PG/IVS/PH-2201/10

M.Sc 4th Semester Examination, 2010

PHYSICS

PAPER — PH - 2201 (A & B)

Full Marks : 40

Time : 2 hours

The figures in the right-hand margin indicate marks

Paper — PH-2201 A

Marks : 20

Time : 1 hour

Answer **Q. No. 1**, **2** and any **one** from the rest

1. Answer any *two* bits : 2×2

(*a*) Write the wave function for a system of three non-interacting identical fermions and show that they follow Pauli principle.

(*Turn Over*)

(*b*) Six non-interacting particles are confined to a potential

$$V(x) = \begin{cases} \infty \text{ for } 0 > x > a \\ 0 \text{ for } 0 < x < a. \end{cases}$$

What is the ground state energy if the particles are (*i*) bosons (*ii*) fermions?

(*c*) Define scattering length. How is it related to zero energy scattering cross-section?

2. Answer any *two* bits: 3×2

(*a*) Write the zeroth order wave function for the excited state of the Helium atom (1s, 2s). Which of the two states singlet or the triplet will have lower energy and by how much?

(*b*) Find an expression for the plane wave in terms of partial waves.

(*c*) Show that an attractive potential leads to a positive phase shift while a repulsive potential leads to a negative phase shift.

3. (*a*) What do you mean by central field approximation? What do you understand by self consistent potential? Explain Hartree method of finding the self consistent potential in an atom.

(*b*) Write the form of spin orbit coupling term in the Hamiltonian. Find the change in energy in the ground state ($l=0$ i.e. s state) and the first excited state ($l=1$ i.e. p state) in an alkali metal atom to first order in the spin orbit coupling potential.

(*c*) In the first excited state ($l=1$ i.e. p state) in an alkali metal atom show the Zeeman splitting of the levels. 4 + 3 + 3

4. (*a*) In the scattering of a two particle system, set up the Schrödinger equation and obtain the integral equation for the wave function. Derive a relation for the scattering amplitude using first Born approximation.

(*b*) Using Born approximation find scattering cross-section for scattering of particles of charge *ne* by an atomic nucleus of charge *ze*. The interaction potential between the two is usually screened by the atomic electrons surrounding the nucleus. The potential representing the interaction is given as: 7 + 3

$$U(r) = -\frac{nze^2}{r} \; e^{-\alpha r}.$$

Paper—PH-2201 B

Marks : 20

Time : 1 hour

Answer **Q. No. 1** and any **one** from the rest

1. Answer any *five* from the following: 2 × 5

(*a*) Explain the term 'degenerate' electron gas.

(*b*) Explain phase transition in terms of modern classification.

(*c*) How Bragg William approximation predicts MFA?

(*d*) If

$$C_V = \frac{\pi^2}{2} NK_B \frac{T}{T_F}$$

calculate entropy as a function of temperature.

(*e*) Explain Landau energy levels and how degeneracy depends on magnetic field ?

(*f*) Draw pressure vs. temperature plot for BE and FD gases.

(*g*) What are critical exponents ?

(*h*) Explain the term 'symmetry breaking' for para-ferro transition.

2. (*a*) Define long range and short range order parameter.

(*b*) Prove that temperature dependance of long range order parameter for Ising spin–system in a magnetic field $\vec{H} = \hat{e}_z H$ is given by

$$L(T) = \tanh \beta(J_e\ rL + \mu_0 H)$$

where r = no. of *n. n.* and other symbols have usual meanings.

(*c*) Also prove that

$$L = \frac{\sqrt{3(T_c - T)}}{T_c}$$

near transition temperature. 2 + 5 + 3

3. (*a*) Prove that two-dimensional ideal B-E gas can not undergo B-E condensation.

(*b*) Write down the expression for free energy of FD gas under magnetic quantization. Prove that degree of degeneracy is given by

$$g = L_x L_y \, H / \frac{hc}{e}$$

for a two-dimensional system of dimension L_x, L_y with magnetic field H.

(*c*) Write down an expression for isothermal susceptibility according to G-L theory of phase transition and explain all the terms. 4 + 4 + 2
