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# 752302

**December 2023**

**M.Sc. (Physics) Semester-III**

STATISTICAL MECHANICS (MPH-302)

Time : 3 Hours] [Max. 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) Write down the partition function for a system of N distinguishable particles distributed in single particle energy state 0, $\epsilon$, $2\epsilon$, $3\epsilon$, $4\epsilon$......etc. (1.5)

(b) With the help of diagram discuss the statistics of occupation number for particles following Maxwell-Boltzman, Fermi-Dirac and Bose-Einstein statistics. (1.5)

(c) Give the relations which provide connection between statistics and thermodynamics. (1.5)

(d) Discuss the minimum size of a phase space cell in classical and quantum statistics. (1.5)

(e) Compare graphically the specific heat of a classical ideal gas, ideal fermi gas and an ideal bose gas as a function of temperature. (1.5)

(f) Calculate volume of single microstate in case of one-dimensional harmonic oscillator (microcanonical ensemble). (1.5)

(g) An ensemble of three level system with energy -E0, 0, E0 is in thermal equilibrium at temperature T. Find the probability of finding the system in the level E = 0 (assume value of $\frac{E0}{kT}$ is 2) (1.5)

(h) What is extensive and intensive property? (1.5)

(i) Calculate the number of ways of arranging four bosons in seven different states. (1.5)

(j) State equal a priori probability. (1.5)

## PART–B

2. (a) Find partition function for a system of classical ideal gas consisting of N identical monoatomic molecules confined to a space of volume V at equilibrium temperature T. Also show that chemical potential is intensive quantity. (8)

(b) State and derive Liouville's theorem and what are its consequences? (7)

3. (a) Derive the equation of state for an ideal fermi gas. Establish the condition leading to the complete degeneracy of the system. Also show that zero point energy is a purely quantum effect. (8)



(b) Explain quantum mechanical ensemble theory using density matrix. Show that in case of stationary ensemble, density and Hamiltonian matrix are diagonal for energy representation. (7)

4. (a) Derive the expression of pressure for an ideal bose gas. Also show that, above critical temperature pressure decreases asymptotically as a function of temperature to approach constant classical value. (8)

(b) Discuss the conditions for onset of Bose-Einstein condensation. In this context, discuss the variation of fugacity with temperature. (7)

5. Using method of cluster expansion, obtain the expression for van der Waals equation of state in virial form for a real gas. (15)

6. (a) Derive the relationship between density fluctuations and spatial correlations in any fluid system. (8)

(b) Derive Fokker-Plank equation and hence derive expression of diffusion equation. (7)

7. (a) Derive the expression of probability and partition function for a system of canonical ensemble. Find variation of entropy when temperature increases from absolute zero to higher value. (8)

(b) Define phase transitions and explain Ising and Heisenberg models. (7)