Chemical Equilibrium Part 1 Review

(1) (a) $K_c = \frac{[H_2]^2[H_2C_2]}{[CH_4]^2}$ (b) $K_c = \frac{[Ni(CO)_4]}{[CO]^4}$ (c) $K_c = [O_2]$

(d) $K_c = \frac{[Cl_2]^2}{[HCl]^4[O_2]}$ (e) $K_c = \frac{[Cl_2][H_2O]}{[O_2][HCl]^2}$ (f) $K_c = \frac{1}{[Ag^+][Cl^-]}$

(g) $K_c = \frac{[H_3O^+][HCO_3^-]}{[CO_2]}$

(2) (a) reactants
(b) products
(c) neither

(3) When a stress is applied to a system at equilibrium, the system shifts in such a way to relieve that stress.

(4) (a) forward (b) reverse (c) reverse (d) forward
(e) forward. (f) forward (g) forward (h) forward.

(5) (a) no shift (same number of gas particles on both sides)
(b) reverse (fewer gas particles)
(c) no shift (same number of gas particles on both sides)

(6) (a) reverse (b) reverse (c) reverse (d) forward (e) no shift

(7) $K_c = \dfrac{[H_2][CO_2]}{[H_2O][CO]}$

(a) $K_c = \dfrac{(.9)(.8)}{(.4)(.5)} = 3.6$ forward (b) $K_c = \dfrac{(.04)(.03)}{(.02)(.01)} = 6$ forward.

(c) $K_c = \dfrac{(2.78)(2.78)}{(1.22)(1.22)} = 5.19$ forward (d) $K_c = \dfrac{(2.39)(1.39)}{(1.22)(0.61)} = 4.46$ forward.

(8) $K_c = \dfrac{[O_2]^3}{[O_3]^2} = \dfrac{(.21)^3}{(6.0\times10^{-5})^2} = 2.57\times10^{12}$

(9) $K_c = \dfrac{[H_2S]^2}{[H_2]^2[S_2]}$

$[H_2S] = \dfrac{2\text{ mol}}{2\text{L}} = 1\text{ mol/L}$

$[H_2] = \dfrac{.4\text{ mol}}{2\text{L}} = 0.2\text{ mol/L}$

$[S_2] = \dfrac{.8\text{ mol}}{2\text{L}} = 0.4\text{ mol/L}$

$= \dfrac{(1)^2}{(.2)^2(.4)}$

$= 62.5$

(10) (a)

	$2CH_4$	H_2C_2	$2H_2$
I	.03	0	0
C	−.0275	+.01375	+.0275
E	.0025	.01375	.0275

(b) $K_c = \dfrac{[H_2]^2[H_2C_2]}{[CH_4]^2}$

$= \dfrac{(.0275)^2(.01375)}{(.0025)^2} = 1.66$

(11)

	H_2	I_2	HI
I	0	0	0.02
C	+x	+x	-2x
E	x	x	.02-2x

$$K_c = \frac{[HI]^2}{[H_2][I_2]}$$

$$54.5 = \frac{(.02-2x)^2}{(x)(x)}$$

$$54.5 = \frac{.0004 - .08x + 4x^2}{x^2}$$

$$54.5x^2 = .0004 - .08x + 4x^2$$

$$50.5x^2 + .08x - .0004 = 0$$

$$x = \frac{-b \pm \sqrt{b^2-4ac}}{2a} = \frac{-.08 \pm \sqrt{(.08)^2 - 4(50.4)(-.0004)}}{2(50.4)}$$

$$= \frac{-.08 \pm .295}{100.8} = \cancel{-.0037} \quad .0021$$

∴ at equilibrium.

$[H_2] = 0.0021$ mol/L

$[I_2] = 0.0021$ mol/L

$[HI] = .02 - 2(.0021) = 0.0158$ mol/L

(12)

	CO	H_2	CH_4	H_2O
I	.1	.3	0	0
C	$-x$	$-3x$	$+x$	$+x$
E	$.1-x$	$.3-3x$	x	x

$$K_c = \frac{[CH_4][H_2O]}{[CO][H_2]^3}$$

$$0.1764 = \frac{(x)(x)}{(.1-x)(.3-3x)^3}$$

Note: for a test or exam you will not be required to solve an equation of this difficulty.

(13)

	NH_3	N_2	H_2
I	$\frac{4}{2}=2$	0	0
C	-1	$+1$	$+1$
E	$\frac{2}{2}=1$	1	1

$$K_c = \frac{[N_2][H_2]}{[NH_3]}$$

$$= \frac{(1)(1)}{(1)}$$

$$K_c = 1$$

(14) (a)

	H_2	F_2	HF
I	2	2	0
C	$-x$	$-x$	x
E	$2-x$	$2-x$	x

$$K_c = \frac{[HF]}{[H_2][F_2]}$$

$$100 = \frac{x}{(2-x)(2-x)}$$

14 continued

$$100 = \frac{x}{4 - 4x + x^2}$$

$$400 - 400x + 100x^2 = x$$

$$100x^2 - 401x + 400 = 0$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{401 \pm \sqrt{(-401)^2 - 4(100)(400)}}{2(100)}$$

$$= \frac{401 \pm 28.3}{200} \qquad \cancel{2.15} \quad 1.86$$

$[H_2] = 2 - (1.86) = 0.14$ mol/L

$[F_2] = 2 - (1.86) = 0.14$ mol/L

$[HF] = 1.86$ mol/L

(b)

	H_2	F_2	HF
I	$.14 + .5 = .64$	.14	1.86
C	$-x$	$-x$	$+x$
E	$.64 - x$	$.14 - x$	$1.86 + x$

$$K_c = \frac{[HF]}{[H_2][F_2]}$$

$$100 = \frac{(1.86 + x)}{(.64 - x)(.14 - x)}$$

14 continued

$$100 = \frac{1.86 + x}{.0896 - .78x + x^2}$$

$$8.96 - 78x + 100x^2 = 1.86 + x$$

$$100x^2 - 79x + 7.1 = 0$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$= \frac{79 \pm \sqrt{(-79)^2 - 4(100)(7.1)}}{2(100)}$$

$$= \frac{79 \pm 58.32}{200} = \begin{matrix} \cancel{.6866} \\ .1034 \end{matrix}$$

$[H_2] = .64 - (.1034) = .54$ mol/L

$[F_2] = .14 - (.1034) = .04$ mol/L

$[HF] = 1.86 + (.1034) = 1.96$ mol/L