(7 pages) **Reg. No. :** .....

Code No. : 5394 **Sub. Code : ZPHM 24**

M.Sc. (CBCS) DEGREE EXAMINATION, APRIL 2023.

Second Semester

Physics – Core

STATISTICAL MECHANICS

(For those who joined in July 2021 onwards)

Time : Three hours Maximum : 75 marks

PART A — (10 × 1 = 10 marks)

Answer ALL questions.

Choose the correct answer :

1. The minimum volume of phase cell in phase space is

   (a) h

   (b) h^2

   (c) h^3

   (d) h^4

2. In a micro canonical ensemble, a system A of fixed volume is in contact with a large reservoir B. Then

   (a) A can exchange neither energy nor particles with B

   (b) A can exchange both energy and particles with B

   (c) A can exchange only energy with B

   (d) A can exchange only particles with B

3. The number of most probable macro states for a system having odd number of particles is

   (a) 1 (b) 2

   (c) 3 (d) 4

4. Maxwell-Boltzman law is for the

   (a) distinguishable particles

   (b) indistinguishable particles

   (c) particles with half integral spin

   (d) Particles with integral spin

5. If g_i be the number of phase cells available in the phase space for distribution of n_i particles in the i^{th} compartment, then according to quantum statistical mechanics.

(a) $\frac{n_i}{g_i} >> 1$ (b) $\frac{n_i}{g_i} << 1$

(c) $\frac{n_i}{g_i} = 1$ (d) $\frac{n_i}{g_i} = 0$

6. Bose-Einstein statistics can be applied to

(a) Electrons (b) Photons

(c) Fermions (d) Protons

7. During Bose-Einstein condensation all the atoms fall back to the

(a) Ground state

(b) First excited state

(c) Highest excited state

(d) Insufficient information

8. For all the quantum states with energy greater than Fermi energy to be empty in a Fermi-Dirac system, the temperature should be

(a) 273 K (b) 373 K

(c) 0 K (d) 100 K

9. Which of the following is a measure of the degree of order across the boundaries in a phase transition system?

(a) Critical point (b) Relevance

(c) Both (a) and (b) (d) Order parameter

10. Magnetic thermometers are based on the principle of

(a) Gauss law (b) Weiss law

(c) Curie's law (d) Kelvin's law

PART B — (5 × 5 = 25 marks)

Answer ALL questions, choosing either (a) or (b).
Each answer should not exceed 250 words.

11. (a) Define phase space. Prove that the phase trajectory of a harmonic oscillator is an ellipse.

Or

(b) What are the principles of conservation of density and the density of distribution of density in phase space? Explain.

12. (a) What is thermodynamic probability? Obtain an expression of condition for maximum probability for a classical system.

Or

(b) Obtain an expression of the probability of magnetic moment distribution of independent atoms.

13. (a) Clarify the differences between distinguishable and indistinguishable particles. Explain the two types of indistinguishable particles with examples.

Or

(b) Write short notes on exchange symmetry of wave functions.

14. (a) State Dulong and Petit's law. What happens at low temperatures? Explain the variation of specific heat of a solid with temperature.

Or

(b) What is Fermi gas? Deduce an expression for the energy of a Fermi gas at absolute zero.

15. (a) What do you mean by first order phase transition? How it can be characterized? Explain.

Or

(b) Give an expression for one dimensional Ising model and explain how this model cannot be ferromagnetic.

PART C — (5 × 8 = 40 marks)

Answer ALL questions, choosing either (a) or (b)
Each answer should not exceed 600 words.

16. (a) State and prove Liouville's theorem.

Or

(b) Establish the relation between statistical and thermodynamical quantities. Derive expression for chemical potential, Helmholtz free energy and Gibb's free energy.

17. (a) Deduce Maxwell-Boltzmann law for the distribution of molecules in a gas.

Or

(b) State and prove Boltzmann's theorem connecting entropy and probability. Explain how it can be used to calculate the entropy of a monoatomic gas and prove that k = R/N.

18. (a) Derive the Fermi-Dirac distribution formula and show that the specific heat of a strongly degenerate Fermi-Dirac gas is directly proportional to its absolute temperature.

Or

(b) What is meant by black–body radiation? Derive the Plank's law of black–body radiation.

19. (a) Derive Debye's formula for the specific heat of solids. Comment on the assumptions and achievements of the theory.

Or

(b) Apply Bose-Einstein statistics to photon gas and hence derive the thermal properties of Bose-Einstein gas.

20. (a) What do you mean by critical exponent? Introduce various critical exponents known to you. Are they quite important?

Or

(b) Give an account of measurement of temperature near absolute zero.
