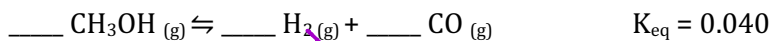


1. ICE Tables (cont'd)  
2. Trial  $K_{eq}$

ICE Tables

Determining Initial Concentrations from  $K_{eq}$  and the Equilibrium Concentrations

(1) Some  $CH_3OH$  was injected into a flask where it established equilibrium with a  $[CO]=0.15M$ . What was the initial concentration of  $CH_3OH$ ?



	$CH_3OH (g)$	$\rightleftharpoons$	$H_2 (g)$	+	$CO (g)$
I	$x$		$0M$		$0M$
C	$-0.15M$		$+0.30M$		$+0.15M$
E	$x-0.15$		$0.30M$		$0.15M$

$$K_{eq} = \frac{(0.30)^2 (0.15)}{(x-0.15)} = 0.040$$

$$0.040x - 0.006 = 0.0135$$

$$\frac{0.040x}{0.040} = \frac{0.0195}{0.040} \quad x = 0.4875$$

$[CH_3OH] = 0.49M$

(2)  $NiS$  reacted with  $O_2$  in a 2.0L flask. When equilibrium was achieved, 0.36 mol of  $SO_2$  were found in the flask. What was the original  $[O_2]$  in the flask?  $K_{eq} = 0.30$

	$NiS (s)$	+	$O_2 (g)$	$\rightleftharpoons$	$SO_2 (g)$	+	$NiO (s)$
Initial			$x$		$0M$		
Change			$-0.27M$		$+0.18M$		
Equilibrium			$x-0.27M$		$0.18M$		

$$K_{eq} = \frac{(0.18)^2}{(x-0.27)^3} = 0.30$$

$$\frac{0.318797}{x-0.27} = 0.6694$$

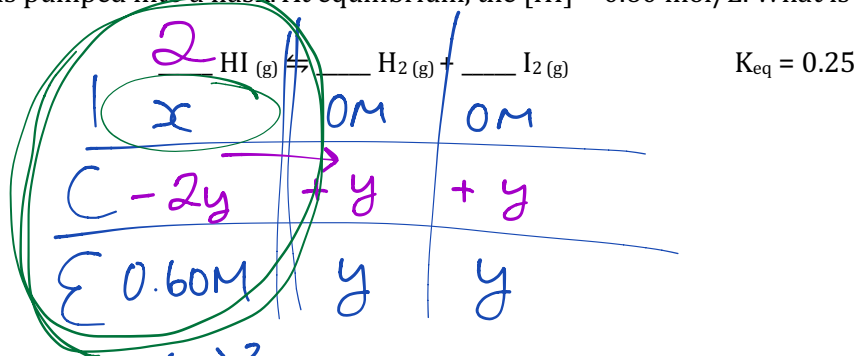
$$0.6694x - 0.1807 = 0.318797$$

$$0.6694x = 0.499535$$

$x = 0.7462$

$[O_2] = 0.75M$

(3) Some HI is pumped into a flask. At equilibrium, the  $[HI] = 0.60 \text{ mol/L}$ . What is the initial  $[HI]$ ?



$$K_{eq} = \frac{(y)^2}{(0.60)^2} = 0.25$$

$$\sqrt{0.09} = \sqrt{y^2}$$

$$0.3 = y$$

$$x - 2y = 0.60$$

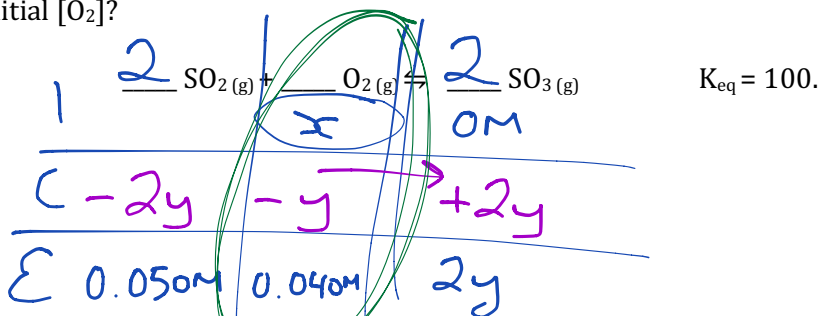
$$x - 2(0.3) = 0.60$$

$$x - 0.6 = 0.6$$

$$x = 1.2$$

$$[HI] = x = 1.2 \text{ M}$$

(4) Some  $\text{SO}_2$  and  $\text{O}_2$  are injected into a flask. At equilibrium, the  $[\text{SO}_2] = 0.050 \text{ M}$  and the  $[\text{O}_2] = 0.040 \text{ M}$ . What was the initial  $[\text{O}_2]$ ?



$$K_{eq} = \frac{(2y)^2}{(0.050)^2 (0.040)} = 100$$

$$\sqrt{0.01} = \sqrt{2y^2}$$

$$\frac{0.1}{2} = \frac{2y}{2}$$

$$0.05 = y$$

$$x - y = 0.040$$

$$x - 0.05 = 0.040$$

$$x = 0.09$$

$$[\text{O}_2] = x = 0.090$$

## Trial $K_{eq}$

With any given values of the concentration of product or reactant, a trial  $K_{eq}$  can be found. From this value, it can be predicted whether the reaction will proceed to the left or right to reach equilibrium.

Trial  $K_{eq}$  is also called the reaction quotient,  $Q$ .

$$\text{Trial } K_{eq} = \frac{[\text{products}]}{[\text{reactants}]} @ \text{ any time}$$

Remember...

The [reactants] and [products] will shift in order to reach equilibrium.

### Comparing trial $K_{eq}$ and actual $K_{eq}$ ...

#### 1. If trial $K_{eq}$ is greater than actual $K_{eq}$ ...

$$\text{Trial } K_{eq} = \frac{[\text{products}]}{[\text{reactants}]}$$

$$K_{eq} = \frac{[\text{products}]}{[\text{reactants}]}$$

- More reactant will need to be formed.
- The reaction will shift left.

#### 2. If trial $K_{eq}$ is less than actual $K_{eq}$ ...

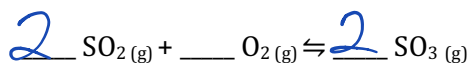
$$\text{Trial } K_{eq} = \frac{[\text{products}]}{[\text{reactants}]}$$

$$K_{eq} = \frac{[\text{products}]}{[\text{reactants}]}$$

- More product will need to be formed.
- The reaction will shift right.

### Example:

(1) The following gases are introduced into a closed flask: 0.057M  $\text{SO}_2$ , 0.057M  $\text{O}_2$  and 0.12M  $\text{SO}_3$ . In which direction will the reaction proceed to establish equilibrium?



$$\begin{aligned} \text{Trial } K_{eq} &= \frac{[\text{SO}_3]^2}{[\text{SO}_2]^2 [\text{O}_2]} \\ &= \frac{(0.12)^2}{(0.057)^2 (0.057)} \\ &= 78 \end{aligned}$$

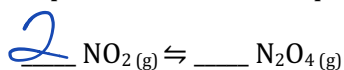
$$K_{eq} = 85$$

$$\text{Trial } K_{eq} < \text{Actual } K_{eq}$$

$$78 < 85$$

Rxn will shift  
right

(2) The following gases are introduced into a closed 1.50 L flask: 1.5 mol of NO<sub>2</sub> and 4.0 mol N<sub>2</sub>O<sub>4</sub>. In which direction will the reaction proceed to achieve equilibrium?



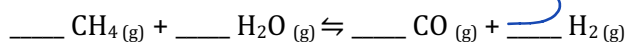
$$K_{\text{eq}} = 0.940$$

$$\begin{aligned} \text{Trial } K_{\text{eq}} &= \frac{[\text{N}_2\text{O}_4]}{[\text{NO}_2]^2} \\ &= \frac{(2.667)}{(1)^2} \\ &= 2.667 \end{aligned}$$

$$\begin{aligned} \text{Trial } K_{\text{eq}} &> \text{Actual } K_{\text{eq}} \\ 2.667 &> 0.940 \end{aligned}$$

Rxn will shift  
LEFT

(3) A mixture contains 0.025M CH<sub>4</sub>, 0.045M H<sub>2</sub>O, 0.10M CO and 0.30M H<sub>2</sub>. In which direction will the reaction proceed to reach equilibrium?



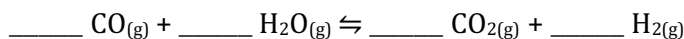
$$K_{\text{eq}} = 4.7$$

$$\begin{aligned} \text{Trial } K_{\text{eq}} &= \frac{[\text{CO}][\text{H}_2]^3}{[\text{CH}_4][\text{H}_2\text{O}]} \\ &= \frac{(0.10)(0.30)^3}{(0.025)(0.045)} \\ &= 2.4 \end{aligned}$$

$$\begin{aligned} \text{Trial } K_{\text{eq}} &< \text{Actual } K_{\text{eq}} \\ 2.4 &< 4.7 \end{aligned}$$

Rxn will shift  
RIGHT

(4) At a certain temperature the reaction:



has a  $K_{\text{eq}} = 0.400$ . Exactly 1.00 mol of each gas was placed in a 100. L vessel and the mixture was allowed to react. Find the equilibrium concentration of each gas.

$$\begin{aligned} \text{Trial } K_{\text{eq}} &= \frac{(0.01)(0.01)}{(0.01)(0.01)} \\ &= 1 \end{aligned}$$

$$\begin{aligned} \text{Trial } K_{\text{eq}} &> \text{Actual } K_{\text{eq}} \\ 1 &> 0.400 \end{aligned}$$

Shift LEFT

CO	H <sub>2</sub> O	CO <sub>2</sub>	H <sub>2</sub>
1 0.01M	0.01M	0.01M	0.01M
+x	+x	-x	-x
0.01+x	0.01+x	0.01-x	0.01-x

$$\begin{aligned} K_{\text{eq}} &= \sqrt{0.400} = \sqrt{\frac{(0.01-x)^2}{(0.01+x)^2}} \\ 0.632 &= \frac{0.01-x}{0.01+x} \end{aligned}$$

Hebden Workbook Pg. 72 #50-52, 54, 58, 61-66

$$\begin{aligned} 0.00632 + 0.632x &= 0.01 - x \\ -0.00632 & \quad +x & -0.00632 & +x \end{aligned}$$

$$\frac{1.632x}{1.632} = \frac{0.00368}{1.632}$$

$$x = 0.00225$$

$$\begin{aligned} [\text{CO}_2] &= [\text{H}_2] \\ &= 0.01 - 0.00225 \\ &= 0.00775 \text{ M} \end{aligned}$$

$$\begin{aligned} [\text{CO}] &= [\text{H}_2\text{O}] \\ &= 0.01 + 0.00225 \\ &= 0.0123 \text{ M} \end{aligned}$$