MANAV RACHNA UNIVERSITY

DEPARTMENT OF PHYSICS

"T3-Examination, May-2018"

Semester: 2nd
Subject: Quantum Mechanics-II
Branch: Physics
Course Type: Core
Time: 3 Hours
Max.Marks: 100

Date of Exam: 24/05/2018
Subject Code: PHH508
Session: I
Course Nature: Hard
Program: M.Sc.
Signature: HOD/Associate HOD:

PART A (20 marks)

Q1

a) Define differential cross section. Why is it easier to do calculations in centre of mass frame? **(2 marks)**

b) State Fermi Golden Rule and explain its significance. **(2 marks)**

c) What is the method of Partial Wave Analysis? Apply it to calculate the differential cross section and hence show that the total cross section is given by **(8 marks)**

$$\sigma = \sum_{l=0}^{\infty} \sigma_l = \frac{4\pi}{k^2} \sum_{l=0}^{\infty} (2l+1) \sin^2 \delta_l.$$

OR

Derive the relation connecting the angles in the Lab frame of reference with those in Centre of Mass Frame of reference. How are the cross sections related in the two frames of references?

d) Explain the variational ansatz and apply it to 1-D Harmonic Oscillator to determine its ground state energy and normalized wave function. **(8 marks)**

OR

What is time dependent perturbation theory. Derive the Fermi Golden Rule.

PART B (40 marks)

Q2

a) ^{4}He(alpha particle) is a boson while ^{3}He is a fermion. Explain. **(2 marks)**

b) For a system of three non-interacting identical particles construct the symmetric & anti symmetric wave functions. **(2 marks)**

c) Specify the symmetry of the following functions: **(2 marks)**

(a) $\psi(x_1, x_2) = 4(x_1 - x_2)^2 + \frac{10}{x_1^2 + x_2^2}$.

(b) $\phi(x_1, x_2) = -\frac{3(x_1 - x_2)}{2(x_1 - x_2)^2 + 7}$.

(c) $\chi(x_1, x_2, x_3) = 6x_1x_2x_3 + \frac{x_1^2 + x_2^2 + x_3^2 - 1}{2x_1^2 + 2x_2^2 + 2x_3^2 + 5}$.

(d) $\Phi(x_1, x_2) = \frac{1}{x_2 + 3} e^{-|x_1|}$.

d) What is a Slater Determinant? How would you explain Pauli's exclusion principle using Slater Determinant? **(2 marks)**

e) Find the wave functions of two systems of identical, non interacting particles: the first consisting of two bosons and the second of two spin 1/2 fermions. **(2 marks)**

Q3 Consider the case of Boron and Carbon : determine the possible ground states for these two atoms and explain the lowest energy state? What is screening effect? In which atoms is it felt? Specify the total angular momenta corresponding to ^4G, ^3H, and ^1D. Find the spectroscopic notation for the ground state configurations of aluminum Al (Z=13) and scandium Sc (Z=21). **(15 marks)**

Q4 Determine the scattering amplitude for the case of scattering by a square well potential. Explain the optical theorem. **(15 marks)**

PART C (40 marks)

Q5

a) State Maxwell's equation. **(2 marks)**

b) Explain the scalar & vector potentials and the Gauge Transformation. **(2 marks)**

c) Define spontaneous and stimulated emission. **(2 marks)**

d) What is Dirac representations of wave functions and operators in quantum mechanics. **(2 marks)**

e) A constant (time independent) perturbation neither removes energy from the system nor supplies energy to it, It simply causes energy-conserving transitions. Explain. **(2 marks)**

Q6 Compare and contrast the frequently used 3 pictures of quantum mechanics and determine the equations of motion for each one. **(15 marks)**

Q7 Electromagnetic radiation of vector potential A(r, t) and electric potential ϕ (r, t) is applied on an atom. Determine the transition probability and plot them. What is the condition of Resonance? **(15 marks)**