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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

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