Reg. No .... Name **20P3005**

MSc DEGREE END SEMESTER EXAMINATION - OCT/NOV 2020: JAN 2021

SEMESTER 3 : PHYSICS

COURSE : **16P3PHYT09 : QUANTUM MECHANICS - II**

(For Regular - 2019 Admission and Supplementary - 2016/2017/2018 Admissions)

Time : Three Hours Max. Marks: 75

PART A

Answer all (1 marks each)

1. If H, H_0 are the total Hamiltonian and the unperturbed Hamiltonian respectively and V_I is the perturbing potential in the interaction picture then the state ket in the interaction picture
   (a) depends on V_I (b) depends on H_0
   (c) depends on H (d) is independent of t
2. In the case of a two state system which is initially in the ground state, interacting with the sinusoidal oscillating potential $V(t)$ on resonance with the system, With $c_g(t)$ and $c_e(t)$ denoting the coefficients for the ground state and the excited state respectively, with time the system undergoes
   (a) absorption of energy (b) emission of energy
   (c) both (d) stays in the ground state
3. In scattering theory, the partial wave expansion is suitable for particles with
   (a) medium energy (b) all energy
   (c) low energy (d) high-energy
4. If σ is the Pauli matrices and $\vec{A}$ and $\vec{B}$ are vectors then $(\vec{\sigma} \cdot \vec{A})(\vec{\sigma} \cdot \vec{B})$ =
   (a) $\vec{A} \cdot \vec{B}$ - i $\vec{\sigma} \cdot (\vec{A} \times \vec{B})$ (b) $\vec{\sigma} \cdot (\vec{A} \times \vec{B})$ - i $(\vec{A} \cdot \vec{B})$
   (c) $\vec{\sigma} \cdot (\vec{A} \times \vec{B})$ + i $(\vec{A} \cdot \vec{B})$ (d) $\vec{A} \cdot \vec{B}$ + i $\vec{\sigma} \cdot (\vec{A} \times \vec{B})$
5. For a system of Bosons the valid relation is
   (a) $[a_k, a_l^\dagger] = \delta_{kl}$ (b) $\{a_k, a_l^\dagger\} = \delta_{kl}$
   (c) $[a_k, a_l^\dagger] = 0$ (d) $\{a_k, a_l^\dagger\} = 0$

(1 x 5 = 5)

PART B

Answer any 7 (2 marks each)

6. Define transition probability.
7. Show that the transition probability is the same in Schrodinger and Interaction picture.
8. What is dipole approximation?
9. What are partial waves in scattering theory?
10. State the meaning of resonance scattering.
11. Write the optical theorem in scattering theory.
12. What is meant by large and small components in relativistic quantum mechanics.
13. Show that $\{\gamma_2, \gamma_2\} = 2$
14. Distinguish between a function and a functional.
15. What is a Poisson bracket? write the equation of motion in terms of the Poisson bracket.

(2 x 7 = 14)

PART C
Answer any 4 (5 marks each)

16. Using time dependent perturbation theory solve a two state problem interacting with a sinusoidal potential.
17. A system in an unperturbed state n is suddenly subjected to a constant perturbation H'(r) which exists during time t $\rightarrow$ 0. Find the probability for the transition from state n to state k and show that it varies harmonically.
18. In the Born approxiamtion, derive the scattering amplitude for scattering from a square well potential, $V(r) = -V_0$ for $0 < r < r_0$ and $V(r) = 0$ for $r > 0$.
19. Determine the current density and the charge density on the basis of Klein Gordon equation.
20. Show that Klein Gordon equation leads to negetive probability density.
21. Distinguish between second quantization of Bosons and Fermions.

(5 x 4 = 20)

PART D
Answer any 3 (12 marks each)

22.1. Discuss the sudden approximation method.

OR

2. Discuss time dependent Perturbation theory and deduce Fermi's Golden Rule.

23.1. Explain resonances in scattering theory. with a neat diagram explain how metastable bound states are formed.

OR

2. Obtain the expression for the differential scattering crosssection when the energy of the incident particle is small compared to the energy of the scattering potential.

24.1. In relativistic quantum mechanics show that the total angular momentum is a constant of motion.

OR

2. Discuss the quantisation of a relativistic spinor field.

(12 x 3 = 36)