Reg. No .... Name **25P2020**

M. Sc. DEGREE END SEMESTER EXAMINATION - APRIL 2025

SEMESTER 2 : PHYSICS

COURSE : **24P2PHYT06 : QUANTUM MECHANICS - I**

(For Regular - 2024 Admission)

Time : Three Hours Max. Weights: 30

PART A

Answer any 8 questions **Weight: 1**

1. Draw the radial wave function for the $n=1, l=0$ state w.r.t $\frac{r}{a_0}$ for the hydrogen atom. (A)
2. Describe a stationary state and a nonstationary state. (U)
3. Write the expression for the finite rotation operator and infinitesimal rotation operator. (U)
4. Write down four properties of the quantum mechanical commutator. (R)
5. Show that the transition amplitude remains same in the Schrodinger picture and the Heisenberg picture. (A)
6. Evaluate the commutation relation $[L_z, [L_y, L_z]]$. (E)
7. Show that the trace of matrix in the new basis is equal to the trace of the matrix in the old basis. (U)
8. Show that for a quantum mechanical SHO, $[N, H] = 0$ (A)
9. How can you obtain the position space wavefunction$\psi_\alpha(x')$ from momentum space wave function $\phi_\alpha(p')$? (A)
10. Why J_+ and J_- are called the raising and lowering operators. (U)

(1 x 8 = 8)

PART B

Answer any 6 questions **Weights: 2**

11. Show that for a system in stationary state the expectation value of an operator does not change with time. (A)
12. Show that incompatible observables dont have a complete set of simultaneous eigenkets. (A)
13. In the $|jm\rangle$ basis forms by the eigenkets of J^2 and J_z show that $\langle jm|J_-J_+|jm\rangle = (j-m)(j+m+1)\hbar^2$ here J_+ and J_- are the ladder operators (A)
14. If A and B are Hermition operators, show that $(AB+BA)$ is Hermition and $(AB-BA)$ is not Hermition. (A)
15. Arrive at the expression for the momentum operator in the position basis (U)
16. If a and $a^\dagger$ are the annihilation and creation operator of a quantum mechanical simple harmonic oscillator show that $a|n\rangle = \sqrt{n}|n-1\rangle$ and $a^\dagger|n\rangle = \sqrt{n+1}|n+1\rangle$ (A)

17. Draw the radial wavefunction and the probability density w.r.t $\frac{r}{a_0}$ for $n = 3$ and $l = 0$ in the case of hydrogen atom. (A)

18. Explain the properties of Pauli's Spin matrices (U)

(2 x 6 = 12)

PART C

Answer any 2 questions **Weights: 5**

19. Given the position space wave function of a Gaussian wave packet
$\langle x'|\alpha\rangle = \frac{1}{\sqrt{d}\pi^{1/4}}e^{[ikx' - \frac{x'^2}{2d^2}]}$
Prove that the Gaussian wave packet is the minimum uncertainity wave packet. (A)

20. (a) Derive the generalized uncertainity relation.
(b) Show that linear momentum is a generator of translation. (U)

21. If σ is a Pauli matrix, a and b are vectors in three dimensions then
(a) Prove that $(\sigma \cdot A)(\sigma \cdot B) = A \cdot B + i\sigma \cdot (A \times B)$ where σ
(b) Derive the matrix representation of the rotation operator $\mathcal{D}(\hat{n}, \phi)$ for the electronic spin. (A)
(c) Write down the properties of the Pauli matrices.

22. 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)

(5 x 2 = 10)

OBE: Questions to Course Outcome Mapping

CO	Course Outcome Description	CL	Questions	Total Wt.

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