B.Sc. 6th Semester (Honours) Examination, 2022 (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 their answers in their own word as far as practicable.

Group-A

1. Answer any five questions from the following: **2×5=10**

a) Define microstates and macro-states.

b) State the basic difference between the canonical and grand canonical ensemble.

a) What are the symmetry properties of the wave function for a system of indistinguishable particles?

b) Define emissive power of a body. State Stefan-Boltzmann's law.

c) Distinguish between ortho and para-hydrogen.

d) Find the number of possible microstates if three particles are distributed in five quantum states according to MB, BE and FD statistics.

e) The Fermi velocity of the electron in a metal is 0.7×10^{6} m/sec. Calculate the Fermi temperature.

f) Using Maxwell's distribution function, show that the mean of the reciprocal of the speed of the molecules in an ideal gas at temperature T is equal to $\sqrt{\frac{2m}{\pi KT}}$, where m is the mass of a molecule.

g) From the statistical definition of entropy, show that the entropy of an ideal Fermi gas at T=0K is zero.

h) If each square cm of Sun's surface radiates energy at the rate of 1.5×10^{3} Cal/sec/ cm^{2} and Stefan constant is 5.7×10^{-8} J/sec/m^{2} /K^{4}. Calculate the temperature of the Sun's surface.

Group-B

2. Answer any two questions: 5x2=10

a) Explain the terms (i) phase point, (ii) phase space and (iii) phase trajectory.

2+2+1

b) Find out the volume of the phase space of a classical linear harmonic oscillator of mass m and angular frequency ω bounded by two surfaces of constant energy E and (E+dE).

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c) State which statistics (Maxwell-Boltzmann, Fermi-Dirac, Bose-Einstein) would be appropriate for the following cases and why?
(i) Density of He^4 gas at room temperature and atmospheric pressure.
(ii) Density of electrons in copper at room temperature.

2.5+2.5

d) Deduce an expression for the mean occupation number of energy state ε_i assuming the particles to obey (i) F. D. Statistics, (ii) B. E. Statistics.

2.5+2.5

Group-C

3. Answer any two questions: 10x2=20

a) Define the microcanonical ensemble. Use it to calculate the entropy of a perfect gas. Show how the internal energy and equation of state for a perfect gas can be obtained from it.

2+8

b) Consider a system of N weakly coupled particles obeying Maxwell-Boltzmann statistics, kept at a temperature T. Each particle may exist in one of the three non-degenerate levels of energy $-\varepsilon$, 0, $+\varepsilon$.

(i) What is the entropy of the system at T=0K

(ii) What is the maximum possible entropy of the system?

(iii) What is the minimum possible energy of the system?

(iv) What is the partition function of the system?

(v) What is the most probable energy of the system?

(vi) If C(T) be the heat capacity of the system, find the value of

$$\int_0^\infty \frac{C(T)}{T}\, dT$$

10

c) (i) Write down the Fermi-Dirac distribution function and define Fermi level at absolute zero and at a finite temperature. What are ‘degenerate’ and ‘non-degenerate distribution function.

(ii) Write down the expression for the energy density of states of an electron gas in a metal. Hence find the Fermi energy of a metal at absolute zero. Also obtain an expression for the zero point pressure.

(iii) Find the Fermi energy at 0K for metallic silver containing one free electron per atom. Also estimate the zero point pressure. (Given density=$10.5\text{X}10^{3}$ Kg/m^{3} atomic weight=107.87).

(2+1)+4+3

d) (i) Elucidate BE condensation. How does it differ from normal condensation?

(ii) Derive an expression of condensation fraction and graphically represent its variation with temperature. (2+1)+7