

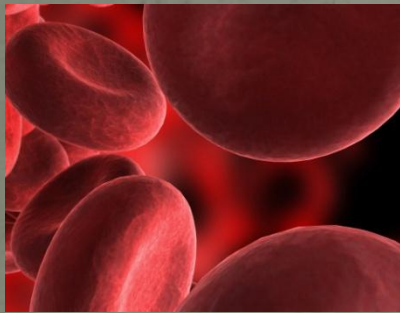
The History of Acids and Bases



What do these substances have in common?



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Ancient Times

- In an attempt to unravel nature's secrets, early scientists would 'taste stuff' and then categorize them as 'sour', 'bitter', 'salty', 'sweet', etc.
- Sour-tasting stuff would give rise to the word 'acid', which comes from the Greek word *oxein*, which mutated into the Latin verb *acere*, which means 'to make sour' (thus the term 'acetic acid', which is the sour tasting component in vinegar, is a redundancy).
- In the 700's an Arabian alchemist Jabir ibn Hayyan prepared *aqua fortis* (nitric acid) by heating saltpetre (KNO_3) and dissolving the resulting gas in water.

Ancient Times

- Bitter-tasting stuff would give rise to the word 'alkaline' which was derived from the Arabic word *alqily* meaning “roasted in a pan” or “the ashes of plants”.
- The term originally meant 'roasting', because the first alkaline substances were obtained by roasting ashes then treating them with water and slaked lime (Ca(OH)_2). This produced NaOH and KOH, two of the most classic bases, which were used to make soap.

Sour and Slippery?

To which category would yogurt belong?



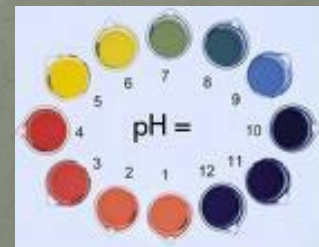
The 13th Century

- Alchemists would mix nitric acid with hydrochloric acid to make *aqua regia*, which is the only substance known to dissolve gold.



The Middle Ages

- Alchemists discovered the properties of acids and bases by reacting them with various substances and with each other.
- They discovered that acids and bases were opposites of each other and that the acidic power of an acid is reduced when an alkali is added.
- Robert Boyle discovered that several plant extracts change color in the presence of acid or alkali. This later gave rise to the use of indicators.



The 18th Century: Lavoisier

- Antoine Laurent Lavoisier (1743-1796) used to perform chemistry shows for the wealthy *noblesse* in Paris, making an extra buck or two.
- By 1776, he had come up with the idea that a certain compound, element, or essence in the acid would be responsible for its acidity. For that reason he called the substance oxy-gene, or 'oxygen' as we know it today. (The Greek “oxys” for sour and “genes” for born).

(He thought it was oxygen since burning substances such as coal, phosphorus and sulfur produced oxides that were acidic when dissolved in water).

The 18th Century: Davy and Priestly

- The British scientist Humphry Davy (1778-1829), who among other things discovered the medicinal uses of nitrous oxide (laughing-gas) by self-experimentations, continued these investigations; and by 1810, he found out that the oxygen was not responsible for the acidity, since certain acids would be acid without containing any oxygen (e.g., HCl).
- Davy thus proposed that hydrogen gives a compound acidic qualities. Around the same time, Joseph Priestly made this same discovery.

The 18th Century: Liebig

- In Munich, by the 1840s, Justus Freiherr von Liebig (1803-1873), one of the big chemistry hot-shots in Germany and the founder of agro-chemistry, enhanced Davy's theory by suggesting that acids contain hydrogen atoms that can be replaced by metals to form salt.
- This was the accepted theory for more than 50 years when Svante Arrhenius came along...



Svante Arrhenius

- Svante August Arrhenius (1859-1927) was a misunderstood genius who was way ahead of his time. He had the insolence to propose in his doctoral thesis that acids, bases and salts split into positive and negative ions when dissolved in water. In 1884, this constituted an act of scientific heresy. He was scornfully awarded a fourth class degree, and was obviously left feeling very hurt. Years later, in 1903, he was proven right: he got his revenge and the Nobel Prize.



Svante Arrhenius

- According to Arrhenius, the definition of acids and bases went like this:
- *Acids are substances delivering hydrogen cations (positively charged hydrogen, often simply called proton or abbreviated H^+) to the solution (water).*
Example: $HCl \rightarrow H^+ + Cl^-$
- Bases are substances delivering hydroxyl anions (OH^-) to the solution (water). Example: $NaOH \rightarrow Na^+ + OH^-$
- Acids and bases react in a neutralisation reaction to form water (where H^+ reacts with OH^- to form H_2O) and the corresponding salt (NaCl from NaOH and HCl).

Brønsted and Lowry

- Inspired by the work of Arrhenius, a Danish fellow named Johannes Nicolaus Brønsted and, independently, an Englishman by the name of Thomas Martin Lowry extended the acid-base theory (1923). (They realized that the Arrhenius model did not account for covalent compounds that behave as acids and bases).
- Acids are substances from which a proton (H^+) can be removed. Bases are substances that bind protons.



Brønsted and Lowry

- According to this theory any compound capable of binding a proton is a base. So, all components can be seen as bases, since virtually anything can bind protons.
- The question is, what binds the proton more strongly?
- Being a base or an acid will depend on what you are comparing it to. If the referring system is water (as it usually is), then anything binding protons stronger than water is a base and anything binding protons weaker than water will be an acid. This is roughly how acids and bases are categorized.
- Brønsted introduced the concept of the conjugate acid-base pair.

Gilbert Newton Lewis: The Modern Theory of Acids and Bases

- For a long time the referring system was water. Substances giving protons (*protonating*) to water are acids; substances water *protonates* are bases.
- An extension to this theory was brewed up by the American chemist, Gilbert Newton Lewis (1875-1946), where the 'donation' is no longer tied to water. The 'donation' is in fact not even restricted to protons. According to Lewis, the crucial things being 'donated' and 'removed' are charges.

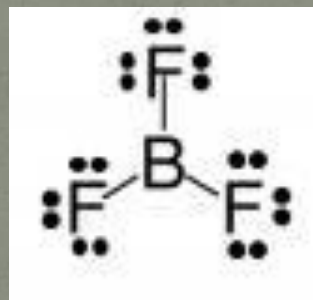
Gilbert Newton Lewis:

The Modern Theory of Acids and Bases

- In the Lewis model, an acid is any substance that has an incomplete valence electron shell and a base is any substance that has an unbonded or free electron pair.

Example: BF_3

A Lewis Acid



This does not change the whole Brønsted concept, but widens the acid-base concept immensely.

The End

