5.3 – ICE Box Problems – Assignment

1. For the reaction

   $N_{2(g)} + 3H_{2(g)} \leftrightarrow 2NH_{3(g)}$

   The initial $[N_2]$ = 0.32 M and the initial $[H_2]$ = 0.66 M. At a certain temperature and pressure the equilibrium $[H_2]$ is found to be 0.30 M. What is K_{eq} under these circumstances?

	$[N_2]$	$[H_2]$	$[NH_3]$
[Initial]	0.32	0.66	0
[Change]	-0.12	-0.36	0.24
[Equilibrium]	0.20	0.3	0.24

$\frac{N_2}{1} = \frac{H_2}{3}$

$\frac{1mol}{x} = \frac{3mol}{0.36M}$

$x = 0.12M$

$3 H_2 : 2 NH_3$

$0.36 : x$

$x = 0.24 M$

$$K_{eq} = \frac{[NH_3]^2}{[H_2]^3[N_2]} = \frac{[0.24]^2}{[0.3]^3[0.2]} = \frac{0.0576}{(0.027)(0.2)}$$

~~Keq = 7.4~~ Keq = 10.7

2. Suppose that $\boxed{\text{2.00 moles of HCl in a 1.00L}}$ glass flask slowly decomposes into H_2 and Cl_2. When equilibrium is reached, the concentrations of H_2 and Cl_2 are both 0.214 M. What is the K_{eq}?

	HCl	H_2	Cl_2
[Initial]	2.0	0	0
[Change]	-0.428	+.214	+0.214
[Equilibrium]	1.572	0.214	0.214

$2HCl \leftrightarrow H_2 + Cl_2$

HCl : H_2

$\frac{2mol}{x} = \frac{1mol}{0.214}$

$x = 0.428$

$$K_{eq} = \frac{[H_2][Cl_2]}{[HCl]^2} = \frac{[0.214][0.214]}{[1.572]^2}$$

$$= \frac{0.045796}{2.471184}$$

$$= 0.0185$$

$$= 1.85 \times 10^{-2}$$

$4NO \leftrightarrow 2N_2O + O_2$

3. Consider the equilibrium: $2N_2O(g) + O_2(g) \leftrightarrow 4NO(g)$ Keq for this rxn
3.00 moles of NO(g) are introduced into a 1.00-Liter evacuated flask. When the system comes to equilibrium, 1.00 mole of $N_2O(g)$ has formed. Determine the equilibrium concentrations of each substance. Calculate the K_c for the reaction based on these data.

	NO	N_2O	O_2
[Initial]	3.0	0	0
[Change]	−2.0	+1.0	+0.5M
[Equilibrium]	1.0	1.0	0.5M

NO : N_2O

$\frac{4\,mol}{x} = \frac{2\,mol}{1.0}$

x=2.0M

O_2 : N_2O

$\frac{1\,mol}{x} = \frac{2\,mol}{1.0}$

x = 0.5m

$$Keq = \frac{[NO]^4}{[N_2O]^2[O_2]}$$

$$= \frac{[1.0]^4}{[1.0]^2[0.5]} = \boxed{2.00}$$

4. At some temperature, $K_{eq} = 33$ for the reaction $H_2 + I_2 \rightarrow 2HI$. If initially, $[H_2] = .0600$ M and $[I_2] = .0300$ M, what are all three equilibrium concentrations?

	H_2	I_2	HI
[Initial]	0.06	0.03	0
[Change]	−x	−x	+2x
[Equilibrium]	0.06−x	0.03−x	2x

Eq:
$[H_2] = 0.06 - 0.0273 = 0.0327M$
$[I_2] = 0.03 - 0.0273 = 0.0027M$
$[HI] = 2(0.0273) = 0.0546M$

Keq = 33

$$Keq = \frac{[HI]^2}{[H_2][I_2]} = \frac{[2x]^2}{(0.06-x)(0.03-x)} = \frac{4x^2}{0.0018 - 0.06x - 0.03x + x^2}$$

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

$$33 = \frac{4x^2}{0.0018 - 0.09x + x^2} \Rightarrow 33(0.0018 - 0.09x + x^2) = 4x^2$$

$$0.0594 - 2.97x + 33x^2 = 4x^2$$
$$0.0594 - 2.97x + 29x^2 = 0$$

C B A

$$x = \frac{-(2.97) \pm \sqrt{(2.97^2) - 4(0.0594)(29)}}{2(29)}$$

$$x = \frac{2.97 \pm \sqrt{1.9305}}{58}$$

x = 0.0752 or 0.0273

5. Graphite (solid carbon) and carbon dioxide are kept at constant pressure at 1000 K until the following reaction reaches equilibrium.

$C_{(s)} + CO_{2(g)} \leftrightarrow 2CO_{(g)}$

If $K_{eq} = 0.021$, calculate the equilibrium concentration of CO if the concentration of CO_2 was initially 0.012 M.

$K_{eq} = 0.021$

	C	CO_2	CO
[Initial]		0.012	0
[Change]		$-x$	$+2x$
[Equilibrium]		$0.012-x$	$2x$?

$$K_{eq} = \frac{[CO]^2}{[CO_2]} = \frac{(2x)^2}{(0.012-x)}$$

$$0.021 = \frac{4x^2}{0.012-x}$$

$$(0.021)(0.012-x) = 4x^2$$

$$\underset{C}{0.000252} - \underset{B}{0.021x} - \underset{A}{4x^2} = 0$$

$$x = \frac{-b \pm \sqrt{b^2-4ac}}{2a} = \frac{-(0.021) \pm \sqrt{(0.021)^2 - 4(4)(0.000252)}}{2(4)}$$

$$x = \frac{0.021 \pm \sqrt{0.004423}}{-8}$$

$$x = \frac{0.021 \pm 0.06688049}{-8}$$

$$\Rightarrow \frac{-0.04588}{-8} = \boxed{0.005735}$$

$$\Rightarrow \frac{0.08788}{-8} = -\cancel{0.01099}$$

$[CO] = 2x$

$= 2(0.005735\text{M})$

$\boxed{[CO] = 0.011\text{ M}}$