(i) Printed Pages : 4

(ii) Questions : 9

Roll No. .....

Sub. Code : 2 6 1 0 6

Exam. Code : 0 4 7 3

M.Sc. Physics 2nd Semester

(2055)

STATISTICAL MECHANICS

Paper : PHY-8022

Time Allowed : Three Hours] **[Maximum Marks : 80**

Note :— Attempt **five** questions in all, selecting **one** question each from Units-I-IV and the compulsory question from Unit-V.

UNIT–I

1. (a) Derive Sackur-Tetrode equation and show that using this equation, the entropy of the system become an extensive quantity.

   (b) The entropy S(N, V, E) is an extensive quantity, show that

$$N\left(\frac{\partial S}{\partial N}\right)_{V,E} + V\left(\frac{\partial S}{\partial V}\right)_{N,E} + E\left(\frac{\partial S}{\partial E}\right)_{N,V} = S$$ 10,6

2. (a) Show that energy shared by the system in a canonical ensemble follows a Gaussian distribution.

   (b) State and prove Liouville's theorem. 8,8

UNIT-II

3. (a) Derive expression for density fluctuation in Grand canonical ensemble.

   (b) Consider a system to be immersed in a large reservoir with which it can exchange both energy and particles. Find an expression for the probability $P_{r,s}$ of the system to be in (N_r, E_s) microstate. 8,8

4. (a) Show that the mean occupation number of the level ϵ for the ideal Fermi or Bose gas is given by

$$< n_\epsilon >= \frac{1}{e^{(\epsilon-\mu)/kT} + a} \quad \text{where } a = +1 \text{ or } -1.$$

   (b) Calculate the value of degeneracy discrimant $(n\lambda^3)$ for hydrogen and helium. 10,6

UNIT-III

5. (a) Set up equation of state for an ideal fermi gas. Hence determine its various properties in terms of particle density and temperature. Establish the conditions leading to complete degeneracy of the system.

(b) Briefly discuss how does the susceptibility of an ideal fermi gas behave with the temperature according to Boltzman treatment, Pauli paramagnetism and Landau diamagnetism. 10,6

6. (a) Describe Bose-Einstein condensation.

(b) Using BE statistics, derive Stefan-Boltzman law of black body radiation. 8,8

UNIT-IV

7. (a) Derive probability distribution law for the fluctuation in entropy S and volume V for system embedded in a reservoir with which it can exchange energy and volume, keeping the number of particles fixed.

(b) Describe the Einstein-Smoluchowski theory of Brownian motion and hence show that any conclusion drawn from Smoluchowski approach are the same as from Einstein approach. 8,8

8. (a) Discuss the Heisenberg model for the interaction energy of the lattice.

(b) What are phase transitions ? Elaborate different types of phase transitions with examples. 8,8

UNIT-V

9. (a) What is photon gas ? Explain.

(b) Draw a labeled diagram to show the isotherms of an ideal Bose gas.

(c) What do you mean by fugacity ? Explain.

(d) Why are the factors $1/N!$ and $1/h^{3N}$ introduced into the derivation of partition function of ideal classical gas ?

(e) Define grand canonical ensemble.

(f) What are fermions and bosons ? Which statistics they obey ?

3,3,3,3,2,2