Total number of printed pages–4

3 (Sem–2/CBCS) CHE HC 2

2024

CHEMISTRY

(Honours Core)

Paper : CHE–HC–2026

(Physical Chemistry–II)

Full Marks : 60

Time : Three hours

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

1. Answer the following questions : $1 \times 7 = 7$

   (a) What do you mean by thermodynamics state function ?

   (b) Why is the first law of thermodynamics necessary ?

   (c) What is meant by $\Delta U = -P\Delta V$?

   (d) Define molar heat capacity at constant volume.

   (e) What do you mean by available energy ?

   (f) Write the S.I. unit of chemical potential.

   (g) Write the statement of second law of thermodynamics given by Kelvin-Planck.

Contd.

2. Answer the following questions : 2×4=8

(a) Define thermodynamic equilibrium.

(b) Show that ΔG is a measure of total non-mechanical work.

(c) How does chemical potential of an ideal solution change with temperature ?

(d) Define state function with an example.

3. Answer ***any three*** from following questions : 5×3=15

(a) Derive the expression of work done in an isothermal reversible expansion of an ideal gas. 88g CO_2 gas is expanded isothermally and reversibly from $100\,L$ to $120\,L$ at 27°C. Calculate the amount of work done by the system. 3+2=5

(b) Derive Gibbs-Duhem equation for a two-component system.

(c) For a cyclic process show that $\oint dS = 0$.

(d) Predict the spontaneity of the following reactions : 1×5=5

(i) $2N_2O_5(g) \rightarrow 4NO_2(g) + O_2(g)$

(ii) $N_2(g) + 3H_2(g) \rightarrow 2NH_3$

(iii) $2SO_2(g) + O_2(g) \rightarrow 2SO_3$

(iv) $2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$

(v) $2HI(g) \rightarrow H_2(g) + I_2(g)$

(e) What is extensive property ? For 1 mole of an ideal gas show that $\bar{C}_P - \bar{C}_V = R$. 1+4=5

4. Answer ***any three*** questions from the following : 10×3=30

(a) What is Joule-Thomson effect ? Show that Joule-Thomson experiment is an isoenthalpic process. Define Joule-Thomson co-efficient. How can you determine Joule-Thomson co-efficient experimentally ? Show that

$$\left(\frac{\partial H}{\partial P}\right)_T = -\mu_{JT} C_P .$$ 1+4+2+1+2=10

(b) Derive the expression of efficiency of Carnot engine. Give the characteristics of η. Give the signs of ω, ΔS and q in each step of the Carnot cycle. 5+2+3=10

(c) (i) Derive Kirchhoff's equation.

(ii) Calculate the standard enthalpy change formation of C_2H_6 from the following data of heat of combustion : 6+4=10

$$C_2H_6 + \frac{7}{2}O_2 \rightarrow 2CO_2 + 3H_2O,\ \Delta H_1 = -1560 kJ\,mol^{-1}$$

$$C + O_2 \rightarrow CO_2,\ \Delta H_2 = -393{\cdot}5\,kJ\,mol^{-1}$$

$$H_2 + \frac{1}{2}O_2 \rightarrow H_2O,\ \Delta H = -286 kJ\,mol^{-1}$$

(d) Show that —

(i) PV^{γ} = constant for an adiabatic process;

(ii) $\Delta S = C_V \ln \frac{T_2}{T_1} + nR \ln \frac{V_2}{V_1}$ for an ideal gas;

(iii) $\Delta S_{mixing} = -nR \sum x_i \ln x_i$

3+2+5=10

(e) (i) For an irreversible process show that $\Delta S_{univ} \geq 0$ 5

(ii) What is residual entropy ? Explain with an example. 1+4=5

(f) (i) Show that

$$K_p = K_x (P)^{\Delta ng} = K_c (RT)^{\Delta ng}$$

(ii) What are colligative properties ? Explain two practical applications of colligative properties.