Chapter 13

27
13.~~29~~ (a) $A_2 + C_2 \rightleftharpoons 2AC$ (most product molecules)

(b) $A_2 + B_2 \rightleftharpoons 2AB$ (fewest product molecules)

28
13.~~30~~ (a) Only rxn. (3), $K_c = \frac{[A][AB]}{[A_2][B]} = \frac{(2)(4)}{(2)(2)} = 2$, is at equil.

(b) $Q_c = \frac{[A][AB]}{[A_2][B]} = \frac{(3)(5)}{(1)(1)} = 15$ for rxn (1)

Since $Q_c > K_c$, the rxn will go in reverse to reach equil.

$Q_c = \frac{[A][AB]}{[A_2][B]} = \frac{(1)(3)}{(3)(3)} = \frac{1}{3}$ for rxn (2)

Since $Q_c < K_c$, the rxn will go in the forward direction.

29
13.~~31~~ (a) $A_2 + 2B \rightleftharpoons 2AB$

(b) The # of AB molecules will increase, because as the volume goes down at a constant temperature, the pressure will increase & the rxn. will shift to the side with fewer molecules to reduce the pressure.

35
13.~~37~~ This equil. mixture has a $K_c \propto \frac{(2)(2)}{(3)^2}$ & is less than 1.

Which means that $\underline{k_f < k_r}$.

13.40

(a) $K_c = \frac{[CO][H_2]^2}{[CH_4][H_2O]}$

(b) $K_c = \frac{[ClF_3]^2}{[F_2]^3[Cl_2]}$

(c) $K_c = \frac{[HF]^2}{[H_2][F_2]}$

13.41 (a) $K_c = \frac{[CH_3CHO]^2}{[C_2H_4]^2[O_2]}$

(b) $K_c = \frac{[N_2][O_2]}{[NO]^2}$

(c) $K_c = \frac{[NO]^4[H_2O]^6}{[NH_3]^4[O_2]^5}$

13.44

$K_c = \frac{[C_2H_5OC_2H_5][H_2O]}{[C_2H_5OH]^2}$

46

13.~~48~~ · The two rxns. are the reverse of each other —

$K_c(\text{rev}) = \frac{1}{K_c(\text{forward})} = \frac{1}{7.5\times10^{-9}} = 1.3\times10^{8}$

48
13.~~50~~ $K_c = \frac{[PCl_3][Cl_2]}{[PCl_5]} = \frac{(1.5\times10^{-2})(3.2\times10^{-2})}{(8.3\times10^{-3})} = 0.058$

58
13.~~60~~ (a) $K_c = \frac{[CO_2]^3}{[CO]^3}$ $K_p = \frac{P_{CO_2}^3}{P_{CO}^3}$

(b) $K_c = \frac{1}{[O_2]^3}$ or $K_p = \frac{1}{P_{O_2}^3}$

(c) $K_c = [SO_3]$ or $K_p = P_{SO_3}$

(d) $K_c = [Ba^{+2}][SO_4^{2-}]$

60
13.~~62~~ (a) Since K_c is very ~~small~~ large, the equil. mixture is mostly product.

(b) Since K_c is very small, the equil. mixture is mostly reactant.

13.63 (a) does not go much in the forward direction

(b) goes almost to completion –

$\underline{13.\overset{65}{\cancel{69}}}$ $Q_c = \frac{[CO]_t [H_2]_t^3}{[H_2O]_t [CH_4]_t} = \frac{(0.15)(0.20)^3}{(0.035)(0.050)} = 0.69$

The rxn is not at equil. since $Q_c < K_c$ ($0.69 < 4.7$)
The rxn. will proceed from left to right to reach equilibrium

$\underline{13.70}$

$K_c = \frac{[NH_3]^2}{[N_2][H_2]^3} = 0.29$ @ equil $[N_2] = 0.036M$ +
$[H_2] = 0.15M$

$[NH_3] = \sqrt{[N_2]\cdot[H_2]^2\cdot K_c} = \sqrt{0.036\cdot 0.15^3\cdot 0.29} =$

$5.9\times10^{-3}M$

$\underline{13.71}$

$K_c = 2.7\times10^2 = \frac{[SO_3]^2}{[SO_2]^2[O_2]}$; Because $[SO_3] = [SO_2]$, then $2.7\times10^2 = \frac{1}{[O_2]}$

$[O_2] = 3.7\times10^{-3}M$

√

13.78 $ClF_3(g) \rightleftharpoons ClF(g) + F_2(g)$

	ClF_3	ClF	F_2
start	1.47	–	–
Δ	−x	+x	+x
equil.	1.47−x	x	x

$$K_p = \frac{P_{ClF} P_{F_2}}{P_{ClF_3}} = 0.140 = \frac{x^2}{1.47-x}$$

$x^2 + 0.140x - 0.2058 = 0$

$$x = \frac{-0.140 \pm \sqrt{0.140^2 - 4 \cdot 1 \cdot -.2058}}{2(1)} = \frac{-0.140 \pm 0.918}{2}$$

$x = 0.389 + ~~-0.529~~$ $P_{ClF} = P_{F_2} = x = 0.385$ atm , $P_{ClF_3} = 1.47 - 0.385 =$

13.80 (a) if Cl^- is added, AgCl(s) increases

(b) Ag^+ is added, AgCl(s) increases

(c) Ag^+ is removed, AgCl(s) decreases

(d) Cl^- removed, AgCl(s) decreases.

if $[Cl^-]$↑ Qc increases to a value greater than K_c, therefore the rxn must go from right to left. to increase AgCl(s)

13.81

(a) ClNO added, NO_2 ↓

(b) NO added, NO_2 ↑

(c) NO removed, NO_2 ↓

(d) $ClNO_2$ added, NO_2 ↑

Adding $ClNO_2$ decrease Qc, the rxn must shift from left to right to [illegible] reach equilibrium, thus increasing the NO_2 conc.

13.83

As the Volume ↑, the Pressure ↓ @ constant temp.

(a) the rxn will shift to the side with larger # of molecules — since the stress is the decrease in pressure — or an increase in volume. — Toward Products

(b) The rxn will shift to the reactants, Since that is the side with the greater # of moles.

(c) This rxn is not altered by changes in volume or pressure, since there are equal # of molecules on Both sides — No change.

13.86- (a) HCl is a source of Cl^-, the rxn. shifts left, the equil. $[CoCl_4^{2-}]$ increases

(b) $Co(NO_3)_2$ is a source of $Co(H_2O)_6^{+2}$, the rxn. shifts left, the equil. conc. of $[CoCl_4^{2-}]$ increases.

(c) All conc. will initially decrease & the rxn. will shift right, the equil. conc. of $[CoCl_4^{2-}]$ decreases

(d) For an exothermic rxn.: the rxn. shifts to the left when the temp increases - the equil $(CoCl_4^{2-})$ increases

13.87

(a) $Fe(NO_3)_3$ is a source of Fe^{+3}. Fe^{+3} added; the $FeCl^{2+}$ conc. increases.

(b) Cl^- removed; the $FeCl^{2+}$ conc. decreases.

(c) An endothermic rxn. shifts to the right as the temperat. increases; the $FeCl^{2+}$ conc. increases.

(d) A catalyst does not affect the composition of the equil. mixture; no change in $FeCl^{2+}$ conc.

94
13.~~92~~ $K_c = k_f / k_r = 0.13 / 6.2 \times 10^{-4} = 210$

13.99 V = 5.0L

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

$[H_2] = [I_2] =$
1 mol/5L = 0.2M

[HI] =
2.5 mol/5L =
0.5M

	$H_2(g)$	$I_2(g)$	$2HI(g)$
start	0.2	0.2	0.5
Δ	−x	−x	+2x
equil.	0.2−x	0.2−x	0.5+2x

$$K_c = \frac{[HI]^2}{[H_2][I_2]} = 129 = \frac{(0.50+2x)^2}{(0.20-x)^2}$$

$$\sqrt{129} = \sqrt{\frac{(0.50+2x)^2}{(0.2-x)^2}} = 11.4 = \frac{0.50+2x}{0.2-x} \;;\; x = 0.133$$

$[H_2] = [I_2] = 0.2 - 0.133 = 0.067M$; $[HI] = 0.5 + 2(0.133) = 0.76$

106
13.~~104~~

$[PCl_5] = 1\text{mol}/5L = 0.2M$

$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$$

	$PCl_5(g)$	$PCl_3(g)$	$Cl_2(g)$
start	0.2	−	−
Δ	−(0.2)(0.7850)	+(0.2)(0.7850)	+(0.2)(0.7850)
equil.	0.0430	+0.1570	+0.1570

$$K_c = \frac{[PCl_3][Cl_2]}{[PCl_5]} = \frac{(0.1570)^2}{(0.0430)} = 0.573$$

$\Delta n = 1$ & $K_p = K_c (RT)^{\Delta n} = 0.573(0.0821)(500) = 23.5$

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17.~~116~~ $2NO_2(g) \rightleftharpoons N_2O_4(g)$

$\Delta n = 1-2 = -1 \quad K_p = K_c(RT)^{-1} = [(216)(0.0821)(298)]^{-}$

$= 8.83$

$$K_p = \frac{P_{N_2O_4}}{(P_{NO_2})^2} = 8.83$$

Let $X = P_{N_2O_4}$ & $Y = P_{NO_2}$

$P_{total} = 1.50$ atm $= X + Y$ & $\frac{X}{Y^2} = 8.83$

Now using these 2 equations we can solve for X & Y

$X = 1.50 - Y$

$\frac{1.50-Y}{Y^2} = 8.83 \longrightarrow 8.83Y^2 + Y - 1.50 = 0$

$$Y = \frac{-1 \pm \sqrt{1^2 - 4(8.83)(-1.50)}}{2(8.83)} = \frac{-1 \pm 7.35}{17.7}$$

$Y = \cancel{-.472}$ & 0.359

$Y = P_{NO_2} = 0.359$ atm

$X = P_{N_2O_4} = 1.50 - Y = 1.5 - 0.359 = 1.14$ atm