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 ?

(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 5.5*K*.

(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 0*K*.

(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 : 5×3=15

(a) Find the change in entropy of the universe as a result of the following processes : 2½+2½=5

(i) A copper block of 400*gm* mass and with thermal capacity (at constant pressure) of 150*J/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 100*m* 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 300*K*. Neglect the mass of electron. 2½+2½=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 : $10\times3=30$

(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 η 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 λ is the mean free path of the gas molecules. 1+1+2+6=10

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

(i) Unattainability of absolute zero

(ii) Adiabatic demagnetization

(iii) Andrew's experiment of CO_2 gas

(iv) Brownian Motion
