**ACIDS and BASES - Introduction**

When you think of acids, "sour" is likely to come to mind. For the ancient Greeks, "sour-tasting" is in fact what defined a category of substances which later became known as acids. Bases were first categorized by their uses in soaps, as well as their ability to counteract properties of acids.

| **Acids** | **Bases** |
| --- | --- |
| conduct electricity in solution | conduct electricity in solution |
| turn blue litmus paper red | turn red litmus paper blue |
| have a sour taste | have a slippery feeling |
| react with bases to create a neutral solution | react with acids to create a neutral solution |
| react with active metals to produce hydrogen gas |  |

**Properties of Acids and Bases**

Acids and bases are versatile and useful materials in many chemical reactions. Some properties that are common to aqueous solutions of acids and bases are listed in the table [below](https://www.ck12.org/book/CK-12-Chemistry-Basic/section/21.1/#x-ck12-dGFibGU6MjEuMQ..).

**Defining Acids and Bases**

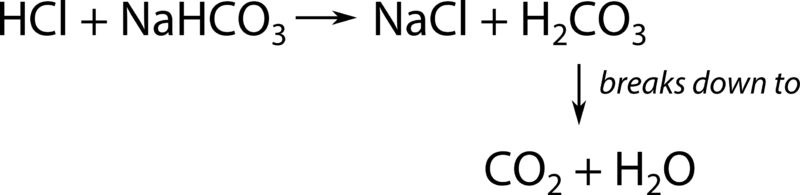
An early way of classifying acids and bases was proposed by Svante Arrhenius, a Swedish chemist, in 1894. An **Arrhenius acid** is any compound that releases H+ ions when dissolved in water. An **Arrhenius base** is a compound that generates hydroxide ions (OH-) when dissolved in water. Some representative examples are given in the table below.

| **Acids** | **Bases** |
| --- | --- |
| hydrochloric acid: HCl → H+ + Cl- | sodium hydroxide: NaOH → Na+ + OH- |
| nitric acid: HNO3 → H+ + NO3- | potassium hydroxide: KOH → K+ + OH- |
| hydrobromic acid: HBr → H+ + Br- | calcium hydroxide: Ca(OH)2 → Ca2+ + 2 OH- |

Many strong acids and bases can be identified based on the Arrhenius model. However, there are many compounds that share a number of common characteristics with acids and bases but do not fit the Arrhenius definitions.

In the early 1920s, the Danish scientist Johannes Brønsted and the English researcher Thomas Lowry each published ideas that expanded the Arrhenius concept. According to this newer definition, a **Brønsted-Lowry acid** is any compound that can donate a proton (an H+ion) to an appropriate acceptor. A **Brønsted-Lowry base** is a compound that can remove (or accept) a proton from a Brønsted-Lowry acid.

So, according to the Brønsted-Lowry definition, acids and bases are proton donors and proton acceptors respectively. We will be using the Brønsted-Lowry model of acids and bases for the remainder of this topic

Overall, the Brønsted-Lowry model suggested that any acid-base reaction could be reduced to the transfer of a proton from an acid to a base. For example, the reaction between hydrochloric acid (HCl) and sodium bicarbonate (NaHCO3) involves the transfer of an H+ ion from the acid (HCl) to the base (the bicarbonate ion).

**Monoprotic and Polyprotic Acids**

Acids can further be categorized based on how many hydrogen protons they contain. A **monoprotic acid** has only one hydrogen proton that would be transferred to a strong base, whereas a **polyprotic acid** has two or more. Common monoprotic acids include HCl, HBr, and HNO3. A common diprotic acid is sulfuric acid (H2SO4), and phosphoric acid (H3PO4) provides an example of a triprotic acid. In each case, all hydrogens are available to participate in acid-base reactions. However, that is not the case for all acidic molecules. For example, in acetic acid (CH3COOH), only the hydrogen bonded to the oxygen atom is acidic. The other three hydrogens are covalently bonded to carbon and cannot be removed by any of the bases that we will consider in this chapter.

| **Name** | **Structure** |  | **Name** | **Structure** |
| --- | --- | --- | --- | --- |
| hydrobromic acid | HBr | carbonic acid | H2CO3 |
| hydrochloric acid | HCl | sulfuric acid | H2SO4 |
| hydrofluoric acid | HF | sulfurous acid | H2SO3 |
| hydroiodic acid | HI |  | |
| nitric acid | HNO3 |
| perchloric acid | HClO4 | **Name** | **Structure** |
| acetic acid | CH3COOH |  | phosphoric acid | H3PO4 |

**Lesson Review Questions**

1. List three characteristics exhibited by acids and three exhibited by bases.
2. Based on Brønsted-Lowry definitions, how can you tell the difference between an acidic substance and a basic substance?
3. What definition is most widely applicable in defining acids and bases?
4. Describe the difference between a monoprotic acid and a polyprotic acid.
5. The formula for propanoic acid is CH3CH2COOH. Is this acid monoprotic or polyprotic? Explain your answer.

**QUESTIONS**

1. All of the following are properties of acids except
   1. sour taste
   2. aqueous solutions are electrolytes
   3. turn litmus blue
   4. react with some metals to produce H2
2. All of the following are properties of bases except
   1. turn litmus red
   2. bitter taste
   3. do not react with metals
   4. aqueous solutions are electrolytes
3. True/False: All acids are strong electrolytes.
4. Fill in the table below

| **Property** | **Acids** | **Bases** |
| --- | --- | --- |
| color with phenolphthalein |  |  |
| color with litmus |  |  |
| taste |  |  |
| reactivity with metals |  |  |

1. An Arrhenius acid is a compound with
   1. reactive hydrogen atoms
   2. ionizable hydrogen atoms
   3. covalently bound hydrogen atoms
   4. hydrogen atoms attached to carbon
2. An Arrhenius base is a compound with
   1. ionizable OH group
   2. covalently bound OH group
   3. reactive OH group
   4. OH group attached to carbon
3. Define the following terms:
   1. monoprotic acid
   2. polyprotic acid
4. A hydrogen ion is often referred to as a
   1. positron
   2. H atom
   3. proton
   4. portion
5. All of the following are true about ammonia (NH3 – a base) except
   1. contains hydroxide group
   2. reacts with acid
   3. turns litmus blue
   4. turns phenolphthalein pink
6. A Brønsted-Lowry acid-base reaction involves
   1. formation of hydroxide ion
   2. transfer and acceptance of a proton
   3. utilization of water
   4. formation of free hydrogen ion
7. True/False: A hydrogen atom is also called a proton.
8. True/False: Water can act as a Brønsted-Lowry acid.
9. True/False: The hydroxide ion is a Brønsted-Lowry acid.