Topic 5H - Alternative Forms of the Equilibrium Constant

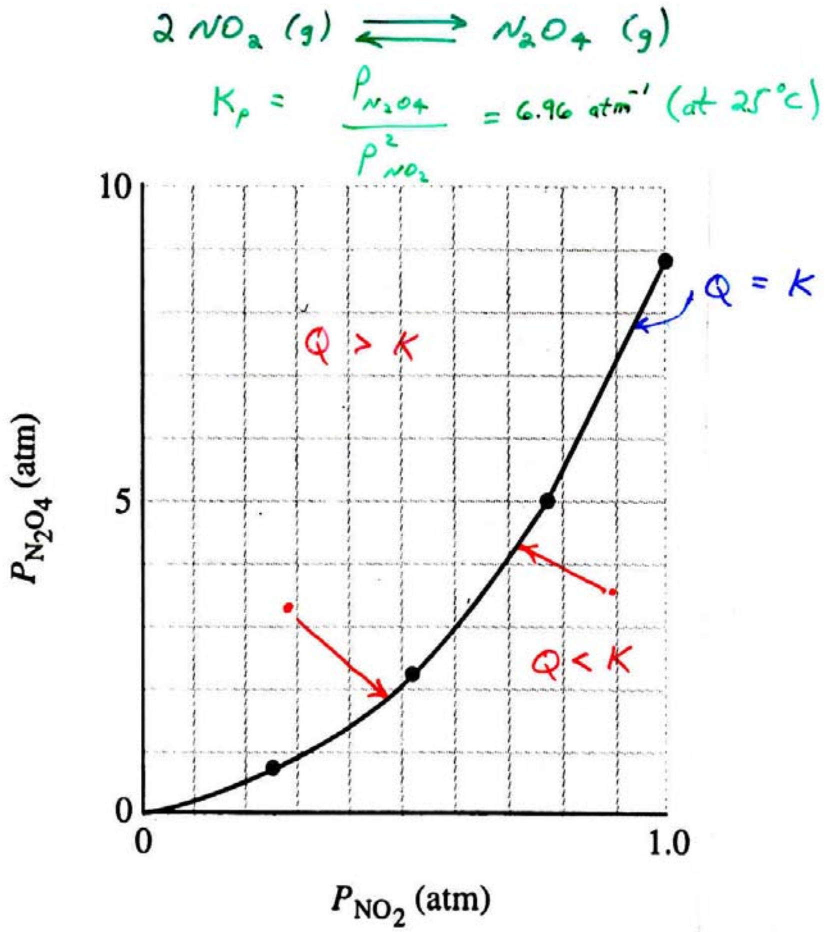
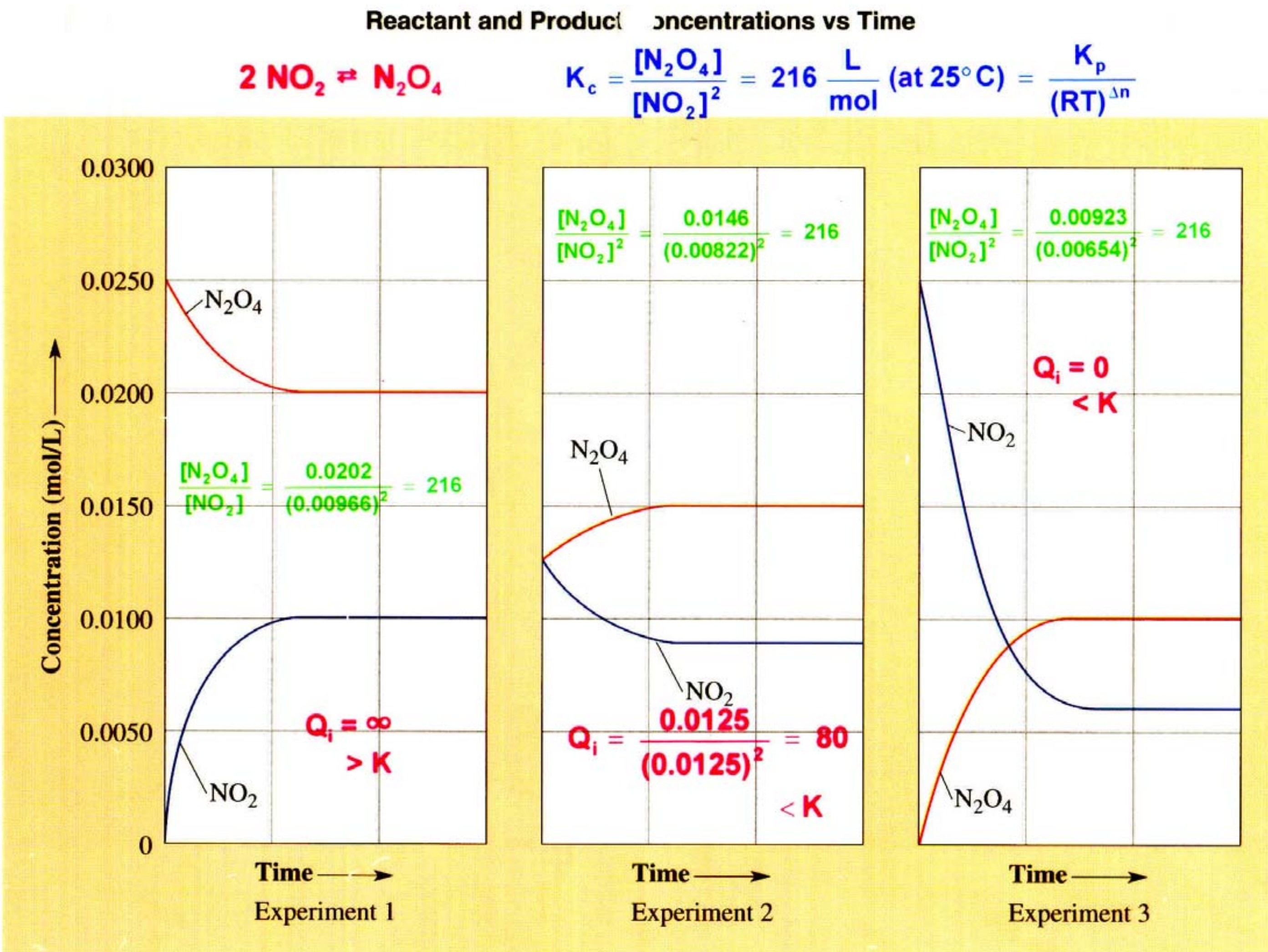
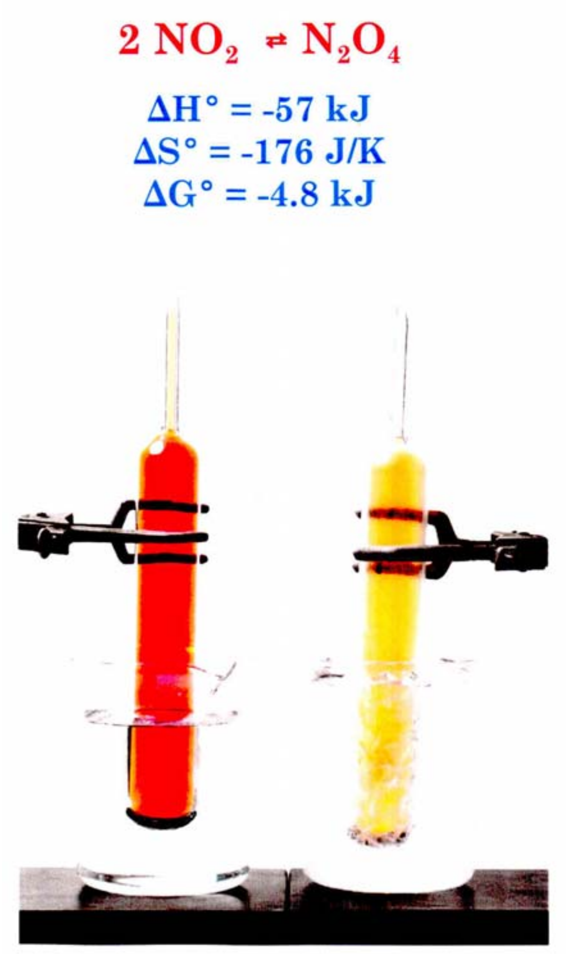


Figure 5-2

At a constant temperature of 25°C, a graph of N_2O_4 partial pressure at equilibrium versus NO_2 partial pressure has the form of a parabola.


Reactant and Product oncentrations vs Time
2 NO2 ⇌ N2O4
Kc = [N2O4] / [NO2]^2 = 216 L/mol (at 25° C) = Kp / (RT)^Δn
Concentration (mol/L)
0.0300
0.0250
0.0200
0.0150
0.0100
0.0050
0
N2O4
NO2
[N2O4] / [NO2] = 0.0202 / (0.00966)^2 = 216
Qi = ∞
> K
Time
Experiment 1
[N2O4] / [NO2]^2 = 0.0146 / (0.00822)^2 = 216
N2O4
NO2
Qi = 0.0125 / (0.0125)^2 = 80
< K
Time
Experiment 2
[N2O4] / [NO2]^2 = 0.00923 / (0.00654)^2 = 216
Qi = 0
< K
NO2
N2O4
Time
Experiment 3


$2\ NO_2 \rightleftharpoons N_2O_4$
ΔH° = -57 kJ
ΔS° = -176 J/K
ΔG° = -4.8 kJ

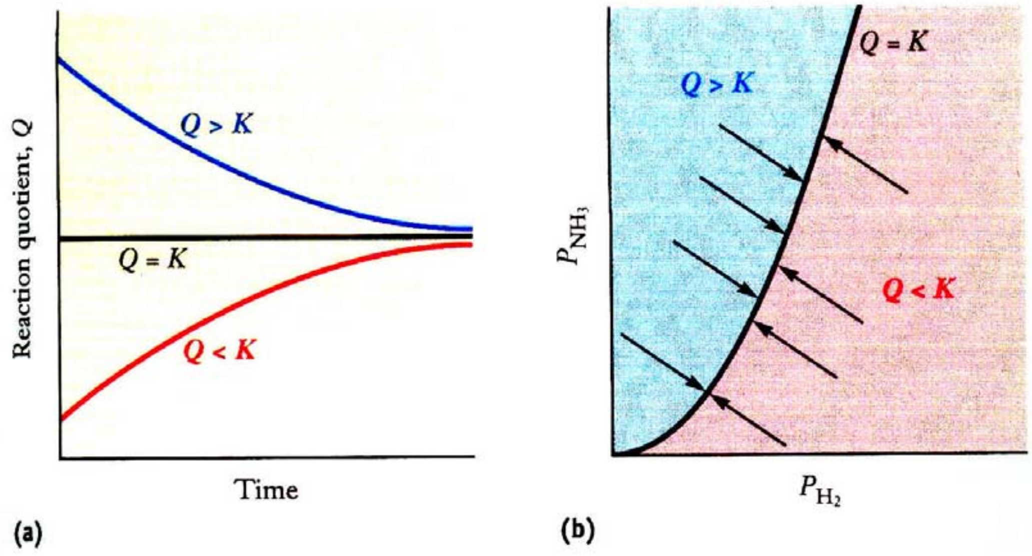


FIGURE 9.5 If nitrogen and hydrogen are mixed in 1:3 proportions together with some ammonia, they react according to the chemical equation

$$N_2(g) + 3\ H_2(g) \rightleftharpoons 2\ NH_3(g)$$

(a) If the initial reaction quotient Q_0 is less than K, it increases with time; if it is greater than K, it decreases. (b) The pathways from (a) are shown here in a graph of the partial pressure of ammonia against that of hydrogen (under conditions where there are three moles of H_2 for each mole of N_2). As the reaction goes toward equilibrium, the partial pressures approach a parabolic curve representing partial pressures that can coexist at chemical equilibrium.

TABLE 6.1 Results of Three Experiments for the Reaction
$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ AT 500 °C

Experiment	Initial Concentrations	Equilibrium Concentrations	$K = \frac{[NH_3]^2}{[N_2][H_2]^3}$
I	$[N_2]_0 = 1.000\ M$ $[H_2]_0 = 1.000\ M$ $[NH_3]_0 = 0$	$[N_2] = 0.921\ M$ $[H_2] = 0.763\ M$ $[NH_3] = 0.157\ M$	$Q_i = 0$ $(< K)$ $K_c = 6.02 \times 10^{-2}\ L^2/mol^2$
II	$[N_2]_0 = 0$ $[H_2]_0 = 0$ $[NH_3]_0 = 1.000\ M$	$[N_2] = 0.399\ M$ $[H_2] = 1.197\ M$ $[NH_3] = 0.203\ M$	$Q_i = \infty$ $(> K)$ $K_c = 6.02 \times 10^{-2}\ L^2/mol^2$
III	$[N_2]_0 = 2.00\ M$ $[H_2]_0 = 1.00\ M$ $[NH_3]_0 = 3.00\ M$	$[N_2] = 2.59\ M$ $[H_2] = 2.77\ M$ $[NH_3] = 1.82\ M$	$Q_i = 4.5$ $(> K)$ $K_c = 6.02 \times 10^{-2}\ L^2/mol^2$

$$K_c = \frac{K_p}{(RT)^{\Delta n}} \qquad \text{(where } \Delta n = -2\text{)}$$

$$K_p = \frac{K_c}{(RT)^2} = \frac{6.02 \times 10^{-2}\ L^2/mol^2}{(0.08205\ L \cdot atm/mol \cdot K \times 773.15\ K)^2}$$

$$= 1.50 \times 10^{-5}\ atm^{-2}$$