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**321601**

**May-2026**

**B.Sc. (Physics) - Vth SEMESTER**

**Statistical Mechanics**

**(BPH24-602T)**

Time : 3 Hours]

[Maximum Marks : 75

*Instructions :*

- 1. It is compulsory to answer all the questions (1.5 marks each) of Part-A in short.*
- 2. Answer any four questions from Part-B in detail.*
- 3. Different sub-parts of a question are to be attempted adjacent to each other.*

**PART - A**

1. (a) Show that entropy increases when two gases at the same temperature and pressure diffuse in to each other. (1.5)

(b) Obtain degree of freedom and dimension of  $\mu$ -space and  $\Gamma$ -space for gas of diatomic molecule in 1-dimension, 2-dimension and 3-dimension. (1.5)

(c) Explain Wein's displacement law. (1.5)

(d) Differentiate three types of ensemble. (1.5)

(e) What is microstate and macrostate? Illustrate with the help of an example. (1.5)

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- (f) Consider a system of three non-interacting fermions having energy levels  $-\epsilon, 0, \epsilon$ . Find the entropy of the system if the total energy of the system is zero. (1.5)
- (g) The fermi energy for metal X is 3.15 eV. Find the value of fermi energy for metal Y given that electron density in metal Y is 9 times that of X. (1.5)
- (h) What is the significance of Chandrashekhar mass limit? (1.5)
- (i) Define phase space and phase trajectory. (1.5)
- (j) How Sackur-Tetrode equation fixes Gibb's Paradox? (1.5)

### PART - B

2. (a) State and prove Liouville's theorem and discuss its consequences. (10)
- (b) Calculate the maximum amount of heat which may be lost per second by radiation from a sphere of 5 cm. in diameter at a temperature of 600K when placed in an enclosure at a temperature of 300K. [ $\sigma = 5.7 \times 10^{-12}$  Watts  $\times$   $\text{cm}^{-2}(\text{C})^{-4}$ ]. (5)
3. (a) Derive condition for a strongly degenerate boson gas. How does the degeneracy depend upon the temperature, number density and mass of particles. (10)
- (b) Explain Bose-Einstein condensation. How the number of particles in ground state vary below transition temperature? (5)

4. (a) State and derive Equipartition theorem. Also discuss its validity at different temperature. (10)
- (b) Deduce the Boltzmann's entropy probability relation  $S = k \ln \Omega(E)$ , where  $S$  is entropy.  $\Omega(E)$  is the number of microstates in the energy interval between  $E$  and  $E + dE$ . and  $k$  is Boltzmann's constant. (5)
5. (a) Find entropy and probability distribution for two energy level system of  $N$  particles. Also explain how probability vary with energy supplied to the system with the help of graph. (10)
- (b) Find the probability and partition function for a system of canonical ensemble. (5)
6. (a) Find expression for fermi energy of free electrons gas. Also show that mean energy of Fermi gas at absolute zero temperature is  $(3/5)E_{F(0)}$ . (10)
- (b) Plot and explain the variation of distribution function for a Fermi gas. (5)
7. (a) Find the expression for relative number of atoms in two ionization states in the interior of stars. (10)
- (b) Derive Wein's displacement law and Stefan's law from Planck's radiation law. (5)