This question paper contains 4 printed pages]

Roll No. | | | | | | | | | | | |

S. No. of Question Paper : **6209**

Unique Paper Code : **222304** **D**

Name of the Paper : **Thermal Physics (PHHT-309)**

Name of the Course : **B.Sc. (Hons.) Physics**

Semester : **III**

Duration : **3 Hours** Maximum Marks : **75**

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt *Five* questions in all, including Question No. **1** which is compulsory.

All questions carry equal marks.

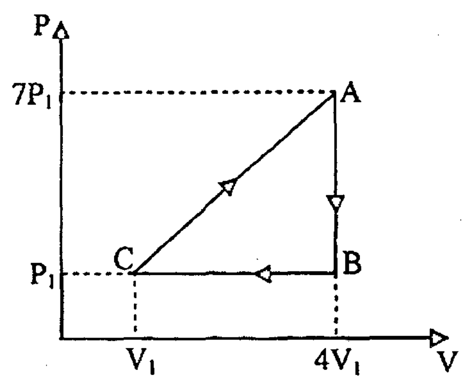
1. Attempt any *five* of the following : 5×3=15

(*a*) Define extensive and intensive thermodynamic variables. Give *one* example of each.

(*b*) State zeroth law of thermodynamics. Hence define temperature.

(*c*) Derive an expression for work done during the adiabatic expansion of an ideal gas.

(*d*) In the cyclic process shown by the following figure, find the work done by the gas in one cycle :



P.T.O.

(*e*) The temperature inside a refrigerator is maintained at 7°C. If room temperature is 34°C, calculate the coefficient of performance of the refrigerator.

(*f*) Prove, using Maxwell's thermodynamic relations, $\left(\frac{\partial C_V}{\partial V}\right)_T = 0$ for a real gas.

(*g*) Using law of equipartition of energy, show that values of $\gamma = \frac{C_P}{C_V}$ for mono-atomic and diatomic gases are 1.66 and 1.4 respectively.

(*h*) Calcualte the mean free path of molecules of a gas when the number density is 3×10^{25} molecules m^{-3} and diameter of each molecule is 2Å.

2. (*a*) Applying first law of thermodynamics, obtain relation between pressure and volume for an ideal gas undergoing adiabatic process. Hence, write relation between pressure and temperature and also volume and temperature. 9

(*b*) One mole of an ideal gas ($\gamma = 1.4$), initially kept at 17°C, is adiabatically compressed so that its pressure becomes 10 times its original value. Calculate : 6

(*i*) Its temperature after compression

(*ii*) Work done on the gas.

3. (*a*) What are Kevlin-Planck statement and Clausius statement of second law of thermodynamics ? Show that both the statements are equivalent. 9

(*b*) Discuss Carnot's reversible cycle that an ideal gas undergoes in Carnot's engine. Derive an expression for efficiency of the engine in terms of temperatures T_1 and T_2 of source and sink respectively. 6

4. (*a*) Distinguish between first order and second order phase transitions. Hence obtain Clausius-Clapeyron's equation. 9

(*b*) Calculate change in boiling point of water when the pressure is increased by 1 atm (10^5 N/m^2). The normal boiling point of water at atmospheric pressure is 373 K, specific volume of steam = 1.671 m^3 kg^{-1}, specific volume of water = 0.001 m^3 kg^{-1} and latent heat of steam = 2.268×10^6 Jkg^{-1}, 3

(*c*) Show that there is always an increase in entropy during an irreversible process. 3

5. (*a*) Using Maxwell's thermodynamic potentials, derive Maxwell's four thermodynamical relations. 9

(*b*) Using appropriate Maxwell's thermodynamic relations, prove : 6

(*i*) $C_P - C_V = T\left(\frac{\partial P}{\partial T}\right)_V \left(\frac{\partial V}{\partial T}\right)_P$

(*ii*) $\left(\frac{\partial U}{\partial V}\right)_T = T\left(\frac{\partial P}{\partial T}\right)_v - P.$

6. (*a*) Derive Maxwell-Boltzmann's distribution law of molecular velocities for a perfect gas. Hence find the expression for the most probable velocity and root mean square velocity. 9

(*b*) Discuss Stern's experiment for verification of this law. 3

(*c*) The mean free path, λ, of molecules of a gas at pressure P and temperature T is 3×10^{-5} cm. Calculate λ for the conditions : 3

(*i*) P, 2T and

(*ii*) 2P, T.

7. (*a*) What is Joule-Thomson effect ? Derive an expression for Joule-Thomson coefficient μ, for a real gas obeying van der Waals' equation. 9

(*b*) Discuss the cases when μ is negative, positive and zero. Obtain the expression for temperature of inversion of the gas. Explain why hydrogen and helium show heating effect at ordinary temperatures while other gases show cooling effect. 6

8. (*a*) Discuss general behaviour of real gases on the basis of Andrew's experiment on CO_2. Define critical temperature. 6

(*b*) Using van der Waals' equation of state, find expressions for critical temperature (T_C), critical pressure (P_C) and critical volume (V_C) in terms of van der Waals' constants '*a*' and '*b*'. Hence prove that for real gases $\frac{RT_C}{P_C V_C} = \frac{8}{3}$, where 'R' is universal gas constant. 9

Values of constants :

Boltzmann's constant, $k = 1.38 \times 10^{-23}$ JK^{-1}

Universal gas constant, R = 8.31 Jmol^{-1} K^{-1}.