

Question Paper

Conducted by the Central Board of Secondary Education (CBSE)



Time Allowed: 2 Hours

Maximum Marks: 35

General Instructions

- (i) This question paper contains **12 questions**. All questions are **compulsory**.
- (ii) The question paper is divided into Sections A, B, C.
- (iii) Section A - Questions 1 to 3 carry 2 marks each.
- (iv) Section B - Questions 4 to 11 carry 3 marks each.
- (v) Section C - Question 12 carries 5 marks.
- (vi) There is no overall choice. Where an internal choice is provided, attempt only one of the alternatives.
- (vii) Use of calculators is not permitted.

You may use the following values of physical constants wherever necessary:

$$\begin{aligned}c &= 3 \times 10^8 \text{ m/s} \\h &= 6.63 \times 10^{-34} \text{ Js} \\e &= 1.6 \times 10^{-19} \text{ C} \\\mu_0 &= 4\pi \times 10^{-7} \text{ T m A}^{-1} \\\epsilon_0 &= 8.854 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2} \\\frac{1}{4\pi\epsilon_0} &= 9 \times 10^9 \text{ N m}^2 \text{ C}^{-2}\end{aligned}$$

$$\begin{aligned}\text{Mass of electron } (m_e) &= 9.1 \times 10^{-31} \text{ kg} \\\text{Mass of neutron} &= 1.675 \times 10^{-27} \text{ kg} \\\text{Mass of proton} &= 1.673 \times 10^{-27} \text{ kg} \\\text{Avogadro's number} &= 6.023 \times 10^{23} \text{ per gm mole} \\\text{Boltzmann constant} &= 1.38 \times 10^{-23} \text{ JK}^{-1}\end{aligned}$$

Section A

1(a). Draw the graph showing the variation of the number (N) of scattered alpha particles with scattering angle (θ) in Geiger-Marsden experiment. Infer two conclusions from the graph.

OR

1(b). Plot suitable graphs to show the variation of photoelectric current with the collector plate potential for the incident radiation of

(i) the same intensity but different frequencies

ν_1, ν_2 and ν_3 ($\nu_1 < \nu_2 < \nu_3$)

(ii) the same frequency but different intensities

I_1, I_2 and I_3 ($I_1 < I_2 < I_3$)

2. Distinguish between intrinsic and extrinsic semiconductors. Although in an extrinsic semiconductor $n_e \neq n_h$, yet it is electrically neutral. Why?

3. Draw energy band diagrams of n-type and p-type semiconductors at temperature $T > 0$ K, depicting the donor and acceptor energy levels. Mention the significance of these levels.

Section B

4(a). A parallel beam of light of wavelength 600 nm is incident normally on a slit of width 0.2 mm. If the resulting diffraction pattern is observed on a screen 1 m away, find the distance of

- (i) first minimum, and
- (ii) second maximum, from the central maximum.

OR

4(b). A thin equiconvex lens of radius of curvature R made of material of refractive index μ_1 is kept coaxially, in contact with an equiconcave lens of the same radius of curvature and refractive index μ_2 ($\mu_2 > \mu_1$). Find:

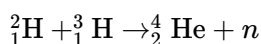
- (i) the ratio of their powers, and
- (ii) the power of the combination and its nature.

5. Define the term — Distance of closest approach. How will it be affected, for an α -particle, if kinetic energy of the particle is doubled?

6. Using Huygen's principle, for a plane wavefront incident on a plane reflecting surface, draw the reflected wavefront. Hence prove laws of reflection.

7. The de-Broglie wavelength associated with an electron is 0.30 nm. Calculate: (a) the speed, and (b) the kinetic energy (in eV), of the electron.

8. Calculate the energy released in MeV in the following reaction:



Given: $m({}^2_1\text{H}) = 2.014102 \text{ u}$

$m({}^3_1\text{H}) = 3.016049 \text{ u}$

$m({}^4_2\text{He}) = 4.002603 \text{ u}$

$m_n = 1.008665 \text{ u}$

9(a). (i) Monochromatic light is incident on a surface separating two media. The frequency of the light after refraction remains unaffected but its wavelength changes. Why?

(ii) The frequency of an electromagnetic radiation is $1.0 \times 10^{11} \text{ Hz}$. Identify the radiation and mention its two uses.

OR

9(b). (i) Trace the path of a ray of light PQ which is incident at an angle i on one face of a glass prism of angle A . It then emerges out from the other face at an angle e . Use the ray diagram to prove that the angle through which the ray is deviated is given by $\angle \delta = \angle i + \angle e - \angle A$.

(ii) What will be the minimum value of δ if the ray passes symmetrically through the prism?

10. State the working principle of an LED. Write any two important advantages and two disadvantages of LED.

11. For a glass prism of refractive index $\sqrt{3}$, the value of angle of minimum deviation δ is equal to the angle of prism A . Find the angle of prism A . How will the angle δ be affected if the prism were immersed in water?

12. The principle of superposition is used to understand the phenomenon of interference of light waves. The principle states that at a particular point, the resultant displacement produced by a number of waves is the vector sum of the displacements produced by each wave. Light waves from two coherent sources produce interference pattern. Thomas Young devised a way to obtain two coherent sources using two identical pinholes (S_1 and S_2) illuminated by a single monochromatic pinhole source S . Using these sources in his experiment known as Young's double slit experiment, Young studied the interference pattern. The pattern consists of alternate bright and dark fringes. The distance between two successive bright or dark fringes depends on the distance between S_1 and S_2 , the distance of the screen from the plane of S_1S_2 and the wavelength of light used.

I. Consider the following waves:

(i) $y_1 = a \sin \omega t$

(ii) $y_2 = a \sin 2\omega t$

(iii) $y_3 = a \sin(\omega t + \phi)$

(iv) $y_4 = a \sin\left(4\omega t + \frac{\pi}{2}\right)$

Which pair of the waves coming from two sources S_1 and S_2 will produce interference?

- (A) (i) and (ii) (B) (ii) and (iii) (C) (iii) and (iv) (D) (iv) and (i)

II. Two light waves of the same intensity I_0 each, having a path difference of $\lambda/4$, emanating from two coherent sources, meet at a point. The resultant intensity at the point will be

- (A) Zero (B) I_0 (C) $2I_0$ (D) $4I_0$

III. Vandana performs Young's double slit experiment by using orange, green and red lights successively. If the fringe widths measured in the three cases are ω_1 , ω_2 and ω_3 respectively, then which of the following is correct?

- (A) $\omega_2 > \omega_1 > \omega_3$ (B) $\omega_1 > \omega_2 > \omega_3$ (C) $\omega_2 > \omega_3 > \omega_1$ (D) $\omega_3 > \omega_2 > \omega_1$

12. (continued)

IV. In a Young's double slit experiment, the slit separation is 0.8 mm and the interference pattern is obtained on a screen kept 50 cm from the plane of the slits S_1 and S_2 . If the first bright fringe is formed 0.4 mm from the central maximum, the wavelength of light used is

- (A) 480 nm (B) 560 nm (C) 640 nm (D) 680 nm

V. Consider the effect on the angular separation of the fringes in a Young's double slit experiment due to the following operations:

(i) the screen is moved away from the plane of the slits,

(ii) the separation between the two slits is increased till fringes are observed.

Which of the following options is correct?

- (A) It remains constant in both cases.
(B) It decreases in both cases.
(C) It remains constant in (i) but decreases in (ii).
(D) It decreases in (i) but remains constant in (ii).

- End of Question Paper -