Ref. No. Ex/PG/SC/CORE/PHY/TH/105/2022

Master of Science (Phys.) Examinations 2022

(1st Year, 2nd Semester)

Subject : Quantum Mechanics-II

Time: Two hours **Full Marks: 40**

Answer any four questions

1. (a) What is the metric tensor, $g_{\mu\nu}$? How do you calculate the elements of the inverse of a metric tensor? (b) What is *d'*Alembertian operator? (c) Express the Klein-Gordon equation in the non-relativistic limit. (d) Obtain (i) the probability current and (ii) the continuity equation corresponding to the Klein-Gordon equation. 4+1+2+3

2. (a) What is the Born approximation to calculate the scattering amplitude in presence of a spherically symmetric potential. (b) The scattering amplitude is expressed as the following summation,

   $f(k, k') = \sum f^{n} (k', k)$.

   With the help of the expansion of the transition operation T show that the second order correction $f^{(2)}$ is related to the Green's function associated to the Helmholtz equation. (c) Using a suitable diagram explain different terms $f^{(n)}$ where n = 1, 2, 3 related to the multistep scattering process.

   2+6+2

3. (a) How many transposition operators are there in a physical system consisting of three (N=3) identical particles? Following the basic action of the permutation operator explain whether any two transposition operators for N=3 commute or not. (b) Show that the decomposition of $\mathbf{P}_{312}$ is not unique. (c) What is an antisymmetrizer (**A**)? How an

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antisymmetrizer can be used to understand the Pauli's exclusion principle? 4+3+3

4. (a) Following the formulation by Ritz prove that $\mathbf{H}\,|\psi\rangle = \langle H\rangle|\psi\rangle$? (b) Suggest a suitable trial function which can be used to calculate the ground state energy of Helium atom. How many parameters are there in your suggested trial function required for the variational method? By using a suitable trial function and applying the same method calculate the ground state energy of the Helium atom. 3+7

5. (a) Establish a relation between the imaginary part of the forward scattering amplitude and the total cross section (σ_{tot}). (b) What is the Eikonal approximation? Hence obtain an expression for $f(k', k)$ in terms of the impact parameter, b. 4+6