19P3005

Reg. No .... Name ....

MSc DEGREE END SEMESTER EXAMINATION - OCTOBER 2019

SEMESTER 3 : PHYSICS

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

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

Time : Three Hours Max. Marks: 75

Section A
Answer all Questions (1 marks each)

1. If $U_I(t, t_0)$ and $U_S(t, t_0)$ denotes the time evolution operator in the interaction picture and the schrodinger picture respectively then
   (a) $\langle n|U_I(t,t_0)|i\rangle = \langle n|U_S(t,t_0)|i\rangle$ (b) $|\langle n|U_I(t,t_0)|i\rangle|^2 = |\langle n|U_S(t,t_0)|i\rangle|$
   (c) $|\langle n|U_I(t,t_0)|i\rangle|^2 = |\langle n|U_S(t,t_0)|i\rangle|^2$ (d) $|\langle n|U_S(t,t_0)|i\rangle|^2 = |\langle n|U_I(t,t_0)|i\rangle|\}$
2. If the state ket in the schrodinger picture is given by $|\alpha, t_0; t\rangle_s$ then the state ket in the interaction picture is
   (a) $|\alpha, t_0; t\rangle_s$ (b) $|\alpha, t_0; t\rangle_s e^{-iH_0t/\hbar}$
   (c) $|\alpha, t_0; t\rangle_s e^{iH_0t/\hbar}$ (d) $|\alpha, t_0; t\rangle_s e^{iHt/\hbar}$
3. V_0 and E denotes the potential and the energy of the incident particles, then Born approximation is valid only when
   (a) $\frac{V_0}{E} \ll 1$ (b) $\frac{E}{V_0} \ll 1$
   (c) $\frac{V_0}{E} \gg 1$ (d) $E \backsim 0$
4. σ is the Pauli matrix then H^{spin} which is the interaction hamiltonian for the electron spin with the applied magnetic field B is
   (a) (e$\hbar$/2mc) $\vec{\sigma} \cdot \vec{B}$ (b) (e$\hbar$/2mc) $\vec{\sigma} \times \vec{B}$
   (c) (- e$\hbar$/2mc) $\vec{\sigma} \cdot \vec{B}$ (d) (- e$\hbar$/2mc) $\vec{\sigma} \times \vec{B}$
5. The generalized momentum p_i conjugate to the generalized coordinate q_i is
   (a) $\frac{\partial L}{\partial \dot{q}}$ (b) $\frac{\partial L}{\partial q}$
   (c) $\frac{\partial L^2}{\partial q}$ (d) $\frac{\partial L^2}{\partial \dot{q}}$

(1 x 5 = 5)

Section B
Answer any 7 (2 marks each)

6. Distinguish between stimulated emission and spontaneous emission.
7. Sate Fermis golden rule.
8. Explain electric dipole approximation in time dependent perturnation theory.
9. Explain hard sphere scattering.
10. Define differential scattering cross section and total scattering cross section.
11. Explain Ramsauer - Townsend effect.
12. Write down the Dirac matrices.

14. What is the need for quantum field theory?
15. Write the classical lagranges equation of motion and explain it.

(2 x 7 = 14)

Section C
Answer any 4 (5 marks each)

16. Derive the differential cross section for photoelectric effect.
17. In the case of Harmonic perturbation, show that the transition rate for a transition from the ground state $|g\rangle$ to the excited state $|e\rangle$ is same as that from $|e\rangle$ to $|g\rangle$.
18. Discuss S wave scattering in the case of a hard sphere and arrive at the S-wave total cross section.
19. Deduce Klein Gordon wave equation for a free particle.
20. For a Dirac particle moving in a central potential show that the orbital angular momentum is not a constant of motion.
21. Discuss canonical quantisation procedure.

(5 x 4 = 20)

Section D
Answer any 3 (12 marks each)

22.1. In the interaction picture derrive the basic coupled differential equation and solve it in the case of a two state problem with the unperturbed Hamiltonian(H_0) and the perturbing potential (V(t)) given by
$H_0 = E_1|1\rangle\langle 1| + E_2|2\rangle\langle 2|$ with $E_2 > E_1$
$V(t) = \gamma e^{i\omega t}|1\rangle\langle 2| + \gamma e^{-i\omega t}|2\rangle\langle 1|$
respectively. Also explain the results.

OR

2. Explain the interaction of an atom with electromagnetic field using time dependent perturbation theory.

23.1. Obtain Rutherford scattering formula by applying first Born approximation.

OR

2. Describe the s wave scattering by a rectangular potential.

24.1. Discuss the relativistic covarience of Dirac equation. Show that spin angular momentum emerge as a natural consequence of angular momentum conservation in quantum mechanism.

OR

2. (a) Derive the Hamiltonian form of the equations of motion (b) Derive the Lagrangian form of the equations of motion.

(12 x 3 = 36)