

B.A./B.Sc. Semester—IV

PHYSICS

Paper—A

(Quantum Mechanics)

Time Allowed—3 Hours]

[Maximum Marks—35

Note :— The candidates are required to attempt *one* question each from Sections B, C, D and E. Section A consisting of *seven* short answer type questions is compulsory. All questions carry equal marks.

SECTION—A

1. Attempts *all* parts :

- (i) Does a photon of energy E have mass ? If so, evaluate it.
- (ii) If a photon strikes an electron tightly bound to the nucleus, what will be the effect on Compton-Shift ?
- (iii) For $n = 1$, find the energy of an electron in a box of length 1 \AA .
- (iv) Which of soft or hard X-rays have a longer wavelength ? Which has high penetrating power ?
- (v) What is Auger effect ?
- (vi) State De-Broglie hypothesis of matter waves.
- (vii) Why do all the molecules not show rotational spectra ?

 $7 \times 1 = 7$

SECTION—B

2. (a) Draw a labeled diagram of the apparatus you will use to demonstrate photo-electric effect.
- (b) Derive Einstein's photo-electric equation. How does it explain the laws of photoelectric emission ?
- (c) Draw a curve showing stopping potential against frequency of a photo-sensitive material. How do you determine Planck's constant with the help of the curve ? 1+5+1
3. Explain the formation of a Gaussian wave packet. Explain its properties. 7

SECTION—C

4. (a) What is a Hermitian operator ? Show that momentum operator $-i\hbar \frac{\partial}{\partial x}$ is Hermitian.
- (b) Find the necessary condition in order that ψ be a simultaneous eigen function of linear operator \hat{A} and \hat{B} . 5+2
5. (a) Prove that relation $\frac{\partial P}{\partial t} + \nabla \cdot \vec{S} = 0$ where \vec{S} is the probability current density and P the probability density.
- (b) Given $\psi(x) = \sqrt{\alpha} e^{-\alpha x}$, find the probability of existence of particle between $x = \frac{1}{\alpha}$ and $x = \frac{2}{\alpha}$. 4+3

SECTION—D

6. State Schrödinger's three dimensional time independent wave equation in Cartesian co-ordinates. Derive from it the wave equation in spherical polar co-ordinates. 7
7. Obtain an expression for the energy levels of one dimensional harmonic oscillator applying Schrödinger's equation. 7

SECTION—E

8. Explain Raman effect on the basis of quantum theory. Explain the origin of stokes and anti stokes lines in Raman spectrum. How is Raman effect a two process? Give the selection rules for Raman Scattering. 7
9. (a) Derive Mosley's law on the basis of Bohr's theory of atom.
- (b) Calculate ionization potential of K-shell electron of Copper. Given Z for Copper is 29 and Rydberg's constant for Hydrogen $R = 1.097 \times 10^7 \text{ m}^{-1}$. 4+3