Unit II

4. (a) Derive the Maxwell-Boltzmann velocity distribution law in three dimensions. **4**

(b) Compute the most probable speed and the mean kinetic energy for a gas following Maxwell-Boltzmann statistics at temperature T. **4**

5. (a) Show that the Maxwell-Boltzmann distribution leads to the equipartition of energy for an ideal gas. **4**

(b) For a Maxwell-Boltzmann gas, calculate the fraction of particles with speeds greater than twice the average speed at T = 300 K. **4**

Unit III

6. (a) Derive the Fermi-Dirac energy distribution law and explain the concept of Fermi temperature. **4**

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B. Sc. EXAMINATION, 2025

(Fourth Semester)

(Re-appear Only)

PHYSICS

Paper–VII

Statistical Physics

Time : 3 Hours] [*Maximum Marks :* 40

Before answering the question-paper, candidates must ensure that they have been supplied with correct and complete question-paper. No complaint, in this regard will be entertained after the examination.

Note : Attempt *Five* questions in all, selecting *one* question from each Unit. Q. No. **1** is compulsory. All questions carry equal marks. Use of a scientific (non-programmable) calculator is allowed.

(Compulsory Question)

1. (a) For a system of 3 distinguishable particles in two equal-sized boxes, calculate the thermodynamic probability for the macrostate with 2 particles in one box and 1 in the other. **1.5**

(b) Derive the condition for thermal equilibrium between two systems in terms of the β parameter. **1.5**

(c) For an ideal gas following Maxwell-Boltzmann statistics, compute the ratio of the root mean square speed to the average speed. **1.5**

(d) Show that the Maxwell-Boltzmann distribution reduces to the classical limit for high temperatures. **1**

(e) Calculate the Fermi energy for a Fermi-Dirac gas with a particle density of 1028 m^{-3} at T = 0 K. **1.5**

(f) For a solid with a Debye temperature of HD = 300 K, estimate the specific heat at T = 30 K using the Debye model. **1**

Unit I

2. (a) Derive the probability theorems for mutually exclusive and independent events. **4**

(b) For N = 3 distinguishable particles distributed in two boxes, compute the number of accessible states and the thermodynamic probability for the most probable distribution. **4**

3. (a) Derive Boltzmann's relation between entropy and thermodynamic probability. **4**

(b) Calculate the variance in the number of particles in one compartment for a system of N = 50 indistinguishable particles distributed in two equal-sized compartments. **4**

(b) For a solid with a Debye temperature of HD = 400 K, calculate the specific heat at T = 20 K and compare it with the Einstein model prediction. 4

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(b) Calculate the zero-point pressure of an electron gas with a Fermi energy of 5 eV. 4

7. (a) Apply Bose-Einstein statistics to derive Plancks radiation law. 4

(b) For a Fermi-Dirac gas at T = 0 K, derive the expression for the specific heat anomaly in metals. 4

Unit IV

8. (a) Derive the Einstein model for the specific heat of solids and explain its shortcomings at low temperatures. 4

(b) Compare the classical Dulong-Petit law with the quantum-based Einstein model for a solid at high temperatures. 4

9. (a) Derive the Debye model for specific heat, emphasizing the role of phonon modes. 4