

PHYSICS PAPER-A

(Statistical Physics and Thermodynamics—I)

Time Allowed : 3 Hours

Maximum Marks : 44

- Note: (1) Attempt five questions in all, selecting two questions from each Sections A and B respectively.
- (2) Section C is compulsory.
- (3) Use of log table and non-programmable calculator is allowed.

SECTION-A

1. (a) Write down in tabular form the various microstates and macrostates of a system of 3 particles arranged in 3 compartments assuming :
- (i) particles to be distinguishable
 - (ii) particles to be indistinguishable
- (b) What is meant by term thermodynamic probability of a macrostate? How is it related to the probability of occurrence of that macrostate?

4

3

(c) A bag contains 5 white and 6 black balls. Three balls are pulled out of bag one by one in a random fashion. Calculate the probability of all the three balls to be white. 2

2. (a) Taking the case of n -particles distributed in 2 compartments with equal a priori probability, discuss the variation of probability of a macrostate on account of small deviations from a state of maximum probability. 6

(b) Eight distinguishable particles are distributed among three compartments of equal size. Find the probability of the (i) macrostate (8, 0, 0) and (ii) macrostate (4, 2, 1). 3

3. (a) The probability for a state which has fractional deviation f from a most probable state is given by :

$$P(f) = P_{\max} e^{-Nf^2/2} . \text{ Find the value of } P_{\max} . \quad 5$$

(b) 5×10^{10} gas molecules are enclosed in a cubical volume imagine the volume to be divided into two equal halves. Calculate the probability for a state in which the no. of molecules in a given state are only 0.001%, different from that in the equilibrium state. 4

SECTION-B

4. (a) Derive Maxwell-Boltzmann law for distribution of molecular speeds. 6
(b) Using Maxwell-Boltzmann law of distribution of molecular speeds calculate the value of average speed. V_{av} . 3

5. (a) What are the assumptions of B-E statistics ? Derive expression for B-E distribution law. 6

(b) There are two compartments a and b . The compartment a has 3 cells whereas b has 4 cells. Five bosons are distributed in these compartments. Find the thermodynamic probability for macrostate (5, 0) and (4, 2). 3

6. (a) What is free electron gas ? Using F-D distribution law find expression for Fermi-Dirac distribution of electron energies and hence prove that :

$$E_f = \frac{h^2}{8m} \left(\frac{3N}{8\pi V} \right)^{2/3} , \text{ where symbols have their usual meanings.} \quad 6$$

(b) The no. of conduction electrons per c.c. is 24.2×10^{22} in Beryllium and 0.91×10^{22} in cesium. If the Fermi energy of conduction electrons in Be is 14.14 eV, calculate the Fermi energy in Cs. 3

SECTION-C

7. Attempt any *eight* parts—

- (i) Three coins are tossed simultaneously. Find the probability of getting at least two heads.
- (ii) In a system of 8 distinguishable particles are distributed in two compartments with equal a priori probability calculate the probability for macrostates :
 - (i) (4, 4),
 - (ii) (3, 5)
- (iii) Calculate the percentage error made in using Stirling's formula $\ln n! = n \ln n - n$ when $n = 7$.
- (iv) What is the minimum size of a phase space cell in classical and quantum mechanical system.
- (v) The Fermi energy of a silver at 0 K is 5.5 eV, find :
 - (a) Average energy per electron in silver.
 - (b) Average speed of electrons.
- (vi) Write differences between B-E and F-D statistics.
- (vii) What is the difference between photon gas and ideal gas ?
- (viii) Sketch the graph showing the Maxwell-Boltzmann distribution of molecular speeds.
- (ix) What is the purpose of dividing phase space into cells ?
- (x) Under what conditions do B-E and F-D statistics lead to classical statistics.

8×1=8