CHAPTER - 05
THERMODYNAMICS & CHEMICAL ENERGETICS

1. 3 Mass, volume – extensive; Density – Intensive

2. 2 $q_p = \Delta H$

3. 3 $W = -P_{ex}\Delta V = -10^5 (10^{-2} - 10^{-3}) = -900$ J or -0.9 kJ

4. 3 $q + w = \Delta u$ and $H-TS = G$ are state functions

5. 3 $C_7H_6(\ell) + 11O_2(g) \longrightarrow 7CO_2(g) + 8H_2O(\ell)$

$\Delta n_g = n_p - n_r = 7 - 11 = -4$

$\because \Delta H = \Delta U + \Delta n_g RT$

$\therefore \Delta H - \Delta U = -4RT$

6. 2 $2Al + \frac{3}{2}O_2 \rightarrow Al_2O_3, \Delta H = -1596\,kJ$ .....(i)

$2Cr + \frac{3}{2}O_2 \rightarrow Cr_2O_3, \Delta H = -1134\,kJ$ .....(ii)

By (i) – (ii)

$2Al + Cr_2O_3 \rightarrow 2Cr + Al_2O_3, \Delta H = -462\,kJ$.

7. 1 $2C(\text{graphite}) + 3H_2(g) \longrightarrow C_2H_6(g)$

$\Delta_f H(C_2H_6) = 2\Delta H_{comb}(C_{graphite}) + 3\Delta H_{comb}(H_2) - \Delta H_{comb}(C_2H_6)$

$= -(286\times 2) - (393.5\times 3) - (-1560) = -572 - 1180.5 + 1560 = -192.5\,kJ/mole$

8. 1 $\Delta_{sol}H = \Delta_{lattice}H + \Delta_{hyd}H = 788 - 784 = 4\ kJ\ mol^{-1}$

9. 2 $T_{eq} = \frac{\Delta H}{\Delta S} = \frac{491.1\times 1000}{198} = 2480.3\ K$

10. 2 $N_2 + 3H_2 \longrightarrow 2NH_3 \left(\Delta n_g < 0\right)$

11. 300 $\Delta u = q + w = (+600) + (-300) = 300\ J$

12. 0 $C + O_2 \longrightarrow CO_2;\ \Delta H = -X$

$$CO_2 \longrightarrow CO + \frac{1}{2}O_2;\ \Delta H = Y$$

$$C + \frac{1}{2}O_2 \longrightarrow CO;\ \Delta_f H(CO) = -X + Y$$

Clearly, a = –1 and b = 1

Thus, a + b = 0 and |a + b| = 0

13. 178

Heat liberated = $890 \times \frac{3.2}{16} = 178\ kJ$

14. A $W_{ABCD} = W_{AB} + W_{BC} + W_{CD} = -P_o(2V_o - V_o) - nRT\ell n\frac{4V_o}{2V_o} - \frac{P_o}{2}(2V_o - 4V_o)$

$= -2P_oV_o\ell n2$

15. B $q_{isoth} = -W = 4Nm^{-2} \times \left(1 - 5m^3\right) = -16Nm$

Now, $q_{Al} = nC_m\Delta T \Rightarrow \Delta T = \frac{q_{Al}}{nC_m} = \frac{16}{1 \times 24} = \frac{2}{3}K$

16. A W = 0 for free expansion; q = 0 for isothermal free expansion; $\Delta T = 0$ is possible in adiabatic expansion of ideal gas

17. D $q_A = -W_A$ ($\because$ isothermal expansion)

$= nRT_1\ell n\frac{V_2}{V_1}$

18. D $\Delta S_{D+E} = \frac{q_{rev,A}}{T_1} = nR\ell n\frac{V_2}{V_1}$

19. ABC Radius of circle = $\frac{V_2 - V_1}{2}$ or $\frac{P_2 - P_1}{2}$

Thus magnitude of work done = $\pi\left(\frac{V_2 - V_1}{2}\right)^2$ OR $\pi\left(\frac{P_2 - P_1}{2}\right)^2$ OR $\pi\left(\frac{V_2 - V_1}{2}\right)\left(\frac{P_2 - P_1}{2}\right)$

20. A Heat supplied by the electric heater = $250 \times 55 = 13.75\text{kJ}$

Heat capacity of calorimeter = $\frac{13.75\text{kJ}}{4.22\text{K}} = 326\text{kJK}^{-1}$

Now, enthalpy of oxidation of methanol = $-C_{p\text{'calorimeter}}$ x $\Delta T_{\text{calorimeter}}$

$= -3.26 \times (26.77 - 22.49) = -13.9\text{kJ}$

21. BC ΔG° is positive for $H_2O_{(\ell)} \rightleftharpoons H_2O_{(g)}$ at 1 atm and 298K; Entropy is the contributory factor for spontaneity of diffusion of two gases

22. BCD Reference state of sulphur is S_{rhombic}

23. BD ΔG° for the reaction, $2Fe_2O_3 + 6CO \rightarrow 4Fe + 6CO_2$ is given by,

$\frac{1487 + (-15432)}{2} = -28.1\text{kJmol}^{-1}$

Thus, reduction of Fe_2O_3 with CO is spontaneous at this temperature

24. 327.37

$C_6H_{6(\ell)} + \frac{15}{2}O_2(g) \rightarrow 6CO_{2(g)} + 3H_2O_{(\ell)}; \Delta n_g = -1.5$

$\Delta H = \Delta u + \Delta ngRT = -327 + (-0.15) \times 8.314 \times 300 \times 10^{-3}$ S

25. 4.80

$CH_3COOH \rightarrow CH_3COO^- + H^+$; $\Delta H^\circ = 17.1\text{kJmol}^{-1}$

For 0.12mol, energy required is $17.1 \times 0.12 = 2.052\text{kJ}$

Now, enthalpy change for the neutralisation of 0.12mol CH_3COOH is, $-57.1 \times 0.12 = -6.852\text{kJ}$

26. 21.97 - 21.98

$\Delta S = \frac{\Delta H}{T} = \frac{6000}{273} = 21.978\text{JK}^{-1}\text{mol}^{-1}$

27. 57.85 - 57.86

$\Delta_r H = \sum \text{BE (reactants)} - \sum \text{BE (products)}$

= (4x+y) – (3x + 84 + 103) = x + y –187 = –25

$x + y = 162 \Rightarrow \frac{9}{5}y + y = 162 \Rightarrow y = 57.857\text{ kcalmol}^{-1}$

28. 191.00

$\Delta_r H = \sum BE(\text{reactants}) - \sum BE(\text{products})$

$= (435 + 240) - (2 \times 430) = -185 kJmol^{-1}$

$\Delta_r S = 2S_{HCl} - (S_{H_2} + S_{Cl_2}) = 20 JK^{-1}mol^{-1}$

Now, $\Delta_r G = \Delta_r H - T\Delta_r S = -185 - 300 \times 20 \times 10^{-3} = -191 kJ$

29. A Reversible isothermal expansion: $\Delta S_{sys} > 0 \Rightarrow \Delta S_{sur} < 0$

Reversible adiabatic compression: $\Delta S_{sys} = \Delta S_{sur} = 0$

Adiabatic free (Irreversible) expansion: $\Delta S_{sys} > 0 \ \& \Delta S_{sur} = 0$

Irreversible isothermal compression: $q_{sys} < 0 \Rightarrow \Delta S_{sur} > 0$