M.Sc. 4th Semester Examination, 2012

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 Group—A and Group—B

PAPER – PHS - 401(A)

[*Marks* : 20]

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

1. Answer any *five* : 2 × 5

(*a*) Define Green's function via an integral equation satisfied by the wave function Ψ in a scattering process.

(*b*) Show that the scattering amplitude in the first Born approximation is real if the potential has inversion symmetry.

(*c*) Consider two identical spin $\frac{1}{2}$ particles. Show that an antisymmetric wave function for this system is consistent with Pauli's exclusion principle.

(*d*) Obtain the ground state energy of the helium atom by variational method.

(*e*) 'The ferromagnetism of iron is a consequence of Hund's rule' – Elaborate this statement.

(*f*) Find the energy shifts in the ground state of a hydrogen atom when it is placed in a magnetic field.

(*g*) For a two electron atom express the form of Coulomb energy and exchange energy. Give the energy of the singlet and triplet state to first order in these energies.

(*h*) Show that if a wave function is an eigen state of a symmetric Hamiltonian corresponding to a non-degenerate eigenvalue, then it is either symmetric or antisymmetric.

2. (*a*) Consider scattering of a particle beam moving along *z*-axis by a spherically symmetric potential centred at origin. Assuming asymptotic solution show that scattering amplitude is given by

$$f(\theta) = \frac{1}{K}\sum_{l=0}^{\infty} (2l+1)\, e^{i\delta_l}\ P_l(\cos\theta)\sin\delta_l.$$

(The symbols have their usual meaning).

(*b*) Prove that differential scattering cross-section due to a particle of charge $-z'e$ by a nucleus of charge ze is given by (in the limit $\alpha \to 0$)

$$\frac{d\sigma}{d\Omega} = \left(\frac{zz'e^2}{2\mu v^2}\right)^2 \ \frac{1}{\sin^4(\theta/2)}.$$

where $V(r) = -\dfrac{zz'e^2}{r}\, e^{-\alpha r}$

μ = reduced mass, v = velocity of the particle.

5 + 5

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 that the Zeeman splitting of the levels. 4 + 3 + 3

PAPER – PHS - 401(B)

[*Marks* : 20]

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

1. Answer any *five* : 2 × 5

(*a*) Write down the expression for free energy of Fermi gas under quantization by magnetic field.

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

(*c*) Distinguish between He-I and He-II in the light of two fluid model.

(*d*) For two-dimensional Debye solid, find an expression of lattice specific heat at low temperature.

(*e*) Prove that B.E. condensation does not take place for one dimensional system.

(*f*) Explain why the electron gas at room temperature is highly degenerate.

(*g*) Draw graphically temperature variation of pressure for classical, B – E and F – D gases.

(*h*) Explain 1st and 2nd order phase transition in terms of order parameter.

2. (*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. 2 + 3

(*b*) Prove that in a photoelectric effect, current density

$$J = \frac{2\pi\alpha\, me}{h}\left(\nu - \nu_0\right)^2$$

where α = probability of absorption of photon in a metal; ν_0 = threshold frequency. (make suitable assumptions). 5

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

$$L(T) = \tan h\left(\mu_0 \beta H_{\text{eff}}\right).$$

(*b*) Define sp. ht at constant pressure, isothermal compressibility and coeff. of volume expansion in terms of Gibb's potential. Prove that entropy is continuous at T_c for 2nd order phase transition with the help of Landau theory. 5 + (3 + 2)