

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.

**BRI-16**

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**PHYSSEM-116** P.T.O.

### 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  $\epsilon$ , show that internal energy is given by :

$$U = \frac{\epsilon}{e^{\epsilon/kT} + 1}$$

4. For a system in grand canonical ensemble, show that grand potential  $\Omega$  is related to grand canonical partition  $\Sigma'$  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 mean occupation number of single particle state  $\epsilon$ , show that Fermi energy  $\epsilon_F$  depends on particle density  $\rho$  and on mass of the particle.
7. Discuss virial 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.