

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. What is meant by energy band gap in a solid? Draw the energy band diagrams for a conductor, an insulator and a semiconductor.

2. Name the device which converts an ac input signal into a dc output signal. Write the principle of working of the device.

3(a). Name the spectral series for a hydrogen atom which lies in the visible region. Find the ratio of the maximum to the minimum wavelengths of this series.

OR

3(b). What are matter waves? A proton and an alpha particle are accelerated through the same potential difference. Find the ratio of the de Broglie wavelength associated with the proton to that with the alpha particle.

Section B

4. (a) Differentiate between nuclear fission and nuclear fusion.

(b) Deuterium undergoes fusion as per the reaction: ${}^2_1\text{H} + {}^2_1\text{H} \rightarrow {}^3_2\text{He} + {}^1_0\text{n} + 3.27 \text{ MeV}$. Find the duration for which an electric bulb of 500 W can be kept glowing by the fusion of 100 g of deuterium.

5. (a) In Geiger-Marsden experiment, calculate the distance of closest approach for an alpha particle with energy $2.56 \times 10^{-12} \text{ J}$. Consider that the particle approaches the gold nucleus ($Z = 79$) in head-on position.

(b) If the above experiment is repeated with a proton of the same energy, then what will be the value of the distance of closest approach?

6. Answer the following, giving reason:

(a) The resistance of a p - n junction is low when it is forward biased and is high when it is reversed biased.

(b) Doping of intrinsic semiconductors is a necessity for making electronic devices.

(c) Photodiodes are operated in reverse bias.

7. (a) The interference pattern is not observed in Young's double slit experiment when the two sources S_1 and S_2 are far apart. Explain.

(b) Mention the conditions for the two sources to be coherent.

(c) What is the effect on the interference pattern in a Young's double slit experiment, if the source of wavelength λ is replaced by another source of wavelength 1.5λ , with the interference pattern still observable?

8. The wavelength of the waves associated with a particle having kinetic energy E is λ . How and by what factor should its kinetic energy be changed so that the wavelength becomes $\left(\frac{\lambda}{3}\right)$?

Also, find the ratio of the final to the initial velocity of the particle.

9(a). (i) Draw a labelled ray diagram showing the formation of the image at infinity by an astronomical telescope.

(ii) A telescope consists of an objective of focal length 150 cm and an eyepiece of focal length 6.0 cm. If the final image is formed at infinity, then calculate:

(I) the length of the tube in this adjustment, and

(II) the magnification produced.

OR

9(b). (i) Draw a labelled ray diagram showing the formation of the image at least distance of distinct vision by a compound microscope.

(ii) A small object is placed at a distance of 3.0 cm from a magnifier of focal length 4.0 cm. Find:

(I) the position of the image formed, and

(II) the linear magnification produced.

10(a). Identify electromagnetic waves which:

(i) are used in radar system.

(ii) affect a photographic plate.

(iii) are used in surgery.

Write their frequency range.

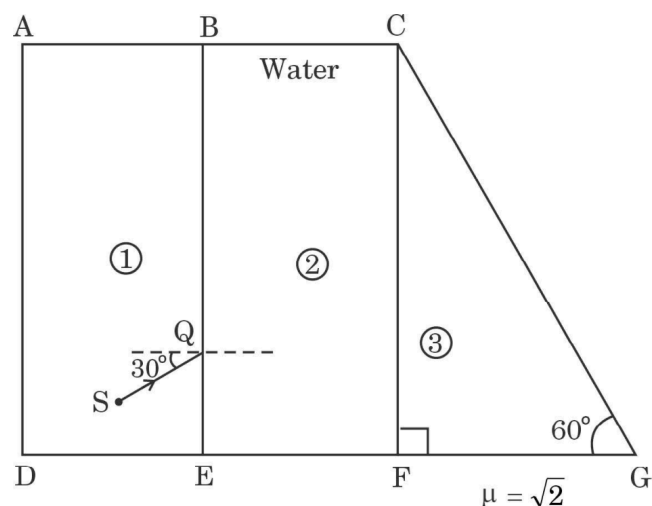
OR

10(b). A plane wavefront is propagating from a rarer into a denser medium. Use Huygens principle to show the refracted wavefront and verify Snell's law.

11. The figure shows a water column BCFE surrounded by two media (1) and (2) of the same refractive index $\sqrt{2}$. A ray of light from a point source S is incident on surface BE at an angle of 30° .

(a) Trace the path of the ray through media (1) and (2) as it emerges out of face CG.

(b) Find the angle of emergence at face CG.

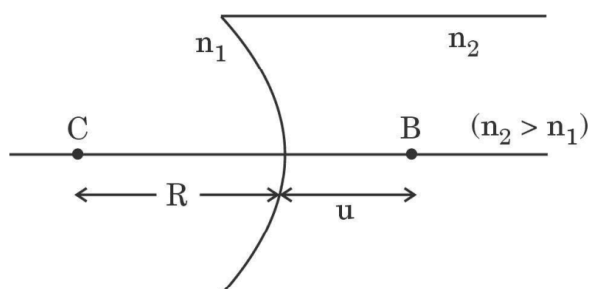


Section C

12. Two transparent media of refractive indices n_1 and n_2 are separated by a spherical transparent surface. The rays of light incident on the surface get refracted into the medium on the other side. The laws of refraction are valid at each point of the spherical surface. A lens is a transparent optical medium bounded by two surfaces, at least one of which should be spherical. The focal length of a lens is determined by the radii of curvature (R_1 and R_2) of its two surfaces and the refractive index (n) of the medium of the lens with respect to the surrounding medium. Depending on R_1 and R_2 , a lens behaves as a diverging or a converging lens. The ability of a lens to diverge or converge a beam of light incident on it defines its power.

(a) An object is placed at the point B as shown in the figure. The object distance (u) and the image distance (v) are related as:

- (i) $\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$
- (ii) $\frac{n_1}{v} - \frac{n_2}{u} = \frac{n_1 - n_2}{R}$
- (iii) $\frac{n_2}{u} - \frac{n_1}{v} = \frac{n_2 - n_1}{R}$
- (iv) $\frac{n_1}{u} - \frac{n_2}{v} = \frac{n_1 - n_2}{R}$



(b) A point object is placed in air at a distance R in front of a convex spherical refracting surface of radius of curvature R . If the medium on the other side of the surface is glass, then the image is:

- (i) real and formed in glass.
- (ii) real and formed in air.
- (iii) virtual and formed in glass.
- (iv) virtual and formed in air.

(c) An object is kept at $2F$ in front of an equiconvex lens. The image formed is:

12. (continued)

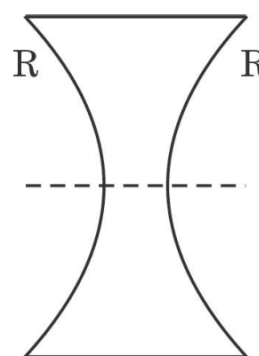
- (i) real and of the size of the object.
- (ii) virtual and of the size of the object.
- (iii) real and enlarged.
- (iv) virtual and diminished.

(d) A thin converging lens of focal length 10 cm and a thin diverging lens of focal length 20 cm are placed coaxially in contact. The power of the combination is:

- (i) -5 D
- (ii) $+5$ D
- (iii) $+15$ D
- (iv) -15 D

(e) An equiconcave lens of focal length f is cut into two identical parts along the dotted line as shown in the figure. The focal length of each part will be:

- (i) $\frac{f}{2}$
- (ii) $\frac{f}{4}$
- (iii) f
- (iv) $2f$



- End of Question Paper -