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BSc(H) Physics III Year

PAPER XIX

Statistical Physics

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Time : 3 Hours

Maximum Marks: 38

Do five questions in all. Question no. 1 is compulsory. Attempt one question from ~~every~~ each unit.

1. Attempt any five of the following. (2×5)

(a) When a room is swept and dust particles collected in a small area, the number of available microstates decreases from e^{10^5} to e^{10^2}. What is the decrease in entropy? Does sweeping a room clean violate the Second Law of Thermodynamics?

(b) Can negative temperatures exist in a system with energy levels going to infinity? Explain.

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

(d) What is ultra-violet catastrophe with reference to the Rayleigh Jean's Law?

(e) Does a collection of quantum harmonic oscillators at thermal equilibrium satisfy Equipartition theorem? Explain.

(f) Show that the electron gas in Silver with number density 5.8×10^{28} electrons/m^3 is strongly degenerate at room temperature.

(g) Discuss the role of optical cavity in lasers?

(h) What are the Ortho and Para Hydrogens? What are their relative contributions to the specific heat of Hydrogen?

Unit I

2. (a) What is the thermodynamic definition of temperature? Explain the emergence of negative temperatures in a system of magnetic dipoles with spin half in a magnetic field.

   (b) How are negative temperatures achieved in laboratory? (5, 2)

3. Find the partition function of a diatomic hetero-nuclear gas including rotational degrees of freedom. Determine the contribution to the specific heat of this gas from rotational motion at high and low temperatures. (7)

Unit II

4. Derive Saha's ionisation formula for a gas of Hydrogen atoms, ions and electrons. Discuss one of its applications. (6,1)

5. (a) Derive expressions for Stefan's and Wien's constants from Planck's black body radiation formula.

(b) Show that the number of modes of vibration per unit volume for radiation in an enclosed volume between frequency ν and $\nu + d\nu$ is $8\pi\nu^2/c^3\, d\nu$. (4,3)

Unit III

6. What is Bose-Einstein condensation? Find the critical temperature below which an ideal gas shows Bose-Einstein condensation. Derive and plot fraction of degenerate Bosons in the ground state and excited states as a function of temperature. (7)

7. a) Give Bose's derivation of Planck's black body radiation formula.

b) Find the energy and specific heat of a photon gas. (4,3)

Unit IV

8. Show that the electron gas in white dwarf stars is strongly degenerate and relativistic. Assume electron number density is $10^{36}/m^3$ and and temperature is 10^7K. Find pressure generated by such a gas. (7)

9. (a) Derive the expression for the energy and entropy of a strongly degenerate system of non relativistic electrons.

(b) Starting from the Third Law of Thermodynamics explain the unattainability of absolute zero. (5,2)