(FOR THE CANDIDATES ADMITTED **SUBJECT CODE** **25 PPS 204**

DURING THE ACADEMIC YEAR 2025-26 ONLY) **REG.NO.:**

N.G.M.COLLEGE (AUTONOMOUS) : POLLACHI

END-OF-SEMESTER EXAMINATIONS : MAY– 2026

M.Sc. – PHYSICS **MAXIMUM MARKS: 75**

II SEMESTER **TIME : 3 HOURS**

QUANTUM MECHANICS – I

SECTION – A (10 X 1 = 10 MARKS)

ANSWER THE FOLLOWING QUESTIONS. **(K1)**

1. If a wave function said to be normalized, then $\int_{-\infty}^{\infty} |\psi|^2 dV$ is equal to

   a) Zero b) Unity c) Infinite c) Finite

2. A particle is not under the influence of any force, then is called

   a) Wave b) Particle c) Free particle d) Either wave or a particle

3. The spherical polar coordinates to give L_z

   a) $L_z = -\hbar\frac{\partial}{\partial\phi}$ b) $L_z = -\hbar\frac{\partial}{\partial\theta}$

   b) $L_z = \hbar\frac{\partial}{\partial\phi}$ d) $L_z = \hbar\frac{\partial}{\partial\theta}$

4. Which of the following is a necessary condition for using non-degenerate perturbation theory?

   a) Energy levels must be equally spaced
   b) The perturbation must be time-dependent
   c) Each unperturbed energy level must be unique
   d) The perturbation must be very large

5. Fermi's Golden Rule gives the expression for the:

   a) Energy eigenvalues of a system
   b) Transition probability per unit time
   c) Expectation value of position
   d) Time evolution of the wave function

ANSWER THE FOLLOWING IN ONE (OR) TWO SENTENCES **(K2)**

6. The equation $\int_{-\infty}^{\infty} x\ |\psi|^2 dx$ represents expectation value is --------------

7. The zero point energy of a harmonic oscillator is ------------------

8. The angular part of the Schrödinger equation in polar coordinates leads to the concept of _______.

9. The Hamiltonian of the helium atom consists of the kinetic energy of electrons, electron–nucleus attraction, and the __________ interaction between electrons.

10. The sudden approximation is applicable when the external perturbation acts for a time that is __________ compared to the characteristic time of the system.

(CONTD …. 2)

SECTION – B (5 X 5 = 25 MARKS)

ANSWER EITHER (a) OR (b) IN EACH OF THE FOLLOWING QUESTIONS.

(K3)

11. a) Deduce the1D Schrodinger wave equation for a free particle.

(OR)

b) Explain how the Gram–Schmidt orthogonalization process ensures mutual orthogonality of vectors.

12. a) Solve the Schrödinger equation for a rigid rotator and obtain the expression for its energy eigenvalues.

(OR)

b) Explain the methods of separation of variables for the Schrödinger equation in polar coordinates.

13. a) Explain why the total wave function of identical particles must be either symmetric or antisymmetric under particle exchange.

(OR)

b) Write the expressions for the Cartesian components L_x, L_y, L_z of the angular momentum operator.

14. a) Analyze why degeneracy is removed in helium due to electron–electron interaction.

(OR)

b) State the conditions of validity of the WKB approximation.

15. a) Obtain the first-order correction in time dependent to the wave function of a non-degenerate system.

(OR)

b) Obtain the general solution of the time-dependent Schrödinger equation using time-dependent perturbation theory.

SECTION – C (5 X 8 = 40 MARKS)

ANSWER EITHER (a) OR (b) IN EACH OF THE FOLLOWING QUESTIONS.

(K4 (Or) K5)

16. a) State and prove Ehrenfest's theorem.

(OR)

b) Outline the different postulates of quantum mechanics.

17. a) Derive the energy Eigen functions of a particle in a one dimensional finite potential step and describe the method of finding the corresponding energy Eigen values.

(OR)

b) Solve the Schrödinger equation for a quantum harmonic oscillator to find the ground state wave function.

18. a) Derive the matrix representation of an operator using its eigenfunctions as a basis.

(OR)

b) Add two angular momenta j_1=1/2, and j_2=1/2 and list all possible total angular momentum states.

19. a) Using perturbation theory, show that the first-order energy correction for the hydrogen ground state in a uniform electric field is zero.

(OR)

b) Using the WKB method, explain quantum mechanical tunneling through a potential barrier.

20. a) Show how selection rules arise from the matrix element in Fermi's Golden Rule.

(OR)

b) Calculate the transition probability between initial and final states using the sudden approximation.

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