# Acids, Bases, Salts, and pH Scale

## Acids and Bases

There are three major Theories of substances known as acids or bases.

1. **The Arrhenius Theory of acids and bases**
   -This theory considers

- Acids are substances which produce hydrogen ions [$H^+$] in solution.
- Bases are substances which produce hydroxide ions [$OH^-$] in solution.

❖ Neutralization happens because hydrogen ions and hydroxide ions react to produce water.

$$H^+_{(aq)} + OH^-_{(aq)} \longrightarrow H_2O_{(l)}$$

2. **The Bronsted-Lowry Theory of acids and bases**
   -This theory considers

- Acids are a proton (hydrogen ion) [$H^+$] donor.
- Bases are a proton (hydrogen ion) [$H^+$] acceptor.

❖ The relationship between the Bronsted-Lowry theory and the Arrhenius theory the Bronsted-Lowry theory doesn't go against the Arrhenius theory in any way it just adds to it.

❖ Hydroxide ions [$OH^-$] are still bases because they accept hydrogen ions from acids and form water.

❖ An acid produces hydrogen ions in solution because it reacts with the water molecules by giving a proton to them**.**

**Consider an acid HA, and think of the reaction as being reversible.**

$$HA + H_2O \rightleftharpoons H_3O^+ + A^-$$

*Thinking about the forward reaction:*

- The HA is an acid because it is donating a proton (hydrogen ion) to the water.
- The water $H_2O$ is a base because it is accepting a proton from the HA.

*But there is also a back reaction between the hydroxonium ion $H_3O^+$ and the $A^-$ ion:*

- The $H_3O^+$ is an acid because it is donating a proton (hydrogen ion) $H^+$ to the $A^-$ ion.
- The $A^-$ ion is a base because it is accepting a proton from the $H_3O^+$.

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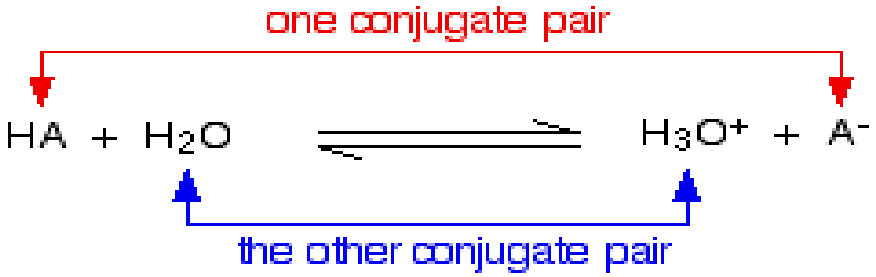
The reversible reaction contains *two* acids and *two* bases. We think of them in pairs, called ***conjugate pairs***.




When the acid HA loses a proton it forms a base $A^-$ , When the base $A^-$ accepts a proton back again, it obviously reforms the acid HA .These two are a conjugate pair.

-If you are thinking about HA as the acid, then $A^-$ is its conjugate base.

-If you are thinking about $A^-$ as the base, then HA is its conjugate acid.

The water and the Hydronium ion are also a conjugate pair. Thinking of the water as a base, the Hydronium ion is its conjugate acid because it has the extra hydrogen ion which it can give away again.

Thinking about the Hydronium ion as an acid, then water is its conjugate base. The water can accept a hydrogen ion back again to reform the Hydronium ion.

### 3. The Lewis Theory of acids and bases

This theory extends well beyond the things you normally think of as acids and bases.

-This theory considers

- Acids are an electron pair acceptor.
- Bases are an electron pair donor.

***Complex ions*** are polyatomic ions, which are formed from a central metal ion that has other smaller ions joined around it. While Bronsted theory can't explain this reaction. Lewis Acid-Base Theory can help to understand the coordination Compounds. a Lewis Base is often the ligand of a coordination compound with the metal acting as the Lewis Acid

$$Al^{3+}+6H_2O \rightleftharpoons [Al(H_2O)6]^{3+}$$

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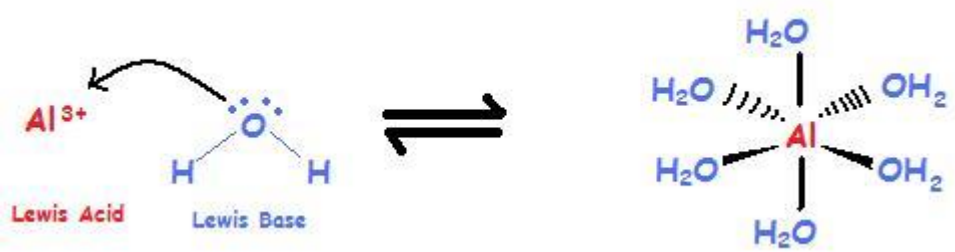
The Aluminum ion is the metal and is a cation with an unfilled valence shell, and it is a Lewis Acid. Water has lone-pair electrons and is an anion, thus it is a Lewis Base.




## Strong Acid and Base

**Strong acid: -**

An acid that is completely ionized in aqueous solution. This means when the strong acid placed in solution such as water, all of the strong acid will dissociate into its ions to a weak acid. The general equation of the dissociation of a strong acid is:

$$HA_{(aq)} \rightarrow H^{+}_{(aq)} + A^{-}_{(aq)}$$

(H) Represents hydrogen ion (cation)

(A) Represents the conjugate base (anion) of the acid.

**Strong Base:-**

A base that is completely ionized in aqueous solution. This means when the strong base is placed in a solution such as water, all of the strong base will dissociate into its ions to a weak base. The general equation of the dissociation of a strong base is:

$$XOH_{(aq)} \rightarrow X^{+}_{(aq)} + OH^{-}_{(aq)}$$

(OH) Represents hydroxide ion (anion)

(X) Represents the conjugate acid (cation) of the base.

# Acids, Bases, Salts, and pH Scale

| 6 Strong Acids | | 6 Strong Bases | |
|---|---|---|---|
| $HClO_4$ | perchloric acid | LiOH | lithium hydroxide |
| HCl | hydrochloric acid | NaOH | sodium hydroxide |
| HBr | hydrobromic acid | KOH | potassium hydroxide |
| HI | hydroiodic acid | $Ca(OH)_2$ | calcium hydroxide |
| $HNO_3$ | nitric acid | $Sr(OH)_2$ | strontium hydroxide |
| $H_2SO_4$ | sulfuric acid | $Ba(OH)_2$ | barium hydroxide |

**Some common strong acids and bases**

## The Salts

Salt is an ionic compound that can be formed by the neutralization reaction of an acid and a base. Salts are composed of related numbers of cations (positively charged ions) and anions (negative ions) so that the product is electrically neutral (without a net charge). These component ions can be inorganic, such as chloride ($Cl^-$),or organic, such as acetate ($CH3OO^-$) and can be monatomic, such as fluoride (F−), or polyatomic, such as sulfate ($SO_4^{-2}$)

$$\text{Acid + Base} \longrightarrow \text{Salt + Water}$$

## Types of salts

1. Alkali Salts
   Salts that produce when strong base react with weak acid for example

$$NaOH + CH_3COOH \longrightarrow \underline{CH_3COONa} + H_2O$$

sodium hydroxide + acetic acid ⟶ sodium acetate + water

# Acids, Bases, Salts, and pH Scale

2. Acidic salts
   Salts that produce when strong acid react with weak base for example

$$NH_4OH + HCl \longrightarrow \underline{NH_4Cl} + H_2O$$

Hydroxide ammonium + hydrochloric acid ⟶ Ammonium Chloride + water

3. Neutral salts
   Salts that produce when strong acid react with strong base for example

$$NaOH + HCl \longrightarrow \underline{NaCl} + H_2O$$

Sodium hydroxide + hydrochloric acid ⟶ Sodium chloride + water

## PH scale

PH :- (potential of hydrogen) is a numeric scale used to specify the acidity or basicity of an aqueous solution. Solutions with a pH less than 7 are acidic and solutions with a pH greater than 7 are basic. Pure water is neutral, at pH 7 (25 °C), being neither an acid nor a base. Contrary to popular belief, the pH value can be less than 0 or greater than 14 for very strong acids and bases respectively

