K24P 3349

Reg. No. : .....

Name : .....

III Semester M.Sc. Degree (C.B.S.S.-Supple./Imp.)
Examination, October 2024
(2021 and 2022 Admissions)
PHYSICS
PHY3C10 : Quantum Mechanics – II

Time : 3 Hours Max. Marks : 60

SECTION – A

Answer **both** questions (either A or B).

1. A) Briefly describe time dependent perturbation theory. Applying this theory, evaluate the transition probability for a constant perturbation.

   OR

   B) Explain the role of symmetry of wave functions of identical particles using the singlet and triplet states of Helium atom.

2. A) Evaluate the differential scattering cross section in the first Born approximation for a Coulomb potential $V(r) = \frac{Z_1 Z_2 e^2}{r}$ where $Z_1 e$ and $Z_2 e$ are the charges of the projectile and target particles respectively.

   OR

   B) Obtain the free particle solution of Dirac's equation. What is Dirac spinor ?

(2×12=24)

SECTION – B

Answer **any four**. (**1** mark for Part **A**, **3** marks for Part **B**, **5** marks for Part **C.**)

3. A) What is electric dipole approximation ?

   B) Mention the selection rules for electric dipole transitions.

   C) State which of the following transitions are allowed and give reasons.

   i) $1s \rightarrow 2s$ ii) $1s \rightarrow 2p$ iii) $2p \rightarrow 3d$ iv) $3s \rightarrow 5d$

P.T.O.

4. A) Distinguish between centre of mass frame and lab frame. How differential scattering cross section and total scattering cross section vary in them ?

   B) What is the significance of phase shift in partial wave analysis of elastic scattering ?

   C) Consider the elastic scattering of 50 MeV neutrons from a nucleus. Te phase shifts measured in the experiment are $\delta_0 = 95°$, $\delta_1 = 72°$, $\delta_2 = 60°$, $\delta_3 = 35°$, $\delta_4 = 18°$, $\delta_5 = 5°$ and all other phase shifts are negligible. Calculate the total scattering cross section. (Given $M_n c^2 = 939.57$ MeV, $\hbar c = 197.33$ MeV fm).

5. A) What are identical particles ?

   B) What is particle exchange operator ? Mention its properties.

   C) Show that $\hat{P}_{ij}\hat{P}_{ik} = \hat{P}_{jk}\hat{P}_{ji} = \hat{P}_{ik}\hat{P}_{jk}$ for a three particle system.

6. A) If $\sigma' = \begin{pmatrix} \sigma & 0 \\ 0 & \sigma \end{pmatrix}$ show that $\sigma'^2_x = \sigma'^2_y = \sigma'^2_z = 1$.

   B) Show that $[\sigma'_x, \alpha_x] = 0$ and $[\sigma'_x, \alpha_y] = 2i\alpha_z$.

   C) Check whether $\sigma' = \begin{pmatrix} \sigma & 0 \\ 0 & \sigma \end{pmatrix}$ is a constant of motion.

   (Given σ is the Pauli matrix and α_x, α_y, α_z are the Dirac matrices.)

7. A) Write down Dirac equation.

   B) Obtain the covariant form of Dirac equation.

   C) Show that the angular momentum associated with the orbital motion of a particle is not a constant of motion.

8. A) What are the conditions for completeness and physical reality as per Einstein's concept ?

   B) Outline Bohr's explanation of EPR paradox.

   C) Describe Bell's inequalities and Bell's theorem.

(4×9=36)
