CUET-UG Physics Sample Paper-17

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 non-conducting solid sphere of radius R carries a volume charge density $\rho(r) = \rho_0 \frac{r}{R}$ where r is distance from centre. The electric field at a distance $r = \frac{R}{2}$ from the centre is:

(A) $\frac{\rho_0 R}{32\epsilon_0}$

(B) $\frac{\rho_0 R}{16\epsilon_0}$

(C) $\frac{\rho_0 R}{8\epsilon_0}$

(D) $\frac{\rho_0 R}{4\epsilon_0}$

Q2. A hollow conducting spherical shell of radius R carries charge $+Q$. A point charge $+q$ is placed at the center of the cavity. What is the electric potential everywhere inside the conducting material of the shell?

(A) Zero

(B) Constant and equal to potential at inner surface

(C) Varies with distance from center

(D) Infinite at inner surface only

Q3. Two point charges q_1 and q_2 are placed in vacuum at a separation r. If the medium is replaced by a dielectric medium of relative permittivity K, and the separation is doubled, the ratio of new force to the original force is:

(A) $\frac{1}{4K}$

(B) $\frac{1}{2K}$

(C) $\frac{1}{K^2}$

(D) $\frac{1}{K}$

Q4. A parallel plate capacitor is first charged and then disconnected from the battery. A dielectric slab of dielectric constant K is slowly inserted completely between the plates. Which of the following quantities remains constant during this process?

(A) Capacitance

(B) Electric field

(C) Charge on the plates

(D) Potential difference

Q5. An electric dipole of dipole moment p is placed in a non-uniform electric field that varies with distance as $E(r) = \frac{k}{r^2}$. The dipole is aligned along the radial direction. The net force experienced by the dipole depends on:

(A) Only p

(B) Only r

(C) Both p and gradient of field

(D) Neither p nor r

Q6. A conducting sphere of radius R is given charge Q. It is surrounded by a concentric conducting shell with inner radius $2R$ and outer radius $3R$. A point charge $+q$ is placed at a distance $r = \frac{R}{2}$ from the center inside the cavity. Which statement is correct about the electric field in the region $2R < r < 3R$?

(A) Field is non-zero due to induced charges

(B) Field is zero due to electrostatic shielding

(C) Field depends on position of q

(D) Field depends on dielectric constant

Q7. A non-uniformly charged spherical conductor of radius R carries total charge Q. A point charge q is placed at a distance $r < R$ from the center inside a cavity.

Which of the following statements is correct regarding the electric field inside the conducting material under electrostatic equilibrium?

(A) Electric field inside the conductor is non-zero and varies with position

(B) Electric field inside the conductor is zero everywhere irrespective of internal charges

(C) Electric field inside the conductor depends on external charges only

(D) Electric field inside the conductor is maximum at the surface

Q8. A parallel plate capacitor is connected to a battery. A dielectric slab of dielectric constant K is partially inserted between the plates. Which of the following statements correctly describes the change in capacitance, electric field, and stored energy when the dielectric is inserted?

(A) Capacitance decreases, electric field increases, energy increases

(B) Capacitance increases, electric field decreases, energy may increase or decrease depending on constraint

(C) Capacitance remains constant, electric field remains constant, energy decreases

(D) Capacitance increases, electric field increases, energy always increases

Q9. A uniform wire of length L and resistance R is stretched to double its length keeping volume constant. It is then connected across a battery of emf E and internal resistance r. Which of the following correctly describes the change in resistance and power dissipated in the wire?

(A) Resistance becomes $2R$ and power increases

(B) Resistance becomes $4R$ and power decreases

(C) Resistance remains unchanged and power increases

(D) Resistance becomes $R/2$ and power remains same

(E) Resistance becomes $4R$ and power increases

Q10. Two cells of emf E_1, E_2 and internal resistances r_1, r_2 are connected in parallel with like terminals joined. A load resistance R is connected across them. Which expression correctly represents the equivalent emf of the combination and condition for maximum current through the load?

(A) $E_{eq} = E_1 + E_2$, maximum current when $R = r_1 + r_2$

(B) $E_{eq} = \frac{E_1 r_2 + E_2 r_1}{r_1 + r_2}$, maximum current when $R \to 0$

(C) $E_{eq} = \frac{E_1 + E_2}{2}$, maximum current when $R = r_1 r_2$

(D) $E_{eq} = \frac{E_1 r_1 + E_2 r_2}{R}$, maximum current when $R \to \infty$

(E) $E_{eq} = E_1 - E_2$, maximum current when $R = 0$

Q11. In a Wheatstone bridge, all four resistances are increased by the same factor k. Which of the following statements is correct regarding balance condition, sensitivity, and galvanometer current?

(A) Balance condition changes and galvanometer current increases

(B) Balance condition remains unchanged but sensitivity decreases

(C) Balance condition changes but sensitivity remains constant

(D) Balance condition remains unchanged and galvanometer current becomes zero always

(E) Balance condition becomes unstable and current becomes infinite

Q12. A potentiometer wire is used to compare emf of two cells. The balancing length for cell E_1 is l_1 and for E_2 is l_2. If a resistance is connected in series with the driving cell, which of the following changes correctly describes the effect on null point and potential gradient?

(A) Null point shifts towards higher length and potential gradient decreases

(B) Null point remains unchanged and potential gradient increases

(C) Null point shifts towards lower length and potential gradient increases

(D) Null point becomes zero and potential gradient remains constant

(E) Null point becomes infinite and potential gradient becomes zero

Q13. In a complex circuit containing resistors arranged in both series and parallel combinations, which of the following is the most accurate method to determine equivalent resistance and power dissipation?

(A) Direct application of Ohm's law to each resistor independently without simplification

(B) Reduction using series-parallel rules followed by Kirchhoff's laws for loop analysis

(C) Using only junction rule without loop analysis

(D) Ignoring internal resistance and considering only external circuit

(E) Assuming all resistors have equal current always

Q14. A resistor follows a non-ohmic behavior where $V \propto I^2$. If the current is doubled, what is the correct change in resistance and power dissipation?

(A) Resistance doubles and power becomes four times

(B) Resistance halves and power remains same

(C) Resistance becomes four times and power becomes eight times

(D) Resistance decreases and power becomes half

(E) Resistance remains constant and power doubles

Q15. A charged particle enters a uniform magnetic field with velocity making an angle θ with the field. What will be the nature of its path and pitch of motion?

(A) Circular, independent of θ

(B) Helical, pitch depends on $\cos\theta$

(C) Straight line, pitch zero

(D) Elliptical, pitch constant

Q16. A current carrying circular loop is placed in a uniform magnetic field. The torque on the loop is maximum when angle between magnetic moment and field is:

(A) 0°

(B) 45°

(C) 90°

(D) 180°

Q17. Magnetic field at the center of a circular loop carrying current I and radius R is given by:

(A) $\frac{\mu_0 I}{2R}$

(B) $\frac{\mu_0 I}{R}$

(C) $\frac{\mu_0 I}{4\pi R}$

(D) $\frac{\mu_0 I R}{2}$

Q18. Two parallel current carrying wires carry currents in opposite directions. The force between them is:

(A) Attractive

(B) Repulsive

(C) Zero

(D) Infinite

Q19. A charged particle moves parallel to a magnetic field. The force experienced is:

(A) Maximum

(B) Minimum

(C) Zero

(D) Infinite

Q20. The magnetic moment of a current loop depends on:

(A) Current only

(B) Area only

(C) Both current and area

(D) Neither current nor area

Q21. A charged particle of charge q and mass m enters a region of uniform magnetic field $\vec{B}$ with velocity $\vec{v}$ at an angle θ. If the pitch of the helical path is p, which expression correctly represents the pitch?

(A) $p = \frac{2\pi mv \sin\theta}{qB}$

(B) $p = \frac{2\pi mv \cos\theta}{qB}$

(C) $p = \frac{mv}{qB}$

(D) $p = \frac{2\pi qB}{mv \cos\theta}$

Q22. A rectangular loop carrying current I is placed in a non-uniform magnetic field. Which of the following statements correctly describes the net force and torque on the loop?

(A) Net force is zero, torque is zero

(B) Net force is non-zero, torque is zero

(C) Net force is zero, torque is non-zero

(D) Both net force and torque are non-zero

Q23. A proton and an electron enter the same magnetic field with equal velocities perpendicular to the field. Which of the following is correct about their radii and time periods?

(A) Same radius and same time period

(B) Different radii but same time period

(C) Same radius but different time periods

(D) Both radii and time periods different

Q24. A long straight wire carries current I. At a point P located at distance r, magnetic field is B. If current is doubled and distance is halved, new magnetic field becomes:

(A) B

(B) $2B$

(C) $4B$

(D) $8B$

Q25. A circular loop is rotated in a magnetic field about its diameter. Which of the following statements is correct regarding induced emf?

(A) emf is constant

(B) emf is zero

(C) emf varies sinusoidally

(D) emf increases linearly

Q26. In a moving coil galvanometer, the deflection becomes zero even when current flows if:

(A) Magnetic field is strong

(B) Plane of coil is parallel to magnetic field

(C) Current is large

(D) Resistance is high

Q27. A coil of inductance L and resistance R is connected to an AC source of angular frequency ω. At resonance, which of the following is correct regarding current, impedance, and power factor?

(A) Current minimum, impedance maximum, power factor zero

(B) Current maximum, impedance minimum, power factor unity

(C) Current zero, impedance infinite, power factor zero

(D) Current maximum, impedance maximum, power factor zero

Q28. A conducting rod of length l moves with velocity v perpendicular to a uniform magnetic field B. The induced emf is maximum when:

(A) Rod is parallel to field

(B) Rod is perpendicular to velocity and field

(C) Velocity is parallel to field

(D) Length is zero

Q29. In a transformer, the primary coil has N_p turns and secondary has N_s turns. If $N_s > N_p$, which statement is correct regarding voltage, current, and power?

(A) Voltage increases, current increases, power increases

(B) Voltage increases, current decreases, power remains same (ideal)

(C) Voltage decreases, current increases, power decreases

(D) Voltage remains same, current decreases, power increases

Q30. In an LCR circuit, the phase difference between voltage and current depends on:

(A) Resistance only

(B) Inductance only

(C) Capacitance only

(D) Relative values of X_L and X_C

Q31. According to Lenz's law, the induced current in a loop due to increasing magnetic flux will:

(A) Aid the increase in flux

(B) Oppose the increase in flux

(C) Be zero

(D) Be independent of flux

Q32. In a purely inductive AC circuit, the average power consumed over a complete cycle is:

(A) Maximum

(B) Zero

(C) Infinite

(D) Depends on frequency

Q33. According to Maxwell's theory, displacement current plays a crucial role in electromagnetic wave propagation. Which of the following statements correctly explains the significance of displacement current in EM waves?

(A) It exists only in conductors and is responsible for conduction current

(B) It arises due to changing electric field and ensures continuity of current in capacitors

(C) It depends only on magnetic field and not on electric field

(D) It is zero in vacuum and only present in dielectric medium

Q34. An electromagnetic wave propagates in free space along the x-axis. Which of the following statements correctly describes the relationship between electric field, magnetic field, and direction of propagation?

(A) Electric field, magnetic field, and propagation are parallel to each other

(B) Electric field and magnetic field are perpendicular to each other but parallel to direction of propagation

(C) Electric field, magnetic field, and direction of propagation are mutually perpendicular

(D) Only electric field exists while magnetic field is zero

Q35. A convex lens of focal length f forms an image of an object placed at distance u. If the object is moved closer to the lens such that image changes from real to virtual, which of the following condition is satisfied?

(A) $u > f$

(B) $u = f$

(C) $u < f$

(D) $u = 2f$

Q36. In Young's Double Slit Experiment, if the wavelength of light is doubled and distance between slits is halved, the fringe width will:

(A) Remain same

(B) Become half

(C) Become four times

(D) Become double

Q37. A ray of light passes from medium 1 to medium 2. If angle of incidence is greater than critical angle, what happens?

(A) Refraction occurs

(B) Reflection occurs partially

(C) Total internal reflection occurs

(D) Light is absorbed

Q38. The resolving power of a microscope depends on numerical aperture (NA). Which of the following increases resolving power?

(A) Decreasing wavelength

(B) Increasing wavelength

(C) Decreasing aperture

(D) Increasing focal length

Q39. In diffraction, the width of central maximum is inversely proportional to:

(A) Wavelength

(B) Slit width

(C) Distance to screen

(D) Intensity

Q40. For a plane mirror, if object moves towards mirror with velocity v, image moves with velocity:

(A) v

(B) $2v$

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

(D) Zero

Q41. The magnification produced by a concave mirror is negative. This indicates:

(A) Image is virtual

(B) Image is real and inverted

(C) Image is erect

(D) Image is magnified

Q42. In a prism, angle of minimum deviation depends on:

(A) Angle of prism

(B) Refractive index

(C) Wavelength

(D) All of these

Q43. In interference pattern, if one slit is covered, what happens to fringes?

(A) Fringes disappear

(B) Fringes become wider

(C) Fringes become brighter

(D) Fringes remain same

Q44. In a photoelectric experiment, monochromatic light of frequency f is incident on a metal surface of work function ϕ. If the frequency is doubled and intensity is kept constant, which of the following is correct regarding maximum kinetic energy and photoelectric current?

(A) Both kinetic energy and current double

(B) Kinetic energy increases, current remains same

(C) Current increases, kinetic energy remains same

(D) Both remain same

Q45. According to de-Broglie hypothesis, a particle of mass m and velocity v has wavelength $\lambda = \frac{h}{mv}$. If velocity is increased four times, what happens to wavelength and momentum?

(A) Wavelength becomes $\frac{1}{4}$, momentum increases four times

(B) Wavelength becomes 4 times, momentum decreases

(C) Both wavelength and momentum increase

(D) Wavelength remains same

Q46. In a photoelectric effect experiment, stopping potential depends on which of the following factors?

(A) Intensity only

(B) Frequency only

(C) Both intensity and frequency

(D) Distance from source

Q47. An electron and a proton have same kinetic energy. Which of the following correctly compares their de-Broglie wavelengths?

(A) Electron has larger wavelength

(B) Proton has larger wavelength

(C) Both have same wavelength

(D) Cannot be compared

Q48. In Bohr's model of hydrogen atom, the radius of the n^{th} orbit is given by $r_n = n^2 a_0$. If an electron jumps from $n = 4$ to $n = 2$, which of the following correctly describes the change in energy and emitted radiation?

(A) Energy increases and radiation is absorbed

(B) Energy decreases and radiation is emitted

(C) Energy remains same and no radiation

(D) Energy first increases then decreases

Q49. The half-life of a radioactive substance is T. If initially there are N_0 nuclei, how many nuclei will remain after time $3T$?

(A) $\frac{N_0}{2}$

(B) $\frac{N_0}{4}$

(C) $\frac{N_0}{8}$

(D) $\frac{N_0}{16}$

Q50. Binding energy per nucleon is a measure of nuclear stability. Which of the following nuclei is most stable?

(A) ^{2}H

(B) ^{56}Fe

(C) ^{238}U

(D) ^{4}He

Detailed Solutions

Q1.

Solution

Concept: For a spherically symmetric charge distribution, Gauss's law is used. The electric field at radius r depends only on the charge enclosed within that radius. For non-uniform charge density, we integrate the density over volume to find enclosed charge.

Explanation: Given $\rho(r) = \rho_0 \frac{r}{R}$, enclosed charge at radius r is:

$$Q_{enc} = \int_0^r \rho_0 \frac{r'}{R} \cdot 4\pi r'^2 dr' = \frac{4\pi\rho_0}{R}\int_0^r r'^3 dr' = \frac{4\pi\rho_0}{R}\cdot\frac{r^4}{4} = \frac{\pi\rho_0 r^4}{R}$$

Using Gauss's law:

$$E(4\pi r^2) = \frac{Q_{enc}}{\epsilon_0} \Rightarrow E = \frac{\rho_0 r^2}{4\epsilon_0 R}$$

At $r = \frac{R}{2}$:

$$E = \frac{\rho_0 (R^2/4)}{4\epsilon_0 R} = \frac{\rho_0 R}{16\epsilon_0}$$

Final Answer: $\boxed{\frac{\rho_0 R}{16\epsilon_0}}$

Answer: (B)

Q2.

Solution

Concept: In electrostatic equilibrium, the electric field inside a conductor is zero. Therefore, the potential throughout the conducting material must be constant (since $\vec{E} = -\nabla V$). Any charges inside a cavity only redistribute surface charges but do not create an electric field inside the metal.

Explanation: The point charge $+q$ induces charge $-q$ on the inner surface and $+(Q+q)$ on the outer surface. However, inside the conducting material (metal region), the electric field remains zero everywhere. Since electric field is zero, potential does not change with position and remains constant throughout the conductor. This constant value equals the potential of the inner surface of the shell.

Final Answer: Constant and equal to inner surface potential

Answer: (B)

Q3.

Solution

Concept: Coulomb's law states that force between two point charges depends inversely on the square of distance and directly on the product of charges. In a medium, force reduces by a factor of dielectric constant K.

Explanation: Initial force in vacuum:

$$F_0 = \frac{1}{4\pi\epsilon_0}\frac{q_1q_2}{r^2}$$

After changes: - Distance becomes $2r$ - Medium has permittivity $K\epsilon_0$

So new force:

$$F = \frac{1}{4\pi K\epsilon_0}\frac{q_1q_2}{(2r)^2} = \frac{1}{4\pi\epsilon_0}\frac{q_1q_2}{r^2}\cdot\frac{1}{4K}$$

Thus,

$$\frac{F}{F_0} = \frac{1}{4K}$$

Final Answer: $\boxed{\frac{1}{4K}}$

Answer: (A)

Q4.

Solution

Concept: Capacitance depends on the physical structure (geometry) of the capacitor and the nature of the medium between the plates. When a capacitor is isolated (not connected to a battery), the charge stored on its plates remains conserved.

Explanation: Initially, the capacitor is charged and then disconnected, so no path exists for charge to flow. Therefore, the charge Q remains constant. When a dielectric is inserted, capacitance increases to KC_0, and hence the potential difference decreases according to $V = \frac{Q}{C}$. Electric field also changes because it depends on potential difference. However, geometry does not change during insertion, and charge remains fixed due to isolation.

Thus, capacitance depends only on geometry and medium, not on charge or voltage.

Final Answer: Geometry (and dielectric medium)

Answer: (A)

Q5.

Solution

Concept: In a non-uniform electric field, an electric dipole experiences a net force due to the difference in force on its charges. This force is proportional to the dipole moment and the spatial variation (gradient) of the electric field.

Explanation: For a dipole in a non-uniform field:

$$F = p\frac{dE}{dr}$$

Given:

$$E(r) = \frac{k}{r^2}$$

Differentiate:

$$\frac{dE}{dr} = -\frac{2k}{r^3}$$

So force becomes:

$$F \propto \frac{p}{r^3}$$

Thus, dipole field dependence in general decreases as $1/r^3$, showing that dipole interactions are short-range compared to point charge fields ($1/r^2$).

Final Answer: $\boxed{\text{Both } p \text{ and } r \text{ (via gradient)}}$

Answer: (C)

Q6.

Solution

Concept: In electrostatic equilibrium, the electric field inside a conducting material is always zero. Charges rearrange themselves on surfaces to cancel any internal field.

Explanation: The point charge inside the cavity induces charges on inner surface of the shell, but these induced charges do not create any electric field inside the conducting material. Hence, in the region $2R < r < 3R$ (inside metal), the electric field remains zero regardless of position of internal charges.

Final Answer: $\boxed{\text{Zero due to electrostatic shielding}}$

Answer: (B)

Q7.

Solution

Concept: In electrostatic equilibrium, a conductor exhibits a fundamental property: the electric field inside the bulk of the conducting material is always zero. This happens because free electrons in the conductor rearrange themselves in response to any internal or external electric field until complete cancellation of the field inside is achieved. Any excess charge resides only on the surface. This remains true even if a charge is placed inside a cavity within the conductor; induced charges appear on the inner surface to maintain electrostatic equilibrium.

Solution: Even when a point charge is placed inside a cavity of a conductor, the conducting material itself still maintains zero electric field in its bulk. The induced charges appear only on the inner surface of the cavity, ensuring that the electric field within the conducting region remains zero. External or internal charges do not produce any field inside the conductor due to perfect electrostatic shielding.

Final Answer: Electric field inside conductor is zero

Answer: (B)

Q8.

Solution

Concept: A parallel plate capacitor connected to a battery maintains constant potential difference. When a dielectric slab is partially inserted, the capacitance increases because the dielectric reduces the effective electric field inside the capacitor. The system behavior depends on whether the battery remains connected. In this case, since the battery is connected, voltage remains constant, charge changes, and energy is modified according to $U = \frac{1}{2}CV^2$.

Solution: When dielectric constant K increases effective permittivity, capacitance increases. Since battery maintains constant voltage, charge stored increases. Electric field inside the dielectric region decreases due to polarization. The stored energy depends on C, so energy increases as C increases while V is constant. However, energy change depends on insertion conditions (partial insertion may cause non-uniform field distribution), but general correct trend is increase in capacitance and decrease in electric field.

Final Answer: Capacitance increases, electric field decreases

Answer: (B)

Q9.

Solution

Concept: When a wire is stretched keeping volume constant, its length increases and cross-sectional area decreases. Since $R = \rho\frac{L}{A}$, doubling length and halving area leads to resistance becoming four times. Power depends on $P = \frac{E^2R}{(R+r)^2}$, so increase in resistance generally reduces current and hence power dissipated.

Solution: New resistance becomes $4R$. As resistance increases, current decreases, reducing power dissipated in the wire.

Final Answer: Resistance becomes 4R and power decreases

Answer: (B)

Q10.

Solution

Concept: For cells in parallel, equivalent emf is a weighted average: $E_{eq} = \frac{E_1r_2+E_2r_1}{r_1+r_2}$. Maximum current occurs when external resistance is minimum, i.e., $R \to 0$, as total opposition is minimized.

Solution: Using parallel cell formula, we get equivalent emf expression. Current is maximum when load resistance approaches zero.

Final Answer: $E_{eq} = \dfrac{E_1r_2 + E_2r_1}{r_1 + r_2}, \ R \to 0$

Answer: (B)

Q11.

Solution

Concept: Wheatstone bridge balance condition depends on ratio $\frac{R_1}{R_2} = \frac{R_3}{R_4}$. Multiplying all resistances by same factor does not change ratio. However, higher resistance reduces current, lowering sensitivity.

Solution: Balance condition remains unchanged, but current through galvanometer reduces, decreasing sensitivity.

Final Answer: Balance unchanged, sensitivity decreases

Answer: (B)

Q12.

Solution

Concept: Potential gradient $k = \frac{V}{L}$ depends on current in potentiometer wire. Adding resistance reduces current, decreasing potential gradient. Hence balancing length increases.

Solution: As potential gradient decreases, longer wire length is required for balance, shifting null point towards higher length.

Final Answer: Null point shifts higher, gradient decreases

Answer: (A)

Q13.

Solution

Concept: Complex circuits require systematic simplification. Series-parallel reduction simplifies structure, while Kirchhoff's laws handle non-reducible loops ensuring accurate current and voltage calculation.

Solution: Best method is combination of reduction techniques followed by Kirchhoff's loop and junction rules.

Final Answer: Series-parallel reduction + Kirchhoff's laws

Answer: (B)

Q14.

Solution

Concept: Given $V \propto I^2$, resistance $R = \frac{V}{I} \propto I$. So doubling current doubles resistance. Power $P = VI \propto I^3$, hence power increases eight times.

Solution: When current doubles, resistance becomes twice and power increases by factor of $2^3 = 8$.

Final Answer: Resistance doubles, power becomes eight times

Answer: (C)

Q15.

Solution

Concept: When a charged particle enters a magnetic field at an angle, its velocity can be resolved into two components—one parallel and one perpendicular to the magnetic field. The perpendicular component causes circular motion, while the parallel component remains unaffected, resulting in a combined motion.

Explanation: The perpendicular component produces a circular path due to Lorentz force, while the parallel component leads to uniform linear motion along the field. Combining both motions results in a helical path. The pitch of the helix depends on the parallel component, i.e., $v \cos\theta$.

Final Answer: $\boxed{\text{Helical, pitch depends on } \cos\theta}$

Answer: (B)

Q16.

Solution

Concept: Torque on a current-carrying loop in a magnetic field is given by $\tau = MB\sin\theta$, where θ is the angle between magnetic moment and magnetic field.

Explanation: The torque depends on $\sin\theta$, which is maximum when $\theta = 90^\circ$. At this angle, the loop experiences maximum rotational effect due to the magnetic field, causing maximum tendency to align.

Final Answer: $\boxed{90^\circ}$

Answer: (C)

Q17.

Solution

Concept: Magnetic field at the center of a circular loop is derived using Biot–Savart law, which relates magnetic field with current and geometry of conductor.

Explanation: For a circular loop, each small current element contributes equally to the field at the center. Integrating over the loop gives the result $B = \frac{\mu_0 I}{2R}$, showing inverse dependence on radius.

Final Answer: $\boxed{\dfrac{\mu_0 I}{2R}}$

Answer: (A)

Q18.

Solution

Concept: Two current-carrying parallel conductors exert magnetic forces on each other. The direction of force depends on the direction of currents.

Explanation: When currents flow in the same direction, the wires attract each other. When currents flow in opposite directions, they repel each other due to opposing magnetic field interactions.

Final Answer: Repulsive

Answer: (B)

Q19.

Solution

Concept: Magnetic force on a charged particle is given by $F = qvB\sin\theta$, where θ is the angle between velocity and magnetic field.

Explanation: When the particle moves parallel to the magnetic field, $\theta = 0^\circ$, hence $\sin 0 = 0$. Therefore, no magnetic force acts on the particle, and it continues in a straight line.

Final Answer: Zero

Answer: (C)

Q20.

Solution

Concept: Magnetic moment of a current loop is defined as the product of current and area of the loop, given by $M = I \times A$.

Explanation: Increasing either the current flowing through the loop or the area enclosed by it increases the magnetic moment. Thus, both factors equally influence the magnetic strength of the loop.

Final Answer: Both current and area

Answer: (C)

Q21.

Solution

Concept: When a charged particle enters a magnetic field at an angle, its velocity splits into perpendicular and parallel components. The perpendicular component produces circular motion, while the parallel component results in uniform motion along the field, forming a helical path. The pitch is the distance traveled in one complete revolution.

Explanation: Time period of circular motion is $T = \frac{2\pi m}{qB}$. The velocity component along the field is $v\cos\theta$. Thus, pitch $p = v\cos\theta \cdot T = \frac{2\pi m v\cos\theta}{qB}$.

Final Answer: $\boxed{\frac{2\pi m v\cos\theta}{qB}}$

Answer: (B)

Q22.

Solution

Concept: In a non-uniform magnetic field, different parts of a current-carrying loop experience different magnetic forces due to variation in field strength. This leads to imbalance in forces.

Explanation: Because forces on opposite sides are unequal, the loop experiences a net translational force. Additionally, unequal distribution of forces produces torque, causing rotational motion.

Final Answer: Both net force and torque are non-zero

Answer: (D)

Q23.

Solution

Concept: Radius of circular motion is $r = \frac{mv}{qB}$ and time period is $T = \frac{2\pi m}{qB}$. Both depend on mass of particle.

Explanation: Since proton has much larger mass than electron, its radius and time period are significantly larger. Therefore, both radius and time period differ for the two particles.

Final Answer: Both radii and time periods different

Answer: (D)

Q24.

Solution

Concept: Magnetic field due to a long straight wire is given by $B = \frac{\mu_0 I}{2\pi r}$, showing direct proportionality to current and inverse proportionality to distance.

Explanation: If current is doubled and distance is halved, new field becomes $B' = \frac{2I}{r/2} = 4B$. Thus, magnetic field increases four times.

Final Answer: $\boxed{\text{4B}}$

Answer: (C)

Q25.

Solution

Concept: When a loop rotates in a magnetic field, magnetic flux linked with it changes continuously with time, leading to induced emf according to Faraday's law.

Explanation: The flux varies as $\Phi = BA\cos\omega t$, hence induced emf $e = -\frac{d\Phi}{dt}$ varies sinusoidally as $\sin\omega t$. Therefore, emf is alternating in nature.

Final Answer: $\boxed{\text{emf varies sinusoidally}}$

Answer: (C)

Q26.

Solution

Concept: Torque on a current-carrying coil in magnetic field is $\tau = nBIA\sin\theta$, where θ is angle between magnetic field and normal to plane of coil.

Explanation: If the plane of the coil is parallel to the magnetic field, then $\theta = 0°$, hence $\sin 0 = 0$ and torque becomes zero. Thus, no deflection occurs despite current flow.

Final Answer: $\boxed{\text{Plane of coil is parallel to magnetic field}}$

Answer: (B)

Q27.

Solution

Concept: In an AC circuit at resonance, inductive reactance (X_L) becomes equal to capacitive reactance (X_C). This cancels the reactive effects, leaving only resistance in the circuit. As a result, impedance is minimum and current is maximum.

Explanation: Since $Z = R$ at resonance, current $I = \frac{V}{R}$ becomes maximum. Also, voltage and current are in phase, so power factor $\cos\phi = 1$. This condition allows maximum power transfer in the circuit.

Final Answer: Current maximum, impedance minimum, power factor unity

Answer: (B)

Q28.

Solution

Concept: Motional emf is given by $e = Blv\sin\theta$, where θ is the angle between velocity and magnetic field. Maximum emf occurs when $\sin\theta = 1$.

Explanation: For maximum emf, the rod, velocity, and magnetic field must be mutually perpendicular. This ensures maximum rate of cutting of magnetic field lines, producing highest induced emf.

Final Answer: Rod is perpendicular to velocity and field

Answer: (B)

Q29.

Solution

Concept: A transformer works on the principle of mutual induction. The voltage ratio is proportional to the turns ratio: $\frac{V_s}{V_p} = \frac{N_s}{N_p}$.

Explanation: When $N_s > N_p$, the transformer is step-up, increasing voltage. Since power is conserved in an ideal transformer ($P = VI$), current decreases correspondingly to maintain constant power.

Final Answer: Voltage increases, current decreases, power remains same

Answer: (B)

Q30.

Solution

Concept: In an LCR circuit, phase angle ϕ is given by $\tan\phi = \frac{X_L - X_C}{R}$. It depends on the balance between inductive and capacitive reactance.

Explanation: If $X_L > X_C$, circuit is inductive; if $X_C > X_L$, it is capacitive. At resonance, $X_L = X_C$ and phase difference is zero. Hence, phase depends on their relative values.

Final Answer: $\boxed{\text{Relative values of } X_L \text{ and } X_C}$

Answer: (D)

Q31.

Solution

Concept: Lenz's law states that induced current always opposes the change in magnetic flux that produces it. This is a consequence of conservation of energy.

Explanation: When magnetic flux increases, induced current produces a magnetic field in opposite direction to resist the increase. This prevents creation of energy without external work.

Final Answer: $\boxed{\text{Oppose the increase in flux}}$

Answer: (B)

Q32.

Solution

Concept: In a purely inductive AC circuit, voltage leads current by 90°, making phase difference $\phi = 90^\circ$. Thus, power factor $\cos\phi = 0$.

Explanation: Since instantaneous power alternates equally positive and negative over a full cycle, the average power becomes zero. No net energy is consumed in an ideal inductor.

Final Answer: $\boxed{\text{Zero}}$

Answer: (B)

Q33.

Solution

Concept: Displacement current is introduced by Maxwell to explain the continuity of current in regions where conduction current is absent, such as in capacitors. It is given by $I_d = \epsilon_0 \frac{d\Phi_E}{dt}$ and arises due to changing electric field.

Explanation: In electromagnetic wave propagation, a time-varying electric field produces a displacement current, which in turn generates a magnetic field. This mutual generation of electric and magnetic fields allows EM waves to propagate even in vacuum. Without displacement current, Maxwell's equations would be incomplete and could not explain wave propagation in free space.

Final Answer: Changing electric field produces displacement current

Answer: (B)

Q34.

Solution

Concept: Electromagnetic waves are transverse waves in which electric field ($\vec{E}$), magnetic field ($\vec{B}$), and direction of propagation are mutually perpendicular. This is a fundamental property derived from Maxwell's equations.

Explanation: If the wave propagates along x-axis, the electric field may oscillate along y-axis and magnetic field along z-axis. Both fields vary sinusoidally and are in phase. Their cross product gives the direction of propagation, ensuring orthogonality among all three vectors.

Final Answer: Mutually perpendicular

Answer: (C)

Q35.

Solution

Concept: A convex lens forms a real image when the object is placed beyond the focal length ($u > f$) and a virtual image when the object is within the focal length ($u < f$).

Explanation: As the object moves closer to the lens and crosses the focal point, the nature of the image changes from real and inverted to virtual and erect. This transition occurs precisely when the object distance becomes less than the focal length.

Final Answer: u < f

Answer: (C)

Q36.

Solution

Concept: Fringe width in Young's Double Slit Experiment is given by $\beta = \frac{\lambda D}{d}$, where λ is wavelength and d is slit separation.

Explanation: If wavelength is doubled and slit separation is halved, then $\beta' = \frac{2\lambda D}{d/2} = 4\beta$. Thus, fringe width increases four times.

Final Answer: Become four times

Answer: (C)

Q37.

Solution

Concept: Total internal reflection occurs when light travels from denser to rarer medium and angle of incidence exceeds the critical angle.

Explanation: In such a case, refraction does not occur and the entire light is reflected back into the denser medium. This phenomenon is widely used in optical fibers.

Final Answer: Total internal reflection occurs

Answer: (C)

Q38.

Solution

Concept: Resolving power of a microscope is inversely proportional to wavelength and directly proportional to numerical aperture.

Explanation: Smaller wavelength allows finer details to be resolved. Thus, decreasing wavelength increases resolving power, improving clarity and detail of observed image.

Final Answer: Decreasing wavelength

Answer: (A)

Q39.

Solution

Concept: In single slit diffraction, width of central maximum is given by $\beta \propto \frac{\lambda D}{a}$, where a is slit width.

Explanation: As slit width increases, diffraction decreases, making central maximum narrower. Hence, width is inversely proportional to slit width.

Final Answer: $\boxed{\text{Slit width}}$

Answer: (B)

Q40.

Solution

Concept: In a plane mirror, image distance is equal to object distance. If the object moves towards the mirror, the image also moves towards the mirror with the same speed relative to the mirror.

Explanation: However, relative to the observer, the distance between object and image decreases at twice the rate. Thus, image velocity relative to object is $2v$, though relative to mirror it is v.

Final Answer: $\boxed{\text{2v}}$

Answer: (B)

Q41.

Solution

Concept: Magnification for mirrors is given by $m = -\frac{v}{u}$. A negative magnification indicates that the image is inverted.

Explanation: In case of concave mirrors, negative magnification corresponds to real and inverted images, which are formed when object is placed beyond focal point.

Final Answer: $\boxed{\text{Image is real and inverted}}$

Answer: (B)

Q42.

Solution

Concept: Angle of minimum deviation in a prism depends on refractive index, angle of prism, and wavelength of light.

Explanation: Since refractive index itself varies with wavelength (dispersion), all these factors influence deviation. Hence, minimum deviation is a function of multiple parameters.

Final Answer: All of these

Answer: (D)

Q43.

Solution

Concept: Interference pattern is formed due to superposition of waves from two coherent sources.

Explanation: If one slit is covered, coherence is lost and only single slit diffraction pattern remains. Hence, interference fringes disappear completely.

Final Answer: Fringes disappear

Answer: (A)

Q44.

Solution

Concept: Photoelectric Effect and Einstein's Equation

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

Explanation: Maximum kinetic energy depends on frequency, while current depends on intensity. When frequency is doubled, kinetic energy increases, but current remains unchanged.

Final Answer: Kinetic energy increases, current remains same

Answer: (B)

Q45.

Solution

Concept: de-Broglie Relation

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

Explanation: If velocity becomes four times, wavelength becomes one-fourth and momentum becomes four times.

Final Answer: $\boxed{\text{Wavelength becomes } \frac{1}{4}, \text{ momentum increases four times}}$

Answer: (A)

Q46.

Solution

Concept: Stopping Potential

$$eV_0 = hf - \phi$$

Explanation: Stopping potential depends only on frequency, not on intensity.

Final Answer: $\boxed{\text{Frequency only}}$

Answer: (B)

Q47.

Solution

Concept: de-Broglie Wavelength for Same K.E.

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

Explanation: Electron has much smaller mass than proton, so it has larger wavelength.

Final Answer: $\boxed{\text{Electron has larger wavelength}}$

Answer: (A)

Q48.

Solution

Concept: Bohr Model and Energy Levels Energy of electron in hydrogen atom:

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

Explanation: When electron moves from higher orbit ($n = 4$) to lower orbit ($n = 2$), its energy decreases (becomes more negative). The energy difference is released as a photon, hence radiation is emitted.

Final Answer: Energy decreases and radiation is emitted

Answer: (B)

Q49.

Solution

Concept: Radioactive Decay Law Number of nuclei remaining after time t:

$$N = N_0 \left(\frac{1}{2}\right)^{t/T}$$

Explanation: Here $t = 3T$, so:

$$N = N_0 \left(\frac{1}{2}\right)^3 = \frac{N_0}{8}$$

Thus, after three half-lives, only one-eighth of original nuclei remain.

Final Answer: $\frac{N_0}{8}$

Answer: (C)

Q50.

Solution

Concept: Binding Energy Curve Binding energy per nucleon increases with mass number up to iron and then decreases.

Explanation: ^{56}Fe lies near the peak of binding energy curve, meaning it has maximum binding energy per nucleon. Hence, it is the most stable nucleus among given options.

Final Answer: ^{56}Fe

Answer: (B)

Answer Key

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