

Roll No.

Total Pages : 4

CMDQ/D-23 **5119**
STATISTICAL MECHANICS

Paper-PHY-302

Time Allowed : 3 Hours]

[Maximum Marks : 60

Note : Attempt **five** questions in all, selecting **one** question from each Unit. Question No. **1** is compulsory. All questions carry equal marks.

Compulsory Question

1. (a) Explain Gibbs paradox for the mixing of two ideal gases 1 and 2, both being initially at the same temperature T . 3
- (b) Discuss mean occupation number of a single-particle state with energy E for Fermi-Dirac and Bose-Einstein statistics. 3
- (c) Ising model shows ferromagnetic behavior in two and three dimensions and not in one dimension. Comment. 3
- (d) What are Thermodynamic fluctuations? Write the expression for their probability distribution law. 3

UNIT-I

2. Determine the following thermodynamic quantities for a system of noninteracting harmonic oscillator using canonical ensemble under classical and quantum-mechanical situation : 12
 - (a) Entropy.
 - (b) Helmholtz free energy.
 - (c) Internal Energy.
 - (d) Specific heats C_p and C_v .
3. (a) Explain Liouville's theorem and its consequences. 6
 - (b) Derive the mean-square fluctuation in the energy E of a system in grand canonical ensemble in terms of its value for canonical ensemble and a term corresponding to the contribution from fluctuating particle number N of the system. 6

UNIT-II

4. (a) Derive grand canonical partition function for the case of Fermions and Bosons. Using this, compute the average number of particles and average energy in each system. 8

- (b) Determine the expression for internal energy of Ideal Bose System. 4
5. (a) Compare the Fermi-Dirac and Bose-Einstein statistics. 4
- (b) Show that the molar specific heat of a strongly degenerate Bose gas is given as : 4
- $$C_V = 1.92R \left(\frac{T}{T_C} \right)^{\frac{3}{2}} . \text{ Represent it graphically.}$$
- (c) What is the effect on Fermi temperature of a free electron gas in three dimensions, if the number density is increased eight times. 4

UNIT-III

6. Discuss Cluster expansion for an ideal Gas and Obtain Virial equation of state. 12
7. Describe Landau theory of phase transition and explain various contributions to specific heat. Does this theory explain the existence of transition temperature? 12

UNIT-IV

8. (a) Explain the concept of Brownian motion and obtain the expression for diffusion constant. 8

- (b) How small must the volume, V_A , of a gaseous subsystem (at normal temperature and pressure) be, so that the root-mean-square deviation in the number, N_A , of particles occupying this volume be 1 percent of the mean value \bar{N}_A ? 4
9. Discuss spectral analysis of fluctuations and obtain the expression for the power spectrum for fluctuation decaying exponentially in time. 12