Lecture 21 – Chapter 17, Sections 5-7
More weak acids and bases

- Chemistry of weak vs. strong acids
- Multiple equilibria – polyprotic acids
  - Examples
### Recognizing Acids

**1. Strong Acids.** Memorize the formulas and names of the six common strong acids.

<table>
<thead>
<tr>
<th>Acid</th>
<th>Formula</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCl (hydrochloric acid)</td>
<td>HCl</td>
<td>hydrochloric acid</td>
</tr>
<tr>
<td>HBr (hydrobromic acid)</td>
<td>HBr</td>
<td>hydrobromic acid</td>
</tr>
<tr>
<td>HI (hydroiodic acid)</td>
<td>HI</td>
<td>hydroiodic acid</td>
</tr>
<tr>
<td>HNO₃ (nitric acid)</td>
<td>HNO₃</td>
<td>nitric acid</td>
</tr>
<tr>
<td>HClO₄ (perchloric acid)</td>
<td>HClO₄</td>
<td>perchloric acid</td>
</tr>
<tr>
<td>H₂SO₄ (sulfuric acid)</td>
<td>H₂SO₄</td>
<td>sulfuric acid</td>
</tr>
</tbody>
</table>

**2. Weak Acids.** Recognize these from general formulas.

- **A. Oxoacids:** \( H_xE_y \), where \( x = 1 \rightarrow 3 \), \( y = 1 \rightarrow 4 \), \( E = B, C, N, P, S, Cl, Br, I, \) others
  - HClO (hypochlorous acid)
  - HNO₂ (nitrous acid)
  - HBrO (hypobromous acid)
  - HNO₂ (nitrous acid)
  - H₂CO₃ (carbonic acid)
- **B. Carboxylic acids:** \( RCO₂H \), where \( R = H \) or any organic group
  - HCO₂H (formic acid)
  - C₆H₅CO₂H (benzoic acid)
- **C. Conjugate acid of a weak base**
  - NH₃⁺ (ammonium ion)
  - C₅H₅NH⁺ (pyridinium ion)
- **D. Miscellaneous examples**
  - HF (hydrofluoric acid)
  - H₂S (hydrogen sulfide)

### Recognizing Bases

**1. Strong Bases.** Memorize the Group 1 hydroxides (\( MOH \)) and the soluble Group 2 hydroxides (\( M(OH)₂ \)).

<table>
<thead>
<tr>
<th>Base</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>LiOH</td>
<td>NaOH</td>
</tr>
<tr>
<td>Ca(OH)₂</td>
<td>Sr(OH)₂</td>
</tr>
<tr>
<td>KOH</td>
<td>Ba(OH)₂</td>
</tr>
</tbody>
</table>

**2. Weak Bases.** Recognize these from general formulas.

- **A. Ammonia (\( NH₃ \)) and amines** \( RNH₂, R₂NH, R₃N \)
  - CH₃NH₂ (methylamine)
  - (CH₃CH₂)₂NH (diethylamine)
  - (C₆H₅)₂NH (diphenylamine)
  - H₂NCH₂CH₂NH₂ (ethylenediamine)
- **B. Conjugate base of a weak acid**
  - F⁻ (fluoride)
  - CN⁻ (cyanide)
  - CH₃CO₂⁻ (acetate)
  - OCl⁻ (hypochlorite)
  - SO₄²⁻ (sulfate)
  - PO₄³⁻ (phosphate)
  - HCO₃⁻ (hydrogen carbonate)
  - NO₂⁻ (nitrite)
  - C₆H₅CO₂⁻ (benzoate)
What makes an acid stronger or weaker?

• Charge
• Strength of X-H bond

• Charge is pretty simple
  – Something positive would like to get rid of positive charge, so it is a good acid, lousy base
  – Something negative would really like some extra positive charge, so it is a lousy acid, good base
  – Something neutral could be most anything
Acid strength?

- More polar bond $\rightarrow$ stronger acid
  - HF stronger acid than CH$_4$
- Weaker X-H bond $\rightarrow$ stronger acid
  - HCl stronger acid than HF
  - HClO$_4$ stronger acid than HOCl
Other groups affect -OH bond

- Trichloroacetic acid is stronger than acetic acid
- Cl pulls lots of electron density to itself and away from rest of molecule
- So, there is less electron density between O and H
  - It has a weaker OH bond and is a stronger acid
How acidic is the bold proton in oxalic acid compared to formic acid?

- Oxalic is more acidic than formic
- Oxalic is less acidic than formic
- They are essentially the same
How acidic is the second proton in oxalic acid compared to formic acid?

1. 2\textsuperscript{nd} Oxalic proton is more acidic than formic acid
2. 2\textsuperscript{nd} Oxalic proton is less acidic than formic acid
3. They are essentially the same
Polyprotic Acids form Multiple Equilibria

- $\text{H}_2\text{SO}_4$ has two protons that can come off
- Three species are all in equilibrium along with $\text{H}_3\text{O}^+$ and $\text{OH}^-$
  - $\text{H}_2\text{SO}_4$
  - $\text{HSO}_4^-$
  - $\text{SO}_4^{2-}$
- Two pairs of conjugate acids and bases
- See Example 17-14
  - Solve equilibrium problem for first proton
  - Plug answers in as starting point for second equilibrium problem
  - Continue if there are still more acidic protons
Polyprotic acid example

- Find the concentrations of all of the species in a 0.062 M solution of carbonic acid \( \text{H}_2\text{CO}_3 \)

\[
\begin{align*}
K_{a1} &= 4.2 \times 10^{-7} \\
K_{a2} &= 4.8 \times 10^{-11}
\end{align*}
\]
Today

- Chem seminar (student-invited speaker) 4:00 Schaap 1000

Monday

- Start on CAPA #13
- Start reading Chapt 18
- It’s not too early to start thinking about Exam 2…