Acid-Base 4 • Chem 220

1. Predict the products and $K$ for the following acid-base reactions:

\[
\begin{align*}
\text{SO}_3^{2-} + \text{HClO} & \rightleftharpoons \text{HSO}_3^- + \text{ClO}^- \\
\frac{3.5 \times 10^{-8}}{6.2 \times 10^{-8}} & = 0.56
\end{align*}
\]

\[
\begin{align*}
\text{NH}_4^+ + \text{HCO}_3^- & \rightleftharpoons \text{NH}_3 + \text{HCO}_2^- \\
\frac{5.6 \times 10^{-10}}{1.8 \times 10^{-4}} & = 3.1 \times 10^{-6}
\end{align*}
\]

2. Identify the following Lewis acid and base in the following reactions. Predict the formula of the products (if not given).

A) \[ \text{AlCl}_3 + \text{NH}_3 \rightleftharpoons \begin{array}{c} \text{Cl} \\ \text{LA} \end{array} \begin{array}{c} \text{N} \\ \text{LB} \end{array} \begin{array}{c} \text{H} \\ \text{Cl} \end{array} \]

B) \[ \text{SO}_2 + \text{H}_2\text{O} \rightleftharpoons \begin{array}{c} \text{H}_2\text{SO}_3 \\ \text{LA} \end{array} \begin{array}{c} \text{O} \\ \text{LB} \end{array} \]

C) \[ \text{CaO} + \text{H}_2\text{O} \rightleftharpoons \begin{array}{c} \text{Ca(OH)}_2 \\ \text{LB} \end{array} \begin{array}{c} \text{O} \\ \text{LA} \end{array} \]

3. A 50.0 mL sample of a 0.500 M NaOH is mixed with 125.0 mL of a 0.250 M solution of nitric acid. What will be the pH, $[\text{H}_3\text{O}^+]$, and $[\text{OH}^-]$ of the resulting solution?

\[
\text{NaOH} + \text{HNO}_3 \rightarrow \text{H}_2\text{O} + \text{NaNO}_3
\]

Initial: 25.0 mL at 3.125 M
Final: 0 mL at 0.25 M

Total volume = 175 mL

\[
[\text{H}^+] = \frac{6.25 \text{ mmol}}{175 \times 10^{-3} \text{ L}} = 0.0357 \text{ M}
\]

\[\text{pH} = 1.45\]

4. A 25.0 mL sample of a 0.500 M KOH is mixed with 25.0 mL of a 0.10 M solution of sulfuric acid. What will be the pH, $[\text{H}_3\text{O}^+]$, and $[\text{OH}^-]$ of the resulting solution?

\[
2\text{KOH} + \text{H}_2\text{SO}_4 \rightarrow \text{K}_2\text{SO}_4 + 2\text{H}_2\text{O}
\]

Initial: 12.5 mmol
Final: -10.0 mmol

\[\text{OH}^- = \frac{2.5 \text{ mmol}}{50 \text{ mL}} = 0.050 \text{ M}
\]

\[\text{pOH} = 1.30 \Rightarrow \text{pH} = 12.70\]

5. Selenite, $\text{SeO}_3^{2-}$, is a weak base anion. What is the pH and the concentration of all selenium-containing species for a 0.25 $M$ solution of sodium selenite, $\text{Na}_2\text{SeO}_3$?

The $K_a$ values for the diprotic selenic acid, $\text{Na}_2\text{SeO}_3$, are:

\[
\begin{align*}
K_{a1} &= 2.7 \times 10^{-3} \\
K_{a2} &= 2.5 \times 10^{-7}
\end{align*}
\]

\[
\begin{align*}
K_{b1} &= 3.7 \times 10^{-2} \\
K_{b2} &= 4.0 \times 10^{-8}
\end{align*}
\]
\[ \text{SeO}_3^{2-} (aq) + \text{H}_2\text{O} (l) \rightleftharpoons \text{HSeO}_3^- (aq) + \text{OH}^- (aq) \]

\[ 0.25 \text{ M} \quad - \quad - \quad \text{H} \quad \text{O} \]

\[ c \quad -x \quad - \quad +x \quad +x \]

\[ c \quad 0.25 - x \quad \approx 0.25 \]

\[ K_{b1} = 4.0 \times 10^{-9} = \frac{x^2}{0.25} \]

\[ x = 1.0 \times 10^{-4} \text{ M} = [\text{OH}^-] \]

\[ p\text{OH} = 4.00 \Rightarrow pH = 10.00 \]

\[ [\text{SeO}_3^{2-}] = 0.25 - x = 0.25 \text{ M} \]
\[ [\text{HSeO}_3^-] = x = 1.0 \times 10^{-4} \text{ M} \]
\[ [\text{H}_2\text{SeO}_3] = K_{b2} = 3.7 \times 10^{-12} \text{ M} \]

\[ pH = 10.00 \]