2026

PHYSICS

(Major)

Paper : PHY4200204MJ

(Heat and Thermodynamics)

Full Marks : 45

Time : 2 hours

The figures in the margin indicate full marks for the questions.

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1. Answer the following questions : 1×5=5

   (a) State two assumptions of Kinetic theory of gas.

   (b) What is temperature of inversion?

   (c) For an isothermal process in ideal gas, temperature.

   (d) The area under P-V curve represents :
   - *(i)* heat
   - *(ii)* work done
   - *(iii)* internal energy
   - *(iv)* entropy

   (e) Third law of thermodynamics states that entropy at absolute zero is :
   - *(i)* infinite
   - *(ii)* maximum
   - *(iii)* zero
   - *(iv)* undefined

2. Answer any *five* questions : 2×5=10

   (a) Calculate the r.m.s. velocity of hydrogen at 27 °C. Given $k = 1{\cdot}38\times10^{-23}$ J/K and mass of hydrogen molecule $= 3{\cdot}34\times10^{-27}$ kg.

   (b) Explain the term degrees of freedom. State the law of equipartition of energy.

   (c) What are the essential features of Brownian motion?

   (d) Calculate the critical temperature of a gas with van der Waals' constants, $a = 6{\cdot}9\times10^{-2}$ Jm^3 mole^{-2} and $b = 2{\cdot}9\times10^{-5}$ m^3 mole^{-1}. The universal gas constant $R = 8{\cdot}31$ J mole^{-1} K^{-1}.

   (e) What are thermodynamic variables? Are they uniquely defined?

   (f) State zeroth law of thermodynamics.

(g) A heat engine absorbs heat of 10^5 kcal from a source which is at 127 °C and rejects part of heat to sink at 27 °C. Calculate temperature efficiency of the engine and work done by it.

(h) Explain in brief reversible and irreversible processes with an example of each.

(i) Write one characteristic of Carnot's engine? Under what conditions is it 100% efficient.

(j) Entropy of universe always increases. Why?

3. Answer any *four* questions : 5×4=20

(a) Describe the experiment of Anderson on carbon dioxide.

(b) Describe the porous plug experiment of Joule and Thomson.

(c) Derive the reduced equation of a gas starting from van der Waals equation of state. What is law of corresponding states? 3+2=5

(d) Write short notes on *(i)* first law of thermodynamics and *(ii)* second law of thermodynamics.

(e) Differentiate between a refrigerator and a heat pump. Define coefficient of performance of a refrigerator and calculate its value. 2+3=5

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(f) Show that for any reversible cyclic change of a system the total change of entropy is zero.

(g) Starting from four thermodynamical potentials derive Maxwell's thermodynamic relations.

(h) Show that for a homogeneous fluid

$$C_P - C_V = T\left(\frac{\partial P}{\partial T}\right)_V \left(\frac{\partial V}{\partial T}\right)_V = \left[P + \left(\frac{\partial U}{\partial V}\right)_T\right]\left(\frac{\partial V}{\partial T}\right)_P$$

4. Answer any *one* questions : 10

(a) Derive the Maxwellian distribution function of molecular speeds. Evaluate the constants A and B and show that molecular distribution depends on temperature. 5+5

(b) What considerations led van der Waals to modify gas equation of state? Deduce van der Waals gas equation $\left(P + \frac{a^2}{V}\right)(V - b) = RT$. What are the dimensions of a and b? What are the limitations of van der Waals gas equation? 2+3+2+3=10

(c) Calculate the amount of work done during *(i)* an isothermal expansion and *(ii)* adiabatic expansion of a gas. 5+5=10

(d) Represent the Carnot's cycle on a P-V diagram and a temperature entropy diagram. Show in it the areas representing *(i)* heat absorbed from the source *(ii)* heat rejected to the sink and *(iii)* available energy. 4+2+2+2=10

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