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Your Roll No. .....

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B.Sc. (Hons.) PHYSICS/III Sem. **B**

Paper PHHT-309

(Thermal Physics)

(Admission of 2010 and onwards)

Time : 3 *Hours* *Maximum Marks* : 75

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

Attempt *Five* question in all including

Question No. **1** which is compulsory.

All questions carry equal marks.

1. Attempt any *five* questions :

   (*i*) Calculate the work done for a quasistatic adiabatic process for an ideal gas.

   (*ii*) State the necessary conditions for reversibility of a process.

   (*iii*) Why is it not possible to attain absolute zero ? Explain.

P.T.O.

(*iv*) Establish the relation :

$$U = F - T\left(\frac{\partial F}{\partial T}\right)_v$$

where symbols have their usual meaning.

(*v*) Prove that :

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

(*vi*) Show that :

$$\frac{E_S}{E_T} = \frac{C_P}{C_V} = \gamma$$

where E_T and E_S are isothermal and adiabatic elasticity respectively.

(*vii*) The mass of a gas molecule is 5×10^{-26} kg and its mean velocity is 4×10^2 m/s at N.T.P. Calculate the average kinetic energy of the gas molecule at 0°C.

(*viii*) Define mean free path. Obtain the relation.

$$\lambda = \frac{1}{\Pi d^2 n}$$

where symbols have their usual meaning. 5×3=15

2. (*i*) Define internal energy and taking U as a function of P and V show that :

(*a*) $\left(\frac{\partial U}{\partial P}\right)_P = \frac{C_V K_T}{\beta}$

(*b*) $\left(\frac{\partial U}{\partial V}\right)_P = \frac{C_P}{V\beta} - P$

where K_T is isothermal compressibility

β is volume expansivity

C_P and C_V are specific heat at constant pressure and volume respectively.

(*ii*) Explain the convective equilibrium of earth's atmosphere and derive the relation for variation of temperature with height in atmosphere. 8,7

3. (*i*) State the second law of thermodynamics and explain its physical significance. Derive an expression for the efficiency of a reversible Carnot's engine.

(*ii*) State and prove the Carnot's Theorem. 9,6

P.T.O.

4. (*i*) Show that entropy always increases for an irreversible process.

(*ii*) Calculate the increase in entropy when the temperature of 1 kg of ice is raised from –20°C to 20°C, given that :

Specific heat of ice = 2.09×10^3 $Jkg^{-1}K^{-1}$

Specific heat of water = 4.18×10^3 $Jkg^{-1}K^{-1}$

Latent heat of ice = 3.35×10^5 Jkg^{-1}

(*iii*) Derive the Ehrenfest's equations for second order phase transitions. 3,4,8

5. (*i*) Derive Maxwell's four thermodynamic relations.

(*ii*) What is adiabatic demagnetisation ? Obtain an expression for change in temperature during the process of adiabatic demagnetisation. 6,9

6. (*i*) Deduce an expression for most probable speed for a gas obeying Maxwell-Boltzmann distribution of molecular speed of gases.

(*ii*) The mean free path of a molecule of a certain gas at temperature of 27°C is 5×10^{-5} m. If the radius of the gas is 2Å, calculate the pressure exerted by the gas molecules.

Given $K_B = 1.38 \times 10^{-23} \times JK^{-1}$

(*iii*) Derive an expression for coefficient of thermal conductivity of gases on the basis of kinetic theory of gases. 4,3,8

7. (*i*) Explain the term "critical temperature" of a gas. Discuss the results obtained by Andrews in his experiment on carbon dioxide.

(*ii*) Obtain the virial equation from the van der Waals equation of a gas. Give the importance of first two virial coefficients.

(*iii*) Express the van der Waals equation in terms of reduced parameters P_r, V_r and T_r.

(*iv*) List the limitations of van der Waals equations. 7,3,3,2

8. What is Joule-Thomson effect ? Obtain an expression for Joule-Thomson coefficient for a real gas. Determine the value of temperature of inversion in terms of van der Waals constants '*a*' and '*b*'. Discuss the Joule-Thomson effect in terms of deviation from Boyle's Law and Joule's Law. 15