Section 14.1
Brønsted-Lowry Acids and Bases

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Learning Objectives

- Identify acids, bases, and conjugate acid-base pairs according to the Brønsted-Lowry definition
- Write equations for acid and base ionization reactions
- Use the ion-product constant for water to calculate hydronium and hydroxide ion concentrations
- Describe the acid-base behavior of amphiprotic substances

History of Acid/Base Theory

- In 1680, Robert Boyle reported traits of acid solutions
  - Ability to dissolve many substances
  - Change the colors of certain natural dyes
  - Lose these traits after coming in contact with alkali (base) solutions
- In the eighteenth century, it was recognized that acids
  - Have a sour taste
  - React with limestone to liberate a gaseous substance
  - Interact with alkalis to form neutral substances.

History of Acid/Base Theory

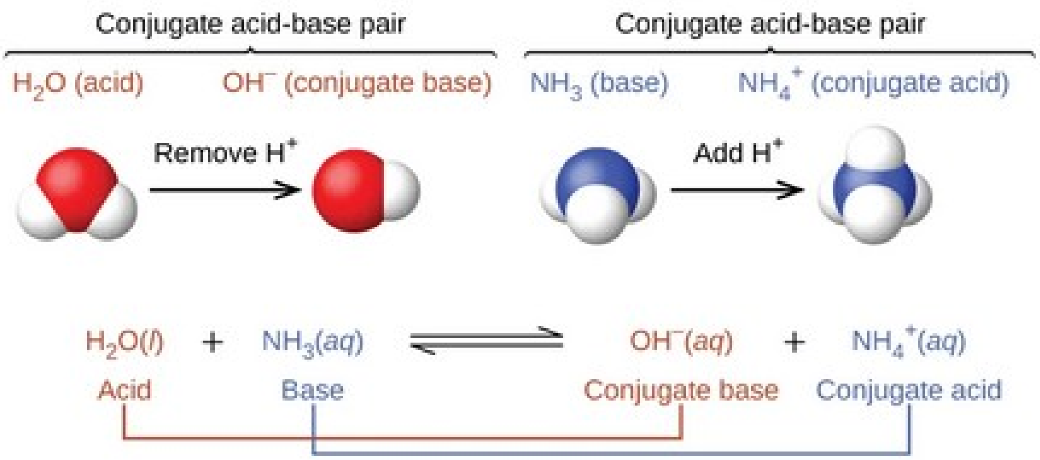
- In 1815, Humphry Davy contributed greatly to the development of the modern acid-base concept
  - Demonstrated that hydrogen is the essential constituent of acids.
- Joseph Louis Gay-Lussac concluded that acids are substances that can neutralize bases and that these two classes of substances can be defined only in terms of each other.
- In 1884, Svante Arrhenius defined an acid as a compound that dissolves in water to yield hydrogen cations and a base as a compound that dissolves in water to yield hydroxide anions.

Brønsted-Lowry Acids and Bases

- In 1923, Johannes Brønsted and Thomas Lowry proposed a theory based on the transfer of hydrogen ions, H^+ (protons).
- A compound that donates a proton to another compound is called a **Brønsted-Lowry acid**.
- A compound that accepts a proton is called a **Brønsted-Lowry base**.
- An acid-base reaction is the transfer of a proton from a donor (acid) to an acceptor (base).

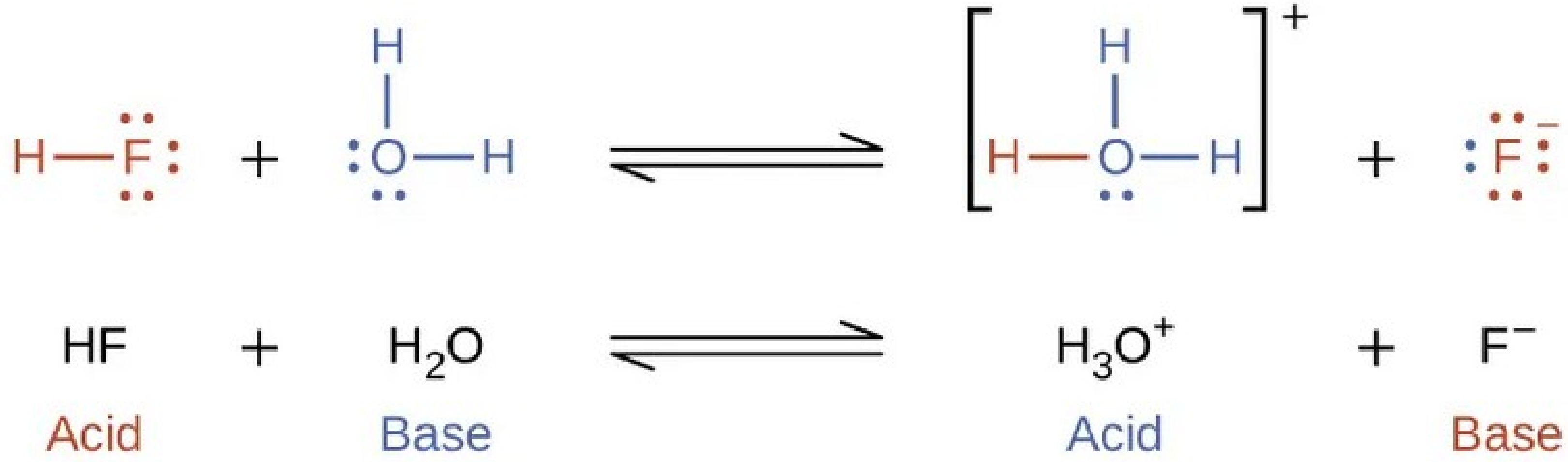
Conjugate Pairs

- When an acid donates H^+, the species that remains is called the **conjugate base** of the acid
  - It reacts as a proton acceptor in the reverse reaction.
- When a base accepts H^+, it is converted to its **conjugate acid**.



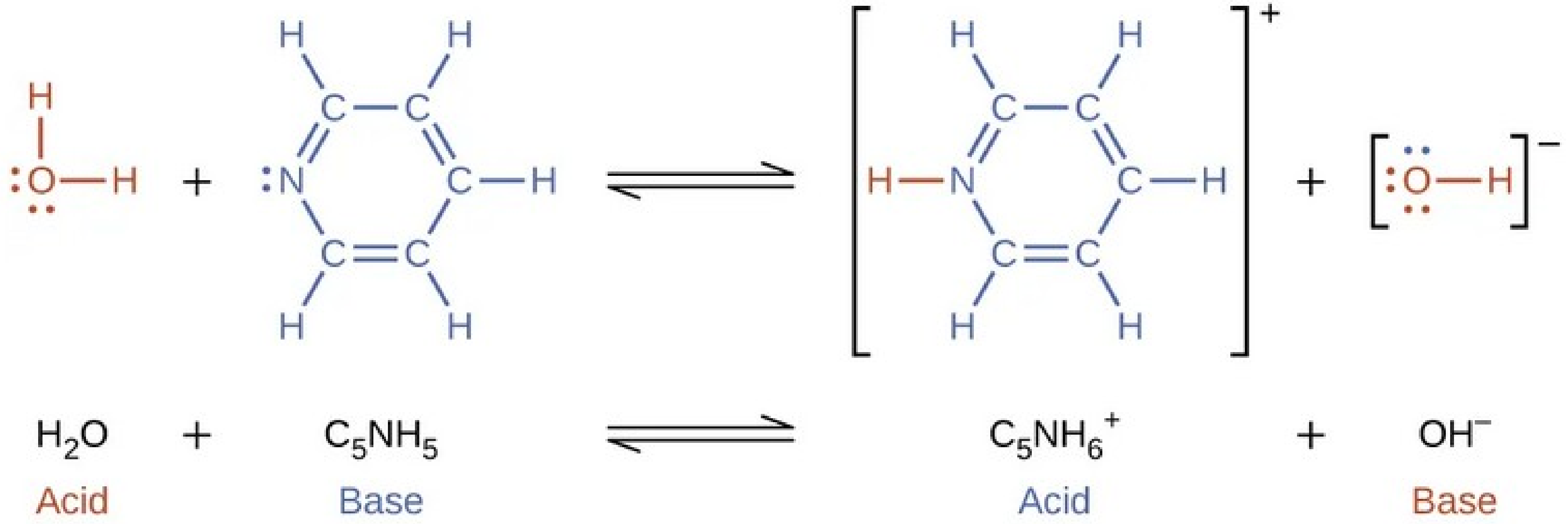
Acid Ionization

- The reaction between a Brønsted-Lowry acid and water is called **acid ionization**.



Base Ionization

- **Base ionization** of a species occurs when it accepts protons from water molecules.



Amphoterism

- Species capable of either donating or accepting protons are called **amphiprotic**, or more generally, **amphoteric**.

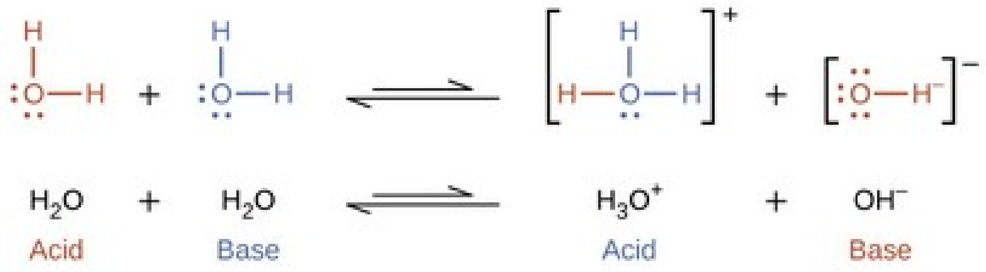
$$HCO_3^-(aq) + H_2O(l) \rightleftharpoons CO_3^{2-}(aq) + H_3O^+(aq)$$

$$HCO_3^-(aq) + H_2O(l) \rightleftharpoons H_2CO_3(aq) + OH^-(aq)$$

- When bicarbonate is added to water, both these equilibria are established simultaneously

Autoionization

- Molecules of an amphiprotic substance can react with one another to yield ions.



- This Process is called **autoionization**.
- The extent of the water autoionization process is reflected in the value of its equilibrium constant, the **ion-product constant for water**, K_w.

Autoionization of Water

- Pure water ionizes only slightly.
  - At 25 °C, K_w has a value of 1.0×10^{-14}
- The process is endothermic
  - The extent of ionization and the concentrations of hydronium ion and hydroxide ion increase with temperature.
  - At 100 °C, the value for K_w is about 5.6×10^{-1}

$$H_2O(l) + H_2O(l) \rightleftharpoons H_3O^+(aq) + OH^-(aq) \qquad K_w = [H_3O^+][OH^-]$$