Exam.Code:0474
Sub. Code: 3720

2022
M.Sc. (Physics)
Third Semester
PHY-8035: Quantum Mechanics – II

Time allowed: 3 Hours Max. Marks: 60

***NOTE**: Attempt five questions in all, including Question No. 9 (Unit-V) which is compulsory and selecting one question each from Unit I - IV.*

x-x-x

UNIT-I

1. (a) Assuming the potential energy for scattering of an electron by an atom as the shielded Coulomb field

$$V(r) = \frac{Ze^2}{r} e^{-\frac{r}{a}}$$

Show that the Born scattering amplitude is

$$f(\theta) = \frac{-2mZe^2}{\hbar^2 K^2}\left[1 + \frac{1}{1+(Ka)^2}\right] \text{ where } K = 2k\sin\frac{\theta}{2}$$ **(5)**

(b) State and prove Optical Theorem. **(7)**

2. (a) Obtain the solution of the equation $(\nabla^2 + k^2)\, G(r, r') = -4\pi\delta(r-r')$ through Green's function method. **(7)**

(b) What are identical particles? From scattering of identical particles, how can one infer the spin of particles? **(5)**

UNIT-II

3. (a) Obtain the non-relativistic limit of Dirac equation for electron interacting with electromagnetic field. **(6)**

(b) Prove that total angular momentum operator commutes with Dirac Hamiltonian in a central field. **(6)**

4. (a) Develop Klein Gordon equation for a spin zero particle and construct the continuity equation. Hence define the probability and current densities. **(6)**

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(b) Explain how the spin and magnetic moment of the electron are obtained in Dirac's relativistic theory. **(6)**

UNIT-III

5. (a)Write down the Lagrangian for complex scalar field. Obtain the Euler Lagrange equations of motion. **(6)**

   (b) Show how we obtain the quantized form of Hamiltonian of the Dirac field. Discuss the result. **(6)**

6. (a) Develop the Lagrangian for non relativistic field. Construct the Euler Lagrange equation of motion. **(6)**

   (b) Describe the terms:

   (i) Annihilation Operator (ii) Creation Operator (iii) Number Operator. **(6)**

UNIT-IV

7. (a) Write down the Lagrangian for electromagnetic field. Obtain the equations of motion. **(6)**

   b) Describe the terms

   (i) Time-ordered product (ii) Normal-Ordered product (iii) Feynman diagrams **(6)**

8. (a) Establish the rules of quantization for Dirac Field. **(6)**

   (b) State the commutation relations used for quantizing Dirac field. **(6)**

UNIT-V

9. Attempt all parts:

   a) Define scattering cross section.

   b) What is second quantization?

   c) Write note on S-matrix.

   d) What are Green functions?

   e) Distinguish incoming and outgoing waves.

   f) What is Zitterbewegung? **(6×2=12)**

X-X-X