(FOR THE CANDIDATES ADMITTED DURING THE ACADEMIC YEAR 2024-25 ONLY)

SUBJECT CODE 24 PPS 309

REG.NO. :

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

END-OF-SEMESTER EXAMINATIONS : NOVEMBER – 2025

M.Sc. – PHYSICS **MAXIMUM MARKS: 75**

SEMESTER : III **TIME : 3 HOURS**

QUANTUM MECHANICS – II

SECTION – A (10 X 1 = 10 MARKS)

ANSWER THE FOLLOWING QUESTIONS. (K1)

1. Which physical quantity is given by the modulus square of the scattering amplitude?

   a) Potential energy b) Differential cross section
   c) Green's function d) Born approximation

2. Tell which scattering process leads to no change in photon energy……
   a) Raman scattering b) Rayleigh scattering
   c) Compton scattering d) stimulated emission

3. Which matrices are used in the Dirac equation formulation?
   a) Pauli matrices b) Gell-Mann matrices
   c) Dirac gamma matrices d) Levi-Civita matrices

4. Which field equation describes spin-0 particles in quantum field theory?
   a) Dirac equation b) Schrödinger equation
   c) Klein-Gordon equation d) Maxwell's equations

5. **Where** does the concept of a two-particle rigid rotor model apply?
   a) In nuclear decay b) In rotational spectra of diatomic molecules
   c) In neutron stars d) In superconductors

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

6. Recall the condition for the validity of the Born approximation.
7. State the process of absorption and emission of radiation
8. Relate the Klein-Gordon equation to the energy levels of electrons in a Coulomb field.
9. Tabulate the classical and quantum equations of motion for fields.
10. Infer the concept of a hydrogen-like orbital.

SECTION – B (5 X 5 = 25 MARKS)

ANSWER EITHER (a) OR (b) IN EACH OF THE FOLLOWING QUESTIONS. (K3)

11. a) Examine the partial wave analysis method and derive the formula for the total scattering cross-section in terms of phase shifts.

(OR)

b) Assess the validity of the Born approximation in quantum scattering. Derive the condition for its applicability and explain its limitations with examples.

(CONTD…….2)

12. a) Assess the physical significance of Einstein's A and B coefficients.

(OR)

b) Compare Rayleigh and Raman scattering mechanisms.

13. a) Show how the Dirac equation predicts the existence of electron spin.

(OR)

b) Examine the concept of negative energy solutions in the Dirac equation and their implications.

14. a) Explain the quantization procedure for particles using the field approach.

(OR)

b) Interpret the physical meaning of the Dirac field and its quantization.

15. a) Examine the concept of Self-Consistent Field (SCF) in the Hartree-Fock method.

(OR)

b) Apply the Linear Combination of Atomic Orbitals (LCAO) method to form molecular orbitals.

SECTION – C (5 X 8 = 40 MARKS)

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

16. a) Criticize the limitations of non-relativistic scattering theories for high-energy particles.

(OR)

b) Infer how experimental scattering data can be used to deduce inter-particle potentials.

17. a) Elaborate electric dipole approximation in the semi-classical theory of radiation.

(OR)

b) Discuss the origin and quantum mechanical explanation of Rayleigh and Raman scattering. Differentiate between the two processes based on energy, mechanism, and selection rules.

18. a) Evaluate the physical significance of negative energy solutions of the Dirac equation. How did Dirac resolve the issue, and what are the implications for modern physics?

(OR)

b) Explain the concept of spin–orbit coupling in the Dirac theory and analyze its role in the fine structure of hydrogen-like atoms.

19. a) Evaluate the process of quantizing the Klein-Gordon and Dirac fields by constructing the corresponding creation and annihilation operators. Justify how the commutation or anticommutation relations influence the physical interpretation of quantum fields

(OR)

b) Discuss the process of quantizing the Schrödinger field. Construct the corresponding Hamiltonian and number operators.

20. a) Evaluate and justify the use of the Hartree-Fock Self-Consistent Field (SCF) method in determining the electronic structure of multi-electron atoms.

(OR)

b) Formulate the one-particle central force problem in quantum mechanics and explain its relevance to atomic structure.

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