Examination Roll No.....

YMCA UNIVERSITY OF SCIENCE & TECHNOLOGY, FARIDABAD

M.Sc. (Physics) 1st SEMESTER (UNDER CBCS)

Quantum Mechanics (PHL-103)

Time: 3 Hours

Max. Marks:75

Note:
1. *It is compulsory to answer the questions of Part -1. Limit your answers within 20-40 word in this part.*
2. *Answer any four questions from Part -2 in detail.*
3. *Different parts of the same question are to be attempted adjacent to each other.*
4. *Use of simple calculator is allowed but exchange of calculator is not allowed*
5. *Assume suitable standard data wherever required, if not given.*

PART -1

Q1 (a) Find the Hermitian conjugate of the operator $\hat{X}\frac{d}{dx}$ (1.5)

(b) If a=(0,4,0); b=(i,-3i,i) and c=(2,0,1); find that they are independent or dependent over complex field. (1.5)

(c) Calculate $\langle L_x \rangle$ and $\langle L_y \rangle$ in the state $|\Phi\rangle=(1/\sqrt{3})[|1,1\rangle+|1,0\rangle+|1,-1\rangle$ where first number in each of the square bracket denotes l & second term denotes m. (1.5)

(d) Find the value of $\frac{1}{2}[L_- L_+ + L_+ L_-]$. (1.5)

(e) Prove that Pauli matrix are unitary. (1.5)

(f) Show that sum of two projection operators cannot be projection operator unless they commute. (1.5)

(g) Define scattering amplitude. (1.5)

(h) What do you mean by Zeeman effect? Can you explain Zeeman effect by perturbation theory? (1.5)

(i) How L-frame is different between CM-frame? (1.5)

(j) Define angular momentum in polar coordinate. (1.5)

PART -2

Q2 (a) Define differential and total scattering cross section. Establish a relation between the scattering cross section $\sigma(\theta,\Phi)$ and the angular dependence $f(\theta,\Phi)$ of scattered wave. (10)

(b) If it is given that $y_2^0(\theta,\Phi)=(\sqrt{5}/16\Pi)[3\cos^2\theta-1]$. Applying L_+ and find an expression for $y_2^1(\theta,\Phi)$ and $y_2^2(\theta,\Phi)$ (5)

Q3 (a) Find the matrix representation for angular momentum operators J^2 and J_z. Derive solution for j=1and j=3/2 (10)

(b) Consider the state $|\Psi_1\rangle=|\Phi_1\rangle+4i|\Phi_2\rangle+5|\Phi_3\rangle$ and $|\Psi_2\rangle=b|\Phi_1\rangle+4|\Phi_2\rangle-3i|\Phi_3\rangle$ where $|\Phi_1\rangle$, $|\Phi_2\rangle$ & $|\Phi_3\rangle$ are orthonormal kets and b is constant. Find 'b' such that $|\Psi_1\rangle$ & $|\Psi_2\rangle$ are orthogonal. (5)

Q4 (a) Calculate the differential cross section in the Born approximation for the scattering of a particle by an attractive square well potential: $V(r)=-V_0$ for r<a and V(r) =0 for r>a with $V_0>0$. (10)

(b) Derive an expression for phase shift in partial wave scattering. (5)

Q5 (a) Explain Schrödinger Picture. Obtain the time derivative of the expectation value of an observable in it. (10)

(b) Define Gram-Schmidt orthogonalization with an example. (5)

Q6 (a) Calculate the first order stark effect for first excited state of hydrogen atom using stationary perturbation theory for degenerate state. (10)

(b) Find and prove Fermi-Golden Rule for the rate of transition to a continuum of final states due to constant perturbation. (5)

Q7 Explain the following: (15)

i. Ground state He atom
ii. Postulate of Quantum Mechanics