Mixtures, Solubility, and Acid/Base Solutions

Acid and Base Solutions

Before You Read

What do you think? Read the two statements below and decide whether you agree or disagree with them. Place an A in the Before column if you agree with the statement or a D if you disagree. After you've read this lesson, reread the statements to see if you have changed your mind.

Before	Statement	After
	5. Acids are found in many foods.	
	6. You can determine the exact pH of a solution by using pH paper.	

Read to Learn

What are acids and bases?

Would someone ever drink an acid? At first thought, you might answer no. After all, when people think of acids, they often think of the acids such as those in batteries or in acid rain. However, acids exist in other items, including milk, vinegar, fruits, and green leafy vegetables.

Along with the word *acid*, you might have heard the word *base*. Like acids, you can also find bases in your home. Detergent, antacids, and baking soda are examples of items that contain bases. But acids and bases are found in more than just household goods. As you will learn in this lesson, acids and bases are necessities for our daily life.

Acids

Have you ever tasted the sourness of a lemon or a grapefruit? The acid in the fruit creates this sour taste. *An* **acid** *is a substance that produces a hydronium ion (H_3O^+) when dissolved in water*.

Nearly all acid molecules contain one or more hydrogen atoms (H). When an acid mixes with water, this hydrogen atom separates from the acid. It quickly combines with a water molecule, resulting in a hydronium ion. *A* **hydronium ion,** H_3O^+, *is a positively charged ion formed when an acid dissolves in water*.

Key Concepts

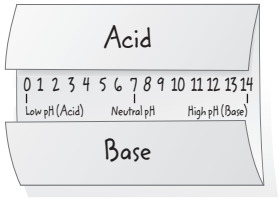
- What happens when acids and bases dissolve in water?
- How does the concentration of hydronium ions affect pH?
- What methods can be used to measure pH?

Study Coach

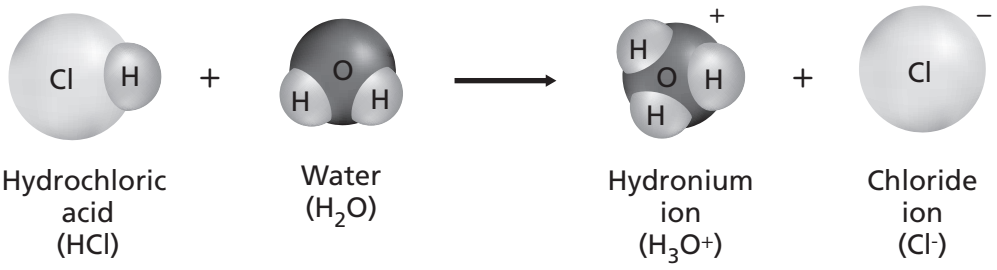
Preview Headings Before you read the lesson, preview all the headings. Make a chart and write a question for each heading beginning with *What* or *How*. As you read, write the answers to your questions.

FOLDABLES®

Draw and label a pH scale in a shutterfold and shade it with colored pencils. Use the scale to compare acid and base solutions.



Acids in Water



Hydrochloric acid (HCl) | Water (H_2O) | Hydronium ion (H_3O^+) | Chloride ion (Cl^-)

Visual Check

1. Identify Circle the atom in hydrochloric acid that joins water in solution.

Visual Check

2. Compare How is dissolving an acid, shown above, similar to dissolving ammonia, shown below?

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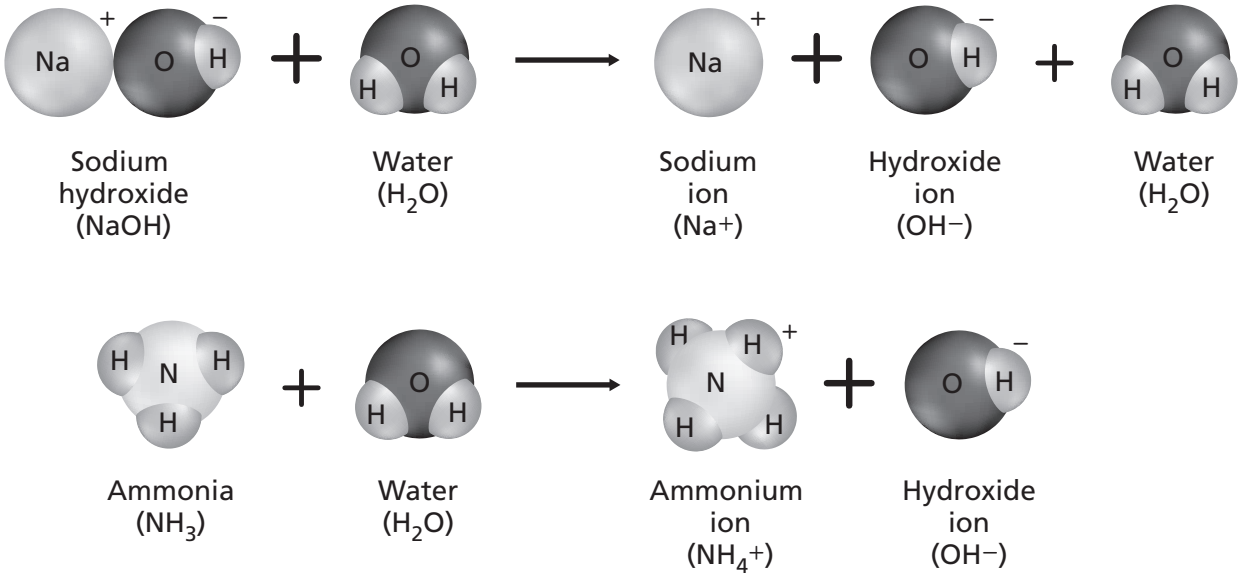
_____

The figure above shows what happens when an acid molecule combines with water. In this example, a hydrogen atom separates from a molecule of hydrochloric acid and combines with a water molecule. The result is a hydronium ion and a chloride ion. The hydronium ion has a positive charge. The chloride ion has a negative charge.

Bases

A **base** *is a substance that produces hydroxide ions (OH^-) when dissolved in water*. When a hydroxide compound such as sodium hydroxide (NaOH) mixes with water, hydroxide ions separate from the base and form hydroxide ions (OH^-) in water. The top part of the figure below illustrates this process.

Bases in Water



Sodium hydroxide (NaOH) | Water (H_2O) | Sodium ion (Na^+) | Hydroxide ion (OH^-) | Water (H_2O)

Ammonia (NH_3) | Water (H_2O) | Ammonium ion (NH_4^+) | Hydroxide ion (OH^-)

Key Concept Check

3. Explain what happens when acids and bases dissolve in water.

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Some bases, such as ammonia (NH_3), do not contain hydroxide ions. These bases produce hydroxide ions by taking hydrogen atoms away from water, leaving hydroxide ions (OH^-). The bottom part of the figure above illustrates this process.

Properties and Uses of Acids and Bases		
	Acids	**Bases**
Ions produced	Acids produce H_3O^+ in water.	Bases produce OH^- ions in water.
Examples	• hydrochloric acid, HCl • acetic acid, CH_3COOH • citric acid, $H_3C_6H_5O_7$ • lactic acid, $C_3H_6O_3$	• sodium hydroxide, NaOH • ammonia, NH_3 • sodium carbonate, Na_2CO_3 • calcium hydroxide, $Ca(OH)_2$
Some properties	• Acids provide the sour taste in food (never taste acids in the laboratory). • Most can damage skin and eyes. • Acids react with some metals to produce hydrogen gas. • H_3O^+ ions can conduct electricity in water. • Acids react with bases to form neutral solutions.	• Bases provide the bitter taste in food (never taste bases in the laboratory). • Most can damage skin and eyes. • Bases are slippery when mixed with water. • OH^- ions can conduct electricity in water. • Bases react with acids to form neutral solutions.
Some uses	• Acids are responsible for natural and artificial flavoring in foods, such as fruits. • Milk contains lactic acid. • Acid in your saliva and stomach breaks down food. • Blueberries, strawberries, and many vegetable crops grow better in acidic soil. • Acids are used to make products such as fertilizers, detergents, and plastics.	• Bases are found in natural and artificial flavorings in food, such as cocoa beans. • Antacids neutralize stomach acid, relieving heartburn. • Cleaners such as shampoo, dish detergent, and window cleaner contain bases. • Many flowers grow better in basic soil. • Bases are used to make products such as rayon and paper.

The table above shows some properties and uses of acids and bases. As you can see, acids and bases are part of everyday life.

What is pH?

Have you ever seen someone test the water in a swimming pool? That person was probably testing the pH of the water. Swimming pool water should have a pH around 7.4. If the pH of the water is higher or lower than 7.4, the water might become cloudy, burn swimmers' eyes, or contain too many bacteria. What does a pH of 7.4 mean?

Hydronium Ions

The **pH** *is an inverse measure of the concentration of hydronium ions (H_3O^+) in a solution*. What does *inverse* mean? It means that as one thing increases, another thing decreases. In this case, as the concentration of hydronium ions increases, pH decreases. A solution with a lower pH is more acidic. As the concentration of hydronium ions decreases, the pH increases. A solution with a higher pH is more basic.

Interpreting Tables

4. Identify List one use of an acid and one use of a base that are part of your everyday life.

Key Concept Check

5. Describe How does the concentration of hydronium ions affect pH?

Balance of Hydronium and Hydroxide Ions

All acid and base solutions contain both hydronium and hydroxide ions. In a neutral solution, such as water, the concentrations of hydronium and hydroxide ions are equal. What distinguishes an acid from a base is which of the two ions is present in the greater concentration. Acids have a greater concentration of hydronium ions (H_3O^+) than hydroxide ions (OH^-). Bases have a greater concentration of hydroxide ions than hydronium ions. Brackets around a chemical formula mean *concentration*.

Acids	$[H_3O^+] > [OH^-]$
Neutral	$[H_3O^+] = [OH^-]$
Bases	$[H_3O^+] < [OH^-]$

The pH Scale

The pH scale, shown in the figure below, indicates how acidic or basic a solution is. Notice that the scale contains values that range from below 0 to above 14. Acids have a pH below 7. Bases have a pH above 7. Solutions that are neutral have a pH of 7—they are neither acidic nor basic.

What do the numbers on the pH scale mean? How is the concentration of hydronium ions different in solutions with a different pH? A change in one pH unit represents a tenfold change in the acidity or basicity of a solution. For example, suppose one solution has a pH of 1 and a second solution has a pH of 2. The first solution is not twice as acidic as the second solution; it is ten times more acidic.

The difference in acidity or basicity between two solutions is represented by 10^n, where n is the difference between the two pH values. For example, how much more acidic is a solution with a pH of 1 than a solution with a pH of 3? First, calculate the difference, n, between the two pH values: $n = 3 - 1 = 2$. Then use the formula, 10^n, to calculate the difference in acidity: $10^2 = 100$. A solution with a pH of 1 is 100 times more acidic than a solution with a pH of 3.

Think it Over

6. Classify How would you classify a soft drink that has a higher concentration of hydronium than hydroxide ions? (Circle the correct answer.)

a. acid

b. neutral

c. base

Visual Check

7. Interpret Is a tomato more or less acidic than detergent? What is the difference in acidity?

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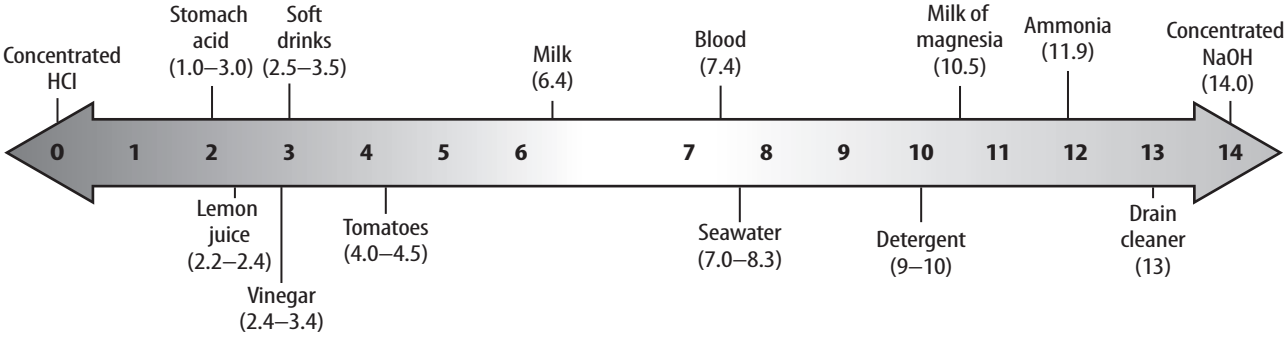
_____

The pH Scale



How is pH measured?

How is the pH of a solution, such as swimming pool water, measured? Water test kits contain chemicals called indicators. When a person adds the chemicals to a water sample, the chemicals change color. The color identifies the solution as an acid or a base.

pH Indicators

Indicators can measure the approximate pH of a solution. *An* **indicator** *is a compound that changes color at different pH values when it reacts with acidic or basic solutions.* The pH of a solution is measured by adding a drop or two of the indicator to the solution. When the solution changes color, the person doing the test matches the color to a set of standard colors. Each standard color corresponds to a certain pH value.

There are many different indicators. Each indicator changes color over a specific range of pH values. For example, bromthymol blue is an indicator that changes from yellow to green to blue between pH 6 and pH 7.6.

pH Testing Strips

You can also use pH testing strips to measure pH. The strips contain an indicator. An indicator changes to a variety of colors over a range of pH values. To use pH strips, dip the strip into the solution. Then match the resulting color to the list of standard colors that represent specific pH values.

pH Meters

Although pH strips are quick and easy, they provide only an approximate pH value. A more accurate way to measure pH is to use a pH meter. A pH meter is an electronic instrument with an electrode that senses the hydronium ion concentration in solution.

Reading Check

8. Describe How do indicators distinguish between acids and bases?

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Think it Over

9. Apply Suppose you are using a water test kit to test the tap water in your home. You add the indicator to a water sample, and the solution changes color. How would you go about determining the pH of the water?

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Key Concept Check

10. Identify What are two methods that can be used to measure the pH of a solution?

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Mini Glossary

acid: a substance that produces a hydronium ion (H_3O^+) when dissolved in water

base: a substance that produces hydroxide ions (OH^-) when dissolved in water

hydronium ion: a positively charged ion (H_3O^+) formed when an acid dissolves in water

indicator: a compound that changes color at different pH values when it reacts with acidic or basic solutions

pH: an inverse measure of the concentration of hydronium ions (H_3O^+) in a solution

1. Review the terms and their definitions in the Mini Glossary. Write a sentence that explains how the concentration of hydronium ions is related to pH.

2. Identify each solution described in the table as an acid, a base, or a neutral solution. Write an *X* in the correct column.

Solutions	acid	base	neutral
Solution A: Contains more hydronium ions than hydroxide ions			
Solution B: Contains more hydroxide ions than hydronium ions			
Solution C: Contains an equal concentration of hydronium and hydroxide ions			
Solution D: Has a pH of 2.3			
Solution E: Has a pH of 8.5			
Solution F: Has a pH of 7			

3. How did your chart help you learn about acids and bases? Choose a question from your chart that was difficult for you. Write the question and its answer below.

What do you think NOW?

Reread the statements at the beginning of the lesson. Fill in the After column with an A if you agree with the statement or a D if you disagree. Did you change your mind?

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Log on to ConnectED.mcgraw-hill.com and access your textbook to find this lesson's resources.

END OF LESSON