Section 3
Solutions of Acids and Bases

Key Concept The pH of a solution is a measurement of the hydronium concentration and is used to tell how acidic or basic a solution is.

What You Will Learn

- Every molecule of a strong acid or a strong base produces ions in solution. Only a few molecules of a weak acid or a weak base form ions.
- When an acid reacts with a base, a salt forms.
- The pH scale is used to determine if a solution is acidic, basic, or neutral.
- Indicators and pH meters can measure pH.

Why It Matters

You can quickly learn how acidic or basic a solution is by measuring the pH.

If you have ever had an upset stomach, you may have felt very much like the boy in **Figure 1.** And you may have taken an antacid. But do you know how antacids work? An antacid is a weak base that neutralizes a strong acid in your stomach. In this section, you will learn about the strengths of acids and bases. You will also learn about reactions between acids and bases.

Figure 1 Antacids may help relieve your stomachache by reacting with the acid in your stomach.

Strengths of Acids and Bases

Acids and bases can be strong or weak. The strength of an acid or a base is not the same as the concentration of an acid or a base. The concentration of an acid or a base is the amount of acid or base dissolved in water. But the strength of an acid or a base depends on the number of molecules that break apart when the acid or the base is dissolved in water.

Strong Versus Weak Acids

As an acid dissolves in water, the acid's molecules break apart and form hydrogen ions, H^+. In water, all of the molecules of a *strong acid* break apart. Sulfuric acid, nitric acid, and hydrochloric acid are all strong acids. In water, only a few molecules of a weak acid break apart. There are only a few hydronium ions in a solution of a weak acid. Acetic acid, citric acid, and carbonic acid are all weak acids.

Standards Check What is the difference between a strong acid and a weak acid?

Strong Versus Weak Bases

When all molecules of a base break apart in water to form hydroxide ions, OH^-, the base is a strong base. Sodium hydroxide, calcium hydroxide, and potassium hydroxide are strong bases. When only a few molecules of a base break apart, the base is a weak base. Two weak bases are ammonium hydroxide and aluminum hydroxide.

Acids, Bases, and Neutralization

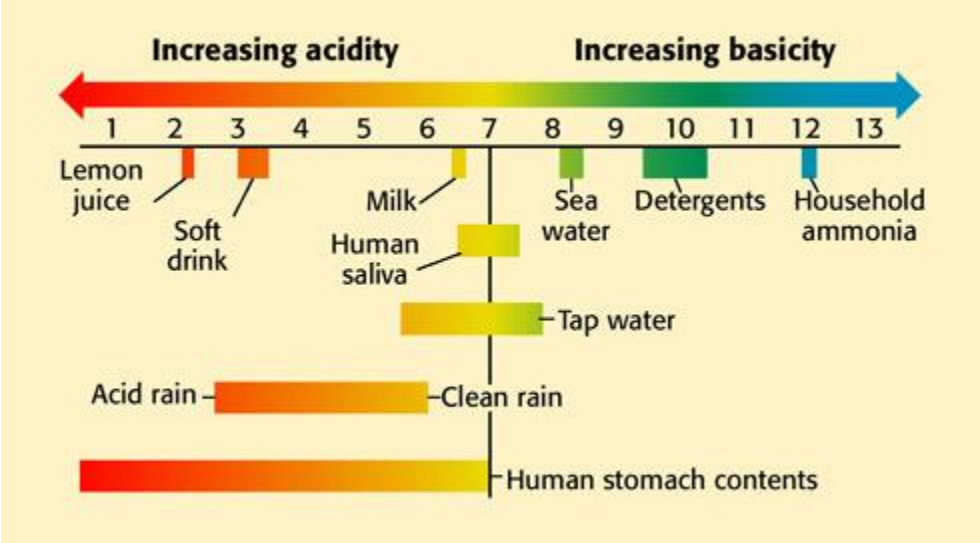
The base in an antacid reacts with stomach acid. The reaction between acids and bases is a **neutralization reaction.** Water, H_2O, is formed

when the hydrogen ions (H^+) from the acid react with the hydroxide ions (OH^-) from the base. Because water is neutral, acids and bases neutralize one another. The other ions from the acid and the base dissolve in the water. If the water evaporates, these ions join to form a compound called a *salt*.

The pH Scale

An indicator, such as litmus, can identify whether a solution contains an acid or a base. To describe how acidic or basic a solution is, scientists use the pH scale. The **pH** of a solution is a measure of the hydronium ion concentration in the solution. A solution that has a pH of 7 is neutral. A neutral solution is neither acidic nor basic. Pure water has a pH of 7. Basic solutions have a pH greater than 7. Acidic solutions have a pH less than 7. **Figure 2** shows the pH values for many common materials. Notice that the pH values decrease as the acidity increases. But the pH values increase as the basicity increases.

Figure 2 pH Values of Common Materials

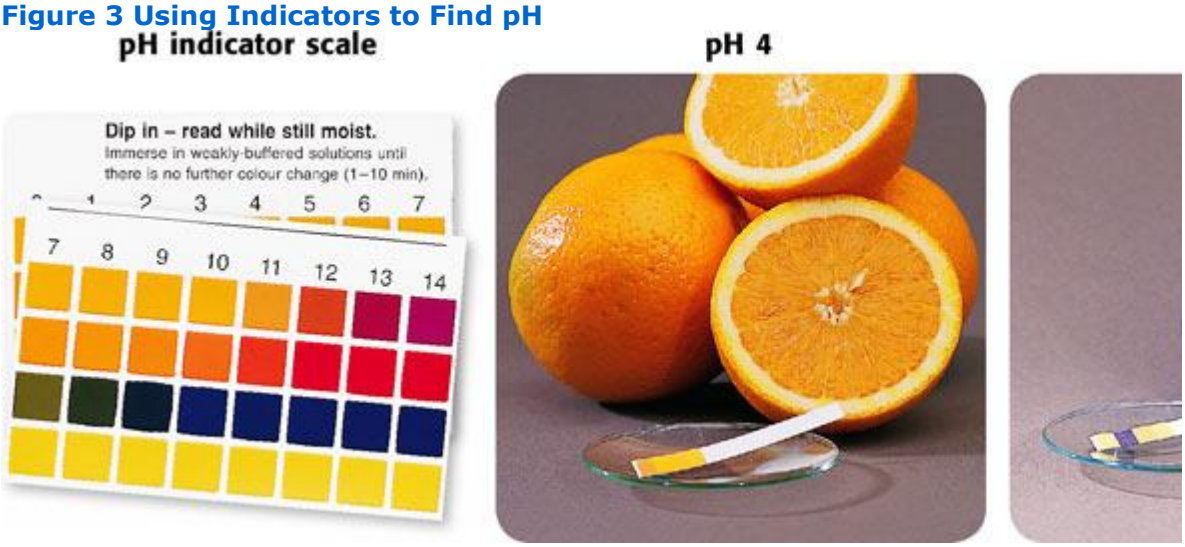


Using Indicators to Determine pH

A combination of indicators can be used to find out how basic or how acidic a solution is. This can be done if the colors of the indicators are known at different pH values.

Figure 3 shows strips of pH paper, which contains several different indicators. These strips were dipped into two different solutions. The pH of each solution is found by comparing the colors on each strip with the colors on the indicator scale provided. This kind of indicator is often used to test the pH of water in pools. Another way to find the pH of a solution is to use an electronic instrument known as a pH meter. These meters can detect and measure hydronium ion concentration directly in solution.

Figure 3 Using Indicators to Find pH



Standards Check How can indicators determine pH?

pH and the Environment

Living things depend on having a steady pH in their environment. Some plants, such as pine trees, prefer acidic soil that has a pH between 4 and 6. Other plants, such as lettuce, need basic soil that has a pH between 8 and 9. Plants may also have different traits under different growing conditions. For example, hydrangea flowers have a natural indicator. The color of the flowers varies when they are grown in soils that have different pH values, as shown in **Figure 4.** Many organisms living in lakes and streams need a neutral pH to survive.

Figure 4 To grow blue flowers, plant hydrangeas in soil that has a low pH. To grow pink flowers, use soil that has a high pH.

Most rain is slightly acidic and has a pH between 5.5 and 6. However, acids are formed when rainwater reacts with compounds found in polluted air. So, the rainwater's pH decreases. In the United States, most acid rain has a pH between 4 and 4.5, but some precipitation has a pH as low as 3.

Salts

When an acid neutralizes a base, a salt and water are produced. A **salt** is an ionic compound formed from the positive ion of a base and the negative ion of an acid. When you hear the word *salt,* you probably think of the table salt you use to season your food. But the sodium chloride found in your salt shaker is only one example of a large group of compounds called *salts*.

Uses of Salts

Salts have many uses in industry and in homes. You already know that sodium chloride is used to season foods. It is also used to make other compounds, including lye (sodium hydroxide) and baking soda. Sodium nitrate is a salt that is used to preserve

food. And calcium sulfate is used to make wallboard, which is used in construction. Another use of salt is shown in **Figure 5.**

Figure 5 Salts help keep roads free of ice by decreasing the freezing point of water.

Section Summary

- Every molecule of a strong acid or base breaks apart to form ions. Few molecules of weak acids and bases break apart to form ions.
- An acid and a base can neutralize one another to make salt and water.
- pH is a measure of hydronium ion concentration in a solution.
- A salt is an ionic compound formed when an acid reacts with a base.

Chapter Summary

The Big Idea

Chemical compounds are classified into groups based on their bonds and on their properties.

Section 1
Ionic and Covalent Compounds

Key Concept The properties of ionic compounds are different from the properties of covalent compounds.

- The physical properties of a compound are determined by the type of bonding in the compound.
- Ionic compounds tend to be brittle, have high melting points, dissolve in water, and often conduct electric current in solution.
- Many covalent compounds tend to be insoluble in water, have low melting points, are not water soluble, and often do not conduct electric current in solution.

The shape of a crystal is determined by the specific pattern in which the ions combine.

Section 2
Acids and Bases

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

- 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.

Indicators change color in an acidic solution or in a basic solution.

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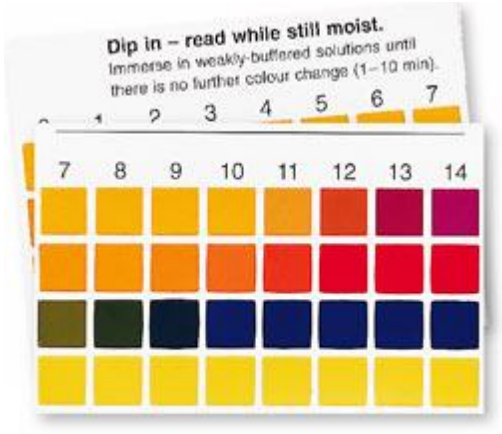

A pH indicator scale can be used to find the pH of a solution.