2009-2010

B.Sc. (Hons.) (PART – III) EXAMINATION

(PHYSICS)

QUANTUM MECHANICS

(PH-303)

Maximum Marks: 40 Duration: Three Hours

Note: Answer all questions.
Use of Calculator is permitted.

1. Answer any three of the following:
(Given h = 6.63 x 10^{-34} J-s, m_p= 1.67x10^{-27} Kg, me = 9.11 x 10^{-31}kg)

(a) Calculate the deBrogli wave length of a 100MeV proton. (2)

(b) The change in wave length of a photon in Compton scattering is 0.012Å, calculate the scattering angle. (2)

(c) A particle is represented by the wave function: (2)

$$\psi(x) = \begin{cases} A\left(a^2 - x^2\right) & \text{if } -a \le x \le +a \\ 0 & |x| > a \end{cases}$$

Find out the normalization constant A and probability density at $x = \pm a/2$

(d) Explain the physical significance of expectation value of an operator. What happens if the state is an eigen state of the operator. (2)

(e) Obtain momentum eigen functions. Discuss the uncertainty in position and momentum of the momentum eigen functions. (2)

(f) Obtain the relation: $m\frac{d}{dt}\langle x\rangle = \langle p_x\rangle$. (2)

2 (a) Calculate the value of the following commutators : (2)
[x, p_x] and [L_x, L_y]

(b) For any operator, show that $(A^+)^+ = A$. (1)

(c) For hermitian operators show that the eigen values are real and eigen functions are orthogonal. Explain the physical significance of real eigen values. (3+1)

OR

2′ (a) Briefly explain the Born's interpretation of the wave function. Discuss the properties that an acceptable wave function must satisfy. (2+2)

(b) For time independent forces show that the probability density is independent of time. Explain the physical significance of this result. (2+1)

3 (a) Solve the time independent schrodinger equation for a particle (2+1)

Contd ··· 2

confined in a one dimensional infinite square well potential. Plot first two eigen functions.

(b) Define parity of a quantum state and explain its physical significance. (1+1)

(c) Using Heisenberg's uncertainty relation calculate the zero point energy of an electron in a rigid box of length 1Å. (2)

OR

(c′) Solve the Schrodinger equation for a particle of energy E incident on a step potential of height V_0 ($E < V_0$). Obtain the reflection coefficient of the incident wave.

4 (a) Write down the eigen value equations for the operators L^z and L_z, where $\vec{L}$ is the angular momentum of a particle. (1)

(b) Explain the meaning of space quantization. What are allowed orientations for the angular momentum vector with z-axis if the angular momentum quantum number $\ell = 1$. (3+1)

(c) Obtain the separation of centre of mass and relative motion for a two particle system in presence of central forces. Discuss the nature of centre of mass motion. (2)

5 (a) Obtain a relation between magnetic moment and angular momentum of a charged particle moving on a circular path. Briefly explain the sterm-Gerlach experiment and its result. (4)

(b) Solve the eigen value equation for the spin operator $S_z = \frac{1}{2}\hbar\sigma_z$ (2)

OR

5′ (a) Use time independent perturbation theory to obtain correction in energy and wave function upto first order (2)

(b) Explain the meaning of degeneracy. Describe Norma Zeeman effect and splitting of energy levels of an electron in hydrogen atom. (1+3)

6 (a) Explain the procedure for obtaining the asymptotic wave function for the scattering of a beam of mono-energetic particles from a fixed target. (2)

(b) Obtain an expression for the radial flux for the particles described by a wave function of the form: $f(\theta,\phi)\frac{e^{ikr}}{r}$ (2)

(c) Write down the spin singlet and triplet wave functions for a system consisting of two identical spin half particles. (3)

Give arguments to obtain the differential cross-section for the scattering of spin half particle from an identical spin half particle.

*****