Roll No. ..... Total Printed Pages - 8

F - 512

M.Sc.(Second Semester)
EXAMINATION, May-June, 2022
PHYSICS
Paper Second
(Statistical Mechanics)

Time : Three Hours] *[Maximum Marks : 80*

Note : Attempt all sections as directed.

Section - A

(Objective/Multiple Choice Questions)

(1 mark each)

Note: Attempt all questions.

Choose the correct answer:

1. In a canonical ensemble, the quantities same for each system is:
   (A) Temperature, Energy and the number of particles
   (B) Temperature, Volume and the number of particles
   (C) Energy, Volume and the number of partictes
   (D) All of the above

2. Five particles are distributed in two phase cells. Then number of macrostates is :
   (A) 10
   (B) 6
   (C) $5/2$
   (D) 32
3. In a classical micro-canonical ensemble for a system of N interacting particles, the fundamental volume in phase space which is regarded as equivalent to one microstate is:
   (A) h^{3N}
   (B) h^{2N}
   (C) h^{N}
   (D) h
   h is Planck's constant
4. The condition of statistical equilibrium is:
   (A) Equality of temperatures
   (B) Equality of pressures
   (C) Equality of chemical potentials
   (D) Equality of all above
5. The classical partition function z gives the:
   (A) Sum of states of the system
   (B) Sum of energy of the system
   (C) Sum of momentum of the system

(D) None of the above

6. For a system with a large value of degree of freedom, the fluctuation is:-

(A) Large

(B) Negligible

(C) Zero

(D) None of the above

7. The relation between entropy and probability is:-

(A) s = k log Ω

(B) s = k/log Ω

(C) Ω = k log s

(D) Ω = k/log s

8. The partition function is defined as z =

(A) $\sum_i g_i e^{-E_i/kT}$

(B) $\sum_i g_i e^{E_i/kT}$

(C) $\sum_i \frac{g_i}{n_i!} e^{-E_i/kT}$

(D) $\sum_i \frac{g_i}{n_i!} e^{E_i/kT}$

9. Bose-Einstein statistics applied to:-

(A) electrons

(B) molecules

(C) photons

(D) All above

10. Which of the following is a boson:-

(A) α - particle

(B) neutron

(C) positron

(D) proton

11. In quantum statistics the particles are:-

(A) identical and distinguishable

(B) molecules only

(C) identical and indistinguishable

(D) Photons only

12. For strongly degenerate fermigas the specific heat:-

(A) is proportional to absolute temperature

(B) is proportional to square of absolute temperature

(C) is proportional to cube of absolute temperature

(D) is independent of temperature

13. For Bose gas, the chemical potential μ is always:-

(A) Positive

(B) Zero

(C) Negative

(D) None of the above

14. The satisfactory explanation of Brownian motion was given by:

(A) Maxwell

(B) Brown

(C) Einstein

(D) Langevin

15. The diffusion coefficient D is:-

(A) Proportional to P

(B) Inversely proportional to P

(C) Does not depend on P

(D) None of the above

16. Helium II is a:-

(A) Conductor

(B) Semiconductor

(C) Insulator

(D) Superconductor

17. The Chandrashekhar limit is:-

(A) 1.2 mass of sun

(B) 1.6 mass of sun

(C) 1.4 mass of sun

(D) 2.3 mass of sun

18. According to Boltzmann canonical distribution law:-

(A) low energy cells contain more particles

(B) high energy cells contain more particles

(C) zero energy molecules are zero

(D) None of the above

19. Transition from non-ferromagnetic state to ferromagnetic state is a phase transition of:-

(A) First order

(B) Second order

(C) Zero order

(D) Not a phase transition

20. Which thermometer can be used to measure temperatures below 1^{o} K:-

(A) Vapour pressure thermometer

(B) Alcohol thermometer

(C) Thermocouple thermometer

(D) Magnetic thermometer

Section - B

(Very Short Answer Type Questions)

(2 marks each)

Note : Attempt all questions.

1. Explain contact between statistics and thermodynamics.
2. Define the terms with examples:
   (a) Macrostate (b) Microstates
3. Define grand canonical ensemble.
4. Explain the partition function for canonical ensemble.
5. Explain density matrix.
6. What do you mean by phase transition?
7. Draw the diagram of the cluster expansion for N = 6 particles for a classical gas.
8. What do you mean by fermi energy?

Section - C

(Short Answer Type Questions)

(3 marks each)

Note : Attempt all questions.

1. Write the physical significance of Ω (N, V, E) in classical gas.
2. What do you mean by Gibbs paradox?

3. Explain the energy density fluctuation.
4. Define canonical ensemble.
5. Write the basic postulates of Bose- Einstein statistics.
6. Explain the thermodynamic behaviour of ideal Fermi gas.
7. State the properties of liquid Helium - II.
8. Discuss what is meant by fluctuation in thermodynamical quantities.

Section - D

(Long Answer Type Questions)

(5 marks each)

Note : Attempt *any four* questions.

1. Establish the connection between statistical and thermodynamical quantities. Derive expression for Helmholtz free energy, Enthalpy and Gibbs' free energy.
2. Define partition function and derive it for a system represented by a grand canonical ensemble.
3. Discuss the phenomenon of Bose-Einstein condensation.
4. Explain: (a) Liouville's theorem (b) Virial equation of state.
5. What are Fermions? Derive the Fermi-Dirac distribution formula. Discuss one application for this distribution.
6. Explain in brief the Einstein-Smoluchowski theory of Brownian motion.
7. Explain theory of white dwarf stars.
8. Give an account of Bose - Einstein statistics and discuss its application to liquid Helium - II.