Reg. No .... Name **23P2019**

M. Sc. DEGREE END SEMESTER EXAMINATION : MARCH 2023

SEMESTER 2 : PHYSICS

COURSE : **21P2PHYT06: QUANTUM MECHANICS I**

(For Regular - 2022 Admission and Supplementary - 2021 Admission)

Duration : Three Hours Max. Weights: 30

PART A

Answer any 8 questions **Weight: 1**

1.	If σ_i are Pauli matrices, find $\sigma_i^\dagger$	(A, CO 3)
2.	Write down the commutation relation between L^2, L_x, L_y and L_z.	(U, CO 1, CO 2)
3.	Show that $\{A, B\}^\dagger = \{A, B\}$	(A, CO 3)
4.	Write the postulate of positive definite metric.	(R, CO 1)
5.	What is $\langle x \rangle$ and $\langle p \rangle$ for the ground state of a simple harmonic oscillator?	(A, CO 1, CO 2)
6.	Prove that $[N, a] = -a$	(A, CO 3)
7.	Write the expression for the energy of an electron in an hydrogen atom	(R, CO 4)
8.	Write the expression for the finite rotation operator and infinitesimal rotation operator.	(U, CO 1, CO 2)
9.	Describe a stationary state and a nonstationary state.	(U, CO 1, CO 2)
10.	Write down four properties of the quantum mechanical commutator.	(R, CO 1, CO 3)

(1 x 8 = 8)

PART B

Answer any 6 questions **Weights: 2**

11.	Show that the expectation value in the Schrodinger picture is same as the expectation value in the Heisenberg picture.	(A, CO 3)
12.	Show that, if the initial state is the eigen state of the obervable which commutes with the Hamiltonian H, The final state after a time t remains perfectly corelated to the initial state.	(A, CO 3)
13.	Using the outcome of the Stern Gerlach experiment find the representation of the operators S_x and S_y in terms of the eigen kets of the operator S_z namely $\vert+\rangle$ and $\vert-\rangle$	(A, CO 2, CO 3, CO 4)
14.	Show that $[J_x, J_y] = i\hbar J_z$	(A, CO 3)
15.	Find the eigenfunctions and the nature of eigenvalues of the operator $\frac{d^2}{dx^2} + \frac{2}{x}\frac{d}{dx}$.	(An, CO 2)
16.	Obtain the commutation relation $[J^2, J_x]$.	(A, CO 3)
17.	The normalized wavefunction of a particle is $\Psi(x) = e^{iax-ibt}$ where A, a and b are constants. Evaluate the uncertainity in its momentum.	(A, CO 3, CO 4)
18.	If a and $a^\dagger$ are the annihilation and creation operator of a quantum mechanical simple harmonic oscillator show that $a\vert n\rangle = \sqrt{n}\vert n-1\rangle$ and $a^\dagger\vert n\rangle = \sqrt{n+1}\vert n+1\rangle$	(A, CO 2, CO 3)

(2 x 6 = 12)

PART C

Answer any 2 questions **Weights: 5**

19. Derive the Schrödinger equation for the time evolution operator after arriving at the expression for the infinitesimal time evolution operator. Also find the formal solutions to the Schrodinger equation thus treating the three cases for the Hamiltonian. (A, CO 3)

20. Obtain the fundamental commutation relations of angular momentum operators (A, CO 3)

21. What are the properties of the infinitesimal translation operator? Show that $1 - iK \cdot dx'$ can be used to represent the infinitesimal translation operator and hence derive the commutation relation between momentum and position operators. (A, CO 3)

22. Calculate the expectation value of x, x^2 and p for a Gaussian wave packet given by (A, CO 1, CO 2, CO 3)

$$\langle x'|\alpha\rangle = \frac{1}{\sqrt{d}\pi^{1/4}} e^{\left[ikx' - \frac{x'^2}{2d^2}\right]}$$

(5 x 2 = 10)

OBE: Questions to Course Outcome Mapping

CO	Course Outcome Description	CL	Questions	Total Wt.
CO 1	Define the formalism of Non relativistic Quantum Mechanics.	R	2, 4, 5, 8, 9, 10, 22	11
CO 2	Demonstrate principles of quantum mechanics.	U	2, 5, 8, 9, 13, 15, 18, 22	15
CO 3	Apply the principles of quantum mechanics to specific quantum mechanical systems.	A	1, 3, 6, 10, 11, 12, 13, 14, 16, 17, 18, 19, 20, 21, 22	38
CO 4	Solve specific problems in quantum mechanics	A	7, 13, 17	5

Cognitive Level (CL): Cr - CREATE; E - EVALUATE; An - ANALYZE; A - APPLY; U - UNDERSTAND; R - REMEMBER;