Roll No. ☐☐☐☐☐☐☐☐

Q.P. Code 55/1/1

PHYSICS (THEORY)

CBSE Class XII Board Examination 2024

Time allowed: 3 hours **Maximum Marks: 70**

General Instructions:

1. The paper has 33 questions in five sections (A to E); all of them must be answered.
2. Section A: Q1–16, multiple choice and Assertion-Reason, 1 mark each.
3. Section B: Q17–21, very short answer, 2 marks each.
4. Section C: Q22–28, short answer, 3 marks each.
5. Section D: Q29–30, case-study based, 4 marks each.
6. Section E: Q31–33, long answer, 5 marks each.
7. There is no overall choice, but some questions in Sections B to E offer an internal choice (OR). Calculators are not allowed.
8. Constants you may use: $c = 3 \times 10^{8}$ m/s, $h = 6.63 \times 10^{-34}$ J s, $e = 1.6 \times 10^{-19}$ C, $\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}, $\varepsilon_0 = 8.854 \times 10^{-12}$ C^2 N^{-1} m^{-2}, $1/(4\pi\varepsilon_0) = 9 \times 10^{9}$ N m^2 C^{-2}, $m_e = 9.1 \times 10^{-31}$ kg, $m_n = 1.675 \times 10^{-27}$ kg, $m_p = 1.673 \times 10^{-27}$ kg, Avogadro number = 6.023×10^{23} per gram mole, Boltzmann constant = 1.38×10^{-23} J K^{-1}.

SECTION A

Q1–16 carry 1 mark each (MCQ; Q13–16 are Assertion-Reason).

1. A thin plastic rod is bent into a circular ring of radius R and carries a uniform linear charge density λ. What is the magnitude of the electric field at the centre of the ring? **1**

(A) $\dfrac{\lambda}{2\varepsilon_0 R}$

(B) Zero

(C) $\dfrac{\lambda}{4\pi\varepsilon_0 R}$

(D) $\dfrac{\lambda}{4\varepsilon_0 R}$

---

2. Ten capacitors of 1 μF each are joined in parallel across a 100 V source. What is the total energy stored? **1**

(A) 10^{-2} J

(B) 10^{-3} J

(C) 0.5×10^{-3} J

(D) 5.0×10^{-2} J

---

3. Points A and B are joined by two parallel branches. The upper branch has a 12 V cell in series with a 1 Ω resistor; the lower branch has a 6 V cell in series with a 0.5 Ω resistor. Both cells have their like terminals on the same side (same orientation). What is the potential difference between A and B? **1**

(A) 6 V

(B) 8 V

(C) 9 V

(D) 12 V

---

4. A loop in the x–y plane carries current I in the clockwise sense and lies in a uniform magnetic field pointing along the z-axis. The loop will tend to: **1**

(A) move along the x-axis

(B) move along the y-axis

(C) shrink

(D) expand

---

5. A 10 cm wire lies along the y-axis and carries 1.0 A in the +y direction. The field in the region is $\vec{B} = (5\,\text{mT})\hat{j} - (8\,\text{mT})\hat{k}$. Find the force on the wire. **1**

(A) $(0.8\,\text{mN})\hat{i}$

(B) $-(0.8\,\text{mN})\hat{i}$

(C) $(80\,\text{mN})\hat{i}$

(D) $-(80\,\text{mN})\hat{i}$

---

6. A galvanometer of resistance G is converted into an ammeter of range 0 to I A. If only 0.1% of I passes through the galvanometer, the resistance of the ammeter is: **1**

(A) $\dfrac{G}{999}$

(B) $\dfrac{G}{1000}$

(C) $\dfrac{G}{1001}$

(D) $\dfrac{G}{100.1}$

---

7. A capacitor C on an ac source of frequency ν has reactance X. If C is doubled and ν is tripled, the new reactance is: **1**

(A) $\frac{X}{6}$ **(B)** 6X

(C) $\frac{2X}{3}$ **(D)** $\frac{3X}{2}$

8. The electric field in four regions is: Region I: $E_x = E_0 \sin(kz - \omega t)$; Region II: $E_x = E_0$; Region III: $E_x = E_0 \sin kz$; Region IV: $E_x = E_0 \cos kz$. In which region does a displacement current exist? **1**

(A) I **(B)** IV

(C) II **(D)** III

9. The second line of the Balmer series of hydrogen is produced by an electron transition: **1**

(A) $n_f = 2$ and $n_i = 3$ **(B)** $n_f = 3$ and $n_i = 4$

(C) $n_f = 2$ and $n_i = 4$ **(D)** $n_f = 2$ and $n_i = \infty$

10. Germanium is doped with arsenic. As a result of this doping: **1**

(A) the Ge lattice structure gets distorted

(B) the number of conduction electrons increases

(C) the number of holes increases

(D) the number of conduction electrons decreases

11. Photons of energy 3.3 eV (beam A) and 11.3 eV (beam B) fall one after the other on a metal of work function 2.3 eV. The ratio of the maximum speed of photoelectrons due to A to that due to B is: **1**

(A) 3 **(B)** 9

(C) 1/3 **(D)** 1/9

12. A moving electron and a moving proton have the same de Broglie wavelength λ. They must have the same: **1**

(A) momentum **(B)** angular momentum

(C) speed **(D)** energy

13. Assertion (A): In the photoelectric effect, the kinetic energy of emitted photoelectrons increases when the intensity of incident light is increased. **1**

Reason (R): The photoelectric current depends on the wavelength of the incident light.

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

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

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

(D) A is false and R is also false.

---

14. Assertion (A): Mutual inductance of two coils is greatest when one coil is wound over the other. **1**

Reason (R): Flux linkage between two coils is greatest when they are wound over each other.

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

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

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

(D) A is false and R is also false.

---

15. Assertion (A): Two long parallel wires hanging freely and connected in series with a battery move away from each other. **1**

Reason (R): Two wires carrying currents in opposite directions repel each other.

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

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

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

(D) A is false and R is also false.

---

16. Assertion (A): A plane mirror or a convex mirror can never form a real image. **1**

Reason (R): A virtual image cannot act as an object to form a real image.

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

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

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

(D) A is false and R is also false.

SECTION B

Q17–21 carry 2 marks each.

17. At what temperature will the resistance of a silver wire become double its resistance at 20 °C? Use 20 °C as reference temperature; temperature coefficient of resistance of silver at 20 °C = $4.0 \times 10^{-3}\ K^{-1}$. **2**

18. Monochromatic light of frequency 5.0×10^{14} Hz goes from air into a medium of refractive index 1.5. Find the wavelength of (i) the reflected light and (ii) the refracted light at the interface. **2**

OR

A plano-convex lens of focal length 16 cm is made of a material of refractive index 1.4. Find the radius of curvature of its curved surface.

19. An object stands 30 cm in front of a concave mirror whose radius of curvature is 40 cm. Find (i) where the image is formed and (ii) the magnification. **2**

20. A neutron of mass m has kinetic energy E, and a photon has the same energy E. If λ_n is the de Broglie wavelength of the neutron and λ_p the wavelength of the photon, find λ_n/λ_p. **2**

21. Draw the current–voltage graph for gallium arsenide (GaAs). Mark on it the region where (a) the resistance is negative and (b) Ohm's law is obeyed. **2**

SECTION C

Q22–28 carry 3 marks each.

22. A cube of side 0.1 m lies in a region where $\vec{E} = 500x\,\hat{i}$ N/C (x in metres). The cube's edges are parallel to the axes, and its left face lies in the plane x = 0.1 m (so the right face is at x = 0.2 m). Calculate (a) the net electric flux through the cube and (b) the charge inside it. **3**

23. Define current density and state whether it is a scalar or a vector. A field $\vec{E}$ is maintained in a metallic conductor having n electrons (mass m, charge −e) per unit volume with relaxation time τ. Show that the current density is $\vec{j} = \alpha\vec{E}$, where $\alpha = \dfrac{ne^2}{m}\tau$. **3**

OR

What is a Wheatstone bridge? Derive the condition for the bridge to be balanced.

24. A proton with kinetic energy 1.3384×10^{-14} J moves horizontally from north to south and enters a uniform 2.0 mT magnetic field pointing east. Find (a) its speed, (b) the magnitude of its acceleration and (c) the radius of its path. Take q/m for the proton = 1.0×10^{8} C/kg. **3**

25. A series LCR circuit is connected to an ac source v = v_m sin ωt. Derive the expression for the average power dissipated in the circuit. Also find the expression for its resonant frequency. **3**

26. (a) It is often said that the wavelength of an electromagnetic wave is related to the typical size of the system that emits it. Give two examples supporting this. **3**
(b) (i) Why do long-distance radio broadcasts use short-wave bands?
(ii) Why are optical and radio telescopes placed on the ground while X-ray astronomy needs satellites orbiting the Earth?

27. State the shortcomings of Rutherford's model of the atom. How did Bohr overcome them? Show that successive orbits in Bohr's atom are not equally spaced. **3**

28. (a) Write any two properties of a nucleus. **3**
(b) Why is the density of a nucleus far greater than that of an atom?
(c) Show that all nuclei have the same density of nuclear matter.

SECTION D

Q29–30 are case-study based, 4 marks each (four 1-mark MCQs; choice in part (iv)).

29. The focal length of a lens depends on the radii of curvature of its two faces and on the refractive index of its material relative to the surrounding medium. Power is 1/f, and powers of lenses in contact add algebraically. **4**

(i) A double-convex glass lens (refractive index n) has both faces of radius R. Its power is: (A) 2(n − 1)/R (B) (2n − 1)/R (C) (n − 1)/2R (D) (2n − 1)/2R

(ii) A double-convex lens of power P (equal radii) is cut into two equal halves by a plane perpendicular to its principal axis. Power of each half: (A) 2P (B) P (C) 4P (D) P/2

(iii) The two halves from (ii) are put back in contact with their flat faces touching (re-forming the original shape). Power of the combination: (A) P/2 (B) P (C) 2P (D) P/4

(iv) A double-convex lens of power P (equal radii) is cut along its principal axis into two halves, and the two halves are placed one behind the other on the same axis, in contact. Power of the combination: (A) Zero (B) P (C) 2P (D) P/2

OR

(iv) (b) Two convex lenses of focal lengths 60 cm and 20 cm are held coaxially in contact. The power of the combination is:

(A) 6.6 D **(B)** 15 D

(C) $\frac{1}{15}$ D **(D)** $\frac{1}{80}$ D

30. A p-n junction diode has low resistance when forward biased and very high resistance when reverse biased, so it conducts only in one direction. This lets it convert ac into dc (rectification): a half-wave rectifier uses only alternate half cycles, a full-wave rectifier uses both. **4**

(i) The rms value of the ac voltage fed to a full-wave rectifier is $V_0/\sqrt{2}$. The rms value of the rectified output is: (A) $V_0/\sqrt{2}$ (B) $V_0^2/\sqrt{2}$ (C) $2V_0/\sqrt{2}$ (D) $V_0/(2\sqrt{2})$

(ii) In a full-wave rectifier, current flows through each diode for: (A) the complete cycle of input (B) half cycle of input (C) less than half cycle of input (D) only the positive half cycle of input

(iii) In a full-wave rectifier: (A) both diodes are forward biased at the same time (B) both are reverse biased at the same time (C) one is forward biased while the other is reverse biased (D) both are forward biased in the first half cycle and reverse biased in the second

(iv) A 50 Hz alternating voltage is applied to a half-wave rectifier. The ripple frequency of the output is: (A) 100 Hz (B) 50 Hz (C) 25 Hz (D) 150 Hz

OR

(iv) A square-wave signal switching between +5 V and −5 V is applied to a circuit in which a

(b) p-n junction diode is in series with a load R_L (output taken across R_L; the diode conducts when the input is positive). The output across R_L is:

(A) Positive pulses of height 10 V (zero otherwise)

(B) Negative pulses of depth −10 V (zero otherwise)

(C) Negative pulses of depth −5 V (zero otherwise)

(D) Positive pulses of height +5 V (zero otherwise)

SECTION E

Q31–33 carry 5 marks each.

31. (i) Derive the potential energy of an electric dipole $\vec{p}$ in a uniform external field $\vec{E}$. When is this potential energy (1) maximum and (2) minimum? **5**

(ii) A dipole is formed by charges −1.0 pC at (0, 0) and +1.0 pC at (3 mm, 4 mm) in the x–y plane. A field $\vec{E} = (1000\ \mathrm{V/m})\,\hat{i}$ is switched on. Find the torque $\vec{\tau}$ on the dipole.

OR

(i) A dipole of moment $\vec{p} = p\,\hat{i}$, made of charges −q and +q separated by 2a, lies along the x-axis with its centre at the origin. Show that its potential at a point x on the axis (x ≫ a) is $V = \frac{1}{4\pi\varepsilon_0}\frac{\vec{p}\cdot\hat{i}}{x^2}$.

(ii) Two isolated metal spheres S_1 and S_2 of radii 1 cm and 3 cm carry the same surface charge density $\left(\frac{2}{\pi} \times 10^{-9}\right)$ C/m². They are far apart and are then joined by a thin wire. Find the new charge on S_1.

---

32. (i) A resistor R and a capacitor C are in series with an ac source v = v_m sin ωt. Derive the impedance of the circuit. **5**

(ii) When does an inductor behave like a plain conductor in a circuit? Give the reason.

(iii) An electric lamp is rated for 110 V dc and 11 A. It is to be run on a 220 V, 50 Hz ac supply by putting a coil in series. Find the inductance of the coil.

OR

(i) Draw a labelled diagram of a step-up transformer and explain its working principle. Explain any three reasons for energy loss in a real transformer.

(ii) A step-up transformer changes a low voltage into a high voltage. Does this go against the law of conservation of energy? Explain.

(iii) A step-up transformer has 200 turns in the primary and 3000 in the secondary. The primary input is 90 V. Find (1) the secondary output voltage and (2) the primary current if the secondary current is 2.0 A.

---

33. (i) A light ray passes through a triangular prism. Sketch how the angle of deviation varies with the angle of incidence and hence define the angle of minimum deviation. **5**

(ii) A ray falls normally on one refracting face of a prism of angle A and is deviated by angle δ. Prove that the refractive index is $n = \dfrac{\sin(A+\delta)}{\sin A}$.

(iii) A prism of refracting angle 60° has refractive index √2. Find (1) the angle of minimum deviation and (2) the corresponding angle of incidence.

OR

(i) State Huygens' principle. A plane wavefront strikes a reflecting surface at angle i. Construct the reflected wavefront and use it to prove that the angle of reflection equals the angle of incidence.

(ii) What are coherent sources of light? Can two independent sodium lamps behave as coherent sources? Explain.

(iii) Light containing a known wavelength 520 nm and an unknown wavelength λ is used in Young's double-slit experiment. The 4th bright fringe of λ falls exactly on the 5th bright fringe of 520 nm. Find λ.

— END —

Questions restated from the CBSE Class XII Board Examination 2024 (set 55/1/1) for practice. Reading passages and map items are described, not reproduced.