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

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

S. No. of Question Paper : **941**

Unique Paper Code : **251101** **G**

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

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

Semester : **I**

Duration : **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 Question No. **1** which is compulsory.

Scientific Calculator is allowed.

All questions carry equal marks.

1. (*a*) If we wish to observe an object which is 2.5 Å in size, what is the minimum energy photon that should be used ?

(*b*) What are the possible number of values which **J** can have if :

(*i*) **L** > **S** and

(*ii*) **S** > **L**.

(*c*) List the inadequacies of classical mechanics.

(*d*) Can we measure the energy levels of a ball of mass 10 g moving in a one-dimensional box of width 10 cm ? Justify your answer.

(*e*) Explain what you understand by Space quantization. 3×5

P.T.O.

2. (*a*) What are matter waves ? Explain how Davisson and Germer's experiment provides a direct evidence of de Broglie hypothesis. 7

(*b*) Suppose that uncertainty in the momentum of the particle is equal to the particle's momentum. How is the minimum uncertainty in the particle's location (Δx) related to its de Broglie's wavelength ? 4

(*c*) X-rays of wavelength 2.0 Å are scattered from a carbon block. The scattered photons are observed at right angle to the direction of the incident beam. Calculate : 4

(*i*) wavelength of the scattered photon

(*ii*) energy of the recoil electron.

3. (*a*) Explain the principle of superposition as applied to quantum mechanics. 5

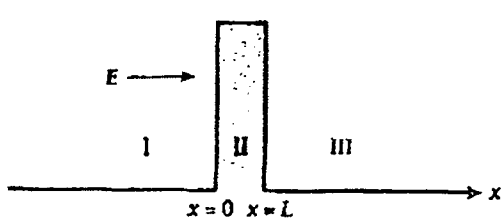
(*b*) A particle limited to the x-axis has the wave function $\psi = ax^2$ between $x = 0$ and $x = 1$; $\psi = 0$ elsewhere :

(*i*) Find the probability that the particle can be found between $x = 0.45$ and $x = 0.55$.

(*ii*) Find the expectation value $\langle x \rangle$ of the particle's position. 3,3

(*c*) State the operator postulate in quantum mechanics. Give *three* quantum mechanical operators corresponding to three different observable quantities. 4

4. A particle of energy E approaches a potential barrier of height V, where V > E. The barrier extends from $x = 0$ to $x = L$ as shown in the figure.



(*a*) Write and solve the Schrödinger wave equation for regions I,II and III. 5

(*b*) Applying the appropriate boundary conditions obtain the probability of transmission of particle through the barrier. 8

(*c*) An electron and a proton with same energy E approach the potential barrier of height V, such that V > E. Which of these two, the electron or the proton has a greater probability of penetrating through the barrier ? 2

5. (*a*) A sample of a certain element is placed in a 0.30 Tesla magnetic field and suitably excited. How far apart are the Zeeman components of the 450 nm spectral line of this element ? 5

(*b*) Find the possible values of total angular momentum quantum number **J** under L-S coupling of two atomic electrons whose orbital quantum number are $l_1 = 1$ and $l_2 = 2$. 5

(*c*) Describe and explain the significance of Stern-Gerlach experiment. 5

6. (*a*) State the basic postulates of quantum mechanics. 5

(*b*) Consider a particle moving in three-dimensional box of sides '*a*', '*b*' and '*c*' defined by

$$V(x, y, z) = 0 \text{ for } 0 < x < a,\ 0 < y < b \text{ and } 0 < z < c$$

$$= \infty \text{ everywhere else}$$

Solve the time independent Schrödinger wave equation for the system and obtain energy eigen values. 8

(*c*) In the above problem find the value of ground state energy if the box is cubical. 2

P.T.O.

7. Write short notes on : 5×3

(*a*) Compton effect

(*b*) Symmetric and anti-symmetric wave functions

(*c*) Zeeman effect.

Value of constants :

$h = 6.624 \times 10^{-34}$ Js

$m_e = 9.1 \times 10^{-31}$ kg

$c = 3 \times 10^8$ m/s

$m_p = 1.67 \times 10^{-27}$ kg

$k_B = 1.38 \times 10^{-23}$ J/K

$\varepsilon_0 = 8.854 \times 10^{-12}$ F/m

$e = 1.6 \times 10^{-19}$ C