[This question paper contains 4 printed pages.]

5991 *Your Roll No.* .....

B.Sc. (H) ELECTRONICS / Ist Sem. B

Paper – ELHT-101

(Applied Quantum Mechanics)

(Admissions of 2010 and onwards)

Time : 3 Hours *Maximum Marks : 75*

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt **Five** *questions in all including Q. No.* **1** *which is compulsory. Scientific calculator is allowed.*

1. (a) List the inadequacies of classical mechanics.

(b) "Compton effect could not be measured with visible radiations." Comment.

(c) An eigenfunction of operator "$\hat{Q} = \frac{d^2}{dt^2}$" is exp[nαt]. Find the corresponding eigenvalues "q_n".

(d) An electron and proton with same energy E approach a potential barrier of height V_0 such that $V_0 > E$. Do they have the same probability of getting through it ? If not, which has the greater probability ?

P.T.O.

(e) State Pauli's exclusion principle. Which of the following particles follow this principle and why ?

Proton, Photon (3×5)

2. (a) Obtain the continuity equation for Quantum Mechanics from Schrödinger wave equation (time dependent form) :

$$\frac{\partial^2 \Psi}{\partial t^2} + \vec{\nabla} \cdot \vec{J} = 0$$

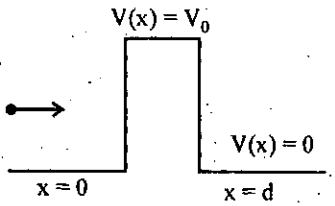
where $\vec{J} = \frac{i\hbar}{2M}\left[\Psi \vec{\nabla} \Psi^* - \Psi^* \vec{\nabla} \Psi\right]$

is probability current.

(b) Explain how continuity equation satisfy the conservation of probability in Quantum Mechanics. (10+5)

3. Consider a particle of mass M and energy E moving from left to right along positive x-axis encounter a potential barrier of height V_0 and width d

$$V(x) = \begin{cases} 0, & x < 0 \\ V_0, & 0 < x < d \\ 0, & x > d \end{cases}$$



(a) Solve Schrödinger wave equation in the three regions.

(b) Find out the probability that the particle penetrate this barrier.

(Assume that the barrier height (V_0) is wide enough for $\psi(x)$ to be severely weakened in the region $0 < x < d$). (5+10)

4. (a) Discuss Davisson and Germer's experiment and explain how it shows existance of matter waves.

(b) List the basic postulates of Quantum Mechanics.

(c) What are stationary states ? Find whether

$$\Psi_1(x, t) = A \sin(k_1 - k_2)x \; e^{jwt}$$

represent a stationary state. (7+4+4)

5. (a) A marble of 10g is restricted to move in 10 cm one-dimensional box. Consider the particle to be quantum mechanical; find out its permitted quantum energies. Also explain the result in the domain of everyday experience.

(b) For the p1s electron of the hydrogen atom

$$\psi(r) = \frac{e^{-r/a_0}}{\sqrt{\pi}\, a_0^{3/2}}$$

Find the expected value of 1/r. (6+9)

6. (a) Describe and explain the significance of Stern-Gerlach experiment.

(b) A beam of silver atoms moving with a velocity of 10^5 cm/s passes through a magnetic field of gradient 0.5 Wb/m^2/cm for a distance of 10 cm. What is the separation between the two components of the beam as it comes out of magnetic field ?

(c) What is the physical significance of magnetic quantum number (m_ℓ) ? (7+5+3)

7. Write short notes on following :

(a) Spin-orbit coupling

(b) Vector Atom Model

(c) Doublet fine structure of alkali spectra (5×3)