Topic 2.4

What are acids and bases, and how do they react?

Key Concepts

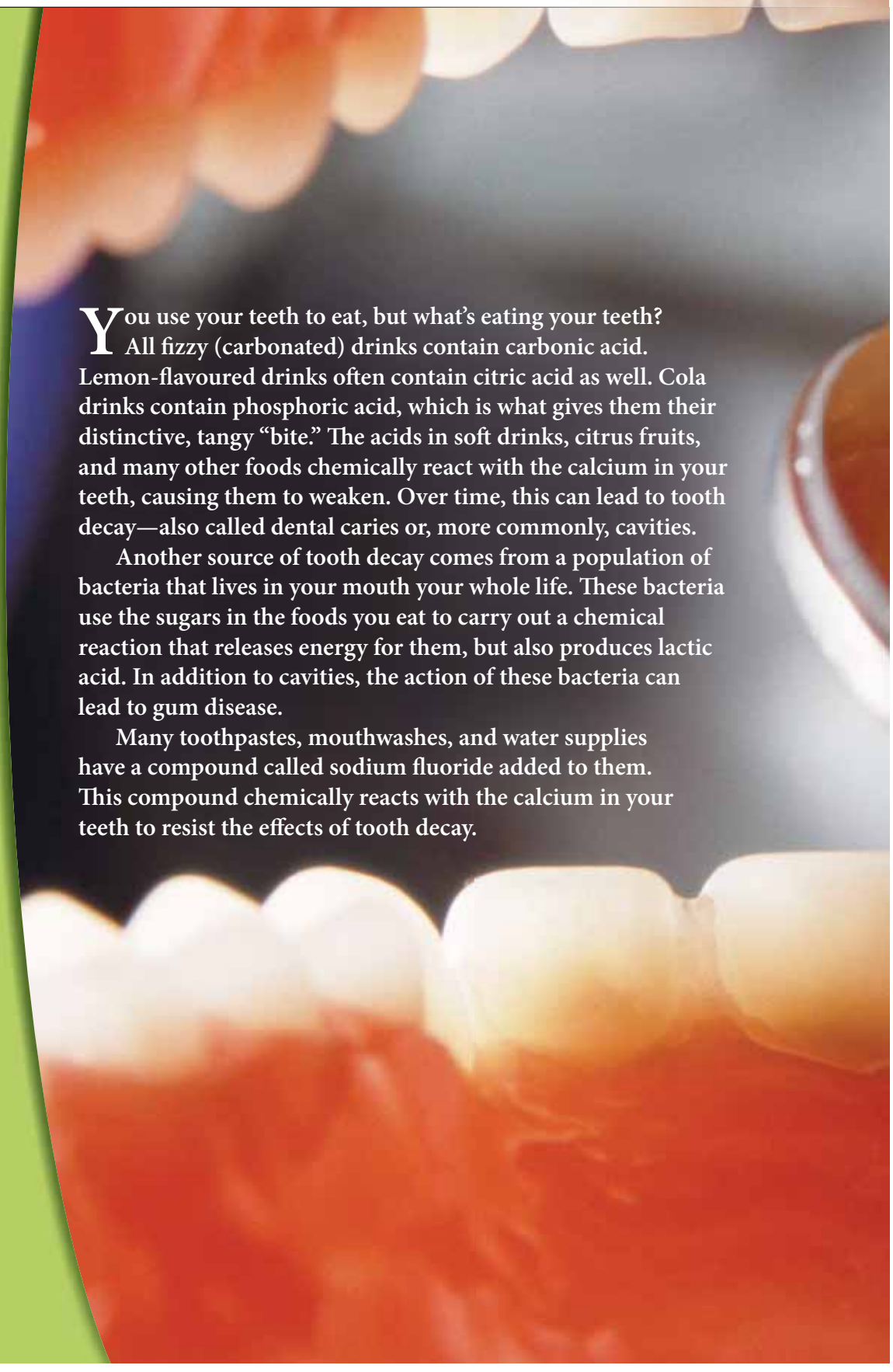
- Acids and bases are compounds with specific properties.
- An acid and a base react in a neutralization reaction to produce a salt and water.
- Chemical reactions involving acids, bases, and other compounds require safe handling to minimize hazards.

Key Skills

Inquiry
Research

Key Terms

acid
base
acid-base indicator
pH scale
neutralization reaction
antacid



You use your teeth to eat, but what's eating your teeth? All fizzy (carbonated) drinks contain carbonic acid. Lemon-flavoured drinks often contain citric acid as well. Cola drinks contain phosphoric acid, which is what gives them their distinctive, tangy "bite." The acids in soft drinks, citrus fruits, and many other foods chemically react with the calcium in your teeth, causing them to weaken. Over time, this can lead to tooth decay—also called dental caries or, more commonly, cavities.

Another source of tooth decay comes from a population of bacteria that lives in your mouth your whole life. These bacteria use the sugars in the foods you eat to carry out a chemical reaction that releases energy for them, but also produces lactic acid. In addition to cavities, the action of these bacteria can lead to gum disease.

Many toothpastes, mouthwashes, and water supplies have a compound called sodium fluoride added to them. This compound chemically reacts with the calcium in your teeth to resist the effects of tooth decay.

Starting Point Activity

You can model the effects of acid on your teeth. All you need is white vinegar, a jar with a lid, and a clean, cooked chicken bone. (The chicken bone contains the same calcium compound that your teeth do.)

First, predict what you think you will observe after the bone has been left in the acidic vinegar for several days. Then test your prediction. As an alternative, observe the acid-treated bone that your teacher may have prepared in advance.

CAUTION: Wash your hands each time you handle the chicken bone. Do not taste the vinegar.

Acids and bases are compounds with specific properties.

acid: a compound that tastes sour, corrodes metals and tissue, and turns blue litmus paper red

base: a compound that tastes bitter, has a slippery texture, corrodes tissue, and turns red litmus paper blue

You experience **acids** and **bases**, and their properties, on a daily basis. Acids and bases are in many of the foods you eat, the soil that grows your food, the fluids in your body, the products you clean with, and the colours of the clothing you wear.

Common Examples of Acids and Their Properties

Common examples of foods that contain acids include lemons, grapefruits, vinegar, apples, and yogurt. These foods have a sour taste. Sourness is one of the properties of acids.

Having a sour taste doesn't mean that it is safe to use the property of taste to identify acids. In fact, many acids are dangerous. They can cause severe burns to the skin and other body tissues because of another property of acids: corrosion. *Corrosion* refers to a chemical reaction in which one substance (such as an acid) "eats away at" or "breaks down" the surface of another substance. Many metals are easily corroded by acids.

As you can see in Figure 2.22, there are many other examples of acids in the world around you. **Table 2.10** lists some properties that are used to identify acids and compares them with properties that are used to identify bases.

▼ **Figure 2.22** Acids are a part of foods, medicines, batteries, cleaning products, and dyes for fabrics and clothing. **CAUTION:** Many acids are dangerous. They can cause severe burns, which can lead to disfigurement and sometimes death. Never touch or taste an unknown acid, or mix an acid with a base or any other substance, without the instruction of a qualified person.

Common Examples of Bases and Their Properties

Common examples of foods that contain bases include eggplant, unsweetened chocolate, bitter melon, and tonic water. These foods have a bitter taste. Bitterness is one of the properties of bases.

The fact that bases have a bitter taste doesn't mean that it is safe to use the property of taste to identify a base. Like acids, many bases are dangerous because they are corrosive. They can corrode skin and other living or once-living tissue. This is one reason why bases are common in oven-cleaning and drain-clearing products. However, bases do not corrode metals, which is another reason why bases are common in oven-cleaning and drain-clearing products.

As you can see in **Figure 2.23**, there are many other examples of bases in the world around you. **Table 2.10** lists some properties that are used to identify bases and compares them with properties that are used to identify acids.

Table 2.10 Comparing Properties Used To Identify Acids and Bases

Property	Acids	Bases
Taste	taste sour	taste bitter
Texture (feel)	have no characteristic texture	have a slippery texture
Conductivity	conduct electric current when dissolved in water	conduct electric current when dissolved in water
Corrosion	corrode living and once-living tissue, as well as metals	corrode living and once-living tissue
Chemical reaction with metals	are reactive with metals	are not reactive with metals
*Chemical reaction with litmus paper	turn blue litmus paper red	turn red litmus paper blue
*Chemical reaction with each other	lose many of their properties when they react with bases	lose many of their properties when they react with acids

*Properties marked with an asterisk (*) are described in more detail on pages 162 to 163 and pages 164 to 165.

▲ **Figure 2.23** Bases are a part of foods, medicines, batteries, cleaning products, and dyes for fabrics and clothing. **CAUTION:** Many bases are dangerous. They can cause severe burns, which can lead to disfigurement and sometimes death. Never touch or taste an unknown base, or mix a base with an acid or any other substance, without the instruction of a qualified person.

LEARNING CHECK

1. Convert **Table 2.10** into a Venn diagram that compares the properties of acids and bases.
2. Name three acids and three bases that you either have or probably have in your home.
3. Explain why people who work with acids and bases should treat these compounds with care and with proper regard to safety.

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Acid-Base Indicators and the pH Scale

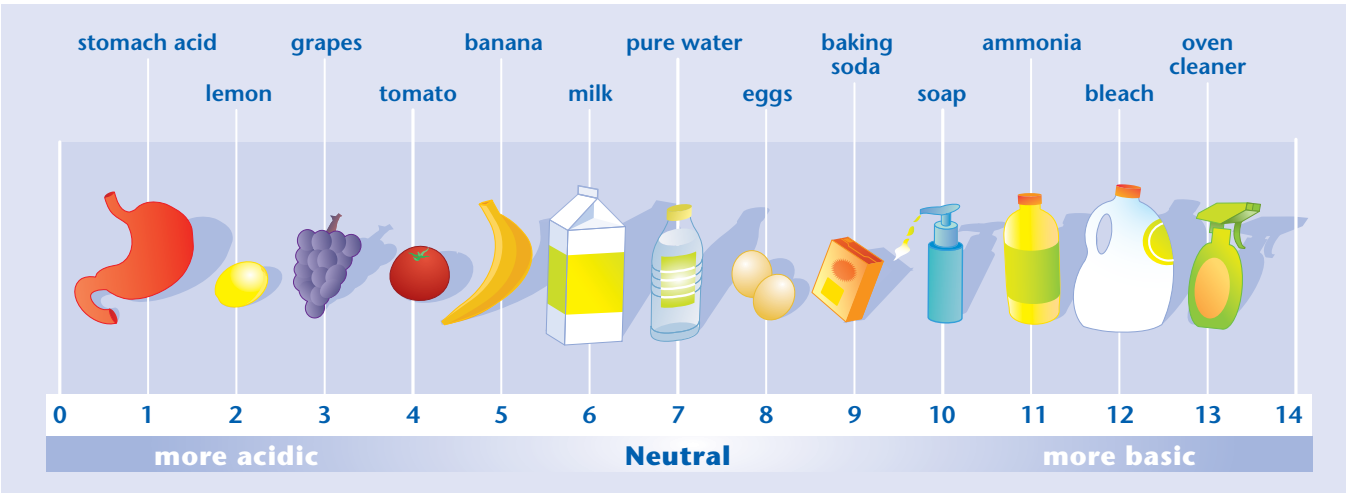
acid-base indicator: a substance that changes colour when added to an acid or a base

One way to identify acids and bases is to use an acid-base indicator. An **acid-base indicator** is a substance that changes colour when it is added to an acid or a base, or when an acid or a base is added to it. Figure 2.24 shows litmus paper, which is one of the most commonly used acid-base indicators.

◀ **Figure 2.24** Litmus paper often comes in two colours—red and blue. Acids turn blue litmus paper red. Bases turn red litmus paper blue.

Another way to identify acids and bases is to use numbers. Not all acids are the same, and neither are all bases. For instance, some acids are more sour, more corrosive, or more reactive than others. Likewise, some bases are more bitter, more corrosive, or more reactive than others. Scientists use the pH scale, like the one in Figure 2.25, to give a numerical value to a substance. The **pH scale** is a sequence of numbers from 0 to 14 that describes how acidic or how basic a substance is. The lower the pH number, the more acidic a substance is. The higher the pH number, the more basic a substance is. When the pH number changes by one, the strength of the acid or base changes by ten times. For example, pH 3 is ten times more acidic than pH 4. Also, pH 9 is ten times more basic than pH 8.

pH scale: a scale from 0 to 14 that describes how acidic or basic a substance is



▲ **Figure 2.25** Acids have a pH less than 7. Bases have a pH greater than 7. Substances with a pH of 7 are neutral, which means that they are neither an acid nor a base.

LEARNING CHECK

1. A substance is tested with red and blue litmus paper. The red litmus paper turns blue, the blue litmus paper stays blue. Identify the substance as an acid or a base.
2. Identify the following as acidic, basic, or neutral: **a)** egg white (pH 7.8); **b)** coffee (pH 5.0); **c)** urine (pH 6.0); **d)** bleach (pH 12.4).
3. Sort the items in question 2 from most basic to most acidic.

Inquiry Focus

Activity 2.14

USING INDICATORS TO IDENTIFY ACIDS AND BASES

In this activity, you will use two acid-base indicators to identify samples of acids and bases. Litmus paper is one of the indicators you will use. Cabbage juice is the other.

Safety

What You Need

- spot plates (10 wells needed per group)
- paper towels
- solutions with pH values from 3 to 11
- tweezers
- litmus paper cut into small squares
- coloured pencils or markers
- medicine dropper
- cabbage juice indicator (prepared in advance)

What To Do

1. Make a table like the one below to record your data.

Indicator Colour in Various Solutions with Different pH Values

pH	3	4	5	6	7	8	9	10	11
Litmus									
Cabbage juice									

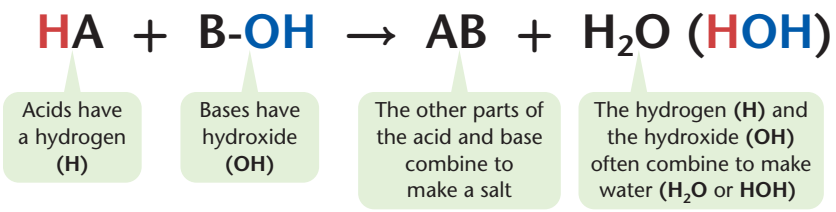
2. Number the wells of the spot plate from 3 to 11.
3. Place a paper towel beside the spot plate.
4. Add five drops of the solution with a pH of 3 to the well marked 3.
5. Add five drops of the solution with a pH of 4 to the well marked 4.
6. Continue adding five drops of the pH solutions to the wells with matching numbers.
7. Use tweezers to pick up one piece of litmus paper. Dip the litmus paper into the solution with a pH of 3. Place the damp litmus paper on the paper towel.
8. Use coloured pencils or markers to duplicate the colour of the litmus paper in your table.
9. Use a dropper to add five drops of cabbage juice indicator to the solution with a pH of 3.
10. Use the coloured pencils or crayons to duplicate the colour of the cabbage juice in your table.
11. Repeat steps 7 to 10 for the other solutions in the wells.
12. Clean up as directed by your teacher.

What Did You Find Out?

1. List the solutions you tested from most acidic to most basic.
2. Which indicator is better for identifying acids and bases? Explain.

An acid and a base react in a neutralization reaction to produce a salt and water.

The chemical reaction between an acid and a base is a double displacement reaction. In many cases, the products of a double displacement reaction are an ionic compound and water. This happens because acids contain hydrogen (H) and bases contain hydroxide (OH). When an acid and a base take part in a chemical reaction, the H in the acid combines with the OH in the base to form water: HOH, or H_2O. The other elements in the acid and base combine to form an ionic compound, as shown in **Figure 2.26**. The ionic compound is called a salt. There are many other salts in addition to table salt, which is sodium chloride.

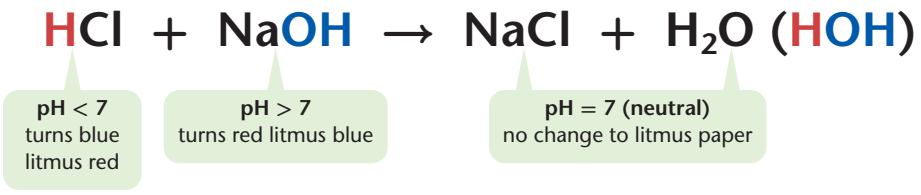


▶ **Figure 2.26** An acid and a base react in a double displacement reaction to form an ionic compound (a salt) and often water.

Neutralization Reactions

neutralization reaction: a reaction between an acid and a base that "neutralizes" their acidic and basic properties

The double displacement reaction between an acid and a base is also called a **neutralization reaction.** It is called a neutralization reaction because the acidic and basic properties cancel each other out. They are neutralized. Study the example in **Figure 2.27**.



▶ **Figure 2.27** The properties of the acid and base are neutralized when the acid and base react.

LEARNING CHECK

1. Explain what happens during a chemical reaction that involves an acid and a base.
2. You could think of an acid and a base as being the chemical opposites of each other. Explain how the concept of a neutralization reaction supports this.
3. Look at the chemical equation shown in **Figure 2.28**. Is this a balanced chemical equation? Explain why or why not.

INVESTIGATION LINK
Investigation 2C, on page 172

Examples of Neutralization Reactions

One example of a neutralization reaction takes place in your body when you eat. Your stomach produces a powerful acid to kill germs that might be in food. This acid is neutralized by a base in your small intestine. If your stomach produces too much acid, you may feel pain around the area of your chest and throat. This is called acid reflux, but you may have heard it called heartburn. **Antacids** are stomach-acid neutralizers. They are made of non-toxic bases. They relieve the pain of excess stomach acid by neutralizing some of the acid. Antacids should only be used to relieve occasional heartburn. Prescription medication should be used if you have heartburn regularly.

Figure 2.28 shows another example of a neutralization reaction. Sulfuric acid is important for manufacturing many substances and products that are used around the world. However, sulfuric acid is often transported by rail, and accidents sometimes occur. When 150 000 L of sulfuric acid accidentally spilled into the Blanche River in the Temiskaming region of northeastern Ontario, clean-up efforts included the use of a base called lime to neutralize the acid.

ACTIVITY LINK
Activity 2.16, on page 170

antacid: non-toxic base that is used to neutralize stomach acid

INVESTIGATION LINK
Investigation 2D, on page 173

▼ **Figure 2.28** People working to clean up the spill of sulfuric acid into the Blanche River used lime to neutralize the acid. The chemical name for lime is calcium hydroxide, and its chemical formula is $Ca(OH)_2$. The word equation and chemical equation for the neutralization reaction are shown on top of the photo.

sulfuric acid + calcium hydroxide → calcium sulfate + water

$$H_2SO_4 + Ca(OH)_2 \rightarrow CaSO_4 + 2H_2O$$

Chemical reactions involving acids, bases, and other compounds require safe handling to minimize hazards.

Go to **scienceontario** to find out more

Acids, bases, and other compounds that are used or produced during chemical reactions can be hazardous to peoples' safety, to the environment, or to both. But with proper precautions, the risks can be minimized. The photos and captions on the next page show examples of professionals who must have specialized knowledge to handle chemical compounds and chemical reactions at their work sites.

LEARNING CHECK

1. Name one hazard experienced by
   a) auto body technicians **b)** food preparation workers
2. What precautions should be taken by the following workers before doing their job?
   a) hair stylist **b)** welder

Research Focus

Activity 2.15

MINIMIZING THE RISKS

Work in small groups. Divide up the professions shown on page 167 so that each group has one profession to explore further. Other professions can be added as necessary.

With your group, do research to find examples so that you can fill in a table like the one shown below. Combine the information in your table with other groups to create a single summary table. Your summary table should include information about:

- professions that use chemical compounds and chemical reactions
- ways that risks and hazards are minimized in these professions.

Be sure to consult WHMIS and MSDS regulations when you are doing your research.

Profession	Benefits of Chemical Reactions (what compounds are used, and how are they used?)	Ways To Minimize Risks to Personal Safety from Compounds and Chemical Reactions	Ways To Minimize Risks to the Environment from Compounds and Chemical Reactions

Hair stylist If you read the warnings on hair products from a drugstore, you know how dangerous these products can be if they are not used properly. The products stylists use in a hair salon are more concentrated and must be handled even more carefully. Stylists wear gloves to protect their hands and aprons to protect their clothes.

Auto body technician The chemicals used in car paint make the paint durable enough to withstand winter road conditions, but they can cause severe damage to skin, eyes, and lungs. Auto body technicians must wear a full-face air-purifying respirator to protect their face and lungs from exposure.

Nail technician Nail technicians are exposed to the chemicals in polish, solvents (nail polish remover), adhesives (for gel and acrylic nails), and the dust formed from polishing. The chemicals that make nails look great can cause both skin irritation and respiratory problems from exposure.

Custodian Some people think the "best" cleaning products are the ones with the most hazard symbols on them! More and more schools and office buildings are switching to "green" cleaning products that not only reduce the environmental impact of cleaning products, but also protect custodians from exposure to dangerous compounds that can harm skin and other body tissues if they are not handled safely.

Food preparation We use a variety of compounds to sanitize surfaces to protect us from food-borne illnesses caused by bacteria and other microbes. But the same compounds that are toxic to microorganisms are also toxic to us. People who work in food preparation must take care to ensure that their skin doesn't come in contact with the chemicals, that they don't breathe in the fumes, and that all traces are washed away before any food comes into contact with these surfaces after cleaning.

Welder You may have noticed that welders wear eye protection to protect their vision against ultraviolet radiation. Other risks that welders face include exposure to metal fumes and the possibility of an explosion. A balloon filled with acetylene, a common welding fuel, has the explosive power of 20 sticks of dynamite!

Firefighter Firefighters not only fight fires, but also battle spills from industrial and automobile accidents. The compounds spilled may be any combination of toxic, flammable, or hazardous—including acids and bases. They must be prepared to protect themselves, the people nearby, and the environment, from the hazardous effects. They wear heat and chemical-resistant clothing, and have breathing apparatus if needed. When possible, they will use other chemical products to help neutralize or clean up the spill.

Case Study Investigation: Acid Rain—Still an Ongoing Concern

What's the Issue

With climate change in the headlines so often, it's easy to forget that there are other serious environmental issues. One of those is acid deposition, often referred to more simply as acid rain.

Normal rain water is naturally acidic because carbon dioxide in air interacts with rain water to form carbonic acid. The resulting acidic rain has a pH of about 5.6. But pollutant gases such as sulfur dioxide and nitrogen oxides also interact with rain water, causing the pH to drop even further. Eastern Canada especially has suffered, and continues to suffer, great damage due to the ongoing formation of acid rain.

The Science behind the Issue

Acidic rain, snow, and ice causes damage to ecosystems on land, in oceans, and even in our towns and cities.

Acid rain is destroying forests in Canada and around the world.

Aquatic Ecosystems

Organisms that are adapted to living in lakes and ponds are very sensitive to the acidity of their watery homes. Some, such as eel and brook trout, can survive in water with a pH as low as 4.5. But others, such as perch and pike, die when the pH falls below 5.0. The pH of the water isn't the only factor that causes harm. Acid rain reacts with soil and rock materials, releasing poisonous metals that can drain into aquatic ecosystems.

Terrestrial Ecosystems

Plants are very sensitive to acidic soil. Many cannot grow in acidic conditions. In natural terrestrial ecosystems such as forests, acidic rain and snow damages the leaves of trees. This makes trees less healthy, interfering with their ability to withstand cold and fight off disease and insects. Acidic rain and snow also deplete the soil of nutrients that plants need to grow and thrive. Canadian scientists predict that unless acid deposition is reduced, half of the conifers in eastern Canada may be harmed.

The boat in this photo is adding lime (calcium carbonate) to a lake affected by acid rain. The calcium reacts with the acid in a neutralization reaction. This solution is a temporary fix, however.

Human Ecosystems

Stone buildings and statues are damaged as the acid in acidic rain and snow eats away at their surfaces. Regional economies can also suffer. For example, income from commercial fishing, sports fishing, and recreation are affected when lakes and forests that towns and cities depend on are damaged by acid rain.

In Ontario, the Sudbury area has been severely affected by acid deposition due to sulfur dioxide emissions from nearby smelter—factories that extract metal from ore. Lakes were hit especially hard. Loss of fishing-related jobs and income was heavy as sports fish levels declined in acidified water. Fortunately, the story of Sudbury has a relatively happy ending. Once smelter emissions were reduced in the area, ecosystem health soon began to improve. However, not all sources of acid rain are local—the United States is a huge contributor to the problems experienced in Canada.

This photo shows a statue after it has been exposed to acid deposition.

Over to You

1. Read the caption for the photo showing a boat adding lime to a lake. Infer why this solution is only a temporary fix to the problem.
2. Why does acid rain affect eastern Canada more severely than western Canada? Do research to find out.
3. Do research to find out why solutions to the problem of acid rain in Canada involve the cooperation of the United States as well.
4. Killarney, Ontario was severely affected by acid rain in the 1970s. Find out why, and find out what people have been doing ever since to help their area recover.

Inquiry Focus

Activity 2.16

NEUTRALIZATION REACTIONS

In this activity, you will use an acid-base indicator to determine when a neutralization reaction is complete. The acid-base indicator you will use is called bromothymol blue. It is blue in a base, yellow in an acid, and green when neutral.

Safety

- Hydrochloric acid and sodium hydroxide are corrosive. Work with them carefully.
- Sodium hydroxide can cause blindness.

What You Need

- graduated cylinder
- dilute hydrochloric acid
- small test tube
- test-tube rack
- dropper with dropper bottles (for each solution)
- bromothymol blue indicator
- dilute sodium hydroxide

What To Do

1. Make a table like the one below to record your data.

Volume of Acid (mL)	Number of Drops Needed to Neutralize Acid
5.0	
2.0	
3.0	

2. Use the graduated cylinder to measure 5.0 mL of the acid. Pour the acid into the test tube.
3. Add two drops of bromothymol blue indicator. Gently swirl the test tube to mix the indicator and the acid. The colour should be yellow.
4. Add one drop of the base to the test tube, and gently swirl to mix. Add a drop at a time until you see the colour change to green.
5. When the colour changes to green, the reaction is complete. The acid is neutralized. Record the number of drops of base you added to neutralize the acid.
6. Rinse the test tube, and repeat steps 2 to 5 using 2.0 mL of acid.
7. Rinse the test tube, and repeat steps 2 to 5 using 3.0 mL of acid.
8. Clean up as directed by your teacher.

What Did You Find Out?

1. What is the pH when the base has neutralized the acid? How do you know?
2. What is the link between the volume of base that is needed to neutralize the acid and the volume of the acid? Explain.
3. You used very small volumes of acid and base in this activity. Yet you did not use acids with a pH of 1 and 2 or bases with a pH of 12, 13, or 14. What does this tell you about the strength of acids and bases with these pH values?

Inquiry Focus

Activity 2.17

THE pH OF COMMON SUBSTANCES IN THE HOME

In this activity, you will use pH paper to determine the pH of some common substances in the home. pH paper is another type of acid-base indicator. It has a different colour for each pH.

Safety

What You Need

- variety of common substances (including cleaners used in the home, fruit juices, and soft drinks)
- distilled water
- small beakers
- pH paper cut into small pieces
- spot plate
- dropper with dropper bottles (for each solution)

What To Do

1. Make a table like the one below to record your data. Leave enough space for the number of substances you will be testing.
2. In the first column, write the name of each substance you will be testing.
3. Predict whether each substance is an acid, a base, or neutral. Write your prediction in the "Prediction" column.
4. If any substance is a solid or thick paste, mix a small amount of the substance with distilled water in a beaker to form a solution.
5. Place a small square of pH paper in a well of a spot plate.
6. Use the medicine dropper to place two drops of the first substance being tested on the pH paper. Record your results.
7. Repeat steps 5 and 6 for the remaining substances.
8. Clean up as directed by your teacher.
9. Complete the data table using the colour key for the pH paper.

Substance	Prediction (Acid, Base, or Neutral)	Colour of pH Paper	pH	Acid, Base, or Neutral?

What Did You Find Out?

1. How did your predictions compare with your results? Explain.
2. Describe the pH of cleaners used in the home. Why do you think these cleaners have this pH in common?
3. Draw and label a pH scale from 3 to 11. On your scale, label the pH of each substance you tested.

Skills

- ✓ **initiating and planning**
- ✓ **performing and recording**
- ✓ **analyzing and interpreting**

communicating

Safety

- Clean up any spills immediately.
- Sodium hydroxide can cause blindness.

What You Need

- dilute hydrochloric acid
- dilute sodium hydroxide solution
- other materials, as determined by your procedure

Acid-Base Neutralization Reactions

You have learned that an acid and a base react to form a salt and water. The water is pure water, with a pH of 7 (neutral). How can you determine that a salt is produced? After all, many salts dissolve in water, so they would not be visible. In this investigation, you will design and carry out a procedure to neutralize an acid with a base and then demonstrate that a salt is produced.

What To Do

1. Work in small groups.
2. Design a procedure to neutralize an acid with a base and separate the salt that is produced. Consider safety precautions, as well as proper clean-up and disposal, in your procedure. Make sure that you have your teacher approve your procedure before you begin.

   Hints:

   - See Activity 2.16 on page 170 for help designing your procedure to neutralize an acid with a base.
   - You can separate the salt that is produced by removing all the water from the neutralized solution. Think about how salts are left behind on glasses and kettles.
   - Make a list of the equipment and materials you will need as you design your procedure.
3. Create a table to record your observations.
4. Follow your procedure, and record your results.
5. Clean up, and put away all the equipment. Wash your hands.

What Did You Find Out?

1. What is the pH of the solution that is produced when an acid is neutralized by a base?
2. How do you know that a salt is also produced in the neutralization of an acid with a base?
3. What is the common name of the salt that was produced in this chemical reaction? (**Hint:** Write the chemical formula for the acid and the base. Note that hydrochloric acid is hydrogen chloride gas dissolved in water. Then write a chemical equation for the reaction.)

Investigation 2D

The Effectiveness of Antacids

Antacids are used to neutralize the stomach acid that causes heartburn. Many kinds of antacids are available. Which antacid is the best? In this investigation, you will design an experiment to determine which antacid is the best, based on the properties that you decide are the most important in an antacid.

Skills

- ✓ **initiating and planning**
- ✓ **performing and recording**
- ✓ **analyzing and interpreting**

communicating

Safety

- Clean up any spills immediately.

What You Need

- hydrochloric acid (stomach acid)
- at least three antacids
- other materials, as determined by your procedure

What To Do

1. Work in small groups.
2. Design a procedure to determine which of the antacids you test is the "best." Consider safety precautions, and proper clean-up and disposal, in your procedure. Make sure that you have your teacher approve your procedure before you begin.

   Hints:

   - As a class, decide what properties make the "best" antacid. Design your procedure to provide enough data to determine which antacid is the "best."
   - When designing an experiment, there should be one independent variable (what you are changing from one trial to the next) and one dependent variable (what you are going to measure in each trial). All the other factors in the experiment should be controlled variables (they should stay the same in every trial). Identify the variables for your experiment.
   - Make a list of the equipment and materials you will need as you design your procedure.
3. Create a table to record your observations.
4. Follow your procedure, and record your results.
5. Clean up, and put away all the equipment. Wash your hands.

What Did You Find Out?

1. What properties did your class decide are the most important in an antacid? In other words, which properties make an antacid the "best"? Explain your decisions.
2. If you were going to give someone advice about the "best" antacid to use, which antacid would it be? Use the results of your investigation to support your answer.
3. Are there any properties that should be considered in an antacid that were not considered in this investigation? Explain your opinion.

Inquiry Focus

Activity 2.18

THE EFFECT OF pH ON CORROSION

Corrosion causes many challenges for society. Cars become rusty. Giant bridges can be damaged by rust. The costs to people and governments add up fast. Although it doesn't cause serious problems, metal coins also become corroded. They come from the mint as a bright silver or copper colour. Exposure to air, sweat, and other substances make them dull and discoloured. These are just a few examples of the results of corrosion. Are there specific things in the environment that speed the process of corrosion?

Acid rain, like all acids, has a pH below 7. Pure water has a pH of 7, and normal rainwater has a pH of about 5.6. The pH of acid rain typically ranges between 4 and 5. How does pH affect the rate at which iron corrodes? In this activity, you will compare the corrosive effects of solutions with different pH values.

Safety

What You Need

- paper towels
- steel wool
- four 250 mL beakers
- marker
- 3 acidic solutions (pH 4, 5, and 6)
- neutral solution (pH 7)

What To Do

1. Design a table to record your observations. Give your table a suitable title.

pH of Solution	Appearance of Steel Wool before Beginning	Appearance of Steel Wool after 24 h
4		
5		
6		
7		

2. Place a paper towel and a small piece of steel wool in the first beaker.
3. Pour enough of the solution with pH 4 into the beaker to soak the paper towel. Make sure that the steel wool is exposed to the air and is touching the paper towel. Label this beaker "pH 4."
4. Repeat steps 2 and 3 for the other three beakers and solutions. Label the beakers "pH 5," "pH 6," and "pH 7."
5. Record your observations of the steel wool.
6. Set aside the samples for 24 h. Then observe the contents again. Record your observations.

What Did You Find Out?

1. What type of changes in the steel wool did you observe after 24 h?
2. Describe any differences among the pieces of steel wool in the four beakers.
3. Which pH caused the faster corrosion?
4. What evidence of a chemical reaction did you observe?

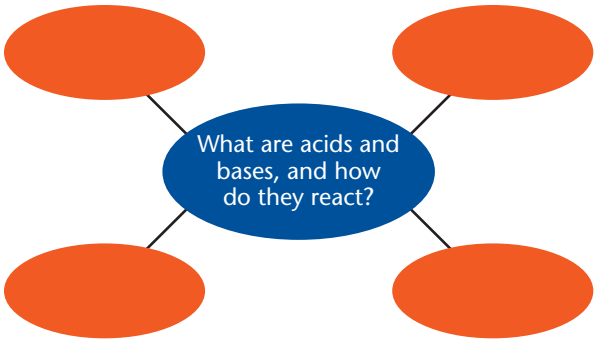
Topic 2.4 Review

Key Concepts

- Acids and bases are compounds with specific properties.
- An acid and a base react in a neutralization reaction to produce a salt and water.
- Chemical reactions involving acids, bases, and other compounds require safe handling to minimize hazards.

Review the Key Concepts

1. K/U Answer the question that is the title of this topic. Copy and complete the graphic organizer below in your notebook. Fill in four examples from the topic using key terms as well as your own words.



2. K/U What colour is litmus in a solution with a pH of 8?

3. T/I Which provides more information about an acid—the pH, or the colour of litmus paper? Explain your answer.

4. T/I A substance is clear, conducts electric current, and is corrosive. Is the substance an acid or a base? What test can you perform to be sure?

5. A Acids are often transported over long distances in containers on trains. Occasionally, one of the containers may leak, or an accident may lead to an acid spill. What would emergency workers do to treat the acid that has spilled? How do they know when the acid spill has been made safe?

6. K/U Why are acid-base reactions called neutralization reactions?

7. K/U What can be added to an acid to neutralize it? How can you know when the acid is neutralized?

8. A One type of indicator is called the universal indicator. Like cabbage juice, universal indicator changes colour over the entire pH scale. It can be purchased on strips of paper like litmus. The indicator scale is shown below, along with the results of using the indicator in three unknown solutions, A, B, and C.

a) Using the indicator scale on the left side of the picture, determine the pH of the three solutions, A, B, and C.

b) Identify the three solutions as acidic, basic, or neutral.

c) Which of the three would taste bitter?

d) Which of the three solutions would conduct electric current?

SCIENCE AT WORK

CANADIANS IN SCIENCE

▲ Glass artist Deeni de Medeiros at work in her home studio

"Making magic"—that's how Deeni de Medeiros describes the work of a glass artist. Deeni is the creative force behind Artworx Glass Studio in Barrie, Ontario. Over the past 10 years, she has worked to develop stylish designs in stained glass and has mastered the delicate art of working with glass that contains the compound titanium dioxide. This compound was first used to make the shield visors worn by Apollo astronauts. When heated to temperatures of up to 1000°C, the glass turns different colours in combinations that can never be completely predicted. Deeni uses this property to create unique works of multi-coloured jewellery and decorative items.

What made you decide to pursue a career as a glass artist?

Deeni was first inspired to take up glasswork by her father, who did stained glass as a hobby. "I started making pieces myself and giving them to friends for Christmas," she says, "and they started saying, 'You could make a living at this!' I got a few tips from my dad, but I never took courses—just learned by trial and error and from surfing the Internet."

How important is a knowledge of chemistry in the work that you do?

Acids play a key role in Deeni's stained glass work. She uses acid on the metal solder that separates the panels to get an aged look. "You have to know exactly how long to leave the acid on before you neutralize it." It's also important to understand how various types of glass behave when they are heated. The rate at which glass softens and hardens when heated and cooled affects how the glass can be manipulated and how the end product will look. Deeni's husband and business partner, Joe, programs the computer that regulates the heat in the kiln.

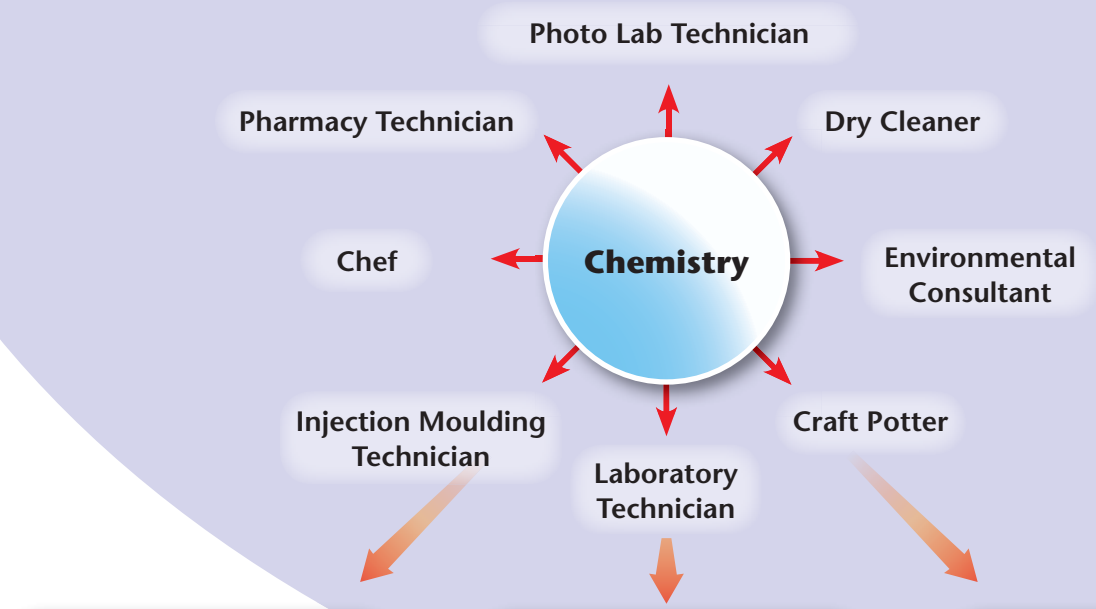
What advice would you give someone who wants to be a glass-blower?

"It has to be a passion to take something that you love and make it into a business," Deeni says. Being a self-employed artist means taking risks. It also means being ready to try new things. "For me, the biggest challenge always comes with the next project, when someone pushes me to do something new, learn a new skill and go to a place I've never been before."

▼ Deeni wears surgical gloves to keep the natural oils on her fingers from reacting with the glass when it is heated.

Put Science To Work

The study of chemistry contributes to these careers, as well as many more!



▲ Steering wheels, Blu-Ray® discs, iPhones®, and circuit boards are all made on injection moulding machines. Operators of these machines must understand the chemical processes that go into the plastics that shape these products.

▲ Laboratory technicians must be familiar with the chemicals involved in a variety of tests that are performed on blood and tissue samples. Because many of the instruments that they use are operated by computers, they must be knowledgeable about computers as well as numeracy and problem-solving skills.

▲ Craft potters are constantly in search of new ways to combine chemical compounds, including salts, to produce striking glazes on bowls, mugs, and figures.

Over To You

1. If you could interview Deeni de Medeiros, what questions would you ask her about her work?
2. What role does chemistry play in the work of a glass artist?
3. Research a career involving chemistry that interests you. If you wish, you may choose from the list above. What are the essential skills needed for this career?

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