

Third Semester M.Sc. in Physics Examination, October 2015
QUANTUM MECHANICS – 2

Time : 3 Hours

Max. Marks : 80

Instruction : Answer all questions.

1. a) Show that in the stationary state perturbation theory, if the Hamiltonian can be written $H = H^0 + H^1$ with $H^0 \psi_n^0 = E_n^0 \psi_n^0$, then the first order correction to energy is $E_n^1 = \langle \psi_n^0 | H^1 | \psi_n^0 \rangle$ and to the wave function is

$$\psi_n^1 = \sum_{m \neq n} \frac{\langle \psi_n^0 | H^1 | \psi_m^0 \rangle}{E_n^0 - E_m^0} \psi_m^0.$$

10

- b) The unperturbed wave functions for the infinite square well are

$$\psi_n^0(x) = \sqrt{\frac{2}{a}} \sin \frac{n\pi x}{a}, \text{ calculate the first order correction to energy if the floor of the well is raised by a constant potential } V_0.$$

5

OR

2. a) Show a single energy level split in to two energy levels according to degenerate perturbation theory.

10

- b) Present a short note on Zeeman effect.

5

3. a) Define total scattering cross section and differential scattering cross section.

4

- b) Obtain an expression for differential scattering cross section from the asymptotic form of wave function.

11

OR

4. a) Obtain expression for scattering cross section for Yukawa potential using Born approximation.

10

- b) Discuss why 'Born approximation cannot be applied to Coulomb potential'.

5



5. a) Distinguish between laboratory and center of mass coordinate systems. Obtain the relation connecting the differential cross sections in these two systems. 10

- b) Write a note on types of collisions. 5

OR

6. a) Define Dirac matrices and discuss the relations among them. 10

- b) Setup Klein-Gordan equation. 5

7. a) Starting from the Lagrangian formalism of fields, arrive at the Euler-Lagrangian equations. 10

- b) Write a note on quantization of electromagnetic fields. 5

OR

8. a) Arrive at the matrix element and hence draw Feynman diagram for coulomb scattering. 10

- b) Write common rules to draw Feynman diagram. 5

9. Answer any four of the following : **(4×5=20)**

- a) What is the degeneracy of Hydrogen atom energy level with quantum number 'n' ?

- b) A simple harmonic oscillator is perturbed by the Hamiltonian $(a + bx + cx^2)$, Calculate the first order correction to energy to the n^{th} energy level.

- c) Discuss time dependent potentials and their importance.

- d) Discuss the motion of a charged particle in weak magnetic field using its Hamiltonian. •

- e) Write a note on impact factor.

- f) Discuss Green's function.

- g) Find the expectation values of

i) $\hat{a}^\dagger \hat{a} \hat{a}^\dagger \hat{a}$

ii) $\hat{a} \hat{a}^\dagger \hat{a}^\dagger \hat{a}^\dagger$.

- h) Write a note on Fock states.