2021

PHYSICS — HONOURS

Paper : CC-6

(Thermal Physics)

Full Marks : 50

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

Answer ***question no.*** **1** and ***any four*** questions from the rest.

1. Answer ***any five*** questions : 2×5

(a) Why is it necessary to introduce the concept of quasi-static process in thermodynamics?

(b) Explain why the specific heat of gas at constant pressure is greater than that at constant volume.

(c) Explain that the perpetual motion machine is not possible according to thermodynamics.

(d) Prove that the adiabatic elasticity of a gas is γ times the isothermal elasticity.

(e) Prove the relation $\left(\frac{\partial U}{\partial V}\right)_T = T\left(\frac{\partial P}{\partial T}\right)_V - P$.

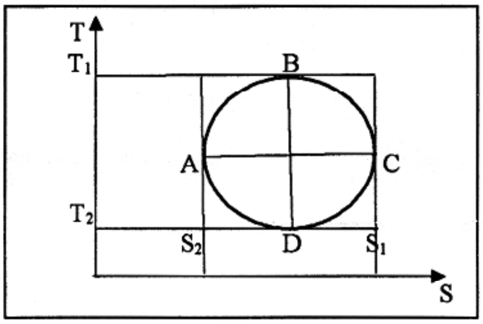
(f) At what temperature will root mean square speed of oxygen molecule be double its value at N.T.P., while pressure remaining constant?

(g) Draw the pressure-temperature diagram of H_2O indicating the phases, boundaries and the tripple point.

2. (a) A Carnot engine operates between temperatures T_1 and T_2 with a gas as working substance whose equation of state is given by $P(V\text{-}b) = RT$. Work out the expression for the heat absorbed and the work done in each part of the cycle and show that the efficiency of the cycle is $\left(1-\frac{T_2}{T_1}\right)$.

(b) Give the Kelvin-Planck statement and Clausius statement of the second law of thermodynamics. Establish the equivalence of the above two statements.

(c) Show that the efficiency of the cycle ABCDA is given by $\eta = \dfrac{2\pi(T_1 - T_2)}{\pi(T_1 - T_2) + 4(T_1 + T_2)}$.



Given $AC = BD$. 3+3+4

3. (a) 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 molecule.

(b) Find out the expression for the most probable speed c_m and the number of molecules $n(c_m)$ having speed c_m.

Plot $n(c)$ vs. c for two different temperatures T and $4T$ on the same graph. 4+(2+2+2)

4. (a) Why isotropic distribution of particles is needed to derive the Maxwell's velocity distribution?

(b) Why Brownian motion is observed below a definite size of particles only?

(c) Find the number of degrees of freedom for (i) H_2O and (ii) CO_2 molecule, assuming linear configuration of the molecules.

(d) State law of equipartition of energy. Hence establish the relation between degrees of freedom and the ratio of two specific heats of a gas. 2+2+3+(1+2)

5. (a) Show that for a real van der Waals' gas $C_P - C_V = R\left\{1 + \dfrac{2a}{RTV^3}(V-b)^2\right\}$.

(b) Show that for an isentropic transformation $\left(\dfrac{\partial V}{\partial T}\right)_S = -\dfrac{C_V}{C_P - C_V}\left(\dfrac{\partial V}{\partial T}\right)_P$.

(c) Assuming the relation $Tds = C_P\, dT - T\left(\dfrac{\partial V}{\partial T}\right)_P dP$, show that for isothermal compression $\Delta Q = -TV\alpha(p_2 - p_1)$, where ΔQ is the heat transfer when the fluid is compressed isothermally, from a pressure p_1 to p_2, α = coefficient of volume expansion. 4+3+3

6. (a) For all living systems, ageing process cannot be stopped. —Which thermodynamics law supports this statement? Explain your answer.

(b) Using the Clausius theorem, show that for any process $S_f - S_i \geq \int_i^f \frac{dQ}{T}$ where the symbols have their usual meanings.

(c) Apply the suitable transformation technique to define Enthalpy in mathematical form.

(d) Using the Clausius-Clapeyron equation, investigate the possibility of latent heat to be zero.

(1+2)+3+2+2

7. (a) Deduce the expression for amount of cooling of a paramagnetic substance by adiabatic demagnetization.

(b) The specific volume of water at 0°C increases by 9.1% on freezing and the latent heat of fusion of ice is 80 cal/gm at atomospheric pressure. Calculate the pressure needed to lower the melting point of ice by 1°C.

(c) Show that the enthalpy $H = \left[\frac{\partial\left(G/T\right)}{\partial\left(1/T\right)}\right]_V$, where G is the Gibbs energy. 3+4+3