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.

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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)