Roll No. ☐☐☐☐☐☐☐☐

Q.P. Code 55/4/1

PHYSICS (THEORY)

CBSE Class XII Board Examination 2025

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 body is given a charge of 8.0×10^{-12} C. What happens to its mass? **1**

(A) It increases by 4.5×10^{-7} kg **(B)** It decreases by 1.0×10^{-6} kg

(C) It decreases by 4.55×10^{-23} kg **(D)** It increases by 9.1×10^{-23} kg

2. Current flows along a cylindrical conductor of radius R. The current density at distance r from the axis is $j = \alpha r$ (directed along the axis), α being a constant. The current through the part of the cross-section from $r = 0$ to $r = R/2$ is proportional to: **1**

(A) R **(B)** R^2

(C) R^3 **(D)** R^4

3. Figure: a uniform magnetic field B points into the page (−Z direction) and fills only the region above the X-axis ($y > 0$). A particle of charge +q, initially just below the X-axis on the positive x side, moves with velocity v along +Y and enters the field region. The particle will describe: **1**

(A) a circular path in the XZ plane

(B) a semicircular path in the XY plane

(C) a helical path with its axis parallel to the Y-axis

(D) a semicircular path in the YZ plane

4. A bar magnet is placed perpendicular to a uniform magnetic field. It is then turned until the torque on it falls to half its starting value. Through what angle has it been turned? **1**

(A) 30° **(B)** 45°

(C) 60° **(D)** 75°

5. Which one of these materials is NOT paramagnetic? **1**

(A) Aluminium **(B)** Sodium chloride

(C) Calcium **(D)** Copper chloride

6. An ammeter in series in an AC circuit shows 10 A. The peak (maximum instantaneous) current in the circuit is: **1**

(A) $10\sqrt{2}$ A **(B)** $10/\sqrt{2}$ A

(C) $10/\pi$ A **(D)** $10/(\sqrt{2}\,\pi)$ A

7. In free space, an electromagnetic wave has an electric-field amplitude of 1000 V m^{-1}. What is the amplitude of its magnetic field? **1**

(A) 3.0×10^{-3} T **(B)** 3.33×10^{-8} T

(C) 3.0×10^{11} T **(D)** 3.33×10^{-6} T

8. A spherical mirror gives a magnification of −2.0. Which mirror is it and what kind of image does it form? **1**

(A) Convex, virtual image
(B) Concave, real image
(C) Concave, virtual image
(D) Convex, real image

9. Pick the correct statement: **1**

(A) Light photons show diffraction but electrons do not.
(B) Electrons possess momentum but photons do not.
(C) Both light photons and electrons show dual (wave–particle) nature.
(D) Not all electromagnetic radiations consist of photons.

10. A red light beam and a blue light beam have the same intensity. Which statement is correct? **1**

(A) The blue beam contains more photons than the red beam.
(B) The red beam contains more photons than the blue beam.
(C) Red light has a shorter wavelength than blue light.
(D) Each photon of blue light has less energy than a photon of red light.

11. Which of these conducts electricity at room temperature? **1**

(A) Sn
(B) Mica
(C) Si
(D) C

12. A long straight vertical wire carries a steady current upwards. The magnetic field lines around it are: **1**

(A) horizontal straight lines pointing radially outward from the wire
(B) straight lines parallel to the wire
(C) concentric horizontal circles around the wire
(D) coaxial helices around the wire

13. Assertion (A): An n-type semiconductor is electrically neutral, not negatively charged. **1**
Reason (R): A neutral pentavalent impurity atom added to the neutral intrinsic crystal gives its fifth electron to the lattice and itself becomes a positive donor ion.

(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) Both A and R are false.

14. Assertion (A): At resonance, a series LCR circuit acts like a purely resistive circuit. **1**
Reason (R): At resonance X_L = X_C, which gives $\omega = \frac{1}{\sqrt{LC}}$.

(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) Both A and R are false.

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15. Assertion (A): In a double-slit experiment, if one slit is covered, the single-slit diffraction pattern of the other slit is seen on the screen. **1**
Reason (R): Interference needs at least two separate waves.

(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) Both A and R are false.

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16. Assertion (A): With monochromatic light falling on a given metal, the photoelectrons come out with speeds ranging from zero up to a certain maximum. **1**
Reason (R): Every metal has a definite work function.

(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) Both A and R are false.

SECTION B

Q17–21 carry 2 marks each.

17. Three identical bulbs P, Q and S are connected to a battery. Bulb S is in series with the battery; the other end of S goes to a junction from which two parallel branches lead back to the battery: one branch has bulb Q, the other has a key K in series with bulb P. **2**

(i) With K closed, compare the brightness of P and Q with that of S.

(ii) With K open, compare the brightness of S and Q.

Give reasons in both cases.

OR

Two cells of emf 10 V each (negligible internal resistance) are stacked one above the other on the left side of a circuit, joined in series in the same sense. A bulb B of resistance 10 Ω connects the junction between the two cells to a junction on the right side. On the right, a 20 Ω resistor goes up from this junction to the top wire, and a 10 Ω resistor goes down from it to the bottom wire; the top wire connects to the free end of the upper cell and the bottom wire to the free end of the lower cell. Find the current through the bulb.

18. In single-slit diffraction with slit width 0.55 mm and light of wavelength 550 nm, find the angle of diffraction (in degrees) of the first secondary maximum. **2**

19. An equiconvex glass lens (refractive index 1.55) has a focal length of 15.0 cm. Find the radius of curvature of each surface. **2**

20. Find the mass of an α-particle in atomic mass units, given: mass of a neutral helium atom = 4.002603 u, mass of a carbon-12 atom = 1.9926×10^{-26} kg (take $m_e = 9.1 \times 10^{-31}$ kg). **2**

21. An intrinsic semiconductor has carrier concentration $5 \times 10^{8}\ m^{-3}$. After doping, the hole concentration becomes $8 \times 10^{12}\ m^{-3}$. **2**

(a) Name (i) the kind of dopant used and (ii) the type of extrinsic semiconductor obtained.

(b) Find the electron concentration in the doped semiconductor.

SECTION C

Q22–28 carry 3 marks each.

22. (i) Derive an expression for the resistivity of a conductor in terms of the number density of free electrons and their relaxation time. **3**

(ii) A current–time graph for a wire shows: a constant current of 2.0 A from t = 1 s to t = 2 s (charge Q_1), and a current rising linearly from 0 at t = 4 s to 1.5 A at t = 6 s, then dropping to zero (charge Q_2). Compare Q_1 and Q_2.

OR

(i) A battery of emf E and internal resistance r is connected to a variable external resistance R.

(I) Find the current I in the circuit and the largest current the battery can give.

(II) Find the terminal voltage V and its largest possible value.

(ii) The same battery gives current I_1 when $R = R_1$ and current I_2 when $R = R_2$. Express r in terms of I_1, I_2, R_1 and R_2.

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23. (a) State the Biot–Savart law in vector form. **3**

(b) Two long, insulated straight wires each carry 2.0 A: one lies along the x-axis (current towards +x) and the other along the y-axis (current towards +y). Find the magnitude and direction of the net magnetic field at P (4 m, 5 m).

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24. Two coils are placed side by side. Coil 2 is joined in series with a battery and a rheostat R_2 (ends M, N); coil 1 is joined to a resistor R_1 (ends O, P). The current in coil 2 is such that its face towards coil 1 acts as a south pole. Find the direction of the induced current in coil 1 (as seen from the side of coil 2) and justify, when: **3**

(a) coil 2 is moved towards coil 1;

(b) coil 2 is moved away from coil 1;

(c) both coils are kept fixed and the resistance R_2 is increased.

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25. (a) Give any three properties of electromagnetic waves. **3**

(b) Briefly explain how and where a displacement current exists while a capacitor is being charged.

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26. A double-slit set-up kept inside a tank of water gives an interference pattern with laser light. The water is then replaced by a transparent liquid of refractive index n greater than that of water. What happens to: **3**

(a) the speed, frequency and wavelength of the laser light;

(b) the fringe width, the shape of the fringes and the position of the central maximum?

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27. Using Einstein's photoelectric equation, explain: **3**

(a) why no photoemission occurs when the incident frequency is below a certain minimum value;

(b) why the maximum kinetic energy of photoelectrons depends on the frequency and not on the intensity of the light;

(c) why the graph of cut-off voltage V_0 against frequency ν is a straight line of slope h/e.

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28. (a) Name the majority and minority charge carriers in p-type and in n-type semiconductors. **3**

(b) Briefly explain how diffusion current and drift current arise in a p-n junction.

SECTION D

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

29. three large, equally spaced, parallel square metal plates P_1, P_2, P_3 (side L, gap d between neighbours) have both gaps fully filled with mica of dielectric constant K. The middle plate P_2 is joined to point A; the outer plates P_1 and P_3 are joined to point B. A is at potential V above B. **4**

(i) Capacitance between A and B: (A) $\varepsilon_0 KL^2/d$ (B) $\varepsilon_0 KL^2/(2d)$ (C) $2\varepsilon_0 KL^2/d$ (D) $2\varepsilon_0 Kd/L^2$

(ii) Magnitude of charge on plate P_1: (A) $\varepsilon_0 VKL^2/(2d)$ (B) $\varepsilon_0 VKL^2/d$ (C) $2\varepsilon_0 VKL^2/d$ (D) $\varepsilon_0 VKL^2/(4d)$

(iii) Electric field between P_1 and P_2: (A) V/d (B) 2V/d (C) V/(2d) (D) d/V

(iv) Separation of an air-filled parallel-plate capacitor with the same plate area L^2 and the same capacitance as this system: (A) d/K (B) 2d/K (C) d/(2K) (D) d/(4K)

OR

(iv) (b) The supply connected between A and B is removed, and A and B are then joined by a conducting wire. The net charge on the whole system becomes:

(A) $\varepsilon_0 VKL^2/(4d)$ **(B)** $\varepsilon_0 VKL^2/(2d)$

(C) $\varepsilon_0 VKL^2/d$ **(D)** Zero

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30. in Bohr's model of hydrogen, an electron (mass m, charge −e) revolves round the proton in a circular orbit of radius r with speed v; the Coulomb attraction provides the centripetal force, angular momentum is quantised in units of $h/2\pi$, and a photon is emitted when the electron drops to a lower level. Take $K = 1/(4\pi\varepsilon_0)$. **4**

(i) The speed v in terms of r and K: (A) $Ke^2/(mr)$ (B) $Ke^2/(mr^2)$ (C) $\sqrt{(Ke^2/(mr))}$ (D) $\sqrt{(Ke^2/(mr^2))}$

(ii) Total energy of the atom: (A) Ke^2/r (B) $-Ke^2/(2r)$ (C) $Ke^2/(2r)$ (D) $(3/2)Ke^2/r$

(iii) A 500 nm photon is emitted in a transition. The change in total energy and the change in kinetic energy of the electron (in eV) are, respectively: (A) 2.48, −2.48 (B) −1.24, 1.24 (C) −2.48, 2.48 (D) 1.24, −1.24

(iv) The frequency of revolution of the electron in the nth orbit is proportional to: (A) n (B) 1/n (C) $1/n^2$ (D) $1/n^3$

OR

(iv) (b) An electron in a hydrogen atom jumps from the −3.4 eV level to the ground state. By how much does its orbit radius change? (Ground-state radius = 0.53 Å)

(A) 0.53 Å **(B)** 1.06 Å

(C) 1.59 Å **(D)** 2.12 Å

SECTION E

Q31–33 carry 5 marks each.

31. (i) Charges +q and −q are placed at (a, 0) and (−a, 0) in the x-y plane. Find the net electric field at the point (0, y). Hence find the field at a distant point ($y \gg a$). **5**

(ii) Charges −2 nC, −1 nC and +5 nC sit at the corners A, B and C of an equilateral triangle of side 0.2 m. They are moved: A to A_1, B to B_1 and C to C_1, where A_1, B_1 and C_1 are the midpoints of AB, BC and CA. Find the total work done.

OR

(i) Show that Gauss's theorem agrees with Coulomb's law. Using Gauss's theorem, find the electric field of a uniformly charged thin spherical shell of radius r at a point at distance y from its centre when (I) $y > r$ and (II) $y < r$.

(ii) A charge of +2 nC is at the origin. What charge (sign and size) must be placed at (0, 0, −6 m) so that the potential at (0, 0, 2 m) is zero?

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32. (i) State Lenz's law and explain why it follows from conservation of energy. **5**

(ii) A square loop of side l/2 lies outside a region of uniform magnetic field B (directed into the page). The field region is a strip of width l, and the loop's front edge is initially a distance l from the strip. The loop is moved to the right with constant velocity v until it has completely left the field.

(I) What is the direction of the induced current as the loop enters the field and as it leaves?

(II) Sketch the magnetic flux φ through the loop versus time t and the induced emf E versus t, marking the important values.

OR

(i) Distinguish between the peak value and the rms value of an alternating current and give the relation between them.

(ii) An element X is connected to an AC source $V = V_0 \sin 2\pi\nu t$ and the voltage is found to lead the current by π/2. When X is replaced by element Y, the voltage lags the current by π/2.

(I) Identify X and Y with the help of phasor diagrams.

(II) If X and Y are connected in series to the source, find the resonance condition and the resonant frequency. What is the impedance then?

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33. (i) An object is 30 cm from a thin convex lens of focal length 10 cm, and a sharp image is formed on a screen. A thin concave lens is now put in contact with the convex lens, and the screen must be moved 45 cm further to get a sharp image again. Find the focal length of the concave lens. **5**

(ii) An equilateral prism has refractive index $\sqrt{3}$. Find its angle of minimum deviation and the angle of incidence in this position.

OR

(i) A teacher demonstrates Young's double-slit interference using a 633 nm laser. The pattern is formed on a wall 5.0 m from the slits, and a fringe width of 5 mm is wanted for comfortable viewing.

(I) What slit separation is needed?

(II) How far from the central maximum is the first minimum?

(ii) Parallel light of wavelength 650 nm falls on a slit 0.6 mm wide, and the diffraction pattern is seen on a screen 60 cm away. Find the distance between the first minima on the two sides of the central maximum.

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Questions restated from the CBSE Class XII Board Examination 2025 (set 55/4/1) for practice. Reading passages and map items are described, not reproduced.