

$$\int_{P^*}^{P^0} \frac{dM_y}{dP} dP = M_y(P^*) - \underbrace{M_x(P^0)}_{M^0_y}$$

Fundamental Theorem of Calculus

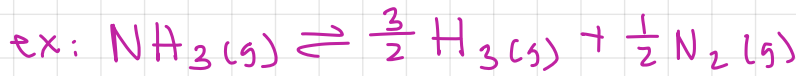
$$\rightarrow \frac{dM_y}{dP} = \frac{\partial}{\partial P} \frac{\partial G}{\partial n_y} = \frac{\partial G}{\partial P} = \frac{\partial V}{\partial n_y} = \frac{RT}{P_y} \quad \begin{matrix} \rightarrow P_y V = n_y RT \\ V = \frac{n_y RT}{P_y} \end{matrix}$$

From this, we obtained $\Delta G_{rxn} = \Delta G^{\circ}_{rxn} + RT \ln Q$

with $Q = \frac{(P_y/P^0)^{v_y} (P_z/P^0)^{v_z}}{(P_A/P^0)^{v_A} (P_B/P^0)^{v_B}}$ for $v_A A + v_B B \rightleftharpoons v_y Y + v_z Z$

At equilibrium $\Delta G_{rxn} = 0 \Rightarrow \Delta G^{\circ}_{rxn} = -RT \ln K$

Get K from ΔG° data which is normally tabulated at 298 K.



$$\Delta G^{\circ}_{rxn} = \frac{3}{2} \Delta G^{\circ}_f(H_2(g)) + \frac{1}{2} \Delta G^{\circ}_f(N_2(g)) - \Delta G^{\circ}_f(NH_3(g))$$

$$= 0 + 0 - (-16.4 \text{ kJ/mol}) = 16.4 \text{ kJ/mol}$$

$$\ln K = \frac{-\Delta G^{\circ}_{rxn}}{RT} = \frac{-16.4 \text{ kJ/mol}}{8.31 \text{ J} \cdot \text{K}^{-1} \cdot \text{mol}^{-1} \cdot 298 \text{ K}} = -6.6$$

$K = 1.36 \times 10^{-3}$ equilibrium lies towards NH_3

Even with gasses we can use concentration instead of pressure (anticipating solutions)

$$P_y V = n_y RT \Rightarrow P_y = \left(\frac{n_y}{V}\right) RT = C_y RT$$

$$Q_P = P_y^{d_y} \dots = (C_y RT)^{v_y} \Rightarrow Q_P = Q_C (RT)^{v_y + v_z - v_A - v_B}$$

$$\frac{(C_y/C_0)^{v_y} (C_z/C_0)^{v_z}}{(C_A/C_0)^{v_A} (C_B/C_0)^{v_B}} \left(\frac{RT C_0}{P^0}\right)^{v_y + v_z - v_A - v_B}$$

$$\Delta G^{\circ}_{rxn} = -RT \ln K \Rightarrow$$

$$\Delta G_{rxn} = -RT \ln K + RT \ln Q = RT \ln Q/K$$

Say $Q < K$ then $\Delta G^{\circ}_{rxn} < 0$ forwards direction is spontaneous

$Q > K$ $\Delta G^{\circ}_{rxn} > 0$ backwards direction is spontaneous



$$\Delta G^\circ_{\text{rxn}} = 4.73 \text{ kJ/mol at } 298 \text{ K}$$

Put 0.8 bar N_2O_4 and 0.2 bar NO_2 in flask

$$\Delta G_{\text{rxn}} = 4.73 + (8.31)(298\text{K}) \ln \frac{(0.2)^2}{0.8} = -2.7$$

The reaction proceeds in forwards direction.