2023

(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 velocity of a molecule increases with the rise in

(a) pressure ( )

(b) time ( )

(c) kinetic energy ( )

(d) temperature ( )

2. The average kinetic energy associated with each degree of freedom is

(a) kT ( )

(b) $\frac{1}{2}kT$ ( )

(c) $\frac{1}{3}kT$ ( )

(d) $\frac{1}{4}kT$ ( )

3. In thermal conduction of gas there is transport of

(a) energy ( )

(b) momentum ( )

(c) mass ( )

(d) particle ( )

4. Maxwell's thermodynamic relation is

(a) $\left(\frac{S}{T}\right)_T \quad \left(\frac{P}{V}\right)_T$ ( )

(b) $\left(\frac{T}{V}\right)_S \quad \left(\frac{P}{S}\right)_V$ ( )

(c) $\left(\frac{T}{P}\right)_P \quad \left(\frac{V}{P}\right)_P$ ( )

(d) $\left(\frac{S}{T}\right)_P \quad \left(\frac{P}{V}\right)_T$ ( )

5. The relative probability between two different energy states having difference $1{\cdot}1 \times 10^{20}$ joules at 400 K temperature is

(a) e^{1} ( )

(b) e^{2} ( )

(c) e ( )

(d) e^{2} ( )

6. Five particles are distributed in two phase cells. The number of macrostates is

(a) 6 ( )

(b) 10 ( )

(c) 32 ( )

(d) $\frac{5}{2}$ ( )

7. In canonical ensemble, there is fluctuation in

(a) matter only ( )

(b) No fluctuation ( )

(c) energy only ( )

(d) both matter and energy ( )

8. A collection of large number macroscopically identical but essentially independent system is

(a) phase space ( )

(b) ensemble ( )

(c) phase cell ( )

(d) -phase ( )

9. In Bose-Einstein distribution law, the particles of a system are identical and

(a) indistinguishable ( )

(b) distinguishable ( )

(c) have zero velocity ( )

(d) have equal mass ( )

10. Photons obey

(a) M-B statistics ( )

(b) F-D statistics ( )

(c) B-E statistics ( )

(d) All of the above ( )

(SECTION : B—SHORT ANSWER)

(*Marks* : 15)

Answer the following : 3×5=15

UNIT—I

1. What is mean free path? Write the expression for mean free path according to Maxwell.

OR

2. Calculate the root mean square velocity of a molecule of mercury vapour at 300 K. (Given, molecular weight of mercury = 221, R 8 3 10^7 joule/mole-K).

UNIT—II

3. What is thermodynamic function or potential? How many thermodynamic functions are there? Name them.

OR

4. Explain triple point with a labelled diagram. What is the value of F in triple point?

UNIT—III

5. Explain how is related to temperature. What is the significance of parameter?

OR

6. When a dice is thrown twice and obtain two numbers, what is the probability that these numbers are 6 and 4 precisely in that order?

UNIT—IV

7. Define ensemble. Write two uses of ensemble.

OR

8. Write a short note on microcanonical ensemble with the help of a labelled diagram.

UNIT—V

9. What is indistinguishability of particles? What role does it play in quantum statistics?

OR

10. What are fermions? Write the basic postulates of F-D statistics.

(SECTION : C—DESCRIPTIVE)

(*Marks* : 50)

Answer the following : 10×5=50

UNIT—I

1. *(a)* What is Brownian motion? Derive Einstein relation for Brownian motion. 6

(b) Write any four postulates of kinetic theory of matter. 4

OR

2. *(a)* State and prove the law of equipartition of energy. 7

(b) Obtain an expression for mean square velocity and root mean square velocity of a gas molecule. 2+1=3

UNIT—II

3. *(a)* Deduce an expression for the coefficient of viscosity ( ). Explain the effect of temperature and pressure on the coefficient of viscosity. 5+3=8

(b) Obtain the relation between coefficient of viscosity and coefficient of diffusion. 2

OR

4. *(a)* Derive the first and second TdS equation. 5

(b) From the general expression of Maxwell's thermodynamical relations, deduce Maxwell's four thermodynamic relations. Use these relations to obtain C_p C_v R. 4+1=5

UNIT—III

5. *(a)* Define thermodynamic probability. Hence calculate the number of microstates for six particles to be distributed in two cells for macrostate (2, 4). 1+3=4

(b) Mention the states or parameters that define the microstate of a system. 2

(c) State and explain the postulate of equal a priori probability. Clarify the concept of a cell in a compartment. 2+2=4

OR

6. *(a)* What are the factors that specify the coordinate of a phase space? Show that the volume of a phase cell is given by d h^3. 1+2=3

(b) Define the functions (*E*) and (*E*). Hence, show that from the relation between (*E*) and (*E*) for a single particle, (*E*) is directly proportional to $\sqrt{E}$. 1+3=4

(c) Starting with the relation between entropy and temperature, obtain the equation

$$S \quad k \log$$

Also, explain each symbol in the above equation. 3

UNIT—IV

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

(b) Compare the different properties among micro-canonical, canonical and grand-canonical ensembles. 4

(c) What do you mean by partition function? 1

OR

8. *(a)* Discuss the thermodynamic quantities in grand-canonical ensemble. Hence, derive an expression for entropy in terms of partition function. 4+2=6

(b) Explain Stirling's approximation in canonical ensemble. 4

UNIT—V

9. *(a)* Using Maxwell-Boltzmann distribution law, deduce the equation for—

(i) total internal energy and specific heat of an ideal gas at constant volume;

(ii) Maxwell-Boltzmann speed distribution law. 6

(b) Write any two limitations of Maxwell-Boltzmann method. 2

(c) How does F-D statistics differ from B-E statistics? 2

OR

10. *(a)* Write a short note on B-E distribution law. Derive an expression

$$n_i \quad \frac{g_i}{e \quad ^{i} \quad 1}$$

for the most probable distribution of particle of a system obeying B-E statistics. 1+6=7

(b) What are Fermi energy and Fermi level? How does Fermi energy vary with temperature? 3

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