(8 pages) **Reg. No. :** .....

Code No. : 5399 **Sub. Code : ZPHM 41**

M.Sc. (CBCS) DEGREE EXAMINATION,
APRIL 2024

Fourth Semester

Physics – Core

QUANTUM MECHANICS – II

(For those who joined in July 2021-2022 only)

Time : Three hours Maximum : 75 marks

PART A — (10 × 1 = 10 marks)

Answer ALL questions.

Choose the correct answer :

1. In the WKB method, in which regions of the potential energy curve is the semiclassical approximation most accurate?
   (a) In regions of rapidly varying potential
   (b) In regions of constant potential
   (c) In regions of slowly varying potential
   (d) In regions of zero potential

2. Which quantum mechanical phenomeon is effectively described by the WKB method for particle in regions of slowly varying potential?
   (a) Particle – wave duality
   (b) Tunneling through a potential bather
   (c) Quantum entanglement
   (d) Electromagnetic interference

3. In the Born approximation, what happens to the scattering amplitude as the incident particle's energy increases?
   (a) The scattreing amplitude decreases
   (b) The scattreing amplitude remains constant
   (c) The scattreing amplitude increases
   (d) The scattreing amplitude becomes zero

4. Which particle wave is associated with l = 2 in particle wave analysis?
   (a) S-wave
   (b) P-wave
   (c) D-wave
   (d) F-wave

5. Which of the following statements is true regarding a symmetric wave function for a system of indentical particle?

(a) It remains unchanged when the particles are exchange

(b) It changes sign when the particles are exchange

(c) It depends on the particle's positions

(d) It represents particles with opposite spins

6. In quantum mechanics ,what is the purpose of spin mattrices (Pauli matrices) in Matrices) in describing spin angular momentum?

(a) To calculate the orbital angular momentum of particles

(b) To determine the position of particles

(c) To represents the possible spin states and their operators

(d) To describe wave function of particles

7. What is the fundamental equation in the Schrodinger picture that describe how the quantum state of a system evolves with time?

(a) Heisenberg equation of motion

(b) Dirac equation

(c) Schrodinger equation

(d) Hamiltonian equation

8. In the Wigner-Eckart theorem, what type of operators are typically considered for describing transition in quantum systems?

(a) Scalar operators

(b) Vectors operators

(c) Tensor operators

(d) Spin operators

9. What property of Dirac's equation allows to successfully predict the existence of antimatter?

(a) It include the concept of wave- particle duality

(b) It allows for the possibility of negative-energy solutions

(c) It incorporates the concept of spin angular momentum

(d) It introduces the concept of wave functions

10. Dirac's equations was a ground breaking development in quantum mechanics, but it had a limitation. What is the limitation of the Dirac equation in describing particles?

(a) It cannot describe particles with spin

(b) It cannot describe particles with fractional charge

(c) It cannot describe particles with mass

(d) It cannot describe particles at rest

PART B — (5 × 5 = 25 marks)

Answer ALL questions, choosing either (a) or (b).

Each answer should not exceed 250 words.

11. (a) Discuss advantages of the variation method over other perturbation methods.

Or

(b) Explain the Principle of J.WKB method.

12. (a) Define total and differential cross-section. How are these related to the angle of scattering?

Or

(b) Explain the Eikonal approximation in scattering theory.

13. (a) Show that $[\sigma_x \sigma_y] = 2i\sigma_z$.

Or

(b) Distinguish between symmetric and anti symmetric wave functions. Give the relation between the type of symmetry and statistics.

14. (a) Deduce the equations of motion in Heisenberg picture. Discuss the correspondence of these equations with those of classical mechanics.

Or

(b) Explain conservation laws and degeneracy associated with symmetries.

15. (a) Obtain an expressions for current and charge densities in Schrodinger's relativistic equation.

Or

(b) If α and β are dirac matrices prove that $\alpha_x = \frac{1}{2}[\alpha_x, \alpha_y, \alpha_y]$.

PART C — (5 × 8 = 40 marks)

Answer ALL questions, choosing either (a) or (b).

Each answer should not exceed 600 words.

16. (a) Apply W.K.B method barrier penetration.

Or

(b) Use the Variational method to estimate the upper limit for the ground state energy of the helium atom.

17. (a) Explain the role of Green's function in Scattering theory.

Or

(b) Deduce a relation between the phase shift, scattering length and effective range for n-p scattering.

18. (a) Discuss the Principle of indistinuishability of identical particles. What are symmetric and anti symmetric wave functions? Construct symmetric and antisymmetric wave functions from unsymmetrised wave functions. Hence show how Pauli exclusion principle follows for fermions.

Or

(b) Show that for a system of two identical particles with spin I, the ratio of number of states which are symmetric under spin interchange to the number of states which are antysymmetric under spin interchange is $\frac{I+1}{I}$.

19. (a) State and prove Wigner- Eckart theorem.

Or

(b) Explain the interaction picture in quantum mechanics and show how it differs from the Schrodinger picture. Obtain the equations of motion in the interaction picture.

20. (a) Obtain Klein- Gordan equation for a charged particle moving in an electromagnetic field. Show that this equation reduces to the Schrodinger equation of motion for the particle in an electromagnetic filed in the non-relativistic limit.

Or

(b) Obtain the Plane wave solution of Dirac's equation.

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