Examination Roll No....................

JC Bose University of Science & Technology, YMCA, Faridabad

M.Sc. (Physics) Semester-I (2016 Scheme)

Quantum Mechanics-I (PHY-103)

Time: 3 Hours   Max. Marks:60

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

Part -A

Q1 (a) Obtain the Hermitian conjugate of the operator $\hat{x}\frac{d}{dx}$. (2)

(b) Describe Hilbert space. (2)

(c) Prove the following commutation relations: (2)

$$[x, p_z] = 0$$
$$[z, p_z] = i\hbar$$

(d) Discuss the completeness condition. (2)

(e) Obtain the commutation relation relation between L_+ and L_-. (2)

(f) For Pauli spin matrices, prove that $\sigma_x \sigma_y = 2i\sigma_z$. (2)

(g) Define differential and total scattering cross-section. (2)

(h) Discuss the validity of Born approximation. (2)

(i) Explain Zeeman effect using perturbation theory. (2)

(j) What is Harmonic perturbation. (2)

Part -B

Q2 (a) Define basis and operators in quantum mechanics. (6)

(b) Define projection operator and obtain P_a^2. (4)

Q3 (a) Explain Schrödinger's picture. Obtain the time derivative of the expectation value of an observable in it. (6)

(b) Consider the states $|\psi_1\rangle = |\phi_1\rangle + 2|\phi_2\rangle + 3|\phi_3\rangle$ and $|\psi_2\rangle = a|\phi_1\rangle + 4|\phi_2\rangle + 2|\phi_3\rangle$, where $|\phi_1\rangle, |\phi_2\rangle$ and $|\phi_3\rangle$ are orthonormal kets. Find the constant '*a*' such that $|\psi_1\rangle$ & $|\psi_2\rangle$ are orthogonal. (4)

Q4 Define raising and lowering operators J_+ and J_- using representation in which J^2 and J_z are diagonal. Also obtain the matrix element for J_x and J_y. (10)

Q5 Find the matrix representation for angular momentum operators J^2 and J_z. Obtain the eigen values for J^2 and J_z operators when spin j = 3/2 and j = 1. (10)

Q6 (a) Calculate the differential scattering cross-section in the Born approximation for the scattering of a particle by an attractive square well potential: (6)

$$V(r) = \begin{cases} -V_o & for\ r < a \\ 0 & for\ r > a \end{cases}$$; where $V_o > 0$.

(b) Derive an expression for phase shift using partial wave method. (4)

Q7 (a) Discuss the time independent perturbation theory for non-degenerate systems and obtain the expression for first order correction to energy. (6)

(b) Explain Fermi Golden rule for the rate of transition to a continuum of final states due to constant perturbation. (4)

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