20000682

QP CODE: 20000682

Reg No : ....

Name : ....

MSc DEGREE (CSS) EXAMINATION , NOVEMBER 2020

Second Semester

M Sc PHYSICS

CORE - PH010202 - QUANTUM MECHANICS-I

2019 Admission Onwards

5205D6F1

Time: 3 Hours | Weightage: 30

Part A (Short Answer Questions)

*Answer any **eight** questions.*

*Weight **1** each.*

1. Compute the commutator$[A, e^A]$.
2. Explain the expansion of a vector $|\alpha\rangle$ is continuous basis $\{|a'\rangle\}$. Express the inner product$\langle\alpha|\beta\rangle$ in this basis.
3. Express $\langle\beta|A|\alpha\rangle$ in terms of the position state wave functions. How will this quantity change if the operator A is a function of the position operator.
4. Give the solution of the Schrodinger equation for the time evolution operator if the Hamiltonian of the system is time dependent and Hamiltonians at different times do not commute.
5. Consider, a spin half system subjected to a magnetic field in the z direction. At time $t = 0$ the state of the system is given by $|\alpha, t_0 = 0\rangle = \frac{1}{\sqrt{2}}(|+\rangle + |-\rangle)$, where $|\pm\rangle$ are the S_z eigenstates. Write down the state of the system at $t > 0$.
6. Evaluate the commutator$[x_i, p_j^n]$.
7. Evaluate $\langle x^3\rangle$ for the harmonic oscillator problem.
8. Write down the orthogonality relation for the state $|j, m\rangle$.
9. Show that for the orbital angular momentum operator L, $L^2 = L_z^2 + \frac{1}{2}(L_+L_- + L_-L_+)$.
10. Show that the Clebsch-Gordon coefficients connecting the $|jm\rangle$ basis and $|m_1m_2\rangle$ basis are non-zero only for $m = m_1 + m_2$.

(8×1=8 weightage)

Part B (Short Essay/Problems)

*Answer any **six** questions.*

*Weight **2** each.*

11. Find the norm of the vectors $|1\rangle \doteq \begin{pmatrix} 3+4i \\ 2i \\ 1 \end{pmatrix}$ and $|2\rangle \doteq \begin{pmatrix} 3-4i \\ 4i \\ 2 \end{pmatrix}$. Normalize these vectors. Check whether the normalized vectors are orthogonal.

12. Consider the operator is defined by $H = \frac{1}{\sqrt{2}}(|+\rangle\langle+| \quad + \quad |+\rangle\langle-| \quad + \quad |-\rangle\langle+| \quad - \quad |-\rangle\langle-|)$. (i)Prove that this operator converts the base kets into a superposition of base kets(ii)Find the action of this operator on the superposition state $C_1|+\rangle + C_2|-\rangle$.

13. A state ket $|\alpha\rangle$ is given by$|\alpha\rangle = 2i|u\rangle + |v\rangle - 5i|w\rangle$ where $\{|u\rangle, |v\rangle, |w\rangle\}$ form an orthonormal basis. (i) Normalize $|\alpha\rangle$; (ii) find the matrix representation of $|\alpha\rangle$ and $\langle\alpha|$ in this basis.

14. What are energy eigenkets? Obtain an expression for time evolution of such states.

15. Obtain the Heisenberg equation of motion.

16. Evaluate the commutator $[J^2, J_k]$.

17. Show that the any 2×2 traceless matrix can be written as a linear combination of Pauli matrices.

18. Obtain the matrix representation ofJ_y in the $\{|j, m\rangle\}$ basis.

(6×2=12 weightage)

Part C (Essay Type Questions)

*Answer any **two** questions.*

*Weight **5** each.*

19. Calculate the uncertainty product for a Gaussian wave packet. Obtain the momentum state wave function corresponding to this wave packet.

20. Obtain the time-energy uncertainty relation and interpret it. Discuss the consequences of this relation.

21. Show that the expectation values of S_x, S_y and S_z transforms like the components of a vector under rotation for a spin 1/2 system. Explain how the Hamiltonian generates the spin precession for a spin 1/2 system.

22. Set up the energy eigenvalue equation for a hydrogenic atom and obtain the energy eigen values. Hence deduce the energy eigenvalues of hydrogen atom.Discuss the degeneracy in hydrogen atom.

(2×5=10 weightage)