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(Pre-CBCS)

(5th Semester)

PHYSICS

SEVENTH PAPER

(Classical Mechanics and Thermal Physics)

(Revised)

Full Marks : 55

Time : 2½ hours

(PART : A—OBJECTIVE)

(*Marks* : 20)

The figures in the margin indicate full marks for the questions

SECTION—A

(*Marks* : 5)

Tick (✓) the correct answer in the brackets provided : 1×5=5

1. A body of mass m moving with velocity v is approaching another body of the same mass but at rest. The kinetic energy of the system of the two bodies as viewed from their center of mass is

(a) mv^2 ( ) *(b)* $\frac{1}{2}mv^2$ ( )

(c) $\frac{1}{4}mv^2$ ( ) *(d)* $\frac{1}{8}mv^2$ ( )

2. The average kinetic energy of one mole of an ideal gas at temperature T is

(a) $\frac{2}{3}kT$ ( ) *(b)* $\frac{2}{3}RT$ ( )

(c) $\frac{3}{2}kT$ ( ) *(d)* $\frac{3}{2}RT$ ( )

3. The coefficient of thermal conductivity at room temperature is the greatest for

(a) oxygen ( ) *(b)* helium ( )

(c) hydrogen ( ) *(d)* carbon dioxide ( )

4. For the canonical ensemble of a classical and discrete system, the canonical partition function is given by

(a) $Z \quad e^{\ E_1}$ ( ) *(b)* $Z \quad e^{\ E_1}$ ( )
i i

(c) $Z \quad e^{\ \overline{E_1}}$ ( ) *(d)* $Z \quad e^{\overline{E_1}}$ ( )
i i

5. Which of the following particles do not obey B-E statistics?

(a) Photons ( ) *(b)* Protons ( )

(c) Pions ( ) *(d)* Gas molecules ( )

SECTION—B

(*Marks* : 15)

Answer the following questions : 3×5=15

1. What is central force? Give at least two important properties of central force.

2. Show that the number of molecules per unit volume of an ideal gas is given by

$$n \quad \frac{PN}{RT}$$

where the symbols have their usual meanings.

3. Prove the thermodynamic relation

$$TdS \quad C_V dT \quad T \left(\frac{P}{T}\right)_V dV$$

where the symbols have their usual meanings.

4. State and explain equal a priori probability.

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

(PART : B—DESCRIPTIVE)

(*Marks* : 35)

The figures in the margin indicate full marks for the questions

1. *(a)* When a particle moves under central force, prove that—

(i) the angular momentum is conserved;

(ii) the areal velocity remains constant. 2+2=4

(b) State Kepler's third law of planetary motion. Deduce Newton's law of gravitation from Kepler's third law. 3

OR

2. *(a)* Discuss the reduction of two-body problem to equivalent one-body problem. 4

(b) What do you understand by constraints and generalized coordinates? What are the constraints and generalized coordinates of a simple pendulum? 3

3. State and explain Einstein's theory of translational Brownian motion. 7

OR

4. Explain Stern's experiment for the experimental verification of Maxwell-Boltzmann law of distribution of molecular velocities. 7

5. *(a)* Explain transport phenomena in gases. 2

(b) Explain the condition of equilibrium in di-component system using Gibbs phase rule. 5

OR

6. What do you mean by 'thermodynamic potentials or functions'? Derive any two Maxwell's thermodynamic relations from thermodynamic potentials. 1+3+3=7

7. *(a)* Derive the relation $S \quad k \ln \quad (E)$, where S = entropy and (E) thermodynamic probability. 4

(b) Show that for thermodynamic equilibrium of any two systems in contact, the parameter of the two systems must be equal. 3

OR

8. What do you mean by ensemble? Explain the three types of ensemble with neat diagrams. 7

9. Using Fermi-Dirac distribution law, derive an expression for the energy distribution of free electrons in metal. Hence, explain Fermi energy and Fermi level. 4+3=7

OR

10. *(a)* Apply M-B energy distribution law to find internal energy and specific heat at constant volume of an ideal gas. 5

(b) Show that at high temperature, both B-E and F-D statistics approach M-B statistics. 2

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