This question paper contains **4** printed pages]

Roll No. | | | | | | | | | | | |

S. No. of Question Paper : **6441**

Unique Paper Code : **251101** **D**

Name of the Paper : **ELHT-101 : Applied Quantum Mechanics**

Name of the Course : **B.Sc. (Hons.) Electronics**

Semester : **I**

Duration : **3 Hours** Maximum Marks : **75**

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

Use of scientific calculator is allowed.

Question No. **1** is compulsory.

Attempt *Five* questions in all.

1. (*a*) What are stationary states ?

(*b*) Which of the following would be an acceptable solution of Schrödinger's wave equation ? (Give explanation) :

(*i*) Atanx

(*ii*) Asinx.

(*c*) Using deBroglie's relation and Bohr's atomic model, show that the electron's orbital radii is :

$$r_n = \frac{n^2 h^2 \epsilon_0}{\pi m e^2}.$$

P.T.O.

(*d*) Obtain expressions for the momentum operator and energy operator starting from free particle wave function.

(*e*) What is meant by spin-orbit coupling ? 5×3

2. (*a*) Derive an expression for wavelength shift ($\Delta\lambda$), caused by Compton scattering.

(*b*) Find the frequency of the light which ejects electrons from a metal surface that are fully stopped by a retarding potential of 3 V. The photoelectric effect begins in this metal at a frequency of 6×10^{14} s^{-1}. Find the work function for this metal.

(*c*) Show that the deBroglie wavelength of an electron is equal to the Compton wavelength when its speed is $\frac{c}{\sqrt{2}}$, c being the speed of light. 6+5+4

3. (*a*) What is meant by the phase velocity and group velocity of a wave-packet ? Show that the group velocity is identical with the velocity of the particle.

(*b*) A proton is confined to a nucleus of radius 5×10^{-15} m. Calculate the minimum possible values of the momentum and the kinetic energy of the proton using the uncertainty principle.

(*c*) Starting from the popular Heisenberg's uncertainty relation $\Delta x \, \Delta p \sim \hbar$, show that $\Delta E \, \Delta t \sim \hbar$ is also a valid relation. 7+6+2

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

(*b*) Name the corresponding experiment based on wave nature of light whose results Davisson-Germer experiment obtains with electrons.

(*c*) In a Davisson-Germer diffraction experiment, electrons of kinetic energy 100 eV are scattered from a crystal. The first maximum in intensity occurs at 10°.

(*i*) What is the spacing between the crystal planes ?

(*ii*) How many peaks will there be in the diffraction pattern ? 6+2+7

5. Consider the wave-function for a particle confined in the region $-4 \leq x \leq 6$ given as :

$$\psi(x) = A(4 + x) \text{ for } -4 \leq x \leq 1;$$

$$\psi(x) = A(6 - x) \text{ for } 1 \leq x \leq 6$$

and zero else-where.

(*a*) Sketch the wave function.

(*b*) Normalize this wave function over the range the particle is confined in.

(*c*) Calculate the expectation value of the particle's kinetic energy. 5+5+5

6. (*a*) Derive an expression for the wave-function of a particle trapped in a one-dimensional box with walls having potential of $V = \infty$.

(*b*) Explain the difference if the potentials of the wall are not infinite.

(*c*) If each degree of freedom contributes to a quantum number for a particle whose motion is constraint, explain the three quantum numbers of the hydrogen atom. 6+4+5

7. Write short notes on :

(*a*) The significance of Stern-Gerlach experiment

(*b*) Heisenberg's Gamma ray microscope

(*c*) Anomalous Zeeman Effect. 5+5+5

Relevant Physical Constants :

(*i*) Planck Constant $h = 6.6 \times 10^{-34}$ Js

(*ii*) Rest mass of the electron $m_0 = 9.1 \times 10^{-31}$ kg

(*iii*) Velocity of light $c = 3 \times 10^8$ m/s.