

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.

All questions carry equal marks.

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) Determine the energy of attraction between an electric dipole and a plane conducting surface at zero potential.
 - (b) A potential difference with a frequency of 50 cycles per second is applied to a coil of resistance 1 k ohms and inductance 2H. Calculate the power factor of the circuits.
 - (c) Distinguish qualitatively between dia-, para-, ferro-, antiferro- and ferrimagnetism. How is the weak and temperature independence paramagnetism of metals explain?
 - (d) If E_0 is the peak value of the input voltage V_{in} , calculate the output voltage V_{out} .
 [Figure: Diode-capacitor voltage-multiplier ladder. An a.c. source V_{in} on the left. From its top terminal the upper line runs through capacitor C_1 to a node, then on to a second node, then through a second series capacitor (label printed as C_3 , marked "Out") to a third node and on to the far right. The lower line runs from the bottom of the source to a node, then through capacitor C_2 to a second node, on to a third node, then through capacitor C_4 to the far right. Four diodes are connected as rungs between the upper and lower lines: D_1 from the node after C_1 down to the left end of C_2 ; D_2 from the second upper node down to the node after C_2 ; D_3 from the node after the upper C_3 down to the left end of C_4 ; D_4 at the far right end joining the end of the upper line to the right end of C_4 . D_1 and D_3 are drawn alike and D_2 and D_4 alike, with alternating orientation (exact diode directions not clearly legible in the source). V_{out} is marked by a dimension arrow along the bottom spanning from the left end (source) to the right end of the ladder.]
2.
 - (a) Derive the wave equations for **E** and **B** and solve one of these for plane wave propagation in an unbounded, homogenous dielectric medium. Further show that in a plane wave (**E,B,K**) form a mutually orthogonal right-handed system.
 - (b) A travelling electromagnetic wave is described by the equation.

$$E_x(z,t) = 0.5 \cos(20t - 2z)$$
 Determine: (i) Speed of the wave, v (ii) Wavelength, λ (iii) Time period, T (iv) Direction of propagation
3.
 - (a) Define quality factor for an A.C. circuit and discuss the meaning of electrical resonance in a series LCR circuit. Explain the term sharpness of resonance.
 - (b) Two coils are connected in series and their total self inductance is 4.40 mH. When one coil is reversed, the total self-inductance is 1.60 mH. All the flux due to the first coil links the second coil, but only 40% of the flux due to the second coil links the first coil. Find the self-inductance of each of the coils and their mutual inductance.
4.
 - (a) Explain the working N-P-N transistor. Derive expression for the current and voltage gains.
 - (b) Simplify the following logic function and draw the corresponding logic diagram:-

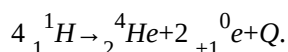
$$Y=(A+B).(A+C).(B+C)$$

- (c) What is the photovoltaic mode of operation for a photo-diode? Describe the construction and working of a silicon solar cell.

SECTION 'B'

5. Answer any THREE of the following:

- (a) Derive an expression for the Compton shift ($\Delta\lambda$) and show that it is independent of the wavelength of incident radiation. Establish parallelism between Compton and Raman scattering
- (b) A deuteron of kinetic energy 40 keV is describing a circular orbit of radius 0.6 m in a plane perpendicular to a magnetic induction **B**. Calculate the kinetic energy of a proton that describes a circular trajectory of radius 0.8 m in the same plane with the same **B**.
- (c) What is the basis of thermonuclear fusion? Estimate the order of temperatures required for promoting the fusion reaction of lighter nuclei. Calculate the Q-value of the proton-proton cycle.



- (d) In nature, we have basically four kinds of forces in the following order of increasing interaction strength: (i) Gravitational (ii) Weak (iii) electromagnetic (iv) Nuclear or strong. Comment on their spatial dependence and give their strength in terms of dimensionless coupling constants.

6. An infinite well potential is

$$V(x) = \begin{cases} 0, & -a/2 < x < a/2 \\ \infty, & x < -a/2, x > a/2 \end{cases}$$

Solve the time independent Schrodinger equation and find the closed form expressions for the eigenvalues and eigenfunction of potential. Give a schematic representation of the first three energy levels and corresponding wave functions and probability distribution functions. Show that the zero-point energy is in accord with the uncertainty principle.

7. (a) Describe the broad features of characteristic X-rays spectra and discuss how these have been accounted for
- (b) Explain why in optical absorption discrete lines are observed but X-ray absorption shows continue with edges. Why the emission and absorption spectra of X-rays are not identical?
8. (a) The atomic number of Na is 11. (i) Write down the electronic configuration for the ground state of the Na atoms (ii) Give the standard spectroscopic notation for the ground state. (iii) The lowest frequency in the absorption spectrum of Na is a doublet. What are the spectroscopic designations of the pair of energy levels to which the atom is excited as a result of this absorption process? (iv) What is the mechanism responsible for the splitting between the pairs of energy levels? (v) Does the level corresponding to the higher value of *j* lie lower or higher?
- (b) Calculate the force constant for the coupling between H and Cl, given that the fundamental frequency of H^1Cl^{35} molecule is 8.7×10^{13} Hz. Assuming the force constant of H^2Cl^{35} to be the same as that of H^1Cl^{35} , calculate the vibration frequency of H^2Cl^{35} .
- (c) Draw the energy level diagram showing the Zeeman splitting of $^2P_{1/2, 3/2}$ and $^2S_{1/2}$ levels in a weak magnetic field. Give the selection rules and the resulting transitions, between the sub-levels. Does the magnetic interaction lift the degeneracy of the level only partially or wholly?