

Total number of printed pages-7

**3 (Sem-3/CBCS) PHY HC 2**

**2022**

**PHYSICS**

(Honours)

Paper : PHY-HC-3026

**(Thermal Physics-II)**

Full Marks : 60

Time : Three hours

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

1. Answer **any seven** of the following questions : 1×7=7
- (a) What is a cyclic process ?
  - (b) Which state of matter has the highest entropy ?
  - (c) How does root mean square velocity change with temperature ?
  - (d) What is velocity space ?

Contd.

(e) Name the transport phenomenon present in a gas that involves transfer of energy.

(f) Write the S.I. unit of Van der Waals' constant 'b'.

(g) Why does the pressure of a gas in a container wall increase when it is heated ?

(h) Is a 'closed system' an 'isolated system' ?

(i) How does the viscosity of a gas vary with pressure ?

(j) Can Gibbs' free energy be negative ?

(k) What is the origin of Doppler broadening in spectral lines ?

(l) In Brownian motion, how does size of the particle affect the speed of the particle ?

2. Answer **any four** of the following questions :

2×4=8

(a) At what temperature will root mean square velocity of a gas be half its value at 0°C.

(b) Represent isobaric process in a P-V diagram.

(c) Evaluate Boyle temperature of a gas if its critical temperature is 5.5K.

(d) Consider a system at room temperature. Explain about the value of entropy for the following situations :

(i) temperature of the system is increased and reached equilibrium state

(ii) temperature is decreased to 0K.

(e) Explain physical significance of zeroth law of thermodynamics.

(f) How mean free path of a molecule is affected by temperature ?

(g) Why does the area of the Maxwell-Boltzmann velocity distribution curve always remain equal to unity ? Explain.

(h) Why specific heat of a gas at constant pressure is always greater than the specific heat of a gas at constant volume ?

3. Answer **any three** of the following questions:  $5 \times 3 = 15$

(a) Find the change in entropy of the universe as a result of the following processes:  $2\frac{1}{2} + 2\frac{1}{2} = 5$

(i) A copper block of 400gm mass and with thermal capacity (at constant pressure) of 150J/deg at 100°C is placed in a lake at 10°C.

(ii) The same block at 10°C is dropped from a height of 100m into the lake.

(b) What are the *four* thermodynamic potentials? How specific heat at constant pressure can be expressed in terms of enthalpy?  $4 + 1 = 5$

(c) Find an expression for coefficient of performance of a refrigerator.

(d) Derive  $C_p - C_v = R$  for perfect gas from Maxwell's thermodynamic relations.

(e) Calculate the average speed and most probable speed of 1 mole of hydrogen molecule at 300K. Neglect the mass of electron.  $2\frac{1}{2} + 2\frac{1}{2} = 5$

(f) Derive an expression for work done during an isothermal process.

(g) A Carnot engine absorbs 100J of heat from a reservoir at a temperature of the normal boiling point of water and rejects heat to a reservoir at the temperature of triple point of water. Find the heat rejected by the engine and its thermal efficiency.  $2\frac{1}{2} + 2\frac{1}{2} = 5$

(h) Show that at the critical temperature, the departure of Van der Waals' gas law from perfect gas law measures 62.5%.

4. Answer **any three** of the following questions:  $10 \times 3 = 30$

(a) State Carnot's theorem. Briefly state the operations of a Carnot cycle by plotting them in (i) P-V diagram and (ii) T-S diagram. Show from T-S diagram that

the efficiency of the cycle is  $1 - \frac{T_2}{T_1}$ ,

being independent of the nature of the working substance, where  $T_1$  and  $T_2$  are the source and sink temperature respectively.  $2 + 3 + 3 + 2 = 10$

(b) Derive all three TdS equations. Write physical significance of TdS equations.

$3 + 3 + 3 + 1 = 10$

(c) What is Joule-Thomson effect ? Derive an expression for Joule-Thomson coefficient. Find the values of Joule-Thomson coefficient for a perfect gas and a real gas.  $2+3+2+3=10$

(d) Derive Maxwell-Boltzmann's velocity distribution law.

(e) What are critical constants of a gas ? Obtain their values in terms of the constants of Van der Waals' equation. Hence deduce the law of corresponding states.  $3+3+4=10$

(f) Define coefficient of thermal conductivity. Show that coefficient of thermal conductivity  $K = \eta C_V$  for an ideal gas, where  $\eta$  is coefficient of viscosity and  $C_V$  is specific heat at constant volume.

(g) Define free path and mean free path. What do you mean by 'collision probability' ? Show that the probability of a gas molecule traversing a distance  $x$  without collision is  $e^{-x/\lambda}$  where  $\lambda$  is the mean free path of the gas molecules.  $1+1+2+6=10$

(h) Write short notes on the following : (**any two**)  $5 \times 2 = 10$

(i) Unattainability of absolute zero

(ii) Adiabatic demagnetization

(iii) Andrew's experiment of  $\text{CO}_2$  gas

(iv) Brownian Motion

---