Roll No. : ....

Total No. of Questions : **16**] [Total No. of Printed Pages : **4**

PHYSSEM–116

M.Sc. (Ist Semester) Examination, Dec., 2022

PHYSICS

Paper - CC–104

(Statistical Mechanics)

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

The question paper contains three Sections.

Section–A **(Marks : 1 × 10 = 10)**

Note :– The candidate is required to answer all the *ten* questions carries **1** mark each. The answer should not exceed **50** words.

Section–B **(Marks : 3 × 5 = 15)**

Note :– The candidate is required to answer *five* questions by selecting at least *one* question from each Unit. Each question carries **3** marks. Answer should not exceed **200** words.

Section–C **(Marks : 5 × 3 = 15)**

Note :– The candidate is required to answer *three* questions by selecting at least *one* question from each Unit. Each question carries **5** marks. The answer should not exceed **500** words.

Section–A

1. (i) Define Stationary Ensemble.

   (ii) Define Entropy.

   (iii) Write the quantum mechanical expression for canonical partition function.

   (iv) Differentiate between Bose-Einstein and Fermi-Dirac statistics.

   (v) Give physical interpretation of partition function.

   (vi) Write the physical meaning of the Fermi energy.

   (vii) Define time auto-correlation function of a quantity A.

   (viii) What is meant by Brownian Motion ?

   (ix) In a first-order phase transition Gibbs function, g is continuous but specific heat at constant pressure C_p is discontinuous. Explain.

   (x) Define fluctuation of a physical quantity f.

Section–B

Unit–I

2. What is meant by Gibbs' paradox ? How one can get rid of this paradox ?

3. For a system in canonical ensemble with energies 0 and $\in$, show that internal energy is given by :

$$U = \frac{\in}{e^{\in/kt} + l}$$

4. For a system in grand canonical ensemble, show that grand potential Ω is related to grand canonical partition Σ' by :

$$\Omega = -kT \, ln \, \Sigma'$$

Unit–II

5. For an ideal Bose gas, explain the thermodynamic behaviour when $T < T_C$, where T_C is critical temperature.

6. Using the expression for means occupation number of single particle state $\in$, show that Fermi energy $\in_F$ depends on particle density p and on mass of the particle.

7. Discuss viriual expansion of the equation of state for a system of interacting particles.

Unit–III

8. Derive the conditions for phase equilibrium for a system consisting of two phases. Which can exist simultaneously in equilibrium with each other ?

9. Discuss fluctuation. Dissipation theorem.

10. Show that in case of the ensemble of Brownian particles in one dimension, mean square value of coordinate :

$$\langle x^2 \rangle = 2Dt$$

where D is the diffusion coefficient of the system.

Section–C

Unit–I

11. State and prove Liouville's theorem. Discuss its physical significance.

12. Derive expression for density and energy fluctuations in the grand canonical ensemble.

Unit–II

13. Discuss the thermodynamic behaviour of an ideal Bose gas when $T > T_C$, where T_C is the transition temperatures.

14. Discuss free electron theory of metals treating electrons as an ideal Fermi gas.

Unit–III

15. Describe in detail the London theory of phase transition.

16. Using Langevin theory, derive the Einstein relation for Brownian motion of particles given by :

$$D = BkT$$

where B is mobility of the system.