2024

(CBCS)

(6th Semester)

PHYSICS

ELEVENTH PAPER

(Thermal and Statistical Physics)

Full Marks : 75

Time : 3 hours

The figures in the margin indicate full marks for the questions

(SECTION : A—OBJECTIVE)

(*Marks* : 10)

Tick (✓) the correct answer in the brackets provided : 1×10=10

1. The r.m.s. velocity of an ideal gas is directly proportional to

(a) T^2 ( )

(b) T^3 ( )

(c) $T^{1/3}$ ( )

(d) $T^{1/2}$ ( )

2. The value of Avogadro's number determined by Perrin was found to be

(a) $6{\cdot}82\times10^{26}$ moles/kg-mole ( )

(b) $6{\cdot}023\times10^{26}$ moles/kg-mole ( )

(c) $6{\cdot}082\times10^{26}$ moles/kg-mole ( )

(d) $6{\cdot}23\times10^{26}$ moles/kg-mole ( )

3. The thermodynamic probability of a system at equilibrium is

(a) maximum ( )

(b) minimum ( )

(c) 0 ( )

(d) 1 ( )

4. The probability of occurrence of two independent events is equal to the _____ of their probability.

(a) sum ( )

(b) difference ( )

(c) product ( )

(d) ratio ( )

5. Pauli's exclusion principle applies to

(a) M-B statistics ( )

(b) F-D statistics ( )

(c) B-E statistics ( )

(d) All of the above ( )

6. The value of $C_p - C_v$ for an ideal gas is

(a) $TE\alpha V^2$ ( )

(b) $TEV\alpha^2$ ( )

(c) $VE\alpha T^2$ ( )

(d) $TE^2\alpha^2V^2$ ( )

7. Five particles are distributed in two phase cells. Then the number of macro states is

(a) 15 ( )

(b) 10 ( )

(c) 32 ( )

(d) 6 ( )

8. According to which of the following statistics, the energy at absolute zero cannot be zero?

(a) M-B ( )

(b) B-E ( )

(c) F-D ( )

(d) All of the above ( )

9. Energy fluctuation is a characteristic feature of

(a) grand canonical ( )

(b) micro-canonical ( )

(c) canonical ( )

(d) All of the above ( )

10. At very low temperature, the coefficient of viscosity of a gas

(a) decreases with decrease of pressure ( )

(b) increases with increase of pressure ( )

(c) is independent of pressure ( )

(d) is equal to pressure ( )

(SECTION : B—SHORT ANSWERS)

(*Marks* : 15)

Answer the following questions in brief : 3×5=15

UNIT—I

1. Write a short note on Brownian motion.

OR

2. Deduce the law of distribution of free path.

UNIT—II

3. Obtain 1st and 2nd TdS equations using Maxwell thermodynamical relations.

OR

4. Derive the relation for coefficient of self-diffusion.

UNIT—III

5. Show that the partition function $Z = \Sigma_i e^{-\beta E_i}$.

OR

6. Explain the term 'constraints'. Hence define accessible and inaccessible states.

UNIT—IV

7. Discuss statistical interpretation of the second law of thermodynamics.

OR

8. Discuss the law of increase of entropy.

UNIT—V

9. Distinguish between bosons and fermions. Give at least three points.

OR

10. Discuss Bose-Einstein statistics.

(SECTION : C—DESCRIPTIVE)

(*Marks* : 50)

Answer the following questions : 10×5=50

UNIT—I

1. *(a)* Deduce the law of equipartition of energy by the methods of momentoids. 7

   (b) Explain mean free path and collision probability. 3

OR

2. *(a)* Deduce the Maxwell-Boltzmann law for the distribution of velocities of the particles of a gas. 8

   (b) What are r.m.s. velocity and most probable velocity? 2

UNIT—II

3. Deduce Gibbs' phase rule. Explain the application of Gibbs' phase rule to mono- and di-component systems. 7+3=10

OR

4. *(a)* Deduce Maxwell's relation from thermodynamic potentials. 8

   (b) Explain the terms 'sphere of influence' and 'collision cross-section'. 2

UNIT—III

5. *(a)* Derive Boltzmann's canonical distribution law. 6

   (b) Derive the relation $S = k \log (W)$, where S = entropy and W = thermodynamic probability. 4

OR

6. *(a)* For the phase space representing a single particle of mass m in a volume V, calculate the number of phase cells in energy range 0 to E. Given that the volume of each phase cell is h_0^3. 6

   (b) Show that for thermodynamical equilibrium of any two systems in contact, the β parameter of the two systems must be identical. 4

UNIT—IV

7. *(a)* Explain micro-canonical, canonical and grand canonical ensembles with the help of necessary diagram. 6

   (b) What do you mean by partition function? Deduce an expression for the partition function for a system in thermal equilibrium. 1+3=4

OR

8. *(a)* Derive the probability distribution function in canonical ensemble. 5

   (b) Discuss the thermodynamic quantities in canonical ensemble and hence derive an expression for Helmholtz free energy in terms of partition function. 5

UNIT—V

9. *(a)* Derive the F-D distribution law. 6

   (b) Compare the basic postulates of M-B, B-E and F-D statistics. 4

OR

10. *(a)* State the differences between classical and quantum statistical thermodynamics in terms of mean distance as well as degeneracy parameter. 4

(b) Using Maxwell-Boltzmann distribution law, show that the internal energy of an ideal monatomic gas depends only on its temperature. Hence show that $C_v = \frac{3}{2}R$. 5+1=6

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