Acids and Bases

Sections 9.1-9.2

Arrhenius Acids

- An acid produces H^+ when dissolved in water

$$\underset{\text{acid}}{HCl(aq)} \rightarrow H^+(aq) + Cl^-(aq)$$

- H^+ doesn't really exist in water, instead the following reaction stakes place

$$H^+(aq) + H_2O(l) \rightarrow H_3O^+(aq)$$

hydrogen ion (proton)

hydronium ion: actually present in aqueous solution

Brønsted-Lowry Acids

- An acid is a proton donor

- H^+ ion is a proton

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

- Acids must contain a hydrogen atom
  - May contain more than one hydrogen atom

Common Brønsted–Lowry Acids		
	HCl hydrochloric acid	H_2SO_4 sulfuric acid
	HBr hydrobromic acid	HNO_3 nitric acid

Polyprotic Acids

- Acid that contains more than one acidic proton
- HCl is a **monoprotic acid** – only one acidic proton
- H_2SO_4 is a **diprotic acid** – has two acidic protons
- H_3PO_4 is a **triprotic acid** – has three acidic protons

Arrhenius Bases

- A base produces OH^- when dissolved in water

$$\mathrm{NaOH(s)} \rightarrow \mathrm{Na^+(aq)} + \mathrm{OH^-(aq)}$$

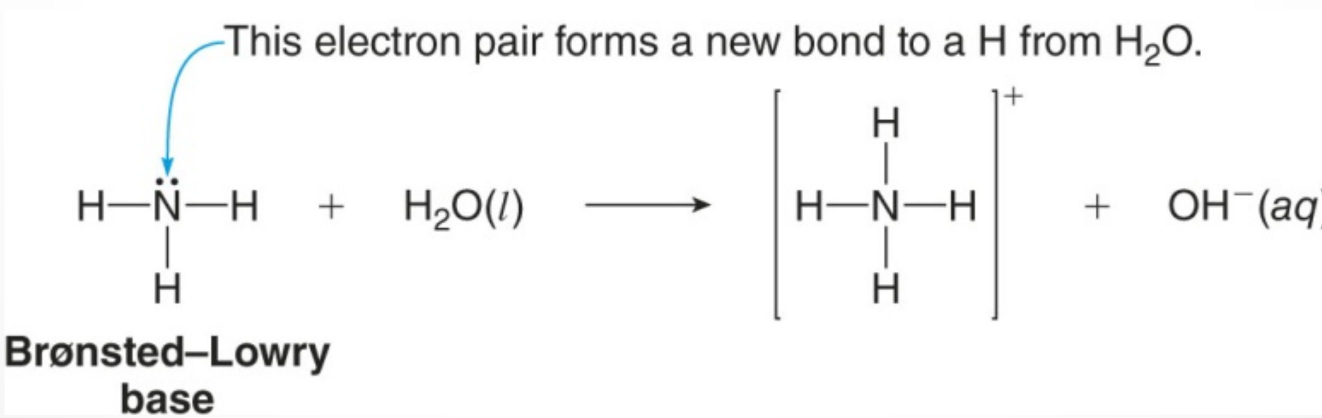
base

Brønsted-Lowry Bases

- A base is a proton acceptor

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

- A base must contain a lone pair of electrons



Example #1

Classify each reactant as a Brønsted-Lowry acid or base.

a. $NH_3(aq) + HCl(aq) \rightarrow Cl^-(aq) + NH_4^+(aq)$

b. $OH^-(aq) + HSO_4^-(aq) \rightarrow H_2O(l) + SO_4^{2-}(aq)$

Example #1 Solved

a. $NH_3(aq) + HCl(aq) \rightarrow NH_4^+(aq) + Cl^-(aq)$

HCl is Brønsted-Lowry acid, donates proton

NH_3 is Brønsted-Lowry base, accepts proton

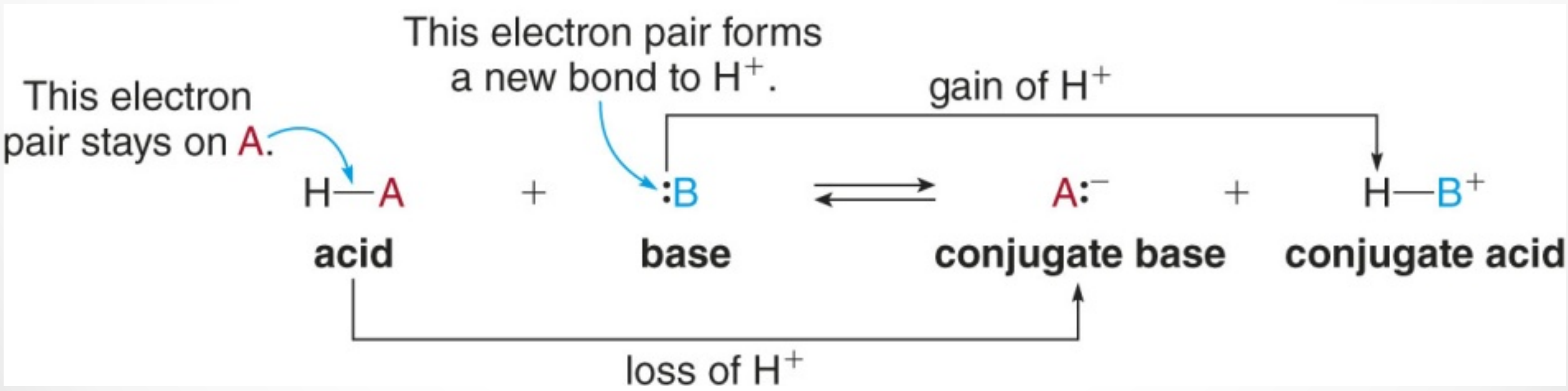
b. $OH^-(aq) + HSO_4^-(aq) \rightarrow H_2O(l) + SO_4^{2-}(aq)$

HSO_4^- is Brønsted-Lowry acid, donates proton

OH^- is Brønsted-Lowry base, accepts proton

Brønsted-Lowry Reactions

- When a Brønsted-Lowry acid reacts with a Brønsted-Lowry base, a proton transfer takes place
- The acid donates the proton and the base accepts it



Conjugate Acid/Base Pairs

- A pair of compounds that differ only by one H^+

gain of H^+

$$HBr + H_2O \rightleftarrows Br^- + H_3O^+$$

acid	base	conj. base	conj. acid

loss of H^+

Example #2

Determine the conjugate base of each species:

a. H_2S

b. HCN

c. HSO_4^-

Example #2 Solved

Conjugate base has one fewer H^+

a. H_2S: **HS^-**

b. HCN: **CN^-**

c. HSO_4^-: **SO_4^{2-}**

Amphoteric

- A compound that can be both an acid and a base
- Contains both a hydrogen atom (to act as an acid) and a lone pair of electrons (to act as a base)

H_2O as a base

Add H^+

$$H_2O \rightarrow H_3O^+$$

H_2O as an acid

Remove H^+

$$H_2O \rightarrow OH^-$$

Example #3

Which of the following substances are amphoteric?

a. H_2O

b. CO_3^{2-}

c. $H_2PO_4^-$

Example #3 Solved

Amphoteric substances can both accept and donate a proton

a. H_2O, can form H_3O^+ and OH^-, **amphoteric**

b. CO_3^{2-}, does not contain a proton, **not amphoteric**

c. $H_2PO_4^-$, can form H_3PO_4 and HPO_4^{2-}, **amphoteric**

Example #4

Which of the following are acids?

a. NaOH

b. HBr

c. NH_3

d. HNO_3

Example #5

Classify each reactant as a Brønsted-Lowry acid or base.

a. $CH_3COOH(aq) + H_2O(l) \rightarrow CH_3COO^-(aq) + H_3O^+(aq)$

b. $HF(aq) + HSO_4^-(aq) \rightarrow F^-(aq) + H_2SO_4(aq)$

Example #6

Determine the conjugate acid of each species:

a. H_2O

b. I^-

c. HCO^{3-}