OCTOBER 2011 **P/ID 40005/PPHE**

Time : Three hours Maximum : 100 marks

PART A — (10 × 2 = 20 marks)

Answer ALL questions.

All questions carry equal marks.

1. Define scattering amplitude.
2. Define phase shift of the l-th partial wave.
3. Write down the interaction part of the Hamiltonian in the presence of external electromagnetic field.
4. Write down the normalized ground state wave function of hydrogen atom.
5. Define four momentum.
6. Write down the expression for the probability density associated with Kleign-Gordon equation.
7. Write down the properties of Dirac matrices.
8. Write down the relation connecting total scattering cross section and imaginary part of the scattering amplitude.
9. Discuss how a four vector transforms under a Lorentz transformation.
10. Write down the Lagrangian density associated with Klein-Gordon field.

PART B — (5 × 6 = 30 marks)

Answer ALL questions.

All questions carry equal marks.

11. (a) Discuss in detail the collision between identical particles.

Or

(b) Write down the expression for the scattering amplitude in first Born approximation and express the scattering cross section in the approximation.

12. (a) Use born approximation to find the scattering cross-section for a delta function potential.

Or

(b) A particle which is initially in the ground state of infinite potential well of width L, is subjected to a perturbation $V(x,t) = x^2 e^{-t/\tau}$ where τ is a constant. Calculate the probability of finding the particle in the first excited state.

13. (a) Write a note on Sudden approximation.

Or

(b) Discuss the adiabatic approximation in detail.

14. (a) Write a note on the negative energy states in Dirac theory.

Or

(b) Show that the Dirac matrices are traceless and the eigen values are ±1.

15. (a) Show that the probability density associated with Dirac equation is positive and definite.

Or

(b) Define Hamiltonian function and obtain the equation of motion for a general dynamical variable $F(q, p, t)$.

PART C — (5 × 10 = 50 marks)

Answer ALL questions.

All questions carry equal marks.

16. (a) Outline the perturbation theory for the time evolution of a system. Obtain Fermi's Golden rule for a constant perturbation switched on at $t = 0$.

Or

(b) In the dipole approximation discuss the semi-classical treatment of interaction of an atom with electromagnetic field.

17. (a) Derive the expression for the scattering amplitude in the Born approximation. What further simplification can be done if V is spherically symmetric?

Or

(b) Obtain the relation connecting the differential scattering cross sections in Lab and Center of mass frame.

18. (a) Obtain the differential scattering cross-section, using Fermi's golden rule considering the scattering potential $V(r)$ as a perturbation.

Or

(b) Discuss Harmonic perturbation and derive the expression for transition probability between two states.

19. (a) Construct the Dirac Hamiltonian for the free particle and discuss the properties of Dirac matrices.

Or

(b) Obtain the plain wave solutions of the Dirac equation for the free particle.

20. (a) Obtain the classical field equation in terms of Lagrangian density.

Or

(b) Quantize the Klein-Gordon field with necessary theory.

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