# Acid - Base Theories

$CH_3COOH \rightarrow H^+ + CH_3COO^-$ | $HCl \rightarrow H^+ + Cl^-$

**Arrhenius Theory of Acids and Bases**

- acids are hydrogen-containing compounds that ionize in aqueous solutions to give $H^+$
- bases ionize to give $OH^-$ ions

Monoprotic Acid - one hydrogen will ionize Ex. $HNO_3$

Diprotic Acid - two hydrogens will ionize Ex. $H_2SO_4$

Triprotic Acid - three hydrogens will ionize Ex. $H_3PO_4$

$H^+ \quad OH^- \longrightarrow H_2O$

Acid + Base ⟶ neutral

Advantage: it explained neutralization as $H^+$ and $OH^-$ combining to give $H_2O$

Disadvantage: not all hydrogen containing substances have acid properties (i.e., $CH_4$) and not all bases have $OH^-$ ($NH_3$).

proton → $H^+$

$1p^+$

$0e^-$

$0n$

1.01

p + n = amu

(1)

## BRONSTED - LOWRY THEORY OF ACIDS & BASES

### Bronsted-Lowry Acids and Bases

A new theory was needed because:
(i) not all acid/base reactions involve water.
(ii) not all bases contain hydroxide ions ($Na_2CO_3$, $NH_3$).

**Bronsted - Lowry Acid - a proton (hydrogen-ion) donor**
**Bronsted - Lowry Base - a proton (hydrogen-ion) acceptor**

- **acids lose a proton** to a water molecule ($H^+$ is a proton!)

Ex. $HCl_{(l)} + H_2O_{(l)} \longleftrightarrow H_3O^+_{(aq)} + Cl^-_{(aq)}$

A B A B

**hydronium ion** (pointing to $H_3O^+$)
(water molecule gains a proton)

- **bases gain a proton** from a water molecule

Ex. $H_2O + NH_{3(aq)} \longleftrightarrow OH^-_{(aq)} + NH_4^+{}_{(aq)}$

A B B A

($H_2O$ acts as an acid, $NH_3$ acts as a base)

However water does not have to be present in order to have a proton exchange.

Ex. $HCl_{(g)} + NH_{3(g)} \longleftrightarrow NH_4^+{}_{(aq)} + Cl^-_{(aq)}$

HCl donates a proton (acid)
$NH_3$ accepts a proton (base)

**amphoteric (amphiprotic) -** substance that can act as a Bronsted-Lowry acid in some reactions and a Bronsted-Lowry base in other reactions.

$HSO_3^-{}_{(aq)} + H_3O^+{}_{(aq)} \longleftrightarrow H_2SO_{3(aq)} + H_2O_{(l)}$

$HSO_3^-{}_{(aq)} + OH^-_{(aq)} \longleftrightarrow SO_3^{2-}{}_{(aq)} + H_2O_{(l)}$

Predict the products for the following reaction, and identify each substance as an acid or a base.

$H^+$

a) $CH_3COOH_{(aq)} + H_2O_{(l)} \rightleftharpoons CH_3COO^-_{(aq)} + H_3O^+_{(aq)}$

A B B A

b) $HNO_{3(aq)} + OH^-_{(aq)} \rightleftharpoons NO^-_{3(aq)} + H_2O_{(l)}$

A B B A

c) $HS^-_{(aq)} + H_2O_{(l)} \rightleftharpoons H_2S_{(aq)} + OH^-_{(aq)}$

$HS^-_{(aq)} + H_2O_{(l)} \rightleftharpoons S^{2-}_{(aq)} + H_3O^+_{(aq)}$

# Conjugate Acid-Base Pairs

$$CH_3COOH_{(aq)} + H_2O_{(l)} \qquad CH_3COO^-_{(aq)} + H_3O^+_{(aq)}$$

## Acid-Base reactions are at equilibrium !

*(Look at forward reaction and reverse reaction)*

- Every acid-base reaction at equilibrium has two acids and two bases.
- Acid on 'product' side is formed by addition of proton to base on 'reactant' side
- Base on 'product' side is formed by removal of a proton from acid on 'reactant' side

**Conjugate acid-base pair**

A pair of substances that differ by only a proton

Ex.

See Appendix F, p. 611

# Homework

**p. 593 #3-5,7,8**