

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 K_{eq} for the reaction:
 $\text{PCl}_5(\text{s}) + \text{H}_2\text{O}(\text{g}) \rightleftharpoons 2\text{HCl}(\text{g}) + \text{POCl}_3(\text{g})$

$$K_{eq} = 23$$

2. $K_{eq} = 798$ for the reaction:
 $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g})$
 In a particular mixture at equilibrium, $[\text{SO}_2] = 4.20 \text{ M}$ and $[\text{SO}_3] = 11.0 \text{ M}$. Calculate the equilibrium $[\text{O}_2]$ in this mixture.

$$[\text{O}_2] = 8.60 \times 10^{-3} \text{ M}$$

3. Consider the following equilibrium:
 $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g})$
 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 $[\text{SO}_3]$ is to be 0.250M. Calculate the K_{eq} value.

$$K_{eq} = 1.07$$

4. Consider the following equilibrium:
 $2\text{NO}_2(\text{g}) \rightleftharpoons \text{N}_2\text{O}_4(\text{g})$
 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} .

	$2 \text{NO}_2(\text{g})$	\rightleftharpoons	$\text{N}_2\text{O}_4(\text{g})$
I	2.00		0.00
C	-0.20		0.10
E	1.80 M		0.10 M

Note the loss of one sig fig

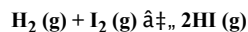
$$K_{eq} = \frac{(0.10)}{(1.80)^2}$$

$$K_{eq} = 0.031$$

5. $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g})$
 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 K_{eq}

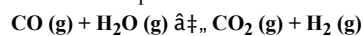
$$K_{eq} = 0.50$$

6. If the initial $[\text{H}_2] = 0.200\text{M}$, $[\text{I}_2] = 0.200\text{M}$ and $K_{eq} = 55.6$ at 250°C calculate the equilibrium concentrations of all molecules.



$$[\text{HI}] = 0.315 \text{ M} \quad [\text{H}_2] = [\text{I}_2] = 0.042 \text{ M}$$

7. 1.60 moles CO and 1.60 moles H₂O are placed in a 2.00L container at 690 °C (K_{eq}=10.0). Calculate all equilibrium concentrations.



$$[\text{CO}_2] = [\text{H}_2] = 0.608 \text{ M} \quad [\text{CO}] = [\text{H}_2\text{O}] = 0.192 \text{ M}$$

8. $\text{SO}_3\text{(g)} + \text{NO(g)} \rightleftharpoons \text{NO}_2\text{(g)} + \text{SO}_2\text{(g)}$
 K_{eq} = 0.800 at 100°C. If 4.00 moles of each reactant are placed in a 2.00L container, calculate all equilibrium concentrations at 100°C.

$$[\text{NO}_2] = [\text{SO}_2] = 0.944 \text{ M} \quad [\text{SO}_3] = [\text{NO}] = 1.06 \text{ M}$$

9. Consider the following equilibrium system: $2\text{NO}_2\text{(g)} \rightleftharpoons \text{N}_2\text{O}_4$
 Two sets of equilibrium data are listed for the same temperature.

Container 1 2.00 L 0.12 moles NO₂ 0.16 moles N₂O₄

Container 2 5.00 L 0.26 moles NO₂ ? moles N₂O₄

Determine the number of moles N₂O₄ in the second container. Get a K_{eq} from the first container and use it for the second container.

Container 1 0.060 M NO₂ .080 M N₂O₄

$$K_{eq} = \frac{[\text{N}_2\text{O}_4]}{[\text{NO}_2]^2}$$

Container 2 0.052 M NO₂

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

$$K_{eq} = \frac{[\text{N}_2\text{O}_4]}{[\text{NO}_2]^2}$$

$$22.22 = \frac{[\text{N}_2\text{O}_4]}{[0.052]^2}$$

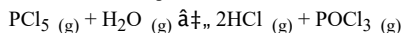
$$[\text{N}_2\text{O}_4] = 0.0600 \text{ M} \times 5.00 \text{ L} \times 0.0600 \text{ M} = 0.30 \text{ moles}$$

$$\text{no. of moles of N}_2\text{O}_4 = 5.00 \text{ L} \times 0.0600 \text{ M} = 0.30 \text{ moles}$$

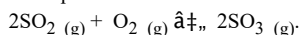
Worksheet #10 Equilibrium Calculations

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 K_{eq} for the reaction:

$$K_{eq} = 0.90$$

2. $K_{eq} = 798$ for the reaction:In a particular mixture at equilibrium, $[\text{SO}_2] = 4.20 \text{ M}$ and $[\text{SO}_3] = 11.0 \text{ M}$. Calculate the equilibrium $[\text{O}_2]$ in this mixture.

$$[\text{O}_2] = 8.60 \times 10^{-3} \text{ M}$$

3. Consider the following equilibrium: $2\text{SO}_2 (g) + \text{O}_2 (g) \rightleftharpoons 2\text{SO}_3 (g)$ 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 $[\text{SO}_3]$ is to be 0.250M. Calculate the K_{eq} value.

(3 marks)

	$2\text{SO}_2 (g)$	+	$\text{O}_2 (g)$	\rightleftharpoons	$2\text{SO}_3 (g)$
I	0.300		0.300		0
C	0.250		0.125		0.250
E	0.050		0.175		0.250

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

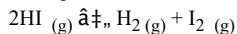
$$K_{eq} = 1.4 \times 10^2$$



Note the loss of one sig fig!

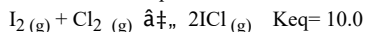
4. $\text{H}_2 (g) + \text{S} (s) \rightleftharpoons \text{H}_2\text{S} (g)$ $K_{eq} = 14$ 0.60 moles of H_2 and 1.4 moles of S are placed into a 2.0L flask and allowed to reach equilibrium. Calculate the $[\text{H}_2]$ at equilibrium. (4 marks)**Don't count S. It is a solid!**

$$[\text{H}_2] = 0.02 \text{ M}$$

5. $K_{eq} = 0.0183$ for the reaction: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 ?

$$[\text{H}_2] = 0.064 \text{ M}$$

6. Consider the equilibrium:



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 .

	$I_2(g)$	+	$Cl_2(g)$	\rightleftharpoons	$2ICl(g)$	$K_{eq} = 10.0$
I	x		x		0	
C	0.020		0.020		0.040	
E	$x - 0.020$		$x - 0.020$		0.040	

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

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

$$.04 = -0.063244 + 3.1622x$$

$$0.103244 = 3.1622x$$

$$x = 0.033 \text{ M}$$

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

7. Consider the equilibrium: $2ICl(g) \rightleftharpoons I_2(g) + Cl_2(g) \quad K_{eq} = 10.0$

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

	$2ICl(g)$	\rightleftharpoons	$I_2(g)$	+	$Cl_2(g)$	$K_{eq} = 10.0$
I	x		0		0	
C	1.2		0.60		0.60	
E	$x - 1.2$		0.60		0.60	

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

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

$$0.60 = 3.162x - 3.7944$$

$$4.3944 = 3.162x$$

$$x = 1.3896 \text{ M}$$

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

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

	$2SO_2(g)$	+	$O_2(g)$	\rightleftharpoons	$2SO_3(g)$	
I	0		0		2.0	Note this reaction starts with a product and shifts left to go to equilibrium. So add on the left and subtract on the right.
C	+.20		+.10		- 0.20	
E	.20		.10		1.8	

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