UNIT 2

Matter and Chemical Change

Ah, pizza! How appetizing! Imagine the taste of melted cheese, fresh veggies, and tangy tomato sauce. Pizza is a colourful, fragrant, mouth-watering assortment of ... chemicals?

Yes, when you bite into pizza you are tasting a mouthful of chemicals. When you watch a spectacular fireworks display, you are observing chemical properties. And when you fry an egg, bake a cake, or observe autumn leaves, you are seeing chemicals at work. What other chemical changes can you name?

The matter that surrounds you constantly interacts and changes both chemically and physically. How is matter sorted out and classified? Which substance is which? Can the changes be understood or predicted? Which chemicals are safe to handle? What is the difference between the chemicals in fireworks and the chemicals in the food we eat?

Investigate the fascinating world of chemical change in Unit 2. Observe and compare chemical substances and the ways they interact.

What mysteries about chemicals would you like to solve?

Unit Contents

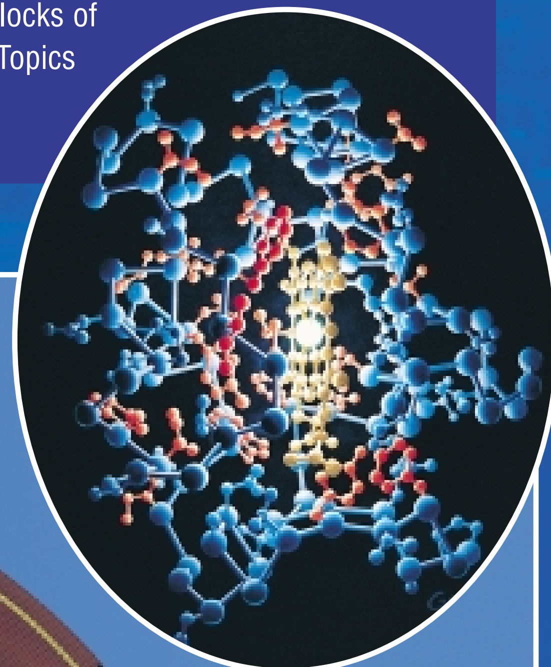
UNIT 2

Preview

Focussing Questions

- What are the properties of materials and what happens to the properties during chemical change?
- How do we know that chemical change occurs?
- What ideas, theories, and models help explain chemical change?

Imagine breaking a piece of matter into smaller and smaller pieces — so small that you would need a powerful microscope to see them. What would be the smallest piece? How could you decide whether it was a pure substance or a mixture? Dig into the building blocks of matter in Topics 1–3.

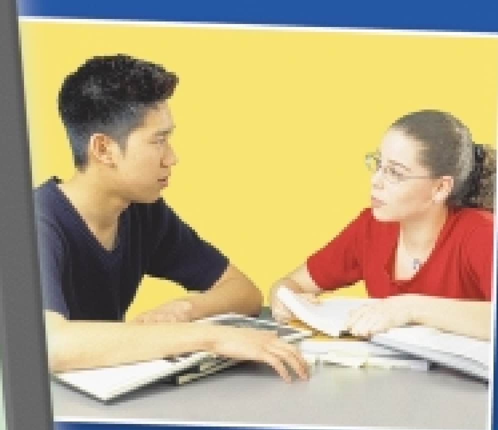


Neon signs create a dazzling display thanks to the properties of elements. How are elements classified? What properties do elements have? Prepare to be dazzled as you find the answers in Topics 4–6.

Do chemical reactions happen only in laboratories? Or can you see them all around you every day? How can chemicals react to produce new substances? The answers are waiting for you in Topics 7–8.

Looking Ahead

Look ahead to the Unit Investigation: Tough as Nails on pages 168–169. In this investigation you will choose a question to investigate about a chemical process and design the steps of an experiment to answer your question. While you work through this unit, notice safety information that will be useful in planning your investigation. Start thinking now about your contributions to the group process. How can you help make decision making smooth and easy? How can you communicate your ideas while also encouraging others to participate?



TOPIC 1 Exploring Matter

DidYouKnow?

When this textbook was published, Canadian scientists had won the Nobel Prize in science ten times. Many of the Nobel laureates were chemists. Visit the web site **www.science.ca**. Why were the scientists awarded the prize? What were their lives like when they were your age? Have any other Canadian scientists been awarded the Nobel Prize since this list was created?

Bertram Brockhouse (1994 Physics)

Michael Smith (1993 Chemistry)

Rudolph Marcus (1992 Chemistry)

Richard E. Taylor (1990 Physics)

Sidney Altman (1989 Chemistry)

John Polanyi (1986 Chemistry)

Henry Taube (1983 Chemistry)

David Hubel (1981 Medicine)

Gerhard Herzberg (1971 Chemistry)

Frederick Banting (1923 Medicine)

You are surrounded by matter. The air you breathe, the clothes you wear, and the food you eat are all examples of matter. What is known about matter? How were the discoveries made? Many answers have come from **chemistry**, the study of the properties of matter and the changes matter undergoes.

The chemistry laboratories shown in movies and television programs often look like the laboratory in the large photograph above. But much of what we know about matter today was discovered in laboratories that were far less advanced, using simple equipment, as shown in the sketch above. Some early chemists had private sources of funding, so they could hire metalworkers and glass blowers to make specialized equipment. Many early chemists were poor, however, and used whatever materials were at hand to make their own equipment. Even with this homemade equipment, they were able to make important discoveries to further the understanding of matter.

Safety First

Although early scientists made many important discoveries, their laboratories were not as safe as the one you will work in this year. Some scientists routinely tasted and smelled chemicals. Safety goggles were rarely worn. Explosions were common and many early scientists met an unfortunate death.

Chemicals must be handled with care. Some materials are **caustic** and will burn, corrode, or destroy organic tissue.

A good laboratory is a safe laboratory. The investigations and activities you perform in your class are carefully monitored by your teacher. The procedures, equipment, and chemicals must all meet strict safety guidelines. You can help to make your laboratory a safer place. Which safety symbols and procedures do you need to know? Find out in the next two activities.

DidYouKnow?

Modern chemists must always be alert for safety concerns. Some chemicals can be very dangerous either alone, or in combination with other chemicals. In 1995 a chemist was studying how heavy metal poisons cause damage to human cells. She wore latex gloves as she carefully poured a mercury compound into a tube. A tiny amount of the toxic compound accidentally spilled onto her glove. Within 15 s the compound was absorbed through the glove into her skin. Less than a year later, the chemist died from mercury poisoning.

Find Out ACTIVITY

Put Safety First

Are you familiar with the Workplace Hazardous Materials Information System (WHMIS) Safety Symbols? Do you recognize the safety symbols that appear within this textbook?

Procedure

1. Turn to Skill Focus 1, Safety Symbols. Read about the WHMIS symbols and the safety symbols used in this textbook.

2. Copy the following descriptions of products into your science notebook.

3. Sketch the corresponding WHMIS safety symbol next to each description. Record an example of each.

4. **Communication and Teamwork** Find a partner and quiz each other about the safety symbols used in investigations in this textbook. Turn to several investigations and ask each other what the symbols mean.

What Did You Find Out?

1. Which WHMIS symbols do you think you might see on materials in this unit?

2. List the safety symbols displayed in investigations and activities in this unit.

3. Why is it important for you to recognize safety symbols?

Description	Symbol	Example
Compressed gas		
Poisonous and infectious material causing immediate and serious toxic effects		
Poisonous and infectious material causing other toxic effects		
Oxidizing material		
Flammable and combustible material		
Corrosive material		
Biohazardous infectious material		
Dangerously reactive material		

Find Out ACTIVITY

Fasten Your Safety Seat Belt

As you read these words, hundreds of scientists are working in laboratories across Canada learning more about the chemicals we use every day. The most important part of every one of those laboratories is the safety equipment. Where is the safety equipment in your laboratory? Do you know how to use it? Suppose you cut yourself during an investigation. Would you know where to find the first-aid kit?

Procedure

1. Review the sample list of safety equipment.
2. Draw a large, aerial (bird's-eye) view of your classroom.
3. Clearly label the name and location of each piece of safety equipment in your classroom.
4. **Communication and Teamwork** Work with a partner or in a small group. Take turns quizzing each other about the location and use of each piece of safety equipment.

Sample List of Safety Equipment

fire extinguisher	fire exit
fire blanket	acid neutralizer
safety goggles	base neutralizer
aprons	eyewash station
broken glass container	telephone
	dustpan and brush
first-aid kit	safety charts
WHMIS chart	safety shield

What Did You Find Out?

1. Which piece of equipment do you feel is the most important? Why?
2. Why must all broken glass be put in a special container?
3. What other special storage containers are in your classroom?

Extend Your Skills

4. What type of fire extinguisher is in your classroom? How is it used?
5. Make a list of the safety equipment you have in your home. Which equipment do you know how to use?
6. How are toxic wastes, such as paint and used batteries, disposed of in your community?

Computer CONNECT

Use the keywords "WHMIS symbols" to start an Internet search. Find a site displaying the WHMIS symbols. Download the symbols and use them to create a safety poster, website, or brochure. Be sure to follow your school's guidelines for downloading information.

Figure 2.1 Which WHMIS symbols can you find on these containers?

Classifying Matter

Chemistry includes facts and observations about matter, laws that summarize patterns of behaviour in matter, and theories that explain the patterns of behaviour. For example, you may recall the particle model of matter from your earlier studies. This model is summarized below.

The Particle Model of Matter

- All matter is made up of extremely tiny particles.
- Each pure substance has its own kind of particle, different from the particles of other pure substances.
- Particles attract each other.
- Particles are always moving.
- Particles at a higher temperature move faster on average than particles at a lower temperature.

The particle model of matter is one example of a scientific model. Scientific models help us to visualize processes that cannot be seen directly. For example, in the particle model of matter, the individual particles would be far too small and move too quickly to be observed directly. You can use the first two points of the particle model to imagine how particles might make up substances. The other three points of the particle model can explain properties such as density and how matter behaves when temperature changes occur.

You have already learned that matter can be classified according to its state as a gas, a liquid, or a solid (see Figure 2.2).

Skill FOCUS

For more information about scientific models, turn to Skill Focus 12.

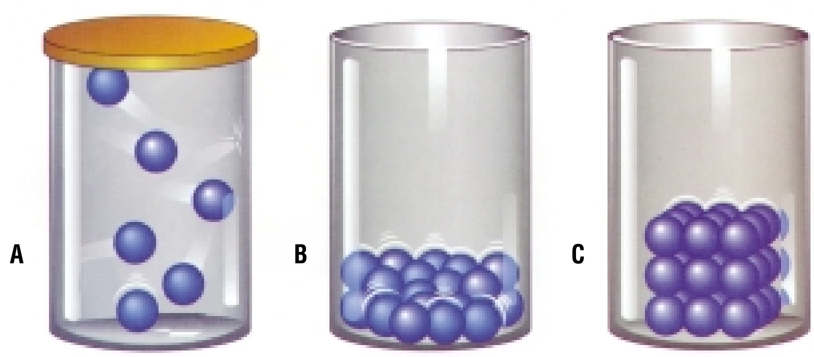


Figure 2.2 Attractive forces between particles are weakest in gases (A), stronger in liquids (B), and strongest in solids (C). Note that gas particles are much farther apart than shown here.

Pause & Reflect

Based on the particle model, draw simple sketches in your Science Log to illustrate the following:

- evaporation of water from a puddle
- solidification of hot liquid lava on a mountainside
- a cold lake
- a hot bath

Matter can be further classified according to its composition as a mixture or a pure substance (see Figure 2.3 on the next page). Each pure substance contains its own unique kind of particle. Mixtures contain at least two kinds of particles.

Mixtures can be classified by their properties. If the particles are uniformly scattered, the mixture is **homogeneous**. If the particles are not uniformly scattered, the mixture is **heterogeneous**.

The classification chart in Figure 2.3 is based on the particle model. However, there is more than one way to classify matter. In this unit, you will see other ways that chemists use to classify thousands of pure substances and millions of mixtures.

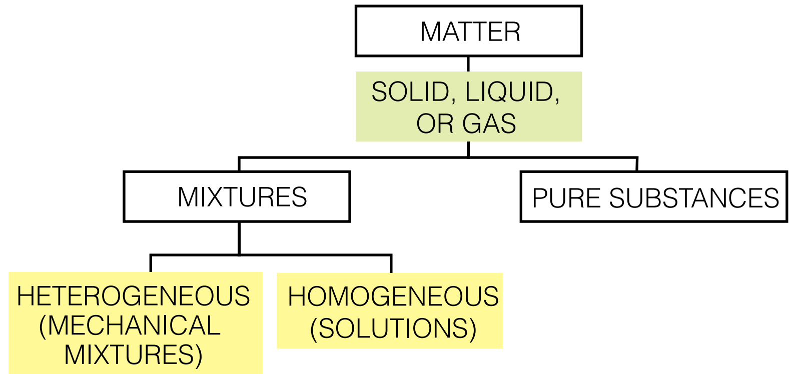


Figure 2.3 A classification system based on the particle model

Find Out **ACTIVITY**

A Classification Puzzle

Brush up on your classification skills by classifying several samples of matter.

Materials

8 vials containing unidentified mixtures or pure substances (provided by your teacher)

Appendix C: Properties of Common Substances

Procedure ✱ Performing and Recording

1. Copy the table below to record your observations and inferences. Give your table a title.

Vial number	Observations	Probable classification	Reason for classification	Probable identity

2. Your teacher will give you eight vials that contain unidentified samples. Three vials contain heterogeneous mixtures, three contain pure substances, and two contain homogeneous solutions. Inspect the contents of each vial visually. *Do not open the vials.*
3. Examine the following list: calcium carbonate (chalk, crushed), carbon (graphite), copper (II) sulfate, glycerol (glycerine), iron filings, rock salt, sugar, vegetable oil, water, and zinc. The vials contain only materials in this list, but some vials may contain two of the materials.
4. Using your observations, classify each sample as homogeneous or heterogeneous. Determine a probable identity for each substance in each heterogeneous mixture using your observations and Appendix C. Record your ideas in your chart.
5. You should now have five vials that are unidentified. These vials contain homogeneous materials. Using Appendix C and your observations, find the three pure substances. Determine a probable identity for each pure substance. Record your ideas in your chart.
6. The remaining two vials contain solutions. Use your observations and Appendix C to determine a probable identity for each substance. Record your ideas in your chart.

What Did You Find Out? ✱ Analyzing and Interpreting

1. How are solutions different from mechanical mixtures? What similarities do they have?
2. Which vials contained materials that were difficult to classify? Why were they difficult?

Extension

3. Examine bottles and jars in your refrigerator at home. Classify the contents as mixtures or pure substances. Which are more common?

Mixtures of Matter

Most matter is found in the form of homogeneous or heterogeneous mixtures. Homogeneous mixtures (solutions) are usually clear if they are liquids and cannot be filtered to separate the particles. The scattering of light cannot be seen when you shine a flashlight in a solution. Heterogeneous mixtures (mechanical mixtures) can be further classified based on the size of particles (see Figure 2.4).

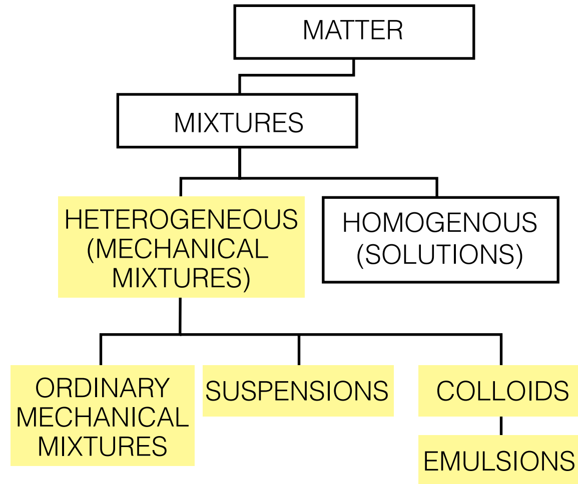


Figure 2.4 A classification of heterogeneous mixtures

In ordinary mechanical mixtures, the different parts are big enough to see, and they stay mixed. For example, granite is an ordinary mechanical mixture because you can see the particles of quartz, feldspar, and mica.

A suspension is a heterogeneous mixture made of large particles that are uniformly mixed but will settle if left undisturbed. Examples of suspensions include flour, charcoal, or powdered chalk mixed in water. Suspensions can be separated by filtering and will scatter light.

Colloids are heterogeneous mixtures composed of fine particles evenly distributed throughout a second substance. Examples of colloids include hair gel and clouds. Whether a mixture forms a solution, colloid, or suspension depends on the size of the particles, solubility, and mixing ability (miscibility).

Emulsions are types of colloids in which liquids are dispersed in liquids. Examples of emulsions include mayonnaise, milk, jelly, and salad dressing. Many emulsions quickly separate to form layers of the original liquids. For example, shaking oil and vinegar salad dressing creates an emulsion, but the dressing soon separates into layers of oil and vinegar. The addition of an emulsifying agent may keep a liquid dispersed in another liquid. If a suitable emulsifying agent is added to oil and vinegar salad dressing, the oil droplets cannot clump together to form a separate layer. You will investigate emulsions in the next Find Out Activity.

Figures 2.5A and 2.5B One way to tell the difference between a solution and a colloid is to shine a light through them. A solution will not allow the light to scatter. A colloid will scatter the light because the particles are larger than those in a solution. This light-scattering property of colloids is called the Tyndall effect. Is the fog shown in the picture a colloid or a solution?

STRETCH Your Mind

Have you seen what happens when drops of detergent are added to a mixture of homogenized milk and food colouring? Try it. The results are quite amazing. Milk is a type of hydrophilic ("water loving") colloid. Fat stays suspended in the milk because of the emulsifying agent casein. The water-loving casein attaches itself to the water and the fat therefore stays suspended. One part of a detergent particle is hydrophilic and another part is hydrophobic ("water hating"). Use this information to explain what happens when detergent is added to the milk and food colouring mixture. Draw a diagram. Can you explain how detergents are able to remove an oil molecule from the water?

Find Out ACTIVITY

Keep It Together

Without emulsifying agents, many products would have to be shaken before being used. Try this activity to see which ingredients work as emulsifying agents. Be sure to measure all substances carefully.

Safety Precaution

Materials

medicine dropper	vinegar
test tubes	cooking oil
test tube rack	eggs
masking tape	baking soda
rubber stoppers	dishwasher liquid
metric measuring spoon	cornstarch

Procedure ✸ Performing and Recording

1. Label seven test tubes from 1–7 and place them in a test tube rack or large beaker.
2. Measure 5 mL of vinegar and 5 mL of cooking oil into each test tube.
3. Test tube 1 will be the control for the investigation. After you have added substances to the other test tubes, they can be compared to test tube 1.
4. Add ten drops of egg yolk to test tube 2. Stopper the test tube and shake for 60 s. Does the mixture separate or remain a suspension? Record your observations.
5. Repeat step 4 for test tubes 3–7, but instead of egg yolk, use egg white in #3, beaten eggs in #4, 1 mL baking soda in #5, dishwashing liquid in #6, and 1 mL cornstarch in #7. Record all observations carefully.

What Did You Find Out? ✸ Analyzing and Interpreting

1. Which substances acted as emulsifying agents?
2. Did you make any permanent suspensions?
3. Which substances did not make emulsions? Why do you think this happened?

Extensions

4. Look on the labels of liquid food products at home. Which contain emulsifying agents? What would happen if the emulsifying agents were not present?
5. Look on the labels of personal care products at home. Which contain emulsifying agents? What would happen if the emulsifying agents were not present?

TOPIC 1 Review

1. Draw the WHMIS symbols for three hazardous materials. Explain the meaning of each.
2. List eight pieces of safety equipment you feel are necessary for a safe school science laboratory.
3. Use the particle model to explain the differences among a pure substance, a solution, and a mechanical mixture. Give one example of each.
4. Classify each of the following as a pure substance, a mechanical mixture, or a solution. How did you decide for each?
   (a) soil
   (b) perfume
   (c) baking powder
   (d) glass cleaner
5. **Thinking Critically** When most people think of solutions, they think of a solid dissolved in a liquid. Solutions that involve other states of matter are possible. Give an example of each solution below.
   (a) gas dissolved in a gas
   (b) gas dissolved in a liquid
   (c) liquid dissolved in a liquid