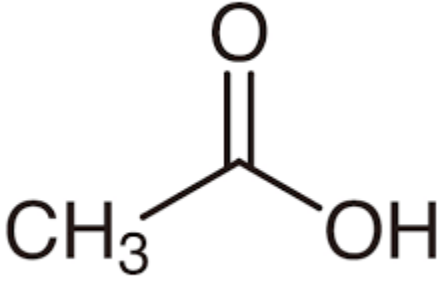
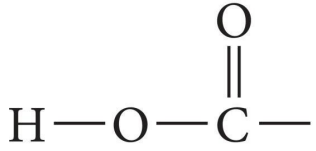
Acids and Bases

Structure of Acids (Organic Acids)



Acetic acid



Carboxylic acid group

Indicators

- Indicators are chemicals that change color depending on the solution's acidity or basicity.
- Demo using butterfly pea flower

Definitions of Acids and Bases

- Arrhenius definition (review)
  - Based on H+ and OH-
  - Flawed, does not account for molecular bases such as ammonia (NH_3)
- Brønsted–Lowry definition (review)
  - Based on reactions in which H+ is transferred
  - This theory is used most often in Ch 104
- Lewis definition
  - Based on electron transfer

  - Will go over this definition later

Brønsted–Lowry Theory

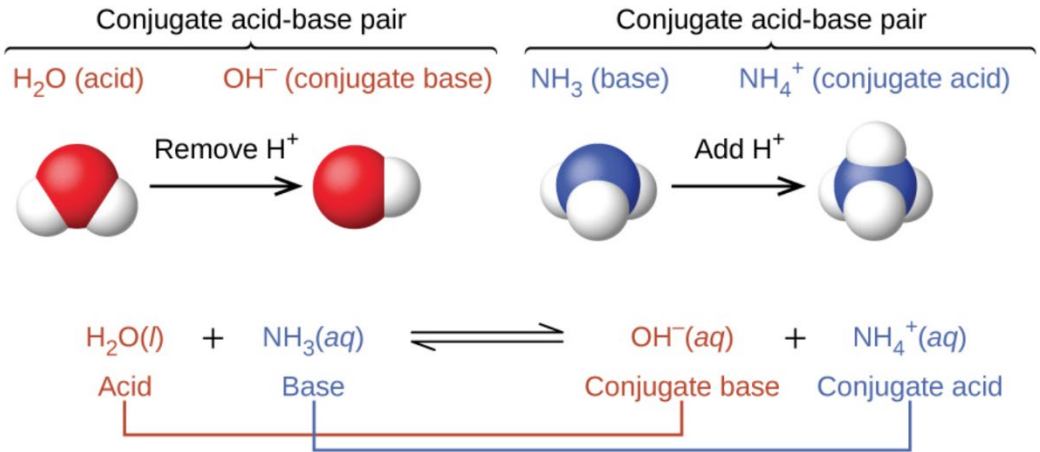
- The acid is an H^+ donor.
- The base is an H^+ acceptor.
- In a Brønsted–Lowry acid–base reaction, the acid molecule donates an H^+ to the base molecule.

$$H–A + :B \Leftrightarrow :A^- + H–B^+$$

Conjugate Acid–Base Pairs

- In a Brønsted-–Lowry acid–base reaction,
  - the original base becomes an acid in the reverse reaction.
  - the original acid becomes a base in the reverse process.

- Each reactant and the product it becomes is called conjugate pair



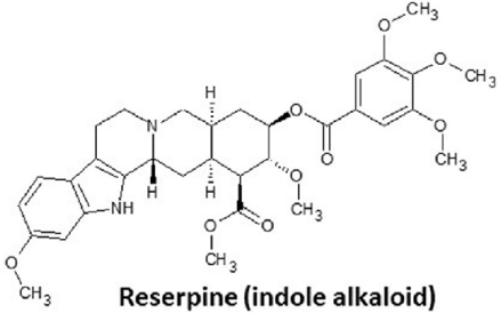
Bronsted Lowry

- $HF\ (aq) + H_2O \rightarrow H_3O^+\ (aq) + F^-\ (aq)$
- $NH_3(aq) + H_2O \rightarrow OH^-\ (aq) + NH_4^+$
- What is the acid and base, conjugate base and conjugate acid?

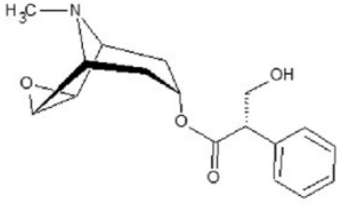
Amphoteric Substances

- **Amphoteric substances** can act as either an acid or a base because they have both a transferable H and an atom with lone pair electrons.

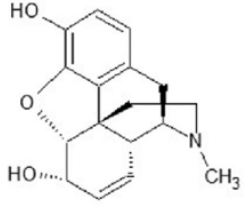
Application to medicine (alkaloids)



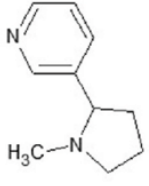
Reserpine (indole alkaloid)



Scopolamine (tropane alkaloid)



Morphine (benzylisoquinoline alkaloid)

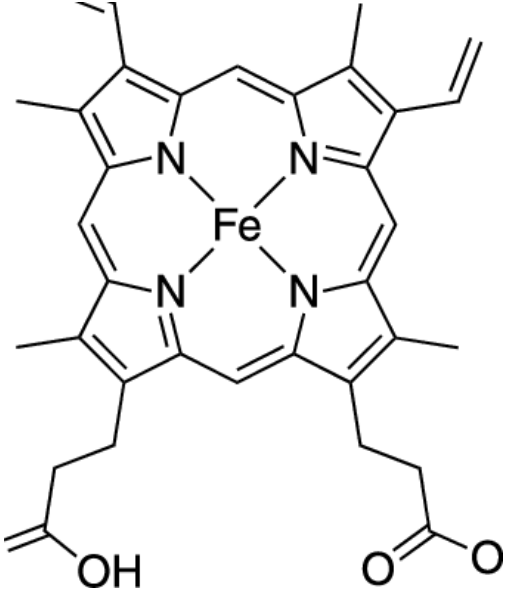


Nicotine (pyridine alkaloid)

Lewis Acid–Base Theory

- Lewis acid–base theory focuses on transferring an electron pair.
- Does NOT require H atoms
- The electron donor is called the Lewis base.
  - Electron rich; therefore nucleophile
- The electron acceptor is called the Lewis acid.
  - Electron deficient; therefore electrophile

Examples of Lewis Acid–Base Reactions



Heme group

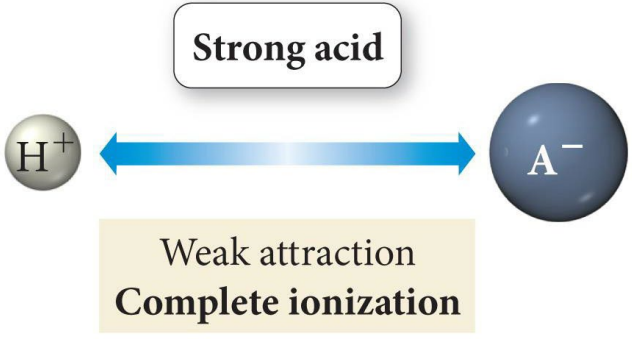
$$Ag^{+}_{(aq)} + 2\ :NH_{3(aq)} \rightarrow Ag(NH_3)_2^{+}$$

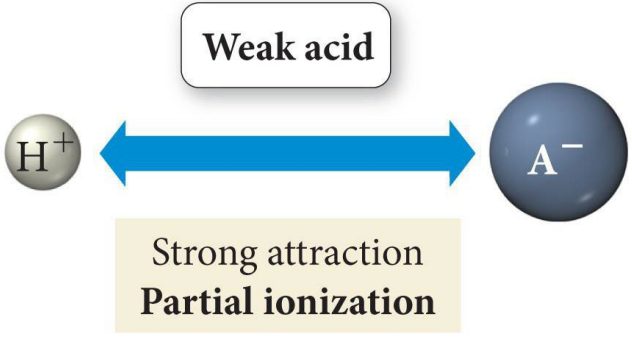
Lewis Acid

Lewis Base

Complex ion!

Ionic Attraction and Acid Strength





Relationship between Bond Strength and Acidity

Acid	Bond Energy kJ/mol	Type of Acid
HF	565	weak
HCl	431	strong
HBr	364	strong

Strong versus weak acids

Autoionization of Water

- Water is amphoteric; it can act either as an acid or a base.
  - Therefore, there must be a few ions present.

- All aqueous solutions contain **both** H_3O^+ and OH^-.
  - The concentration of H_3O^+ and OH^- are equal in water.
  - $[H_3O^+] = [OH^-] = 10^{-7}$M at 25 °C, $K_w = [H_3O^+][OH^-]$

$K_w = 1.00 \times 10^{-14}$ (equilibrium constant for autoionization of water)

Measuring Acidity: pH

- The acidity or basicity of a solution is often expressed as **pH**.
- $pH = -\log[H_3O^+]$
- pH < 7 is acidic; pH > 7 is basic. pH = 7 is neutral.
- $[H_3O^+] = 10^{-pH}$

TABLE 15.6 The pH of Some Common Substances

Substance	pH
Gastric juice (human stomach)	1.0–3.0
Limes	1.8–2.0
Lemons	2.2–2.4
Soft drinks	2.0–4.0
Plums	2.8–3.0
Wines	2.8–3.8
Apples	2.9–3.3
Peaches	3.4–3.6
Cherries	3.2–4.0
Beers	4.0–5.0
Rainwater (unpolluted)	5.6
Human blood	7.3–7.4
Egg whites	7.6–8.0
Milk of magnesia	10.5
Household ammonia	10.5–11.5
4% NaOH solution	14

Example Problems Strong Acids and Bases

Weak acids (Example Problem)

Weak Bases (example problems)

Hydrolysis of Salts

Hydrolysis of Salts Example Problem

Diprotic Acids (more than one ionization)

Example: What is the pH of a 0.0100 M solution of sulfuric acid?