

CUET UG Physics Sample Paper - 18

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 soap bubble is given a negative charge. Its radius will:

- (A) Increase
- (B) Decrease
- (C) Remain unchanged
- (D) Expand and contract oscillationally

Q2. The electric potential at a point (x, y, z) is given by $V = -x^2y$ Volts. The electric field \vec{E} at that point is:

- (A) $2xy\hat{i} + x^2\hat{j}$
- (B) $x^2\hat{i} + 2xy\hat{j}$
- (C) $-2xy\hat{i} - x^2\hat{j}$
- (D) $2xy\hat{i} - x^2\hat{j}$

Q3. Two capacitors C_1 and C_2 are connected in series. If $C_1 > C_2$, the charge on C_1 is:

- (A) Greater than on C_2
- (B) Less than on C_2
- (C) Equal to that on C_2



(D) Zero

Q4. Which of the following is not a property of equipotential surfaces?

(A) They do not cross each other

(B) The work done in moving a charge on them is zero

(C) For a uniform electric field, they are concentric spheres

(D) The electric field is always normal to them

Q5. A point charge q is placed at the center of a hemispherical surface of radius R . The total flux through the curved surface is:

(A) q/ϵ_0

(B) $q/2\epsilon_0$

(C) $q/4\epsilon_0$

(D) Zero

Q6. If an electron is brought toward another electron, the electrostatic potential energy of the system:

(A) Increases

(B) Decreases

(C) Becomes zero

(D) Remains the same

Q7. The unit of "Permittivity of free space" (ϵ_0) is:

(A) $C^2N^{-1}m^{-2}$

(B) $N m^2C^{-2}$

(C) $C N m$

(D) $F m$



- Q8.** The capacitance of a spherical conductor of radius 9 cm is:
- (A) 1 pF
 - (B) 10 pF
 - (C) $1\mu\text{F}$
 - (D) 9 pF
- Q9.** The relaxation time τ in a conductor:
- (A) Increases with increase in temperature
 - (B) Decreases with increase in temperature
 - (C) Is independent of temperature
 - (D) Is the same for all metals
- Q10.** Five identical resistors each of resistance R are connected in the form of a Wheatstone bridge. The equivalent resistance between the battery terminals is:
- (A) $5R$
 - (B) R
 - (C) $R/5$
 - (D) $2R$
- Q11.** A cell of emf E and internal resistance r is connected to a load R . Maximum power is delivered to the load when:
- (A) $R = r/2$
 - (B) $R = r$
 - (C) $R = 2r$
 - (D) $R = 0$
- Q12.** Potentiometer is preferred over a voltmeter for measuring emf because:



- (A) It is more sensitive
- (B) It has a high resistance
- (C) It does not draw any current from the cell at balance
- (D) It is cheaper

Q13. The resistivity of a semiconductor _____ with an increase in temperature.

- (A) Increases
- (B) Decreases
- (C) Remains constant
- (D) First increases then decreases

Q14. In a meter bridge, the balance point is found at 40 cm from the left end. If the resistance in the right gap is 12Ω , the resistance in the left gap is:

- (A) 8Ω
- (B) 10Ω
- (C) 18Ω
- (D) 4Ω

Q15. A cyclotron is used to accelerate:

- (A) Electrons
- (B) Neutrons
- (C) Positive ions
- (D) Both (A) and (C)

Q16. The magnetic moment of a current-carrying circular loop of radius r is M . If the radius is doubled and current is halved, the new magnetic moment is:

- (A) M



- (B) $2M$
- (C) $4M$
- (D) $M/2$

Q17. At the magnetic poles of the Earth, the angle of dip is:

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

Q18. The magnetic field inside a long straight solenoid carrying current I is B . If the current is doubled and number of turns per unit length is halved, the new field is:

- (A) B
- (B) $2B$
- (C) $B/2$
- (D) $4B$

Q19. A permanent magnet should have:

- (A) High retentivity, High coercivity
- (B) Low retentivity, Low coercivity
- (C) High retentivity, Low coercivity
- (D) Low retentivity, High coercivity

Q20. Lorentz force is given by:

- (A) $q(\vec{E} + \vec{v} \cdot \vec{B})$
- (B) $q(\vec{E} + \vec{v} \times \vec{B})$
- (C) $q(\vec{B} + \vec{v} \times \vec{E})$



(D) $q(\vec{E} - \vec{v} \times \vec{B})$

Q21. The unit of magnetic flux is:

- (A) Weber
- (B) Tesla
- (C) Henry
- (D) Gauss

Q22. An eddy current is produced when:

- (A) A metal is kept in a varying magnetic field
- (B) A metal is kept in a steady magnetic field
- (C) A circular coil is placed in a magnetic field
- (D) Current is passed through a superconductor

Q23. In an AC circuit, the peak value of voltage is 423 V. Its rms value is:

- (A) 423 V
- (B) 300 V
- (C) 600 V
- (D) 211.5 V

Q24. The Q-factor of a resonant circuit is given by:

- (A) $\frac{1}{R}\sqrt{\frac{L}{C}}$
- (B) $\frac{1}{L}\sqrt{\frac{R}{C}}$
- (C) $R\sqrt{\frac{C}{L}}$
- (D) $\frac{1}{R}\sqrt{\frac{C}{L}}$



- Q25.** If the frequency of AC source is doubled, the capacitive reactance X_C will:
- (A) Double
 - (B) Become half
 - (C) Become four times
 - (D) Remain unchanged
- Q26.** The core of a transformer is laminated to reduce:
- (A) Hysteresis loss
 - (B) Copper loss
 - (C) Eddy current loss
 - (D) Flux leakage
- Q27.** Which part of the electromagnetic spectrum is used in RADAR?
- (A) Ultraviolet rays
 - (B) Infrared rays
 - (C) Microwaves
 - (D) Gamma rays
- Q28.** The ratio of the amplitude of electric field to magnetic field (E_0/B_0) in an EM wave is:
- (A) c
 - (B) $1/c$
 - (C) c^2
 - (D) \sqrt{c}
- Q29.** An object is placed at the focus of a concave mirror. The image will be formed at:



- (A) Focus
- (B) Center of curvature
- (C) Infinity
- (D) Between F and C

Q30. The power of a lens is -2.5 D. Its focal length is:

- (A) -40 cm
- (B) -25 cm
- (C) $+40$ cm
- (D) -4 m

Q31. Ray optics is valid when characteristic dimensions are:

- (A) Much smaller than wavelength of light
- (B) Much larger than wavelength of light
- (C) Equal to wavelength of light
- (D) Independent of wavelength

Q32. In Brewster's Law, the reflected ray and refracted ray are:

- (A) Parallel
- (B) Perpendicular
- (C) At 45°
- (D) At 180°

Q33. Which of the following is used in optical fibers?

- (A) Total Internal Reflection
- (B) Scattering
- (C) Diffraction



(D) Refraction

Q34. For a normal eye, the least distance of distinct vision is:

- (A) 25 m
- (B) 2.5 cm
- (C) 25 cm
- (D) Infinity

Q35. The scattering of light is proportional to:

- (A) λ
- (B) $1/\lambda^2$
- (C) $1/\lambda^4$
- (D) λ^4

Q36. A magnifying glass has a focal length of 5 cm. Its magnifying power for a normal eye (at LDDV) is:

- (A) 5
- (B) 6
- (C) 25
- (D) 1

Q37. In an interference pattern, the ratio of maximum to minimum intensity is 9:1. The ratio of amplitudes is:

- (A) 3:1
- (B) 2:1
- (C) 9:1
- (D) 4:1



Q38. The de-Broglie wavelength of a particle of mass m and kinetic energy K is:

(A) $h/\sqrt{2mK}$

(B) $\sqrt{2mK}/h$

(C) $h/2mK$

(D) h/mK

Q39. The stopping potential in a photoelectric experiment depends on:

(A) Intensity of light

(B) Frequency of light

(C) Distance of source

(D) Surface area of metal

Q40. Davisson-Germer experiment proved:

(A) Particle nature of electrons

(B) Wave nature of electrons

(C) Transverse nature of EM waves

(D) Quantization of charge

Q41. If the momentum of a particle is doubled, its de-Broglie wavelength becomes:

(A) Double

(B) Half

(C) Four times

(D) Unchanged

Q42. In the Rutherford scattering experiment, most of the α -particles pass through the foil undeflected. This proves:



- (A) The nucleus is positive
- (B) Most of the atom is empty space
- (C) Electrons revolve in orbits
- (D) Neutrons exist in the nucleus

Q43. The energy of an electron in the $n = 3$ state of a Hydrogen atom is:

- (A) -13.6 eV
- (B) -3.4 eV
- (C) -1.51 eV
- (D) -0.85 eV

Q44. One Curie is equal to:

- (A) 3.7×10^{10} disintegrations/sec
- (B) 10^6 disintegrations/sec
- (C) 1 disintegration/sec
- (D) 3.7×10^7 disintegrations/sec

Q45. When a β -particle is emitted, the atomic number:

- (A) Increases by 1
- (B) Decreases by 1
- (C) Remains same
- (D) Decreases by 2

Q46. The density of a nucleus is:

- (A) Proportional to A
- (B) Proportional to $A^{1/3}$
- (C) Independent of A



(D) Proportional to A^3

Q47. In a p-type semiconductor, the majority charge carriers are:

(A) Electrons

(B) Holes

(C) Photons

(D) Neutrons

Q48. The width of the depletion layer in a p-n junction _____ when forward biased.

(A) Increases

(B) Decreases

(C) Remains same

(D) Becomes infinite

Q49. A NOR gate is a combination of:

(A) OR and NOT gate

(B) AND and NOT gate

(C) OR and AND gate

(D) NOT and NOT gate

Q50. The decimal equivalent of the binary number $(1011)_2$ is:

(A) 10

(B) 11

(C) 13

(D) 9



Detailed Solutions

Q1.

Solution

Concept:

When a soap bubble is charged, regardless of whether the charge is positive or negative, the like charges spread over its surface. These like charges exert an outward electrostatic pressure (repulsive force) on the surface of the bubble. This outward force acts against the surface tension of the bubble, which normally tries to contract it.

Solution:

1. Let a charge q be given to a soap bubble of radius R . 2. The electrostatic pressure P_e acting outwards on the surface is given by:

$$P_e = \frac{\sigma^2}{2\epsilon_0}$$

where $\sigma = \frac{q}{4\pi R^2}$ is the surface charge density. 3. This outward pressure acts in the same direction as the internal air pressure, effectively reducing the net inward pressure caused by surface tension. 4. To maintain equilibrium, the bubble expands until the inward and outward forces balance again. 5. Therefore, the radius of the bubble increases. This holds true for both negative and positive charges because the term σ^2 is always positive.

Final Answer: Increase

Answer: (A)



Q2.

Solution**Concept:**

The relationship between the electric field \vec{E} and the electric potential V is given by the negative gradient of the potential:

$$\vec{E} = -\nabla V = -\left(\frac{\partial V}{\partial x}\hat{i} + \frac{\partial V}{\partial y}\hat{j} + \frac{\partial V}{\partial z}\hat{k}\right)$$

This means the electric field component in any direction is the negative partial derivative of the potential with respect to that direction.

Solution:

1. Given potential function: $V = -x^2y$. 2. Calculate the x-component of the electric field (E_x):

$$E_x = -\frac{\partial V}{\partial x} = -\frac{\partial}{\partial x}(-x^2y) = -(-2xy) = 2xy$$

3. Calculate the y-component of the electric field (E_y):

$$E_y = -\frac{\partial V}{\partial y} = -\frac{\partial}{\partial y}(-x^2y) = -(-x^2) = x^2$$

4. Calculate the z-component of the electric field (E_z):

$$E_z = -\frac{\partial V}{\partial z} = -\frac{\partial}{\partial z}(-x^2y) = 0$$

5. Combining the components into vector form:

$$\vec{E} = E_x\hat{i} + E_y\hat{j} + E_z\hat{k} = 2xy\hat{i} + x^2\hat{j}$$

Final Answer: $2xy\hat{i} + x^2\hat{j}$

Answer: (A)



Q3.

Solution**Concept:**

In a series combination of capacitors, the same amount of charge Q flows from the source and accumulates on the plates of each capacitor. This is a fundamental property of series circuits, analogous to the same current flowing through resistors in series.

Solution:

1. Let two capacitors C_1 and C_2 be connected in series to a battery of voltage V . 2. When the circuit is closed, a charge $+Q$ appears on the first plate of C_1 , which induces $-Q$ on its second plate. 3. This $-Q$ leaves $+Q$ on the first plate of C_2 (due to charge conservation on the isolated middle section), which then induces $-Q$ on the second plate of C_2 . 4. Consequently, the charge on C_1 is Q and the charge on C_2 is Q . 5. The magnitude of the charge remains identical regardless of the individual capacitance values ($C_1 > C_2$). The potential differences across them will differ ($V_1 = Q/C_1$ and $V_2 = Q/C_2$), but the charges are equal.

Final Answer: Equal to that on C_2

Answer: (C)

Q4.

Solution**Concept:**

An equipotential surface is a surface where every point has the same electric potential. Key properties include: 1. No work is done in moving a charge between two points on the surface. 2. The electric field is always perpendicular to the surface. 3. Two surfaces can never intersect. 4. The shape of the surface depends on the charge configuration.

Solution:

1. Property A: Equipotential surfaces do not cross each other (Correct). If they did, a single point would have two different potential values, which is impossible. 2. Property B: Work done moving a charge on the surface is zero (Correct) because $W = q\Delta V$, and on an equipotential surface, $\Delta V = 0$. 3. Property C: For a uniform electric field, the surfaces are concentric spheres (Incorrect). For a uniform field, the potential changes only along the field lines, so the equipotential surfaces are planes perpendicular to the field lines. (Concentric spheres are for point charges). 4. Property D: The electric field is always normal to the surface (Correct). If it weren't, there would be a tangential component of the field that would do work, contradicting the definition.

Final Answer: For a uniform electric field, they are concentric spheres

Answer: (C)



Q5.

Solution**Concept:**

Gauss's Law states that the total electric flux through a closed surface is equal to the net charge enclosed divided by ϵ_0 :

$$\Phi_{total} = \frac{q_{enclosed}}{\epsilon_0}$$

For a point charge at the center of a sphere, the flux is distributed uniformly across the entire surface area.

Solution:

1. Imagine a full sphere of radius R with a point charge q at its center. 2. The total flux through the entire closed sphere, according to Gauss's Law, is $\Phi_{sphere} = q/\epsilon_0$. 3. A hemisphere is exactly half of a full sphere. 4. Because the charge is placed at the center (the midpoint of the flat base), the electric field lines radiate symmetrically in all directions. 5. Exactly half of the field lines will pass through the curved surface of the hemisphere, while the other half would have passed through the "missing" lower half of the imaginary sphere. 6. Therefore, the flux through the curved hemispherical surface is:

$$\Phi_{curved} = \frac{1}{2}\Phi_{sphere} = \frac{q}{2\epsilon_0}$$

Final Answer: $q/2\epsilon_0$

Answer: (B)



Q6.

Solution**Concept:**

The electrostatic potential energy (U) of a system of two point charges q_1 and q_2 separated by a distance r is given by:

$$U = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r}$$

Potential energy is a scalar quantity. Its value depends on the signs of the charges and the distance between them. For like charges, the potential energy is positive, and for unlike charges, it is negative.

Solution:

1. Electrons are negatively charged particles, so $q_1 = -e$ and $q_2 = -e$. 2. The product of the charges is $q_1 q_2 = (-e)(-e) = +e^2$, which is a positive value. 3. The potential energy formula becomes:

$$U = \frac{1}{4\pi\epsilon_0} \frac{e^2}{r}$$

4. When one electron is brought toward another, the distance r between them decreases. 5. In the expression for U , the distance r is in the denominator. As r decreases, the value of the fraction increases. 6. Since the overall value is positive, an increase in the magnitude means the potential energy of the system increases. 7. Physically, this corresponds to the work that must be done against the repulsive electrostatic force to bring the like charges closer together.

Final Answer: Increases

Answer: (A)



Q7.

Solution**Concept:**

The permittivity of free space (ϵ_0) is a physical constant that represents the capability of a vacuum to permit electric field lines. It appears in Coulomb's Law, which describes the force between two point charges:

$$F = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r^2}$$

Solution:

1. To find the unit of ϵ_0 , we can rearrange Coulomb's Law:

$$\epsilon_0 = \frac{1}{4\pi F} \frac{q_1 q_2}{r^2}$$

2. Substitute the standard SI units for each variable in the equation: - Charge (q_1, q_2) is measured in Coulombs (C). - Force (F) is measured in Newtons (N). - Distance (r) is measured in Meters (m). 3. The resulting unit is:

$$\text{Unit of } \epsilon_0 = \frac{\text{C} \cdot \text{C}}{\text{N} \cdot \text{m}^2} = \text{C}^2 \text{N}^{-1} \text{m}^{-2}$$

4. Alternatively, using the relation for capacitance ($C = \epsilon_0 A/d$), the unit can also be expressed as Farads per meter (F m^{-1}).

Final Answer: $\text{C}^2 \text{N}^{-1} \text{m}^{-2}$

Answer: (A)



Q8.

Solution**Concept:**

The capacitance (C) of an isolated spherical conductor of radius R is given by the formula:

$$C = 4\pi\epsilon_0 R$$

In this formula, $4\pi\epsilon_0$ is a constant approximately equal to $\frac{1}{9 \times 10^9}$ F/m.

Solution:

1. Identify the given radius: $R = 9 \text{ cm} = 9 \times 10^{-2} \text{ m}$. 2. Use the value of the constant $\frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \text{ Nm}^2\text{C}^{-2}$. 3. Therefore, $4\pi\epsilon_0 = \frac{1}{9 \times 10^9} \text{ C}^2\text{N}^{-1}\text{m}^{-2}$. 4. Substitute these values into the capacitance formula:

$$C = \left(\frac{1}{9 \times 10^9} \right) \times (9 \times 10^{-2})$$

5. Simplify the expression:

$$C = 1 \times 10^{-11} \text{ F}$$

6. To convert this to picoFarads (pF), where $1 \text{ pF} = 10^{-12} \text{ F}$:

$$C = 10 \times 10^{-12} \text{ F} = 10 \text{ pF}$$

Final Answer: 10 pF

Answer: (B)

Q9.

Solution**Concept:**

Relaxation time (τ) is the average time interval between two successive collisions of a free electron with the ions/atoms in a conductor. It is related to the thermal motion of electrons.

Solution:

1. As the temperature of a conductor increases, the thermal energy of the metal ions increases, causing them to vibrate with greater amplitude and frequency. 2. Simultaneously, the average thermal speed of the free electrons increases. 3. Due to the increased vibrations of the ions and the higher speed of the electrons, the probability of collisions increases. 4. Because collisions occur more frequently, the time interval between them (τ) becomes shorter. 5. Since the resistivity ρ is inversely proportional to relaxation time ($\rho = \frac{m}{ne^2\tau}$), a decrease in τ leads to the well-known increase in resistance for metals at higher temperatures.

Final Answer: Decreases with increase in temperature

Answer: (B)



Q10.

Solution**Concept:**

A Wheatstone bridge consists of four resistance arms (P, Q, R, S) arranged in a quadrilateral, with a galvanometer in one diagonal and a battery in the other. If the bridge is balanced, no current flows through the galvanometer.

Solution:

1. Let the four arms be P, Q, R , and S , and the galvanometer resistance be G . We are given $P = Q = R = S = G = R_{wire}$. 2. The balance condition for a Wheatstone bridge is $P/Q = R/S$. 3. Since $R/R = R/R = 1$, the bridge is perfectly balanced. 4. Because the bridge is balanced, no current flows through the central galvanometer arm. This means the central resistor does not contribute to the equivalent resistance. 5. The circuit simplifies to two parallel branches: - Branch 1 (Top): Two resistors in series, $R + R = 2R$. - Branch 2 (Bottom): Two resistors in series, $R + R = 2R$. 6. The equivalent resistance R_{eq} of these two $2R$ branches in parallel is:

$$\frac{1}{R_{eq}} = \frac{1}{2R} + \frac{1}{2R} = \frac{2}{2R} = \frac{1}{R}$$

7. Thus, $R_{eq} = R$.

Final Answer: R

Answer: (B)



Q11.

Solution**Concept:**

The Maximum Power Transfer Theorem states that to obtain maximum external power from a source with a finite internal resistance, the resistance of the load must equal the internal resistance of the source as viewed from its output terminals.

Solution:

1. Consider a circuit with a cell of EMF E , internal resistance r , and external load resistance R . 2. The current I in the circuit is given by:

$$I = \frac{E}{R + r}$$

3. The power P delivered to the load R is:

$$P = I^2 R = \left(\frac{E}{R + r} \right)^2 R$$

4. To find the condition for maximum power, we differentiate P with respect to R and set it to zero ($\frac{dP}{dR} = 0$):

$$\frac{d}{dR} \left[\frac{E^2 R}{(R + r)^2} \right] = 0$$

5. Applying the quotient rule:

$$E^2 \left[\frac{(R + r)^2(1) - R(2)(R + r)}{(R + r)^4} \right] = 0$$

$$(R + r)^2 - 2R(R + r) = 0$$

$$(R + r) - 2R = 0 \implies r - R = 0$$

6. This yields the condition $R = r$. At this point, exactly half the total power is dissipated internally and half is delivered to the load.

Final Answer: $R = r$

Answer: (B)



Q12.

Solution**Concept:**

A potentiometer is an instrument used for measuring an unknown voltage or EMF by balancing it against a known potential difference. It operates on the null-point principle.

Solution:

1. A voltmeter, when connected across a cell, draws a small amount of current from the cell to show a deflection. This current causes a potential drop across the internal resistance of the cell, meaning the voltmeter measures terminal voltage ($V = E - Ir$) rather than the true EMF (E). 2. A potentiometer works on the principle that at the balance point (null point), the potential difference being measured is exactly equal to the potential drop across a specific length of the potentiometer wire. 3. At this balance point, no current flows through the galvanometer connected to the cell being measured. 4. Because the potentiometer draws no current from the source at the moment of measurement, it effectively acts as an ideal voltmeter with infinite resistance. 5. This allows for the measurement of the true EMF of the cell, making it a more accurate and "ideal" instrument for this purpose.

Final Answer: It does not draw any current from the cell at balance

Answer: (C)

Q13.

Solution**Concept:**

Semiconductors have a negative temperature coefficient of resistance. Unlike metals, where resistance increases with temperature, the electrical properties of semiconductors improve as they get warmer.

Solution:

1. The resistivity ρ depends on the number of free charge carriers (n) and the relaxation time (τ):

$$\rho = \frac{m}{ne^2\tau}$$

2. In semiconductors, the energy gap between the valence band and the conduction band is small. 3. As the temperature increases, more thermal energy is provided to the valence electrons. This allows a significant number of electrons to break their covalent bonds and jump into the conduction band. 4. This results in a massive increase in the number of charge carriers (n). 5. Although the relaxation time (τ) decreases slightly due to increased collisions (as in metals), the exponential increase in n dominates the expression. 6. Since n is in the denominator, the total resistivity ρ decreases significantly as temperature rises.

Final Answer: Decreases

Answer: (B)



Q14.

Solution**Concept:**

A meter bridge works on the principle of the Wheatstone bridge. When the bridge is balanced, the ratio of the resistances in the two gaps is equal to the ratio of the lengths of the wire segments on either side of the jockey.

$$\frac{R}{S} = \frac{l}{100 - l}$$

Solution:

1. Let R be the unknown resistance in the left gap and S be the known resistance in the right gap.
2. Given: $S = 12\Omega$ and the balance point $l = 40$ cm.
3. The remaining length of the wire is $100 - l = 100 - 40 = 60$ cm.
4. Apply the balance condition:

$$\frac{R}{12} = \frac{40}{60}$$

5. Simplify the fraction on the right:

$$\frac{R}{12} = \frac{2}{3}$$

6. Solve for R :

$$R = 12 \times \frac{2}{3} = 4 \times 2 = 8\Omega$$

7. Thus, the resistance in the left gap is 8Ω .

Final Answer: 8Ω

Answer: (A)

Q15.

Solution**Concept:**

A cyclotron is a type of particle accelerator that uses a combination of a static magnetic field and an oscillating electric field to accelerate charged particles in a spiral path.

Solution:

1. The cyclotron operates by using a magnetic field to bend the path of a particle into a circle and an electric field to give it a "kick" of energy every time it crosses the gap between the "Dees."
2. ****Positive Ions:**** Particles like protons, deuterons, and alpha particles have sufficient mass and a positive charge, making them ideal for acceleration in a cyclotron.
3. ****Electrons:**** Because electrons have an extremely small mass, they reach relativistic speeds very quickly. This causes their mass to increase and their frequency of revolution to fall out of sync with the oscillating electric field (the "resonance" condition fails). Therefore, special accelerators like betatrons are used for electrons.
4. ****Neutrons:**** Since neutrons are electrically neutral, they are not affected by either the electric or the magnetic fields used in a cyclotron and cannot be accelerated by it.
5. Thus, the cyclotron is primarily used for accelerating positive ions.

Final Answer: Positive ions

Answer: (C)



Q16.

Solution**Concept:**

The magnetic moment (M) of a current-carrying loop is given by the product of the current (I) and the area of the loop (A):

$$M = I \times A$$

For a circular loop of radius r , the area is $A = \pi r^2$. Therefore, the magnetic moment is $M = I\pi r^2$.

Solution:

1. Let the initial magnetic moment be $M_1 = I_1\pi r_1^2$. 2. According to the problem: - The radius is doubled: $r_2 = 2r_1$ - The current is halved: $I_2 = I_1/2$ 3. Calculate the new area A_2 :

$$A_2 = \pi r_2^2 = \pi(2r_1)^2 = 4\pi r_1^2 = 4A_1$$

4. Calculate the new magnetic moment M_2 :

$$M_2 = I_2 \times A_2 = \left(\frac{I_1}{2}\right) \times (4A_1)$$

5. Simplify the expression:

$$M_2 = 2(I_1A_1) = 2M_1$$

6. Thus, the new magnetic moment becomes twice the original value.

Final Answer: $2M$

Answer: (B)

Q17.

Solution**Concept:**

The angle of dip (or magnetic inclination) is the angle made by the Earth's total magnetic field vector with the horizontal direction at any point on the Earth's surface. It is measured using a dip circle.

Solution:

1. At the **Magnetic Equator**, the Earth's magnetic field lines are parallel to the surface. Therefore, a magnetic needle stays perfectly horizontal, and the angle of dip is 0° . 2. As we move from the equator toward the poles, the field lines begin to tilt toward the Earth. 3. At the **Magnetic Poles**, the magnetic field lines are directed vertically (straight down at the North Magnetic Pole and straight up at the South Magnetic Pole). 4. Consequently, a magnetic needle freely suspended at the poles will stand perfectly vertical. 5. The angle between a vertical needle and the horizontal plane is 90° . Therefore, the angle of dip at the magnetic poles is 90° .

Final Answer: 90°

Answer: (C)



Q18.

Solution**Concept:**

The magnetic field (B) inside an ideal long solenoid is given by the formula:

$$B = \mu_0 n I$$

where μ_0 is the permeability of free space, n is the number of turns per unit length (N/L), and I is the current flowing through the wire.

Solution:

1. Let the initial magnetic field be $B_1 = \mu_0 n_1 I_1$. 2. According to the problem: - The current is doubled: $I_2 = 2I_1$ - The number of turns per unit length is halved: $n_2 = n_1/2$ 3. Substitute these new values into the magnetic field formula to find B_2 :

$$B_2 = \mu_0 n_2 I_2 = \mu_0 \left(\frac{n_1}{2}\right) (2I_1)$$

4. Simplify the expression:

$$B_2 = \mu_0 n_1 I_1 = B_1$$

5. Since the factors of 2 and 1/2 cancel each other out, the strength of the magnetic field remains unchanged.

Final Answer: B

Answer: (A)

Q19.

Solution**Concept:**

A permanent magnet is a material that retains its magnetic properties even after the external magnetizing field is removed. This requires specific characteristics in the material's hysteresis loop.

Solution:

1. **Retentivity (Remanence):** This is the ability of a material to stay magnetized after the external field is turned off. A permanent magnet must have **high retentivity** so that it remains a strong magnet over time. 2. **Coercivity:** This is the intensity of the external magnetic field required to demagnetize the material. A permanent magnet must have **high coercivity** so that its magnetism is not easily destroyed by stray magnetic fields, temperature changes, or mechanical shocks. 3. Materials like Steel or Alnico (an alloy of Aluminum, Nickel, and Cobalt) are used for making permanent magnets because they exhibit both high retentivity and high coercivity. 4. In contrast, soft iron has high retentivity but low coercivity, making it suitable for electromagnets but not permanent ones.

Final Answer: High retentivity, High coercivity

Answer: (A)



Q20.

Solution**Concept:**

The Lorentz force is the total force exerted on a point charge q moving through a region where both an electric field \vec{E} and a magnetic field \vec{B} are present.

Solution:

1. A charge q in an electric field \vec{E} experiences an electric force \vec{F}_e given by:

$$\vec{F}_e = q\vec{E}$$

This force acts in the direction of the field (for a positive charge) regardless of whether the charge is moving or stationary. 2. A charge q moving with velocity \vec{v} in a magnetic field \vec{B} experiences a magnetic force \vec{F}_m given by:

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

This force is always perpendicular to both the velocity and the magnetic field. 3. The total Lorentz force \vec{F} is the vector sum of these two individual forces:

$$\vec{F} = \vec{F}_e + \vec{F}_m$$

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

4. Factoring out the charge q :

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

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

Answer: (B)



Q21.

Solution**Concept:**

Magnetic flux (Φ) is a measure of the total magnetic field which passes through a given area. Mathematically, it is the dot product of the magnetic field vector (\vec{B}) and the area vector (\vec{A}):

$$\Phi = \vec{B} \cdot \vec{A} = BA \cos \theta$$

where θ is the angle between the magnetic field and the normal to the area.

Solution:

1. In the SI system, the unit of magnetic field (B) is the Tesla (T) and the unit of area (A) is the square meter (m^2). 2. Therefore, the derived unit of magnetic flux is Tesla-meter² ($T m^2$). 3. This specific unit is given the name **Weber (Wb)** in honor of the German physicist Wilhelm Eduard Weber. 4. To relate it to other units: - $1 \text{ Wb} = 1 \text{ V s}$ (Volt-second) - $1 \text{ Wb} = 10^8 \text{ Maxwell}$ (CGS unit) 5. Tesla is the unit for magnetic flux density (field strength), Henry is for inductance, and Gauss is the CGS unit for magnetic flux density.

Final Answer: Weber

Answer: (A)

Q22.

Solution**Concept:**

Eddy currents (also known as Foucault currents) are loops of electrical current induced within conductors by a changing magnetic field in the conductor, according to Faraday's law of induction.

Solution:

1. When a solid piece of metal is subjected to a **varying magnetic field** (or moves through a non-uniform magnetic field), the magnetic flux through the bulk of the metal changes. 2. According to Faraday's Law, an EMF is induced in the metal. 3. Since the metal provides a continuous closed path with low resistance, this induced EMF causes circulating currents to flow within the body of the conductor. 4. These currents flow in closed loops in planes perpendicular to the magnetic field. 5. These currents are called "eddy" currents because they resemble the eddies or whirlpools seen in water. They produce heat due to the I^2R effect, which is why transformer cores are laminated to minimize them.

Final Answer: A metal is kept in a varying magnetic field

Answer: (A)



Q23.

Solution**Concept:**

For a sinusoidal alternating current or voltage, the Root Mean Square (rms) value is the "effective" value that would produce the same heating effect as a DC source. The relationship between the peak value (V_0) and the rms value (V_{rms}) is:

$$V_{rms} = \frac{V_0}{\sqrt{2}} \approx 0.707V_0$$

Solution:

1. Given the peak value of voltage: $V_0 = 423$ V. 2. We need to calculate the rms value:

$$V_{rms} = \frac{423}{\sqrt{2}}$$

3. Using the value $\sqrt{2} \approx 1.414$:

$$V_{rms} = \frac{423}{1.414}$$

4. Performing the division:

$$V_{rms} \approx 299.15 \text{ V}$$

5. Rounding to the nearest whole number provided in the options, we get 300 V. 6. Most standard household voltages (like 230 V) are specified as rms values; their peak values are significantly higher (around 325 V).

Final Answer: 300 V

Answer: (B)



Q24.

Solution**Concept:**

The Quality factor (Q-factor) of a resonant series LCR circuit is a dimensionless parameter that describes how underdamped an oscillator or resonator is. It characterizes the "sharpness" of the resonance peak.

Solution:

1. The Q-factor is defined as the ratio of the resonant frequency (ω_r) to the bandwidth ($\Delta\omega$):

$$Q = \frac{\omega_r L}{R}$$

2. We know the resonant frequency for a series circuit is:

$$\omega_r = \frac{1}{\sqrt{LC}}$$

3. Substitute this value into the Q-factor formula:

$$Q = \frac{1}{\sqrt{LC}} \cdot \frac{L}{R}$$

4. Simplify the expression:

$$Q = \frac{1}{R} \cdot \frac{L}{\sqrt{L} \cdot \sqrt{C}} = \frac{1}{R} \sqrt{\frac{L}{C}}$$

5. A high Q-factor means the circuit is highly selective, having low energy loss relative to the energy stored.

Final Answer: $\frac{1}{R} \sqrt{\frac{L}{C}}$

Answer: (A)



Q25.

Solution**Concept:**

Capacitive reactance (X_C) is the opposition offered by a capacitor to the flow of alternating current. It is inversely proportional to both the frequency of the AC source and the capacitance. The formula is:

$$X_C = \frac{1}{2\pi fC}$$

Solution:

1. Let the initial capacitive reactance be $X_{C1} = \frac{1}{2\pi f_1 C}$. 2. The frequency of the AC source is doubled, so $f_2 = 2f_1$. 3. The new capacitive reactance X_{C2} will be:

$$X_{C2} = \frac{1}{2\pi(2f_1)C}$$

4. Rearranging the expression:

$$X_{C2} = \frac{1}{2} \left(\frac{1}{2\pi f_1 C} \right)$$

5. Therefore:

$$X_{C2} = \frac{X_{C1}}{2}$$

6. As the frequency increases, the capacitor "charges and discharges" more rapidly, offering less opposition to the current. Thus, doubling the frequency makes the reactance half.

Final Answer: Become half

Answer: (B)



Q26.

Solution**Concept:**

A transformer operates on the principle of mutual induction. When alternating current flows through the primary coil, it creates a varying magnetic flux in the iron core. This flux links with the secondary coil, inducing an EMF. However, the varying flux also induces circulating currents in the solid iron core itself.

Solution:

1. The solid iron core is a conductor. A changing magnetic flux through it induces EMFs that drive circulating currents, known as **eddy currents**. 2. These eddy currents generate heat due to the resistance of the iron ($P = I^2R$), leading to energy loss and overheating of the transformer. 3. To minimize this, the core is not made of a single solid block. Instead, it is made of thin sheets or **laminations** of silicon steel. 4. Each lamination is coated with an insulating layer (like varnish or oxide). 5. This arrangement breaks the large circulating paths of the eddy currents into much smaller loops within each thin sheet, significantly increasing the effective resistance and reducing the total energy loss due to heat.

Final Answer: Eddy current loss

Answer: (C)

Q27.

Solution**Concept:**

RADAR (Radio Detection and Ranging) is a system used to detect the distance, speed, and characteristics of distant objects. It works by emitting electromagnetic waves and measuring the time it takes for the reflected signal to return.

Solution:

1. RADAR systems require waves that can travel long distances without significant spreading (low diffraction) and can be easily reflected by metallic objects like airplanes or ships. 2. **Microwaves** (wavelengths ranging from 1 mm to 1 m) are ideal for this purpose. 3. Because of their short wavelengths compared to radio waves, they can be focused into narrow beams using relatively small antennas. 4. They are not easily bent (diffracted) by atmospheric conditions, allowing for precise directional detection. 5. In addition to RADAR, microwaves are also used in satellite communication and microwave ovens.

Final Answer: Microwaves

Answer: (C)



Q28.

Solution**Concept:**

In an electromagnetic wave traveling in a vacuum, the oscillating electric field (\vec{E}) and magnetic field (\vec{B}) are in phase and perpendicular to each other. Their magnitudes are related by a constant value.

Solution:

1. According to Maxwell's equations, the relationship between the peak amplitude of the electric field (E_0) and the magnetic field (B_0) at any point in space and time is:

$$E_0 = cB_0$$

2. Here, c represents the speed of light in a vacuum, which is approximately 3×10^8 m/s. 3. Rearranging the formula to find the ratio E_0/B_0 :

$$\frac{E_0}{B_0} = c$$

4. This ratio shows that the electric field contributes significantly more to the energy density than the magnetic field in terms of absolute SI units, although their energy contributions are actually equal because $u_E = \frac{1}{2}\epsilon_0 E^2$ and $u_B = \frac{1}{2\mu_0} B^2$.

Final Answer: c

Answer: (A)

Q29.

Solution**Concept:**

The image formation by a concave mirror follows the mirror formula $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$. The position of the image depends on where the object is placed relative to the focal point (F) and center of curvature (C).

Solution:

1. When an object is placed at the focus ($u = -f$) of a concave mirror: 2. Substitute the values into the mirror formula:

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

3. Solving for $1/v$:

$$\frac{1}{v} = \frac{1}{-f} + \frac{1}{f} = 0$$

4. If $1/v = 0$, then $v = \infty$. 5. Ray Diagram Explanation: Light rays emerging from an object at the focus strike the mirror and are reflected parallel to the principal axis. Parallel rays meet only at infinity. 6. The resulting image is formed at infinity, is highly enlarged, real, and inverted.

Final Answer: Infinity

Answer: (C)



Q30.

Solution**Concept:**

The power (P) of a lens is defined as the reciprocal of its focal length (f) when the focal length is measured in meters. The unit of power is the Diopter (D).

$$P = \frac{1}{f(\text{in meters})} \implies f(\text{in meters}) = \frac{1}{P}$$

Solution:

1. Given the power of the lens: $P = -2.5$ D. 2. Calculate the focal length in meters:

$$f = \frac{1}{-2.5} \text{ m}$$

3. Convert the decimal:

$$f = -0.4 \text{ m}$$

4. To convert meters to centimeters, multiply by 100:

$$f = -0.4 \times 100 \text{ cm} = -40 \text{ cm}$$

5. The negative sign indicates that the lens is a diverging or concave lens.

Final Answer: -40 cm

Answer: (A)

Q31.

Solution**Concept:**

Ray optics (or geometrical optics) is an approximation of light behavior that assumes light travels in straight lines called rays. This approximation is valid only under certain conditions relative to the wavelength (λ) of light.

Solution:

1. Light is fundamentally an electromagnetic wave. Waves tend to bend around corners or spread out when passing through small openings, a phenomenon known as diffraction. 2. The extent of diffraction depends on the ratio of the wavelength to the size of the aperture or object (a). 3. If the wavelength λ is comparable to or larger than the dimensions of the object ($a \leq \lambda$), wave effects like interference and diffraction become dominant. 4. However, if the objects and apertures involved are ****much larger than the wavelength**** ($a \gg \lambda$), the bending of light is negligible. 5. In this limit, we can ignore the wave nature and treat light as rays traveling in rectilinear paths. Since visible light has very small wavelengths (hundreds of nanometers), ray optics works perfectly for everyday objects like mirrors and lenses.

Final Answer: Much larger than wavelength of light

Answer: (B)



Q32.

Solution**Concept:**

Brewster's Law describes the condition under which light reflected from a transparent surface is completely polarized. This occurs when the light is incident at a specific angle called the Brewster angle (i_p).

Solution:

1. According to Brewster's Law, the refractive index of the medium is given by $\mu = \tan i_p$. 2. From Snell's Law, $\mu = \frac{\sin i_p}{\sin r}$, where r is the angle of refraction. 3. Equating the two:

$$\tan i_p = \frac{\sin i_p}{\cos i_p} = \frac{\sin i_p}{\sin r}$$

4. This implies $\cos i_p = \sin r$, which can be written as $\sin(90^\circ - i_p) = \sin r$. 5. Therefore, $90^\circ - i_p = r$, or $i_p + r = 90^\circ$. 6. The angle between the reflected ray and the refracted ray is $180^\circ - (i_p + r)$. 7. Substituting $i_p + r = 90^\circ$, we get the angle as $180^\circ - 90^\circ = 90^\circ$. 8. Thus, the reflected and refracted rays are **perpendicular** to each other.

Final Answer: Perpendicular

Answer: (B)

Q33.

Solution**Concept:**

Optical fibers are thin strands of high-quality glass or plastic used to transmit light signals over long distances with minimal loss of signal strength.

Solution:

1. An optical fiber consists of a "core" surrounded by a "cladding" layer with a slightly lower refractive index ($\mu_{core} > \mu_{cladding}$). 2. Light enters the core at one end at a specific angle. When it hits the boundary between the core and the cladding, it travels from a denser medium to a rarer medium. 3. If the angle of incidence is greater than the critical angle, the light does not exit the fiber but is reflected back into the core. 4. This process, called **Total Internal Reflection (TIR)**, happens repeatedly as the light travels down the fiber, effectively "trapping" the light inside the core even if the fiber is bent. 5. This principle allows data to be transmitted at the speed of light through fiber-optic cables used in telecommunications.

Final Answer: Total Internal Reflection

Answer: (A)



Q34.

Solution**Concept:**

The least distance of distinct vision (LDDV), also known as the "near point," is the minimum distance at which the human eye can see an object clearly without any strain on the ciliary muscles.

Solution:

1. To see nearby objects, the ciliary muscles contract to increase the curvature (and power) of the eye lens, a process called accommodation.
2. There is a limit to how much the eye lens can bulge. If an object is brought closer than this limit, the image formed on the retina becomes blurred.
3. For a healthy young adult with normal vision, this standard minimum distance is precisely **25 cm**.
4. Objects placed closer than 25 cm will appear fuzzy or cause significant eye strain.
5. As people age, this distance typically increases (a condition called presbyopia) because the eye lens loses its elasticity.

Final Answer: 25 cm

Answer: (C)

Q35.

Solution**Concept:**

Rayleigh scattering explains why the sky is blue and the sunset is red. It describes the scattering of light by particles that are much smaller than the wavelength of the light.

Solution:

1. According to Rayleigh's Law of Scattering, the intensity of scattered light (I) is inversely proportional to the fourth power of the wavelength (λ) of the incident light.
2. Mathematically:

$$I \propto \frac{1}{\lambda^4}$$

3. This means that shorter wavelengths are scattered much more strongly than longer wavelengths.
4. In the visible spectrum, blue and violet have shorter wavelengths compared to red and orange. Therefore, blue light is scattered about 10 times more efficiently than red light by the atmosphere, which is why the sky appears blue.
5. At sunset, light travels through a thicker layer of the atmosphere; most of the blue light is scattered away, leaving only the longer-wavelength red light to reach our eyes.

Final Answer: $1/\lambda^4$

Answer: (C)



Q36.

Solution**Concept:**

A magnifying glass (simple microscope) is a convergent lens used to see small objects. Its magnifying power (M) depends on where the final image is formed. For a normal eye, the most comfortable viewing for maximum detail occurs when the image is at the Least Distance of Distinct Vision ($D = 25$ cm).

Solution:

1. The formula for the magnifying power of a simple microscope when the image is formed at the near point (D) is:

$$M = 1 + \frac{D}{f}$$

2. We are given the focal length $f = 5$ cm and the standard distance $D = 25$ cm. 3. Substitute these values into the formula:

$$M = 1 + \frac{25}{5}$$

4. Calculate the result:

$$M = 1 + 5 = 6$$

5. This means the object will appear 6 times larger than it would if viewed by the naked eye at the same distance. If the image were formed at infinity, the magnification would be $M = D/f = 5$.

Final Answer: 6

Answer: (B)



Q37.

Solution**Concept:**

The intensity (I) of light in an interference pattern is proportional to the square of its amplitude (a). When two waves interfere, the maximum and minimum intensities are determined by the sum and difference of their individual amplitudes (a_1 and a_2).

Solution:

1. The maximum intensity I_{max} and minimum intensity I_{min} are given by:

$$I_{max} \propto (a_1 + a_2)^2 \quad \text{and} \quad I_{min} \propto (a_1 - a_2)^2$$

2. We are given the ratio:

$$\frac{I_{max}}{I_{min}} = \frac{9}{1}$$

3. Taking the square root of both sides:

$$\frac{a_1 + a_2}{a_1 - a_2} = \sqrt{\frac{9}{1}} = 3$$

4. Rearrange to solve for the ratio of a_1 to a_2 :

$$a_1 + a_2 = 3(a_1 - a_2) \implies a_1 + a_2 = 3a_1 - 3a_2$$

$$4a_2 = 2a_1 \implies \frac{a_1}{a_2} = \frac{4}{2} = \frac{2}{1}$$

5. Therefore, the ratio of the amplitudes of the two interfering waves is 2:1.

Final Answer: 2:1

Answer: (B)



Q38.

Solution**Concept:**

The de-Broglie hypothesis states that every moving particle has an associated wave nature. The wavelength (λ) of this matter wave is related to the momentum (p) of the particle.

Solution:

1. The basic de-Broglie equation is:

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

2. Kinetic energy (K) is related to momentum (p) by the formula:

$$K = \frac{p^2}{2m} \implies p = \sqrt{2mK}$$

3. Substitute this expression for momentum into the de-Broglie equation:

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

4. This formula shows that the wavelength is inversely proportional to the square root of both the mass and the kinetic energy of the particle. For example, a heavier particle with the same energy as a lighter one will have a shorter de-Broglie wavelength.

Final Answer: $h/\sqrt{2mK}$

Answer: (A)

Q39.

Solution**Concept:**

The stopping potential (V_0) is the minimum negative potential applied to the anode of a photoelectric cell to just stop the most energetic photoelectrons from reaching it. It is a direct measure of the maximum kinetic energy of the emitted electrons.

Solution:

1. According to Einstein's photoelectric equation:

$$eV_0 = K_{max} = h\nu - \phi$$

2. In this equation, h is Planck's constant, ν is the frequency of incident light, and ϕ is the work function of the metal. 3. From the formula, it is clear that V_0 depends linearly on the **frequency** (ν) of the incident light. If the frequency increases, the stopping potential must also increase to counteract the higher energy of the electrons. 4. Notably, V_0 is **independent of intensity** (number of photons), as intensity only affects the number of electrons emitted (the current), not their individual energy.

Final Answer: Frequency of light

Answer: (B)



Q40.

Solution**Concept:**

Historically, light was known to exhibit both wave and particle properties. However, whether matter (like electrons) also behaved as waves was a theoretical proposal by de-Broglie until it was experimentally verified.

Solution:

1. In 1927, C.J. Davisson and L.H. Germer performed an experiment where they directed a beam of electrons at a nickel crystal. 2. They observed that the electrons were scattered in specific directions, producing a pattern identical to the ****diffraction**** patterns produced by X-rays (which are waves). 3. Since diffraction is a phenomenon exclusive to waves, this experiment provided the first direct evidence of the ****wave nature of electrons****. 4. This confirmed the de-Broglie hypothesis and laid the experimental foundation for quantum mechanics.

Final Answer: Wave nature of electrons

Answer: (B)

Q41.

Solution**Concept:**

The de-Broglie wavelength (λ) of a particle is inversely proportional to its linear momentum (p). The relationship is defined by the fundamental equation of matter waves:

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

where h is Planck's constant ($6.626 \times 10^{-34} \text{ J} \cdot \text{s}$).

Solution:

1. Let the initial momentum of the particle be p_1 and the initial wavelength be $\lambda_1 = h/p_1$. 2. The problem states that the momentum is doubled, so the new momentum is $p_2 = 2p_1$. 3. The new de-Broglie wavelength λ_2 is:

$$\lambda_2 = \frac{h}{p_2} = \frac{h}{2p_1}$$

4. Substitute λ_1 into the expression:

$$\lambda_2 = \frac{1}{2} \left(\frac{h}{p_1} \right) = \frac{\lambda_1}{2}$$

5. Since the wavelength is inversely proportional to momentum, doubling the "heaviness" or speed (momentum) of the particle results in its associated wavelength becoming half.

Final Answer: Half

Answer: (B)



Q42.

Solution**Concept:**

In 1911, Ernest Rutherford conducted the Gold Foil Experiment by bombarding a thin sheet of gold with alpha particles (α -particles). The observation of the trajectories of these particles led to the discovery of the atomic nucleus.

Solution:

1. Observations showed that more than 99% of the α -particles passed through the gold foil without any deviation. 2. If the atom were a solid "plum pudding" (as previously thought), the particles would have been deflected by the matter inside. 3. The fact that they passed through undeflected implies that they encountered no obstacles in their path. 4. This led Rutherford to conclude that "most of the space inside the atom is empty". 5. The small fraction of particles that were deflected or bounced back indicated that the positive charge and most of the mass were concentrated in a tiny central region called the nucleus.

Final Answer: Most of the atom is empty space

Answer: (B)

Q43.

Solution**Concept:**

According to the Bohr model of the Hydrogen atom, the energy (E_n) of an electron in the n^{th} principal quantum level is given by the formula:

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

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

Solution:

1. We are asked to find the energy for the $n = 3$ state (the second excited state). 2. Substitute $n = 3$ into the formula:

$$E_3 = -\frac{13.6}{3^2}$$

3. Calculate the denominator: $3^2 = 9$. 4. Perform the division:

$$E_3 = -\frac{13.6}{9} \approx -1.511... \text{ eV}$$

5. Comparing this with the other levels: $n = 1$: -13.6 eV - $n = 2$: -3.4 eV - $n = 3$: -1.51 eV - $n = 4$: -0.85 eV

Final Answer: -1.51 eV

Answer: (C)



Q44.

Solution**Concept:**

The activity of a radioactive sample is the rate at which its nuclei decay. The SI unit of activity is the Becquerel (Bq), where 1 Bq = 1 decay per second. However, the Curie (Ci) is a common non-SI unit.

Solution:

1. The Curie was originally defined as the activity of 1 gram of Radium-226. 2. It represents a very high rate of decay compared to a single Becquerel. 3. By experimental measurement and definition:

$$1 \text{ Curie (Ci)} = 3.7 \times 10^{10} \text{ disintegrations per second (dps or Bq)}$$

4. This value is used to quantify the strength of radioactive sources used in medicine and industry. 5. Other related units include the Rutherford (Rd), where 1 Rd = 10^6 dps.

Final Answer: 3.7×10^{10} disintegrations/sec

Answer: (A)

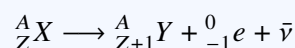
Q45.

Solution**Concept:**

Beta minus (β^-) decay occurs when a nucleus has too many neutrons. In this process, a neutron inside the nucleus transforms into a proton, an electron (the β -particle), and an antineutrino.

Solution:

1. The nuclear equation for β^- decay is:



2. Since a neutron (0 charge) turns into a proton (+1 charge), the total number of nucleons (Mass Number A) remains the same. 3. However, the number of protons in the nucleus increases by exactly one. 4. Because the atomic number (Z) represents the number of protons, the atomic number of the daughter nucleus increases by 1. 5. This shift results in the formation of a new element one position further to the right in the periodic table.

Final Answer: Increases by 1

Answer: (A)



Q46.

Solution**Concept:**

The nucleus of an atom contains almost all of its mass and is composed of protons and neutrons. Experimental data shows that the volume of a nucleus is directly proportional to the number of nucleons (Mass Number A) it contains.

Solution:

1. The radius of a nucleus is given by $R = R_0 A^{1/3}$, where R_0 is a constant. 2. The volume (V) of the nucleus, assuming it is spherical, is:

$$V = \frac{4}{3}\pi R^3 = \frac{4}{3}\pi (R_0 A^{1/3})^3 = \frac{4}{3}\pi R_0^3 A$$

3. Density (ρ) is defined as mass divided by volume. The mass of the nucleus is approximately $A \times m_u$, where m_u is the atomic mass unit. 4. Therefore, nuclear density is:

$$\rho = \frac{\text{Mass}}{\text{Volume}} = \frac{A \cdot m_u}{\frac{4}{3}\pi R_0^3 A}$$

5. The term A cancels out from both the numerator and the denominator:

$$\rho = \frac{m_u}{\frac{4}{3}\pi R_0^3}$$

6. Since m_u , π , and R_0 are all constants, the density of nuclear matter is the same for all nuclei, regardless of their size or mass number.

Final Answer: Independent of A

Answer: (C)



Q47.

Solution**Concept:**

Extrinsic semiconductors are created by adding small amounts of impurities to a pure (intrinsic) semiconductor like Silicon. A p-type (positive-type) semiconductor is created by "doping" with trivalent atoms.

Solution:

1. In Silicon (Si), each atom has 4 valence electrons. 2. To create a p-type material, an impurity from Group 13 (like Boron, Aluminum, or Indium) is added. These atoms have only 3 valence electrons. 3. When an impurity atom replaces a Silicon atom, it can only form three covalent bonds. The fourth position remains empty, creating a "hole." 4. These holes act as positive charge carriers because they can accept an electron from a neighboring bond. 5. Because every impurity atom contributes a hole, the number of holes (n_h) becomes much greater than the number of thermally generated free electrons (n_e). 6. Therefore, in a p-type semiconductor, holes are the majority charge carriers.

Final Answer: Holes

Answer: (B)

Q48.

Solution**Concept:**

A p-n junction consists of a depletion layer—a region near the junction devoid of mobile charge carriers. The width of this layer is sensitive to the external voltage (bias) applied to the junction.

Solution:

1. In **forward bias**, the positive terminal of the battery is connected to the p-side and the negative terminal to the n-side. 2. The positive terminal repels holes in the p-side toward the junction, and the negative terminal repels electrons in the n-side toward the junction. 3. This "push" from the external field forces the charge carriers to enter the depletion region, neutralizing some of the immobile ions. 4. As a result, the width of the depletion layer **decreases**. 5. This reduction in width lowers the potential barrier, allowing current to flow easily across the junction.

Final Answer: Decreases

Answer: (B)



Q49.

Solution**Concept:**

Logic gates are the building blocks of digital circuits. Universal gates like NAND and NOR are created by combining basic gates (AND, OR, NOT).

Solution:

1. The NOR gate stands for "NOT-OR." 2. Its logical operation is the negation of the OR operation. If the inputs are A and B , the output is $Y = \overline{A + B}$. 3. To construct a NOR gate, the outputs of an OR gate are fed into a NOT gate (inverter). 4. Truth Table Check: - OR Gate: Output is 1 if A or B is 1. - NOT Gate: Flips the result. - Result: NOR output is 1 only when both inputs are 0, and 0 otherwise. 5. This combination effectively creates the NOR logic functionality.

Final Answer: OR and NOT gate

Answer: (A)

Q50.

Solution**Concept:**

The binary system is a base-2 system using only digits 0 and 1. To convert a binary number to a decimal (base-10) number, we multiply each digit by 2 raised to the power of its position index (starting from 0 on the right).

Solution:

1. The given binary number is $(1011)_2$. 2. Identify the positional weights: - Rightmost digit (1): $1 \times 2^0 = 1 \times 1 = 1$ - Second digit from right (1): $1 \times 2^1 = 1 \times 2 = 2$ - Third digit from right (0): $0 \times 2^2 = 0 \times 4 = 0$ - Leftmost digit (1): $1 \times 2^3 = 1 \times 8 = 8$ 3. Sum the values:

$$\text{Decimal Value} = 8 + 0 + 2 + 1$$

4. Calculate the total:

$$8 + 2 + 1 = 11$$

5. Thus, $(1011)_2$ is equal to 11 in the decimal system.

Final Answer: 11

Answer: (B)



Answer Key

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

