Acid-Base Theories

A) Antoine Lavoisier (1743-1794)

Lavoisier classified all chemicals into acids, bases and salts

He believed that all acids were oxygen containing chemicals and the presence of oxygen gave them their sour taste

His theory is, of course, flawed as witnessed by HCl as an acid and the fact that metal oxides form bases

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B) Sir Humphrey Davy (1810)

Proposed that acids contain hydrogen rather than oxygen as he showed that HCl was an acid that did not contain oxygen

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C) Svante Arrhenius (1887)

His theory revolves around the role of water when an acid or base dissolves forming a solution. His main points are:

- Acids dissociate in water forming hydrogen ions H^+ as one product
- Bases dissociate in water forming hydroxide ions OH^- as one product
- Neutralization reactions involve the reaction of H^+ ions in the acid reacting with OH^- ions forming water salt as products

There are some flaws in his theory:

- Some substances such as NH3 and Na2CO3 behave as bases and do not contain OH-

- His theory on acids and bases can only be applied to aqueous solutions
- His theory does not address relative strengths of acids and bases

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D) Bronsted-Lowry (1923)

An **acid** is a proton H^+ donor to a base
A **base** is a proton acceptor

Examples:

$$HCl + H_2O \rightarrow H_3O^+ + Cl^-$$

$$NH3 + H_2O \rightarrow NH_4^+ + OH^-$$

In the first example, hydrochloric acid is donating a proton- an acid

In the second example, ammonia is accepting a proton- a base

<u>Amphiprotic substances</u>

Chemicals that can react as acids in some reactions and bases in other reactions

Examples:

$H_2O + H_2O \rightarrow H_3O^+ + OH^-$ (water as acid and base)

$HCO_3^- + H_2O \rightarrow H_2CO_3 + OH^-$ (hydrogen carbonate as a base)
$HCO_3^- + H_2O \rightarrow H_3O^+ + CO_3^{2-}$ (hydrogen carbonate as an acid)

$HSO_4^- + OH^- \rightarrow SO_4^{2-} + H_2O$ (hydrogen sulfate ion-acid)
$HSO_4^- + H_3O^+ \rightarrow H_2SO_4 + H_2O$ (hydrogen sulfate ion-base)

Bronsted-Lowry conjugate acid-base pairs

Acid 1 + Base 2 ←→ Base 1 + Acid 2

Conjugate pair 1 (Acid 1 – Base 1) Conjugate pair 2 (Base 2 – Acid 2)

What does this mean?
An acid reacts with a base and forms a conjugate base that can accept a proton

A base can react with an acid to form a conjugate acid that can donate a proton

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Example:

$$CH_3COOH + OH^- \leftrightarrow H_2O + CH_3COO^-$$

Acid Base Acid Base

The acetic acid donates a proton making it a B-L acid

The hydroxide accepts a proton making it a B-L base

Water can donate a proton in solution making it a B-L acid

The acetate ion can also accept a proton making it a B-L base

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How do we predict equilibrium?

The direction of acid-base equilibria is away from the stronger acid base side and towards the weaker acid-base side

The stronger the acid, the weaker its conjugate base
The stronger the base, the weaker its conjugate acid