## Section 2
# Acids and Bases

**Key Concept** You can use the characteristics of a solution to determine if it is acidic or basic.

### What You Will Learn
- An acidic solution has an increased number of hydronium ions. A basic solution has an increased number of hydroxide ions.
- Acids are sour, react with many metals, conduct electric current, and change the color of indicators.
- Bases are bitter, feel slippery, conduct electric current, and change the color of indicators.

### Why It Matters
Acids and bases are present in food and numerous products used in the home.

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Lemons contain a substance called an *acid*. One property of acids is a sour taste. In this section, you will learn about the properties of acids and bases.

### Acids and Their Properties
A sour taste is not the only property of an acid. Have you noticed that when you squeeze lemon juice into tea, the color of the tea becomes lighter? This change happens because acids cause some substances to change color. An **acid** is any compound that increases the number of hydronium ions, $H_3O^+$, when dissolved in water. Hydronium ions form when a hydrogen ion, $H^+$, separates from the acid and bonds with a water molecule, $H_2O$, to form a hydronium ion, $H_3O^+$.

**Standards Check** How is a hydronium ion formed?

### Acids Have a Sour Flavor
The boy in **Figure 1** has discovered that acids taste sour. The taste of lemons, limes, and other citrus fruits is a result of citric acid. However, taste, touch, or smell should NEVER be used to identify an unknown chemical. Many acids are *corrosive,* which means that they destroy body tissue, clothing, and many other things. Most acids are also poisonous.

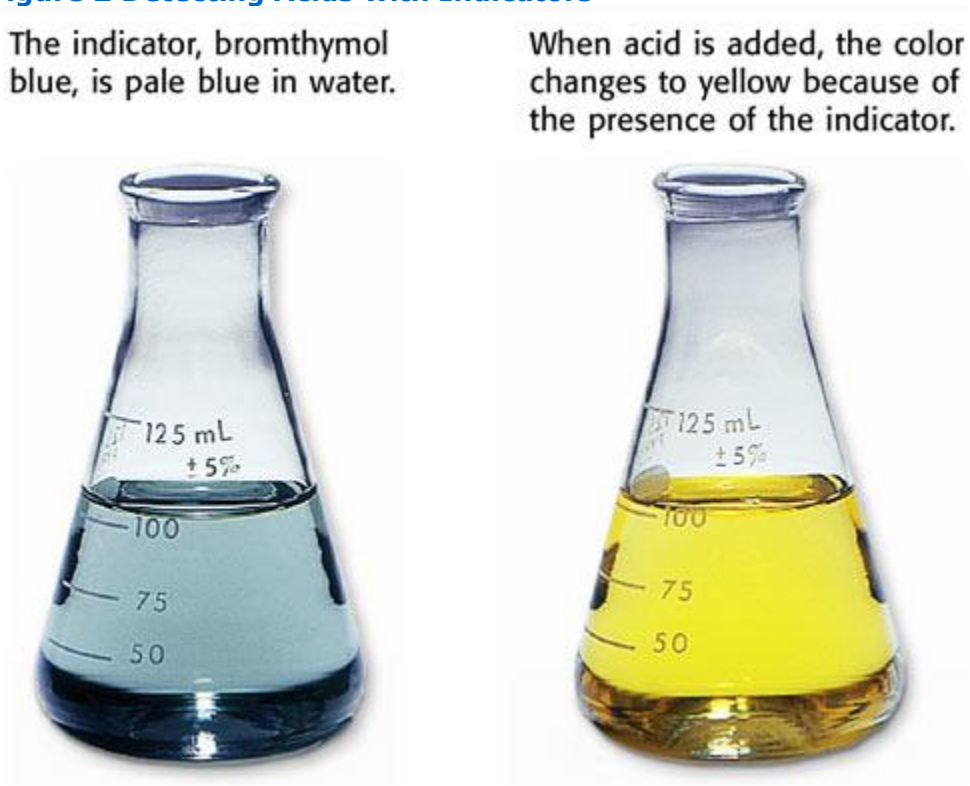

**Figure 1** Foods that have a sour taste usually contain acids.

## Acids Change Colors of Indicators

A substance that changes color in the presence of an acid or base is an

**indicator.** Both flasks shown in **Figure 2** have an indicator called *bromthymol blue* (BROHM THIE MAWL BLOO) in them. The flask on the left contains water and the indicator. Acid has been added to the flask on the right. The color changes from pale blue to yellow because the indicator detects the presence of an acid.

### Figure 2 Detecting Acids with Indicators




Another indicator commonly used in the lab is litmus. Paper strips containing litmus are available in both blue and red. When an acid is added to blue litmus paper, the color of the litmus changes to red.

### Acids React with Metals

Acids react with some metals to make hydrogen gas. For example, hydrogen gas is made when hydrochloric acid reacts with zinc metal, as shown in **Figure 3.** The equation for the reaction is shown below:

$$2HCl + Zn \longrightarrow H_2 + ZnCl_2$$

**Figure 3** Bubbles of hydrogen gas form when zinc metal reacts with hydrochloric acid. **What other substance is produced by this reaction?**

In this reaction, zinc takes the place of hydrogen in hydrochloric acid. This reaction happens because zinc is an active metal. But if the element silver were put into hydrochloric acid, nothing would happen. Silver is not an active metal, which means it is less reactive. So, it will not take the place of the hydrogen, and no reaction will take place.

## Acids Conduct Electric Current

When acids dissolve in water, they break apart and form ions in the solution. The ions make it possible for the solution to conduct an electric current. A car battery is one example of how an acid can be used to produce an electric current. The sulfuric acid in the battery conducts an electric current to help start the car's engine.

## Uses of Acids

Acids are used in many fields of industry and in homes. Sulfuric acid is the most widely made chemical in the world. It is used to make many products, including paper, paint, detergents, and fertilizers. Nitric acid is used to make fertilizers, rubber, and plastics. Hydrochloric acid is used to separate metals from the other materials in their ores. It is also used in swimming pools to help keep them free of algae. Hydrochloric acid even aids in digestion in your stomach. Hydrofluoric acid is used to etch glass, as shown in **Figure 4.** Citric acid and ascorbic acid (vitamin C) are found in orange juice. Acetic (uh SEET ik) acid is the main ingredient in vinegar. And carbonic acid and phosphoric acid help give a sharp taste to soft drinks.

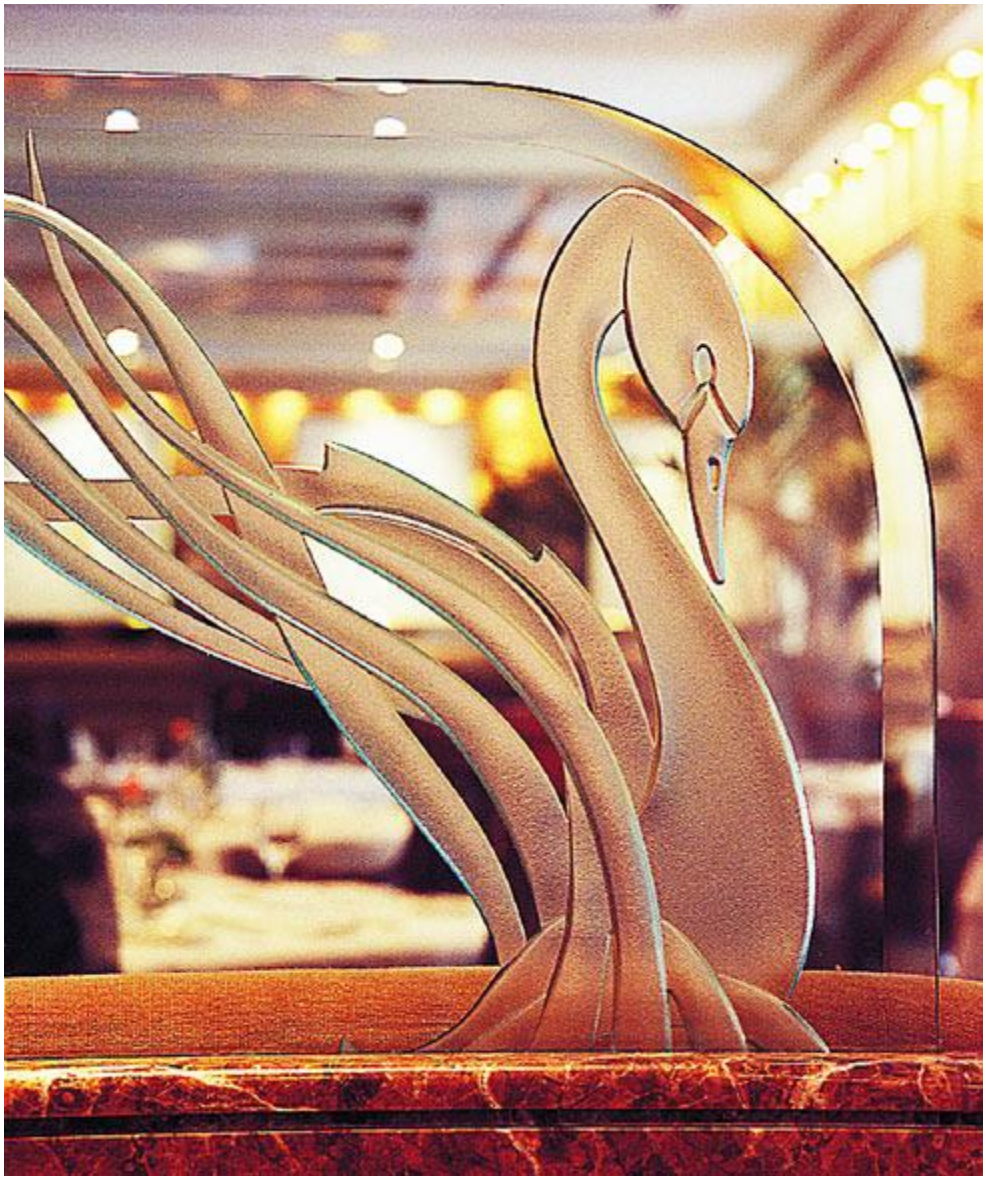


**Figure 4** Hydrofluoric acid was used to etch the image of a swan into this glass.

**Standards Check** What are three uses of acids?

## Bases and Their Properties

A **base** is any compound that increases the number of hydroxide ions, $OH^-$, when dissolved in water. For example, sodium hydroxide breaks apart to form sodium ions and hydroxide ions, as shown below.

$$NaOH \rightarrow Na^+ + OH^-$$

So, a sodium hydroxide solution will have more hydroxide ions than hydronium ions.

Hydroxide ions give bases their properties. **Figure 5** shows examples of how bases are used in everyday life.

**Figure 5 Examples of Bases**

**Soaps** are made by using sodium hydroxide, which is a base. Soaps remove dirt and oils from skin and feel slippery when you touch them.

**Baking soda** is a very mild base. It is used in toothpastes and mouthwashes to neutralize acids, which can produce unpleasant odors.

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### Bases Have a Bitter Flavor and a Slippery Feel

The properties of a base solution include a bitter taste and a slippery feel. If you have ever accidentally tasted soap, you know the bitter taste of a base. Soap will also have

the slippery feel of a base. However, taste, touch, or smell should NEVER be used to identify an unknown chemical. Like acids, many bases are corrosive. If your fingers feel slippery when you are using a base in an experiment, you may have gotten the base on your hands. You should quickly rinse your hands with large amounts of water and tell your teacher.

Standards Check What gives bases their properties?

## Bases Change Colors of Indicators

Like acids, bases change the color of an indicator. Bases turn most indicators a different color than acids do. For example, bases change the color of red litmus paper to blue. And the indicator, bromthymol blue, turns a darker blue when a base is added to it, as shown in **Figure 6.**

**Figure 6 Detecting Bases with Indicators**

The indicator, bromthymol blue, is pale blue in water.


When a base is added to the indicator, the indicator turns dark blue.


## Bases Conduct Electric Current

Solutions of bases conduct an electric current because bases increase the number of hydroxide ions, $OH^-$, in a solution. A hydroxide ion is actually a hydrogen atom and an oxygen atom bonded together. An extra electron gives the hydroxide ion a negative charge.

## Uses of Bases

Like acids, bases have many uses. Sodium hydroxide is a base used to make soap and paper. It is also used in oven cleaners and in products that unclog drains. Calcium hydroxide, $Ca(OH)_2$, is used to make cement and plaster. Ammonia is found in many household cleaners and is used to make fertilizers. And magnesium hydroxide and aluminum hydroxide are used in antacids to treat heartburn. **Figure 7** shows some of the many products that contain bases. Carefully follow the safety

instructions when using these products. Remember that bases can harm your skin.


**Figure 7** Bases are common around the house. They are useful as cleaning agents, cooking aids, and medicines.

**Standards Check** What happens to bromthymol blue when an antacid is added?

## Section Summary

- An acid is a compound that increases the number of hydronium ions in solution.
- Acids taste sour, turn blue litmus paper red, react with metals to produce hydrogen gas, and may conduct an electric current when in solution.
- Acids are used for industrial purposes and in household products.
- A base is a compound that increases the number of hydroxide ions in solution.
- Bases taste bitter, feel slippery, and turn red litmus paper blue. Most solutions of bases conduct an electric current.
- Bases are used in cleaning products and antacids.