The Nature of Acids and Bases

Chapter 8.1

The Arrhenius Theory of Acids and Bases

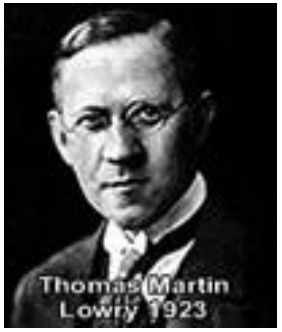
- An **acid** is a substance that produces hydrogen ions in aqueous solution
- A **base** is a substance that produces hydroxide ions in aqueous solution

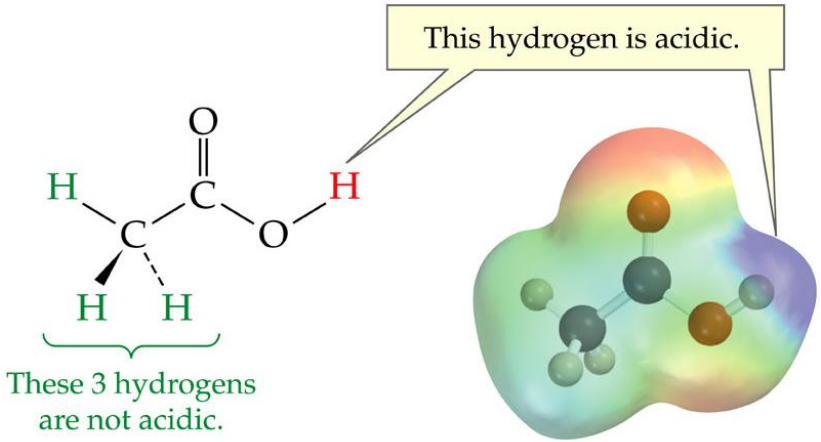
$$HCl(g) \xrightarrow{water} H^+(aq) + Cl^-(aq)$$

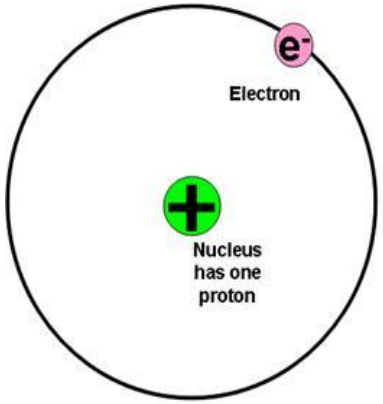
$$NaOH(s) \xrightarrow{water} Na^+(aq) + OH^-(aq)$$

The Brønsted-Lowry Theory of Acids and Bases

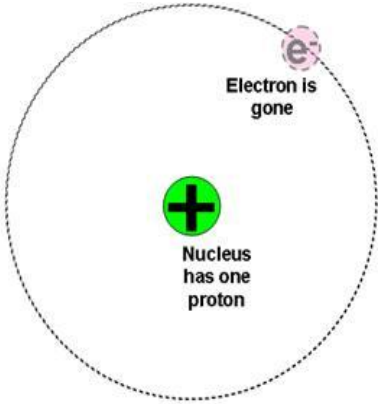
- An **acid** is a hydrogen ion *donor*
- A **base** is a hydrogen ion *acceptor*





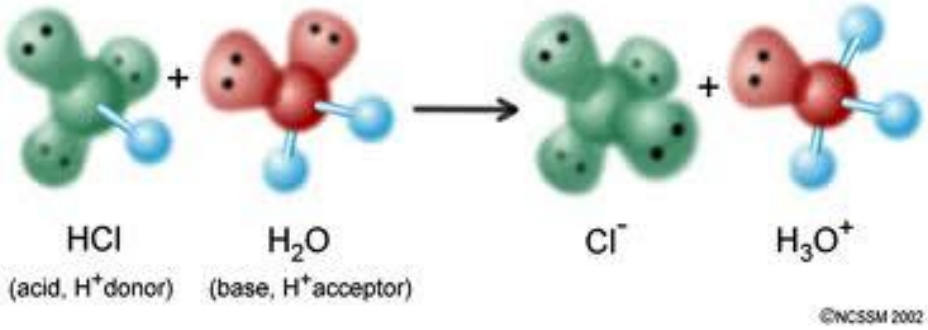


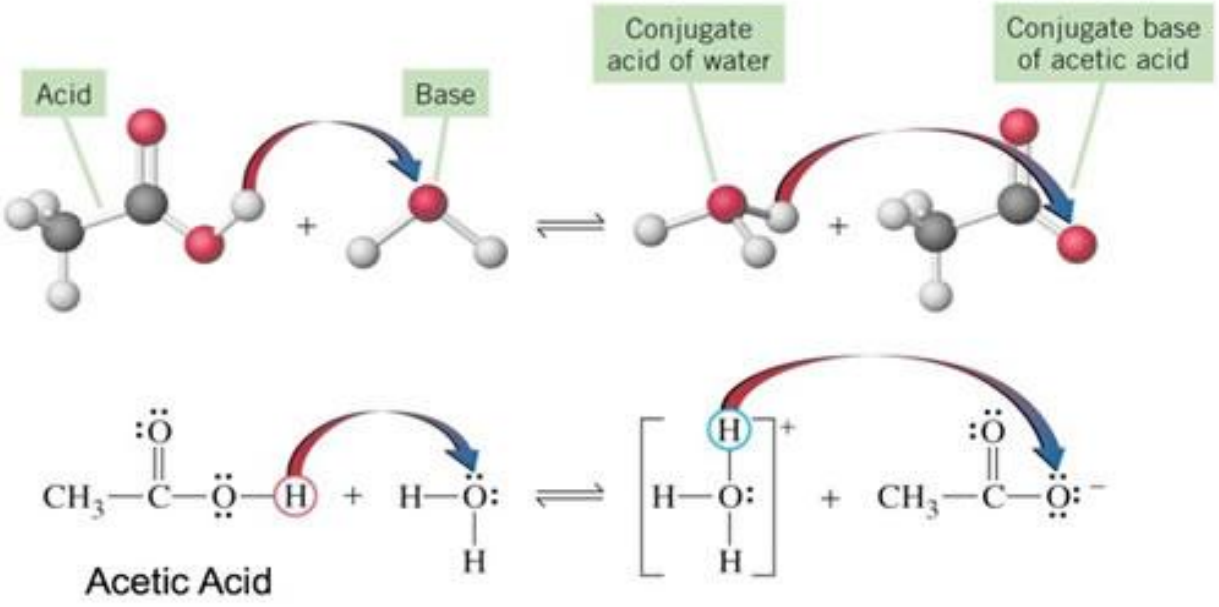
Hydrogen atom = 1 p^+ and 1e^-
"H"



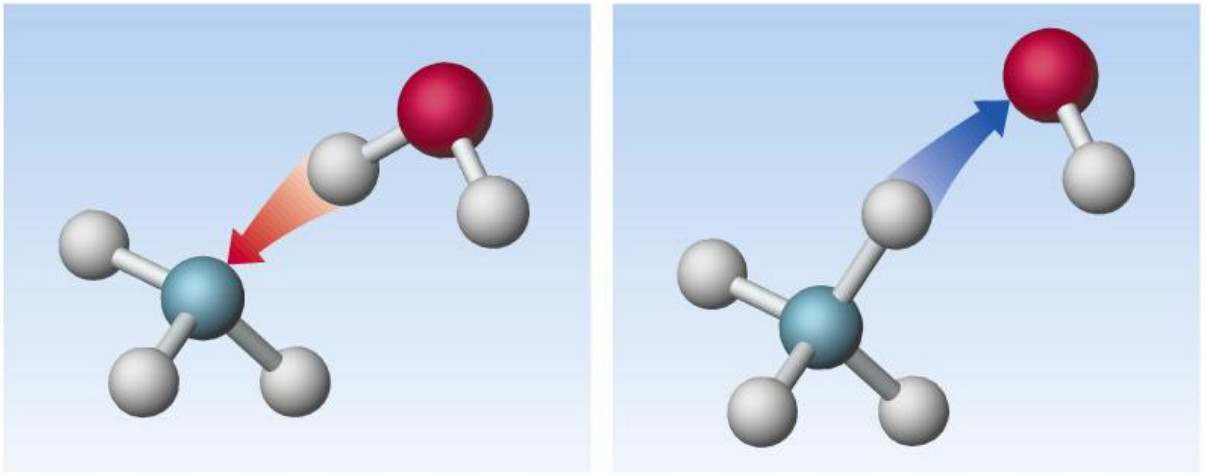
Hydrogen ion = 1 p^+ only
"H^+"

Brønsted-Lowry Acids



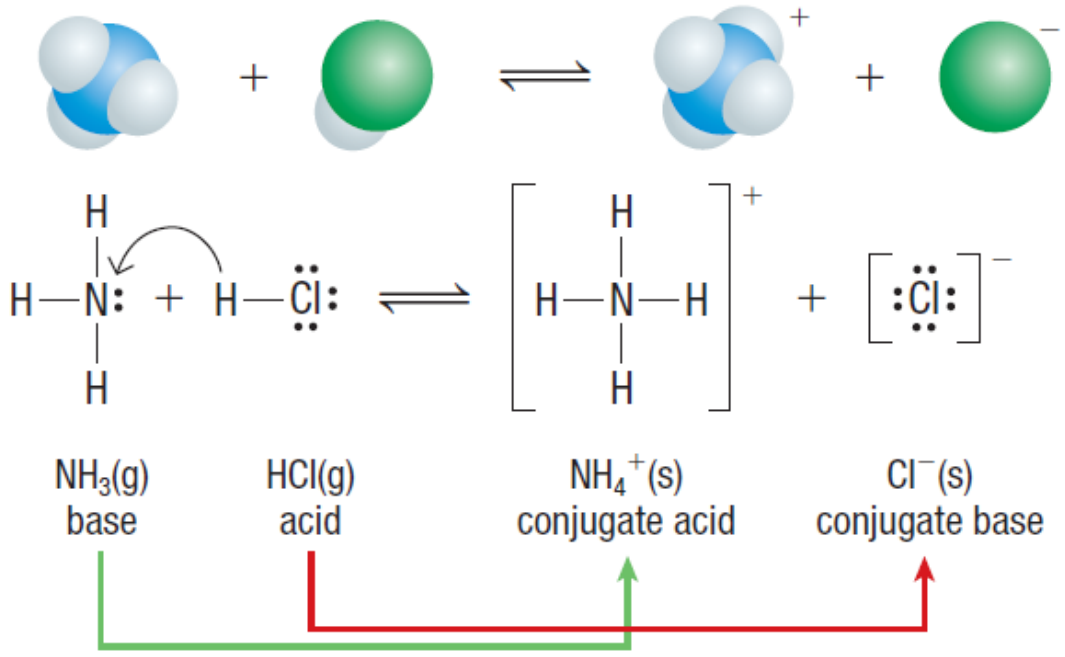


Brønsted-Lowry Bases



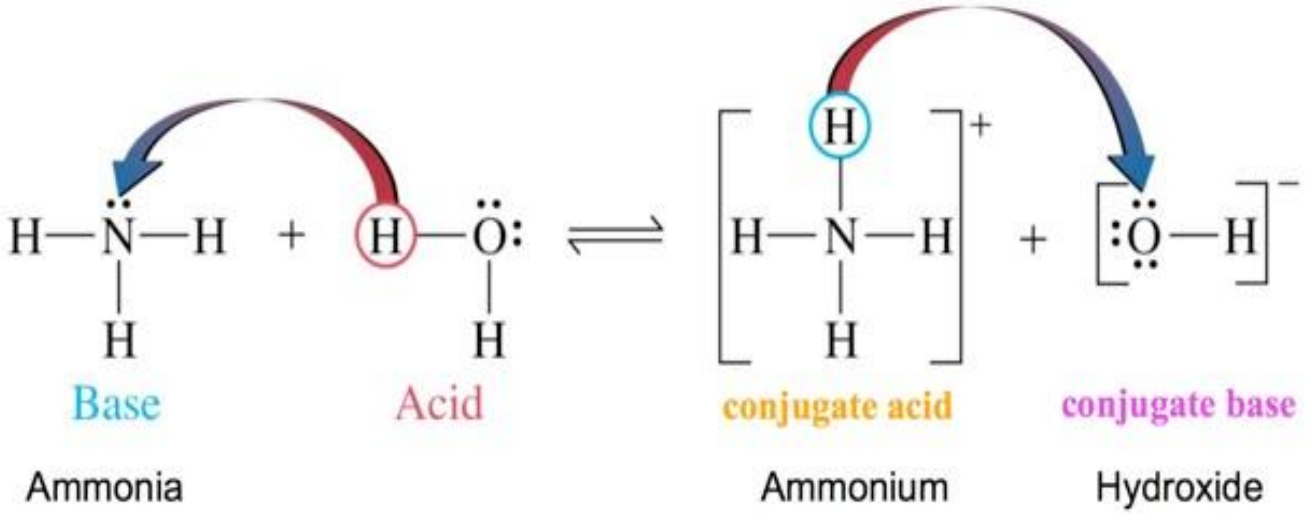
$$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$$

Brønsted-Lowry Acids and Bases



Conjugate Acid-Base Pairs

- A **conjugate acid** is the substance that forms when a base accepts a hydrogen ion
- A **conjugate base** is the substance that forms when an acid loses a hydrogen ion



Practice

- Label the acid, base, conjugate acid, and conjugate base in each of the following reactions:

a) $HCN + H_2O \rightleftharpoons H_3O + CN^-$

b) $HF + CH_3COOH \rightleftharpoons CH_3COOH_2^+ + F^-$

c) $CH_3COOH + NH_3 \rightleftharpoons NH_4^+ + CH_3COO^-$

Amphiprotic (Amphoteric) Substances

- An **amphiprotic** (or amphoteric) substance is able to donate or accept a hydrogen ion and thus can act as both an acid and a base depending on the reaction

Acting as a base $HCl + H_2O \rightleftharpoons Cl^- + H_3O^+$

Acting as an acid $NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$

The Acid Ionization Constant (K_a)

- Ka is the equilibrium constant for the ionization of an acid (also called the acid dissociation constant)

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

$$K_a = \frac{[H_3O^+(aq)][A^-(aq)]}{[H_2O(l)][HA(aq)]}$$

simplified version

$$HA(aq) \rightleftharpoons H^+(aq) + A^-(aq)$$

$$K_a = \frac{[H^+(aq)][A^-(aq)]}{[HA(aq)]}$$ where $[H^+(aq)]$ is equivalent to $[H_3O^+(aq)]$

Example: $H_3PO_4 \rightleftharpoons H^+ + H_2PO_4^-$ $\qquad K_a = \frac{[H^+]\,[H_2PO_4^-]}{[H_3PO_4]}$

Example

Write the acid ionization constant equation for the equilibrium reaction of ethanoic acid and water:

$$HC_2H_3O_2(aq) \rightleftharpoons H^+(aq) + C_2H_3O_2^-(aq)$$

Table 1 Some Acid Ionization Constants

Acid	Acid ionization constant, K_a
hydrocyanic, HCN(aq)	6.2×10^{-10}
benzoic, $HC_6H_5CO_2$(aq)	6.3×10^{-5}
propanoic, $HC_3H_5O_2$(aq)	1.3×10^{-5}
ethanoic (acetic), $HC_2H_3O_2$(aq)	1.8×10^{-5}
hydrofluoric, HF(aq)	6.6×10^{-4}
nitrous, HNO_2(aq)	4.6×10^{-4}
methanoic (formic), $HCHO_2$(aq)	1.8×10^{-4}

K_a values can be looked up on p. 726 of your text

HOMEWORK

Required Reading:

p. 486-494

(remember to supplement your notes!)

Questions:

p. 492 #1,2

p. 493 #1

p. 494 #1-11