Acid & Base Strengths

Chapter 19
• pH scale is used to express concentration of acids and bases

Based on a scale of 0-14

\[
\begin{align*}
\text{pH} < 7 & = \text{acid} \\
\text{pH of 7} & = \text{neutral} \\
\text{ph} > 7 & = \text{base}
\end{align*}
\]
pH of Common Substances

Figure 5.17  pH values of some common substances. Here the “bar” is colored red at one end and blue at the other. These are the colors of litmus paper, commonly used in the laboratory to decide if a solution is acidic (litmus is red) or basic (litmus is blue). (Charles D. Winters)
Strong Acids

- **Definition:** Dissociates (ionizes) completely in solution and produces maximum # of $H^+ / (H_3O^+)$

- **Ex:** $\text{HCl} \text{(aq)} + \text{H}_2\text{O} \text{(l)} \rightarrow \text{H}_3\text{O}^+ \text{(aq)} + \text{Cl}^- \text{(aq)}$

- **Single** arrow pointing toward products

- Because HCl is **100%** dissociated, reaction goes to completion and no reverse reaction occurs
Weak Acids

- **Definition:** Dissociates (ionizes) only **partially** in solution

- **Produces** fewer $\text{H}^+ / \text{H}_3\text{O}^+$ ions

- **Ex:** $\text{HC}_2\text{H}_3\text{O}_2\text{ (aq)} + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+\text{ (aq)} + \text{C}_2\text{H}_3\text{O}_2^-\text{ (aq)}$

- **Arrow points in forward and reverse direction**

  - Reaction occurs at **equal** rates and all reactants and products are present in equilibrium
Strong or Weak Acid?

**Binary Acid**
- Contains **Hydrogen** and an anion (-)
- Ex: HCl

**Ternary Acid**
- Contains **Hydrogen** and a polyatomic anion
- Ex: H₂SO₄
Rules for Strong/Weak Acids

• **Binary Acids** → Only strong binary acids are HCl, HBr, and HI

– All other binary acids are **WEAK**
Rules for Strong/Weak Acids

• Ternary Acids $\rightarrow$ Compare # of oxygen to hydrogen in formula
  
  – If # of oxygen exceeds # of hydrogen by 2 or more, then acid is STRONG

  » Ex: $\text{H}_3\text{PO}_4 \rightarrow 3$ hydrogen / 4 oxygen $\rightarrow$ WEAK

  » Ex: $\text{H}_2\text{SO}_4 \rightarrow 2$ hydrogen / 4 oxygen $\rightarrow$ STRONG

  – Only strong ternary acids are $\text{H}_2\text{SO}_4$, $\text{HNO}_3$, $\text{HClO}_3$, and $\text{HClO}_4$

  » All other ternary acids are WEAK
Strong Acids to Memorize

**STRONG ACIDS**

- $\text{HCl} \rightarrow \text{hydrochloric acid}$
- $\text{HBr} \rightarrow \text{hydrobromic acid}$
- $\text{HI} \rightarrow \text{hydroiodic acid}$
- $\text{H}_2\text{SO}_4 \rightarrow \text{sulfuric acid}$
- $\text{HNO}_3 \rightarrow \text{nitric acid}$
- $\text{HClO}_4 \rightarrow \text{perchloric acid}$

**WEAK ACIDS**

- Everything else…
Strong Bases

- **Definition:** Dissociates completely in solution and produces maximum # of OH⁻ ions

- **Ex:** \( \text{NaOH}_\text{(s)} + \text{H}_2\text{O}_\text{(l)} \rightarrow \text{Na}^+ \text{(aq)} + \text{OH}^- \text{(aq)} \)

- Like strong acids, **single arrow pointing toward products**

- Therefore, **no reverse reaction occurs**
Weak Bases

• **Definition:** Dissociates only *partially* in solution

• Produces *fewer* OH\(^-\) ions

• Ex: \(\text{NH}_3\) \(_{\text{aq}}\) + \(\text{H}_2\text{O}\) \(_{\text{l}}\) \(\rightleftharpoons\) \(\text{NH}_4^+\) \(_{\text{aq}}\) + OH\(^-\) \(_{\text{aq}}\)

• Like weak acids, *arrow* points in *forward* and *reverse* direction
Rules for Strong/Weak Bases

• Only **strong** binary bases are:
  - **Ex:** LiOH, NaOH, KOH, RbOH, CsOH, Ca(OH)$_2$, Sr(OH)$_2$, Ba(OH)$_2$

  » All other binary bases are **WEAK**
Acid/Base Strength to Conjugates

• **STRONG A/B = WEAK CB/CA**, respectively, and **VICE VERSA**
Acid/Base Neutralization Reactions

- Products of an Acid-Base reaction are a salt compound (ionic) and water

Acid-Base Reaction Trends

- $\text{SA} + \text{SB} = \text{Neutral}$
- $\text{WA} + \text{WB} = \text{Neutral}$
- $\text{SA} + \text{WB} = \text{Acidic}$
- $\text{WA} + \text{SB} = \text{Basic}$
Acid-Base Neutralization Reactions

• LiOH + HBr $\rightarrow$ LiBr + H$_2$O

• B A CB CA

• SB SA WCB WCA

• = NEUTRAL
Why the Trend for Conjugate Acid/Base?

- Weak acids **DO NOT** want to give up its protons
  - That is why they are called **WEAK** acids

- Strong acids **DO** want to give up its protons
  - If you have a weak acid that **does not want** to give up its proton, and you take away its proton, wouldn't it make sense that it really wants to get it back? → Therefore, has a **STRONG** Conjugate Base
Why the Trend for Conjugate Acid/Base?

• And **bases** are substances that **accept** protons
  
  – If it really wants to get a proton then it is called a **strong base**, and if it does not want to get a proton, it is called a **weak base**

• The opposite is true