### CHEM 1423
#### Chapters 17
#### Homework Solutions

**TEXTBOOK HOMEWORK**

#### 17.29 2 HBr(g) ⇆ H₂(g) + Br₂(g)

\[ P_{\text{HBr}} = 0.2 \text{ atm, } P_{\text{H₂}} = 0.01 \text{ atm, } P_{\text{Br₂}} = 0.01 \text{ atm} \]

\[ Q = \frac{P_{\text{H₂}} \cdot P_{\text{Br₂}}}{P_{\text{HBr}}} = \frac{(0.01)(0.01)}{(0.2)^2} = 2.5 \times 10^{-3} > K_p \left( 4.18 \times 10^{-9} \right) \]

Because \( Q \neq K_p \), the reaction is **not** at equilibrium.

Because \( Q > K_p \), the reaction will move towards the left until \( Q = K_p \)

#### 17.38 2 NO(g) + Cl₂(g) ⇆ 2 NOCl(g) \( K_p = 6.5 \times 10^4 \), \( P_{\text{NO}} = 0.35 \text{ atm, } P_{\text{Cl₂}} = 0.10 \text{ atm} \)

\[ P_{\text{NO}} = 0.35 \text{ atm, } P_{\text{Cl₂}} = 0.10 \text{ atm} \]

\[ K_p = 6.5 \times 10^4 = \frac{P_{\text{NOCl}}^2}{P_{\text{NO}} \cdot P_{\text{Cl₂}}} = \frac{P_{\text{NOCl}}^2}{(0.35)^2 (0.10)} = \frac{P_{\text{NOCl}}^2}{1.225 \times 10^{-2}} \]

\[ P_{\text{NOCl}}^2 = (6.5 \times 10^4) (1.225 \times 10^{-2}) = 796.3 \]

\[ P_{\text{NOCl}} = \sqrt{796.3} = 28.2 \text{ atm} \]

#### 17.41 2 H₂S(g) ⇆ 2 H₂(g) + S₂(g) \( K_c = 9.3 \times 10^{-8} \), \( [H₂S]_o = 0.45 \text{ mol/3 L} = 0.15 \text{ M} \)

<table>
<thead>
<tr>
<th></th>
<th>H₂S</th>
<th>H₂</th>
<th>S₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial</td>
<td>0.15</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Change</td>
<td>-2x</td>
<td>+2x</td>
<td>+x</td>
</tr>
<tr>
<td>Equilibrium</td>
<td>0.15-2x</td>
<td>2x</td>
<td>x</td>
</tr>
</tbody>
</table>

As stated in the problem (see outline), one may assume that very little \( H₂S \) will **decompose** (because \( K_c \) is very small). Therefore, at equilibrium, \([H₂S] = 0.15 - 2x \approx 0.15 \text{ M}\)

\[ K_c = 9.3 \times 10^{-8} = \frac{[H₂]^2 [S₂]}{[H₂S]^2} = \frac{(2x)^2 (x)}{(0.15)^2} = 177.8 x^3 \]

\[ x^3 = \frac{9.3 \times 10^{-8}}{177.8} = 5.23 \times 10^{-10} \]

\[ x = \left( 5.23 \times 10^{-10} \right)^{\frac{1}{3}} = 8.06 \times 10^{-4} \text{ M} \]

\([H₂] = 2x = 1.61 \times 10^{-3} \text{ M, } [S₂] = x = 8.06 \times 10^{-4} \text{ M}\)
17.44  \( 2 \text{ ICl(g)} \rightleftharpoons \text{ I}_2(g) + \text{ Cl}_2(g) \), \( K_c = 0.110 \), \([\text{ICl}]_0 = 0.50 \text{ mol/5.0 L} = 0.10 \text{ M} \)

<table>
<thead>
<tr>
<th></th>
<th>ICl</th>
<th>I(_2)</th>
<th>Cl(_2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial</td>
<td>0.10</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Change</td>
<td>-2x</td>
<td>+x</td>
<td>+x</td>
</tr>
<tr>
<td>Equilibrium</td>
<td>0.10-2x</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

Note: Because it is not stated in the problem, you may NOT assume that very little H\(_2\)S will decompose.

\[ K_c = 0.110 = \frac{[\text{I}_2][\text{Cl}_2]}{[\text{ICl}]^2} = \frac{(x)(x)}{(0.10-2x)^2} = \frac{x^2}{(0.10-2x)^2} \]

Take square root of both sides

\[ \sqrt{0.110} = 0.332 = \frac{x}{0.10-2x} \]

\[ 0.332(0.10 - 2x) = x \]

\[ 0.0332 - 0.664x = x \]

\[ 1.664x = 0.0332 \]

\[ x = 0.01995 = 0.020 \]

\[ [\text{I}_2] = [\text{Cl}_2] = x = 0.020 \text{ M} \quad [\text{ICl}] = 0.10 - 2x = 0.10 - 2(0.02) = 0.060 \text{ M} \]

17.46  \( 4 \text{ NH}_3(g) + 3 \text{ O}_2(g) \rightleftharpoons 2 \text{ N}_2(g) + 6 \text{ H}_2\text{O(g)} \)

\([\text{NH}_3]_o = [\text{O}_2]_o = 0.015 \text{ mol/1.00 L} = 0.015 \text{ M} \), \([\text{N}_2]_{\text{equil}} = 1.96 \times 10^{-3} \text{ M} \)

Let’s make an ICE Table

<table>
<thead>
<tr>
<th></th>
<th>NH(_3)</th>
<th>O(_2)</th>
<th>N(_2)</th>
<th>H(_2)O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial</td>
<td>0.015</td>
<td>0.015</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Change</td>
<td>-4x</td>
<td>-3x</td>
<td>+2x</td>
<td>+6x</td>
</tr>
<tr>
<td>Equilibrium</td>
<td>0.015-4x</td>
<td>0.015-3x</td>
<td>2x</td>
<td>6x</td>
</tr>
</tbody>
</table>

We can determine the value of \( x \) by using the equilibrium concentration, \([\text{N}_2]\).

\([\text{N}_2]_{\text{equil}} = 2x = 1.96 \times 10^{-3} \]

\[ x = 9.80 \times 10^{-4} \]

\([\text{H}_2\text{O}] = 6x = 5.88 \times 10^{-3} \]

\([\text{NH}_3] = 0.015-4x = 1.108 \times 10^{-2} \]

\([\text{O}_2] = 0.015-3x = 1.206 \times 10^{-2} \)

\[ K_c = \frac{[\text{N}_2]^2[\text{H}_2\text{O}]^6}{[\text{NH}_3]^4[\text{O}_2]^3} = \frac{(1.96 \times 10^{-3})^2(5.88 \times 10^{-3})^6}{(1.108 \times 10^{-2})^4(1.206 \times 10^{-2})^3} = 6.01 \times 10^{-6} \approx 6.0 \times 10^{-6} \]
17.47  \( \text{FeO(s)} + \text{CO(g)} \rightleftharpoons \text{Fe(s)} + \text{CO}_2(g) \quad K_P = 0.403 \)

Note: We can ignore FeO(s) and Fe(s). Only gases need be considered.

\[
\begin{array}{|c|c|c|c|}
\hline
 & \text{FeO(s)} & \text{CO(g)} & \text{Fe(s)} & \text{CO}_2(g) \\
\hline
\text{Initial} & -- & 1.00 \text{ atm} & 0 & 0 \\
\text{Change} & -- & -x & -- & +x \\
\text{Equilibrium} & -- & 1.00-x & -- & x \\
\hline
\end{array}
\]

\[
K_P = 0.403 = \frac{P_{\text{CO}_2}}{P_{\text{CO}}} = \frac{x}{1.00-x} \\
0.403(1.00 - x) = x \\
0.403 - 0.403x = x \\
1.403x = 0.403 \\
x = \frac{0.403}{1.403} = 0.287 \text{ atm} \\
P_{\text{CO}} = 1.00-x = 1.00-0.287 = 0.713 \text{ atm} , \quad P_{\text{CO}_2} = x = 0.287 \text{ atm}
\]

17.56  An increase in volume results in a decrease in pressure. Therefore, the equilibrium will move in the direction which increases the number of moles of gas. However, there is no change in the equilibrium constant.

(a) \( \text{F}_2(g) \rightleftharpoons 2 \text{ F(g)} \): Equil. will move to the right. More F and less F$_2$. No change in K

(b) \( 2 \text{ CH}_4(g) \rightleftharpoons \text{ C}_2\text{H}_2(g) + 3 \text{ H}_2(g) \): Equil. will move to the right. More C$_2$H$_2$ and H$_2$ and less CH$_4$. No change in K

17.61  When the temperature is decreased, the equilibrium will move in the exothermic direction. K will change accordingly.

(a) Exothermic reaction \( \dbar H_{\text{rxn}} = -151 \text{ kJ} \). Equilibrium will move to right and K will increase.

(b) Exothermic reaction \( \dbar H_{\text{rxn}} = -451 \text{ kJ} \). Equilibrium will move to right and K will increase.

(c) Exothermic reaction. Equilibrium will move to right and K will increase.

(d) Endothermic reaction. Equilibrium will move to left and K will decrease.