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III Semester M.Sc. Degree Examination, November 2006
Branch – II : PHYSICS
PH 231 : Quantum Mechanics

Time: 3 Hours Max. Marks: 75

PART – A

Answer **any five** questions. **Each** question carries **3** marks.

1. a) Show that the components of orbital angular momentum operators satisfy the relation $\vec{L}\times\vec{L} = i\vec{L}$.

   b) What is meant by adiabatic approximation ?

   c) State Wigner – Eckast theorem and explain its significance.

   d) State and explain Fernois Golden rule.

   e) Write a note on Lamb Shift.

   f) Show that $\gamma_\mu\gamma_\upsilon\gamma_\mu = -2\gamma_\gamma$ where $\gamma_\mu, \gamma_\upsilon$ are Dirac's gamma matrices. (There is summation over repeated indices.)

   g) Show that $[a_k, N_k] = a_k$ and $\left[a_k^+, N_k\right] = -a_k^+$ where a_k, a_k^+ and N_k are the bosonic annhilation, creation and number operators. **(5×3=15 Marks)**

PART – B

Answer **all** questions. **Each** carries **15** marks.

2. a) i) Obtain the common Eigen states of the angular momentum operators J^2 & J_z for a particle. Comment on the nature of the eigen values.

   ii) Show that $J_+ J_- = J^2 + \hbar J_z - J_z^2$ where $J_\pm = J_x \pm i J_y$.

   OR

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b) Use the first order perturbation theory to find out the energy levels of the ground state of the Helium atom. How are the results modified if one uses the variation technique ?

3. a) What is Born approximation ? Apply it to obtain the differential cross section for a square well potential and discuss its validity.

OR

b) i) What is meant by electric dipole transition ?

ii) Obtain expressions for transition probability of spontaneous and induced emission of radiation for such transitions.

4. a) i) Deduce the Dirac equation for a free particle. Show how the relations of this equation predict the existence of positron.

ii) Show that the Dirac α and β matrices need to be at least 4×4 matrices.

OR

b) i) Explain the principle of indistinguishability of identical particles. Considering the case of a system of two identical particles show that the wave function is either symmetric or antisymmetric.

ii) Taking the atom as an example show that the singlet state is always higher in energy than the triplet state. **(3×15=45 Marks)**

PART – C

Answer **any three** questions. **Each** question carries **5** marks.

5. a) Evaluate the Clebsch-Gordon Coefficient C(121; 1-2-1) using its symmetry properties given C(112 : 112) = 1.

b) Assuming that a perturbation $H^1 = CX$ (C being a constant) is applied to a particle in a one dimensional box of side L. Show that the first order correction to its energy is $\frac{CL}{2}$.

c) Show that the zero energy scattering cross section for scattering by hard sphere of radius 'a' is $4\pi a^2$.

d) Write down the different spin wave functions for a two electro system whose interaction is negligible.

e) Obtain the canonically conjugate momentum density and the Hamiltonian density for the given Lagrangian field density $L = A\phi^2 + B(\partial_\mu \phi)^2; \mu = 1,2,3,4$ for the scalar field ϕ. Treat A and B as constants. **(3×5=15 Marks)**

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