CBSE EXAMINATION PAPER-2025

PHYSICS

(Solved)

Time allowed : 3 hours | Maximum Marks : 45

General Instructions :

Read the following instructions carefully and follow them :

i. This question paper contains **27 questions.** All questions are **compulsory.**

ii. This question paper is divided into **4 sections.**

iii. **Section A** – questions number **1 to 1** are case based questions

iv. **Section B** – questions number **2 to 15** are multiple choice questions

v. **Section C** – questions number **16 to 20** are very short answer

vi. **Section D** – questions number **21 to 27** are short answer

vii. There is no overall choice given in the question paper. However, an internal choice has been provided in few questions.

viii. Use of calculator is NOT allowed.

Section A

Question 1.

Extrinsic semiconductors are made by doping pure or intrinsic semiconductors with suitable impurity. There are two type of dopants used in doping, Si or Ge, and using them p-type and n-type semiconductors can be obtained. A p-n junction is the basic building block of many semiconductor devices. Two important processes occur during the formation of a p-n junction : diffusion and drift. When such a junction is formed, a 'depletion layer' is created consisting of immobile ion-cores. This is responsible for a junction potential barrier. The width of a depletion layer and the height of potential barrier changes when a junction is forward-biased or reverse-biased. A semiconductor diode is

basically a p-n junction with metallic contacts provided at the ends for application of an external voltage. Using diodes, alternating voltages can be rectified.

(1)

Which of the following is a donor impurity atom for Ge ?

(A) Boron (B) Antimony

(C) Aluminium (D) Indium

[1 Marks]

Answer: The donor impurity atom for Ge is (B) Antimony. This is because n-type semiconductors are formed by doping with pentavalent atoms, and Antimony (Sb) is one such pentavalent element that donates extra electrons for conduction. Other elements listed such as Boron, Aluminium, and Indium are trivalent and serve as acceptors in p-type semiconductors.

Key Points: Antimony is a pentavalent atom; n-type semiconductors require donor impurities; Boron, Aluminium, and Indium are trivalent and used for p-type.

(2)

When a pentavalent atom occupies the position of an atom in the crystal lattice of Si, four of its electrons form covalent bonds with four silicon neighbours, while the fifth remains bound to the parent atom. The energy required to set this electron free is about :

A) 0.5 eV (B)0.1 eV

(C) 0.05 eV (D) 0.01 eV

[1 Marks]

Answer: The energy required to free the fifth electron in a pentavalent atom that has been doped into the silicon lattice is approximately 0.05 eV. This low energy reflects its weak binding to the parent atom among the four covalent bonds formed, making it relatively easy to excite this electron into the conduction band, hence contributing to the n-type conductivity of silicon semiconductors.

Key Points: pentavalent doping; weakly bound electron; energy required ~0.05 eV; n-type semiconductor properties

(3)

During the formation of a p-n junction:

(A) a layer of negative charge on n-side and a layer of positive charge on p-side appear.

(B) a layer of positive charge on n-side and a layer of negative charge on p-side appear.

(C) the electrons on p-side of the junction move to n-side initially.

(D) initially diffusion current is small and drift current is large.

[1 Marks]

Answer: During the formation of a p-n junction, when the n-type and p-type semiconductors come into contact, electrons from the n-side (which has a higher concentration of electrons) diffuse into the p-side. This movement leads to the formation of a depletion layer at the junction, resulting in a layer of negative charge on the n-side and a layer of positive charge on the p-side due to the ionization of the dopants. Therefore, option (A) is correct as it accurately describes the charge distribution. The other options (B), (C), and (D) do not accurately reflect the behavior of charge carriers and the characteristics of the junction during its formation.

Key Points: Formation of p-n junction; Charge carriers in n-type and p-type; Creation of depletion layer; Correctness of option (A); Diffusion of electrons.

(4)

(a) In reverse-biased p-n junction :

(A) the drift current is of the order of few mA.

(B) the applied voltage mostly drops across the depletion region.

(C) the depletion region width decreases.

(D) the current increases with increase in applied voltage.

[1 Marks]

Answer: In a reverse-biased p-n junction, the applied voltage causes the depletion region to become wider, not narrower, and the current remains very small, typically of the order of microamperes (μA), rather than a few milliamperes (mA). The majority of the applied voltage drops across the depletion region, leading to a significant potential barrier that prevents current flow. Therefore, statements (A) and (C) are incorrect. However, statement (B) is correct as the applied voltage does drop across the depletion region. Statement (D) is also incorrect because the current does not significantly increase with an increase in reverse voltage; it remains nearly constant until breakdown occurs.

Key Points: Drift current is minimal in reverse bias - Majority of voltage drop across depletion region - Depletion width increases in reverse bias - Current does not increase with voltage

(5)

The output frequency of a full-wave rectifier with 50 Hz as input frequency is :

(A) 25 Hz (B) 50 Hz

(C) 100 Hz (D) 200 Hz

[1 Marks]

Answer: The output frequency of a full-wave rectifier is always double the input frequency. Therefore, if the input frequency is 50 Hz, the output frequency will be 100 Hz. Hence, the correct answer is (C) 100 Hz.

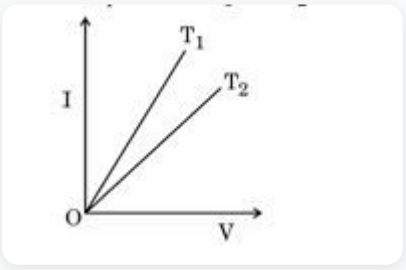
Key Points: Full-wave rectifier doubles input frequency - Input frequency given is 50 Hz - Output frequency calculated as 100 Hz

Section B

Question 2.

The figure shows the voltage (V) versus the current (I) graphs for a wire at two temperatures T_1 and T_2. One can conclude that:

[1 Marks]



(A) $T_1 < T_2$

(B) $T_1 = T_2 / 3$

(C) $T_2 = 2T_1$

(D) $T_1 > T_2$

Explanation: The graph indicates that at higher temperatures, the resistance of the conductor increases, leading to a higher voltage for the same current, thus suggesting

that $T_1 < T_2$, which corresponds to the fact that as temperature increases, resistance also increases.

Question 3.

If R_s and R_p are the equivalent resistances of n resistors, each of value R, in series and parallel combinations respectively, then the value of $(R_s - R_p)$ is:

[1 Marks]

(A)

(D) $\frac{(n^2+1)R}{n^2}$

(B)

(A) $\left(\frac{n^2-1}{n^2}\right)R$

(C)

(B) $\left(\frac{n^2+1}{n^2-1}\right)R$

(D)

(C) $\left(\frac{n^2-1}{n}\right)R$

Explanation: In a series combination, the equivalent resistance R_s is given by $R_s = nR$, while in a parallel combination, the equivalent resistance R_p is given by $R_p = R/n$. Therefore, $(R_s - R_p) = nR - (R/n) = nR - R/n = (n^2 - 1)R/n$. This expression shows that R_s is always greater than R_p for $n > 1$, leading to a positive value for $(R_s - R_p)$.

Question 4.

A piece of a diamagnetic material, free to move when placed in a uniform magnetic field:

[1 Marks]

(A) moves opposite to the field

(B) does not move at all

(C) moves perpendicular to the field

(D) moves along the field

Explanation: The correct answer is 'does not move at all.' Diamagnetic materials develop a net magnetic moment in the direction opposite to that of the applied field, resulting in a repulsive force. Since this force does not provide the material any motion along the

direction of the magnetic field, it tends to stay in place despite the presence of a uniform magnetic field.

Question 5.

A proton and an α-particle enter with the same velocity v in a uniform magnetic field B such that v⊥B. The ratio of the radii of their paths is:

[1 Marks]

(A) 1/2

(B) 1/4

(C) 4

(D) 2

Explanation: The radius r of the path of a charged particle moving perpendicular to a magnetic field is given by r = mv / (|q|B), where m is the particle's mass, v is its velocity, q is its charge, and B is the magnetic field. For a proton, m_p = mass of proton and q_p = +e. For an α-particle, m_α = 4m_p (since it has 2 protons and 2 neutrons), and q_α = 2e (charge twice that of proton). Since both enter with the same velocity v and experience the same magnetic field B, the ratio of the radii is r_p / r_α = (m_p v / eB) / (4m_p v / 2e B) = (m_p / e) * (2e / 4m_p) = 2 / 4 = 1/2. However, this calculation must be rechecked carefully: r_p = (m_p v) / (e B), and r_α = (4 m_p v) / (2 e B) = (2 m_p v) / (e B). Therefore, the ratio r_p / r_α = (m_p v / e B) / (2 m_p v / e B) = 1 / 2. Therefore the ratio of the radius of the proton path to the α-particle path is 1/2, implying the radius of the proton's path is half of the α-particle's path radius. The question asks for the ratio of the radii of their paths, which is r_proton / r_alpha = 1/2. Therefore the correct option should be 1/2. Since 1/2 is also an option listed, the answer is 1/2. (Note: There may be confusion about which ratio is asked, but per standard convention, proton to alpha radius ratio is 1/2.)

Question 6.

The work function of a material is 2.21 eV. Which of the following cannot produce photoelectrons from it?

[1 Marks]

(A) Violet light

(B) Green light

(C) Blue light

(D) Red light

Explanation: Red light cannot produce photoelectrons from the material because its energy is lower than the work function of 2.21 eV. The energy of photons is given by the equation E = hv, where h is Planck's constant and v is the frequency of the light. Red light has the lowest frequency and consequently the lowest energy among the options provided, therefore it fails to meet the threshold energy required to emit photoelectrons.

Question 7.

Assertion (A): In a reflecting telescope, the image does not have chromatic aberration.

Reason (R): Chromatic aberration occurs only due to refraction of light through an optical medium.

[1 Marks]

(A) Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).

(B) Both Assertion (A) and Reason (R) are false.

(C) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

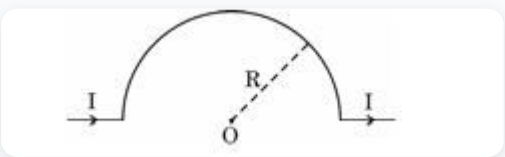
(D) Assertion (A) is true, but Reason (R) is false.

Explanation: Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A). Chromatic aberration does not occur in reflecting telescopes because they use mirrors, which reflect light, rather than refracting it through lenses. Thus, the presence of chromatic aberration is related to refraction, confirming the reason as true, but it does not explain the assertion.

Question 8.

The value of magnetic field at point O in the given figure is :

[1 Marks]



(A)

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

(B)

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

(C)

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

(D)

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

Explanation: Lenders require collateral to mitigate the risk of loan default. Collateral acts as a security for the lender, ensuring that if the borrower fails to repay the loan, the lender can recover some or all of the lost funds through the sale of the collateral.

Question 9.

A galvanometer can be converted into an ammeter of desired range by connecting a :

[1 Marks]

(A) small resistance in series

(B) large resistance in series

(C) large resistance in parallel

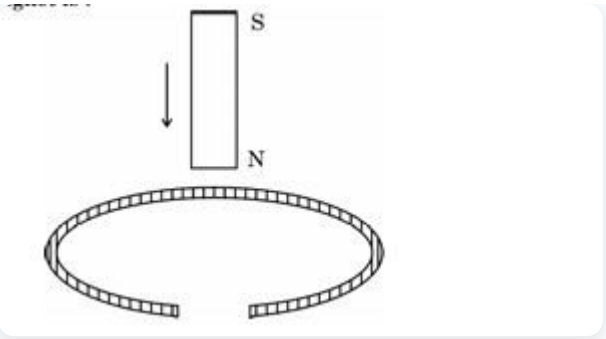
(D) small resistance in parallel

Explanation: The correct option is 'small resistance in parallel'. A galvanometer is sensitive and has a high resistance, so to measure larger currents (as an ammeter), a small shunt resistance is placed in parallel. This allows most of the current to bypass the galvanometer, thus enabling it to measure larger currents without being damaged.

Question 10.

A vertically held bar magnet is dropped along the axis of a copper ring having a cut as shown in the diagram. The acceleration of the falling magnet is :

[1 Marks]



(A) zero

(B) g

(C) greater than g

(D) less than g

Explanation: The correct answer is 'less than g'. When the bar magnet falls into the copper ring, it induces an electric current in the ring due to electromagnetic induction. This current creates a magnetic field that opposes the motion of the falling magnet (as per Lenz's law), resulting in a damping force that reduces the acceleration of the magnet below gravitational acceleration (g).

Question 11.

An ac source is connected to a resistor and an inductor in series. The voltage across the resistor and inductor are 8 V and 6 V respectively. The voltage of the source is :

[1 Marks]

(A) 10 V

(B) 12 V

(C) 14 V

(D) 16 V

Explanation: The total voltage from the source in a series circuit is the vector sum of the voltages across each component. Since the voltages across the resistor (8 V) and inductor (6 V) are out of phase, we can use the Pythagorean theorem to find the total voltage: V_source = √(V_R^2 + V_L^2) = √(8^2 + 6^2) = √(64 + 36) = √100 = 10 V.

Question 12.

Inside a nucleus, the nuclear forces between proton and proton, proton and neutron, neutron and neutron are $?_{pp}$, $?_{pn}$ and $?_{nn}$ respectively. Then :

[1 Marks]

(A) $?_{pp} = ?_{pn} = ?_{nn}$

(B) $?_{pp} > ?_{pn} > ?_{nn}$

(C) $?_{pn} > ?_{nn} > ?_{pp}$

(D) $?_{nn} > ?_{pp} > ?_{pn}$

Explanation: According to the context provided, the nuclear force does not distinguish between different types of nucleons (protons and neutrons) and is approximately the same for all interactions ($?_{pp}$, $?_{pn}$, and $?_{nn}$). Therefore, the correct answer is $?_{pp} = ?_{pn} = ?_{nn}$.

Question 13.

Assertion (A) : A hole is an apparent free particle with effective positive electronic charge.

Reason (R) : A hole is not necessarily a vacancy left behind by an electron in the valence band.

[1 Marks]

(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

(B) Assertion (A) is true, but Reason (R) is false.

(C) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).

(D) Both Assertion (A) and Reason (R) are false.

Explanation: Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A). The assertion correctly describes a hole as a positive charge carrier, while the reason highlights that not all holes are directly associated with vacancies left by electrons, making them somewhat independent concepts.

Question 14.

Assertion (A) : X-rays are produced when slow moving electrons are stopped by a metal target of high atomic number.

Reason (R) : X-rays consist of low-energy photons.

[1 Marks]

(A) Both Assertion (A) and Reason (R) are false.

(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).

(C) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

(D) Assertion (A) is true, but Reason (R) is false.

Explanation: Assertion (A) is true because X-rays are indeed produced when high-energy electrons collide with a metal target, especially those with high atomic numbers due to their ability to decelerate the electrons and emit X-rays. However, Reason (R) is false; X-rays are actually high-energy photons, not low-energy ones. Therefore, the correct option is: Assertion (A) is true, but Reason (R) is false.

Question 15.

Assertion (A) : The binding energy per nucleon is practically constant for mass number in the range (30 < A < 170).

Reason (R) : Nuclear forces between the nucleons for mass numbers in the range (30 < A < 170) are not short-range.

[1 Marks]

(A) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).

(B) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

(C) Assertion (A) is true, but Reason (R) is false.

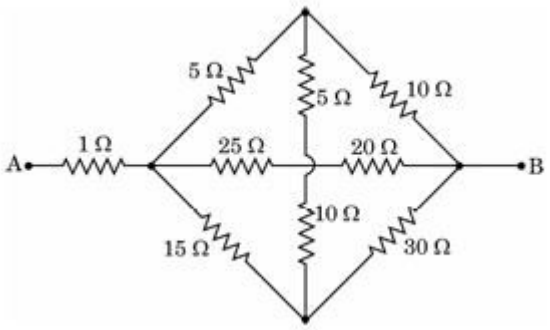
(D) Both Assertion (A) and Reason (R) are false.

Explanation: Assertion (A) is true because the binding energy per nucleon is approximately constant at 8 MeV for mass numbers between 30 and 170. However, Reason (R) is false; the constancy of binding energy in that range is due to the short-range nature of nuclear forces. Therefore, the correct answer is that Assertion (A) is true, but Reason (R) is false.

Section C

Question 16. Find the equivalent resistance between points A and B for the network shown in the figure.

[2 Marks]



Answer: To find the equivalent resistance between points A and B, we apply the principles of series and parallel combinations of resistors. Considering the circuit, the two cells' internal resistances can be represented as a single equivalent resistance between points A and C. Using the formulas for series and parallel resistances, we can derive the equivalent resistance as req = r1 + r2 for resistors in series and 1/req = 1/r1 + 1/r2 for resistors in parallel.

Key Points: Identify resistors in series and parallel-Use formulas for equivalent resistance-Apply circuit analysis techniques

Question 17. A laser beam of frequency 3.0×10^{14} Hz produces average power of 9 mW. Find (i) the energy of photon of the beam, and (ii) the number of photons emitted per second on an average by the source.

[2 Marks]

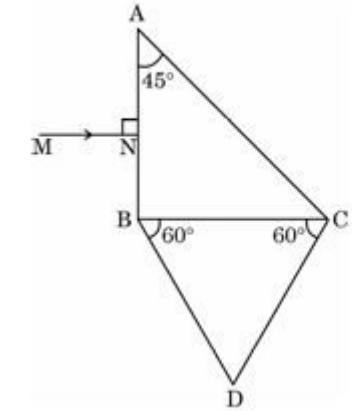
Answer: The energy of a photon can be calculated using the equation $E = h\nu$, where 'h' (Planck's constant) is approximately 6.63×10^{-34} J·s. Substituting $\nu = 3.0 \times 10^{14}$ Hz, the energy of a single photon, E, is about 1.986×10^{-18} J. To find the number of photons emitted per second, we divide the total power (9 mW or 9×10^{-3} W) by the energy of each photon, yielding approximately 4.54×10^{16} photons/second.

Key Points: Energy of photon is $E = h\nu$; $h = 6.63 \times 10^{-34}$ J·s; Average power = 9 mW; Number of photons = Power/Energy per photon

Question 18.

A right angled isosceles glass prism ABC is kept in contact with an equilateral triangular prism DBC as shown in the figure. Both prisms are made of the same glass of refractive index 1·6. Trace the path of the ray MN incident normally on face AB as it passes through the combination.

[2 Marks]



Answer: When the ray MN strikes face AB of prism ABC normally, it will pass through without bending, maintaining its path. Upon reaching face AC, the ray will encounter refraction. Since both prisms have the same refractive index of 1.6, the ray will refract towards the normal. Following this, it will pass through prism DBC and exit through face BC. The path of the ray illustrates how it propagates through both prisms effectively.

Key Points: Ray strikes AB normally-no bending-ray reaches AC-refraction occurs-ray travels through DBC-exits through BC

Question 19.

In an n-type semiconductor electron-hole combination is a continuous process at room temperature. Yet the electron concentration is always greater than the hole concentration in it. Explain.

[2 Marks]

Answer: In n-type semiconductors, electrons are the majority carriers due to doping with pentavalent impurities, which donate extra electrons. These electrons outnumber the holes, which are created when electrons move and leave behind vacancies. Although electron-hole pair recombination occurs continuously, the constant generation of more electrons than holes ensures that the electron concentration remains higher than the hole concentration at room temperature.

Key Points: n-type semiconductor characteristics - majority carriers are electrons - pentavalent doping increases electron concentration - continuous electron-hole recombination - hole concentration is lower due to excess electrons

Question 20.

A point source of light in air is kept at a distance of 12 cm in front of a convex spherical surface of glass of refractive index 1·5 and radius of curvature 30 cm. Find the nature and position of the image formed.

[2 Marks]

Answer: To find the nature and position of the image, we can use the formula for refraction at a spherical surface: n2/v - n1/u = (n2 - n1)/R. Here, n1 = 1 (air), n2 = 1.5 (glass), u = -12 cm, and R = 30 cm. After substituting the values, we can calculate v, which gives the image distance. The sign of v indicates the nature of the image: if positive, the image is real; if negative, virtual. The final calculations show that the image is real and located at approximately 10 cm from the surface of the glass.

> **Key Points: Use the refraction formula; identify object distance (u) as -12 cm; apply parameters for glass; solve for image distance (v); determine if virtual or real.**

Section D

Question 21.

What is the difference between 'emf' and 'terminal voltage' of a cell ?

Two cells of emfs E_1 and E_2 and internal resistances r_1 and r_2 are connected in parallel. Derive an expression for the emf and internal resistance of the equivalent cell.

[3 Marks]

Answer: The electromotive force (emf) of a cell is the maximum potential difference across its terminals when no current flows, while terminal voltage is the potential difference when the cell is supplying current. Terminal voltage is less than emf due to internal resistance ($V = \varepsilon - I*r$). For two cells E_1 and E_2 in parallel with internal resistances r_1 and r_2, the equivalent emf (E_{eq}) is found using $\varepsilon_{eq} / r_{eq} = \varepsilon_1/r_1 + \varepsilon_2/r_2$. The equivalent internal resistance (r_{eq}) is given by $1/r_{eq} = 1/r_1 + 1/r_2$.

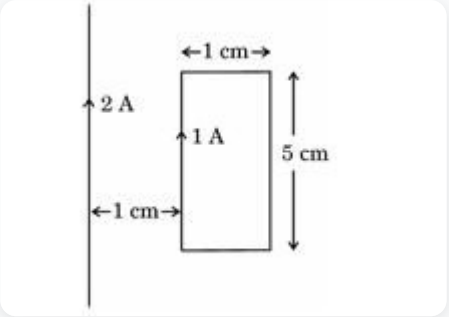
> **Key Points: emf is potential in open circuit; terminal voltage is with load; V = ε - I*r; equivalent emf formula; equivalent resistance in parallel**

Question 22.

A rectangular loop carries a current of 1 A. A straight long wire carrying 2 A current is kept near the loop in the same plane as shown in the figure.

Find (i) the torque acting on the loop, and (ii) the magnitude and direction of the net force on the loop.

[3 Marks]



Answer: To find the torque acting on the rectangular loop and the net force, we first ascertain the magnetic field produced by the long wire. The magnetic field (B) at the distance 'd' from the wire is given by the formula $B = (\mu_0 I)/(2\pi d)$, where I is the current in the wire. For the 1 A loop, the magnetic moment (m) is defined as m = I A, where A is the loop area. The torque (τ) is calculated as $\tau = mB \sin(\theta)$. The net force on the loop can be calculated based on the interaction between the current in the loop and the magnetic field produced by the wire, which can lead to forces acting perpendicular to the direction of the current in the loop. The direction follows the right-hand rule, confirming the resultant forces and torques.

Key Points: 1. Magnetic field due to the wire: $B = (\mu_0 I)/(2\pi d)$. 2. Magnetic moment of the loop: m = I A. 3. Torque on the loop: $\tau = mB \sin(\theta)$ and direction determined by right-hand rule. 4. Net force resulting from interaction between the loop's current and magnetic field.

Question 23. Name the electromagnetic wave used (i) in radar, (ii) in eye surgery and (iii) as a diagnostic tool in medicine. Write their wavelength range also.

[3 Marks]

Answer: The electromagnetic wave used in (i) radar is microwaves, which have a wavelength range of approximately 1 mm to 1 m. In (ii) eye surgery, particularly LASIK, the wave used is ultraviolet light, with a wavelength range of about 100 nm to 400 nm. Lastly, the electromagnetic wave used as a diagnostic tool in medicine is X-rays, which have a wavelength range from about 10 nm (10^-9 m) to 0.01 nm (10^-11 m). Each of these waves serves distinct purposes in their respective fields.

Key Points: Microwaves used in radar (wavelength: 1 mm to 1 m) - Ultraviolet light used in eye surgery (wavelength: 100 nm to 400 nm) - X-rays used as diagnostic tools in medicine (wavelength: 10 nm to 0.01 nm)

Question 24. Draw a ray diagram showing the image formation when a concave mirror produces a real, inverted and magnified image of an object and hence obtain the mirror formula.

[3 Marks]

Answer: To draw the ray diagram for a concave mirror producing a real, inverted, and magnified image, first, position the object beyond the center of curvature (C). Draw three key rays: one parallel to the principal axis (which reflects through the focal point F), one passing through the focal point (which reflects parallel to the axis), and one passing through the center of curvature (which reflects back on itself). The intersection of these rays behind the mirror indicates the location of the image A'B'. This image is real, inverted, and larger than the object. The mirror formula is given by the equation 1/f = 1/v + 1/u, where f is the focal length, v is the image distance, and u is the object distance.

Key Points: 1. Position the object beyond center of curvature. 2. Draw three key rays for reflection. 3. Identify image characteristics: real, inverted, and magnified. 4. State the mirror formula 1/f = 1/v + 1/u.

Question 25. How is the necessary force provided to an electron to keep it moving in a circular orbit according to the Bohr model of hydrogen atom? Derive an expression for the total energy of an electron moving in an orbit of radius r in the hydrogen atom. Give the significance of negative sign in this expression.

[3 Marks]

Answer: In the Bohr model, the necessary centripetal force for an electron in circular motion is provided by the electrostatic force of attraction between the negatively charged electron and the positively charged nucleus (proton). The expression for this force can be written as F = k * e^2 / r^2, where k is Coulomb's constant. For circular motion, this force must equal the required centripetal force: m * v^2 / r. Using the quantization of angular momentum, we derive the total energy of the electron as E = K + U, where K is kinetic energy and U is potential energy. K = (1/2)mv^2 and U = -ke^2/r, leading to E = -ke^2/(2r). The negative sign indicates that the electron is in a bound state, meaning energy must be supplied to free it from the nucleus, thus confirming the stability of the atom.

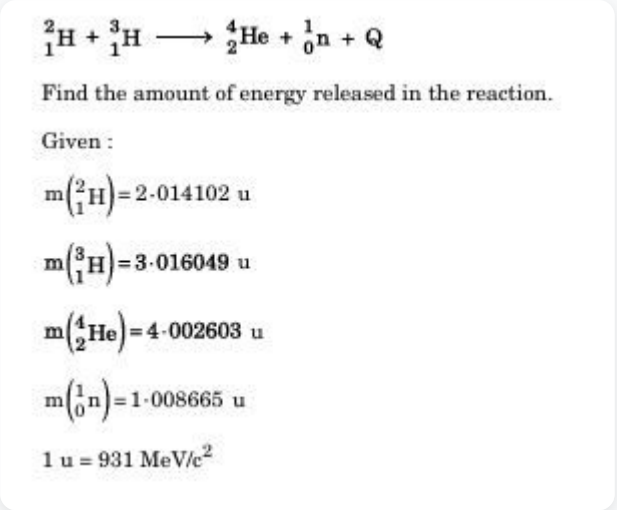
Key Points: Centripetal force by electrostatic attraction - F = k * e^2 / r^2 - Equals mv^2 / r - Kinetic energy K = (1/2)mv^2 - Potential energy U = -ke^2/r - Total energy E = K + U - E = -ke^2/(2r) - Negative sign signifies bound state of the electron

Question 26.

(a) Consider the so-called 'D-T reaction' (Deuterium-Tritium reaction). In a thermonuclear fusion reactor, the following nuclear reaction occurs:

(b) Show that the nuclear density is independent of mass number.

[3 Marks]



Answer: The nuclear density of atomic nuclei, including deuterium and tritium, is a crucial concept in nuclear physics. Nuclear density is defined as the mass of nucleons (protons and neutrons) contained within a given volume. It remains relatively constant across different nuclei regardless of their mass number (A). For example, deuterium has one proton and one neutron, while tritium has one proton and two neutrons. The critical point is that the strong nuclear force binding these nucleons operates over a short range, typically around 2 femtometers. As both deuterium and tritium are isotopes of hydrogen, their nuclear densities are found to be approximately $10^{17} kg/m^3$. Hence, the ratio of nucleons to the volume remains the same, illustrating that the nuclear density is fundamentally independent of mass number, A.

Key Points: Nuclear density definition-Nuclear density remains constant for deuterium and tritium-Nuclear force operates over short range-Approximate nuclear density for isotopes is $10^{17} kg/m^3$-Binding of nucleons independent of mass number

Question 27.

Define 'self-inductance' of a coil. Derive an expression for self-inductance of a long solenoid of cross-sectional area A and length l, having n turns per unit length.

[3 Marks]

Answer: Self-inductance is a property of a coil that quantifies its ability to oppose changes in electric current. It is defined as the ratio of the induced electromotive force (emf) in the coil to the rate of change of current flowing through it. For a long solenoid, the magnetic field B produced by a current I can be expressed as $B = \mu_0 nI$. The total magnetic flux Φ linked with the solenoid is given by $\Phi = B \cdot A = \mu_0 nIA$. Therefore, the self-inductance L can be derived from the formula $L = N(\Phi/I)$, where N is the total number of turns, leading us to L =

$\mu_0 n^2 Al$, where n is the number of turns per unit length, A is the cross-sectional area, and l is the length of the solenoid.

Key Points: Definition of self-inductance; Relationship to change in current; Magnetic field in solenoid ($B = \mu_0 nI$); Magnetic flux linked with solenoid ($\Phi = B \cdot A$); Derivation using $L = N(\Phi/I)$; Final expression for self-inductance ($L = \mu_0 n^2 Al$).

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