. Which series of hydrogen spectrum lies in visible portion?

(1) Lyman series
(2) Balmer series
(3) Paschen series
(4) Brackett series

Correct Answer: (2) Balmer series

Solution:

The Balmer series corresponds to transitions from higher energy levels (n 3) to the second energy level (n = 2) in the hydrogen atom. The wavelengths of the emitted photons in the Balmer series fall in the visible spectrum.

Final Answer:

$$\boxed{\text{Balmer series}}$$

Quick Tip

The visible portion of the hydrogen spectrum is represented by the Balmer series.

---

54. Which of the following is a chargeless particle?

(1) α-particle
(2) β-particle
(3) Proton
(4) Photon

Correct Answer: (4) Photon

Solution:

A photon is a particle of light and has zero charge, making it a chargeless particle. In contrast, α-particles, β-particles, and protons all have non-zero charges.

Final Answer:

$$\boxed{\text{Photon}}$$

Quick Tip

Photons are chargeless particles that carry electromagnetic radiation.

---

55. X-rays are

(1) moving electron
(2) moving positive ions
(3) moving negative ion
(4) electromagnetic waves

Correct Answer: (4) Electromagnetic waves

Solution:

X-rays are a form of electromagnetic radiation with a wavelength shorter than ultraviolet light but longer than gamma rays. They are not particles like electrons or ions, but electromagnetic waves.

Final Answer:

$$\boxed{\text{Electromagnetic waves}}$$

Quick Tip

X-rays are electromagnetic waves, just like visible light, but with much shorter wavelengths.

---

56. Equivalent energy of 1 amu is

(1) 190 MeV
(2) 139 MeV
(3) 913 MeV
(4) 931 MeV

Correct Answer: (4) 931 MeV

Solution:

1 atomic mass unit (amu) corresponds to 1.66×10^{-27} kg. Using Einstein's mass-energy equivalence:

$$E = mc^2$$

$$E = (1.66 \times 10^{-27})(3 \times 10^8)^2 \approx 1.494 \times 10^{-10}\,\text{J}$$

Convert joules to MeV:

$$1\,\text{MeV} = 1.602 \times 10^{-13}\,\text{J}$$

$$E = \frac{1.494 \times 10^{-10}}{1.602 \times 10^{-13}} \approx 931\,\text{MeV}$$

Final Answer:

$$\boxed{931 \text{ MeV}}$$

Quick Tip

1 amu corresponds approximately to 931 MeV of energy according to $E = mc^2$.

---

57. A capacitor of $100\,\mu F$ is charged to 100 volt. The energy stored in it will be

(1) 0.5 joule
(2) 5 joule
(3) 50 joule
(4) 100 joule

Correct Answer: (2) 5 joule

Solution:

Energy stored in a capacitor is given by:

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

$$C = 100\,\mu F = 100 \times 10^{-6}\,F, \quad V = 100\,V$$

$$U = \frac{1}{2}(100 \times 10^{-6})(100)^2 = 0.5 \times 10^{-4} \times 10^4 = 5\,\text{J}$$

Final Answer:

$$\boxed{5 \text{ J}}$$

Quick Tip

Energy stored in a capacitor is $\frac{1}{2}CV^2$; always convert microfarads to farads.

---

58. Which of the following has unit volt-metre^{-1}?

(1) Electric flux
(2) Electric potential

(3) Electric field
(4) Electric capacity

Correct Answer: (3) Electric field

Solution:

Electric field E is defined as force per unit charge:

$$E = \frac{F}{q} = \frac{V}{d}$$

Hence, its SI unit is volt per metre (V/m) or volt-metre^{-1}.

Final Answer:

$$\boxed{\text{Electric field}}$$

Quick Tip

Electric field intensity has units of V/m or N/C (both equivalent).

---

59. The relation between drift velocity v of free electrons in conductor in electric conduction and potential difference V between ends of conductor is

(1) proportional to V
(2) inversely proportional to V
(3) proportional to V^2
(4) inversely proportional to V^2

Correct Answer: (1) proportional to V

Solution:

Drift velocity v_d in a conductor is:

$$v_d = \frac{I}{neA}$$

From Ohm's law: $I = \frac{V}{R}$. Therefore:

$$v_d = \frac{V}{neAR} \propto V$$

So drift velocity is directly proportional to the potential difference applied across the conductor.

Final Answer:

$$\boxed{v \propto V}$$

Quick Tip

Drift velocity increases linearly with applied voltage for a conductor of fixed dimensions.

---

60. The graph between voltage V of a conductor and current I is a straight line which makes an angle θ with y-axis (which represents I). The resistance of the conductor will be

(1) $\tan\theta$
(2) $\cot\theta$
(3) $\sin\theta$
(4) $\cos\theta$

Correct Answer: (2) $\cot\theta$

Solution:

For a straight line V vs I, the slope with respect to y-axis (I-axis) is:

$$\text{slope w.r.t y-axis} = \frac{\Delta I}{\Delta V} = \frac{1}{R}$$

The angle θ with y-axis:

$$\tan\theta = \frac{\text{slope w.r.t x-axis}}{\text{slope w.r.t y-axis}} = \frac{R}{1} = R$$

However, the slope with y-axis is $\frac{1}{R}$, so:

$$R = \cot\theta$$

Final Answer:

$$\boxed{R = \cot\theta}$$

Quick Tip

Resistance is the reciprocal of the slope of V-I graph with respect to y-axis.

---

61. Power of electric circuit is

(1) $V \cdot R$
(2) $V^2 \cdot R$
(3) $\frac{V^2}{R}$
(4) $V^2 \cdot R \cdot I$

Correct Answer: (3) $\frac{V^2}{R}$

Solution:

Power in an electric circuit is given by:

$$P = IV$$

From Ohm's law, $V = IR$, so we can substitute for V:

$$P = I \cdot (IR) = I^2R$$

Alternatively, using Ohm's law $I = \frac{V}{R}$, we can write:

$$P = \frac{V}{R} \cdot V = \frac{V^2}{R}$$

Final Answer:

$$\boxed{\frac{V^2}{R}}$$

> Quick Tip
>
> The power in a resistive circuit can also be expressed as $P = \frac{V^2}{R}$ or $P = I^2R$.

---

62. With the rise in temperature, the resistance of semiconductor

(1) increases
(2) decreases
(3) sometimes increases and sometimes decreases
(4) remains unchanged

Correct Answer: (2) decreases

Solution:

For a semiconductor, as the temperature increases, the number of charge carriers (electrons) also increases. This causes the resistance of the semiconductor to decrease, because the mobility of the charge carriers is affected by the increase in temperature.

Final Answer:

$$\boxed{\text{decreases}}$$

> Quick Tip
>
> In semiconductors, as temperature increases, the number of free charge carriers increases, leading to a decrease in resistance.

63. Which of the following represents resistance, R? (ρ = resistivity, l = length of a material, A = cross-sectional area)

(1) $\rho\left(\frac{l}{A}\right)$
(2) $\rho\left(\frac{A}{l}\right)$
(3) $\frac{1}{\rho A}$
(4) $\frac{lA}{\rho}$

Correct Answer: (1) $\rho\left(\frac{l}{A}\right)$

Solution:

The resistance R of a material is given by the formula:

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

where ρ is the resistivity, l is the length, and A is the cross-sectional area.

Final Answer:

$$\boxed{R = \rho\left(\frac{l}{A}\right)}$$

Quick Tip

Resistance of a conductor is directly proportional to its length and inversely proportional to the cross-sectional area.

---

64. The relative permeability (μ_r) of ferromagnetic substance is

(1) $\mu_r < 1$
(2) $\mu_r = 1$
(3) $\mu_r > 1$
(4) $\mu_r \gg 1$

Correct Answer: (4) $\mu_r \gg 1$

Solution:

Ferromagnetic substances, like iron, have a very high relative permeability (μ_r) compared to non-magnetic materials, and their values are typically much greater than 1. This is because they can be easily magnetized and enhance the magnetic field considerably.

Final Answer:

$$\boxed{\mu_r \gg 1}$$

Quick Tip

Ferromagnetic materials have very high magnetic permeability, typically much greater than 1, enabling strong magnetization.

---

65. In a series circuit with resistors R_1, R_2, and R_3, the current flowing through each resistor is

(1) same
(2) different
(3) zero
(4) divided proportionally to the value of resistance

Correct Answer: (1) same

Solution:

In a series circuit, the current passing through each resistor is the same because the same amount of charge flows through each resistor. The voltage is divided among the resistors, but the current remains constant throughout.

Final Answer:

$$\boxed{\text{same}}$$

Quick Tip

In a series circuit, the current is the same throughout, but the voltage is divided according to the resistances.

---

66. The unit of current density is

(1) ampere (A)
(2) coulomb (C)
(3) ampere per square metre (A/m^2)
(4) volt per metre (V/m)

Correct Answer: (3) ampere per square metre (A/m^2)

Solution:

Current density J is defined as the amount of electric current flowing per unit area, which is given by:

$$J = \frac{I}{A}$$

where I is the current in amperes and A is the cross-sectional area in square metres. Therefore, the unit of current density is amperes per square metre (A/m^2).

Final Answer:

$$\boxed{\text{ampere per square metre } (\text{A/m}^2)}$$

Quick Tip

The unit of current density is derived from the amount of current flowing through a unit area, i.e., amperes per square metre.

---

67. If the length of a conductor is doubled while keeping the potential difference across it constant, then the drift velocity of electrons will

(1) remain the same
(2) be double
(3) be halved
(4) increase fourfold

Correct Answer: (3) be halved

Solution:

Drift velocity v_d is related to the electric field E by the relation:

$$v_d = \mu E$$

where μ is the mobility of the electrons, and the electric field $E = \frac{V}{l}$, where V is the potential difference and l is the length of the conductor.
When the length l is doubled while keeping the potential difference V constant, the electric field E becomes half. As a result, the drift velocity v_d also becomes half.

Final Answer:

$$\boxed{\text{be halved}}$$

Quick Tip

In a conductor, the drift velocity is directly proportional to the electric field, which depends on the potential difference and inversely on the length of the conductor.

---

68. The direction of magnetic field inside a current-carrying solenoid is

(1) circular
(2) parallel to axis
(3) perpendicular to the axis
(4) random

Correct Answer: (2) parallel to axis

Solution:

Inside a current-carrying solenoid, the magnetic field lines are parallel to the axis of the solenoid. This is due to the uniformity of the field produced by the circular current loops, which add up to create a strong, uniform magnetic field along the axis of the solenoid.

Final Answer:

$$\boxed{\text{parallel to axis}}$$

Quick Tip

In a solenoid, the magnetic field is strongest inside and is parallel to the axis of the solenoid.

---

69. Which of the following devices is based on the principle of electromagnetic induction?

(1) Voltmeter
(2) Electric motor
(3) Electric generator
(4) Ammeter

Correct Answer: (3) Electric generator

Solution:

An electric generator operates based on the principle of electromagnetic induction, where a conductor moves through a magnetic field to induce an electric current. This is the working principle of devices like dynamos and generators.

Final Answer:

$$\boxed{\text{Electric generator}}$$

Quick Tip

An electric generator converts mechanical energy into electrical energy using the principle of electromagnetic induction.

70. The self-inductance of a solenoid depends on

(1) The current flowing through its medium
(2) The number of turns per unit length
(3) The length of the solenoid
(4) Both (2) and (3)

Correct Answer: (4) Both (2) and (3)

Solution:

The self-inductance L of a solenoid depends on the number of turns per unit length n and the length of the solenoid. The formula for self-inductance of a solenoid is:

$$L = \mu_0 n^2 A l$$

where μ_0 is the permeability of free space, n is the number of turns per unit length, A is the cross-sectional area, and l is the length of the solenoid. The current does not directly affect the self-inductance but affects the magnetic field inside the solenoid.

Final Answer:

$$\boxed{\text{Both (2) and (3)}}$$

Quick Tip

The self-inductance of a solenoid increases with the number of turns per unit length and the length of the solenoid.

Section-B

1. What do you mean by power of accommodation of eye?

Correct Answer: The power of accommodation of the eye is the ability of the eye to adjust the focal length of the eye lens so as to focus on objects at different distances.

Solution:

The eye lens can change its shape to focus light rays from objects at various distances onto the retina. This change in focal length is known as the accommodation of the eye. The power of accommodation is quantitatively expressed as the difference in the refractive power (in dioptres) of the eye when focusing on the nearest point (least distance of distinct vision, usually 25 cm) and the far point (infinity).

Final Answer:

$$\boxed{\text{Ability of eye lens to focus on objects at different distances by changing its focal length.}}$$

Quick Tip

Power of accommodation measures the flexibility of the eye lens in adjusting focus for near and distant objects.

---

2. Explain electrical resonance.

Correct Answer: Electrical resonance occurs in an AC circuit containing inductance L and capacitance C when the inductive reactance equals the capacitive reactance, resulting in maximum current and voltage across the circuit.

Solution:

Step 1: Understanding AC circuit with L and C.
In a series L-C circuit, the inductive reactance is $X_L = 2\pi f L$ and the capacitive reactance is $X_C = \frac{1}{2\pi f C}$.

Step 2: Condition for resonance.
Electrical resonance occurs when:

$$X_L = X_C \quad \Rightarrow \quad 2\pi f L = \frac{1}{2\pi f C}$$

Step 3: Resonant frequency.
Solving for f, the resonance frequency is:

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$

Step 4: Consequence of resonance.
At resonance, the total impedance of the circuit is minimum (equal to resistance if any), and the current becomes maximum. The voltages across L and C can be very high, even though the applied voltage is finite.

Final Answer:

$$\boxed{\text{Electrical resonance is when } X_L = X_C \text{ in an AC circuit, giving maximum current.}}$$

Quick Tip

Resonance in an AC circuit leads to maximum energy transfer and occurs at $f_0 = \frac{1}{2\pi\sqrt{LC}}$.

---

3. The applied voltage in an alternating circuit is 220 V. If $R = 8\ \Omega$ and $X_L = X_C = 6\ \Omega$, then find the root mean square value of voltage and the impedance of the circuit.

Correct Answer: The root mean square (rms) value of voltage is 220 V, and the impedance Z of the circuit is 10 Ω.

Solution:

Step 1: Calculating Impedance (Z).
In an AC circuit with resistance R and reactance $X_L = X_C$, the impedance Z is given by the formula:

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

Since $X_L = X_C$, we have:

$$Z = \sqrt{R^2 + 0^2} = R$$

Thus, the impedance is:

$$Z = 8\ \Omega$$

Step 2: Calculating RMS voltage.
The root mean square (rms) voltage V_{rms} is related to the peak voltage V_0 by the formula:

$$V_{rms} = \frac{V_0}{\sqrt{2}}$$

Given $V_0 = 220$ V, we can directly conclude that the rms value of the voltage is also 220 V, as the voltage is already given in rms form. Hence,

$$V_{rms} = 220\ \text{V}$$

Final Answer:

$$\boxed{\text{RMS voltage} = 220\ \text{V}, \quad \text{Impedance} = 8\ \Omega}$$

Quick Tip

For an R-L-C circuit with $X_L = X_C$, the impedance becomes purely resistive, i.e., $Z = R$. The rms voltage is simply the applied voltage when the circuit is already described in terms of rms.

---

4. How does the refractive index of any medium depend upon the wavelength of light?

Correct Answer: The refractive index of a medium decreases as the wavelength of light increases. This is because the refractive index (n) is inversely proportional to the wavelength (λ) of light. This behavior is typically observed in the visible spectrum and is described by the phenomenon of dispersion.

Solution:

The refractive index n of a medium is given by the formula:

$$n = \frac{c}{v}$$

where c is the speed of light in vacuum and v is the speed of light in the medium.
Step 1: Relation between refractive index and wavelength.
The speed of light in a medium is related to the refractive index and wavelength by:

$$v = \frac{c}{n}$$

Since the frequency f of the light does not change while passing through a medium, the relation between the speed of light, wavelength, and refractive index can be written as:

$$n = \frac{\lambda_0}{\lambda}$$

where λ_0 is the wavelength of light in vacuum and λ is the wavelength of light in the medium.
Step 2: Effect of wavelength on refractive index.
As the wavelength of light increases, the refractive index decreases. This is because the light waves travel more easily through the medium as their wavelength increases, resulting in a lower refractive index. This phenomenon is most prominent in dispersive media such as glass or water.

Final Answer: The refractive index of any medium is inversely proportional to the wavelength of light. As the wavelength increases, the refractive index decreases.

Quick Tip

In a dispersive medium, the refractive index decreases with increasing wavelength, which is why light of shorter wavelengths (blue) bends more than light of longer wavelengths (red).

---

5. What is Curie temperature?

Correct Answer: Curie temperature (T_C) is the temperature at which a ferromagnetic material undergoes a transition from ferromagnetism to paramagnetism. Above this temperature, the material loses its permanent magnetic properties and becomes paramagnetic.

Solution:

Ferromagnetic materials, such as iron, cobalt, and nickel, have a strong magnetic property at temperatures below a certain critical temperature. This temperature is called the Curie temperature, named after Pierre Curie, who discovered the phenomenon.
Step 1: Behavior below Curie temperature.
Below the Curie temperature (T_C), the individual magnetic moments of the atoms in a ferromagnetic material are aligned in a particular direction due to strong interactions between the magnetic moments. This alignment results in a net macroscopic magnetization, meaning the material behaves as a magnet.
Step 2: Behavior above Curie temperature.
At temperatures above the Curie temperature, the thermal energy becomes large enough to disrupt the alignment of the magnetic moments. As a result, the material loses its ferromagnetic

properties and behaves as a paramagnet, where the magnetic moments are randomly oriented and the material does not exhibit a net magnetization.

Final Answer: The Curie temperature is the critical temperature above which a ferromagnetic material loses its ferromagnetic properties and becomes paramagnetic.

> **Quick Tip**
>
> The Curie temperature is different for each ferromagnetic material. For example, the Curie temperature of iron is approximately 770°C, while for cobalt, it is about 1,115°C.

---

6. Write two properties of paramagnetic substance.

Correct Answer: Two properties of paramagnetic substances are: 1. Paramagnetic substances are weakly attracted to a magnetic field. 2. The magnetic moment of a paramagnetic substance aligns with the applied magnetic field but does not retain the magnetization when the field is removed.

Solution:

Step 1: Weak attraction to magnetic field.
Paramagnetic substances have a positive magnetic susceptibility ($\chi > 0$), meaning they are weakly attracted to an external magnetic field. However, the attraction is not as strong as that in ferromagnetic materials. The degree of magnetization is proportional to the applied magnetic field, but the effect is relatively weak.
Step 2: Alignment with magnetic field.
The magnetic moments of the atoms or molecules in paramagnetic substances tend to align with the external magnetic field, but they do not become permanently magnetized. Once the external magnetic field is removed, the substance loses its magnetization, unlike ferromagnetic substances that retain their magnetization.

Final Answer: - Paramagnetic substances are weakly attracted to magnetic fields. - The magnetic moment of a paramagnetic substance aligns with the applied magnetic field but does not remain after the field is removed.

> **Quick Tip**
>
> Examples of paramagnetic materials include oxygen (O_2) and aluminum (Al), which have unpaired electrons that cause weak attraction to a magnetic field.

---

7. Convert decimal numbers 21 and 43 into their equivalent binary numbers.

Correct Answer: - The binary equivalent of 21_{10} is 10101_2. - The binary equivalent of 43_{10} is 101011_2.

Solution:

Step 1: Convert 21 to binary.
Divide 21 by 2 and note the remainder:

$$21 \div 2 = 10 \text{ remainder } 1 10 \div 2 = 5 \text{ remainder } 0 5 \div 2 = 2 \text{ remainder } 1 2 \div 2 = 1 \text{ remainder } 0 1 \div 2 = 0 \text{ remainde}$$

Now, read the remainders from bottom to top, the binary equivalent of 21 is 10101_2.
Step 2: Convert 43 to binary.
Similarly, divide 43 by 2:

$$43 \div 2 = 21 \text{ remainder } 1 21 \div 2 = 10 \text{ remainder } 1 10 \div 2 = 5 \text{ remainder } 0 5 \div 2 = 2 \text{ remainder } 1 2 \div 2 = 1 \text{ remain}$$

Reading the remainders from bottom to top, the binary equivalent of 43 is 101011_2.

Final Answer: - The binary equivalent of 21_{10} is 10101_2. - The binary equivalent of 43_{10} is 101011_2.

Quick Tip

To convert a decimal number to binary, divide the number by 2, record the remainder, and repeat until the quotient is zero. The binary number is the sequence of remainders read from bottom to top.

---

8. Write down the difference between nuclear fission and nuclear fusion.

Correct Answer: Nuclear fission: Splitting of a heavy nucleus into two or more lighter nuclei with the release of energy. Nuclear fusion: Combining of two light nuclei to form a heavier nucleus with the release of energy.

Solution:

Step 1: Understand nuclear fission.
- In fission, a heavy nucleus (e.g., Uranium-235 or Plutonium-239) absorbs a neutron and splits into two lighter nuclei.
- This process releases a large amount of energy, additional neutrons, and gamma radiation.
- Fission is used in nuclear power plants and atomic bombs.

Step 2: Understand nuclear fusion.
- In fusion, two light nuclei (e.g., Hydrogen isotopes) combine to form a heavier nucleus (e.g., Helium).
- This process releases tremendous energy, much higher per reaction than fission.
- Fusion occurs in the Sun and stars and is used in hydrogen bombs and proposed fusion reactors.

Step 3: Key Differences.

Property	Fission	Fusion
Process	Splitting of heavy nucleus	Combining of light nuclei
Energy Released	Large	Very large
Example	U-235 + n $\rightarrow$ Kr + Ba + 3n	D + T $\rightarrow$ He + n
Application	Nuclear reactors, atomic bombs	Hydrogen bombs, stars

Final Answer: - Fission: Heavy nucleus splits $\rightarrow$ energy release. - Fusion: Light nuclei combine $\rightarrow$ energy release.

Quick Tip

Remember: Fission = Split, Fusion = Fuse; both release energy but fusion releases more per reaction.

---

9. Write the necessary conditions for total internal reflection of light.

Correct Answer: 1. Light must be travelling from a denser medium to a rarer medium. 2. The angle of incidence must be greater than the critical angle for the given pair of media.

Solution:

Step 1: Understand total internal reflection.
- Total internal reflection is the complete reflection of light at the boundary of two media.
- It occurs when light travels from a denser medium to a rarer medium (e.g., from water to air, or from glass to air).
- No light passes into the second medium; it is entirely reflected back into the denser medium.

Step 2: Condition 1 - Light must move from denser to rarer medium.
- This is because, for the phenomenon to occur, the speed of light must decrease when transitioning from the denser to the rarer medium.

Step 3: Condition 2 - Angle of incidence must exceed the critical angle.
- The critical angle is the minimum angle of incidence for which total internal reflection occurs.
- If the angle of incidence is greater than the critical angle, no light refracts into the second medium, and total internal reflection happens.

Step 4: Key Formula for Critical Angle.
- The critical angle θ_c is given by:

$$\theta_c = \sin^{-1}\left(\frac{n_2}{n_1}\right)$$

where n_1 is the refractive index of the denser medium, and n_2 is the refractive index of the rarer medium.

Final Answer: For total internal reflection: - The light must be moving from denser to rarer medium. - The angle of incidence must be greater than the critical angle.

Quick Tip

For total internal reflection, remember: Angle ¿ Critical angle = Total internal reflection!

---

10. Write Fleming's left hand rule.

Correct Answer: Fleming's Left Hand Rule states that: - If the first finger, the second finger, and the thumb of the left hand are held at right angles to each other, then: - The first finger points in the direction of the magnetic field (north to south). - The second finger points in the direction of the current (from positive to negative). - The thumb will point in the direction of the motion of the conductor (force acting on it).

Solution:

Step 1: Understanding the rule.
- Fleming's Left Hand Rule is used to determine the direction of force experienced by a current-carrying conductor placed in a magnetic field.
- The rule is applicable in situations where we are working with motors or generators.

Step 2: Directions of fingers.
- First Finger: It represents the direction of the magnetic field (denoted as B), pointing from the North pole to the South pole of the magnetic field.
- Second Finger: It indicates the direction of the current (I), which flows from the positive terminal to the negative terminal.
- Thumb: It shows the direction of the force (F) on the conductor due to the interaction of the magnetic field and current. The force moves perpendicular to both the magnetic field and current.

Step 3: Important application.
- This rule is used in electric motors to find the direction of rotation of the motor's armature. The current in the armature and the magnetic field produce a force that causes the armature to rotate.

Final Answer: Fleming's Left Hand Rule helps determine the direction of force in a conductor, based on the directions of the magnetic field and current.

Quick Tip

Remember: Left hand = magnetic field, current, and force (in that order).

---

11. Write down two basic differences between interference and diffraction.

Correct Answer:
Two basic differences between interference and diffraction are:

Solution:
1. Nature of Phenomena: - Interference is the phenomenon where two or more waves superimpose to form a resultant wave, either enhancing (constructive interference) or reducing (destructive interference) the overall amplitude. - Diffraction, on the other hand, occurs when a wave encounters an obstacle or aperture that is comparable in size to its wavelength, causing the wave to bend around the edges and spread out.
2. Occurrence: - Interference requires at least two coherent sources of light (light with a constant phase relationship) to produce constructive and destructive interference patterns. - Diffraction occurs due to the wave nature of light and can happen with a single wave passing through an aperture or around an obstacle, without needing multiple sources.
Final Answer: - Interference is the superposition of waves to form a resultant wave, while diffraction is the bending and spreading of waves around obstacles. - Interference requires multiple coherent sources, while diffraction can occur with a single wave.

Quick Tip

Remember: Interference is about wave superposition, while diffraction deals with wave bending around obstacles.

---

12. Compare the magnetic properties of steel and soft iron.

Correct Answer:
The magnetic properties of steel and soft iron differ significantly in the following ways:

Solution: 1. Magnetic Retentivity: - Steel: Steel has high magnetic retentivity, meaning it retains its magnetism even after the external magnetic field is removed. This property makes it suitable for making permanent magnets. - Soft Iron: Soft iron has low magnetic retentivity, meaning it loses its magnetism as soon as the external field is removed. It is suitable for temporary magnets or electromagnets.
2. Magnetic Permeability: - Steel: Steel has lower magnetic permeability, meaning it is less efficient at becoming magnetized in a magnetic field. - Soft Iron: Soft iron has high magnetic permeability, meaning it becomes magnetized more easily when exposed to a magnetic field.
3. Application: - Steel: Steel is used for making permanent magnets due to its ability to retain magnetization. - Soft Iron: Soft iron is used in applications where temporary magnetization is required, such as in electromagnets, transformers, and electrical machines.

Final Answer: Steel has high retentivity and low permeability, making it suitable for permanent magnets, while soft iron has high permeability and low retentivity, making it suitable for temporary magnets.

Quick Tip

Steel is ideal for permanent magnets due to high retentivity, while soft iron is ideal for electromagnets due to high permeability.

---

13. Mention the two characteristic properties of the material suitable for making core of a transformer.

Correct Answer:
The material suitable for making the core of a transformer should possess the following two characteristic properties:

Solution:
1. High Magnetic Permeability: - The material should have a high magnetic permeability, which means it should allow magnetic lines of force to pass through it easily. This increases the efficiency of the transformer by minimizing energy loss due to reluctance.
2. Low Hysteresis Loss: - The material should have low hysteresis loss. Hysteresis loss occurs due to the lag between the magnetization and demagnetization of the core material during alternating current (AC) operation. Materials with low hysteresis loss minimize energy waste and improve transformer efficiency.
Final Answer: Materials suitable for transformer cores should have high magnetic permeability and low hysteresis loss for efficient performance.

Quick Tip

For transformer cores, materials with high permeability and low hysteresis loss (like silicon steel) are preferred to minimize energy losses.

---

14. A proton and an electron have the same kinetic energy. Which one has the greater de Broglie wavelength and why?

Correct Answer:
The electron will have the greater de Broglie wavelength.

Solution:
The de Broglie wavelength (λ) of a particle is given by the formula:

$$\lambda = \frac{h}{p}$$

where h is Planck's constant, and p is the momentum of the particle, which is the product of its mass m and velocity v:

$$p = mv$$

Now, since the proton and the electron have the same kinetic energy, the kinetic energy K is given by:

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

For a given kinetic energy, the velocity v of a particle is inversely proportional to the square root of its mass. Since the electron has much less mass than the proton, it will have a greater velocity. Given that the de Broglie wavelength is inversely proportional to the momentum ($\lambda \propto \frac{1}{mv}$), the electron, which has a higher velocity and lower mass, will have a greater momentum and therefore a greater de Broglie wavelength than the proton.

Final Answer: The electron has the greater de Broglie wavelength because, for the same kinetic energy, the electron, having a smaller mass, moves faster and thus has a greater wavelength.

Quick Tip

The de Broglie wavelength of a particle is inversely proportional to its momentum, and for the same kinetic energy, lighter particles (like electrons) have a higher velocity and thus a greater wavelength.

---

15. Define volume density of charge. Write its SI unit.

Solution:
The volume density of charge is defined as the amount of electric charge per unit volume of a region in space.

$$\rho_v = \frac{dq}{dV}$$

where dq is the infinitesimal charge contained in an infinitesimal volume dV.

SI Unit: The SI unit of volume charge density is Coulomb per cubic metre ($\mathrm{C/m^3}$).

Quick Tip

Volume charge density indicates how much charge is distributed in a given volume of space and is different from surface or linear charge densities.

---

16. Explain magnetic moment. Write its SI unit.

Solution:
Magnetic moment ($\vec{\mu}$) is a vector quantity that represents the strength and orientation of a magnet's magnetic field. It is defined as the product of the current flowing through a loop of wire and the area of the loop.

$$\vec{\mu} = I \cdot A$$

where: - I is the current flowing through the loop, and - A is the area of the loop.
Magnetic moment is also used to describe the torque a magnet experiences in an external magnetic field.

SI Unit: The SI unit of magnetic moment is Ampere-meter squared ($\mathrm{A{\cdot}m^2}$).

Quick Tip

The magnetic moment of a current loop is directly proportional to the current and the area of the loop. For a bar magnet, it represents how strongly the magnet interacts with an external magnetic field.

---

17. Write two properties of beta (β) rays.

Solution:
Beta rays (β-rays) are high-energy, high-speed electrons (β^-) or positrons (β^+) emitted during the radioactive decay of certain types of nuclei. Two important properties of beta rays are:
1. Penetrating Power: Beta rays have greater penetrating power than alpha rays, but they are less penetrating than gamma rays. They can pass through materials like paper and thin plastic but can be stopped by materials like aluminum.
2. Charge and Mass: Beta rays consist of electrons (β^-) or positrons (β^+), which carry a charge of -1 or $+1$ (respectively) and have a mass equal to that of an electron (9.11×10^{-31} kg).

Quick Tip

Beta rays are a form of ionizing radiation and are commonly associated with beta decay in radioactive elements. They are stopped by materials such as aluminum or glass.

---

18. Explain Bohr's stable orbit.

Solution:
Bohr's stable orbit refers to the orbits of electrons in an atom that are stable, non-radiating, and do not lose energy as they move around the nucleus. According to Bohr's model of the atom:
1. Electron Movement in Quantized Orbits: Electrons revolve around the nucleus in fixed, circular orbits without radiating energy. These orbits are called stable orbits, and the electron does not spiral into the nucleus despite being attracted by the Coulomb force.
2. Quantized Energy Levels: The electron in a stable orbit can only have specific, quantized energy levels. These energy levels are determined by the radius of the orbit. The allowed orbits are those for which the angular momentum of the electron is an integer multiple of $\hbar$ (reduced Planck's constant). This is given by:

$$mvr = n\hbar$$

where n is a positive integer, m is the electron's mass, v is its velocity, and r is the radius of the orbit.
3. No Radiation in Stable Orbits: In these stable orbits, the electron does not emit radiation, and thus it does not lose energy. If the electron radiated energy, it would spiral into the nucleus, but in Bohr's model, this does not happen as long as the electron is in one of the allowed orbits.

Quick Tip

Bohr's stable orbit model explains why atoms emit or absorb light only at certain discrete frequencies, corresponding to the transition of electrons between quantized energy levels.

---

19. An electric dipole is held in a uniform electric field. The dipole is aligned parallel to the electric field. Find the work done in rotating it through an angle of $180°$.

Solution:
To find the work done in rotating an electric dipole in a uniform electric field, we use the formula for the potential energy of a dipole in an electric field.
The potential energy U of a dipole in an electric field is given by:

$$U = -\vec{p} \cdot \vec{E} = -pE\cos\theta$$

where: - p is the dipole moment, - E is the electric field strength, - θ is the angle between the dipole moment and the electric field.
Step 1: Initial and Final Potential Energies
- Initially, the dipole is aligned parallel to the electric field, so $\theta_1 = 0°$. The potential energy at this position is:

$$U_1 = -pE\cos 0° = -pE$$

- After rotating the dipole through an angle of $180°$, the dipole becomes anti-parallel to the electric field, so $\theta_2 = 180°$. The potential energy at this position is:

$$U_2 = -pE\cos 180° = pE$$

Step 2: Work Done in Rotating the Dipole
The work done in rotating the dipole from the initial position to the final position is the change in potential energy:

$$W = U_2 - U_1 = pE - (-pE) = 2pE$$

Thus, the work done in rotating the dipole through an angle of $180°$ is:

$$\boxed{2pE}$$

Quick Tip

The work done in rotating an electric dipole in a uniform electric field depends on the change in the orientation of the dipole with respect to the field. In this case, it is directly related to the dipole moment and the electric field strength.

---

20. Mention two different modes of propagation used in communication system.

Solution:
Two modes of propagation used in communication systems are:

1. Ground Wave Propagation: - In this mode, the radio waves travel along the Earth's surface. The waves are guided by the curvature of the Earth and are usually used for long-range communication over the surface of the Earth. This type of propagation is effective at lower frequencies (MF and HF bands).
2. Sky Wave Propagation: - In this mode, radio waves are reflected from the ionosphere back to the Earth's surface, allowing communication over long distances. This type of propagation is primarily used for high-frequency communication and is affected by factors such as time of day, solar activity, and the frequency of the wave.
These modes are essential for long-distance communication, especially in radio and television transmission.

Quick Tip

Ground wave propagation is mainly used for short-range communication, while sky wave propagation is used for long-range communication, especially when the Earth's curvature limits direct line-of-sight propagation.

Section-C

21. State and prove Gauss's theorem in electrostatics. Calculate the electric field intensity at a point outside a hollow uniformly charged sphere.

Solution:
Gauss's Theorem: Gauss's theorem, also known as Gauss's law, states that the net electric flux Φ_E passing through a closed surface is proportional to the total electric charge enclosed within the surface. Mathematically, it is expressed as:

$$\Phi_E = \oint_S \vec{E} \cdot d\vec{A} = \frac{Q_{\text{enc}}}{\varepsilon_0}$$

Where: - Φ_E is the electric flux passing through the closed surface S, - $\vec{E}$ is the electric field intensity at each point on the surface, - $d\vec{A}$ is the differential area vector on the surface, - Q_{enc} is the total charge enclosed by the surface, - ε_0 is the permittivity of free space.

Proof of Gauss's Theorem: Consider a point charge Q placed at the center of a spherical Gaussian surface of radius r.
1. The electric field due to the point charge is radially symmetric and directed outward. 2. The magnitude of the electric field at any point on the spherical surface is given by Coulomb's law:

$$E = \frac{1}{4\pi\varepsilon_0} \frac{Q}{r^2}$$

Where r is the distance from the center of the charge.
3. The area of the spherical Gaussian surface is given by:

$$A = 4\pi r^2$$

4. The electric flux passing through the spherical surface is:

$$\Phi_E = E \cdot A = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2} \cdot 4\pi r^2$$

Simplifying this expression, we get:

$$\Phi_E = \frac{Q}{\varepsilon_0}$$

Thus, Gauss's law is proven for a point charge.

Electric Field Intensity Outside a Hollow Uniformly Charged Sphere: Now, consider a hollow uniformly charged sphere with charge Q. According to Gauss's law, the electric field outside a spherical shell is equivalent to the electric field produced by a point charge Q located at the center of the sphere.
1. Choose a spherical Gaussian surface outside the sphere with radius r, where $r > R$ (the radius of the shell). 2. The electric field at any point on this surface will be radial and directed outward. 3. By symmetry, the magnitude of the electric field at any point on the surface will be:

$$E = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}$$

Thus, the electric field intensity at a point outside the hollow uniformly charged sphere is identical to that produced by a point charge Q located at the center of the sphere.

Final Answer: The electric field intensity at a point outside the hollow uniformly charged sphere is:

$$E = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}$$

Where r is the distance from the center of the sphere to the point of interest.

> Quick Tip
>
> Gauss's law is particularly useful for calculating electric fields in highly symmetric situations, such as spherical, cylindrical, or planar symmetry.

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22. State Kirchhoff's laws and use them to obtain the condition for balance of a Wheatstone bridge.

Solution:
Kirchhoff's Laws:
Kirchhoff's laws are two fundamental rules used to analyze electric circuits. They are:

1. Kirchhoff's Current Law (KCL): It states that the algebraic sum of currents at any junction in a circuit is zero. Mathematically,

$$\sum I_{\text{in}} = \sum I_{\text{out}}$$

This implies that the total current entering a junction is equal to the total current leaving the junction.

2. Kirchhoff's Voltage Law (KVL): It states that the algebraic sum of the potential differences (voltages) around any closed loop or mesh is zero. Mathematically,

$$\sum V = 0$$

This implies that the sum of the voltage drops and rises in a closed loop is zero.

Condition for Balance of Wheatstone Bridge:
A Wheatstone bridge is a circuit used to measure an unknown resistance by balancing two legs of a bridge circuit. It consists of four resistances arranged in a diamond shape:
- R_1, R_2 are known resistors, - R_3 is the unknown resistor, - R_4 is a variable resistor (or known resistor).
A galvanometer is connected between the middle points of the two legs, and a battery is connected to the ends of the bridge.

For balance, no current should flow through the galvanometer. This means the potential difference across the galvanometer is zero.
Using Kirchhoff's laws, we apply KVL to the two loops in the Wheatstone bridge.
1. For loop 1 (containing R_1, R_2, and the battery):
Let the potential difference across the resistors be V_1, V_2, and V_g (across the galvanometer).

$$V_1 = IR_1, \quad V_2 = IR_2$$

2. For loop 2 (containing R_3, R_4, and the battery):
Similarly, for the second loop:

$$V_3 = I'R_3, \quad V_4 = I'R_4$$

Since the galvanometer is in the middle, the potential across the galvanometer must be zero:

$$V_1 - V_2 = V_3 - V_4$$

This implies:

$$IR_1 - IR_2 = I'R_3 - I'R_4$$

By simplifying this equation, we get the condition for balance of the Wheatstone bridge:

$$\frac{R_1}{R_2} = \frac{R_3}{R_4}$$

Final Answer: The condition for balance of the Wheatstone bridge is:

$$\frac{R_1}{R_2} = \frac{R_3}{R_4}$$

This means that when the ratio of the two known resistors R_1 and R_2 is equal to the ratio of the unknown resistor R_3 and the variable resistor R_4, the bridge will be balanced, and the galvanometer will show zero current.

Quick Tip

In a balanced Wheatstone bridge, the ratio of the resistances in one arm is equal to the ratio of the resistances in the other arm. This is used for precise measurement of unknown resistances.

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23. Define wavefront and secondary wavelets. Verify the law of reflection on the basis of Huygens' wave theory.

Solution:
Wavefront:
A wavefront is the locus of all points in a medium that are in the same phase of vibration. In simple terms, it is a surface on which all points are vibrating in unison. Wavefronts can be classified into three types based on the shape of the wave:
1. Spherical Wavefront: These are wavefronts produced by a point source and are spherical in shape. 2. Planar Wavefront: These wavefronts are produced by a plane source and are flat. 3. Cylindrical Wavefront: These wavefronts are produced by a line source and are cylindrical in shape.

Secondary Wavelets:
Secondary wavelets are the new waves that are generated from each point on the primary wavefront, as per Huygens' principle. According to this principle, every point on a wavefront can be considered as a source of secondary spherical wavelets that spread out in all directions with the speed of the wave. These wavelets combine to form the new wavefront at a later time.

Huygens' Principle and Law of Reflection:
Huygens' principle states that every point on a wavefront acts as a source of secondary wavelets. The new wavefront is formed by the envelope of these secondary wavelets. This principle is used to explain the behavior of light and the phenomena of reflection and refraction.
To verify the law of reflection using Huygens' principle:

1. Consider a wavefront incident on a plane mirror at an angle θ_i.
2. Each point on the incident wavefront acts as a source of secondary wavelets. The wavefront can be thought of as the envelope of all these wavelets.
3. After reflection, the secondary wavelets at the surface of the mirror generate a reflected wavefront.
4. According to Huygens' principle, the direction of the reflected wavefront will be such that the angle of incidence θ_i is equal to the angle of reflection θ_r. The angle between the normal to the mirror and the incident wavefront is θ_i, and the angle between the normal and the reflected wavefront is θ_r.
5. Since the reflected wavefront is formed by the envelope of the secondary wavelets, the law of reflection (i.e., $\theta_i = \theta_r$) is verified.

This is how Huygens' principle explains the law of reflection in a simple and intuitive way.

Quick Tip

Huygens' principle is a powerful tool for explaining wave phenomena like reflection, refraction, and diffraction by treating each point on a wavefront as a source of secondary wavelets.

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24. What is equivalent lens? Derive an expression for equivalent focal length of two lenses of focal lengths f_1 and f_2 kept at a distance d.

Solution:
Equivalent Lens:
An equivalent lens is a single lens that produces the same effect as a system of two or more lenses placed together. When two lenses are placed in contact or at a finite distance from each other, we can replace the entire system with a single equivalent lens that has the same focal length and other optical properties as the original system. This equivalent lens will produce the same image for any given object as the combination of lenses would have done.

Expression for Equivalent Focal Length:
Let us consider two thin lenses with focal lengths f_1 and f_2 placed in air at a distance d apart. Let the object be placed at a distance u from the first lens, and let the image formed by the first lens serve as the object for the second lens.
The first lens produces an image at a distance v_1, and the second lens forms the final image at a distance v_2. The object distance for the second lens is the distance from the first image to the second lens, which is $d - v_1$.
We know that for each lens, the lens equation holds:

$$\frac{1}{f_1} = \frac{1}{v_1} - \frac{1}{u}$$

$$\frac{1}{f_2} = \frac{1}{v_2} - \frac{1}{d - v_1}$$

Since the final image is formed by the second lens, the object distance for the system is the effective distance between the first object and the final image. Thus, the equivalent focal length f_{eq} of the system can be found by using the relation for combined focal lengths of two thin lenses:

$$\frac{1}{f_{\text{eq}}} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$$

This is the expression for the equivalent focal length of two lenses placed at a distance d apart.

Quick Tip

For two lenses placed at a distance, the combined focal length is not simply the sum of individual focal lengths but also depends on the distance between the lenses.

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25. Define self-inductance and mutual inductance. Find an expression for mutual inductance of two coaxial solenoids.

Solution:

Self-Inductance:

Self-inductance is a property of a coil (or solenoid) that quantifies its ability to induce an emf (electromotive force) in itself when there is a change in the current passing through it. The self-induced emf is proportional to the rate of change of current, and the constant of proportionality is called the self-inductance, denoted by L. Mathematically,

$$\text{Induced emf} = -L\frac{dI}{dt}$$

where L is the self-inductance, and $\frac{dI}{dt}$ is the rate of change of current.

Mutual Inductance:

Mutual inductance is a property of two coils placed near each other. When the current in one coil changes, it induces an emf in the other coil. The mutual inductance M between two coils is defined as the constant of proportionality between the induced emf in the second coil and the rate of change of current in the first coil. Mathematically,

$$\text{Induced emf in coil 2} = -M\frac{dI_1}{dt}$$

where M is the mutual inductance, and $\frac{dI_1}{dt}$ is the rate of change of current in coil 1.

Expression for Mutual Inductance of Two Coaxial Solenoids:

Consider two coaxial solenoids, each with N_1 and N_2 turns, radii r_1 and r_2, and lengths l_1 and l_2. Let I_1 be the current in the first solenoid and I_2 be the current in the second solenoid. The mutual inductance M depends on the magnetic flux linkage between the two solenoids.

The magnetic field B produced by the first solenoid is given by:

$$B = \frac{\mu_0 N_1 I_1}{l_1}$$

where μ_0 is the permeability of free space.

The flux Φ linking the second solenoid is:

$$\Phi = B \cdot A \cdot N_2 = \frac{\mu_0 N_1 I_1 A N_2}{l_1}$$

where A is the cross-sectional area of the solenoids.

The mutual inductance M is defined as the ratio of the induced flux in the second solenoid to the rate of change of current in the first solenoid:

$$M = \frac{\Phi}{dI_1/dt} = \frac{\mu_0 N_1 N_2 A}{l_1}$$

Thus, the expression for the mutual inductance of two coaxial solenoids is:

$$M = \frac{\mu_0 N_1 N_2 A}{l_1}$$

Quick Tip

Mutual inductance depends on the geometry of the coils and the relative positioning of the two coils, such as the length, radius, and number of turns.

26. What is photoelectric effect? What are the laws of photoelectric effect? Explain this law given by Einstein.

Solution:
Photoelectric Effect:
The photoelectric effect is the phenomenon in which electrons are ejected from a material (usually a metal) when it is exposed to light or electromagnetic radiation. This effect was first observed by Heinrich Hertz in 1887 and was later explained by Albert Einstein in 1905. The ejected electrons are called photoelectrons. The photoelectric effect demonstrates the particle nature of light, as the energy of the incident photons is absorbed by the electrons, which leads to their ejection from the metal surface.

Laws of Photoelectric Effect:
1. Effect of Intensity of Light: - The number of photoelectrons emitted is directly proportional to the intensity of the incident light, provided that the frequency of the light is above a certain threshold frequency. Higher intensity means more photons striking the surface, which leads to more ejected electrons.
2. Effect of Frequency of Light: - Photoelectrons are emitted only when the frequency of the incident light is greater than or equal to a certain threshold frequency (f_0) specific to the material. Below this frequency, no photoelectrons are emitted regardless of the intensity of light.
3. Effect of Kinetic Energy of Photoelectrons: - The kinetic energy of the emitted photoelectrons depends on the frequency of the incident light and not on its intensity. Higher frequency light results in higher kinetic energy of the photoelectrons.

Einstein's Explanation of Photoelectric Effect:
Einstein extended Max Planck's quantum theory to explain the photoelectric effect. According to Einstein, light consists of discrete packets of energy called photons. The energy E of a photon is given by the equation:

$$E = hf$$

where h is Planck's constant, and f is the frequency of the light.
When light strikes the surface of a material, the energy from the photons is transferred to the electrons. For an electron to be ejected, the energy of the photon must be greater than or equal to the work function (W) of the material, which is the minimum energy required to release an electron from the surface. If the energy of the photon is greater than the work function, the excess energy is converted into the kinetic energy of the ejected electron.
The equation governing this process is:

$$hf = W + K.E.$$

where: - hf is the energy of the incoming photon, - W is the work function of the material, - $K.E.$ is the kinetic energy of the emitted electron.
Thus, Einstein's theory provided a quantum mechanical explanation for the photoelectric effect, confirming that light behaves as both a wave and a particle.

Quick Tip

The photoelectric effect is one of the key pieces of evidence supporting the particle nature of light and the concept of photons.
