MAY 2012 **P/ID 40003/PPHC**

Time : Three hours Maximum : 100 marks

PART A – (10 × 2 = 20 marks)

Answer ALL questions.

All questions carry equal marks.

1. What are eigenfunctions and eigenvalues of an operator?
2. Can we measure the kinetic and potential energies of a particle simultaneously with arbitrary precision? Why?
3. What is quantum mechanical tunneling?
4. What are s and p-orbitals? Give polar representations of their angular part.
5. Why time-reversal operator is not linear?
6. Wave function, possess even or odd parity. Explain
7. How could one get the classical turning points if the potential is known?
8. The result of the variation method always gives an upper limit for the ground state energy of the system. Why?
9. What are Pauli's spin matrices?
10. What is spin-orbit interaction? For s-electron, the spin-orbit interaction is zero. Why?

PART B — (5 × 6 = 30 marks)

Answer ALL questions.

All questions carry equal marks.

11. (a) Show that the rate of change of expectation value of the position is classical velocity of the particle.

Or

(b) Illustrate the uncertainty principle on the basis of single-slit experiment.

12. (a) Calculate the expectation values of position and of the momentum of a particle trapped in a one dimensional infinite potential well.

Or

(b) Separate the Schrödinger equation of a particle in spherically symmetric potential in to three equations by separable variable method.

13. (a) Prove that rotation in space leads to conservation of angular momentum.

Or

(b) Distinguish between the Heisenberg and Schrödinger pictures.

14. (a) Explain how perturbation theory is applied to the degenerate levels of a system for a time-independent perturbation.

Or

(b) List the connection formula and explain them.

15. (a) Show that $(\sigma \cdot A)(\sigma \cdot B) = A \cdot B + i\sigma \cdot (A \times B) \cdot A$ and B are arbitrary vectors commute with σ.

Or

(b) What are Clebsh-Gordan coefficients? Derive their properties.

PART C — (5 × 10 = 50 marks)

Answer ALL questions.

All questions carry equal marks.

16. (a) Obtain the time-dependent Schrödinger's equation and separate it into space and time-dependent parts. Show that the probability density P and current density J satisfy the continuity equation.

Or

(b) Show that eigenvalues of a Hermitian operator are real and the eigen functions of a Hermitian operator belonging to different eigenvalues are orthogonal.

17. (a) Write the Schrödinger equation for a rectangular barrier potential problem. Solve it to obtain an expression for the transmission coefficient for a particle having energy lesser than the barrier height.

Or

(b) Evaluate the eigenvalues and describe the method getting the energy eigenfunctions of the harmonic oscillator using abstract operator method.

18. (a) Derive the equations of motion for states and operators in the Schrödinger and interaction pictures.

Or

(b) Show that Hamiltonian of a system is the generator of infinitesimal translation in time and hence explain the time evolution of the system.

19. (a) Discuss the first-order time-independent perturbation theory for non-degenerate stationary state. Obtain the corrected eigenfunctions and eigenvalue.

Or

(b) Evaluate the ground state energy of the harmonic oscillator using the Gaussian function as the trial function.

20. (a) Derive the eigenvalue spectrum of J^2 and J_z.

Or

(b) Derive the matrices for the operators J^2, J_z, J_x and J_y for $j = 1$.

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