[This question paper contains 2 printed pages.]

Sr. No. of Question Paper : 8731 **C** **Roll No............**

Unique Paper Code : 251101

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

Name of the Course : B.Sc. (H) Electronics, Part – I

Semester : I

Duration : 3 Hours

Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Use of scientific calculator is allowed.
3. Question No. 1 is compulsory.
4. Attempt **five** questions in all.

1. (a) Show that the group velocity associated with the group of waves representing the particle motion is equal to the particle velocity.

   (b) An electron is travelling towards a potential barrier of height V_0. Explain for what value of V_0 will quantum mechanical results of tunnelling probabilities agree to that of classical mechanics.

   (c) On the basis of Heisenberg's uncertainty principle, show that free electrons do not exist in the nucleus.

   (d) "Measurable dynamical variables of classical mechanics appear as operators in quantum mechanics". Using this concept show that

   $$\Psi^* \hat{p} \Psi \neq \hat{p} \Psi^* \Psi$$

   (e) Write down the allowed values of quantum numbers l, s, j and m_j for a d-electron. (3x5)

2. (a) In Compton experiment, starting with the expression for Compton wavelength shift, derive an expression for the kinetic energy of the recoil electron.

   (b) X-rays of wavelength 10×10^{-12} m are scattered from a target. Find the

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wavelength of the x-rays scattered through 45°. Find the maximum wavelength present in the scattered x-rays. Find the maximum kinetic energy of the recoil electron. (6+9)

3. (a) Describe the Davisson and Germer experiment for the study of electron diffraction. Give one practical application of electron diffraction.

   (b) Compute the de Broglie Wavelength of an electron having kinetic energy of 100 MeV.

   (c) Explain why silver was important in Stern and Gerlach experiment. (8+3+4)

4. (a) What are the postulates of wave mechanics ? Derive Schrodinger's time independent wave equation. What is the significance of wave function ?

   (b) If $\Psi_1(x,t)$ and $\Psi_2(x,t)$ are both solutions of Schrodinger's equation for a given potential V(x), show that the linear combination

$$\Psi = a_1\Psi_1 + a_2\Psi_2$$

   in which a_1 and a_2 are arbitrary constants is also a solution. (8+7)

5. A particle moves in a 1-D potential box of infinite height and width "L".

   (a) Obtain the general solution for the normalised wave function of the particle, inside and outside the box.

   (b) What is the probability of finding the particle in a small interval Δx at the centre of the box, when it is in the second lowest energy state ?

   (c) Calculate the average value, $<p^2>$. (8+3+4)

6. A particle travelling with energy "E" along the x-axis encounters a potential barrier

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

   Calculate the reflectance and transmittance coefficient for $E<V_0$. (15)

7. (a) On the basis of quantum theory obtain the expression for the change in energy of the spectral lines in weak magnetic fields.

   (b) Describe the spectral pattern for the yellow lines of Sodium corresponding to $2P_{1/2}$ to $2S_{1/2}$ and $2P_{3/2}$ to $2S_{1/2}$.

   (c) Mention the polarisation of spectral lines. (8+4+3)