Ch. 17 # 65, 67, 69 (page 826)

65. $NO_{(g)} + O_{3(g)} \rightarrow NO_{2(g)} + O_{2(g)}$

ΔG°_f (kJ/mol): 87 163 52 0

$\Delta G^\circ_{rxn} = 52 - 87 - 163 = -198 \text{ kJ/mol}$

$$Q = \frac{P_{NO_2} P_{O_2}}{P_{NO} P_{O_3}} = \frac{(1.00\times10^{-7})(1.00\times10^{-3})}{(1.00\times10^{-6})(2.00\times10^{-6})} = 50$$

$G = G^\circ + RT \ln Q$

$= -198 \text{ kJ/mol} + \left(.008314 \frac{\text{kJ}}{\text{mol K}}\right)(298\text{K})(\ln 50)$

$= -198 \frac{\text{kJ}}{\text{mol}} + 9.69 \frac{\text{kJ}}{\text{mol}}$

$= -188.3 \frac{\text{kJ}}{\text{mol}} = \boxed{-188 \text{ kJ}}$

67. $2NO_{2(g)} \rightleftharpoons N_2O_{4(g)}$

ΔG°: $52 \frac{\text{kJ}}{\text{mol}}$ $98 \frac{\text{kJ}}{\text{mol}}$

$Q = \frac{P_{N_2O_4}}{(P_{NO_2})^2}$

$\Delta G^\circ_{rxn} = 98 \frac{\text{kJ}}{\text{mol}} - 2\left(52 \frac{\text{kJ}}{\text{mol}}\right) = -6 \frac{\text{kJ}}{\text{mol}} = -6000 \frac{\text{J}}{\text{mol}}$

$\Delta G = \Delta G^\circ + RT \ln Q$

a) $\Delta G = -6000 \frac{\text{J}}{\text{mol}} + \left(8.314 \frac{\text{J}}{\text{mol K}}\right)(298\text{K})\left(\ln \frac{1.0}{1.0^2}\right) = -6000 \text{ J/mol}$

$Q = 1$

$(\Delta G = \Delta G^\circ) < 0$ forward rxn is spontaneous.

b) $\Delta G = -6000 \frac{\text{J}}{\text{mol}} + \underbrace{\left(8.314 \frac{\text{J}}{\text{mol K}}\right)(298\text{K})\left(\ln \frac{.50}{(.21)^2}\right)}_{6015.9 \,=\, 6000 \text{ (s.f.)}} = 15.9 \text{ kJ/mol} \approx 0 \frac{\text{kJ}}{\text{mol}}$

ΔG is 0
reaction is at equilibrium (no shift)

c) $\Delta G = -6000 \frac{\text{J}}{\text{mol}} + \left(8.314 \frac{\text{J}}{\text{mol K}}\right)(298\text{K}) \ln\left(\frac{1.6}{.29^2}\right) = 1300 \frac{\text{J}}{\text{mol}}$

ΔG is (+)
reaction shifts left to reach equilibrium

69. $NO_{(g)} + O_{3(g)} \rightleftharpoons NO_{2(g)} + O_{2(g)}$

ΔG° : $87 \frac{kJ}{mol}$ $163 \frac{kJ}{mol}$ $52 \frac{kJ}{mol}$ 0

$\Delta G^\circ = 52 - 87 - 163 = -198\ kJ$

$\Delta G^\circ = -RT \ln K$

$\ln K = \frac{-\Delta G^\circ}{RT} = \frac{-(-198\ \cancel{kJ} \times 1000\ \cancel{J}/\cancel{kJ})\ \cancel{mol^{-1}}}{\left(8.314 \frac{\cancel{J}}{\cancel{mol}\cancel{K}}\right)(298\ \cancel{K})}$

$\ln K = 79.912$

inverse $\ln K$ → $K = \boxed{5.07 \times 10^{34}}$