

## 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).** (i) Define the terms: 'impact parameter' and 'distance of closest approach' for an  $\alpha$ -particle in Geiger-Marsden scattering experiment.

(ii) What will be the value of the impact parameter for scattering angle (I)  $\theta = 0^\circ$  and (II)  $\theta = 180^\circ$ ?

**1(b).** Photoelectric emission occurs when a surface is irradiated with the radiation of frequency (i)  $\nu_1$  and (ii)  $\nu_2$ . The maximum kinetic energy of the electrons emitted in the two cases are  $K$  and  $2K$  respectively. Obtain the expression for the threshold frequency for the surface.

**2.** Briefly explain the working of a light emitting diode. Mention its two uses.

**3.** Explain the formation of depletion region in a  $p$ - $n$  junction.

## Section B

4. With the help of a circuit diagram, explain the working of a  $p$ - $n$  junction diode as a full-wave rectifier. Also draw its input and output waveforms.

5. Find the ratio of the de Broglie wavelengths associated with an alpha particle and a proton, if both

- (a) have the same speeds,
- (b) have the same kinetic energy,
- (c) are accelerated through the same potential difference.

6(a). (i) Depict the variation of the potential energy of a pair of nucleons with the separation between them.

(ii) Imagine the fission of a  ${}^{56}_{26}\text{Fe}$  into two equal fragments of  ${}^{28}_{13}\text{Al}$  nucleus. Is the fission energetically possible? Justify your answer by working out  $Q$  value of the process.

Given:  $m({}^{56}_{26}\text{Fe}) = 55.93494 \text{ u}$ ,  $m({}^{28}_{13}\text{Al}) = 27.98191 \text{ u}$ .

7(a). (i) Depict a plane electromagnetic wave propagating along the  $x$ -axis. Write the expressions for its oscillating electric and magnetic fields.

(ii) Write three characteristics of electromagnetic waves.

7(b). Name the electromagnetic waves which are produced by the following:

- (i) Radioactive decays of nucleus
- (ii) Welding arcs
- (iii) Hot bodies

Write one use each of these waves.

8(a). Draw a labelled ray diagram showing the formation of an image by an astronomical refracting telescope in normal adjustment. Hence, obtain the expression for its magnifying power.

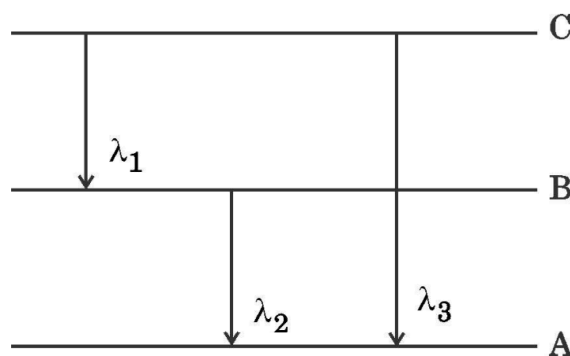
8(b). A plane wavefront of light of wavelength ' $\lambda$ ' is incident normally on a narrow slit of width ' $a$ ' and a diffraction pattern is observed on a screen at a distance ' $D$ ' from the slit.

(i) Depict the intensity distribution in the pattern observed.

(ii) Obtain the expression for the first maximum from the central maximum.

9(b). (i) State Bohr's quantization condition for defining stationary orbits.

(ii) Use the energy level diagram shown below to obtain the relation between three wavelengths  $\lambda_1$ ,  $\lambda_2$  and  $\lambda_3$  emitted due to the transition of electron from the energy states  $C$  and  $B$ .



10. (a) Is the speed of light in glass independent of the colour of light? Give reason.

(b) A small bulb is placed at the bottom of a tank containing water to a depth of 70 cm. Find the area of the surface of water through which light from the bulb can emerge out. Given refractive index of water is  $\frac{4}{3}$ .

11. The refractive index of an equilateral triangular prism kept in air is  $\sqrt{2}$ . Calculate:

- (a) the angle of minimum deviation.
- (b) the critical angle for the prism.

**12.** The British physicist Thomas Young explained the interference of light using the principle of superposition of waves. He observed the interference pattern on the screen, in his experimental set-up, known now as Young's double slit experiment. The two slits  $S_1$  and  $S_2$  were illuminated by light from a slit  $S$ . The interference pattern consists of dark and bright bands of light. Such bands are called fringes. The distance between two consecutive bright and dark fringes is called fringe width.

**(a)** If the screen is moved closer to the plane of slits  $S_1$  and  $S_2$ , then the fringe width:

- (i) will decrease, but the intensity of bright fringe remains the same.
- (ii) will increase, but the intensity of bright fringe decreases.
- (iii) will decrease, but the intensity of bright fringe increases.
- (iv) and the intensity both remain the same.

**(b)** What will happen to the pattern on the screen, when the two slits  $S_1$  and  $S_2$  are replaced by two independent but identical sources?

- (i) The intensity of pattern will increase
- (ii) The intensity of pattern will decrease
- (iii) The number of fringes will become double
- (iv) No pattern will be observed on the screen

**(c)** Two sources of light are said to be coherent, when both emit light waves of:

- (i) same amplitude and have a varying phase difference.
- (ii) same wavelength and a constant phase difference.
- (iii) different wavelengths and same intensity.
- (iv) different wavelengths and a constant phase difference.

**(d)** The fringe width in a Young's double slit experiment is  $\beta$ . If the whole set-up is immersed in a liquid of refractive index ' $\mu$ ', then the new fringe width will be:

- (i)  $\beta$
- (ii)  $\mu\beta$

**12.** (continued)

(iii)  $\frac{\beta}{\mu}$

(iv)  $\frac{\beta}{2}$

**(e)** The total path difference between two waves meeting at points  $P_1$  and  $P_2$  on the screen are

$\left(\frac{3\lambda}{2}\right)$  and  $(2\lambda)$  respectively. Then:

- (i) bright fringes are formed at both points.
- (ii) dark fringes are formed at both points.
- (iii) a bright fringe is formed at  $P_1$  and a dark fringe is formed at  $P_2$ .
- (iv) a bright fringe is formed at  $P_2$  and a dark fringe is formed at  $P_1$ .

- End of Question Paper -