

PHYSICS

(Paper II)

Time Allowed : Three Hours
Maximum Marks : 300

QUESTION PAPER SPECIFIC INSTRUCTIONS

(Please read each of the following instructions carefully before attempting questions)

There are EIGHT questions divided in two Sections.

Candidate has to attempt FIVE questions in all.

Question Nos. 1 and 5 are compulsory and out of the remaining, any THREE are to be attempted choosing at least ONE question from each Section.

The number of marks carried by a question/part is indicated against it.

Wherever any assumptions are made for answering a question, they must be clearly indicated.

Word limit in questions, wherever specified, should be adhered to.

SECTION 'A'

1. Answer any THREE of the following:
 - (a) Current is flowing in a single-turn circular coil of radius 0.1 m such that at a point 5mm from the centre of the coil on the axis perpendicular to the plane of the coil the magnetic field is 0.1 mT. Find the current in the coil. Hence calculate the magnetic moment of the current carrying coil. 20
 - (b) For an R-L- C series resonant circuit, show that $f_0 = \sqrt{f_1 f_2}$, where f_0 is the resonance frequency and f_1 , and f_2 are the half-power frequencies. Is this relation true for a parallel resonance circuit in which R, L and C are connected in parallel to each other? Explain. 20
 - (c) What are the salient characteristics of ferromagnetic? Explain how the Curie law of paramagnetism is modified to the Curie - Weiss law. 20
 - (d) A circuit of a NOT gate is given in the figure below. Explain how you will determine the values of the resistances R_B , R and R_L .
 [Figure: Single-transistor (nnp, common-emitter) NOT gate. Input v_{in} : a rectangular pulse of height 5 V applied between ground (o) and the input terminal; input connected through series resistor R_B to the base. From the base node a resistor R goes down to a -5 V supply. Collector connected through load resistor R_L to the +5 V supply; output v_o taken from the collector. Emitter (arrow outward) connected to ground.] 20
2. A series R-L circuit has a constant d.c. voltage V applied at the time $t = 0$ by closing a switch.
 - (a) Derive an expression for the current in the circuit. 15
 - (b) Calculate the voltage drops across R and across L. 10
 - (c) At what time are these voltage drops equal? 10
 - (d) Find the power dissipated by R and power stored in L. 10
 - (e) Show that the steady-state energy is stored in the magnetic field. 15
3.
 - (a) The introduction of the displacement current is one of the major contributions of Maxwell. Discuss. 10
 - (b) Using Maxwell's equations, derive the electromagnetic wave equations for a conducting medium and solve it. 40
 - (c) What is the limiting case of a metallic conductor in the above case? Explain. 10
4.
 - (a) Discuss the different breakdown mechanisms for a reverse biased Zener diode. 20
 - (b) Do these mechanisms have different temperature coefficients? Explain. 10

- (c) Which one of these mechanisms shows a negative dynamic resistance? Why? 10
- (d) A Zener diode of 1 W power has a dynamic resistance of 10 mΩ at the breakdown voltage of 3V. What will be the fluctuations in the current through the diode if the voltage fluctuates by 100 mV? What will happen to the diode? Why? 20

SECTION 'B'

5. Answer any THREE of the following:
- (a) A μ (of mass 207 m) is in the ground state of a muonic atom whose nucleus is Pb ($Z = 82$, $A = 204$, and radius = 7 fm). Calculate the first Bohr radius in units of the nuclear radius and the Rydberg constant in units of the Rydberg constant of the hydrogen atom. Comment on your results. 20
- (b) X-ray photons of wavelength 2.0 pm are incident on free electrons. They are scattered at an angle of 60° from the incident direction. Determine the following: (i) Momentum of the incident photon in keV/c (ii) Compton shift (iii) Kinetic energy and recoil angle of the electron 20
- (c) The momentum of an electron is 600 keV/c. Determine its de Broglie wavelength and the phase and group velocities of its de Broglie waves. 20
- (d) Which of the following reactions are allowed? What are the conservation laws violated by the rest? Classify the particles (fermions / bosons, mesons / baryons, leptons/ hadrons) involved and the type of interactions in the case of the allowed ones. (i) $\Sigma^0 \rightarrow \pi^+ + \pi^-$ (ii) $\pi^- + p \rightarrow n + \pi^0$ (iii) $\pi^+ + p \rightarrow \pi^+ + p + \pi^- + \pi^0$ (iv) $\pi^0 \rightarrow \gamma + \gamma$ 20
6. (a) A 500 μ A beam of electrons of kinetic energy 1.5 eV [?] enter a region with a sharply defined boundary in which their energy is reduced to 10eV by a difference of potential. Determine the reflected and transmitted currents. Derive the formulae used. 40
- (b) Determine the eigenvalues and eigenfunctions of the operators $D + 137$, $D^2 - 2xD + 4$, where $D \equiv d/dx$. Assume the eigenfunction of the second operator to be a quadratic. 20
7. (a) Using the uncertainty principle, show that the electrons cannot exist inside the nucleus. How does then one account for the beta decay of a nucleus? 10
- (b) How do you explain the continuous spectrum in beta decay of radioactive nuclei? 25
- (c) A nuclear reactor has an output power of 1 MW with a thermal efficiency of 30%. How much uranium per day is consumed to run this reactor, if the average energy released per fission of ^{235}U is 200 MeV, and the uranium is enriched to 2% ^{235}U ? 25
8. (a) Describe the Stern-Gerlach experiment and discuss its significance. 20
- (b) Determine all the term [?] symbols of p^2 equivalent electrons and arrange these states in increasing order of energy. Justify your answer. 20
- (c) Explain why superconductors are perfect diamagnets. 20