

## Question Paper

Conducted by the Central Board of Secondary Education (CBSE)



Time Allowed: 3 Hours

Maximum Marks: 70

### General Instructions

- (i) This edition contains **35 numbered questions**, including the subparts and alternatives supplied in the source.
- (ii) Original question numbering is retained. Answer the alternatives according to the OR labels and instructions within each question.
- (iii) The available questions follow the original Sections A, B, C, D, E.

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

|                                                                                |                                                                |
|--------------------------------------------------------------------------------|----------------------------------------------------------------|
| $c = 3 \times 10^8 \text{ m/s}$                                                | Mass of electron ( $m_e$ ) = $9.1 \times 10^{-31} \text{ kg}$  |
| $h = 6.63 \times 10^{-34} \text{ Js}$                                          | Mass of neutron = $1.675 \times 10^{-27} \text{ kg}$           |
| $e = 1.6 \times 10^{-19} \text{ C}$                                            | Mass of proton = $1.673 \times 10^{-27} \text{ kg}$            |
| $\mu_0 = 4\pi \times 10^{-7} \text{ T m A}^{-1}$                               | Avogadro's number = $6.023 \times 10^{23} \text{ per gm mole}$ |
| $\epsilon_0 = 8.854 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$ | Boltzmann constant = $1.38 \times 10^{-23} \text{ JK}^{-1}$    |
| $\frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \text{ N m}^2 \text{ C}^{-2}$        |                                                                |

## Section A

1. An electron experiences a force  $(1.6 \times 10^{-16} \text{ N}) \hat{i}$  in an electric field  $\vec{E}$ . The electric field  $\vec{E}$  is:

- (A)  $(1.0 \times 10^3 \text{ N/C}) \hat{i}$       (B)  $-(1.0 \times 10^3 \text{ N/C}) \hat{i}$   
 (C)  $(1.0 \times 10^{-3} \text{ N/C}) \hat{i}$       (D)  $-(1.0 \times 10^{-3} \text{ N/C}) \hat{i}$

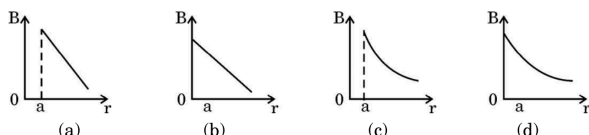
2. Which one of the following is not a scalar quantity?

- (A) Electric field      (B) Voltage  
 (C) Resistivity      (D) Power

3. The current density due to drift of electrons in a conductor is given by (symbols have their usual meanings):

- (A)  $neAv_d$       (B)  $\frac{neA}{v_d}$   
 (C)  $\frac{ne}{v_d}$       (D)  $nev_d$

4. Which of the following graphs correctly represents the variation of the magnitude of the magnetic field outside a straight infinite current-carrying wire of radius ' $a$ ', as a function of distance ' $r$ ' from the centre of the wire?



- (A) Graph (a)      (B) Graph (b)  
 (C) Graph (c)      (D) Graph (d)

5. A particle of mass  $m$  and charge  $q$  moving with a uniform velocity  $\vec{v} = v_{0x} \hat{i} + v_{0y} \hat{j}$  enters a region with a magnetic field  $\vec{B} = B_0 \hat{j}$ . After some time, an electric field  $\vec{E} = E_0 \hat{j}$  is also switched on in the region. The resulting path described by the particle will be:

- (A) a circle in  $x$ - $z$  plane      (B) a parabola in  $x$ - $y$  plane  
 (C) a helix with constant pitch      (D) a helix with increasing pitch

6. An inductor, a capacitor and a resistor are connected in series across an ac source of voltage. If the frequency of the source is decreased gradually, the reactance of:

- (A) both the inductor and the capacitor decreases.      (B) inductor decreases and the capacitor increases.  
 (C) both the inductor and the capacitor increases.      (D) inductor increases and the capacitor decreases.

7. The electromagnetic radiations used to kill germs in water purifiers are called:

- (A) Infrared waves      (B) X-rays  
 (C) Gamma rays      (D) Ultraviolet rays

8. In the wave picture of light, the intensity  $I$  of light is related to the amplitude  $A$  of the wave as:

- (A)  $I \propto \sqrt{A}$       (B)  $I \propto A$   
 (C)  $I \propto A^2$       (D)  $I \propto \frac{1}{A^2}$

9. In a single-slit diffraction experiment, the width of the slit is halved. The width of the central maximum, in the diffraction pattern, will become:

- (A) half      (B) twice  
 (C) four times      (D) one-fourth

10. A graph is plotted between the stopping potential (on  $y$ -axis) and the frequency of incident radiation (on  $x$ -axis) for a metal. The product of the slope of the straight line obtained and the magnitude of charge on an electron is equal to:

- (A)  $h$  (Planck's constant)      (B)  $\frac{h}{e}$   
 (C)  $he$       (D)  $\frac{e}{h}$

**11.** Light of frequency  $6.4 \times 10^{14}$  Hz is incident on a metal of work function 2.14 eV. The maximum kinetic energy of the emitted electrons is about:

- (A) 0.25 eV (B) 0.51 eV  
(C) 1.02 eV (D) 0.10 eV

**12.** The ratio of maximum frequency and minimum frequency of light emitted in Balmer series of hydrogen spectrum, in Bohr's model, is:

- (A)  $\frac{9}{5}$  (B)  $\frac{5}{9}$   
(C)  $\frac{16}{7}$  (D)  $\frac{7}{16}$

**13.** At a certain temperature in an intrinsic semiconductor, the electrons and holes concentration is  $1.5 \times 10^{16} \text{ m}^{-3}$ . When it is doped with a trivalent dopant, hole concentration increases to  $4.5 \times 10^{22} \text{ m}^{-3}$ . In the doped semiconductor, the concentration of electrons ( $n_e$ ) will be:

- (A)  $3 \times 10^9 \text{ m}^{-3}$  (B)  $5 \times 10^7 \text{ m}^{-3}$   
(C)  $5 \times 10^9 \text{ m}^{-3}$  (D)  $6.75 \times 10^{38} \text{ m}^{-3}$

**14.** If a p-n junction diode is reverse biased:

- (A) the potential barrier is lowered. (B) the potential barrier remains unaffected.  
(C) the potential barrier is raised. (D) the current is mainly due to majority carriers.

**15.** A voltage signal is described by:  $v = V_0$  for  $0 \leq t \leq \frac{T}{2}$  and  $v = 0$  for  $\frac{T}{2} \leq t \leq T$  for a cycle. Its rms value is:

- (A)  $\frac{V_0}{\sqrt{2}}$  (B)  $V_0$   
(C)  $\frac{V_0}{2}$  (D)  $\sqrt{2} V_0$

**16. Assertion (A):** The internal resistance of a cell is constant.

**Reason (R):** Ionic concentration of the electrolyte remains same during use of a cell.

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

**17. Assertion (A):** When radius of a circular loop carrying a steady current is doubled, its magnetic moment becomes four times.

**Reason (R):** The magnetic moment of a circular loop carrying a steady current is proportional to the area of the loop.

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

**18. Assertion (A):** The nucleus  $^{15}_7\text{X}$  is more stable than the nucleus  $^{17}_7\text{Y}$ .

**Reason (R):**  $^{17}_7\text{X}$  contains more number of protons.

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

## Section B

**19.** A wire of length  $l$  is in the form of a circular loop  $A$  of one turn. This loop is reshaped into loop  $B$  of three turns. Find the ratio of the magnetic fields at the centres of loop  $A$  and loop  $B$  for the same current through them.

**20.** What is meant by the term 'displacement current'? Briefly explain how this current is different from a conduction current.

**21.** (a) State Huygens' principle. How did Huygens explain the absence of the backwave?

OR

(b) Use Huygens' principle to show reflection/refraction of a plane wave by (i) concave mirror, and (ii) a convex lens.

**22.** The refractive indices of two media  $A$  and  $B$  are 2 and  $\sqrt{2}$  respectively. What is the critical angle for their interface?

**23.** (a) Draw a graph showing the variation of binding energy per nucleon as a function of mass number  $A$ . The binding energy per nucleon for heavy nuclei ( $A > 170$ ) decreases with the increase in mass number. Explain.

OR

(b) Using Bohr's postulates, obtain the expression for radius of  $n^{\text{th}}$  stable orbit in a hydrogen atom.

**24.** Explain the roles of diffusion current and drift current in the formation of the depletion layer in a p-n junction diode.

**25.** Explain the property of a p-n junction which makes it suitable for rectifying alternating voltages. Differentiate between a half-wave and a full-wave rectifier.

## Section C

26. A potential difference  $V$  is applied across a conductor of length  $l$  and uniform cross-section area  $A$ . How will the (i) electric field  $E$ , (ii) drift velocity  $v_d$ , and (iii) current density  $j$  be affected when (a)  $V$  is doubled and (b)  $l$  is halved (keeping other factors constant)?

27. What is meant by the term 'mutual inductance' of a pair of coils? Obtain an expression for the mutual inductance of two long coaxial solenoids, each of length  $l$  but having different number of turns  $N_1$  and  $N_2$  and radii  $r_1$  and  $r_2$  ( $r_2 > r_1$ ).

28. (a) An ac source  $V = V_m \sin \omega t$  is connected across an ideal capacitor. Derive the expression for the (i) current flowing in the circuit, and (ii) reactance of the capacitor. Plot a graph of current  $i$  versus  $\omega t$ .

OR

(b) A series combination of an inductor  $L$ , a capacitor  $C$  and a resistor  $R$  is connected across an ac source of voltage in a circuit. Obtain an expression for the average power consumed by the circuit. Find power factor for (i) purely inductive circuit, and (ii) purely resistive circuit.

29. Calculate the wavelength of de Broglie waves associated with a proton having  $\left(\frac{500}{1.673}\right)$  eV energy. How will the wavelength be affected for an alpha particle having the same energy?

30. (a) (i) Prove that the nuclear density is same for all nuclei.

(ii) Draw a plot of potential energy of a pair of nucleons as a function of their separation. Draw two inferences from this plot.

OR

(b) (i) Draw a graph to show the variation of the number of scattered particles detected ( $N$ ) in Geiger-Marsden experiment as a function of scattering angle ( $\theta$ ).

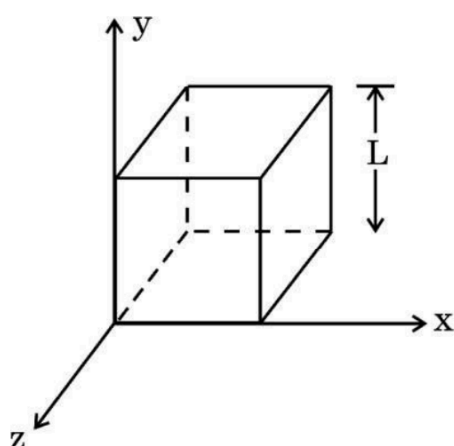
(ii) Discuss briefly two conclusions that can be drawn from this graph and how they lead to the discovery of nucleus in an atom.

## Section D

**31.** (a) (i) Define electric flux and write its SI unit.

(ii) Use Gauss' law to obtain the expression for the electric field due to a uniformly charged infinite plane sheet.

(iii) A cube of side  $L$  is kept in space, as shown in the figure. An electric field  $\vec{E} = (Ax + B)\hat{i}$  exists in the region. Find the net charge enclosed by the cube.



OR

(b) (i) Define electric potential at a point and write its SI unit.

(ii) Two capacitors are connected in series. Derive an expression of the equivalent capacitance of the combination.

(iii) Two point charges  $+q$  and  $-q$  are located at points  $(3a, 0)$  and  $(0, 4a)$  respectively in  $x$ - $y$  plane. A third charge  $Q$  is kept at the origin. Find the value of  $Q$ , in terms of  $q$  and  $a$ , so that the electrostatic potential energy of the system is zero.

**32.** (a) (i) Write the principle and explain the working of a moving coil galvanometer. A galvanometer as such cannot be used to measure the current in a circuit. Why?

(ii) Why is the magnetic field made radial in a moving coil galvanometer? How is it achieved?

OR

(b) (i) Derive an expression for magnetic field on the axis of a current-carrying circular loop.

(ii) Write any two points of difference between a diamagnetic and a paramagnetic substance.

**33.** (a) (i) Draw a ray diagram showing the formation of a real image of an object placed at a distance ' $u$ ' in front of a concave mirror of radius of curvature ' $R$ '. Hence, obtain the relation for the image distance ' $v$ ' in terms of  $u$  and  $R$ .

(ii) A 1.8 m tall person stands in front of a convex lens of focal length 1 m, at a distance of 5 m. Find the position and height of the image formed.

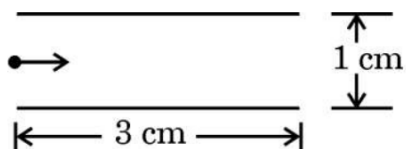
OR

(b) (i) Draw a ray diagram showing refraction of a ray of light through a triangular glass prism. Hence, obtain the relation for the refractive index ( $\mu$ ) in terms of angle of prism ( $A$ ) and angle of minimum deviation ( $\delta_m$ ).

(ii) The radii of curvature of the two surfaces of a concave lens are 20 cm each. Find the refractive index of the material of the lens if its power is  $-5.0$  D.

## Section E

34. A beam of electrons moving horizontally with a velocity of  $3 \times 10^7$  m/s enters a region between two plates as shown in the figure. A suitable potential difference is applied across the plates such that the electron beam just strikes the edge of the lower plate.



Answer the following questions based on the above:

- (a) How long does an electron take to strike the edge?
- (b) What is the shape of the path followed by the electron and why?
- (c) Find the potential difference applied.

OR

- (c) Find the magnitude and direction of the magnetic field which should be created in the space between the plates so that the electron beam goes straight undeviated.

35. Diffraction of light is bending of light around the corners of an object whose size is comparable with the wavelength of light. Diffraction actually defines the limits of ray optics. This limit for optical instruments is set by the wavelength of light. An experimental arrangement is set up to observe the diffraction pattern due to a single slit.

Answer the following questions based on the above:

- (a) How will the width of central maximum be affected if the wavelength of light is increased?
- (b) Under what condition is the first minimum obtained?
- (c) Write two points of difference between interference and diffraction patterns.

OR

- (c) Two students are separated by a 7 m partition wall in a room 10 m high. If both light and sound waves can bend around obstacles, how is it that the students are unable to see each other even though they can converse easily?

- End of Question Paper -