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Acids and bases

☐**Acids and bases,** two related classes of chemicals; the members of each class have a number of common properties when dissolved in a solvent, usually water.

Properties

Acids in water solutions exhibit the following common properties: they taste sour; turn litmus paper red; and react with certain metals, such as zinc, to yield hydrogen gas. Bases in water solutions exhibit these common properties: they taste bitter; turn litmus paper blue; and feel slippery. When a water solution of acid is mixed with a water solution of base, water and a salt are formed; this process, called neutralization, is complete only if the resulting solution has neither acidic nor basic properties.

Classification

Acids and bases can be classified as organic or inorganic. Some of the more common organic acids are: citric acid, carbonic acid, hydrogen cyanide, salicylic acid, lactic acid, and tartaric acid. Some examples of organic bases are: pyridine and ethylamine. Some of the common inorganic acids are: hydrogen sulfide, phosphoric acid, hydrogen chloride, and sulfuric acid. Some common inorganic bases are: sodium hydroxide, sodium carbonate, sodium bicarbonate, calcium hydroxide, and calcium carbonate.

Acids, such as hydrochloric acid, and bases, such as potassium hydroxide, that have a great tendency to dissociate in water are completely ionized in solution; they are called strong acids or strong bases. Acids, such as acetic acid, and bases, such as ammonia, that are reluctant to dissociate in water are only partially ionized in solution; they are called weak acids or weak bases. Strong acids in solution produce a high concentration of hydrogen ions, and strong bases in solution produce a high concentration of hydroxide ions and a correspondingly low concentration of hydrogen ions. The hydrogen ion concentration is often expressed in terms of its negative logarithm, or pH (see separate article). Strong acids and strong bases make very good electrolytes (see electrolysis), i.e., their solutions readily conduct electricity. Weak acids and weak bases make poor electrolytes.

See buffer; catalyst; indicators, acid-base; titration.

Acid-Base Theories

There are three theories that identify a singular characteristic which defines an acid and a base: the Arrhenius theory, for which the Swedish chemist Svante Arrhenius was awarded the 1903 Nobel Prize in chemistry; the Brönsted-Lowry, or proton donor, theory, advanced in 1923; and the Lewis, or electron-pair, theory, which was also presented in 1923. Each of the three theories has its own advantages and disadvantages; each is useful under certain conditions.

The Arrhenius Theory When an acid or base dissolves in water, a certain percentage of the acid or base particles will break up, or dissociate (see dissociation), into oppositely charged ions. The Arrhenius theory defines an acid as a compound that can dissociate in water to yield hydrogen ions, H^+, and a base as a compound that can dissociate in water to yield hydroxide ions, OH^-. For example, hydrochloric acid, HCl, dissociates in water to yield the required hydrogen ions, H^+, and also chloride ions, Cl^-. The base sodium hydroxide, NaOH, dissociates in water to yield the required hydroxide ions, OH^-, and also sodium ions, Na^+.

The Brönsted-Lowry Theory Some substances act as acids or bases when they are dissolved in solvents other than water, such as liquid ammonia. The Brönsted-Lowry theory, named for the Danish chemist Johannes Brönsted and the British chemist Thomas Lowry, provides a more general definition of acids and bases that can be used to deal both with solutions that contain no water and solutions that contain water. It defines an acid as a proton donor and a base as a proton acceptor. In the Brönsted-Lowry theory, water, H_2O, can be considered an acid or a base since it can lose a proton to form a hydroxide ion, OH^-, or accept a proton to form a hydronium ion, H_3O^+ (see amphoterism). When an acid loses a proton, the remaining species can be a proton acceptor and is called the conjugate base of the acid. Similarly when a base accepts a proton, the resulting species can be a proton donor and is called the conjugate acid of that base. For example, when a water molecule loses a proton to form a hydroxide ion, the hydroxide ion can be considered the conjugate base of the acid, water. When a water molecule accepts a proton to form a hydronium ion, the hydronium ion can be considered the conjugate acid of the base, water.

The Lewis Theory Another theory that provides a very broad definition of acids and bases has been put forth by the American chemist Gilbert Lewis. The Lewis theory defines an acid as a compound that can accept a pair of electrons and a base as a compound that can donate a pair of electrons. Boron trifluoride, BF_3, can be considered a Lewis acid and ethyl alcohol can be considered a Lewis base.
