Worksheet #9 Equilibrium Calculations

Solve each problem and show all of your work.

1. At equilibrium, a 5.0L flask contains:
0.75 mol of PCl_5 0.50 mol of H_2O 7.50 mol of HCl 5.00 mol of $POCl_3$
Calculate the Keq for the reaction:
$PCl_{5\,(s)} + H_2O_{\,(g)}$ â‡„ $2HCl_{\,(g)} + POCl_{3\,(g)}$

Keq = 23

2. Keq= 798 for the reaction:
$2SO_{2\,(g)} + O_{2\,(g)}$ â‡„ $2SO_{3\,(g)}$.
In a particular mixture at equilibrium, $[SO_2]$= 4.20 M and $[SO_3]$=11.0 M. Calculate the equilibrium $[O_2]$ in this mixture.

$[O_2] = 8.60 \times 10^{-3}$ M

3. Consider the following equilibrium:
$2SO_2\,(g) + O_2\,(g)$ â‡„ $2SO_3\,(g)$
When a 0.600 moles of SO_2 and 0.600 moles of O_2 are placed into a 1.00 litre container and allowed to reach equilibrium, the equilibrium $[SO_3]$ is to be 0.250M. Calculate the Keq value.

Keq =1.07

4. Consider the following equilibrium:
$2\,NO_{2(g)}$ â‡„ $N_2O_{4(g)}$
If 2.00 moles of NO_2 are placed in a 1.00 L flask and allowed to react. At equilibrium 1.80 moles NO_2 are present. Calculate the K_{eq}.

$2\,NO_{2(g)}$ â‡„ $N_2O_{4(g)}$

I	**2.00**	**0.00**
C	**-0.20**	**0.10**
E	**1.80 M**	**0.10 M**

Note the loss of one sig fig

$$\text{Keq} = \frac{(0.10)}{(1.80)^2}$$

Keq = 0.031

5. **$2\,SO_{2(g)}$ + $O_{2(g)}$ â‡„ $2\,SO_{3(g)}$**
4.00 moles of SO_2 and 5.00 moles O_2 are placed in a 2.00 L container at 200°C and allowed to reach equilibrium. If the equilibrium concentration of O_2 is 2.00 M, calculate the Keq

Keq = 0.50

6. If the initial $[H_2]$ = 0.200M, $[I_2]$ = 0.200M and Keq = 55.6 at 250°C calculate the equilibrium concentrations of all molecules.
$H_2\,(g) + I_2\,(g)$ â‡„ $2HI\,(g)$

[HI] = 0.315 M **$[H_2] = [I_2]$ = 0.042 M**

7. 1.60 moles CO and1.60 moles H_2O are placed in a 2.00L container at 690 ^oC (Keq=10.0).
Calculate all equilibrium concentrations.
$CO\ (g) + H_2O\ (g) \rightleftharpoons CO_2\ (g) + H_2\ (g)$

$[CO_2] = [H_2] = 0.608$ M **$[CO] = [H_2O] = 0.192$ M**

8. **$SO_{3(g)} + NO_{(g)} \rightleftharpoons NO_{2(g)} + SO_{2(g)}$**
$K_{eq} = 0.800$ at 100^oC. If 4.00 moles of each reactant are placed in a 2.00L container, calculate all equilibrium concentrations at 100^oC.

$[NO_2] = [SO_2] = 0.944$ M **$[SO_3] = [NO] = 1.06$ M**

9. Consider the following equilibrium system: $2NO_{2(g)} \rightleftharpoons N_2O_4$
Two sets of equilibrium data are listed for the same temperature.

Container 1	2.00 L	0.12 moles NO_2	0.16 moles N_2O_4
Container 2	5.00 L	0.26 moles NO_2	? moles N_2O_4

Determine the number of moles N_2O_4 in the second container. Get a Keq from the first container and use it for the second container.

Container 1 **0.060 M NO_2** **.080 M N_2O_4**

Container 2 **0.052 M NO_2**

$$\textbf{Keq} = \frac{[N_2O_4]}{[NO_2]^2}$$

$$= \frac{[0.080]}{[0.060]^2} = 22.22$$

$$\textbf{Keq} = \frac{[N_2O_4]}{[NO_2]^2}$$

$$22.22 = \frac{[N_2O_4]}{[0.052]^2}$$

$[N_2O_4]$ = 0.0600 M 5.00 L x 0.0600 M = 0.30 moles

no. of moles of N_2O_4 = 5.00 L x 0.0600 M = 0.30 moles

Worksheet #10 Equilibrium Calculations
Solve each problem and show all of your work in your portfolio.

1. At equilibrium, a 2.0 L flask contains:
0.200 mol of PCl_5 0.30 mol of H_2O 0.60 mol of HCl 0.300 mol of $POCl_3$
Calculate the Keq for the reaction:
$PCl_{5\ (g)} + H_2O_{\ (g)}$ â‡„ $2HCl_{\ (g)} + POCl_{3\ (g)}$

Keq = 0.90

2. Keq= 798 for the reaction:
$2SO_{2\ (g)} + O_{2\ (g)}$ â‡„ $2SO_{3\ (g)}$.
In a particular mixture at equilibrium, $[SO_2]$= 4.20 M and $[SO_3]$= 11.0M. Calculate the equilibrium $[O_2]$ in this mixture.

$[O_2] = 8.60 \times 10^{-3}$ M

3. Consider the following equilibrium: $2SO_{2\ (g)} + O_{2\ (g)}$ â‡„ $2SO_{3\ (g)}$
When a 0.600 moles of SO_2 and 0.600 moles of O_2 are placed into a 2.00 litre container and allowed to reach equilibrium, the equilibrium $[SO_3]$ is to be 0.250M. Calculate the Keq value.
(3 marks)

	$2SO_{2\ (g)}$	+	$O_{2\ (g)}$	â‡„	$2SO_{3\ (g)}$
I	0.300		0.300		0
C	0.250		0.125		0.250
E	0.050		0.175		0.250

$$Keq = \frac{(0.250)^2}{(0.050)^2(0.175)}$$

Note the loss of one sig fig!

Keq = 1.4×10^2

4. $H_{2\ (g)} + S_{\ (s)}$ â‡„ $H_2S_{\ (g)}$ Keq= 14
0.60 moles of H_2 and 1.4 moles of S are placed into a 2.0L flask and allowed to reach equilibrium. Calculate the $[H_2]$ at equilibrium. (4 marks)

Don't count S. It is a solid!
$[H_2]$ = 0.02 M

5. Keq=0.0183 for the reaction:
$2HI_{\ (g)}$ â‡„ $H_{2\ (g)} + I_{2\ (g)}$
If 3.0 moles of HI are placed in a 5.00L vessel and allowed to reach equilibrium, what is the equilibrium concentration of H_2?

$[H_2]$ = 0.064 M

6. Consider the equilibrium:

$I_{2\,(g)} + Cl_{2\,(g)}$ â‡„ $2ICl_{(g)}$ Keq= 10.0

The same number of moles of I_2 and Cl_2 are placed in a 1.0L flask and allowed to reach equilibrium. If the equilibrium concentration of ICl is 0.040 M, calculate the initial number of moles of I_2 and Cl_2.

$I_{2\,(g)}$ + $Cl_{2\,(g)}$ â‡„ $2ICl_{(g)}$ Keq = 10.0

I	**x**	**x**	**0**
C	**0.020**	**0.020**	**0.040**
E	**x – 0.020**	**x - 0.020**	**0.040**

$$\frac{(0.040)^2}{(x-0.020)^2} = 10.0$$

$$\frac{.04}{(x-0.020)} = 3.1622$$

.04 = -0.063244 + 3.1622x

0.103244 = 3.1622x

x = 0.033 M

$$1.0\ L \times 0.033\ \frac{mole}{L} = 0.033\ mole$$

7. Consider the equilibrium: $2ICl_{(g)}$ â‡„ $I_{2\,(g)} + Cl_{2\,(g)}$ Keq= 10.0

If x moles of ICl were placed in a 5.0 L container at 10 ^oC and if an equilibrium concentration of I_2 was found to be 0.60 M, calculate the number of moles ICl initially present.

$2ICl_{(g)}$ â‡„ $I_{2\,(g)}$ + $Cl_{2\,(g)}$ Keq= 10.0

I	**x**	**0**	**0**
C	**1.2**	**0.60**	**0.60**
E	**x – 1.2**	**0.60**	**0.60**

$$\frac{(0.60)^2}{(x-1.2)^2} = 10.0$$

$$\frac{0.60}{(x-1.2)} = 3.162$$

0.60 = 3.162x - 3.7944

4.3944 = 3.162x

x = 1.3896 M

$$5.0\ L \times \frac{1.3896\ moles}{L} = 6.9\ moles$$

8. A student places 2.00 moles SO_3 in a 1.00 L flask. At equilibrium $[O_2]$ = 0.10 M at 130 ^oC. Calculate the K_{eq}.

$2SO_{2(g)}$ + $O_{2(g)}$ â‡„ $2SO_{3(g)}$

I	**0**	**0**	**2.0**	**Note this reaction starts with a product and shifts left to go to equilibrium.**
C	**+.20**	**+.10**	**- 0.20**	**So add on the left and subtract on the right.**
E	**.20**	**.10**	**1.8**	

$$K_{eq} = \frac{(1.8)^2}{(0.1)(.2)^2} = 810$$