B. Sc Semester VI (honours) Examination, 2021 (CBCS)

Subject: Physics

Paper: CC-XIV (Statistical Mechanics)

Time: 2 Hours | Full Marks: 40

The figures in the margin indicate full marks. Candidates are required to give answers in their own words as far as practicable.

Answer any eight of the following questions: 5×8=40

1. Establish a relation between entropy and thermodynamic probability. Calculate the translational entropy of gaseous iodine (Molecular weight 234) at 300K and 1 atmosphere. [Given: R= 8.31 JK^{-1} mol^{-1}., V=0.224 m^3]
2. Define μ space and Γ space. A linear harmonic oscillator moves with a constant energy along X-axis. What will be its phase trajectory? Can different phase trajectories insect each other?
3. A system of N distinguishable particles are distributed in two non-degenerate levels separated by an energy gap ϵ and are in equilibrium with a reservoir at a temperature T. Find (i) the internal energy (ii) specific heat capacity of the system.
4. A negative temperature system is hotter than a system with positive temperature. Explain why?
5. Show that for a two dimensional electron gas, the number of electrons per unit area is given by, $n = \frac{4\pi m\, k_B T}{h^2} ln\left(e^{E_F/k_B T} + 1\right)$, where the symbols have their usual meaning.
   Consider a free electron at Fermi level in a metal at 0K. Show that the de Broglie wavelength of the electron is $2\left(\frac{\pi}{3n}\right)^{1/3}$, where n is the number of free electrons per unit volume in the metal.
6. Plot the variation of energy density ρ_λ as a function of wavelength λ at three different temperatures obeying Planck's law of black body radiation. Show that Planck's law reduces to Wien's law for $h\nu \gg k_B T$ and to Rayleigh-Jeans law for $h\nu \ll k_B T$.
7. Define partition function. Write down the properties of partition function. Show that the relation between partition function Z and average pressure is $\bar{p} = k_B T \left(\frac{\partial \ln Z}{\partial V}\right)$, where the symbols have their usual meaning.

8. Distinguish between mathematical probability and thermodynamic probability.

   Consider a system of three fixed particles each having spin $^{1}/_{2}$ so that each spin can point up or down (along or opposite some direction chosen as the Z axis). Each particle has a magnetic moment along Z axis of μ when it points up and and - μ when points down. The system is placed in a magnetic field H pointing along Z axis. List all possible states of the system. If the total energy of the system is - μH, what is the probability that the spin of the first particle points up?
9. Write down Bose Einstein distribution function. What are the basic assumptions used in the derivation of the Bose Einstein distribution function. Under what condition BE distribution reduces to classical Maxwell-Boltzmann distribution? What is meant by lambda point?
10. What are the limitations of Debye theory? Show that the zero point energy of one mole of a solid crystal according to Debye's theory is $\frac{9}{8}R\Theta_D$, where Θ_D is the Debye temperature. Explain whether the addition of the zero point energy term affects the Einstein and the Debye results of specific heat.