M.Sc. 4th Semester Examination, 2013

PHYSICS

PAPER — PHS-401(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

Use separate scripts for Gr. — A & B

GROUP — A

[ Marks : 20 ]

Time : 1 hours

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

1. Answer any five :

   2 × 5

   (a) Write and interpret the integral equation showing the causal relationship between the

   (Turn Over)
wave functions at two different times via a Green's function.

(b) Write the antisymmetric wave function of $n$ non-interacting electrons in the form of a determinant and show that it is consistent with Pauli's exclusion principle.

(c) Explain the reason behind the fact that five of the six $3d$ electrons in iron have parallel spins so that each iron atom has a large resultant magnetic moment.

(d) What is the difference between the Hartree and the Hartree-Fock methods so far as the many-electron wave function is concerned?

(e) State Koopmans' theorem.

(f) Estimate the Zeeman splitting $\Delta v$ of hydrogen spectral lines in a magnetic field of 1 weber/m$^2$.

\[
\left[ \text{Given, } \frac{e\hbar}{2m} = 9.3 \times 10^{-24} \text{ J/weber/m}^2, \right.
\hbar = 6.6 \times 10^{-34} \text{ J.s} \]

PG/IVS/PHS-401/13 (Continued)
(g) What do you mean by phase shift in a scattering experiment? Explain the nature of phase shift in case of attractive and repulsive scattering potentials.

(h) Establish the selection rules for electric dipole transition.

2. Consider the scattering of a particle by a potential $V(r)$.

(a) Write the Lippmann-Schwinger integral equation for the wave function of the scattered particle.

(b) Set up the Born series as a solution of the Lippmann-Schwinger equation. What is the drawback of this procedure of solution?

(c) Discuss the fredholm method of solution of the Lippmann-Schwinger equation. $2 + (2 + 1) + 5$

3. (a) Establish the expression of a plane wave in terms of spherical waves.

(b) In the partial wave analysis of scattering find the criterion for determining the significant number of spherical waves.
(c) Obtain an expression for the phase shift $\delta_0$ for $s$-wave scattering by the potential

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

GROUP — B

[ Marks : 20 ]

Time : 1 hours

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

1. Answer any five :

(a) Draw entropy and specific heat as a function of temperature for 1st order and 2nd order phase transitions.

(b) Explain phase transition in the light of Lee and Yang's theory.

(c) In what limit do the B-E and F-D gas behave as classical gases and why?

(d) What are critical exponents?

PG/IVS/PHS-401/13 (Continued)
(e) Explain the term 'symmetry breaking' for para-ferro transition.

(f) Explain the term 'degenerate' electron gas.

(g) Distinguish between condensed matter and B-E condensation.

(h) Explain 'mean field' theory in context of Bragg William's approximation for Ising model.

2. (a) Find out an expression of the carrier statistics for two dimensional Fermi gas.

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

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

\[ g = \frac{AH}{\frac{hc}{e}} \]

for a two-dimensional system of area \( A \) with magnetic field \( H \).

\[ 3 + 3 + 1 + 3 \]
3. (a) Prove that one dimensional Ising system does not show Ferromagnetic at $T = 0 \text{ K}.$

(b) For a 2nd order-phase transition Gibb's free energy is given by

$$G(T, m) = G_0(T) + a(T)m^2 + b(T)m^4 + \ldots$$

where $m$ is the order parameter obtain the possible values of $m$ for stable phase.

Prove that entropy is continuous at $T_c$ with the help of $G-L$ theory.