chapter 24 Solutions, Acids, and Bases

section 3 Acids, Bases, and Salts

What You'll Learn

- to compare acids and bases
- to recognize common acids and bases
- how acids and bases ionize and dissociate

Before You Read

Think of a food or drink you like that tastes sour. What do you think gives it a sour taste?

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_____

Mark the Text

Underline As you read, underline any words or sentences you think might be important to remember. When you finish reading, look back at what you underlined to make sure you understand it.

FOLDABLES

Compare and Contrast Make the following Foldable to help you understand acids and bases.

Describe	Properties	Common Examples
Acids		
Bases		

Read to Learn

Acids

What do you think about when you hear the word *acid?* Do you think of a substance that can burn your skin or put a hole in metal? Many sour foods contain acids. Some acids are dangerous, others are safe, and some are good to eat.

What are the properties of acids?

When an acid dissolves in water, some of the hydrogen atoms in the acid are released as hydrogen ions, H^+. An **acid** is a substance that produces hydrogen ions, H^+, in a water solution. The ability to produce H^+ ions gives acids their common properties. When an acid dissolves in water, the H^+ ions join with water molecules to form hydronium ions. A hydronium ion (hi DROH nee um • I ahn), H_3O^+, is a combination of an H^+ ion and a water molecule.

Acids have some common properties. All acids taste sour. The familiar, sour taste of many foods, such as tomatoes and oranges, is due to acids. However, you should never taste an unknown substance to see if it is acidic. Some acids can cause painful burns to skin.

Acids are corrosive, which means they eat away some metals. When an acid reacts with a metal, hydrogen gas is released and metallic compounds form. Acids also cause indicators to change color. An **indicator** is an organic compound that changes color in an acid or a base. Litmus paper is an indicator that turns red in acid.

What are some common acids?

Many foods contain acids. Citrus fruits contain citric acid. Lactic acid is found in yogurt and buttermilk. Pickled foods contain vinegar, also known as acetic acid. Your stomach uses acid to help digest food. At least four acids (sulfuric, phosphoric, nitric, and hydrochloric) play roles in industrial applications.

Some common acids and their uses are listed in the table below. Many of these acids are important in making products such as fertilizer. Remember that many acids can burn your skin.

Common Acids and Their Uses

Name, Formula	Use	Other Information
Acetic acid, CH_3COOH	Food preservation and preparation	When in solution with water, it is known as vinegar.
Acetylsalicylic acid, $HOOC-C_6H_4-OOCCH_3$	Pain relief, fever relief, to reduce inflammation	Known as aspirin
Ascorbic acid, $H_2C_6H_6O_6$	Antioxidant, vitamin	Called vitamin C
Carbonic acid, H_2CO_3	Carbonated drinks	Involved in cave, stalactite, and stalagmite formation and acid rain
Hydrochloric acid, HCl	Digestion as gastric juice in stomach, to clean steel in a process called pickling	Commonly called muriatic acid
Nitric acid, HNO_3	To make fertilizers	Colorless, yet yellows when exposed to light
Phosphoric acid, H_3PO_4	To make detergents, fertilizers and soft drinks	Slightly sour but pleasant taste, detergents containing phosphates cause water pollution
Sulfuric acid, H_2SO_4	Car batteries, to manufacture fertilizers and other chemicals	Dehydrating agent, causes burns by removing water from cells

Picture This

1. **Identify** Look at the acids listed in the table. What is the first element in the chemical formula of most acids?

Bases

Bases can be defined in two ways. A **base** is any substance that forms hydroxide ions, OH^-, in a water solution. A base is also any substance that accepts H^+ ions from acids. ☑

Unlike acids, not many foods are bases. Egg whites and baking powder are two foods that are basic. Some medicines, such as antacids, are basic. A common base is soap. A characteristic of bases is that they feel slippery, like soapy water. Many cleaning products contain bases. Bases are important in industry, also. For example, sodium hydroxide is a base that is used in the paper industry. It separates cellulose fibers from wood pulp. Then the cellulose fibers are used to make paper.

Reading Check

2. **Define** What is the term for a substance that can form hydroxide ions or accept hydrogren ions?

What are the properties of bases?

Bases are considered the opposites of acids. While bases and acids do share some features, bases also have their own properties. When they are not dissolved in water, many bases are solids in the form of crystals. In solution, bases feel slippery and taste bitter. Like strong acids, strong bases are corrosive. Bases can burn your skin. Never taste or touch a substance to see if it is basic. Bases also cause indicators to change color. Litmus paper is an indicator that turns blue in bases.

What are some common bases?

The table below lists some common bases and their uses. You may have used many common bases found in cleaning products and not even known it.

Common Bases and Their Uses

Name, Formula	Use	Other Information
Aluminum hydroxide, $Al(OH)_3$	Color-fast fabrics, antacid, water purification	Sticky gel that collects suspended clay and dirt particles on its surface
Calcium hydroxide, $Ca(OH)_2$	Leather-making, mortar and plaster, lessen acidity of soil	Called caustic lime
Magnesium hydroxide, $Mg(OH)_2$	Laxative, antacid	Called milk of magnesia when in water
Sodium hydroxide, NaOH	To make soap, oven cleaner, drain cleaner, textiles, and paper	Called lye and caustic soda; generates heat (exothermic) when combined with water, reacts with metals to form hydrogen
Ammonia, NH_3	Cleaners, fertilizer, to make rayon and nylon	Irritating odor that is damaging to nasal passages and lungs

Picture This

3. **Identify** Look at the bases listed in the table. What atoms do most of the bases have in their chemical formulas?

_____

_____

Solutions of Acids and Bases

Many food products and cleaning products that contain acids and bases are solutions. Water is the main solvent for these solutions because water molecules have polarity. ☑

Reading Check

4. **Explain** Why is water the main solvent for acidic and basic solutions?

_____

_____

What happens when acids dissolve in water?

Remember that an acid produces hydrogen ions (H^+) in water. When an acid dissolves in water, the negative ends of nearby water molecules attract the positive hydrogen in the acid. The acid separates into ions, which is called dissociation. After dissociation, there are negative ions and positive H^+ ions. The H^+ ions join with water molecules to form hydronium ions (H_3O^+). So, an acid gives off hydronium ions when it dissolves in water. The figures on the next page shows hydrogen chloride (HCl) splitting into hydronium and chloride ions.

Hydrochloric Acid in Water

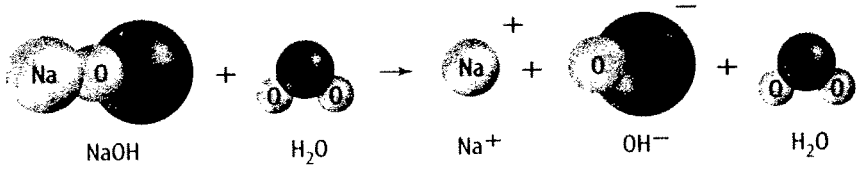
$$HCl + H_2O \rightarrow H_3O^+ + Cl^-$$

What happens when bases dissolve in water?

Bases form hydroxide ions (OH^-) in water. In the table of bases on the previous page, you may have noticed that most bases have "OH" in their formulas. When bases dissolve in water, the positive ends of nearby water molecules attract the OH^- ions in the base. The base dissociates. After dissociation, there are positive ions and negative OH^- ions. Unlike acid dissociation, the OH^- ions do not combine with water molecules. The figure shows the dissociation of sodium hydroxide (NaOH).

Sodium Hydroxide in Water

$$NaOH + H_2O \rightarrow Na^+ + OH^- + H_2O$$



Neutralization

Neutralization is a chemical reaction between an acid and a base that happens in a water solution. The products of the reaction are not acids or bases. One of the products is always water. For instance, the base sodium hydroxide, NaOH, neutralizes hydrochloric acid, HCl. Hydronium ions from the acid combine with hydroxide ions from the base. The product is neutral water.

$$H_3O^+(aq) + OH^- \rightarrow 2H_2O(l)$$

Antacids are popular medicines. They contain bases or other compounds that neutralize the acids in your stomach. One of these popular antacids is sodium bicarbonate, $NaHCO_3$.

Picture This

5. **Identify** When HCl dissociates, what ions does it produce?

_____

Think it Over

6. **Determine** Why is water always the product of neutralization?

_____

_____

_____

How do acid-base reaction equations look?

A general equation shows acid-base reactions in water.

$$\text{acid} + \text{base} = \text{salt} + \text{water}$$

The complete equation for the reaction between HCl and NaOH is this.

$$HCl(aq) + NaOH(aq) + NaCl(aq) + H_2O(l)$$

How is salt formed?

As shown in the equation above, NaOH is neutralizing HCl. But only half of the ions are shown in the equation. The other ions react to form a salt. A salt is a compound formed when the negative ions from an acid combine with the positive ions from a base. When HCl reacts with NaOH, the salt formed is sodium chloride.

$$Na^+(aq) + Cl^-(aq) \rightarrow NaCl(aq)$$

How is ammonia unlike other bases?

Ammonia, NH_3, is a base that does not contain OH^-. In water, ammonia actually splits water molecules. An ammonia molecule attracts a hydrogen ion from a water molecule to form an ammonium ion, NH_4^+. The water molecule is now a hydroxide ion, OH^-.

Ammonia is found in many household cleaners. Never use products containing ammonia with other cleaners that contain chlorine (often sodium hypochlorite). Cleaners with chlorine include bathroom bowl cleaners and bleach. Ammonia reacts with the chlorine and gives off toxic gases. The gases can severely damage lungs and cause death.

Some Common Salts and Their Uses

Name, Formula	Common Name	Uses
Sodium chloride, NaCl	Salt	Food, manufacture of chemicals
Sodium hydrogen carbonate, $NaHCO_3$	Sodium bicarbonate Baking soda	Food, antacids
Potassium nitrate, KNO_3	Saltpeter	Fertilizers
Ammonium chloride, NH_4Cl	Sal ammoniac	Dry-cell batteries

Picture This

7. **Circle** the salts that are used in foods.

● After You Read

Mini Glossary

acid: a substance that produces hydrogen ions, H^+, in a water solution

base: any substance that forms hydroxide ions, OH^-, in a water solution or a substance that accepts H^+ ions from acids

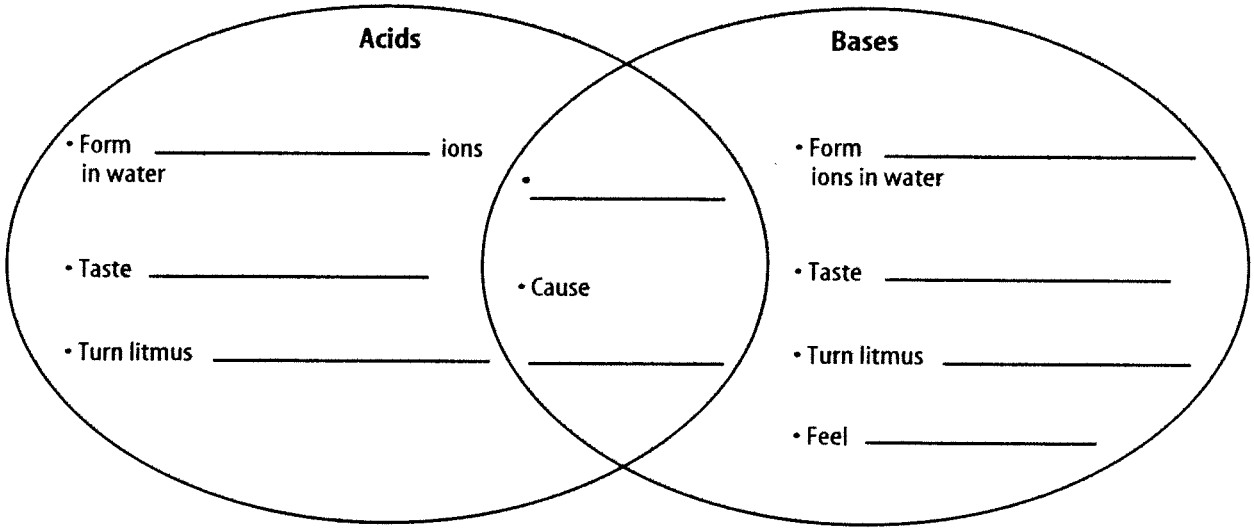
indicator: an organic compound that changes color in an acid or a base

1. Review the terms and their definitions in the Mini Glossary. Write a sentence using the term for the substance that makes many foods taste sour.

_____

_____

2. Fill in the Venn diagram with properties of acids and bases. Be sure to put any properties that acids and bases have in common in the part where the ovals overlap.



3. You underlined words and sentences in this section that you thought would be important to remember. How did this help you learn about the topics in the section?

_____

_____

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End of Section

chapter 24

Solutions, Acids, and Bases

section 4 Strength of Acids and Bases

What You'll Learn

- what makes acids and bases strong or weak
- to compare strength and concentration
- about pH and acid or base strength

Before You Read

Describe the difference between a food that is very sour and a food that is just a little sour.

_____

_____

Study Coach

Identify the Main Point

Write down the main point of each paragraph as you read this section. After you read, look over the main points to make sure you understand them.

Read to Learn

Strong and Weak Acids and Bases

Some acids, such as the sulfuric acid in car batteries, can burn your skin. Some acids are stronger than others. The strength of an acid or a base depends on how many acid molecules dissociate into ions in water. A **strong acid** is one in which almost all the acid molecules dissociate in water.

Hydrochloric acid (HCl), nitric acid (HNO_3), and sulfuric acid (H_2SO_4), are examples of strong acids. A **weak acid** is one in which only a small number of the acid molecules dissociate in water. Acetic acid (CH_3COOH) and carbonic acid (H_2CO_3) are weak acids.

Ions in solution can conduct electric current. Acids and bases can carry an electric current because they dissociate into ions. The more ions in a solution, the more electric current the solution can conduct. Strong acids have many ions in solution, so they conduct current well. Weak acids have few ions in solution and do not conduct current as well.

What are equations for acid dissociation?

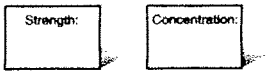
A chemical equation shows the substances that react and the substances that form in a reaction. An arrow points from the reactants to the products. An equation for the dissociation of a strong acid uses a single arrow that points toward the ions that form.

$$HCl(g) + H_2O(l) \rightarrow H_3O^+(aq) + Cl^-(aq)$$

FOLDABLES

D Compare and Contrast

Make the following Foldable to understand how the strength and concentration of acids and bases are the same and different.



Weak Acids In weak acids, such as acetic acid (CH^2COOH), just some of the acid dissociates. An equation for the dissociation of a weak acid uses double arrows pointing in opposite directions. The arrows show that not all of the acid dissociates.

$$CH_3COOH(l) + H_2O(l) \leftrightarrows H_3O^+(aq) + CH_3COO^-(aq)$$

What are strong and weak bases?

A **strong base** is one that dissociates completely in solution. Sodium hydroxide (NaOH) is an example of a strong base. An equation for the dissociation of a strong base uses a single narrow pointing toward the ions that form.

$$NaOH(s) + H_2O(l) \rightarrow Na^+(aq) + OH^-(aq)$$

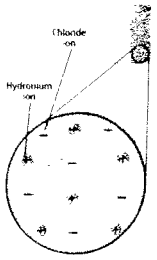
A **weak base** is one that does not dissociate completely in solution. Ammonia (NH_3) is a weak base. An equation for the dissociation of a weak base uses double arrows pointing in opposite directions. ☑

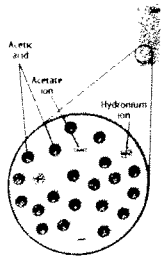
$$NH3(aq) + H_2O \leftrightarrows NH_4^+(aq) + OH{-}(aq)$$

How are strength and concentration described?

The words *strong* and *weak* refer to how easy it is for the acid or base to dissociate in solution. Strong acids and bases dissociate completely. Weak acids and bases dissociate only partially. The words *dilute* and *concentrated* tell how much acid or base is dissolved in the solution. A dilute solution means there is a small amount of acid or base in the solution. A concentrated solution means there is a large amount of acid or base in the solution.

You can have dilute solutions of strong acids and bases. You also can have concentrated solutions of weak acids and bases. The figure below, at left, shows a dilute solution of a strong acid. The figure below, at right, shows a concentrated solution of a weak acid. Notice which acid is more dissociated.





Reading Check

1. **Identify** Circle the phrase that is true for a weak base in a solution.

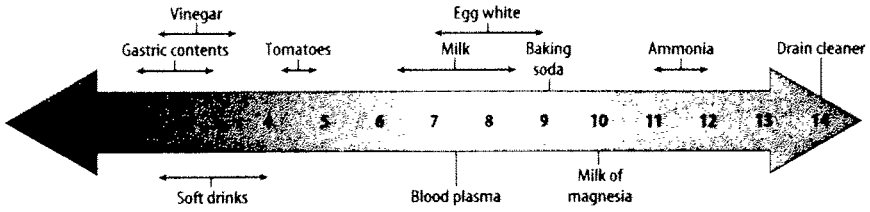
   a. dissociates completely
   b. partly dissociates
   c. forms an acid
   d. does not dissolve much

Picture This

2. **Describe** In the figure, the solution of acetic acid is more concentrated than the solution of hydrochloric acid. Does this mean acetic acid is stronger than hydrochloric acid? Explain.

Picture This

3. **Analyze** Which substance is more basic: baking soda or milk of magnesia? Which substance is more acidic: soft drinks or tomatoes?



Solution pH

If you have a swimming pool or keep tropical fish, you know that the pH of the water must be kept at certain levels. The **pH** of a solution is a measure of the concentration of H^+ ions in the solution. The pH of a solution is measured on a scale ranging from 0 to 14. The greater the concentration of H^+ ions is, the lower the pH and the more acidic the solution.

The figure shows a pH scale and the pH of some common acid and base substances. Solutions with a pH lower than 7 are acidic. Solutions with a pH greater than 7 are basic. The greater the pH value, the more basic the solution is. A solution with a pH of 7 is neutral. In a neutral solution, the concentrations of H^+ and OH^- ions are equal. Pure water at 25°C has a pH of 7.

You can measure pH with universal indicator paper. The paper changes color when H_3O^+ or OH^- ions are present in solution. The color of the paper is then compared to colors in a chart to find the pH. You also can find pH with an electronic pH meter. The meter has electrodes that measure the pH when they are placed in a solution.

Blood pH

The pH of your blood must remain between 7.0 and 7.8. If your blood pH goes outside of this range, enzymes do not work. Enzymes are protein molecules that act as catalysts for many of your body's reactions. Why doesn't your blood pH change when you eat acidic foods? Your blood contains compounds called buffers that allow small amounts of acids or bases to be absorbed without changing the pH. ☑

Buffers are solutions containing ions that react with additional acids or bases to decrease their effects on pH. The buffers help your blood stay at an almost constant pH of 7.4. One buffer system in the blood involves bicarbonate ions, HCO_3^-. Even small amounts of concentrated acids will not change the pH much.

Reading Check

4. **Explain** What are the compounds called that allow you to eat acidic foods without causing a pH change in your blood?

After You Read

Mini Glossary

pH: a measure of the concentration of H^+ ions in a solution

strong acid: an acid in which almost all the acid molecules dissociate in water

strong base: a base that dissociates completely in solution

weak acid: an acid in which only a small number of the acid molecules dissociate in water

weak base: a base that does not dissociate completely in solution

1. Review the terms and their definitions in the Mini Glossary. Choose two related terms and use them together in a sentence.

_____

_____

2. Complete the table to describe acids and bases.

Understanding Acids and Bases	
Property	**Description**
Strength	• **Strong acids and bases almost completely dissociate in solution.** • **Weak acids and bases** _____
Concentration	• **Concentrated acids and bases** _____ • **Dilute acids and bases have few particles in solution.**
pH	• **Acids have a pH lower than 7.** • **Bases have a pH** _____

3. As you read this section, you wrote down the main points of the section. How did these help you understand the section better?

_____

_____

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End of Section