Chapter 14 Part 2

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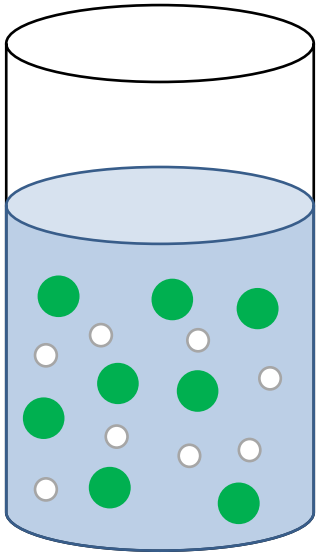
Acid and base strength

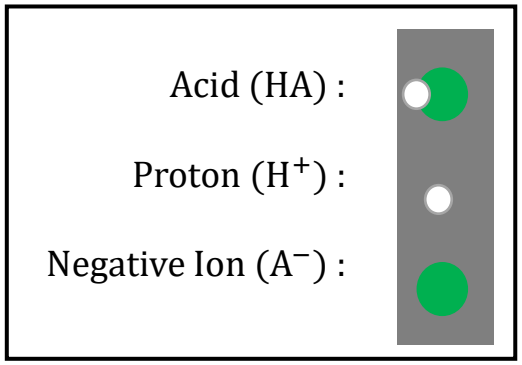
- The strength of an acid or a base is determined by it's ability to ionize (break apart into ions) in aqueous solution.
- The closer that an acid or base is to 100% ionization, the stronger it is.

Strong vs. Weak Acids

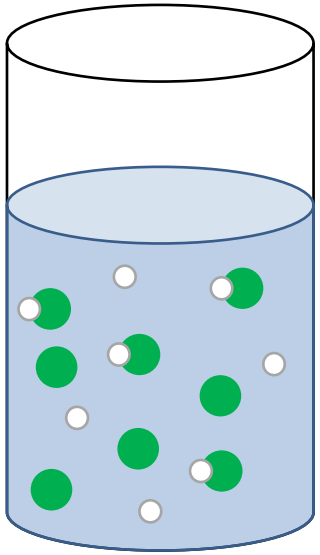
Strong Acid



Since strong acids fully dissociate in water, we see all the H^+ ions separated from the A^- ions



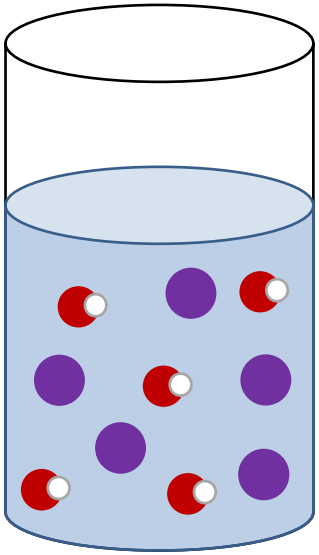
Weak Acid



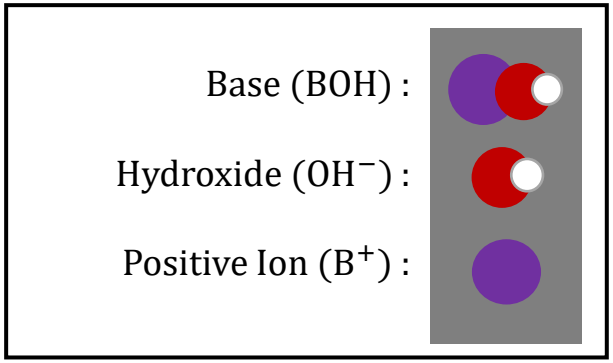
Since weak acids only partially dissociate in water, we see some H^+ ions separated from the A^- ions and some undissociated HA molecules

Strong vs. Weak Bases

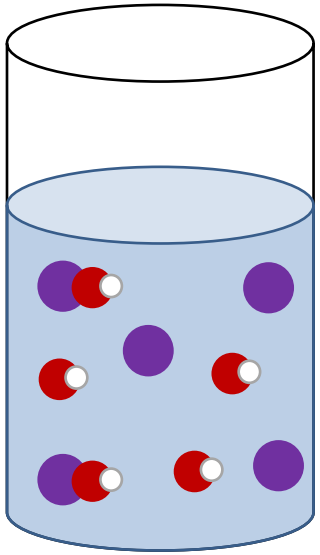
Strong Base



Since strong bases fully dissociate in water, we see all the OH^- ions separated from the B^+ ions



Weak Base



Since weak bases only partially dissociate in water, we see some the OH^- ions separated from the B^+ ions and some undissociated BOH molecules

Acid and Base Hydrolysis

Acid Hydrolysis

$$HA(aq) + H_2O(l) \leftrightharpoons H_3O^+(aq) + A^-(aq)$$

Base Hydrolysis

$$B(aq) + H_2O(l) \leftrightharpoons HB^+(aq) + OH^-(aq)$$

Strong Acids and Bases

Strong acids and bases ionize completely in aqueous solution

Memorize These!

Strong Acids		Strong Bases	
$HClO_4$	Perchloric acid	LiOH	Lithium hydroxide
$HClO_3$	Chloric acid	NaOH	Sodium hydroxide
HCl	Hydrochloric acid	KOH	Potassium hydroxide
HBr	Hydrobromic acid	RbOH	Rubidium hydroxide
HI	Hydroiodic acid	CsOH	Cesium hydroxide
HNO_3	Nitric acid	$Ca(OH)_2$	Calcium hydroxide
H_2SO_4	Sulfuric acid	$Sr(OH)_2$	Strontium hydroxide
		$Ba(OH)_2$	Barium hydroxide

Percent Ionization

For weak acids

$$\% \text{ ionization} = \frac{[H_3O^+]_{eq}}{[HA]_0} \times 100$$

For weak bases

$$\% \text{ ionization} = \frac{[OH^-]_{eq}}{[B]_0} \times 100$$

- $[H_3O^+]_{eq}$ is the equilibrium hydronium ion concentration
- $[HA]_0$ is the initial concentration of the weak acid
- $[OH^-]_{eq}$ is the equilibrium concentration of the hydroxide ion concentration
- $[B]_0$ is the initial concentration of the weak base

Percent Ionization of a Weak Acid

Calculate the percent ionization of a 0.534 M solution of formic acid with a pH of 2.01.

Percent Ionization

Would an acid or base be stronger with a higher or lower percent ionization?

Percent Ionization

What is the percent ionization of strong acids and bases in aqueous solution?

Calculating ion concentrations in strong acid solutions

Calculate $[H_3O^+]$, $[OH^-]$, and $[Cl^-]$ in 0.015 M HCl(aq).

Finding the pH of strong base solutions

What is the pH of 0.022 M $Ca(OH)_2$?

Acid ionization constant (K_a)

Acid-ionization constant K_a

$$HA(aq) + H_2O(l) \leftrightharpoons H_3O^+(aq) + A^-(aq)$$

$$K_a = \frac{[H_3O^+][A^-]}{[HA]}$$

Base ionization constant (K_b)

Base-ionization constant K_b

$$B(aq) + H_2O(l) \leftrightharpoons HB^+(aq) + OH^-(aq)$$

$$K_b = \frac{[HB^+][OH^-]}{[B]}$$

Acid and base ionization constants

Would an acid or base be stronger with a higher or lower ionization constant?

Base strength

Which of the following bases is the strongest?

Base	**K_b**
NO_2^-	2.22×10^{-11}
$CH_3CO_2^-$	5.6×10^{-10}
NH_3	1.8×10^{-5}

Acid and Base Strength Summary

Stronger Acids have

- Larger % ionizations
- Larger K_a values

Stronger Bases have

- Larger % ionizations
- Larger K_b values

pK_a and pK_b

$$pK_a = -\log K_a$$

$$pK_b = -\log K_b$$

Relating K_a and K_b using K_w

For a conjugate acid and base pair,

$$K_w = K_a \times K_b = 1.0 \times 10^{-14}$$

Relating K_a and K_b using K_w

What is the pK_a of NH_4^+? The K_b of NH_3 is 1.8×10^{-5}.

Determining the K_a of a weak acid solution

A 0.250 M aqueous solution of butyric acid, $HC_4H_7O_2$, is found to have pH 2.72. Determine K_a for butyric acid.

Finding the pH of a weak acid solution

What is the pH of a solution that is 0.100 M $HC_2H_3O_2(aq)$? For $HC_2H_3O_2$, $K_a = 1.8 \times 10^{-5}$.

When to neglect x

- If K_a is at least 10^4 times smaller than the initial concentration of the acid, you can neglect x
- If K_a is between 0 and 10^2 times smaller than the initial concentration of the acid, you cannot neglect x
- If K_a is 10^3 times smaller than the initial concentration of the acid, you are at the borderline and have to check

Weak organic bases

- Weak organic bases are generally end in NH_3, NH_2, NH or N

$$NH_3 + H_2O \rightarrow NH_4^+ + OH^-$$

$$CH_3NH_2 + H_2O \rightarrow CH_3NH_3^+ + OH^-$$

$$(CH_3)_2NH + H_2O \rightarrow (CH_3)_2NH_2^+ + OH^-$$

$$C_5H_5N + H_2O \rightarrow C_5H_5NH^+ + OH^-$$

Writing autoionization reactions

Identify the correct ionization reaction for hydrazine H_2NNH_2.

A. $H_2NNH_2(aq) \rightleftharpoons H^+(aq) + H_2NNH^-(aq)$

B. $H_2NNH_2(aq) \rightleftharpoons 4\ H^+(aq) + 2\ N^{3-}(aq)$

C. $H_2NNH_2(aq) + H_2O(l) \rightleftharpoons H_2NNH_3{}^+(aq) + OH^-(aq)$

D. $H_2NNH_2(aq) + H_2O(l) \rightleftharpoons H_2NNH^-(aq) + H_3O^+(aq)$

Finding the pH of a weak base solution

What is the pH of a solution that is 0.00250 M $CH_3NH_2(aq)$? For $CH_3NH_3^+$, $K_a = 2.4 \times 10^{-11}$.

Determining percent ionization of a weak acid

What is the percent ionization of acetic acid in 1.0 M $HC_2H_3O_2$? For $HC_2H_3O_2$, $K_a = 1.8 \times 10^{-5}$.

Determining percent ionization of a weak base

What is the percent ionization of ammonia in 2.0 M NH_3? For NH_4^+, $K_a = 5.6 \times 10^{-10}$.