K23P 1422

Reg. No. : .....

Name : .....

III Semester M.Sc. Degree (CBSS – Reg./Supple./Imp.)
Examination, October 2023
(2020 Admission Onwards)
PHYSICS
PHY3C10 : Quantum Mechanics – II

Time : 3 Hours Max. Marks : 60

SECTION – A

Answer **both** questions (either **a** or **b**).

1. a) i) Define scattering amplitude and differential scattering cross section. **3**

   ii) Explain the method of partial wave analysis and apply it to the case of quantum mechanical scattering of low energy incident particles due to a spherically symmetric potential. Hence arrive at the asymptotic form of total scattering cross-section and get the optical theorem. **9**

   OR

   b) i) Explain the principle of identical particles and use it to obtain the energy states of helium atom.

   ii) Explain the scattering of identical particles. **(6+6)**

2. a) Establish the correctness of the Dirac equation as the relativistic wave equation of spin half particles, by applying it to explain the spectra of hydrogen atom. **12**

   OR

   b) Explain the major steps in the formulation of Lagrangian field theory. Obtain classical field equation in terms of the Lagrangian density. Obtain the equivalent expression in terms of Lagrangian. **12**

(2×12=24)

P.T.O.

SECTION – B

Answer **any four** questions. **1** mark for Part **a**, **3** marks for Part **b** and **5** marks for Part **c**.

3. a) Write the expression for the Hamiltonian of an electron in an electromagnetic field characterized by the potentials φ and A.

   b) Explain time-dependent perturbation theory. Give an expression for first order contribution to the coefficient $c_n(t)$ in terms of $H'(r, t)$. What will be its form if the system is initially at $t = 0$?

   c) A system in an unperturbed state n is suddenly subjected to a constant perturbation $H'(r)$ which exists during time $0 \rightarrow t$. Find the probability for transition from state n to state k and show that it varies simple harmonically with angular frequency $(E_k - E_n)/2\hbar$ and amplitude $4\,|H'_{kn}|^2/(E_k - E_n)^2$.

4. a) Write the formula for differential scattering cross-section in a weak potential that makes use the first order Born approximation.

   b) Derive the above formula.

   c) Calculate the differential and total scattering cross-sections in the Born approximation in the potential $V(r) = V_0 \dfrac{e^{-r/R}}{r}$ known as Yukawa potential.

5. a) What is meant by exchange degeneracy ?

   b) Describe how symmetric and anti-symmetric wave functions are constructed from an unsymmetrized solution of the Schrodinger equation for a system of indistinguishable particles.

   c) Show that identical particles represented by anti-symmetric wave functions obey Pauli's exclusion principle.

6. a) Write the covariant form of the Dirac equation.

   b) Show that a Dirac particle has spin ½.

   c) Show that in the non-relativistic limit, Dirac equation reduces to Pauli equation for electron.

7. a) What is meant by a gauge theory ?

   b) Distinguish between World-Space and Minkowski-Space formulations. What are the expected advantages of World-Space formulation in quantum field theory ?

   c) For a system of fermions, show that the occupation number n_k must be restricted to 0 and 1.

8. a) Write down the expression for resultant quantum mechanical state after a measurement that yield an eigenvalue a of an observable that is related with the initial state ψ and projection operator Π_a corresponding to a.

   b) Write a short note on Von Neumann's theorem concerning with quantum mechanical description of elementary processes. Explain its drawback.

   c) State Bell's inequality and Bell's theorem. Derive the inequality. **(4×9=36)**

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