QP CODE: 22002352

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Reg No : .....

Name : .....

MSc DEGREE (CSS) EXAMINATION , NOVEMBER 2022

Second Semester

CORE - PH010202 - QUANTUM MECHANICS-I

M Sc PHYSICS,M.Sc.SPACE SCIENCE

2019 Admission Onwards

F8445380

Time: 3 Hours Weightage: 30

Part A (Short Answer Questions)

*Answer any **eight** questions.*

*Weight **1** each.*

1. If $|+\rangle$ and $|-\rangle$ forms an orthonormal basis, find the matrix representation of the operator $S_- = \hbar(|-\rangle\langle+|)$. Explain the action of S_- on the states $|+\rangle$ and $|-\rangle$.
2. Prove that the trace of a matrix is independent of the representation.
3. Explain the meaning of the statement "$|p'_x, p'_y, p'_z\rangle$ is a simultaneous momentum eigenstate of the obesrvables p_x,p_y and p_z".
4. Give the properties of time evolution operator.
5. Write down the Heisenberg equation of motion.
6. What is transition amplitude?
7. Give the energy eigenvalues of a linear harmonic oscillator.
8. Evaluate the commutator $[J^2, J_z]$.
9. Write down the properties of Pauli matrices.
10. Evaluate the commutator $[L_i, p_j]$, where $\mathbf{L}$ is the angular momentum operator and $\mathbf{p}$ is the momentum operator.

(8×1=8 weightage)

Part B (Short Essay/Problems)

*Answer any **six** questions.*

*Weight **2** each.*

11. Suppose $|i\rangle$ and $|j\rangle$ are eigenkets of some Hermitian Operator A. Under what circumstance can we conclude that $|i\rangle + |j\rangle$ is also an eigenstate of A?
12. Evaluate $\langle(\Delta S_x)^2\rangle\langle(\Delta S_y)^2\rangle$ and verify the generalised uncertainly relations in S_x and S_y.
13. Show that $\langle x'|p^n|\alpha\rangle = (-i\hbar)^n \frac{\partial^n}{\partial x'^n}\langle x'|\alpha\rangle$.
14. Calculate the expectation value of an operator B with respect to a non stationary state $|\alpha, t_0 = 0; t\rangle = \sum_{a'} c_{a'}(t)|a'\rangle$.
15. The life time of hydrogen in the $2p$ state to decay to $1s$ ground state is $1.6 \times 10^{-9} s$. Estimate the uncertainty ΔE in energy of the excited state. Find the corresponding line width in angstrom.
16. Evaluate $\exp\left[\frac{iS_z\phi}{\hbar}\right] S_x \exp\left[\frac{-iS_z\phi}{\hbar}\right]$ by using the expansion of S_x in the eigenstates $|\pm\rangle$ of S_z.
17. Show that $J_-|j,m\rangle = \sqrt{(j+m)(j-m+1)}\hbar|j,m-1\rangle$.
18. Obtain the matrix representations of the angular momentum operators $\vec{J}^2$ and J_z in the $|jm\rangle$ basis, for a system with $j = 1$.

(6×2=12 weightage)

Part C (Essay Type Questions)

*Answer any **two** questions.*

*Weight **5** each.*

19. Write short notes on (a) ket space and bra space (b) inner product (c) norm of a vector.
20. Obtain the Schrodinger equation for time evolution operator. Discuss its solutions under various conditions.
21. What are Clebsch-Gordon coefficients? Evaluate the Clebsch-Gordon coefficients for the addition of two angular momenta with $j_1 = 1/2$ and $j_2 = 1/2$.
22. Obtain the energy eigenvalues of a hydrogenic atom. Also deduce the expressions for the radial wave functions corresponding to the two lowest eigenstates.

(2×5=10 weightage)