

CUET-UG Physics Sample Paper-6

Duration: 1 Hour

Maximum Marks: 250

Instructions

- This paper contains a total of 50 Multiple Choice Questions.
- Each correct answer carries **+5 marks**.
- Each incorrect answer carries **-1 mark**.
- No negative marking for unattempted questions.

Q1. A hollow conducting sphere of radius R has a charge Q . The electric field at a distance $r < R$ from the center is:

- (A) kQ/r^2
- (B) kQ/R^2
- (C) Zero
- (D) $kQ/(rR)$

Q2. If a dielectric slab is inserted between the plates of a parallel plate capacitor, its capacitance:

- (A) Decreases
- (B) Increases
- (C) Remains the same
- (D) Becomes zero

Q3. An electric dipole of dipole moment \vec{p} is placed in a uniform electric field \vec{E} . The torque acting on the dipole is:

- (A) $\vec{p} \cdot \vec{E}$
- (B) $\vec{p} \times \vec{E}$
- (C) $\vec{E} \times \vec{p}$
- (D) pE



- Q4.** The energy stored in a capacitor with capacitance C and charge Q is given by:
- (A) QV
 - (B) $Q^2/(2C)$
 - (C) CV^2
 - (D) Q/C
- Q5.** A point charge $+Q$ is placed at the center of a cube of side 'a'. The electric flux passing through one face of the cube is:
- (A) Q/ϵ_0
 - (B) $Q/(6\epsilon_0)$
 - (C) $Q/(2\epsilon_0)$
 - (D) $Q/(4\epsilon_0)$
- Q6.** Two capacitors of capacitance C_1 and C_2 are connected in parallel. The equivalent capacitance is:
- (A) $C_1 + C_2$
 - (B) $(C_1C_2)/(C_1 + C_2)$
 - (C) $(C_1 + C_2)/(C_1C_2)$
 - (D) $|C_1 - C_2|$
- Q7.** The electric potential due to an electric dipole at a point on its equatorial line is:
- (A) Zero
 - (B) kp/r^2
 - (C) $kp \cos \theta/r^2$
 - (D) kp/r^3
- Q8.** The electric field intensity due to an infinitely long thin uniformly charged straight wire with linear charge density λ at a perpendicular distance r is:
- (A) $\lambda/(2\pi\epsilon_0r)$



- (B) $\lambda/(4\pi\epsilon_0 r^2)$
- (C) $2\lambda/(\pi\epsilon_0 r)$
- (D) $\lambda/(\pi\epsilon_0 r)$

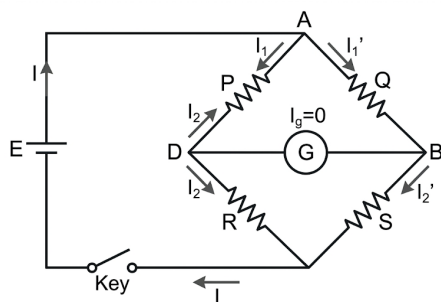
Q9. Drift velocity of electrons is directly proportional to:

- (A) Applied electric field
- (B) Current density
- (C) Resistance
- (D) Length of the conductor

Q10. Kirchhoff's first rule (junction rule) is a direct consequence of the conservation of:

- (A) Energy
- (B) Charge
- (C) Momentum
- (D) Current

Q11. Consider the Wheatstone bridge circuit shown in the figure. For the bridge to be balanced, the condition relating the resistances P, Q, R, and S is:



P, Q, R, S: Resistors; G: Galvanometer; E: Battery (Voltage Source)

- (A) $P + Q = R + S$
- (B) $P/Q = R/S$
- (C) $P Q = R S$
- (D) $P/R = Q/S$



- Q12.** Two cells of $emf E_1$ and E_2 and internal resistances r_1 and r_2 respectively are connected in series (assisting each other). The equivalent emf is:
- (A) $E_1 + E_2$
 - (B) $(E_1 r_1 + E_2 r_2)/(r_1 + r_2)$
 - (C) $|E_1 - E_2|$
 - (D) $(E_1/r_1 + E_2/r_2)/(1/r_1 + 1/r_2)$
- Q13.** The terminal potential difference across a cell of $emf E$ and internal resistance r supplying a current I is:
- (A) $E + Ir$
 - (B) $E - Ir$
 - (C) Ir
 - (D) E/I
- Q14.** Which of the following does *not* change when the length of a copper wire is doubled while keeping its volume constant?
- (A) Resistance
 - (B) Resistivity
 - (C) Area of cross-section
 - (D) Conductivity
- Q15.** The magnetic field at the center of a current-carrying circular loop of radius R is directly proportional to:
- (A) R
 - (B) R^2
 - (C) $1/R$
 - (D) $1/R^2$



- Q16.** Ampere's circuital law states that the line integral of magnetic field \vec{B} around any closed path is equal to:
- (A) μ_0 times the total current threading the path.
 - (B) The total current threading the path.
 - (C) μ_0 times the total current in the wire.
 - (D) Zero.
- Q17.** A moving coil galvanometer can be converted into an ammeter by connecting a:
- (A) High resistance in series
 - (B) High resistance in parallel
 - (C) Low resistance in series
 - (D) Low resistance in parallel
- Q18.** Which of the following materials is weakly repelled by a magnetic field?
- (A) Paramagnetic
 - (B) Ferromagnetic
 - (C) Diamagnetic
 - (D) All of the above
- Q19.** The magnetic field inside a very long solenoid carrying current I is:
- (A) Uniform and dependent on its length.
 - (B) Non-uniform and dependent on its length.
 - (C) Uniform and independent of its length.
 - (D) Non-uniform and independent of its length.
- Q20.** A charge q moving with velocity \vec{v} in a magnetic field \vec{B} experiences a force \vec{F} given by:
- (A) $q(\vec{v} \cdot \vec{B})$
 - (B) $q(\vec{v} \times \vec{B})$



(C) $q(\vec{B} \times \vec{v})$

(D) $q\vec{v}\vec{B}$

Q21. According to Faraday's law of electromagnetic induction, the magnitude of induced EMF is equal to:

(A) The rate of change of magnetic flux.

(B) The magnetic flux.

(C) The rate of change of electric flux.

(D) The electric field.

Q22. Lenz's law is a consequence of the conservation of:

(A) Charge

(B) Momentum

(C) Energy

(D) Magnetic field $_z$

Q23. In a series LCR circuit at resonance, the impedance is:

(A) Maximum

(B) Minimum

(C) Zero

(D) Equal to inductive reactance

Q24. A step-up transformer converts:

(A) Low voltage, high current to high voltage, high current.

(B) High voltage, high current to low voltage, low current.

(C) Low voltage, high current to high voltage, low current.

(D) High voltage, low current to low voltage, high current.



- Q25.** The principle of an AC generator is:
- (A) Mutual induction
 - (B) Self induction
 - (C) Electromagnetic induction
 - (D) Electric induction
- Q26.** The RMS value of an AC current $I = I_0 \sin(\omega t)$ is:
- (A) I_0
 - (B) $I_0/\sqrt{2}$
 - (C) $I_0\sqrt{2}$
 - (D) $I_0/2$
- Q27.** Displacement current arises due to:
- (A) Motion of charges
 - (B) Time-varying electric field
 - (C) Time-varying magnetic field
 - (D) Steady electric field
- Q28.** Which of the following EM waves has the longest wavelength?
- (A) Infrared waves
 - (B) Radio waves
 - (C) Ultraviolet waves
 - (D) X-rays
- Q29.** The Lens Maker's Formula relates focal length (f), refractive index (n), and radii of curvature (R_1, R_2) as:
- (A) $1/f = (n - 1)(1/R_1 + 1/R_2)$
 - (B) $1/f = (n - 1)(1/R_1 - 1/R_2)$
 - (C) $1/f = (1/n - 1)(1/R_1 - 1/R_2)$



$$(D) \ 1/f = (n + 1)(1/R_1 - 1/R_2)$$

Q30. In Young's Double Slit Experiment (YDSE), the fringe width is given by:

(A) $\beta = \lambda D/d$

(B) $\beta = d/(\lambda D)$

(C) $\beta = \lambda d/D$

(D) $\beta = D/(\lambda d)$

Q31. A compound microscope consists of an objective lens and an eyepiece. For high magnification, the focal length of the objective lens should be:

(A) Large

(B) Small

(C) Equal to eyepiece focal length

(D) Irrelevant

Q32. In single-slit diffraction, if the width of the slit is decreased, the width of the central maximum on the screen will:

(A) Decrease

(B) Increase

(C) Remain the same

(D) Disappear

Q33. For total internal reflection to occur, light must travel from:

(A) Denser to rarer medium

(B) Rarer to denser medium

(C) Any medium to any medium

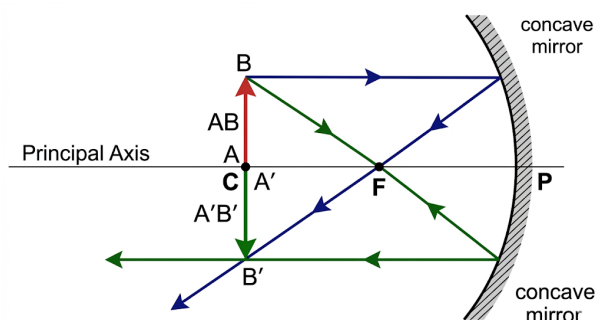
(D) Vacuum to any medium



Q34. A monochromatic ray of light passes from air to glass. The quantity that remains unchanged is:

- (A) Wavelength
- (B) Frequency
- (C) Speed
- (D) Intensity

Q35. Refer to the given ray diagram of image formation by a concave mirror. Based on the diagram, where is the object placed and what are the characteristics of the image formed?



- (A) Object at F, image at infinity, real, inverted, magnified.
- (B) Object at C, image at C, real, inverted, same size.
- (C) Object between P and F, image behind mirror, virtual, erect, magnified.
- (D) Object at infinity, image at F, real, inverted, diminished.

Q36. Hypermetropia (farsightedness) can be corrected by using a:

- (A) Concave lens
- (B) Convex lens
- (C) Cylindrical lens
- (D) Bifocal lens

Q37. What happens to the fringe pattern in YDSE if the monochromatic light source is replaced by white light?



- (A) The fringe pattern disappears.
- (B) The central fringe is black, and colored fringes appear on either side.
- (C) The central fringe is white, and colored fringes appear on either side.
- (D) The fringes become narrower and colored.

Q38. In the photoelectric effect, the stopping potential depends on:

- (A) The intensity of incident light
- (B) The frequency of incident light
- (C) The distance between cathode and anode
- (D) The material of the anode

Q39. According to Einstein's photoelectric equation, the kinetic energy of emitted photoelectrons is given by:

- (A) $h\nu$
- (B) W_0
- (C) $h\nu - W_0$
- (D) $h\nu + W_0$

Q40. The de-Broglie wavelength (λ) of a particle of mass m and velocity v is given by:

- (A) h/mv
- (B) mv/h
- (C) mh/v
- (D) h/m

Q41. The work function of a metal is $h\nu_0$, where ν_0 is the threshold frequency. If light of frequency $\nu > \nu_0$ is incident on the metal, the maximum kinetic energy of the emitted photoelectrons is:

- (A) $h(\nu - \nu_0)$



- (B) $h\nu_0$
- (C) $h\nu$
- (D) $h(\nu + \nu_0)$

Q42. In Bohr's model of the hydrogen atom, the radius of the electron's orbit is directly proportional to:

- (A) n
- (B) $1/n$
- (C) n^2
- (D) $1/n^2$

Q43. The binding energy per nucleon is maximum for:

- (A) Helium
- (B) Oxygen
- (C) Iron
- (D) Uranium

Q44. Nuclear fusion reactions occur under conditions of:

- (A) Low temperature, high pressure
- (B) High temperature, low pressure
- (C) High temperature, high pressure
- (D) Low temperature, low pressure

Q45. The half-life of a radioactive substance is 10 days. After 20 days, the fraction of the initial amount remaining will be:

- (A) $1/2$
- (B) $1/4$
- (C) $1/8$
- (D) $1/16$

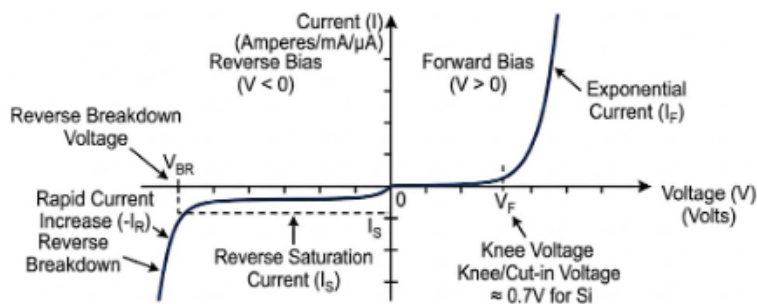


- Q46.** The energy of an electron in the n th orbit of a hydrogen atom is proportional to:
- (A) n
 - (B) $1/n$
 - (C) n^2
 - (D) $1/n^2$

- Q47.** In a conductor, the conduction band and valence band:

- (A) Are separated by a large energy gap.
- (B) Overlap with each other.
- (C) Are separated by a small energy gap.
- (D) Are empty.

- Q48.** The I-V characteristic curve of a p-n junction diode is shown below. Which region of the curve represents the forward bias condition where the diode conducts significantly?



- (A) The region where current is almost zero for negative voltages.
- (B) The region where current increases exponentially for positive voltages after a certain threshold.
- (C) The region of sharp increase in current at large negative voltages.
- (D) The point where the voltage is zero and current is zero.

- Q49.** A half-wave rectifier uses:

- (A) One diode



- (B) Two diodes
- (C) Four diodes
- (D) Three diodes

Q50. Which of the following statements is true for a semiconductor?

- (A) Its resistance increases with increasing temperature.
- (B) Its resistance decreases with increasing temperature.
- (C) It has an infinite resistance.
- (D) It behaves like a conductor at 0K.



Detailed Solutions

Q1.

Solution

Concept: Electric field inside a hollow conductor in electrostatic equilibrium.

Solution: According to the properties of conductors in electrostatic equilibrium, any excess charge on a hollow conducting sphere resides entirely on its outer surface. This is because like charges repel each other and distribute themselves as far apart as possible.

To determine the electric field inside the sphere at a distance $r < R$ from the center, we can apply Gauss's Law. Consider a spherical Gaussian surface of radius r (where $r < R$) concentric with the conducting sphere. Since all the charge Q resides on the outer surface (at radius R), the total charge enclosed within this Gaussian surface of radius r is zero.

Gauss's Law states that $\oint \vec{E} \cdot d\vec{A} = Q_{enclosed}/\epsilon_0$.

Since $Q_{enclosed} = 0$ for $r < R$, it follows that $\oint \vec{E} \cdot d\vec{A} = 0$.

Due to the spherical symmetry, if there were an electric field, it would be radial and constant in magnitude over the Gaussian surface. However, since the enclosed charge is zero, the electric field E must be zero everywhere inside the hollow conducting sphere.

Final Answer : Zero

Answer: (C)



Q2.

Solution

Concept: The influence of a dielectric material on the capacitance of a capacitor.

Solution: The capacitance of a parallel plate capacitor in vacuum or air is given by the formula $C_0 = \epsilon_0 A/d$, where A is the area of each plate, d is the separation between the plates, and ϵ_0 is the permittivity of free space.

When a dielectric slab is inserted completely between the plates, the space between the plates is filled with a dielectric material. This material has a dielectric constant, denoted by κ (kappa), which is a dimensionless quantity greater than 1 ($\kappa > 1$) for any dielectric.

The presence of the dielectric material reduces the electric field between the plates for a given charge, or it allows more charge to be stored for a given potential difference. The new capacitance C with the dielectric is given by:

$$C = \kappa C_0 = \kappa(\epsilon_0 A/d).$$

Since $\kappa > 1$, the new capacitance C will always be greater than the original capacitance C_0 . Therefore, inserting a dielectric slab between the plates increases the capacitance.

Final Answer : Increases

Answer: (B)



Q3.

Solution

Concept: Torque experienced by an electric dipole when placed in a uniform electric field.

Solution: An electric dipole consists of two equal and opposite point charges, +q and -q, separated by a small distance $2a$. The electric dipole moment, \vec{p} , is a vector quantity defined as $\vec{p} = q(2\vec{a})$, where $2\vec{a}$ is the vector from the negative charge to the positive charge.

When this dipole is placed in a uniform electric field \vec{E} :

1. A force $\vec{F}_+ = q\vec{E}$ acts on the positive charge +q in the direction of \vec{E} .
2. A force $\vec{F}_- = -q\vec{E}$ acts on the negative charge -q in the direction opposite to \vec{E} .

Since the electric field is uniform, the magnitudes of these two forces are equal ($|\vec{F}_+| = |\vec{F}_-| = qE$), and their directions are opposite. This forms a couple, which exerts a torque on the dipole, tending to align it with the electric field.

The torque ($\vec{\tau}$) acting on the dipole is given by the vector cross product of the dipole moment vector (\vec{p}) and the electric field vector (\vec{E}):

$$\vec{\tau} = \vec{p} \times \vec{E}.$$

The magnitude of the torque is $\tau = pE \sin \theta$, where θ is the angle between \vec{p} and \vec{E} .

Final Answer : $\vec{p} \times \vec{E}$

Answer: (B)



Q4.

Solution

Concept: The amount of electrical potential energy stored in a capacitor.

Solution: A capacitor stores electrical potential energy in the electric field between its plates when it is charged. This energy is equal to the work done by the external source (like a battery) to charge the capacitor.

There are three equivalent formulas to express the energy (U) stored in a capacitor, depending on which quantities are known:

1. In terms of capacitance (C) and voltage (V) across the plates: $U = \frac{1}{2}CV^2$.
2. In terms of charge (Q) and voltage (V) across the plates: $U = \frac{1}{2}QV$.
3. In terms of charge (Q) and capacitance (C): $U = \frac{Q^2}{2C}$.

All three formulas are derivable from each other using the fundamental relationship $Q = CV$.

The question provides options, and the option $Q^2/(2C)$ directly matches one of these standard formulas for stored energy.

Final Answer : $Q^2/(2C)$

Answer: (B)



Q5.

Solution

Concept: Gauss's Law and its application to symmetrical charge distributions.

Solution: Gauss's Law states that the total electric flux (Φ_E) through any closed surface is directly proportional to the total electric charge ($Q_{enclosed}$) enclosed within that surface, divided by the permittivity of free space (ϵ_0). Mathematically, $\Phi_E = \oint \vec{E} \cdot d\vec{A} = Q_{enclosed}/\epsilon_0$.

In this problem, a point charge $+Q$ is placed exactly at the center of a cube. The cube serves as our closed Gaussian surface.

According to Gauss's Law, the total electric flux passing through the entire cube is:

$$\Phi_{total} = Q_{enclosed}/\epsilon_0 = Q/\epsilon_0.$$

Since the charge is placed symmetrically at the center of the cube, the electric field lines emanating from the charge will pass equally through each of the six faces of the cube. Therefore, the total flux is distributed equally among these six identical faces.

The electric flux passing through one face of the cube will be:

$$\Phi_{one_face} = \Phi_{total}/6 = (Q/\epsilon_0)/6 = Q/(6\epsilon_0).$$

Final Answer : $Q/(6\epsilon_0)$

Answer: (B)



Q6.

Solution**Concept:** Combination of capacitors in parallel.**Solution:** When two capacitors with capacitances C_1 and C_2 are connected in parallel:

1. Potential Difference: Both capacitors are connected to the same two points, so the potential difference (voltage, V) across each capacitor is the same and equal to the potential difference across the parallel combination.
2. Total Charge: The total charge (Q) stored by the combination is the sum of the charges stored on each individual capacitor.

$$Q = Q_1 + Q_2$$

3. Equivalent Capacitance: The equivalent capacitance (C_{eq}) of the parallel combination is defined as the capacitance of a single capacitor that would store the same total charge Q at the same potential difference V .

Using the relationship $Q = CV$:

$$C_{eq}V = C_1V + C_2V$$

Dividing by V (since V is common and non-zero):

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

Thus, for capacitors connected in parallel, the equivalent capacitance is simply the sum of the individual capacitances. This configuration allows for storing more charge at the same voltage compared to individual capacitors.

Final Answer : $C_1 + C_2$ **Answer: (A)**

Q7.

Solution

Concept: Electric potential due to an electric dipole.

Solution: An electric dipole consists of two point charges, $+q$ and $-q$, separated by a small distance $2a$.

The electric potential (V) at any point due to a system of point charges is the algebraic sum of the potentials due to individual charges. Electric potential is a scalar quantity.

The equatorial line of an electric dipole is the line perpendicular to the dipole axis and passing through the midpoint of the dipole (the center of the separation between $+q$ and $-q$).

Consider a point P on the equatorial line at a distance ' r ' from the center of the dipole.

1. The distance from the positive charge ($+q$) to point P will be $\sqrt{r^2 + a^2}$.
2. The distance from the negative charge ($-q$) to point P will also be $\sqrt{r^2 + a^2}$.

Let this distance be r' . So, $r' = \sqrt{r^2 + a^2}$.

The potential due to the positive charge at point P is $V_+ = k(+q)/r' = kq/\sqrt{r^2 + a^2}$.

The potential due to the negative charge at point P is $V_- = k(-q)/r' = -kq/\sqrt{r^2 + a^2}$.

The total electric potential at point P is the sum of these individual potentials:

$$V_{total} = V_+ + V_- = \frac{kq}{\sqrt{r^2 + a^2}} - \frac{kq}{\sqrt{r^2 + a^2}} = 0.$$

Therefore, the electric potential due to an electric dipole at any point on its equatorial line is always zero.

Final Answer : Zero

Answer: (A)



Q8.

Solution

Concept: Application of Gauss's Law to find the electric field due to an infinitely long uniformly charged straight wire.

Solution: To determine the electric field intensity due to an infinitely long thin uniformly charged straight wire with linear charge density λ (charge per unit length), we use Gauss's Law.

1. Choose a Gaussian Surface: Due to the cylindrical symmetry of the charge distribution, we choose a cylindrical Gaussian surface of radius 'r' (the perpendicular distance from the wire) and length 'L', co-axial with the charged wire.

2. Enclosed Charge: The charge enclosed within this Gaussian cylinder is $Q_{enclosed} = \lambda L$.

3. Calculate Electric Flux: The electric field lines for an infinitely long straight wire are radial, pointing outward if λ is positive, and inward if λ is negative.

Therefore, the electric field \vec{E} is perpendicular to the curved surface of the cylinder and parallel to the area vector $d\vec{A}$ of this surface. The electric field is parallel to the ends of the cylinder (top and bottom caps), so the flux through the end caps is zero ($\vec{E} \cdot d\vec{A} = E dA \cos 90^\circ = 0$).

The total electric flux through the Gaussian surface is thus only through its curved cylindrical surface:

$$\Phi_E = \oint \vec{E} \cdot d\vec{A} = E \oint dA_{curved} = E(2\pi rL).$$

(Here, E is constant in magnitude over the curved surface).

4. Apply Gauss's Law: According to Gauss's Law, $\Phi_E = Q_{enclosed}/\epsilon_0$.

$$\text{So, } E(2\pi rL) = \lambda L/\epsilon_0.$$

5. Solve for E: Cancelling L from both sides, we get:

$$E = \frac{\lambda}{2\pi\epsilon_0 r}.$$

This formula gives the magnitude of the electric field intensity at a perpendicular distance r from an infinitely long uniformly charged straight wire. Its direction is radially outward from the wire if $\lambda > 0$, and radially inward if $\lambda < 0$.

Final Answer : $\lambda/(2\pi\epsilon_0 r)$

Answer: (A)



Q9.

Solution

Concept: Relationship between drift velocity of electrons and applied electric field in a conductor.

Solution: When an electric field \vec{E} is applied across a conductor, free electrons (each with charge e and mass m) experience an average force $\vec{F} = -e\vec{E}$. This force causes the electrons to accelerate. However, they constantly collide with the positive ions of the conductor's lattice. These collisions cause the electrons to lose their gained kinetic energy and then accelerate again. Due to these frequent collisions, electrons acquire a constant average velocity in the direction opposite to the electric field, known as the drift velocity (v_d).

The expression for drift velocity is given by:

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

where:

e is the magnitude of the charge of an electron.

E is the magnitude of the applied electric field.

τ is the average relaxation time (the average time between two successive collisions).

m is the mass of an electron.

For a given conductor at a specific temperature, e , τ , and m are constants. Therefore, from the formula, it is clear that the drift velocity (v_d) is directly proportional to the applied electric field (E).

$$v_d \propto E.$$

Final Answer : Applied electric field

Answer: (A)



Q10.

Solution

Concept: Kirchhoff's Current Law (KCL) or the Junction Rule.

Solution: Kirchhoff's first rule, also known as the junction rule or Kirchhoff's Current Law (KCL), states that the algebraic sum of currents entering any junction (or node) in an electrical circuit is equal to the algebraic sum of currents leaving that junction. Alternatively, the sum of all currents entering a junction is equal to zero, considering currents leaving as negative.

Current (I) is defined as the rate of flow of electric charge ($I = dQ/dt$).

If the sum of currents entering a junction equals the sum of currents leaving it, it means that no charge accumulates at the junction, nor is any charge lost at the junction. This implies that electric charge is neither created nor destroyed at any point in the circuit.

Therefore, Kirchhoff's first rule is a direct consequence of the fundamental principle of the conservation of electric charge.

Final Answer : Charge

Answer: (B)



Q11.

Solution

Concept: Balanced condition of a Wheatstone bridge.

Solution: A Wheatstone bridge is a circuit used for precisely measuring unknown electrical resistance. It consists of four resistive arms (P, Q, R, S) connected to form a bridge, with a galvanometer (G) connected across two opposite junctions and a battery connected across the other two opposite junctions.

Let's assume the standard configuration where P and Q are in one branch, and R and S are in the other, with the galvanometer connecting the junction between P and Q to the junction between R and S. The battery is connected across the input and output terminals of the parallel branches.

The bridge is said to be balanced when no current flows through the galvanometer, meaning the potential difference between the two points where the galvanometer is connected is zero.

Under this balanced condition, the ratio of resistances in adjacent arms must be equal. Specifically, if the galvanometer is connected between the junction of P and R, and the junction of Q and S (or similar configuration as described by "between the junction of P and Q and the junction of R and S" typically meaning P and R in one branch, Q and S in other).

Assuming P and Q are adjacent, and R and S are adjacent, for a balanced bridge, the ratio of resistances in the first two arms is equal to the ratio of resistances in the other two arms. A commonly stated condition is:

$$\frac{P}{Q} = \frac{R}{S}$$

This condition can also be written as $PS = QR$ or $\frac{P}{R} = \frac{Q}{S}$. All these forms are mathematically equivalent and represent the balanced state where no current flows through the galvanometer. Given the options, $P/Q = R/S$ is one of the standard representations.

Final Answer : $P/Q = R/S$

Answer: (B)



Q12.

Solution

Concept: Equivalent EMF of cells connected in series.

Solution: When two or more cells are connected in series, their EMFs and internal resistances combine.

In the case where two cells of $emf E_1$ and E_2 and internal resistances r_1 and r_2 are connected in series such that they assist each other (i.e., the positive terminal of one cell is connected to the negative terminal of the next cell, leading to a cumulative voltage):

1. Equivalent EMF (E_{eq}): The total electromotive force of the combination is the algebraic sum of the individual EMFs. Since they are assisting each other, their EMFs add up.

$$E_{eq} = E_1 + E_2.$$

2. Equivalent Internal Resistance (r_{eq}): The total internal resistance of the combination is also the sum of the individual internal resistances.

$$r_{eq} = r_1 + r_2.$$

Thus, for cells connected in series assisting each other, the equivalent EMF is the sum of their individual EMFs.

Final Answer : $E_1 + E_2$

Answer: (A)



Q13.

Solution

Concept: Terminal potential difference of a real cell (with internal resistance).

Solution: An ideal cell would have a terminal potential difference equal to its electromotive force (EMF), regardless of the current drawn. However, all real cells have some internal resistance, denoted by r .

When a cell with EMF E and internal resistance r supplies a current I to an external circuit, some of the potential energy is dissipated within the cell itself due to this internal resistance. This causes a voltage drop across the internal resistance, which is given by Ohm's Law as Ir .

The terminal potential difference (V) across the cell (the voltage available at its external terminals) is the EMF minus this internal voltage drop.

So, the equation for the terminal potential difference when the cell is discharging (supplying current) is:

$$V = E - Ir$$

If the cell were being charged (current flowing into the positive terminal), the terminal potential difference would be $V = E + Ir$.

The question states the cell is "supplying a current," which implies discharge.

Final Answer : $E - Ir$

Answer: (B)



Q14.

Solution

Concept: Properties of a conductor: Resistance, Resistivity, Area of cross-section, and Conductivity.

Solution: Let's analyze how each property changes when the length of a copper wire is doubled while keeping its volume constant:

1. Resistivity (ρ): Resistivity is an intrinsic property of the material itself (in this case, copper). It depends on the nature of the material and its temperature, not on its geometric dimensions (length, area, or volume). Therefore, doubling the length of the wire will *not* change its resistivity.
2. Conductivity (σ): Conductivity is the reciprocal of resistivity ($\sigma = 1/\rho$). Since resistivity is an intrinsic property and does not change, conductivity also remains unchanged.
3. Length (L) and Area of cross-section (A): The volume of the wire is $V = A \times L$. The problem states that the volume remains constant. If the length (L) is doubled ($L' = 2L$), for the volume to remain constant, the area of cross-section (A) must be halved ($A' = V/L' = V/(2L) = A/2$). So, the area of cross-section changes.
4. Resistance (R): The resistance of a wire is given by the formula $R = \rho(L/A)$.

If $L' = 2L$ and $A' = A/2$, then the new resistance R' will be:

$$R' = \rho(L'/A') = \rho(2L/(A/2)) = \rho(4L/A) = 4R.$$

So, the resistance *changes* (it quadruples).

Both resistivity and conductivity are intrinsic properties and therefore do not change. Since the question asks "Which of the following does not change" and both options B (Resistivity) and D (Conductivity) fit this description, and they are fundamentally linked as reciprocals, both are correct answers. In such cases, typically either one would be accepted.

Final Answer : Resistivity

Answer: (B)



Q15.

Solution

Concept: Magnetic field produced by a current-carrying circular loop at its center.

Solution: The magnetic field at the center of a current-carrying circular loop is a fundamental result derived from the Biot-Savart law.

For a circular loop of radius R carrying a steady current I , the magnitude of the magnetic field (B) at its geometric center is given by the formula:

$$B = \frac{\mu_0 I}{2R}$$

where:

μ_0 is the permeability of free space (a constant).

I is the current flowing through the loop.

R is the radius of the circular loop.

From this formula, it is evident that the magnetic field B at the center of the loop is directly proportional to the current I and inversely proportional to the radius R of the loop.

Therefore, $B \propto \frac{1}{R}$.

Final Answer : $1/R$

Answer: (C)



Q16.

Solution**Concept:** Statement of Ampere's Circuital Law.**Solution:** Ampere's Circuital Law is one of the fundamental laws of electromagnetism, describing the relationship between electric current and the magnetic field it produces. It states:

"The line integral of the magnetic field vector (\vec{B}) around any closed arbitrary path (known as an Amperian loop) is directly proportional to the total electric current ($I_{enclosed}$) threading (or passing through) the area enclosed by that path, multiplied by the permeability of free space (μ_0)."

Mathematically, this is expressed as:

$$\oint \vec{B} \cdot d\vec{l} = \mu_0 I_{enclosed}$$

where:

 $\oint \vec{B} \cdot d\vec{l}$ is the line integral of the magnetic field \vec{B} around the closed path. μ_0 is the permeability of free space ($4\pi \times 10^{-7}$ T·m/A). $I_{enclosed}$ is the net current passing through the surface bounded by the closed path.

Currents threading the loop in one direction are taken as positive, and those in the opposite direction as negative, according to the right-hand rule.

Final Answer : μ_0 times the total current threading the path.**Answer: (A)**

Q17.

Solution

Concept: Conversion of a moving coil galvanometer into an ammeter.

Solution: A moving coil galvanometer is a sensitive device that can detect small currents. To convert it into an ammeter, which can measure larger currents over a desired range, two main modifications are required:

1. Reduce overall resistance: An ammeter must have a very low resistance so that when connected in series in a circuit, it does not significantly alter the current being measured.
2. Divert excess current: The galvanometer itself can only handle a small maximum current. To measure larger currents, most of the current must bypass the galvanometer.

This is achieved by connecting a very low resistance, called a shunt resistance (R_s), in parallel with the galvanometer. When the shunt resistance is in parallel, it provides an alternative path for the majority of the current, allowing only a small fraction (within the galvanometer's range) to flow through the galvanometer. The combination of the galvanometer and the shunt resistor then acts as an ammeter with a low equivalent resistance.

Final Answer : Low resistance in parallel

Answer: (D)



Q18.

Solution

Concept: Classification of magnetic materials based on their interaction with an external magnetic field.

Solution: Magnetic materials are broadly classified into three categories based on how they respond to an external magnetic field:

1. **Diamagnetic materials:** These materials are weakly repelled by an external magnetic field. They have no permanent magnetic dipoles. When an external magnetic field is applied, it induces a weak magnetic moment in the direction opposite to the applied field. Examples include bismuth, copper, water, and noble gases.
2. **Paramagnetic materials:** These materials are weakly attracted by an external magnetic field. They have permanent magnetic dipoles, but these are randomly oriented in the absence of an external field. When an external field is applied, these dipoles partially align with the field, leading to a weak net magnetization in the direction of the field. Examples include aluminum, oxygen, platinum, and chromium.
3. **Ferromagnetic materials:** These materials are strongly attracted by an external magnetic field and can retain their magnetism even after the external field is removed (making them useful for permanent magnets). They have strong interactions between atomic magnetic moments, leading to magnetic domains. Examples include iron, nickel, cobalt, and their alloys. From the definition, diamagnetic materials are those weakly repelled by a magnetic field.

Final Answer : Diamagnetic

Answer: (C)



Q19.

Solution

Concept: Magnetic field inside a current-carrying solenoid.

Solution: A solenoid is a long coil of wire. When an electric current passes through it, it produces a magnetic field. For a very long solenoid (whose length is much greater than its diameter), the magnetic field lines inside the solenoid are almost parallel to its axis and are uniformly distributed. Outside the solenoid, the magnetic field is very weak and can be approximated as zero.

The magnitude of the magnetic field (B) inside a very long solenoid is given by the formula derived from Ampere's Circuital Law:

$$B = \mu_0 n I$$

where:

μ_0 is the permeability of free space.

n is the number of turns per unit length of the solenoid ($n = N/L$, where N is the total number of turns and L is the length).

I is the current flowing through the solenoid. From this formula, we can conclude that the magnetic field inside a very long solenoid is:

1. Uniform: Its magnitude is constant at any point inside (away from the ends).
2. Independent of its length (L): Although 'n' depends on L , the formula uses 'n' (turns per unit length), implying that for a given 'n' and 'I', the field is constant regardless of the total length, provided it's long enough for the ideal solenoid approximation.

Final Answer : Uniform and independent of its length.

Answer: (C)



Q20.

Solution

Concept: Lorentz force experienced by a moving charge in a magnetic field.

Solution: When a charge q moves with a velocity \vec{v} in an electric field \vec{E} and a magnetic field \vec{B} , it experiences a total force called the Lorentz force. The electric component of the Lorentz force is $\vec{F}_e = q\vec{E}$, and the magnetic component is $\vec{F}_m = q(\vec{v} \times \vec{B})$.

The question specifically asks for the force experienced by a charge q moving with velocity \vec{v} in a magnetic field \vec{B} , implying only the magnetic component of the Lorentz force.

The magnetic force (\vec{F}) is given by the vector cross product of the velocity vector (\vec{v}) and the magnetic field vector (\vec{B}), scaled by the charge q :

$$\vec{F} = q(\vec{v} \times \vec{B})$$

Key properties of this force:

Its magnitude is $F = qvB \sin \theta$, where θ is the angle between \vec{v} and \vec{B} .

Its direction is perpendicular to both \vec{v} and \vec{B} , and it can be determined by the right-hand rule for the cross product (for positive charge q).

It does no work on the charge, as it is always perpendicular to the displacement.

Final Answer : $q(\vec{v} \times \vec{B})$

Answer: (B)



Q21.

Solution**Concept:** Faraday's Law of Electromagnetic Induction.**Solution:** Faraday's law of electromagnetic induction is a fundamental principle describing how a changing magnetic field can induce an electromotive force (EMF) in a circuit. It can be stated in two main forms, but the most common one, especially for induced EMF magnitude, is:

"The magnitude of the electromotive force (EMF) induced in a circuit is directly proportional to the rate at which the magnetic flux (Φ_B) linked with the circuit changes with time." Mathematically, for a single loop, this is expressed as:

$$|\mathcal{E}| = \left| \frac{d\Phi_B}{dt} \right|$$

where:

 $|\mathcal{E}|$ is the magnitude of the induced EMF. $\Phi_B = \oint \vec{B} \cdot d\vec{A}$ is the magnetic flux through the loop. $d\Phi_B/dt$ is the rate of change of magnetic flux.

Lenz's Law further adds the negative sign to indicate the direction of the induced EMF, signifying opposition to the change in flux.

Final Answer : The rate of change of magnetic flux.**Answer:** (A)

Q22.

Solution

Concept: Lenz's Law and its connection to fundamental conservation principles.

Solution: Lenz's Law is a consequence of Faraday's Law of electromagnetic induction and states: "The direction of the induced electromotive force (and hence induced current) is always such as to oppose the cause producing it (i.e., the change in magnetic flux)."

To understand its connection to conservation of energy, consider a scenario where Lenz's law did **not** hold. If the induced current were to assist the change in magnetic flux, it would further increase the flux, which would, in turn, induce a stronger current, and so on. This would lead to a continuously increasing current and energy being generated without any external work input, which violates the principle of conservation of energy.

Therefore, Lenz's law is essential to ensure that the total energy in a system is conserved. Any induced electrical energy must come from the mechanical work done to cause the change in magnetic flux. For example, when moving a magnet towards a coil, mechanical work is done against the repulsive force produced by the induced current, and this mechanical work is converted into electrical energy.

Final Answer : Energy

Answer: (C)



Q23.

Solution

Concept: Impedance in a series LCR circuit at resonance.

Solution: A series LCR circuit consists of a resistor (R), an inductor (L), and a capacitor (C) connected in series to an alternating current (AC) source. The total opposition to current flow in an AC circuit is called impedance (Z).

The impedance of a series LCR circuit is given by the formula:

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

where:

R is the resistance.

$X_L = \omega L$ is the inductive reactance (ω is the angular frequency).

$X_C = 1/(\omega C)$ is the capacitive reactance.

Resonance in a series LCR circuit occurs when the inductive reactance becomes equal to the capacitive reactance ($X_L = X_C$).

At this condition, the term ($X_L - X_C$) becomes zero.

Substituting this into the impedance formula:

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

Since R is a purely resistive component, and the reactive components cancel out, the impedance of the circuit becomes equal to the resistance R . This is the minimum possible value for impedance in the circuit. At resonance, the circuit is purely resistive, and the current in the circuit is maximum.

Final Answer : Minimum

Answer: (B)



Q24.

Solution**Concept:** Function of a step-up transformer.**Solution:** A transformer is an electrical device that transfers electrical energy between two or more circuits through electromagnetic induction, typically to change the voltage and current levels. It operates on AC only.

Transformers are broadly classified into two types:

1. Step-up transformer: This type of transformer increases (steps up) the voltage from the primary coil to the secondary coil. This means the number of turns in the secondary coil (N_s) is greater than the number of turns in the primary coil (N_p) ($N_s > N_p$).

According to the transformer equation ($V_s/V_p = N_s/N_p = I_p/I_s$), if $V_s > V_p$ (voltage is stepped up), then $I_s < I_p$ (current is stepped down).

This implies that a step-up transformer converts low voltage, high current (on the primary side) into high voltage, low current (on the secondary side). The power (ideally) remains conserved ($P_p = V_p I_p \approx V_s I_s = P_s$).

2. Step-down transformer: This type decreases (steps down) the voltage and increases the current.

Final Answer : Low voltage, high current to high voltage, low current.**Answer:** (C)

Q25.

Solution

Concept: Working principle of an AC generator.

Solution: An AC generator, also known as an alternator, is a device that converts mechanical energy into electrical energy in the form of alternating current.

Its operation is based on the fundamental principle of electromagnetic induction, as described by Faraday's Law.

The main components of an AC generator include a rotating coil (armature) placed in a magnetic field. When the coil rotates, the magnetic flux linked with it changes continuously. This changing magnetic flux induces an electromotive force (EMF) and consequently an electric current in the coil. The direction of the induced current reverses periodically as the coil rotates, thereby producing alternating current.

Final Answer : Electromagnetic induction

Answer: (C)

Q26.

Solution

Concept: RMS (Root Mean Square) value of an alternating current.

Solution: For an alternating current (AC) that varies sinusoidally with time, like $I = I_0 \sin(\omega t)$, the instantaneous current is continuously changing. The peak value (I_0) represents the maximum current. However, for practical purposes, it's useful to define an "effective" value that would produce the same heating effect as a direct current (DC) of that magnitude. This effective value is called the Root Mean Square (RMS) value.

The RMS value of a sinusoidal alternating current $I = I_0 \sin(\omega t)$ is mathematically derived as:

$$I_{rms} = \frac{I_0}{\sqrt{2}}$$

where I_0 is the peak (or maximum) current.

This relationship also applies to alternating voltage: $V_{rms} = \frac{V_0}{\sqrt{2}}$. The factor $\sqrt{2}$ is approximately 1.414.

Final Answer : $I_0/\sqrt{2}$

Answer: (B)



Q27.

Solution

Concept: Maxwell's concept of displacement current and its origin.

Solution: Displacement current (I_d) was introduced by James Clerk Maxwell to make Ampere's Circuital Law consistent with the continuity equation of charge and to explain the propagation of electromagnetic waves. Ampere's law in its original form only accounted for conduction current. However, Maxwell realized that a changing electric field, like that between the plates of a charging capacitor, should also produce a magnetic field, even in the absence of moving charges (conduction current).

The displacement current is defined as:

$$I_d = \epsilon_0 \frac{d\Phi_E}{dt}$$

where ϵ_0 is the permittivity of free space and $\frac{d\Phi_E}{dt}$ is the rate of change of electric flux ($\Phi_E = \int \vec{E} \cdot d\vec{A}$).

Thus, displacement current arises due to a time-varying electric field. It has the same units as conduction current and contributes to the total current in Ampere-Maxwell's law.

Final Answer : Time-varying electric field

Answer: (B)



Q28.

Solution

Concept: The electromagnetic spectrum and the relationship between wavelength and frequency.

Solution: Electromagnetic (EM) waves are characterized by their wavelength (λ) or frequency (f). These two quantities are inversely related by the speed of light ($c = f\lambda$) in a vacuum. The electromagnetic spectrum arranges all types of EM waves in order of increasing wavelength (decreasing frequency) or vice versa.

The order of EM waves from longest wavelength to shortest wavelength is generally:

Radio waves > Microwaves > Infrared waves > Visible light > Ultraviolet waves > X-rays > Gamma rays.

Among the options provided:

Radio waves: Have the longest wavelengths (from millimeters to many kilometers).

Infrared waves: Have wavelengths longer than visible light but shorter than microwaves (typically 700 nm to 1 mm).

Ultraviolet waves: Have wavelengths shorter than visible light but longer than X-rays (typically 10 nm to 400 nm).

X-rays: Have very short wavelengths, much shorter than UV light (typically 0.01 nm to 10 nm).

Therefore, radio waves have the longest wavelength among the given choices.

Final Answer : Radio waves

Answer: (B)



Q29.

Solution

Concept: The Lens Maker's Formula for spherical lenses.

Solution: The Lens Maker's Formula is a mathematical expression that relates the focal length (f) of a thin spherical lens to its refractive index (n) and the radii of curvature of its two surfaces (R_1 and R_2). It is specifically derived for a lens placed in air (or vacuum).

The formula is given by:

$$\frac{1}{f} = (n - 1) \left(\frac{1}{R_1} - \frac{1}{R_2} \right)$$

where:

f is the focal length of the lens.

n is the refractive index of the lens material relative to the surrounding medium (usually air, so it's the absolute refractive index of the lens material).

R_1 is the radius of curvature of the first surface (the surface on which light first falls). R_2 is the radius of curvature of the second surface.

The sign convention for R_1 and R_2 is crucial: A radius of curvature is positive if the center of curvature is on the side of the outgoing light (for convex surfaces facing the incident light), and negative if it's on the side of the incident light (for concave surfaces facing the incident light). Or, more simply, for a convex surface, R is positive, and for a concave surface, R is negative. For a plano-surface, R is infinite.

Final Answer : $1/f = (n - 1)(1/R_1 - 1/R_2)$

Answer: (B)



Q30.

Solution

Concept: Interference pattern in Young's Double Slit Experiment (YDSE).

Solution: Young's Double Slit Experiment (YDSE) demonstrates the wave nature of light through interference. When a monochromatic light source illuminates two narrow, closely spaced slits, an interference pattern of alternating bright and dark fringes is observed on a screen placed some distance away.

The fringe width (β) is defined as the distance between the centers of two consecutive bright fringes (constructive interference) or two consecutive dark fringes (destructive interference).

The formula for fringe width in YDSE is derived as:

$$\beta = \frac{\lambda D}{d}$$

where:

λ (lambda) is the wavelength of the monochromatic light used.

D is the distance between the slits and the screen.

d is the distance between the two slits.

This formula shows that fringe width is directly proportional to the wavelength and the screen distance, and inversely proportional to the slit separation.

Final Answer : $\beta = \lambda D/d$

Answer: (A)



Q31.

Solution

Concept: Magnification in a compound microscope.

Solution: A compound microscope uses two converging lenses: an objective lens (close to the object) and an eyepiece (close to the eye). Its primary purpose is to achieve high magnification for viewing very small objects.

The total magnification (M) of a compound microscope is the product of the magnification produced by the objective lens (M_o) and the magnification produced by the eyepiece (M_e):

$$M = M_o \times M_e$$

The objective lens forms a real, inverted, and magnified image of the object. For high magnification from the objective lens, the object needs to be placed very close to its focal point, and the focal length of the objective lens (f_o) itself should be very small. A smaller f_o allows the objective to gather more light and form a larger intermediate image at a given tube length.

Typically, $M_o \approx L/f_o$, where L is the tube length. To maximize M_o , f_o must be minimized.

Therefore, for a compound microscope to achieve high magnification, the focal length of the objective lens should be small.

Final Answer : Small

Answer: (B)



Q32.

Solution

Concept: Diffraction pattern from a single slit.

Solution: In single-slit diffraction, when monochromatic light passes through a narrow slit, it deviates from its straight path and spreads out, creating a diffraction pattern of alternating bright and dark bands (maxima and minima) on a screen. The most prominent feature is the central maximum, which is the brightest and widest.

The angular width of the central maximum is given by 2θ , where $\sin \theta = \lambda/a$ (for the position of the first minimum on either side of the central maximum), λ is the wavelength of light, and a is the width of the slit.

For small angles, $\sin \theta \approx \theta$. So, $\theta \approx \lambda/a$.

The linear width (W) of the central maximum on a screen at a distance D from the slit is $W = 2D \tan \theta \approx 2D\theta$.

Substituting the value of θ :

$$W \approx 2D \frac{\lambda}{a}$$

From this formula, it is clear that the width of the central maximum (W) is inversely proportional to the width of the slit (a). Therefore, if the width of the slit is decreased, the width of the central maximum on the screen will increase.

Final Answer : Increase

Answer: (B)



Q33.

Solution**Concept:** Conditions for Total Internal Reflection (TIR).**Solution:** Total Internal Reflection (TIR) is an optical phenomenon that occurs when light waves traveling from a medium with a higher refractive index to a medium with a lower refractive index (e.g., from glass to air, or water to air) strike the interface between the two media.

For TIR to occur, two crucial conditions must be met:

1. Light must travel from a denser medium to a rarer medium: This means the refractive index of the first medium (where light originates) must be greater than the refractive index of the second medium (into which light is trying to enter).
2. The angle of incidence (i) in the denser medium must be greater than the critical angle (c): The critical angle is the specific angle of incidence for which the angle of refraction in the rarer medium is 90 degrees. If $i > c$, light does not refract into the rarer medium but is instead entirely reflected back into the denser medium.

If light travels from a rarer to a denser medium, it always bends towards the normal, and total internal reflection cannot happen.

Final Answer : Denser to rarer medium**Answer: (A)**

Q34.

Solution

Concept: Changes in properties of light during refraction.

Solution: When a monochromatic ray of light (meaning light of a single wavelength/frequency) passes from one medium (like air) to another medium (like glass), it undergoes refraction. During this process, several properties of the light wave change, while one fundamental property remains constant.

Let's analyze each option:

1. Wavelength (λ): The speed of light changes as it enters a different medium ($v = c/n$, where n is the refractive index). Since the frequency remains constant, the wavelength must change according to the wave equation $v = f\lambda$. As light typically slows down in a denser medium (like glass from air), its wavelength decreases.
2. Frequency (f): The frequency of light is determined by its source and represents the number of wave cycles passing a point per second. When light enters a new medium, its frequency does not change. This is because the rate at which wave crests arrive at the boundary from the first medium must be the same as the rate at which they leave the boundary into the second medium to maintain continuity.
3. Speed (v): The speed of light is different in different media. It is maximum in vacuum (c) and generally decreases in denser media. So, the speed changes when light passes from air to glass.
4. Intensity: The intensity of light is related to the amplitude of the wave. When light strikes an interface, some of it is reflected, and some is transmitted (refracted). Therefore, the intensity of the transmitted light is generally less than the incident light, meaning intensity changes.

Thus, frequency is the only quantity that remains unchanged.

Final Answer : Frequency

Answer: (B)



Q35.

Solution

Concept: Image formation rules for concave mirrors.

Solution: The image description explicitly states: "An object 'AB' is placed vertically upright at the center of curvature (C) of the mirror." It then details the ray tracing for this specific object position and concludes with "forming an inverted image A'B' at C."

For a concave mirror, there are specific rules for image formation based on the object's position:

When the object is at infinity, the image is at F (focus), real, inverted, and highly diminished.
When the object is beyond C, the image is between F and C, real, inverted, and diminished.

When the object is at C (center of curvature), the image is also formed at C. The image is real, inverted, and of the same size as the object. This is confirmed by the ray diagram: a ray parallel to the principal axis reflects through F, and a ray passing through F reflects parallel to the principal axis, with their intersection point forming the image at C.

When the object is between C and F, the image is beyond C, real, inverted, and magnified.

When the object is at F, the image is at infinity, real, inverted, and highly magnified.

When the object is between F and P (pole), the image is behind the mirror, virtual, erect, and magnified.

Based on the description and standard mirror physics, the object is at C, and the image is at C, real, inverted, and of the same size.

Final Answer : Object at C, image at C, real, inverted, same size.

Answer: (B)



Q36.

Solution

Concept: Correction of common vision defects (refractive errors).

Solution: Hypermetropia, also known as farsightedness or hyperopia, is a common vision defect where a person can see distant objects clearly but has difficulty focusing on nearby objects.

This condition occurs because:

1. The eyeball is too short.
2. The converging power of the eye lens is too weak.

As a result, light rays from a nearby object converge **behind** the retina instead of directly on it, leading to a blurred image.

To correct hypermetropia, additional converging power is required to bring the focal point forward onto the retina. A convex lens (which is a converging lens) is used for this purpose.

The convex lens converges the incoming light rays slightly before they enter the eye, allowing the eye's natural lens to then focus them correctly on the retina.

A concave lens (diverging) is used to correct myopia (nearsightedness).

A cylindrical lens is used to correct astigmatism.

A bifocal lens is used to correct presbyopia (age-related farsightedness), which combines both distant and near vision corrections.

Final Answer : Convex lens

Answer: (B)



Q37.

Solution

Concept: Interference pattern of white light in Young's Double Slit Experiment (YDSE).

Solution: In Young's Double Slit Experiment (YDSE), the fringe width (β) is given by the formula $\beta = \frac{\lambda D}{d}$, where λ is the wavelength of light, D is the distance to the screen, and d is the slit separation.

When a monochromatic light source (single wavelength) is used, we observe distinct bright and dark fringes of uniform width.

However, if the monochromatic light source is replaced by white light (which is a combination of light of different wavelengths, corresponding to different colors, e.g., VIBGYOR), each constituent color will produce its own interference pattern with its own fringe width because β depends on λ .

1. Central Fringe: At the central position (where the path difference is zero for all wavelengths), all colors constructively interfere. Therefore, the central fringe will be white.
2. Colored Fringes: On either side of the central white fringe, the fringes will be colored. This is because fringes for different colors will overlap at different positions due to their different wavelengths and hence different fringe widths. For example, violet light (shortest wavelength) will have the narrowest fringes, and red light (longest wavelength) will have the widest fringes. As we move away from the center, the colors will separate, creating a spectrum of colors in each fringe. After a few fringes, the patterns overlap so much that the distinct fringes disappear, and uniform illumination is observed.

Final Answer : The central fringe is white, and colored fringes appear on either side.

Answer: (C)



Q38.

Solution

Concept: The photoelectric effect and the factors affecting stopping potential.

Solution: In the photoelectric effect, when light of a suitable frequency is incident on a metal surface, electrons (photoelectrons) are emitted. The stopping potential (V_0) is the minimum negative potential applied to the anode (collector plate) with respect to the cathode (emitter plate) that is just sufficient to stop the most energetic photoelectrons from reaching the anode, thereby reducing the photoelectric current to zero.

According to Einstein's photoelectric equation, the maximum kinetic energy (K_{max}) of the emitted photoelectrons is given by:

$$K_{max} = h\nu - W_0$$

where h is Planck's constant, ν is the frequency of the incident light, and W_0 is the work function of the metal.

The stopping potential is related to the maximum kinetic energy by the equation:

$$K_{max} = eV_0$$

Combining these two equations:

$$eV_0 = h\nu - W_0$$

$$V_0 = \frac{h\nu}{e} - \frac{W_0}{e}$$

From this relation, it is clear that the stopping potential (V_0) depends on:

1. The frequency of incident light (ν): A higher frequency light leads to higher kinetic energy electrons and thus a greater stopping potential.
2. The work function (W_0) of the metal: W_0 is characteristic of the material of the cathode.

The stopping potential does *not* depend on the intensity of incident light (which only affects the number of emitted photoelectrons, not their maximum kinetic energy) or the distance between cathode and anode.

Final Answer : The frequency of incident light

Answer: (B)



Q39.

Solution

Concept: Einstein's photoelectric equation, which explains the energy relationships in the photoelectric effect.

Solution: Einstein's photoelectric equation is based on the idea that light consists of discrete energy packets called photons. When a photon of energy $h\nu$ (where h is Planck's constant and ν is the frequency of light) is incident on a metal surface:

1. A part of this energy is used to overcome the forces holding the electron within the metal. This minimum energy required to eject an electron from the metal surface is called the work function (W_0) of the metal.
2. The remaining energy of the photon is converted into the kinetic energy of the emitted photoelectron. Since W_0 is the *minimum* energy required, the electrons ejected with this minimum energy will have the *maximum* kinetic energy.

Thus, the principle of conservation of energy gives:

Energy of incident photon = Work function + Maximum kinetic energy of emitted photoelectron

$$h\nu = W_0 + K_{max}$$

Rearranging this equation to find the kinetic energy (K_{max}):

$$K_{max} = h\nu - W_0$$

This equation explains all the observed features of the photoelectric effect.

Final Answer : $h\nu - W_0$

Answer: (C)



Q40.

Solution

Concept: De-Broglie hypothesis of wave-particle duality.

Solution: In 1924, Louis de Broglie proposed that particles, like electrons, also exhibit wave-like properties, just as waves (like light) exhibit particle-like properties (photons). This concept is known as wave-particle duality.

The wavelength associated with a particle, known as the de-Broglie wavelength (λ), is inversely proportional to its momentum (p). The relationship is given by:

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

where h is Planck's constant (6.626×10^{-34} J·s).

For a particle of mass m moving with a velocity v , its linear momentum is $p = mv$.

Substituting this into the de-Broglie wavelength equation:

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

This formula applies to all matter particles, demonstrating their wave nature.

Final Answer : h/mv

Answer: (A)



Q41.

Solution

Concept: Einstein's photoelectric equation and the relationship between work function, threshold frequency, and maximum kinetic energy.

Solution: According to Einstein's photoelectric equation, the maximum kinetic energy (K_{max}) of a photoelectron emitted from a metal surface is given by:

$$K_{max} = h\nu - W_0$$

where:

h is Planck's constant.

ν is the frequency of the incident light.

W_0 is the work function of the metal.

The work function (W_0) is the minimum energy required to eject an electron from the metal surface. It is related to the threshold frequency (ν_0) by the equation:

$$W_0 = h\nu_0$$

The threshold frequency ν_0 is the minimum frequency of incident light below which no photoemission occurs, regardless of the intensity. For photoemission to occur, the incident frequency ν must be greater than or equal to ν_0 ($\nu \geq \nu_0$).

Given that $W_0 = h\nu_0$ and incident light has frequency $\nu > \nu_0$, we can substitute W_0 into the photoelectric equation:

$$K_{max} = h\nu - h\nu_0$$

Factoring out h :

$$K_{max} = h(\nu - \nu_0)$$

This gives the maximum kinetic energy of the emitted photoelectrons.

Final Answer : $h(\nu - \nu_0)$

Answer: (A)



Q42.

Solution

Concept: Bohr's model for hydrogen atom: quantization of electron orbits and their radii.

Solution: According to Bohr's model for the hydrogen atom, electrons revolve in specific, quantized circular orbits. The radius of the n^{th} orbit (r_n) is given by the formula:

$$r_n = \frac{\epsilon_0 n^2 h^2}{\pi m e^2}$$

where:

ϵ_0 : permittivity of free space.

n : principal quantum number (orbit number).

h : Planck's constant.

m : mass of the electron.

e : charge of the electron.

All terms ϵ_0 , h , π , m , and e are fundamental physical constants. Their combination forms a constant value.

Therefore, the radius of the electron's orbit (r_n) is directly proportional to the square of the principal quantum number (n^2).

$$r_n \propto n^2$$

The radius of the first Bohr orbit ($n = 1$) is the Bohr radius, $a_0 \approx 0.529 \times 10^{-10}$ m. So, $r_n = a_0 n^2$.

Final Answer : n^2

Answer: (C)



Q43.

Solution

Concept: Nuclear stability and the binding energy curve.

Solution: The binding energy of a nucleus is the energy required to break it into its constituent protons and neutrons. The binding energy per nucleon is a measure of the stability of a nucleus. A higher binding energy per nucleon indicates a more stable nucleus.

If we plot binding energy per nucleon versus mass number (A), we observe a characteristic curve:

1. It starts low for light nuclei (like Hydrogen and Helium).
2. It rises rapidly, reaching a maximum value.
3. It then gradually decreases for heavier nuclei.

Helium ($A=4$) has a relatively high binding energy per nucleon for a light element, but not the maximum.

Oxygen (e.g., $A=16$) is more stable than Helium but less than Iron. Uranium (e.g., $A=238$) is a very heavy nucleus with lower binding energy per nucleon, making it less stable and prone to fission.

Final Answer : Iron

Answer: (C)



Q44.

Solution

Concept: Requirements for nuclear fusion reactions.

Solution: Nuclear fusion is a process where two light atomic nuclei combine to form a single heavier nucleus, releasing a tremendous amount of energy. This process powers the sun and other stars.

For nuclear fusion to occur, several extreme conditions must be met:

1. **High Temperature:** Nuclei are positively charged and experience strong electrostatic repulsion (Coulomb barrier) when they approach each other. To overcome this repulsion and allow the strong nuclear force to bind them, the nuclei must have extremely high kinetic energies. This translates to incredibly high temperatures, typically millions of Kelvin (thermonuclear conditions). At these temperatures, matter exists in a plasma state.
2. **High Pressure (or density):** To increase the probability of nuclei colliding and fusing, the density of the plasma must be very high. This ensures that the nuclei are packed closely enough for frequent collisions. High pressure is often used to achieve this high density and to confine the plasma for a sufficient duration.

Therefore, nuclear fusion reactions occur under conditions of high temperature and high pressure.

Final Answer : High temperature, high pressure

Answer: (C)



Q45.

Solution**Concept:** Radioactive decay and half-life calculation.**Solution:** The half-life ($T_{1/2}$) of a radioactive substance is the time required for half of the initial number of radioactive nuclei in a sample to decay.

Given:

Half-life ($T_{1/2}$) = 10 daysTotal time (t) = 20 days

First, calculate the number of half-lives that have passed:

$$\text{Number of half-lives } (n) = \frac{\text{Total time}}{\text{Half-life}} = \frac{20 \text{ days}}{10 \text{ days}} = 2$$

The fraction of the initial amount remaining (N/N_0) after n half-lives is given by the formula:

$$\frac{N}{N_0} = \left(\frac{1}{2}\right)^n$$

Substitute $n = 2$:

$$\frac{N}{N_0} = \left(\frac{1}{2}\right)^2 = \frac{1}{4}$$

So, after 20 days, $\frac{1}{4}$ of the initial amount of the radioactive substance will remain.**Final Answer :** 1/4**Answer: (B)**

Q46.

Solution

Concept: Energy levels of an electron in Bohr's model of the hydrogen atom.

Solution: According to Bohr's model for the hydrogen atom, electrons can only exist in specific, quantized energy levels or orbits. The energy of an electron in the n^{th} stationary orbit is also quantized.

The formula for the energy of an electron in the n^{th} orbit (E_n) of a hydrogen atom is given by:

$$E_n = -\frac{me^4}{8\epsilon_0^2 h^2 n^2}$$

where:

m is the mass of the electron.

e is the charge of the electron.

ϵ_0 is the permittivity of free space.

h is Planck's constant.

n is the principal quantum number (the orbit number, $n = 1, 2, 3, \dots$).

All the terms in the numerator and denominator except n^2 are fundamental constants. When these constants are evaluated, the energy formula simplifies to:

$$E_n = -\frac{13.6}{n^2} \text{ eV}$$

From this formula, it is clear that the energy of an electron in the n^{th} orbit of a hydrogen atom is inversely proportional to the square of the principal quantum number (n^2). $E_n \propto \frac{1}{n^2}$

The negative sign indicates that the electron is bound to the nucleus.

Final Answer : $1/n^2$

Answer: (D)



Q47.

Solution

Concept: Energy band theory in solids, specifically for conductors.

Solution: In solids, the discrete energy levels of isolated atoms combine to form continuous bands of energy when atoms come together to form a crystal lattice. The two most important bands for electrical conductivity are:

1. Valence band: This band corresponds to the energy levels of the outermost electrons that are typically involved in bonding and are tightly bound to the atoms. These electrons are generally not free to move and contribute to current.
2. Conduction band: This band consists of higher energy levels that are usually empty or partially filled. Electrons in the conduction band are free to move throughout the material and are responsible for electrical conduction.

The behavior of a material as a conductor, semiconductor, or insulator depends on the arrangement and separation of these bands, specifically the energy gap (E_g) between the valence band and the conduction band.

Conductors (like copper): In conductors, the valence band and the conduction band overlap with each other. This means there is no energy gap, and electrons can easily move from the valence band into the conduction band even at very low temperatures. There are plenty of free electrons available for conduction, making conductors highly conductive.

Insulators: Have a large energy gap ($E_g > 3$ eV) between the valence and conduction bands.

Semiconductors: Have a small energy gap ($E_g \approx 1$ eV) between the valence and conduction bands.

Final Answer : Overlap with each other.

Answer: (B)



Q48.

Solution

Concept: I-V (Current-Voltage) characteristics of a p-n junction diode.

Solution: A p-n junction diode is a semiconductor device that allows current to flow predominantly in one direction. Its behavior is characterized by its I-V curve, which plots the current through the diode as a function of the voltage across it.

The curve typically shows three main regions:

1. **Forward Bias (positive voltage):** When the p-side of the diode is connected to a higher potential than the n-side (positive voltage applied). In this region, initially, a very small current flows. However, once the applied voltage exceeds a certain threshold voltage (also called knee voltage or cut-in voltage, typically around 0.7 V for silicon and 0.3 V for germanium), the depletion region width decreases significantly, and charge carriers can easily cross the junction. As a result, the current starts to increase rapidly and exponentially with a further increase in positive voltage. This is the region where the diode conducts significantly.

2. **Reverse Bias (negative voltage):** When the n-side is connected to a higher potential than the p-side (negative voltage applied). In this region, the depletion region widens, and only a very small current (reverse saturation current) flows due to minority carriers. This current is almost negligible and is nearly constant over a wide range of reverse voltages.

3. **Reverse Breakdown:** If the reverse bias voltage is increased to a sufficiently large negative value (breakdown voltage), the diode breaks down, leading to a sharp and abrupt increase in reverse current.

Based on this, the region where the current increases exponentially for positive voltages after a certain threshold represents the forward bias condition where the diode conducts significantly.

Final Answer : The region where current increases exponentially for positive voltages after a certain threshold.

Answer: (B)



Q49.

Solution

Concept: The basic components and operation of a half-wave rectifier circuit.

Solution: A rectifier is an electronic circuit that converts alternating current (AC) into direct current (DC). This process, known as rectification, typically involves using semiconductor diodes.

A half-wave rectifier is the simplest type of rectifier. It allows only one half-cycle of the AC input voltage to pass through to the load, blocking the other half-cycle.

The basic circuit for a half-wave rectifier consists of:

1. An AC input source (often connected to a step-down transformer to provide the desired AC voltage).
2. One p-n junction diode.
3. A load resistor, where the rectified DC output is obtained.

During the positive half-cycle of the AC input, the diode is forward-biased and conducts, allowing current to flow through the load. During the negative half-cycle of the AC input, the diode is reverse-biased and blocks the current flow. As a result, only positive (or negative, depending on diode orientation) half-cycles of the AC input appear across the load, producing a pulsating DC output.

Final Answer : One diode

Answer: (A)



Q50.

Solution

Concept: Temperature dependence of electrical resistance in semiconductors.

Solution: The electrical resistance of a material is determined by the number of charge carriers available for conduction and their mobility.

Let's analyze the behavior of semiconductors with temperature:

1. At 0 Kelvin (absolute zero): In intrinsic semiconductors, virtually no electrons have enough thermal energy to break covalent bonds and move into the conduction band. Thus, there are very few free charge carriers (electrons and holes), and the semiconductor behaves almost like an insulator, possessing very high (ideally infinite) resistance.
2. With increasing temperature: As the temperature of a semiconductor increases, the thermal energy provided causes more covalent bonds to break. This releases a significant number of electrons from the valence band into the conduction band, and simultaneously creates an equal number of holes in the valence band. Both these free electrons and holes act as charge carriers.

The increase in the number of charge carriers (carrier concentration) is exponential with temperature for semiconductors. While the increased thermal vibrations of the lattice atoms do increase the scattering of these carriers (which would tend to increase resistance), the effect of the dramatically increasing carrier concentration is much more dominant.

Therefore, the net effect in a semiconductor is that its resistance decreases with increasing temperature. This behavior is opposite to that of metals, where resistance increases with temperature due to increased scattering of a nearly constant number of free electrons.

Final Answer : Its resistance decreases with increasing temperature.

Answer: (B)



Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	C	2	B	3	B	4	B	5	B
6	A	7	A	8	A	9	A	10	B
11	B	12	A	13	B	14	B	15	C
16	A	17	D	18	C	19	C	20	B
21	A	22	C	23	B	24	C	25	C
26	B	27	B	28	B	29	B	30	A
31	B	32	B	33	A	34	B	35	B
36	B	37	C	38	B	39	C	40	A
41	A	42	C	43	C	44	C	45	B
46	D	47	B	48	B	49	A	50	B

