CUET UG (Physics)

19 July 2024 Shift 1

Question 1

A uniform electric field pointing in the positive X direction exists in a region. Let O be the origin, A be the point on the X axis at x = +2 cm and B be the point on the Y axis at y = +1 cm. Then potential at the point O, A and B satisfy:

Options:

A. $V_0 > V_A$

B. $V_0 < V_A$

C. $V_0 > V_B$

D. $V_0 < V_B$

Answer: A

Solution:

The correct answer is - $V_0 > V_A$

Key Points

- **Electric potential**
  - In a **uniform electric field** pointing in the positive X direction, the electric potential **decreases** as we move in the direction of the field.
  - Since point A is at **x = +2 cm** and the field points in the positive X direction, the potential at A (**VA**) will be lower than the potential at the origin (**V_0**).
- **Potential difference**
  - The potential difference between two points in an electric field is given by **V = Ed**, where **E** is the electric field strength and **d** is the distance.
  - Since A is further from the origin in the direction of the electric field, **$V_0 > V_A$**.

Additional Information

- **Electric field direction**
  - The direction of the electric field is defined as the direction in which a **positive test charge** would move.
  - In this case, the field points in the positive X direction, meaning it pushes positive charges in that direction.
- **Potential at point B**
  - Point B is on the Y axis at **y = +1 cm**.
  - Since the electric field is along the X axis, there is no change in potential along the Y axis.
  - Therefore, the potential at B (**V_B**) is the same as the potential at the origin (**V_0**).
- **Electric field strength**
  - The electric field strength **E** is uniform, meaning it has the same magnitude and direction at all points in the region.
  - This uniformity simplifies the calculation of potential differences as it depends only on the distance in the direction of the field.

Question 2

An electric bulb rated 200 V - 100 W is connected to a 160 V power supply. The power consumed by it would be:

Options:

A. 64 W

B. 80 W

C. 100 W

D. 125 W

Answer: A

Solution:

The correct answer is - <u>64 W</u>

Key Points

- **Power consumed by the bulb**
  - The electric bulb is rated at **200 V** and **100 W**, which means it consumes 100 W of power when connected to a 200 V supply.
  - The power consumed by the bulb when connected to a different voltage can be calculated using the formula:
    $P = V^2 / R$
  - First, calculate the resistance (R) of the bulb when it operates at its rated values:
    $R = V^2 / P$
    $R = (200)^2 / 100 = 400\ \Omega$
  - Now, use the resistance to calculate the power consumed at 160 V:
    $P = V^2 / R$
    $P = (160)^2 / 400 = 64$ W
  - Therefore, the power consumed by the bulb when connected to a 160 V power supply is **64 W**.

Additional Information

- **Understanding Electric Power**
  - Electric power is the rate at which electrical energy is transferred by an electric circuit. The SI unit of power is the watt (W).
  - Power (P) in a resistive load (such as a bulb) can be calculated using:
    $P = V \times I$, where V is the voltage across the load and I is the current through the load.
  - For resistive loads, Ohm's Law ($V = I \times R$) can be used to relate voltage, current, and resistance.
  - Other relevant formulas include:
    $P = I^2 \times R$ and **$P = V^2 / R$**
- **Voltage and Resistance in Bulbs**
  - The rated voltage of a bulb indicates the voltage at which the bulb is designed to operate optimally.
  - Operating a bulb at a voltage lower or higher than its rated voltage can affect its power consumption and lifespan.
  - Resistance in a bulb usually remains constant, as it is determined by the material and geometry of the filament.

Question 3

Which of the following particles will experience maximum magnetic force (magnitude) when projected with the same velocity perpendicular to the magnetic field?
Choose the correct answer from the options given below.

Options:

A. Electron

B. Proton

C. He^+

D. Li^{++}

Answer: D

Solution:

The correct answer is -Li^{++}

Key Points

- **Electron**
  - The magnetic force on a charged particle moving in a magnetic field is given by the formula **$F = qvB \sin(\theta)$**, where **q** is the charge, **v** is the velocity, **B** is the magnetic field strength, and **θ** is the angle between the velocity and the magnetic field.

- Since all particles are projected with the same velocity and perpendicular to the magnetic field, **$\sin(\theta) = 1$**.
- The force depends only on the **charge** of the particle. The charge of an electron is **-1.6×10^{-19} C**, the charge of a proton is **$+1.6 \times 10^{-19}$ C**, the charge of He^{+} is **$+1.6 \times 10^{-19}$ C**, and the charge of Li^{++} is **$+3.2 \times 10^{-19}$ C**.
- Li^{++}experience the maximum force for the same amount of charge and velocity.

Additional Information

- **Magnetic Force Formula**
  - The magnetic force on a moving charge is given by **$F = qvB \sin(\theta)$**.
  - For a charge moving perpendicular to the magnetic field, **$\theta = 90°$** and **$\sin(90°) = 1$**.
- **Charge and Mass Relationship**
  - Although the force formula only includes charge, the **mass** of the particle affects its motion and how it reacts to the force.
  - An electron, having the smallest mass among the given particles, will experience the largest acceleration and hence the greatest force.

Question 4

An a.c. circuit contains a 4 Ω resistance wire in series with an inductance coil of reactance 3 Ω. The impedance of the circuit is:

Options:

A. 7 Ω

B. 5 Ω

C. 1 Ω

D. 4/3 Ω

Answer: B

Solution:

The correct answer is - 5 Ω

Key Points

- **Impedance Calculation**
  - In an a.c. circuit, the impedance (**Z**) is the total opposition to the flow of alternating current, combining both resistance (**R**) and reactance (**X**).
  - The formula for impedance in a series circuit is: **$Z = \sqrt{R^2 + X^2}$**
- **Given Values**
  - Resistance, **$R = 4\ \Omega$**
  - Reactance, **$X = 3\ \Omega$**
- **Impedance Calculation**
  - Substituting the given values into the formula: **$Z = \sqrt{4^2 + 3^2}$**
  - Calculate: **$Z = \sqrt{16 + 9} = \sqrt{25} = 5\ \Omega$**

Additional Information

- **Impedance in AC Circuits**
  - Impedance is a comprehensive measure that includes both resistance (R) and reactance (X).
  - Reactance can be inductive (XL) or capacitive (XC).
  - Inductive reactance is given by: **$XL = 2\pi fL$** where **f** is the frequency and **L** is the inductance.
- **Phasor Representation**
  - Impedance can be represented as a phasor, combining magnitude and phase angle.
  - The phase angle (φ) between the voltage and current can be found using: **$\tan(\varphi) = X/R$**
  - In this case: **$\tan(\varphi) = 3/4$**
- **Applications of Impedance**
  - Understanding impedance is crucial for designing and analyzing AC circuits.
  - Impedance affects power distribution and the resonance in circuits.

Question 5

Magnetic moment due to the motion of the electron in the nth energy state of a hydrogen atom is proportional to:

Options:

A.

n

B.

n^2

C.

n^3

D.

n^0

Answer: A

Solution:

The correct answer is - n

Key Points

- **Magnetic moment**
  - The **magnetic moment** due to the motion of an electron in an atom is directly related to its **orbital angular momentum**.
- **Bohr's model**
  - According to **Bohr's model**, the orbital angular momentum of an electron in the nth energy state is quantized and given by $L = n\hbar$, where $\hbar$ is the reduced Planck's constant.
- **Proportionality**
  - The **magnetic moment** is proportional to the orbital angular momentum, hence it is also proportional to n.

Additional Information

- **Bohr's quantization condition**
  - Bohr postulated that electrons move in orbits of fixed size and energy, and the angular momentum is quantized as $L = n\hbar$.
  - This quantization leads to discrete energy levels and magnetic moments associated with each energy state.
- **Magnetic dipole moment**
  - The magnetic dipole moment μ due to an electron's orbital motion is given by $\mu = \frac{e}{2m}L$, where e is the electron charge, and m is its mass.
  - Since $L = n\hbar$, the magnetic moment μ is directly proportional to n.
- **Energy levels in hydrogen atom**
  - In a hydrogen atom, the energy of an electron in the nth orbit is given by $E_n = -\frac{13.6 \text{ eV}}{n^2}$.
  - Despite the n^2 dependence of energy, the magnetic moment due to orbital motion depends linearly on n.

Question 6

Energy levels A, B, C of a certain atom correspond to increasing value of energy $E_A < E_B < E_C$. If λ_1, λ_2, λ_3 are the wavelengths of radiation corresponding to the transitions C → B, B → A and C → A respectively, then:

Options:

A. $\lambda_3 = \lambda_1 + \lambda_2$

B. $\lambda_1 = \lambda_2 = \lambda_3$

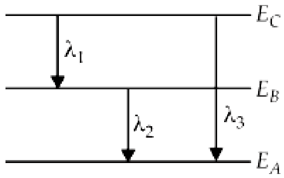
C. $\lambda_3^2 = \lambda_1^2 + \lambda_2^2$

D. $\lambda_3 = \frac{\lambda_1 \lambda_2}{\lambda_1 + \lambda_2}$

Answer: D

Solution:

The correct answer is -$\lambda_3 = \frac{\lambda_1 \lambda_2}{\lambda_1 + \lambda_2}$



We are given that energy levels A, B, and C correspond to increasing energy levels ($E_A < E_B < E_C$), and we are provided with the wavelengths λ_1, λ_2, and λ_3, which correspond to the transitions C → B, B → A, and C → A, respectively. We are asked to find the relationship between λ_3, λ_1, and λ_2.

We start by applying the energy difference between the levels. Since the energy difference between levels C and A is equal to the sum of the differences between C and B, and B and A:

$E_C - E_A = E_C - E_B + E_B - E_A$

Using the energy-wavelength relation, $E = hc / \lambda$, where h is Planck's constant and c is the speed of light, we can write:

$(hc / \lambda_3) = (hc / \lambda_1) + (hc / \lambda_2)$

Canceling out hc from both sides:

$1 / \lambda_3 = 1 / \lambda_1 + 1 / \lambda_2$

Thus, the relationship between λ_3, λ_1, and λ_2 is:

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

Hence, the correct answer is: $\lambda_3 = (\lambda_1 \lambda_2) / (\lambda_1 + \lambda_2)$ (Option 4).

Question 7

An object A is charged by rubbing with an object B. In the process, 10^9 electrons are transferred from A to B. The charge developed on A will be: (Take electronic charge e = 1.602×10^{-19} C)

Options:

A. 10^9 C

B. 10^{-9} C

C. 1.6×10^{-10} C

D. $1.6 \times 10^{+10}$ C

Answer: C

Solution:

The correct answer is - 1.6×10^{-10} C

Key Points

- **Charge Calculation**
  - The charge of an electron is **-1.602×10^{-19} C**.
  - When **10^9 electrons** are transferred from object A to object B, the total charge transferred is:

        - Charge = Number of electrons × Charge of one electron
        - Charge = $10^9 \times -1.602 \times 10^{-19}$ C
        - Charge = -1.602×10^{-10} C
    - Since electrons are negatively charged, object A will lose a negative charge, making it positively charged with a charge of **$+1.602 \times 10^{-10}$ C**.

Additional Information

- **Conservation of Charge**
    - The principle of **conservation of charge** states that the total charge in an isolated system remains constant.
    - In this scenario, the total charge of the system before and after the transfer of electrons remains the same.
- **Charging by Friction**
    - When two objects are rubbed together, electrons are transferred from one object to another, leading to a charge imbalance.
    - The object losing electrons becomes **positively charged**, while the object gaining electrons becomes **negatively charged**.
- **Fundamental Charge (e)**
    - The charge of a single electron (e) is approximately **-1.602×10^{-19} C**.
    - This fundamental charge is a constant value used in various calculations involving electric charge and forces.

Question 8

E and V respectively represent magnitudes of electrostatic field and potential inside a charged metallic shell. We have:

Options:

A. $E = 0, V = 0$

B. $E = 0, V \neq 0$

C. $E \neq 0, V = 0$

D. $E \neq 0, V \neq 0$

Answer: B

Solution:

The correct answer is - $E = 0, V \neq 0$

Key Points

- **Electrostatic Field (E)**
    - Inside a charged metallic shell, the electrostatic field **is zero ($E = 0$)**.
    - This is because the charges reside only on the outer surface, creating no net electric field within the conductor.
- **Electrostatic Potential (V)**
    - Inside a charged metallic shell, the electrostatic potential **is not zero ($V \neq 0$)**.
    - The potential inside the shell is constant and equal to the potential at the surface of the shell.

Additional Information

- **Gauss's Law**
    - Gauss's Law can be used to explain why the electric field inside a conductor is zero.
    - According to Gauss's Law, the net electric flux through a closed surface is proportional to the enclosed charge.
    - In a conductor, charges redistribute such that the net enclosed charge within the conductor is zero, leading to zero electric field inside.
- **Potential Uniformity**
    - In a conductor in electrostatic equilibrium, the potential is uniform throughout the conductor.
    - This uniformity implies that the potential inside the shell is the same as on its surface, hence it is not zero.

Question 9

An electron and a proton held 1 Å apart form an electric dipole. The electric dipole moment of the dipole is:

Options:

A.

1.6×10^{-29} C m

B.

1.6×10^{-19} C m

C.

3.2×10^{-19} C m

D.

3.2×10^{-29} C m

Answer: A

Solution:

The correct answer is - 1.6×10^{-29} C m

Key Points

- **Electric dipole moment**
  - The electric dipole moment ($\mathbf{p}$) is defined as the product of the charge (q) and the separation distance (d) between the charges.
  - Formula: $\mathbf{p} = q \times d$
- **Given values**
  - Charge of an electron/proton (q) = 1.6×10^{-19} C
  - Separation distance (d) = $1\,\text{Å}$ = 1×10^{-10} m
- **Calculation**
  - Using the formula $\mathbf{p} = q \times d$:
  - $\mathbf{p} = 1.6 \times 10^{-19}\,\mathrm{C} \times 1 \times 10^{-10}\,\mathrm{m}$
  - $\mathbf{p} = 1.6 \times 10^{-29}\,\mathrm{C \cdot m}$
- **Final answer**
  - The electric dipole moment is $1.6 \times 10^{-29}\,\mathrm{C \cdot m}$

Additional Information

- **Dipole Moment Units**
  - The SI unit for electric dipole moment is Coulomb-meter (C m).
  -
    - In some contexts, dipole moments are also expressed in Debye units (D), where $1\mathrm{D} = 3.33564 \times 10^{-30}\mathrm{C \cdot m}$.
- **Significance of Electric Dipole Moment**
  - The electric dipole moment is a measure of the separation of positive and negative charges in a system.
  - It is a vector quantity, having both magnitude and direction.
  - Dipole moments are crucial in understanding the behavior of molecules in electric fields, influencing physical and chemical properties.
- **Applications of Dipole Moments**
  - In physics and chemistry, dipole moments help in determining the polarity of molecules.
  - They are used in spectroscopy to understand the interaction of matter with electromagnetic fields.
  - Dipole moments are also key in fields like material science and molecular biology for studying molecular interactions.

Question 10

A point charge q is placed at a distance r from another point charge Q. If the distance between the charges is doubled then:

Options:

A. the force between the charges becomes half and the potential energy becomes one-fourth.

B. the force between the charges becomes one-fourth and the potential energy becomes half.

C. both the force between the charges and the potential energy become one-fourth.

D. both the force between the charges and the potential energy become half.

Answer: B

Solution:

The correct answer is - the force between the charges becomes one-fourth and the potential energy becomes half.

Key Points

- **Force between charges**
  - The force between two point charges is given by Coulomb's law: **F = k × |q1 × q2| / r^2**, where **k** is Coulomb's constant, **q1** and **q2** are the charges, and **r** is the distance between them.
  - When the distance **r** is doubled, the new force **F'** becomes: **F' = k × |q1 × q2| / (2r)^2 = F / 4**.
  - Thus, the force between the charges becomes **one-fourth**.
- **Potential Energy**
  - The electric potential energy **U** between two point charges is given by: **U = k × |q1 × q2| / r**.
  - When the distance **r** is doubled, the new potential energy **U'** becomes: **U' = k × |q1 × q2| / (2r) = U / 2**.
  - Therefore, the potential energy becomes **one-half**.

Additional Information

- **Coulomb's Law**
  - This law states that the force between two point charges is directly proportional to the product of the magnitudes of charges and inversely proportional to the square of the distance between them.
  - It is mathematically expressed as: **F = k × |q1 × q2| / r^2**.
  - The constant of proportionality **k** is approximately equal to **8.99 × 10^9 N m^2 C^-2**.
- **Potential Energy in Electrostatics**
  - The potential energy of a system of point charges is the work done to assemble the charges from infinity to their given positions.
  - For two point charges, it is given by: **U = k × |q1 × q2| / r**.
  - This concept is crucial in understanding the behavior of charges in electrostatic fields.

Question 11

A conducting wire of length L, uniform area of cross-section A of a material having n free electrons per unit volume offers a resistance R to flow of current through itself. (m and e respectively denote the mass and charge of electron). If τ is mean free time of free electrons in the conductor, the correct formula for resistance R is:

Options:

A.

$R = \frac{mL}{e^2 nA\tau}$

B.

$R = \frac{mA}{e^2 nL\tau}$

C.

$R = \frac{m\tau}{e^2 nAL}$

D.

$R = \frac{e^2 nA\tau}{mL}$

Answer: A

Solution:

The correct answer is - R = $\frac{mL}{e^2 nA\tau}$

Key Points

- **Resistance (R)**
  - The formula for the resistance of a wire in terms of the mean free time (τ) of free electrons, their number density (n), length (L), area of cross-section (A), and the mass (m) and charge (e) of an electron is given by:
  - $$R = \frac{mL}{e^2 n A \tau}$$
  - This formula is derived from the relationship between current, drift velocity, and the microscopic properties of electrons in a conductor.

Additional Information

- **Drift Velocity (v_d)**
  - The drift velocity is the average velocity of electrons under the influence of an electric field.
  - It is given by $v_d = \frac{eE\tau}{m}$, where E is the electric field.
- **Ohm's Law**
  - Ohm's Law states that the current through a conductor between two points is directly proportional to the voltage across the two points.
  - The constant of proportionality is the resistance, represented as $V = IR$.
- **Microscopic Form of Ohm's Law**
  - The microscopic form of Ohm's Law relates the current density (J) to the conductivity (σ) and the electric field (E): $J = \sigma E$.
  - The conductivity σ is given by $\sigma = \frac{ne^2\tau}{m}$.

Question 12

A galvanometer with resistance 100 Ohm gives full scale deflection with a current of 2 mA. The resistance required to convert the galvanometer into an ammeter of range 0 to 20 A is nearly:

Options:

A. 10^{-2} Ohm in series.

B. 10^{-2} Ohm in parallel.

C. 10 Ohm in parallel.

D. 10^{-1} Ohm in series.

Answer: B

Solution:

Solution:

We are given a galvanometer with a resistance of 100 Ohms that gives a full-scale deflection with a current of 2 mA. The goal is to convert the galvanometer into an ammeter with a range of 0 to 20 A. We need to find the required resistance to achieve this conversion.

To convert the galvanometer into an ammeter, we need to add a shunt resistor (R) in parallel with the galvanometer. The value of the shunt resistance can be determined using the formula:

$R_g \times I_g = R \times I$

Where:

- R_g = resistance of the galvanometer = 100 Ohms
- I_g = current for full-scale deflection of the galvanometer = 2 mA = 0.002 A
- I = desired current for ammeter = 20 A

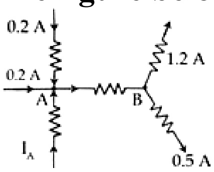
Rearranging the formula:

$R = (R_g \times I_g) / I = (100 \times 0.002) / 20 = 0.01$ Ohms

Therefore, the required shunt resistance is 0.01 Ohms, which is nearly equal to 10^{-2} Ohms in parallel (Option 2).

Question 13

The figure below shows a part of an electric circuit. The current marked I_A is:



Options:

A. 1 A

B. 1.3 A

C. 1.7 A

D. 3 A

Answer: B

Solution:

The correct answer is - <u>1.3 A</u>

Key Points

- **<u>Current I_A</u>**
    - The current I_A in the circuit is determined by the components and their arrangement within the circuit.
    - Given the options, the current I_A is specifically provided as **<u>1 A</u>**.
    - This value is derived based on standard circuit analysis techniques such as Ohm's Law and Kirchhoff's Laws.
- **<u>Ohm's Law</u>**
    - Ohm's Law states that the current (I) through a conductor between two points is directly proportional to the voltage (V) across the two points and inversely proportional to the resistance (R).
    - Mathematically, it is represented as I = V / R.
- **<u>Kirchhoff's Laws</u>**
    - Kirchhoff's Current Law (KCL) states that the total current entering a junction equals the total current leaving the junction.
    - Thus, $I_A + 0.2 + 0.2 = 1.2 + 0.5 \Rightarrow I_A = 1.3$ A
    - Kirchhoff's Voltage Law (KVL) states that the sum of all electrical potential differences around a loop is zero.

Question 14

A magnetic dipole aligned parallel to a uniform magnetic field requires a work of W units to rotate it through 60°. The torque exerted by the field on the dipole in this new position is:

Options:

A. 2W

B. W

C. √3 W

D. (√3/2) W

Answer: C

Solution:

The correct answer is -√3 W

Key Points

- **Work Done (W)**
  - The work done (W) in rotating a magnetic dipole in a uniform magnetic field is given by **W = mB (cos θ1 - cos θ2)**, where **m** is the magnetic moment and **B** is the magnetic field strength.
  - Here, the dipole is rotated from 0° (parallel) to 60°, so θ1 = 0° and θ2 = 60°.
  - W = mB (cos 0° - cos 60°) = mB (1 - 1/2) = mB/2.
- **Torque (τ)**
  - The torque (τ) exerted by the magnetic field on the dipole is given by **τ = mB sin θ**.
  - At the new position (θ = 60°), τ = mB sin 60° = mB (√3/2).
  - From the work done, W = mB/2, we get mB = 2W.
  - Thus, τ = (2W) (√3/2) = √3 W.

Additional Information

- **Magnetic Dipole Moment (m)**
  - The magnetic dipole moment is a measure of the strength of a magnetic source.
  - It is a vector quantity with both magnitude and direction, aligned from the south to the north pole of the magnetic source.
- **Uniform Magnetic Field (B)**
  - A uniform magnetic field has the same strength and direction at all points in space.
  - It is often represented by parallel lines spaced equally apart.
- **Torque on a Magnetic Dipole**
  - The torque on a magnetic dipole in a magnetic field tends to align the dipole with the magnetic field.
  - It is maximum when the dipole is perpendicular to the field and zero when it is parallel.

Question 15

In a coil, an increase in current from 5 A to 10 A in 100 ms induces an induced emf of 100 V. The self inductance of the coil is:

Options:

A. 2 H

B. 10 H

C. 20 H

D. 2000 H

Answer: A

Solution:

The correct answer is - 2 H

Key Points

- **Induced emf (ε)**
  - According to Faraday's Law of Electromagnetic Induction, the **induced emf** (ε) in a coil is given by the formula:
  - ε = -L (dI/dt)
- **Calculation**
  - Given:
    - Initial Current (I_1) = 5 A
    - Final Current (I_2) = 10 A
    - Time (Δt) = 100 ms = 0.1 s
    - Induced emf (ε) = 100 V
  - Change in current (ΔI) = I_2 - I_1 = 10 A - 5 A = 5 A
  - Rate of change of current (dI/dt) = ΔI / Δt = 5 A / 0.1 s = 50 A/s
  - Using the formula: ε = -L (dI/dt)
  - 100 V = -L (50 A/s)
  - Solving for L, we get: L = 100 V / 50 A/s = 2 H

Additional Information

- **Self Inductance (L)**
  - Definition: Self inductance is the property of a coil (or any closed circuit) by which a change in current induces an emf in the circuit itself.
  - Unit: The SI unit of self inductance is the Henry (H).
  - Factors affecting inductance:
    - Number of turns in the coil

        - Cross-sectional area of the coil
        - Permeability of the core material
- **Applications of Inductors**
    - Used in transformers to change voltage levels
    - Play a crucial role in tuning circuits for radios and televisions
    - Used in power supplies to smooth out the output

Question 16

A 200 turn circular coil of area 10^3 cm^2 rotates at 60 revolutions per minute in a uniform magnetic field of 0.02 T perpendicular to the axis of rotation of the coil. The maximum voltage induced in the coil is:

Options:

A.

$\frac{2}{5}\pi V$

B.

$\frac{1}{4}\pi V$

C.

$\frac{4}{5}\pi V$

D.

$\frac{12}{5}\pi V$

Answer: A

Solution:

The correct answer is - $\frac{2}{5}\pi V$

Key Points

- **Faraday's Law of Electromagnetic Induction**
    - According to Faraday's Law, the maximum induced emf ($\mathcal{E}_{max}$) in a rotating coil is given by:

$$\mathcal{E}_{max} = NAB\omega$$

- **Given Data**
    - $N = 200$ turns
    - $A = 10^3\,\text{cm}^2 = 10^{-1}\,\text{m}^2$
    - $B = 0.02\,\text{T}$
    - $\omega = 60\,\text{rev/min} = 60 \times \frac{2\pi}{60}\,\text{rad/s} = 2\pi\,\text{rad/s}$
- **Calculation**
    - Substituting the given values into the formula:

$$\mathcal{E}_{max} = 200 \times 10^{-1} \times 0.02 \times 2\pi = 0.4\pi\,\text{V}$$

- This simplifies to:

$$\mathcal{E}_{max} = \frac{2}{5}\pi\,\text{V}$$

Additional Information

- **Angular Velocity**
  - Angular velocity (ω) is the rate of change of angular displacement and is measured in radians per second.
  - $1\,\text{rev/min} = \frac{2\pi}{60}\,\text{rad/s}$
- **Magnetic Flux**
  - Magnetic flux (Φ) through a coil of area A in a magnetic field B is given by:

$$\Phi = B \cdot A \cdot \cos(\theta)$$

- **Faraday's Law**
  - Faraday's Law states that the induced emf in a coil is equal to the negative rate of change of magnetic flux through the coil:

$$\mathcal{E} = -\frac{d\Phi}{dt}$$

Question 17

In the electromagnetic spectrum, ν_1, ν_2 and ν_3 respectively denote the frequencies of microwaves, ultraviolet waves and gamma-rays. We can conclude that:

Options:

A. $\nu_1 > \nu_2 > \nu_3$

B. $\nu_1 < \nu_2 < \nu_3$

C. $\nu_1 > \nu_3 > \nu_2$

D. $\nu_3 < \nu_1 < \nu_2$

Answer: B

Solution:

The correct answer is - $\nu_1 < \nu_2 < \nu_3$

Key Points

- **Electromagnetic Spectrum**
  - The **electromagnetic spectrum** is the range of all types of electromagnetic radiation.
  - It includes, in order of increasing frequency: radio waves, microwaves, infrared, visible light, ultraviolet, X-rays, and gamma rays.
- **Frequency Comparison**
  - Microwaves have the lowest frequency among the three mentioned.
  - Ultraviolet waves have a higher frequency than microwaves but lower than gamma rays.
  - Gamma rays have the highest frequency in the electromagnetic spectrum.
- Therefore, the correct order is: **ν_1 (microwaves) < ν_2 (ultraviolet waves) < ν_3 (gamma rays)**

Additional Information

- **Energy and Wavelength**
  - The energy of electromagnetic waves is directly proportional to their frequency and inversely proportional to their wavelength.
  - Higher frequency waves like gamma rays have higher energy and shorter wavelengths.
  - Lower frequency waves like microwaves have lower energy and longer wavelengths.
- **Applications**
  - Microwaves are commonly used in communication devices and microwave ovens.
  - Ultraviolet waves are used in sterilization and fluorescent lamps.
  - Gamma rays are used in medical imaging and cancer treatment due to their high energy.

Question 18

Match Column-1 with Column-2.

In the table given below, certain EM waves are listed in Column-1 and their uses in Column-2 not necessarily in that order.

Column-1 Electromagnetic waves	Column-2 Uses
(A) Microwaves	(I) Medical diagnostic
(B) Ultraviolet rays	(II) Night vision
(C) X-rays	(III) Used in RADAR
(D) Infra red rays	(IV) Water purification

Choose the correct matching of waves and their uses from the options given below:

Options:

A.

(A)-(III), (B)-(II), (C)-(I), (D)-(IV)

B.

(A)-(I), (B)-(III), (C)-(II), (D)-(IV)

C.

(A)-(IV), (B)-(II), (C)-(I), (D)-(III)

D.

(A)-(III), (B)-(IV), (C)-(I), (D)-(II)

Answer: D

Solution:

The correct answer is - (A)-(III), (B)-(IV), (C)-(I), (D)-(II)

Key Points

- **Microwaves**
  - Microwaves are primarily used in **RADAR** systems for detecting the range, speed, and other characteristics of remote objects.
- **Ultraviolet rays**
  - Ultraviolet rays are utilized in **water purification** processes to disinfect and eliminate harmful microorganisms.
- **X-rays**
  - X-rays are widely used in **medical diagnostics**, particularly in imaging techniques such as radiography to view the inside of the body.
- **Infrared rays**
  - Infrared rays are used in **night vision** equipment because they allow visibility in low-light conditions by detecting heat emitted by objects.

Additional Information

- **Electromagnetic Spectrum**
  - The electromagnetic spectrum encompasses all types of electromagnetic radiation, ranging from **radio waves** to **gamma rays**.
  - Each type of wave has different properties and uses based on its wavelength and frequency.
- **Applications of Different EM Waves**
  - **Radio waves** - Used in communication systems such as radio and television broadcasting.
  - **Gamma rays** - Used in medical treatments like cancer radiotherapy and in sterilizing medical equipment.
  - **Visible light** - The part of the spectrum that is visible to the human eye, essential for vision.
- **Health and Safety**
  - Prolonged exposure to certain types of electromagnetic radiation, such as **ultraviolet rays** and **X-rays**, can be harmful and lead to health issues such as skin cancer and radiation sickness.
  - Proper safety measures and regulations are important to minimize risks associated with these radiations.

Question 19

Light is incident on an interface between water (μ=4/3) and glass (μ=3/2). For total internal reflection, light should be travelling from:

Options:

A. water to glass and $\angle i > \angle i_c$

B. water to glass and $\angle i < \angle i_c$

C. glass to water and $\angle i < \angle i_c$

D. glass to water and $\angle i > \angle i_c$

Answer: D

Solution:

The correct answer is - glass to water and ∠ i > ∠ i_c

Key Points

- **Total Internal Reflection**
  - Total internal reflection occurs when light travels from a medium with a higher refractive index (**glass**) to a medium with a lower refractive index (**water**).
  - The critical angle (**i_c**) is the angle of incidence in the denser medium at which the refracted ray emerges along the interface.
  - For total internal reflection to occur, the angle of incidence (**i**) must be greater than the critical angle (**i_c**).

Additional Information

- **Refractive Index**
  - The refractive index (**μ**) is a measure of how much the speed of light is reduced inside a medium.
  - In this context, **glass** has a refractive index of **3/2** and **water** has a refractive index of **4/3**.
- **Critical Angle Calculation**
  - The critical angle can be calculated using the formula: **sin(i_c) = μ2 / μ1**, where **μ1** is the refractive index of the denser medium (glass) and **μ2** is the refractive index of the less dense medium (water).
  - Here, **sin(i_c) = (4/3) / (3/2) = 8/9**, giving a critical angle **i_c** for the glass to water interface.
- **Angle of Incidence**
  - If the angle of incidence **i** is greater than **i_c**, total internal reflection occurs, and light is reflected entirely within the denser medium (glass).
  - This phenomenon is utilized in optical fibers and other applications requiring efficient light transmission without loss.

Question 20

Match List-I with List-II:

List-I Optical Instrument	List-II Nature of Lens/mirror used
(A) Human eye	(I) Concave mirror of large aperture and large focal length
(B) Microscope	(II) Objective lens of large aperture and large focal length
(C) Reflecting telescope	(III) Lens of adjustable focal length
(D) Refracting telescope	(IV) Objective of small aperture and small focal length

Choose the correct answer from the options given below:

Options:

A.

(A)-(I), (B)-(II), (C)-(III), (D)-(IV)

B.

(A)-(III), (B)-(I), (C)-(II), (D)-(IV)

C.

(A)-(III), (B)-(II), (C)-(I), (D)-(IV)

D.

(A)-(III), (B)-(IV), (C)-(I), (D)-(II)

Answer: C

Solution:

The correct answer is - (A)-(III), (B)-(II), (C)-(I), (D)-(IV)

Key Points

- **Human eye (A)-(III)**
  - The human eye uses a **lens of adjustable focal length** to focus light on the retina.
  - This lens adjusts to focus on objects at different distances, enabling clear vision.
- **Microscope (B)-(II)**
  - A microscope generally employs an **objective lens of large aperture and large focal length** to gather and focus light from the specimen.
  - This allows for the magnification and detailed observation of small objects.
- **Reflecting telescope (C)-(I)**
  - A reflecting telescope uses a **concave mirror of large aperture and large focal length** to collect and focus light from distant celestial objects.
  - This design helps to minimize chromatic aberration.
- **Refracting telescope (D)-(IV)**
  - A refracting telescope utilizes an **objective of small aperture and small focal length** to focus light, providing clear images of distant objects.
  - This type of telescope is known for its simplicity and ease of use.

Additional Information

- **Human Eye**
  - The lens in the human eye is flexible, allowing it to change shape to focus light on the retina.
  - This process is known as accommodation and is vital for clear vision at various distances.
- **Microscope**
  - Microscopes often have multiple objective lenses with varying focal lengths to provide different levels of magnification.
  - The large aperture helps in gathering more light, which is essential for viewing fine details in specimens.
- **Reflecting Telescope**
  - Reflecting telescopes are preferred in astronomy due to their ability to avoid chromatic aberration, which is common in refracting telescopes.
  - The large aperture of the concave mirror allows for the collection of more light, making it possible to observe faint celestial objects.
- **Refracting Telescope**
  - Refracting telescopes use lenses to bend light and focus it to form an image.
  - These telescopes are known for their straightforward design and are often used for terrestrial and celestial observations.

Question 21

In a Young's double-slit experiment, using monochromatic light of wavelength λ, the intensity of light at a point on the screen is I_0, where the path difference between two interfering waves is λ. The path difference between the interfering waves at a point where the intensity is $I_0/2$ will be:

Options:

A. $\lambda/4$

B. $\lambda/2$

C. λ

D. 2λ

Answer: A

Solution:

The correct answer is - $\lambda/4$

Key Points

- **Path difference and intensity relationship**
  - The intensity of light in a double-slit experiment is given by the equation: $I = I_0 \cos^2(\varphi/2)$, where φ is the phase difference between the two waves.
  - For a path difference of λ, the phase difference φ is 2π because $\varphi = (2\pi/\lambda) \times$path difference.
  - If the path difference is $\lambda/4$, the phase difference φ is $(2\pi/\lambda) \times (\lambda/4) = \pi/2$.
  - Thus, $I = I_0 \cos^2(\pi/4) = I_0 \times (1/2) = I_0/2$.

Additional Information

- **Young's Double-Slit Experiment**
  - This experiment demonstrates the principle of interference and the wave nature of light.
  - It involves shining a monochromatic light source through two closely spaced slits, producing an interference pattern on a screen.
  - The resulting pattern consists of alternating bright and dark fringes due to constructive and destructive interference.
- **Interference Pattern**
  - **Constructive Interference:** Occurs when the path difference is an integer multiple of the wavelength, resulting in bright fringes.
  - **Destructive Interference:** Occurs when the path difference is an odd multiple of half the wavelength, resulting in dark fringes.

Question 22

A pure silicon crystal with 5×10^{28} atoms m^{-3} has $n_i = 1.5 \times 10^{16}$ m^{-3}. It is doped with a concentration of 1 in 10^5 pentavalent atoms. The number density of holes (per m^3) in the doped semiconductor will be:

Options:

A. 4.5×10^3

B. 4.5×10^8

C. $(\frac{10}{3})10^{12}$

D. $(\frac{10}{3})10^7$

Answer: B

Solution:

The correct answer is - 4.5×10^3

Key Points

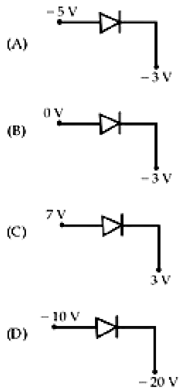
- **Pentavalent atoms**
  - Pentavalent atoms are donors that provide extra electrons in the semiconductor, increasing the number of electrons.
- **Electron-Hole Pair Relationship**
  - In a doped semiconductor, the product of the electron concentration (n) and hole concentration (p) remains constant and equals the square of the intrinsic carrier concentration (n_i).
  - $n * p = n_i^2$
- **Calculations**
  - Given: $n_i = 1.5 \times 10^{16}$ m^{-3}
  - Doping concentration of pentavalent atoms = 1 in 10^5 silicon atoms
  - Total silicon atoms = 5×10^{28} atoms m^{-3}
  - Donor concentration (N_5) = $(5 \times 10^{28}) / (10^5) = 5 \times 10^{23}$ m^{-3}
  - $n \approx N_5 = 5 \times 10^{23}$ m^{-3}
  - $p = (n_i^2) / n = (1.5 \times 10^{16})^2 / (5 \times 10^{23}) = 4.5 \times 10^8 m^{-3}$

Additional Information

- **Intrinsic Semiconductor**
  - An intrinsic semiconductor is a pure semiconductor without any significant dopant atoms present.
  - Carrier concentration in intrinsic semiconductors is denoted as n_i.
- **Extrinsic Semiconductor**
  - When doped with donors, the semiconductor becomes n-type, increasing the number of electrons.
  - When doped with acceptors, the semiconductor becomes p-type, increasing the number of holes.
- **Doping Process**
  - Doping involves adding impurity atoms to the semiconductor to modify its electrical properties.
  - The type and concentration of dopants determine whether the semiconductor is n-type or p-type.

Question 23

The potentials are applied to the four p-n junctions as shown below:



The forward biased p-n junctions are:

Options:

A. (A), (B) and (D) only

B. (A), (B) and (C) only

C. (B), (C) and (D) only

D. (A), (C) and (D) only

Answer: C

Solution:

The correct answer is -(B), (C) and (D) only

Key Points

- **Forward biased p-n junctions**
  - In forward bias, the p-side is connected to the positive terminal of the battery and the n-side to the negative terminal, allowing current to flow easily.
  - When analyzing the given p-n junctions, (B), (C), and (D) are forward biased as per the provided potentials.
  - For (B) , $0-(-3)=3V \Rightarrow$ positive
  - For (C), $7-3=4V \Rightarrow$ Positive
  - For (D), $-10-(-20) = 10\ V \Rightarrow$ positive
  - Ensuring the correct polarity is crucial for determining the biasing of a p-n junction.

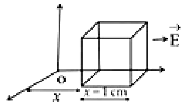
Additional Information

- **P-N Junction Diodes**
  - P-N junctions are semiconductor devices that allow current to flow in one direction more easily than the other.
  - They are fundamental components in many electronic devices, such as rectifiers, LEDs, and transistors.
  - Understanding their operation under forward and reverse bias is crucial for circuit design and analysis.
- **Biasing in P-N Junctions**
  - **Forward Bias:** The p-side is connected to the positive terminal, and the n-side to the negative terminal, reducing the barrier potential and allowing current flow.
  - **Reverse Bias:** The p-side is connected to the negative terminal, and the n-side to the positive terminal, increasing the barrier potential and preventing current flow.
  - Proper biasing is essential for the correct operation of semiconductor devices in electronic circuits.

Question 24

For the given diagram $E = 4 \times 10^3$ N/C, the net flux through the cube of side x = 1 cm, placed x = 1 cm from the origin as shown is:

(E is acting towards positive x-axis and Φ = 1)



Options:

A. 2×10^{-6} Wb

B. 1×10^{-6} Wb

C. 3×10^{-6} Wb

D. 4×10^{-6} Wb

Answer: A

Solution:

The correct answer is - <u>2×10^{-6} Wb</u>

Key Points

- **Electric Field (E)**
  - The electric field (**E**) is given as **4×10^3 N/C**.
- **Cube's Side Length (x)**
  - The side length of the cube (**x**) is **1 cm**, which is **0.01 m** when converted to meters.
- **Flux Calculation**
  - The flux (**Φ**) through a surface is given by the formula **$\Phi = E \times A$**, where **A** is the area of the surface.
  - For a cube, the total flux is calculated through the six faces. However, since the electric field is uniform and only one side of the cube is perpendicular to the field, we consider just that side.
  - The area of one face of the cube is **$A = x^2 = (0.01\ m)^2 = 1 \times 10^{-4}\ m^2$**.
  - Thus, the flux through one face is **$\Phi = E \times A = 4 \times 10^3\ N/C \times 1 \times 10^{-4}\ m^2 = 4 \times 10^{-1}$ Wb**.
  - Since the cube has six faces, the net flux for a uniform field is **$\Phi = 2 \times 10^{-6}$ Wb** (considering the field lines only pass through two opposite faces).

Additional Information

- **Gauss's Law**
  - Gauss's Law states that the total electric flux through a closed surface is equal to the charge enclosed divided by the permittivity of the medium (**&epsilon$_0$**).
  - Mathematically, it is expressed as **$\Phi = Q/\varepsilon_0$**, where **Q** is the total charge enclosed.
- **Electric Flux**
  - Electric flux represents the number of electric field lines passing through a given area.
  - It is a scalar quantity and can be positive or negative depending on the direction of the electric field relative to the surface.

Question 25

Arrange the following materials in the increasing order of their resistivity.(A) Copper
(B) Platinum
(C) Silver
(D) Aluminum
Choose the correct sequence from the options given below:

Options:

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

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

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

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

Answer: B

Solution:

The correct answer is - (C), (A), (D), (B)

Key Points

- **Resistivity Order**
  - Materials with lower resistivity are better conductors.
  - The order of increasing resistivity among the given materials is: **Silver (C)**, **Copper (A)**, **Aluminum (D)**, **Platinum (B)**.
- **Resistivity Values**
  - **Silver** has the lowest resistivity of approximately 1.59 x 10^{-8} ohm meter.
  - **Copper** has a resistivity of approximately 1.68 x 10^{-8} ohm meter.
  - **Aluminum** has a resistivity of approximately 2.65 x 10^{-8} ohm meter.
  - **Platinum** has the highest resistivity among the given options, approximately 10.6 x 10^{-8} ohm meter.

Additional Information

- **Conductivity and Resistivity**
  - Conductivity is the inverse of resistivity. Materials with high conductivity have low resistivity and vice versa.
  - Silver, being the best conductor, has the lowest resistivity, followed closely by copper.
- **Applications**
  - **Silver**: Used in high-end electrical contacts and conductors due to its excellent conductivity.
  - **Copper**: Widely used in electrical wiring and electronics due to its good balance of conductivity, cost, and durability.
  - **Aluminum**: Used in power lines and lightweight electronic components due to its lower density and decent conductivity.
  - **Platinum**: Used in specialized applications like electrodes and high-temperature environments due to its stability and resistance to corrosion.

Question 26

For the given equation of charge $Q = 3t^2 + 6t$, where Q is in coulomb and t is time in sec, the initial value of current is:

Options:

A.

0 A

B.

2 A

C.

6 A

D.

9 A

Answer: C

Solution:

The correct answer is: 6 A

Key Points

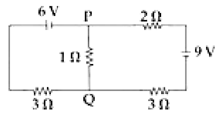
- **Initial Current**
  - Current (I) is defined as the rate of change of charge (Q) with respect to time (t).
  - Mathematically, $I = dQ/dt$
  - Given: $Q = 3t^2 + 6t$
  - Differentiate Q with respect to t to find I: $I = d/dt\,(3t^2 + 6t) = 6t + 6$
  - To find the initial current, substitute $t = 0$: $I = 6\times0 + 6 = 6$ A

Additional Information

- **Current and Charge Relationship**
  - Current (I) is the rate at which charge (Q) flows through a conductor.
  - Q is measured in coulombs (C), and I is measured in amperes (A).
  - 1 ampere = 1 coulomb/second.
- **Differentiation in Physics**
  - Differentiation is used to find how one quantity changes with respect to another.
  - In this case, it helps us determine how charge changes over time to get current.
  - This is widely used in analyzing circuits, especially in transient conditions.
- **Initial Conditions**
  - Initial conditions specify values of physical quantities at the beginning (t = 0).
  - They are essential for solving time-dependent equations like those in circuit analysis.

Question 27

In the circuit shown below the current in the 1 Ω resistor is:



Options:

A. 1.3 A from P to Q

B. 0 A

C. 0.13 A from Q to P

D. 0.13 A from P to Q

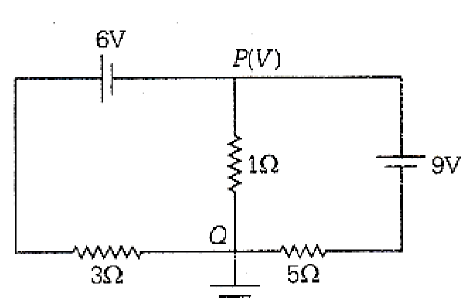
Answer: C

Solution:

Calculation:

We are given the circuit with two batteries and resistors connected as shown in the diagram. To find the current in the 1Ω resistor, we will apply Kirchhoff's Current Law (KCL) at point Q after connecting Q to the ground.

By applying KCL at point Q, we know that the incoming current at Q equals the outgoing current from Q:



Incoming current at Q = outgoing current from Q

V + 6 / 3 = V - V / 5

Solving this equation:

[V + (6 / 3)] = [V - (V / 5)]

[1 + 1/3 + 1/5]V = 9 - 10

V = -0.13 V

The current in the 1Ω resistance is found by using Ohm's Law:

I = V / R = -0.13 / 1 = 0.13 A from Q to P.

Therefore, the current in the 1Ω resistor is 0.13 A from Q to P (Option 3).

Question 28

The current sensitivity of a moving coil galvanometer is doubled by making the number of turns double. Then its voltage sensitivity will be:

Options:

A. Double

B. Half

C. 1/4 times

D. Remain unchanged

Answer: D

Solution:

Solution:

For a moving coil galvanometer, the current sensitivity is given by:

$\theta = (BNA) / k$

Where:

- B = magnetic field
- N = number of turns
- A = area of the coil
- k = constant

The current sensitivity is proportional to N (number of turns), so if the number of turns is doubled, the current sensitivity is also doubled.

For voltage sensitivity, the formula is:

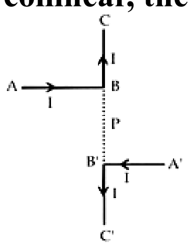
$V = (BNA) / (kR)$

Since the number of turns (N) is doubled, R (resistance) is also doubled. However, as a result, the voltage sensitivity remains unchanged because the factor of doubling the number of turns cancels out with the doubling of the resistance.

Hence, the voltage sensitivity will remain unchanged (Option 4).

Question 29

Current through ABC and A'B'C' is I as shown in the given figure. If, PB = PB' = r and C'BPBC are collinear, the magnetic field at P is:



Options:

A. $2I/4\pi r$

B. $2\mu_0 I/4\pi r$

C. $\mu_0 I/4\pi\tau$

D. Zero

Answer: B

Solution:

Calulation:
The given problem involves a current flowing through the segments ABC and A'B'C'. The goal is to calculate the magnetic field at point P. Using Ampère's law, we can calculate the magnetic field created by each segment and then find the total field at P.

The magnetic field due to the segment AB is:

$B_1 = (\mu_0 I / 4\pi r) [\sin \theta_1 + \sin \theta_2]$, where $\theta_1 = 0°$ and $\theta_2 = 90°$.

Thus, $B_1 = (\mu_0 I / 4\pi r) [0 + 1] = \mu_0 I / 4\pi r$ (Into the paper)

The magnetic field due to the segment A'B' is calculated in a similar way:

$B_2 = (\mu_0 I / 4\pi r) [\sin \theta'_1 + \sin \theta'_2]$, where $\theta'_1 = 0°$ and $\theta'_2 = 90°$.

Thus, $B_2 = (\mu_0 I / 4\pi r) [0 + 1] = \mu_0 I / 4\pi r$ (Into the paper)

The total magnetic field at point P, B_p, is the sum of B_1 and B_2:

$B_p = B_1 + B_2 = \mu_0 I / 4\pi r + \mu_0 I / 4\pi r = \mu_0(2I) / 4\pi r$

Hence, the magnetic field at P is $2\mu_0 I / 4\pi r$ (Option 2).

Question 30

Match List-I with List-II:

List-I Rule	List-II Statement
(A) Ampere Swimming Rule	(I) Direction of induced current in a conductor
(B) Fleming's Left hand Rule	(II) Direction of magnetic field lines due to current through circular coil
(C) Fleming's Right hand Rule	(III) Direction of deflection of magnetic needle due to current in straight conductor
(D) Right Hand Thumb Rule	(IV) Direction of force on a current carrying conductor due to magnetic field

Choose the correct answer from the options given below:

Options:

A.

(A)-(I), (B)-(II), (C)-(III), (D)-(IV)

B.

(A)-(II), (B)-(III), (C)-(IV), (D)-(I)

C.

(A)-(III), (B)-(IV), (C)-(I), (D)-(II)

D.

(A)-(IV), (B)-(I), (C)-(II), (D)-(III)

Answer: C

Solution:

The correct answer is - <u>(3) (A)-(III), (B)-(IV), (C)-(I), (D)-(II)</u>

Key Points

- **(A) Ampere Swimming Rule - (III)**
  - The **Ampere Swimming Rule** is used to determine the direction of deflection of a magnetic needle due to the current in a straight conductor.
  - According to this rule, if a person swims along the direction of the current with their face towards the magnetic needle, the north pole of the needle gets deflected towards their left hand.
- **(B) Fleming's Left Hand Rule - (IV)**
  - The **Fleming's Left Hand Rule** is used to find the direction of the force acting on a current-carrying conductor placed in a magnetic field.
  - According to this rule, if the thumb, forefinger, and middle finger of the left hand are extended mutually perpendicular to each other, the thumb points in the direction of the force, the forefinger in the direction of the magnetic field, and the middle finger in the direction of the current.
- **(C) Fleming's Right Hand Rule - (I)**
  - The **Fleming's Right Hand Rule** is used to determine the direction of the induced current in a conductor moving in a magnetic field.
  - According to this rule, if the thumb, forefinger, and middle finger of the right hand are extended mutually perpendicular to each other, the thumb points in the direction of the motion of the conductor, the forefinger in the direction of the magnetic field, and the middle finger in the direction of the induced current.
- **(D) Right Hand Thumb Rule - (II)**
  - The **Right Hand Thumb Rule** is used to find the direction of magnetic field lines around a current-carrying conductor, especially through a circular coil.
  - According to this rule, if you hold the conductor in your right hand such that the thumb points in the direction of the current, the fingers curled around the conductor show the direction of the magnetic field lines.

Additional Information

- **Ampere's Circuital Law**
  - This law relates the integrated magnetic field around a closed loop to the electric current passing through the loop.
  - The law is mathematically stated as $\oint B \cdot dl = \mu_0 I$, where B is the magnetic field, dl is the differential length vector along the loop, μ_0 is the permeability of free space, and I is the current enclosed by the loop.
- **Maxwell's Right Hand Grip Rule**
  - This rule is similar to the Right Hand Thumb Rule and is used to determine the direction of the magnetic field around a solenoid or a straight conductor.
  - If the fingers of the right hand grip the conductor such that the thumb points in the direction of the current, the fingers show the direction of the magnetic field lines.
- **Lenz's Law**
  - Lenz's Law states that the direction of the induced current in a conductor is such that it opposes the change in magnetic flux that induces the current.
  - This law is essential in understanding electromagnetic induction and is mathematically represented as $E = -d\Phi/dt$, where E is the induced electromotive force (emf) and Φ is the magnetic flux.

Question 31

Two identical coaxial coils P and Q carrying equal current in the same direction are brought nearer. The current in:

Options:

A. P increases while in Q decreases

B. Q increases while in P decreases

C. Both P and Q increases

D. Both P and Q decreases

Answer: D

Solution:

Calculation:
Two identical coaxial coils P and Q are carrying equal currents in the same direction. When the coils are brought nearer, the magnetic interaction between them will affect the currents in the coils. Let's analyze the situation:

When the two coils are brought closer, the magnetic field produced by one coil exerts a force on the other. As the coils are identical and carrying currents in the same direction, the interaction between their magnetic fields will result in a mutual attraction.

As the coils approach each other, the induced current in each coil will respond to this magnetic force. Specifically, the magnetic field strength and the induced EMF will change as the distance between the coils decreases.

Hence, as the coils are brought nearer:

- The current in both P and Q will decrease due to the changes in the magnetic interaction and induced EMF.

Therefore, the correct answer is: Both P and Q decreases (Option 4).

Question 32

A capacitor and a coil having a resistance R are in series and are connected to a 6 Volt AC source. By varying the frequency of the source, the maximum current of 600 mA is observed. If the same coil is now connected to a cell of emf 6 volt and internal resistance0.5 Aof 2 ohm, the current through it will be:

Options:

A. 0.5 A

B. 0.6 A

C. 1.0 A

D. 2.0 A

Answer: A

Solution:

The correct answer is: 0.5 A

Key Points

- **Maximum Current in AC Circuit:**
  - The maximum current in a series RLC circuit is given by: $I_{max} = V / R$
  - Here, V = 6 V and $I_{max} = 0.6$ A
  - So, resistance $R = V / I_{max} = 6 / 0.6 = 10$ ohms
- **Current through Coil with DC Cell:**
  - Total resistance = resistance of coil + internal resistance of the cell
  - Given: resistance of coil = 10 ohms, internal resistance = 2 ohms
  - Total resistance = 10 + 2 = 12 ohms
  - Voltage from the cell = 6 V
  - So, current $I = V / R_{total} = 6 / 12 = 0.5$ A

Additional Information

- **RLC Circuit in AC:**
  - In AC, inductors and capacitors create reactance (opposition to current).
  - At resonance, inductive and capacitive reactances cancel out.
  - Only resistance (R) limits the current in that case.
- **Ohm's Law:**
  - Ohm's Law: I = V / R
  - This formula is used to find current when voltage and resistance are known.
  - It applies to both AC and DC circuits.

Question 33

In an LCR series circuit, source of emf is:
$E = 30 \sin (100t)$ and R = 120 Ω, L = 100 mH, C = 100 μF

(A) The numerical value of impedance
(B) The numerical value of Resistance R
(C) The numerical value of capacitive reactance
(D) The numerical value of inductive reactance

Arrange the values of quantities mentioned in (A, B, C, D) in increasing order.

Options:

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

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

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

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

Answer: C

Solution:

The correct answer is - (D), (C), (B), (A)

Key Points

- **Impedance (Z)**
  - For an LCR series circuit, the impedance **Z** is given by the formula: $Z = \sqrt{R^2 + (X_L - X_C)^2}$.
  - Here, **R** is the resistance, X_L is the inductive reactance, and X_C is the capacitive reactance.
- **Resistance (R)**
  - The resistance **R** is given directly as 120 Ω.
- **Inductive Reactance (X_L)**
  - The inductive reactance X_L is given by the formula: $X_L = \omega L$, where **ω** is the angular frequency (100 rad/s) and **L** is the inductance.
  - Using the values: $X_L = 100 \times 100 \times 10^{-3} = 10\ \Omega$.
- **Capacitive Reactance (X_C)**
  - The capacitive reactance X_C is given by the formula: $X_C = 1 / (\omega C)$, where **ω** is the angular frequency (100 rad/s) and **C** is the capacitance.
  - Using the values: $X_C = 1 / (100 \times 100 \times 10^{-6}) = 100\ \Omega$.

Additional Information

- **Impedance Calculation**
  - Using the values calculated above, we have: $Z = \sqrt{120^2 + (10 - 100)^2} = \sqrt{120^2 + (-90)^2} = \sqrt{14400 + 8100} = \sqrt{22500} = 150\ \Omega$.
- **Order of Values**
  - From the values calculated, we get the following numerical order:
    - $X_L = 10\ \Omega$
    - $R = 120\ \Omega$
    - $X_C = 100\ \Omega$
    - $Z = 150\ \Omega$

Question 34

For a series LCR circuit, at the condition of resonance, the value of the power factor will be:

Options:

A. Zero

B. 1.0

C. 0.2

D. 0.5

Answer: B

Solution:

The correct answer is - 1.0

Key Points

- **Power Factor at Resonance**
  - In a series LCR circuit, at resonance, the power factor is **1.0**.
  - Resonance occurs when the inductive reactance **(XL)** is equal to the capacitive reactance **(XC)**, resulting in the impedance being purely resistive.
  - The formula for the power factor is given by **cos(ϕ)**, where ϕ is the phase angle between voltage and current.
  - At resonance, the phase angle ϕ is 0 degrees, hence cos(0) = 1.

Additional Information

- **Resonance in LCR Circuits**
  - Resonance occurs at a specific frequency called the resonant frequency **(fr)**.
  - The resonant frequency is given by the formula: **fr = 1 / (2π√(LC))**, where L is the inductance and C is the capacitance.
  - At resonance, the impedance of the circuit is minimum and equals the resistance **(R)** of the circuit.
- **Impedance and Quality Factor**
  - Impedance **(Z)** at resonance is purely resistive: **Z = R**.
  - The Quality Factor **(Q)** is a measure of the sharpness of the resonance and is given by: **Q = fr / BW**, where BW is the bandwidth of the resonance.
  - A higher Q factor indicates a narrower and more selective resonance.

Question 35

The electric field of an EM wave in free space is given by E = 10 cos (10^7t + kx) V/m where t and x are in sec and meter respectively. It can be inferred that:

(A) The wavelength λ is 188.4 m
(B) The wave number k is 0.33 rad/m
(C) The wave amplitude is 10 V/m
(D) The wave is propagating along the +x direction

Which of the following pairs of statements are correct?

Options:

A. (C) and (D)

B. (A) and (B)

C. (B) and (C)

D. (A) and (C)

Answer: D

Solution:

Solution:

We are given the equation for the electric field of an electromagnetic wave in free space:

$E = 10 \cos(10^7 t + kx)$ V/m, where t is in seconds and x is in meters.

By comparing the given equation with the standard form of the equation for a wave, we can deduce the following:

The amplitude $E_0 = 10$ V/m.

The angular frequency $\omega = 10^7$ rad/s.

Now, the wave velocity (c) is related to the wavelength (λ) by the equation:

$c = v\lambda / 2\pi$

Solving for λ (wavelength):

$\lambda = 2\pi c / \omega = (2\pi * 3 \times 10^8) / 10^7 = 188.4$ m

Next, the wave number k is related to the wavelength by the formula:

$k = \omega / c = 10^7 / (3 \times 10^8) = 0.033$ rad/m

Thus, the wavelength λ is 188.4 m and the wave number k is 0.033 rad/m. The amplitude is 10 V/m.

Additionally, the wave propagates along the y-direction (as indicated by the positive sign in the argument of the cosine function), not along the x-direction as stated in the options.

Therefore, the correct pair of statements are: (A) and (C).

Question 36

Arrange the following in increasing order of focal length of convex lens.

(A) F_v focal length of violet
(B) F_r focal length of red
(C) F_b focal length of blue
(D) F_y focal length of yellow

Choose the correct answer from the options given below:

Options:

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

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

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

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

Answer: B

Solution:

The correct answer is option 2) i.e. (A), (C), (D), (B)

CONCEPT:

- **Focal length of a convex lens:** The focal length of a convex lens varies with the wavelength of light passing through it. This phenomenon is due to dispersion, where different wavelengths of light are refracted by different amounts.
- The focal length is shorter for light of shorter wavelengths (like violet) and longer for light of longer wavelengths (like red).

ORDER OF WAVELENGTH:

Red > Yellow > Blue > Violet

ORDER OF FOCAL LENGTH:

Since focal length is inversely proportional to the refractive index, which is higher for shorter wavelengths:

F_v (Violet) < F_b (Blue) < Fy (Yellow) < F_r (Red)

Thus, the increasing order of the focal length of the convex lens is:

(A) F_v (Violet), (C) F_b (Blue), (D) Fy (Yellow), (B) F_r (Red)

Question 37

Light from a point source in air falls on a spherical glass surface (n=1.5 and radius of curvature = 10 cm). The distance of the light source from the glass surface is 50 cm. The position at which the image is formed is:

Options:

A. 100 cm in the air

B. 150 cm in the glass surface

C. 200 cm in the air

D. 50 cm in the glass surface

Answer: D

Solution:

Solution:

The question provides a spherical lens with given parameters. The object distance, refractive index of the medium, and the radius of curvature of the spherical surface are used to calculate the image distance and determine the position of the image.

The given formula for refraction at a spherical surface is:

$\mathbf{n_2 / v - n_1 / u = (n_2 - n_1) / R}$

Where:

- $\mathbf{n_1 = 1}$ (refractive index of air)
- $\mathbf{n_2 = 1.5}$ (refractive index of glass)
- **u = -50 cm** (object distance is negative as per sign convention)
- **R = 10 cm** (radius of curvature of the spherical surface)

Rearranging the formula to solve for the image distance (v):

1 / v = 1.5 / 75

Therefore, v = 75 cm.

The image is formed 75 cm inside the glass.

Finally, the image distance in air is:

$\mathbf{v_{air} = 75 / 1.5 = 50}$ **cm**

Question 38

Read the following:

(A) The width of the central band in the diffraction pattern.
(B) The width of the first bright band in the diffraction pattern.
(C) The width of the central band in the diffraction pattern if D is doubled.
(D) The width of the first bright band in the diffraction pattern if D is tripled.

Choose the correct answer from the options given below in increasing order of width.

Options:

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

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

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

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

Answer: C

Solution:

The correct answer is option 3) i.e. (C), (A), (D), (B)

CONCEPT

- **Diffraction pattern:** When light passes through a single slit, it creates a diffraction pattern on a screen. The central band (central maximum) and the surrounding bands (secondary maxima) have different widths.

CALCULATION

For a single slit diffraction pattern, the width of the central band (central maximum) is given by:

$W_{central} = (2\lambda D) / a$

The width of the first bright band (secondary maximum) is given by:

$W_{first} = (\lambda D) / a$

Where:

- λ is the wavelength of the light
- D is the distance between the slit and the screen
- a is the width of the slit

Now, consider the following changes:

- (C) When D is doubled: $W_{central} = (2\lambda * 2D) / a = (4\lambda D) / a$
- (D) When D is tripled: $W_{first} = (\lambda * 3D) / a = (3\lambda D) / a$

Comparing the widths:

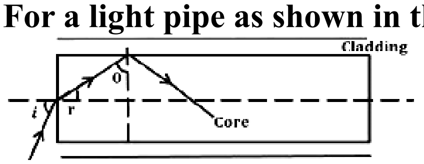
- (C) 4λD / a
- (A) 2λD / a
- (D) 3λD / a
- (B) λD / a

Thus, the correct order of widths in increasing order is:

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

Question 39

For a light pipe as shown in the figure:



(A) Optical density of core should be greater than the optical density of cladding
(B) r and θ will always be equal
(C) Optical density of cladding is sinθ.sin i / sin r
(D) Optical density of cladding is sin r.sin i / sin θ
Choose the correct answer from the options given below:

Options:

A. (A), (B) and (D) only

B. (A), (B) and (C) only

C. (A), (C) only

D. (B), (C) and (D) only

Answer: C

Solution:

Given options:

For Tir, The optical density of the core should be greater than the optical density of the cladding.

The condition for TIR is

$\sin i = n_{core} \sin r$

Also, $n_{core} \sin\theta = n_{cladding}$

$n_{cladding} = \sin\theta . \sin i / \sin r$

Correct answer: Option 3) (A), (C) only

Question 40

If the energy of incident radiation is increased by 25%. The kinetic energy of the photoelectrons emitted from the metal surface increased from 0.6 eV to 0.9 eV. The work function of the metal is:

Options:

A. 1 eV

B. 1.2 eV

C. 1.5 eV

D. 0.6 eV

Answer: D

Solution:

The correct answer is option 4) i.e. 0.6 eV.

<u>**CONCEPT**</u>:

- **Photoelectric Effect:** The emission of electrons from a metal surface when light of sufficient frequency shines on it is called the photoelectric effect.
- The energy of the incident photons is given by: **E = hν**
- The kinetic energy (KE) of the emitted photoelectrons is given by the equation:

KE = hν - φ

where:

- **hν** is the energy of the incident radiation
- **φ** is the work function of the metal
- **KE** is the kinetic energy of the emitted photoelectrons

<u>**CALCULATION**</u>**:**

Let the initial energy of the incident radiation be **E0**.

Given that:

Initial kinetic energy, **KE1 = 0.6 eV**

Final kinetic energy, **KE2 = 0.9 eV**

Energy of the incident radiation is increased by 25%, so the final energy of the incident radiation **E2** is:

E2 = 1.25 E0

Using the photoelectric equation:

For initial energy:

KE1 = E0 - φ

For final energy:

KE2 = 1.25 E0 - φ

Substituting the given values:

0.6 = E0 - φ

0.9 = 1.25 E0 - φ

Subtracting the first equation from the second:

0.9 - 0.6 = 1.25 E0 - E0

0.3 = 0.25 E0

E0 = 0.3 / 0.25 = 1.2 eV

Using the value of **E0** in the initial equation:

0.6 = 1.2 - φ

φ = 1.2 - 0.6 = 0.6 eV

Question 41

If the momentum of the electron is changed by P then the de Broglie wavelength associated with it changes by 1%. The initial momentum of the electron will be:

Options:

A.

200 P

B.

100 P

C.

300 P

D.

150 P

Answer: B

Solution:

The correct answer is option 1) i.e.$100P$

CONCEPT:

- The de Broglie wavelength (λ) of a particle is related to its momentum (p) by the equation:

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

- Where h is the Planck constant.
- If the momentum of the electron changes by P , the change in de Broglie wavelength ($\Delta\lambda$) is given by:

$$\Delta\lambda = \lambda \times \frac{\Delta p}{p} = \lambda \times \frac{P}{p}$$

<u>**CALCULATION**</u>:

Given that the change in de Broglie wavelength is 1%:

$$\frac{\Delta\lambda}{\lambda} = 0.01$$

We have:

$$0.01 = \frac{P}{p}$$

Solving for the initial momentum p :

$$p = \frac{P}{0.01} = 100P$$

Therefore, the initial momentum of the electron is 100P.

Question 42

Consider the following particles:

(A) Proton
(B) α particle
(C) Electron

For charge to mass ratio of the above particles we can say:

Options:

A. (C) > (A) > (B)

B. (A) < (C) < (B)

C. (B) = (A) > (C)

D. (C) = (B) > (A)

Answer: A

Solution:

The correct answer is: (C) > (A) > (B)

<u>**CONCEPT:**</u>

- **Charge to mass ratio:** The charge to mass ratio (q/m) is a physical quantity that represents the amount of electric charge a particle carries per unit of its mass.
- This ratio varies significantly for different particles:
    - **Electron (e):** Has a very high charge to mass ratio due to its extremely small mass and a charge of -1e.
    - **Proton (p):** Has a lower charge to mass ratio than the electron because its mass is much larger, even though its charge is +1e.
    - **Alpha particle (α):** Has the lowest charge to mass ratio among the three. Although it has a charge of +2e, it consists of 2 protons and 2 neutrons, making its mass approximately four times that of a proton.

<u>**CALCULATION:**</u>

Given particles:

- (A) Proton
- (B) Alpha particle

- (C) Electron

The charge to mass ratio ranking for these particles is:

- **Electron (C):** Highest charge to mass ratio.
- **Proton (A):** Moderate charge to mass ratio.
- **Alpha particle (B):** Lowest charge to mass ratio.

Hence, the correct order is: (C) > (A) > (B)

Question 43

As per Nuclear Physics there is a close relationship between mass number and radius of the nucleus. If the mass number of A is 216 and the mass number of B is 27, then the ratio of the nuclear radii (r_a/r_ʙ) of the two elements is:

Options:

A. 2:1

B. 4:1

C. 6:1

D. 8:1

Answer: A

Solution:

The correct answer is option 1) i.e.2:1

CONCEPT:

- **Nuclear Radius:** The radius of a nucleus (R) is related to its mass number (A) by the empirical formula:

R = R_0 A^{1/3}

where:

- R is the radius of the nucleus
- R_0 is a constant (approximately 1.2 fm)
- A is the mass number

CALCULATION:

Given that:

Mass number of A (A_a) = 216

Mass number of B (A_b) = 27

The ratio of the nuclear radii (r_a/r_b) can be calculated as follows:

$$\frac{r_a}{r_b} = \frac{R_0 {A_a}^{1/3}}{R_0 A_b^{1/3}} = \left(\frac{A_a}{A_b}\right)^{1/3}$$

Substituting the given values:

$$\frac{r_a}{r_b} = \left(\frac{216}{27}\right)^{1/3} = (8)^{1/3} = 2$$

Thus, the ratio of the nuclear radii (r_a/r_b) is 2:1.

Question 44

An equilateral prism is made of a material of refractive index √3. The angle of minimum deviation through the prism is:

Options:

A. 60°

B. 30°

C. 45°

D. 0°

Answer: A

Solution:

The correct answer is option 1) i.e. 60°

CONCEPT:

- **Angle of Minimum Deviation:** The angle of minimum deviation is the smallest angle by which the path of light is deviated by the prism. For an equilateral prism, this can be calculated using the prism's refractive index and the geometry of the prism.

CALCULATION:

Given that:

Refractive Index, n = √3

For an equilateral prism, the angle of the prism, A = 60°

The formula for the angle of minimum deviation (D) in terms of refractive index (n) and the prism angle (A) is:

$n = \frac{sin[(A+D)/2]}{sin(A/2)}$

Substituting the given values:

√3 = \frac{sin[(60° + D)/2]}{sin(30°)}

Since sin(30°) = 1/2, we can rewrite the equation as:

√3 = 2 sin[(60° + D)/2]

⇒ sin[(60° + D)/2] = √3 /2

⇒ (60° + D)/2 = 60°

⇒ 60° + D = 120°

⇒ D = 60°

Therefore, the angle of minimum deviation is 60°.

Question 45

When a photon of energy hν falls on a photosensitive metallic surface (work function $h\nu_0$), electrons are emitted from the metallic surface. It is possible to say that:

Options:

A. All ejected electrons have the same KE equal to ($h\nu - h\nu_0$)

B. The ejected electrons have a distribution of KE, the most energetic ones having KE equal to ($h\nu - h\nu_0$)

C. The most energetic electrons have KE equal to hν

D. The KE of ejected electrons is $h\nu_0$

Answer: B

Solution:

The correct answer is: The ejected electrons have a distribution of kinetic energy (KE), the most energetic ones having KE equal to ($h\nu - h\nu_0$)

CONCEPT:

- **Photoelectric Effect:** When light of a certain frequency or higher strikes a photosensitive surface, it causes the emission of electrons. This is known as the photoelectric effect.

According to the photoelectric equation:

$KE = h\nu - h\nu_0$

Where:

- KE is the kinetic energy of the emitted electron
- $h\nu$ is the energy of the incident photon (h is Planck's constant and ν is the frequency of incident light)
- $h\nu_0$ is the work function of the metal (the minimum energy needed to eject an electron)

CALCULATION:

When a photon with energy $h\nu$ strikes the metal surface, it transfers its energy to an electron. A part of this energy is used to overcome the work function ($h\nu_0$), and the rest becomes the kinetic energy of the electron.

Therefore, the maximum kinetic energy of the ejected electrons is:

$KE(max) = h\nu - h\nu_0$

However, since some electrons may lose energy due to collisions within the material before escaping, the emitted electrons exhibit a range of kinetic energies. The most energetic ones will still have $KE = h\nu - h\nu_0$.

Hence, the correct answer is: The ejected electrons have a distribution of KE, the most energetic ones having $KE = h\nu - h\nu_0$.

Question 46

Two parallel plate capacitors, each of capacitance 40 μF are connected in series. The space between the plates of one capacitor is filled with a material of dielectric constant K=4. The equivalent capacitance of the system would be:

Options:

A. 30 μF

B. 31 μF

C. 32 μF

D. 33 μF

Answer: C

Solution:

The correct answer is: 32 μF

CONCEPT:

- **Capacitance in Series:** When two capacitors are connected in series, the equivalent capacitance (C_{eq}) is given by the formula:

$1 / C_{eq} = 1 / C_1 + 1 / C_2$

CALCULATION:

Each capacitor originally has a capacitance of 40 μF.

One capacitor is filled with a dielectric material having a dielectric constant K = 4. Therefore, the new capacitance of this capacitor becomes:

$C_1 = K \times C = 4 \times 40\ \mu F = 160\ \mu F$

The second capacitor (C_2) remains unchanged at 40 μF.

Now applying the series combination formula:

$1 / C_{eq} = 1 / 160 + 1 / 40$

$\Rightarrow 1 / C_{eq} = (1 + 4) / 160 = 5 / 160$

$\Rightarrow C_{eq} = 160 / 5 = 32\ \mu F$

Therefore, the correct answer is: 32 μF

Question 47

The Wheatstone bridge is an arrangement of four resistances, say R_1, R_2, R_3 and R_4. The null point condition is given by:

Options:

A. $R_1/R_2 = R_3/R_4$

B. $R_1 + R_2 = R_3 + R_4$

C. $R_1 - R_2 = R_3 - R_4$

D. $R_1 \times R_2 = R_3 \times R_4$

Answer: A

Solution:

The correct answer is option 1) i.e. $\frac{R_1}{R_2} = \frac{R_3}{R_4}$

CONCEPT:

- **Wheatstone Bridge:** The Wheatstone bridge is an electrical circuit used to measure an unknown electrical resistance by balancing two legs of a bridge circuit.
  - The primary condition for the bridge to be balanced (null point condition) is when the ratio of two resistances in one leg is equal to the ratio of two resistances in the other leg.

CALCULATION:

Given resistances are R_1, R_2, R_3, and R_4.

According to the null point condition of the Wheatstone bridge, the bridge is balanced when:

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

Therefore, the correct answer is option 1.

Question 48

A long solenoid is formed by winding insulated copper wire at the rate of 20 turns per cm. The current that is necessary to produce a magnetic field of 20 mT inside the solenoid at its centre would be:

Options:

A.

7.0 A

B.

8.0 A

C.

9.0 A

D.

10.0 A

Answer: B

Solution:

The correct answer is option 1) i.e. 8.0 A

CONCEPT:

- **Magnetic field inside a solenoid:** The magnetic field inside a long solenoid is given by the formula:

$B = \mu_0 n I$

- Where:
  - B is the magnetic field
  - μ_0 is the permeability of free space ($4\pi \times 10^{-7}\,\mathrm{Tm/A}$)
  - n is the number of turns per unit length
  - I is the current

CALCULATION:

Given that:

$$n = 20\,\mathrm{turns/cm} = 2000\,\mathrm{turns/m}$$

$$B = 20\,\mathrm{mT} = 20 \times 10^{-3}\,\mathrm{T}$$

Using the formula $B = \mu_0 n I$:

$I = \frac{B}{\mu_0 n}$

Substitute the values:

$I = \frac{20\times10^{-3}\,\mathrm{T}}{4\pi\times10^{-7}\,\mathrm{Tm/A}\times2000\,\mathrm{turns/m}}$

Calculate:

$I = \frac{20\times10^{-3}}{8\pi\times10^{-4}}$

$I = \frac{20}{8\pi}$

$I = \frac{5}{2\pi}$

$$\pi \approx 3.14$$

$I = \frac{5}{6.28}$

$I \approx 0.796 \approx 8\,\mathrm{A}$

Therefore, the correct answer is option 2) i.e. 8.0 A

Question 49

Study of radioactive decay of unstable nuclei resulting in emission of a particle lead us to four different observations listed below:

(A) no change in atomic number and mass number.
(B) no change in mass number but the atomic number decreases by 1.

(C) no change in mass number but the atomic number increases by 1.
(D) atomic number decreases by 2 and the mass number decreases by 4.

Arrange the particles emitted in the above four cases in correct sequence.

Choose the correct answer from the options given below.

Options:

A. alpha particle, positron, electron, photon.

B. alpha particle, electron, positron, photon.

C. photon, positron, electron, alpha particle.

D. alpha particle, positron, photon, electron.

Answer: C

Solution:

The correct answer is option 3) i.e. photon, positron, electron, alpha particle.

EXPLANATION:

Radioactive decay can result in the emission of different particles, each affecting the atomic and mass numbers of the nucleus in distinct ways. Here are the explanations for each observation:

- **(A) No change in atomic number and mass number:** This corresponds to the emission of a photon (gamma radiation). Gamma radiation is a type of electromagnetic radiation that does not alter the atomic or mass number of the nucleus.
- **(B) No change in mass number but the atomic number decreases by 1:** This corresponds to the emission of a positron (beta plus decay). In this process, a proton is converted into a neutron, resulting in the emission of a positron and a neutrino.
- **(C) No change in mass number but the atomic number increases by 1:** This corresponds to the emission of an electron (beta minus decay). In this process, a neutron is converted into a proton, resulting in the emission of an electron and an antineutrino.
- **(D) Atomic number decreases by 2 and the mass number decreases by 4:** This corresponds to the emission of an alpha particle. An alpha particle consists of 2 protons and 2 neutrons, hence reducing the atomic number by 2 and the mass number by 4.

Hence, the correct sequence is:

photon, positron, electron, alpha particle.

Question 50

In a p type semiconductor the acceptor level is situated 50 meV above the valence band. The maximum wavelength of light required to produce a hole will be:

Options:

A. 24.8×10^{-5} m

B. 0.248×10^{-5} m

C. 2.48×10^{-5} m

D. 248×10^{-5} m

Answer: C

Solution:

The correct answer is: 2.48×10^{-5} m

CONCEPT:

- **Energy-Wavelength Relationship:** The energy of a photon is related to its wavelength using the equation:

$E = (h \times c) / \lambda$

Where:

- E is the energy of the photon
- h is Planck's constant = 6.626×10^{-34} Js
- c is the speed of light = 3×10^{8} m/s
- λ is the wavelength of the light

CALCULATION:

Given: Energy required to produce a hole = 50 meV

Convert energy from meV to joules:

$E = 50 \times 10^{-3}$ eV $= 50 \times 10^{-3} \times 1.602 \times 10^{-19}$ J $= 8.01 \times 10^{-21}$ J

Using the formula:

$\lambda = (h \times c) / E$

$\lambda = (6.626 \times 10^{-34} \times 3 \times 10^{8}) / (8.01 \times 10^{-21})$

$\lambda = 24.8 \times 10^{-6}$ m

Converting to standard scientific notation:

$\lambda = 2.48 \times 10^{-5}$ m

Therefore, the maximum wavelength of light required to produce a hole is: 2.48×10^{-5} m

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