

PHYSICS

(Paper II)

Time Allowed : Three Hours
Maximum Marks : 250

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.

Attempts of questions shall be counted in sequential order. Unless struck off, attempt of a question shall be counted even if attempted partly. Any page or portion of the page left blank in the Question-cum-Answer Booklet must be clearly struck off.

SECTION 'A'

1. (a) Find the deBroglie wave length of (i) a neutron and (ii) an electron moving with a kinetic energy of 500 eV. (1 eV = 1.602×10^{-19} J) 10
- (b) The mean life time of Λ^0 particle is 2.6×10^{-10} s. What will be the uncertainty in the determination of its mass in eV? 10
- (c) If $\hat{x}$ and $\hat{p}$ are the position and momentum operators, prove the commutation relation $[\hat{p}^2, \hat{x}] = -2i\hbar\hat{p}$. 10
- (d) Given that the spacing between vibrational levels of CO molecules is 8.45×10^{-2} eV of energy. Find the force constant of the molecule. 10
- (e) Write down Pauli spin matrices. Express J_x , J_y and J_z in terms of Pauli spin matrices. 10
2. (a) Using the commutation relations

$$[x, p_x] = [y, p_y] = [z, p_z] = i\hbar,$$
 deduce the commutation relation between the components of angular momentum operator L.

$$[L_x, L_y] = i\hbar L_z$$

$$[L_y, L_z] = i\hbar L_x$$
 and

$$[L_z, L_x] = i\hbar L_y.$$
20
- (b) Obtain the time-dependent Schrödinger equation for a particle. Hence deduce the time-independent Schrödinger equation. 20
- (c) A sample of a certain element is placed in a magnetic field of flux density 0.3 tesla. How far apart is the Zeeman component of a spectral line of wavelength 4500 Å? Given: $e/m = 1.76 \times 10^{11}$ C/kg, $c = 3.0 \times 10^8$ ms⁻¹. 10
3. (a) Solve the Schrödinger equation for a particle of mass m confined in a one-dimensional potential well of the form:

$$V=0, \text{ when } 0 \leq x \leq L$$

$$=\infty, \text{ when } x < 0, x > L$$
 Obtain the discrete energy values and the normalized eigen functions. 20

- (b) Discuss the vibrational spectra of a diatomic molecule treating it as an anharmonic oscillator. 10
- (c) An electron is moving in a one dimensional box of infinite height and width 1 Å. Find the minimum energy of electron. 10
4. (a) Obtain an expression for the normal Zeeman shift. Illustrate the Zeeman splitting of spectral lines of H atom and the allowed transitions for the $l=1$ and $l=2$ states. 20
- (b) Explain how the nuclear spin I depends on the mass number A and atomic number Z of atoms. 10
- (c)(i) Obtain an expression for the resonance condition in NMR. 10
- (c)(ii) Explain the relaxation processes in NMR spectroscopy. 10

SECTION 'B'

5. (a) Explain why stable light nuclei have equal number of protons and neutrons whereas heavy nuclei have excess of neutron. 10
- (b) It is possible to estimate the nuclear radius from the study of alpha decay? Explain how. 10
- (c) The velocity of sound in f.c.c. gold and f.c.c. copper is 2100 m/s and 3800 m/s respectively. If the Debye temperature of copper is 348 K, then determine the Debye temperature of gold. Take the densities of gold and copper as $1.93 \times 10^4 \text{ kg/m}^3$ and $0.89 \times 10^4 \text{ kg/m}^3$ respectively. 10
- (d) How does the energy gap in superconductors differ from the energy gap in insulator? How does it vary with temperature for superconductors? 10
- (e) In a cubic unit cell, find the angle between normals to the plane (111) and (121). 10
6. (a) Explain the working of SEM and TEM and highlight the major differences in principles. Draw neat schematic diagrams. 20
- (b) Give the basic structure of n-channel depletion type MOSFET. Draw the drain current-drain voltage characteristics both in depletion as well as enhancement modes. 20
- (c) How are elementary particles classified on the basis of their participation in fundamental interaction? 10
7. (a)(i) What are salient features of nuclear forces? 10
- (a)(ii) Discuss Yukawa's theory of nuclear forces. 10
- (b)(i) How does liquid drop model explain fission? 10
- (b)(ii) What are the limitations of shell model? 10
- (c) Lead in the superconducting state has critical temperature of 6.2 K at zero magnetic field and a critical field of 0.064 MA m^{-1} at 0 K. Determine the critical field at 4 K. 10
8. (a) What is the reciprocal lattice and why is it named so? Derive the relationships for the primitive translation vectors of the reciprocal lattice in terms of those of the direct lattice. 20
- (b) What are the magic numbers in nuclei? List the experimental evidences indicating their existence. 20
- (c) An electric field of 100 V/m is applied to a sample of n-type semiconductor whose Hall coefficient is $-0.0125 \text{ m}^3/\text{coulomb}$. Determine the current density in the sample assuming $\mu_x = 0.36 \text{ m}^2 \text{ v}^{-1} \text{ s}^{-1}$. 10