2008

PHYSICS

PAPER—PH 2201 A & B

Full Marks : 40

Time : 2 hours

The figures in the right-hand margin indicate marks

Candidates are required to give their answers in their own words as far as practicable

Illustrate the answers wherever necessary

GROUP—A

(*Quantum Mechanics*)

[*Marks* : 20]

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

1. Answer any *two* bits: 2×2

(*a*) Show the 1_p - 1_s transition of an atom placed in a magnetic field $\vec{B}$ along z-axis.
(The 1_p and 1_s corresponds to $s = 0$)

(*b*) Obtain an expression for phase shift δ_0 for s wave scattering by the potential

$$V(r) = \begin{cases} \infty & \text{for } 0 \leq r \leq a \\ 0 & \text{for } r > a \end{cases}$$

(*c*) Indistinguishability of identical particles lead to symmetric or antisymmetric nature of wave functions. — Justify.

(*d*) If the s-wave phase shift suffered by an extremely low energy electron (0·001 a.u. of energy) by a spherically symmetric potential be 10°, then calculate the scattering length and total scattering cross-section of the scattering process. In a.u. $e = m = \hbar = 1$.

2. Answer any *two* bits: 3x2

(*a*) Two non-interacting electrons having same spin state are in a infinite potential well defined by

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

Write the Hamiltonian for the system. Find the lowest energy state and the corresponding wave function.

(*b*) Prove the optical theorem

$$\sigma_{tot} = \frac{4\pi}{k} I_m [\, f(0) \,].$$

Where symbols carry their usual meaning, $I_m[\, f(0) \,]$ in the imaginary part of forward scattering amplitude.

(*c*) Find an expression for estimating the potential energy in a multielectron system using Thomas - Fermi model of the atom.

3. (*a*) Obtain an expression for scattering amplitude using integral equation and Green's function. Simplify the expression using first Born approximation for the wave function.

(*b*) Derive Rutherford's scattering formula for scattering from a pure Coulomb potential

$$V(r) = \frac{-zz'e^2}{r} e^{-\alpha r}.$$ 10

4. (*a*) Write the Hamiltonian for an alkali atom in presence of a magnetic field taking into account the spin-orbit term.

(*b*) In absence of the magnetic field calculate the doublet separation for states with definite l ($l \neq 0$). What will be the effect of spin orbit term for the state with $l = 0$.

(*c*) Find the splitting of the energy level of the $^2p_{3/2}$, $^2p_{1/2}$ and $^2s_{1/2}$ states in presence of the magnetic field. Show all allowed transitions involving the above transitions. 10

GROUP—B

(*Statistical Mechanics*)

[*Marks* : 20]

Answer any *two* questions

1. (*a*) Derive expressions for the pressure, specific heat at constant volume and the number of particles in the excited states of a Bose gas below the condensation temperature.

   (*b*) Find out an expression for free energy of F.D gas under magnetic quantization. (2 x 3) + 4

2. (*a*) Discuss Bragg-William approximations and show that the equilibrium value of long range order parameter is given by

$$L(T) = \tanh \mu_0 \beta H_{eff}.$$

   (*b*) From the above expression also prove that the temperature dependance of long range order parameter predicts the 2nd kind phase transition as well as characteristic of MFA (mean field approximation). 6 + 4

3. (*a*) Find out an expression for the carrier statistics for 2D Fermi gas.

(*b*) From Planck's radiation law formulate Rayleigh - Jean's and Wien's laws respectively.

(*c*) Prove that BE condensation is a 1st order phase transition (According to Ehrenfest) and 3rd order phase transition (according to Landaue). 3 + 3 + (2 + 2)