Chapter 14 Part 1

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Arrhenius Acids and Bases

- Arrhenius Acids dissolve in water to yield H_3O^+ (hydronium) ions

$$HCl(aq) + H_2O(l) \rightarrow Cl^-(aq) + H_3O^+(aq)$$

- Arrhenius Bases dissolve in water to yield OH^- (hydroxide) ions

$$NaOH(aq) \rightarrow Na^+(aq) + OH^-(aq)$$

Bronsted-Lowry Acids and Bases

- Bronsted-Lowry Acids donate a proton (H^+) to another compound

$$HF(aq) + NH_3(g) \leftrightharpoons F^-(aq) + NH_4^+(aq)$$

- Bronsted-Lowry Bases accept a proton (H^+) from another compound

$$HF(aq) + NH_3(g) \leftrightharpoons F^-(aq) + NH_4^+(aq)$$

Writing autoionization reactions

Identify a correct ionization reaction for acetic acid.

A. $HC_2H_3O_2(aq) \rightleftharpoons 4\ H^+(aq) + C_2O_2^-(aq)$

B. $HC_2H_3O_2(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + C_2H_3O_2^-(aq)$

C. $HC_2H_3O_2(aq) \rightarrow H^+(aq) + C_2H_3O_2^-(aq)$

D. $H^+(aq) + C_2H_3O_2^-(aq) \rightarrow HC_2H_3O_2(aq)$

Writing autoionization reactions

Identify the correct ionization reaction for lithium hydroxide.

A. $LiOH(aq) \rightarrow Li^{+}(aq) + OH^{-}(aq)$

B. $LiOH(aq) \rightarrow LiO^{-}(aq) + H^{+}(aq)$

C. $LiOH(aq) \rightleftharpoons Li^{+}(aq) + OH^{-}(aq)$

D. $LiOH(aq) \rightleftharpoons LiO^{-}(aq) + H^{+}(aq)$

Bronsted-Lowry Acids and Bases

$$HF(aq) + NH_3(g) \leftrightharpoons F^-(aq) + NH_4^+(aq)$$

- Acid
- Base
- Conjugate Acid
- Conjugate Base

Bronsted-Lowry Acids and Bases

$$HF(aq) + NH_3(g) \leftrightharpoons F^-(aq) + NH_4^+(aq)$$

- Acid
- Base
- Conjugate Acid
- Conjugate Base

Bronsted-Lowry Acids and Bases

$$HF(aq) + NH_3(g) \leftrightharpoons F^-(aq) + NH_4^+(aq)$$

- Acid
- Base
- Conjugate Acid
- Conjugate Base

Bronsted-Lowry Acids and Bases

$$HF(aq) + NH_3(g) \leftrightharpoons F^-(aq) + NH_4^+(aq)$$

- Acid
- Base
- Conjugate Acid
- Conjugate Base

Bronsted-Lowry Acids and Bases

Identify the acid, base, conjugate acid, and conjugate base in each of the following reactions.

A. $S^{2-} + H_2O \leftrightharpoons OH^- + HS^-$

B. $HSO_4{}^- + NH_3 \leftrightharpoons NH_4{}^+ + SO_4{}^{2-}$

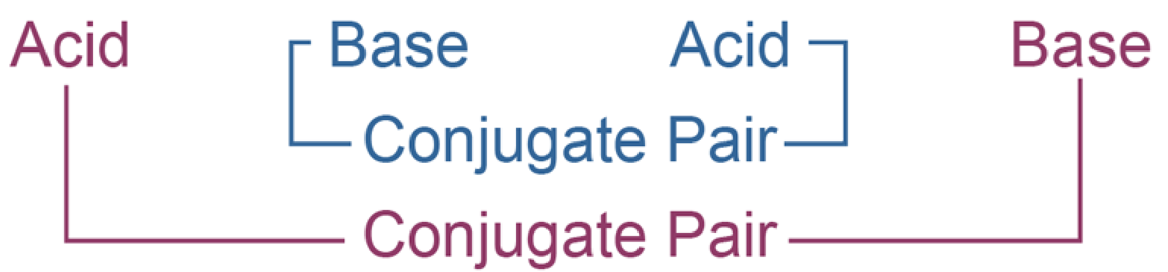
C. $NH_4{}^+ + HSO_4{}^- \leftrightharpoons H_2SO_4 + NH_3$

D. $H_2O + H_2CO_3 \leftrightharpoons HCO_3{}^- + H_3O^+$

Conjugate Acid–Base Pairs

- In the reaction below, acetic acid, $HC_2H_3O_2$, donates H^+ to H_2O. Acetic acid acts as the Brønsted acid and water acts as the Brønsted base.
- In the reverse reaction, hydronium ion donates a proton to acetate ion, making H_3O^+ the acid and acetate the base.

$$HC_2H_3O_2(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + C_2H_3O_2^-(aq)$$



Conjugate Acid–Base Pairs

- Chemical species (molecules and ions) whose formulas differ by only an H^+ are conjugate acid–base pairs.
- Every Brønsted acid has a conjugate base and every Brønsted base has a conjugate acid.

$$NH_3(aq) + H_2O(l) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$$

Conjugate Acid–Base Pairs

Identify a conjugate acid–base pair in this reaction.

$$HBr(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + Br^-(aq)$$

A. H_2O (acid) and H_3O^+ (base)
B. HBr (acid) and Br^- (base)
C. HBr (acid) and H_2O (base)
D. H_3O^+ (acid) + Br^- (base)

Amphoteric and Amphiprotic species

- Any compound capable of acting as both an acid or a base is amphoteric.
- When this action as acid and base involves donating and accepting protons (H^+), it can also be described as amphiprotic.
- This allows them to be either acids or bases according to the Bronsted-Lowry definition

$$HCO_3^- + HCl \leftrightharpoons H_2CO_3 + Cl^-$$

$$HCO_3^- + NH_3 \leftrightharpoons CO_3^{2-} + NH_4^+$$

Equilibrium constant of water, K_w

$$H_2O(l) + H_2O(l) \leftrightharpoons H_3O^+ + OH^-$$

$$K_w = [H_3O^+][OH^-] = 1.0 \times 10^{-14}$$

Equilibrium constant of water, K_w

What are the hydronium ion concentration and hydroxide ion concentration of water?

$[H_3O^+]$ and $[OH^-]$

If $K_w = [H_3O^+][OH^-]$, are the concentrations of hydronium and hydroxide directly or inversely proportional?

$[H_3O^+]$ and $[OH^-]$

A solution of sulfur dioxide in water has a hydronium ion concentration of 5.0×10^{-5} M. What is the concentration of hydroxide ion?

pH and pOH

- The pH and pOH of a solution are defined as

$$\mathrm{pH} = -\log[\mathrm{H_3O^+}]$$

$$\mathrm{pOH} = -\log[\mathrm{OH^-}]$$

pH, pOH, and pK_w

- The pH, pOH, and pK_w of a solution are defined as

$$\mathrm{pH} = -\log[\mathrm{H_3O^+}]$$

$$\mathrm{pOH} = -\log[\mathrm{OH^-}]$$

$$\mathrm{pK_w} = -\log \mathrm{K_w}$$

$$\mathrm{pK_w} = \mathrm{pH} + \mathrm{pOH}$$

Sig Figs in pH Calculations

- Only the digits that come after the decimal point in a pH value are significant.
  - A pH of 6.23 has two significant figures, not three.
- Thus, the number of significant digits in the concentration determines the number of digits after the decimal point in the pH value.
  - $[H_3O^+] = 0.00157$ M (three significant figures) corresponds to pH = 2.804, not 2.80.

pK_w

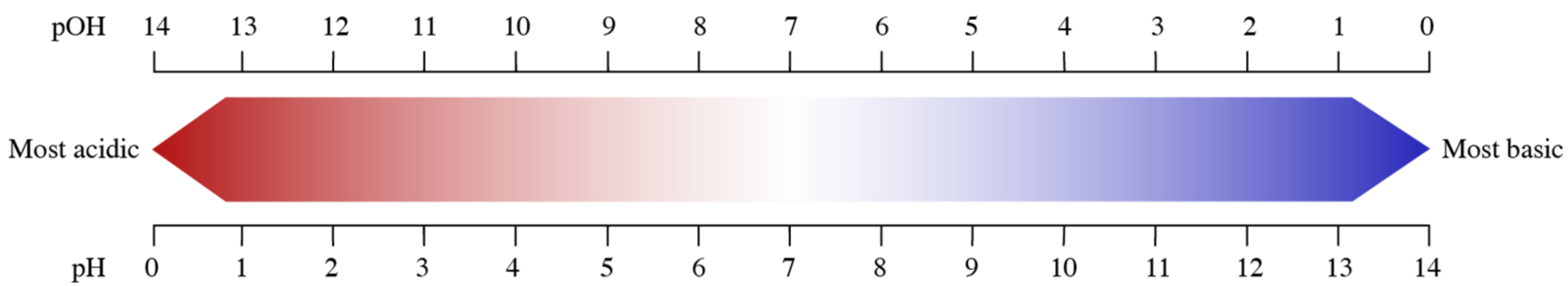
$$pK_w = -\log K_w = -\log 1.0 \times 10^{-14} = 14$$

$$pK_w = pH + pOH$$

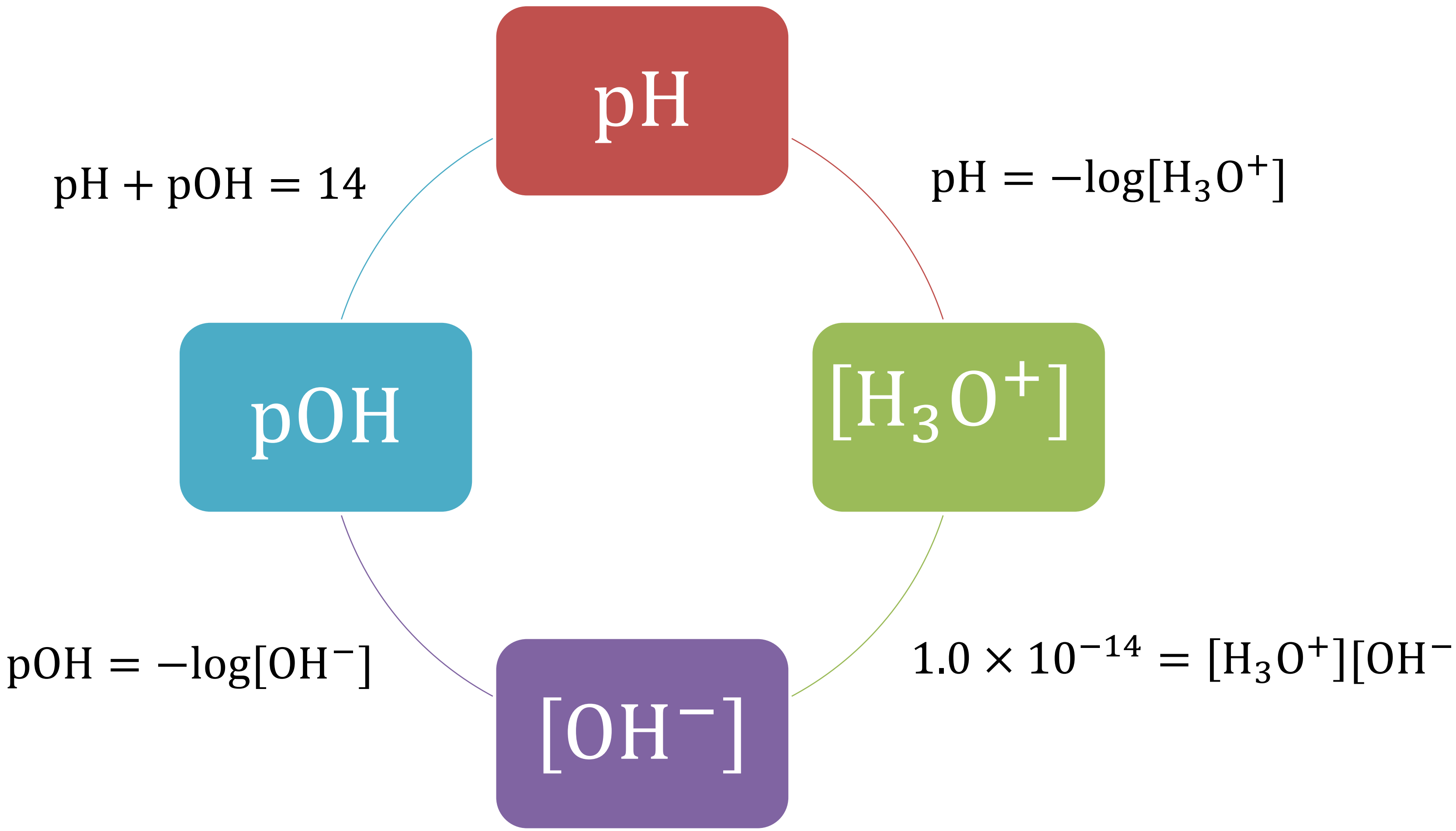
$$14 = pH + pOH$$

Acidic vs. Basic pH

- Something with a pH of 7 is considered neutral
- Something with a pH below 7 is considered an acid
- Something with a pH above 7 is considered a base



pH, pOH, $[H_3O^+]$, and $[OH^-]$



pH of a solution

Calculate the pH of a solution that has a hydronium concentration of 5.6×10^{-9} M.

pH of a solution

Calculate the pH of a solution that has a hydroxide concentration of 3.6×10^{-3} M.

pOH of a solution

Calculate the pH of a solution that has a pOH of 1.5.

pOH of a solution

Calculate the pOH of a solution that has a hydronium concentration of 3.6×10^{-3} M.