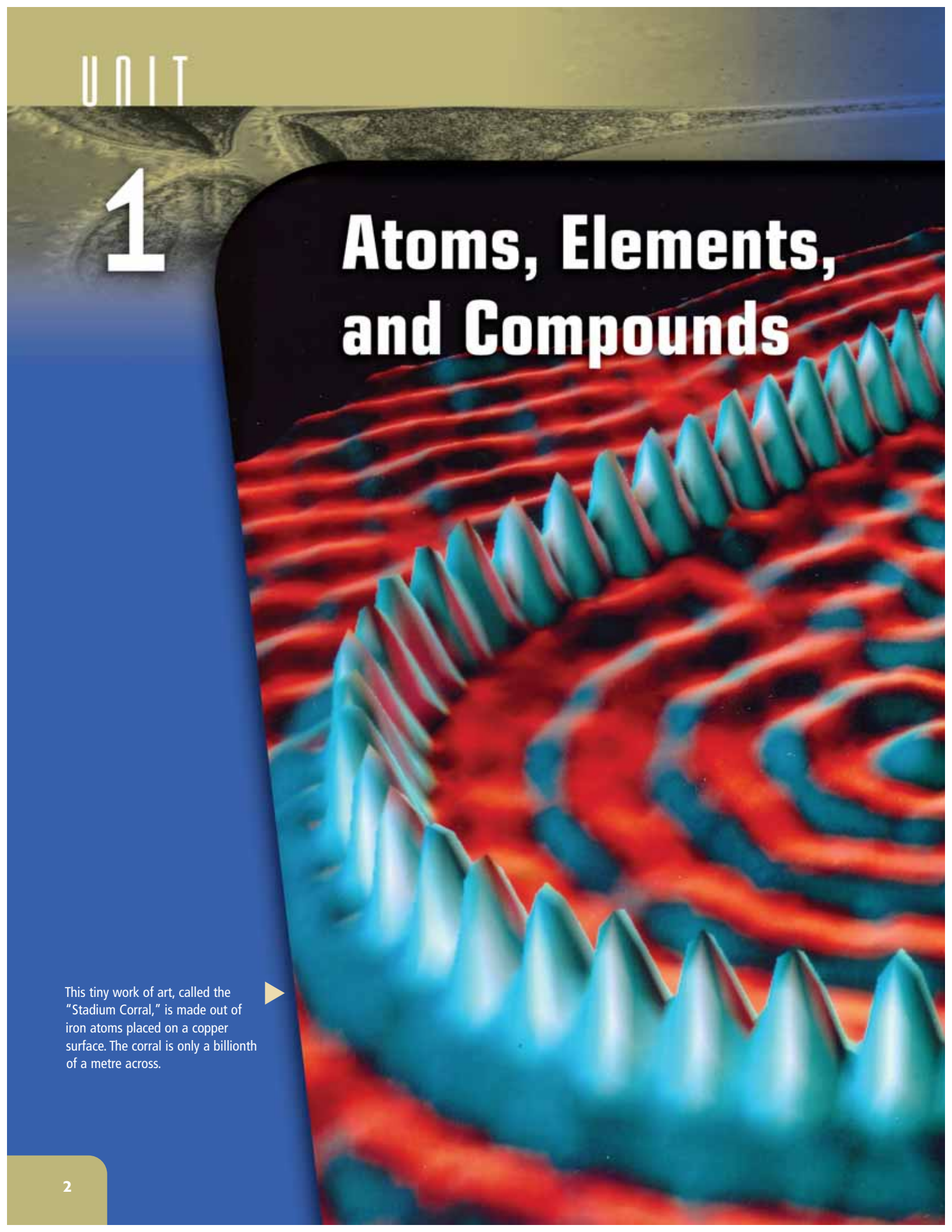
UNIT

1 Atoms, Elements, and Compounds



This tiny work of art, called the "Stadium Corral," is made out of iron atoms placed on a copper surface. The corral is only a billionth of a metre across.

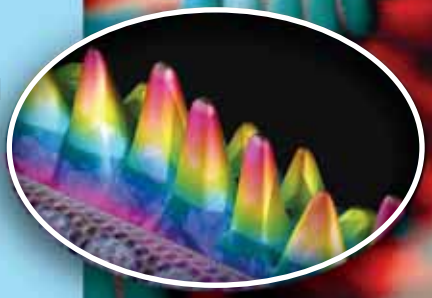
Key Ideas

1 **Atomic theory explains the composition and behaviour of matter.**

1.1 Safety in the Science Classroom
1.2 Investigating Matter
1.3 Atomic Theory

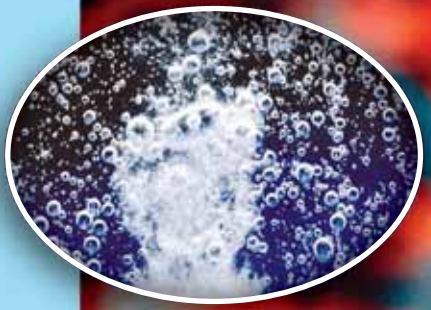
2 **Elements are the building blocks of matter.**

2.1 Elements
2.2 The Periodic Table and Chemical Properties
2.3 The Periodic Table and Atomic Theory



3 **Elements combine to form compounds.**

3.1 Compounds
3.2 Names and Formulas of Ionic Compounds
3.3 Physical and Chemical Changes



Getting Started

Wastewater can contaminate fresh water sources

Water: we drink it, bathe in it, and grow crops in it. When it is in its liquid state, we play in it, like the kayaker shown here. When it is in its solid state we can ski, skate, and walk across it. Regardless of what state water is in, the tiny particles that make up water stay the same.

Unfortunately, we sometimes add pollutants to water, such as when we mishandle sewage wastes, dump inappropriate chemicals down our sinks, or allow toxic effluents from industry to mix with the water in our streams and lakes.

You may have heard of pollutants such as dioxins, methyl mercury, and lead. All of these chemicals are dangerous water contaminants that can cause disease, nerve damage, and cancer. There are places where these contaminants, as well as others, are present in community water supplies. Thankfully, research is providing new solutions for purifying contaminated water.

In nature, water is purified as it evaporates from the salty oceans and falls back to Earth as pure rainwater. The ground itself is a water filter. Water can flow hundreds of kilometres underground through sand and gravel formations and be cleaned in the process. Forests and woodlands act as natural sponges by slowing water flow, allowing microbes to absorb chemicals, purifying the water. Certain chemicals in the rocks can even destroy some harmful pollutants.

Lee Wilson is an award winning research chemist and a member of the Canadian Métis community. The first person from his village to earn a PhD in chemistry, he applies his understanding of the properties of matter to solving the problem of contaminated water.

Wilson's research involves developing materials with microscopic holes just the right size to trap the particles of pollutants but still let the particles of clean water pass through. Different-sized pores can be manufactured to capture different sizes of pollutants.

Imagine being able to place a pump into polluted water and out of the other end comes water fit to drink. Now imagine being able to do this for an entire village or town. In a world where clean water is in short supply, ways to make water clean and keep it clean will always be in demand.

Lee Wilson

internet connect

Find out more about the work of Lee Wilson and his colleagues. Visit **www.bcscience9.ca.**

Combining Chemicals

Find Out ACTIVITY

In this activity, you will describe the changes that occur when various chemicals are combined in a beaker.

Materials

- 400 mL beaker
- 50 mL water
- 150 mL vinegar
- 5 raisins
- 25 g baking soda

What to Do

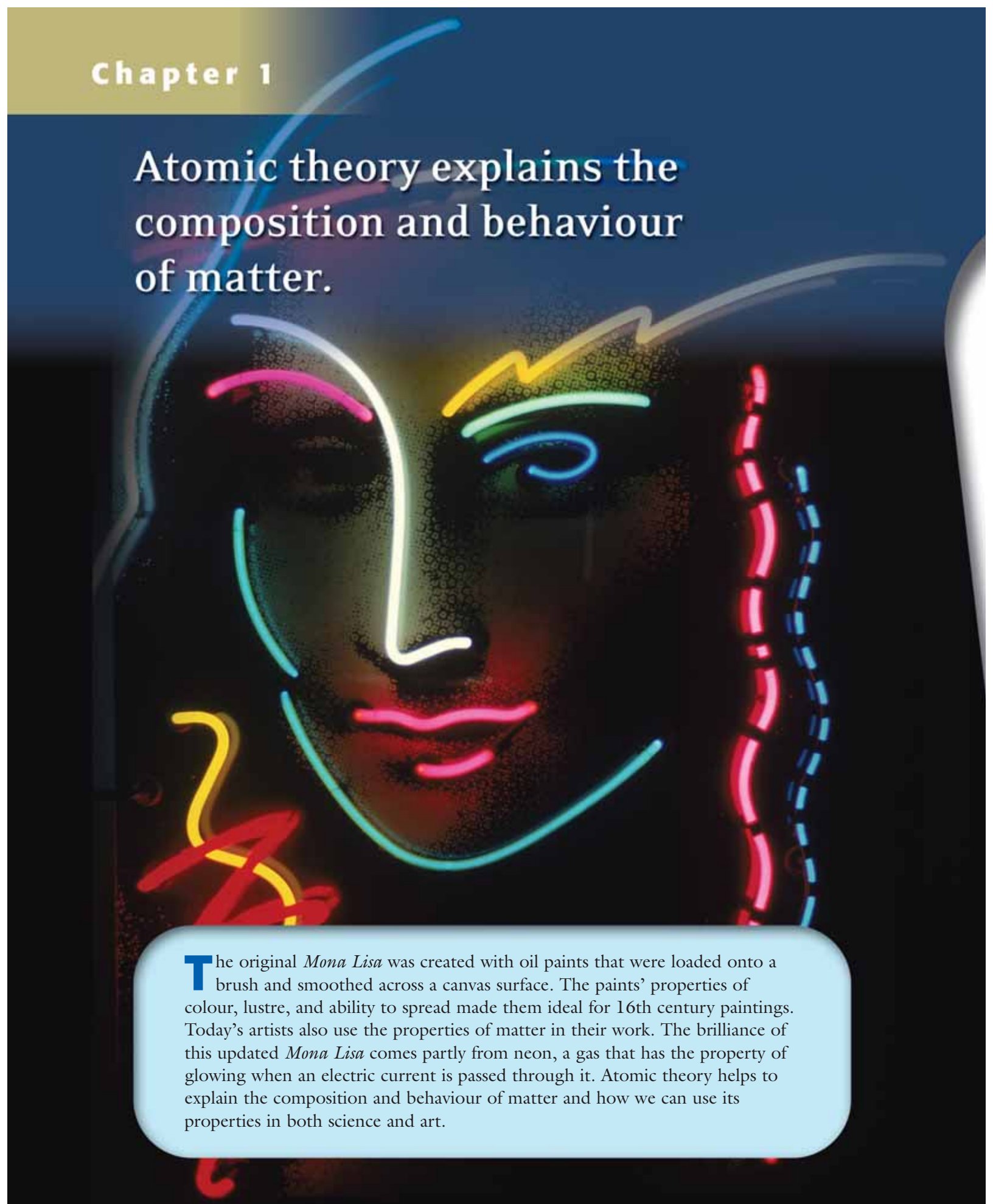
1. Pour 50 mL of water into the 400 mL beaker.
2. Add 150 mL of vinegar to the beaker of water. Record your observations.
3. Add the raisins to the beaker. Record your observations.
4. Slowly add the 25 g of baking soda to the beaker. Immediately record your observations and then describe any changes that occur at 1 min, 3 min, and 5 min.

What Did You Find Out?

1. List and describe the different changes you observed in the beaker.
2. What happened to the solid baking soda that you added to the beaker?
3. Describe and explain what happened to the raisins after the baking soda was added.

Chapter 1

Atomic theory explains the composition and behaviour of matter.



The original *Mona Lisa* was created with oil paints that were loaded onto a brush and smoothed across a canvas surface. The paints' properties of colour, lustre, and ability to spread made them ideal for 16th century paintings. Today's artists also use the properties of matter in their work. The brilliance of this updated *Mona Lisa* comes partly from neon, a gas that has the property of glowing when an electric current is passed through it. Atomic theory helps to explain the composition and behaviour of matter and how we can use its properties in both science and art.

What You Will Learn

In this chapter, you will

- **explain** the three states of matter using the kinetic molecular theory
- **identify** physical properties of matter
- **describe** the development of the atomic theory
- **identify** and **describe** three subatomic particles that make up an atom

Why It Is Important

Matter can appear in many forms. One way scientists try to understand matter is by studying its properties. Another way is by using models to describe the nature of matter itself. Both methods enrich our understanding of the physical world.

Skills You Will Use

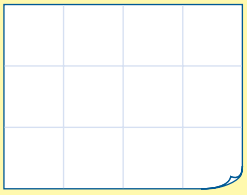
In this chapter, you will

- **work** co-operatively and safely in a laboratory setting
- **observe** differences in the properties of various substances
- **explain** subatomic particles based on their properties and location in an atom
- **use** models to understand the structure of matter

FOLDABLES™
Reading & Study Skills

Make the following Foldable and use it to take notes on what you learn in Chapter 1.

STEP 1 **Fold** a sheet of large paper to form four columns and three rows.



STEP 2 **Label** the columns as shown below.

Chapter 1	Solid	Liquid	Gas

STEP 3 **Label** the rows "Physical Properties" and "Kinetic Molecular Theory."

STEP 4 **Use** the table to take notes on each state of matter.

Chapter 1	Solid	Liquid	Gas
Physical Properties			
Kinetic Molecular Theory			

Organize As you read this chapter, use your Foldable to organize your notes on the physical properties and the kinetic molecular theory as they relate to the states of matter. On the back of the Foldable, sketch a time line and use it to describe the development of the atomic theory, and include information on the identification of subatomic particles.

1.1 Safety in the Science Classroom

Safe practice in the science lab includes knowing how to behave safely during lab activities and what to do in an emergency. Lab safety rules restrict certain kinds of activities, such as horsesplay or eating during a lab. But they also make it possible for you to safely carry out investigations that contain an element of risk. Warning labels are used on commercial, industrial, and home products that contain hazardous chemicals. Several labelling systems are used, including the Workplace Hazardous Materials Information System (WHMIS).

Words to Know

hazard symbol
WHMIS

Welcome to the science laboratory! In this unit, you will gain experience observing and controlling changes in matter. Experimenting is a central part of science, and no study of chemistry is complete without it (Figure 1.1). In all activities, you must make safety the first priority. Remember to stay alert in experiments and watch out for your safety and the safety of others.

Make Safety Your First Priority

You need to be careful and considerate in the laboratory. But more than good behaviour is required. To be able to work safely and with confidence, you must have the right kind of knowledge, an awareness of what is happening, and an ability to act.

You need to know safety rules *before* you start a science activity. This knowledge helps you prevent accidents. For example, to prevent broken glass or a chemical damaging your eyes, wear safety eyewear.

Know and follow the safety rules in your lab and know what to do in an emergency. General rules about safety are explained in this section. Your teacher will help you apply the rules to your science classroom.

You need to be aware of safe procedures *while you are doing* your lab activity. Be careful of what you are doing and also of what others are doing.

Figure 1.1 Many discoveries in chemistry are based on experiments done in laboratories.

You can put your knowledge and awareness to good use by acting to prevent or deal with an accident. Most accidents can be prevented. When you spot an emergency, first call out a general warning loud and clear, such as "Fire!" or "Help!"—and then take action.

In an emergency, *you do not need permission* to use emergency equipment—just recognize the emergency and take action. Always act first to protect yourself and others from harm. To do this, you need to know where the emergency equipment is in your lab and how to use it. Your teacher will show you.

Did You Know?

Accident rates for workers in British Columbia are highest for young and newly hired employees. This is because safe skills need to be learned and practised until they become second nature.

1-1A Science Lab Safety

Think About It

Safe lab procedures include anticipating dangers and recognizing them when they occur. In this activity, you will identify unsafe practices shown in the illustration. Some are obvious, while others are more subtle. Try to find as many as you can.

What to Do

1. Work with a partner. Identify as many unsafe practices as you can find in the illustration.
2. Make a three-column table. In the first column, list the unsafe practices you have identified. In the second column, list an injury that might occur as a result of each practice. In the third column, suggest a safer, better way to carry out each procedure.

What Did You Find Out?

1. Share your observations with your class.
2. Add to your list any observations another group made that you had not already identified.

Rules to Help You Stay Safe

Rules for safe conduct in the lab are based on common sense and knowledge of safe lab practices and procedures. Keep in mind that careful and orderly behaviour is not just good manners, it protects you and others from dangerous situations that might occur.

Here is a list of safety rules that apply to all lab work in science.

Safety Rules for the Science Lab

General

1. Always work under supervision and only on approved activities. Never change a procedure without your teacher's permission.
2. Make sure you know the procedure and have read it over before you start an experiment.
3. Make sure you know how to use your lab equipment properly before you start an experiment.
4. Always use appropriate protective equipment, such as a lab apron or protective eyewear. Tell your teacher if you are wearing contact lenses.
5. Do not wear loose clothing, sandals, or open-toed shoes.
6. Do not eat, drink, or chew gum in the laboratory.
7. Never engage in horseplay.
8. Know the location and use of all emergency equipment and emergency exits (Figure 1.2).
9. In case of an emergency, follow procedures your teacher has taught you. Use whatever emergency equipment is appropriate to respond to the emergency. Act immediately to protect people first and then equipment.

Glassware

10. Never use broken or chipped glassware. Dispose of it in a "sharps" bucket or as your teacher directs. Use clean glassware, and after use wash it, or put it in an approved place to soak.

Chemicals

11. Know the safety precautions and hazards for all chemicals you are using before you start your lab.
12. If you come in contact with a substance, wash the affected area immediately and thoroughly with water. If you get anything in your eyes, do not touch them. Wash them immediately and continuously for 15 minutes and inform your teacher.

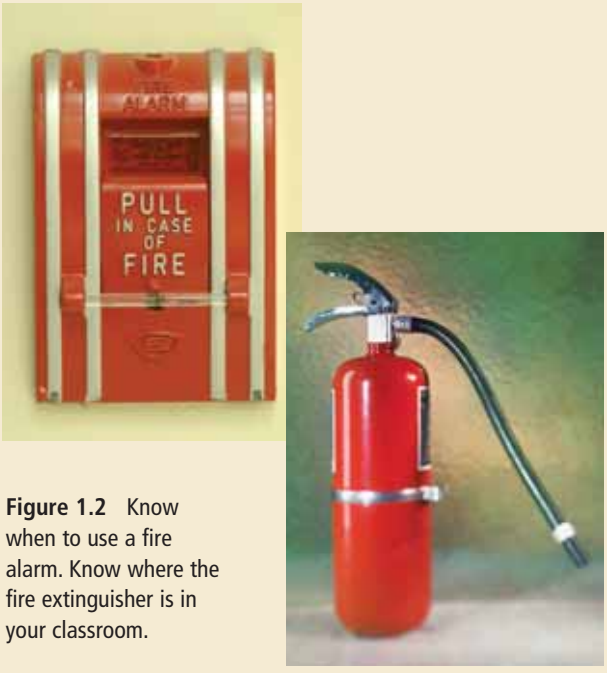


Figure 1.2 Know when to use a fire alarm. Know where the fire extinguisher is in your classroom.

13. Hold containers away from your face when pouring liquids.
14. Read labels on containers. Never use a chemical from a container that does not have a readable label. Take it to your teacher.
15. When in the lab, never put anything in your mouth such as fingers, equipment, hair, pencils, or chemicals that you are working with, even if they are food items.
16. Never return a chemical to its original container. Doing this could contaminate the original stock.
17. Never put any chemical down the sink or into the garbage without permission.
18. Clean up any spills according to your teacher's instructions.
19. If you are asked to smell a substance, never smell it directly. Hold the container at arm's length and waft fumes toward you. Gradually bring the container closer to your nose until you can smell the fumes safely (Figure 1.3).

20. When diluting a concentrated acid with water, add the acid to the water, not the water to the acid. This prevents sudden overheating of the water.

Hot Plates and Open Flames

21. Handle hot objects carefully. Be especially careful with a hot plate even if it looks as though it has cooled down.
22. Know how to light and operate a Bunsen burner.
23. Tie back long hair and avoid fuzzy clothing and long sleeves when you are in an area with open flames.
24. Never leave an open flame unattended, even for a moment. Assign someone else to watch it, or turn the flame off.

Electrical Equipment

25. Make sure your hands are dry when touching electrical cords, plugs, or sockets.
26. Pull the plug, not the cord, when unplugging electrical equipment.
27. Report frayed cords and any other damaged equipment to your teacher.
28. If any electrical component becomes hot during an activity, disconnect the circuit immediately.

Figure 1.3 Never smell anything in the lab directly. Always waft the fumes toward your nose.

Reading Check

1. What do you need to know before you start a science activity?
2. What should you do if you begin using a piece of glassware and then discover it has a small chip or nick in it?
3. Explain what is incomplete about the following rule: Never taste a chemical.
4. What should you do with a chemical container that has a label you cannot read?
5. Describe the safe way to smell a substance.

WHMIS Symbols

An important safety step when using any chemical, whether around the home, in the lab, or in the workplace, is to check the warning symbols on the container. The **Workplace Hazardous Materials Information System (WHMIS)** is used to ensure that everyone has access to appropriate safety information about any hazardous substance they may encounter that is manufactured and sold. In this system, eight symbols provide easy-to-read warnings. A chemical container may have one or more of the symbols shown in Figure 1.4.

Figure 1.4 WHMIS symbols

Other Safety Hazard Symbols

Many products ranging from household cleaners to spray paints are labelled with another type of safety **hazard symbol** (Figure 1.5). You may have noticed these symbols on products used at home in the laundry room or with garden equipment. Each hazard symbol provides two kinds of warnings:

- whether the hazard is the container or its contents, shown by the shape of the border
- the type of hazard—explosive, corrosive, flammable, or poisonous—shown by an image at the centre of the symbol

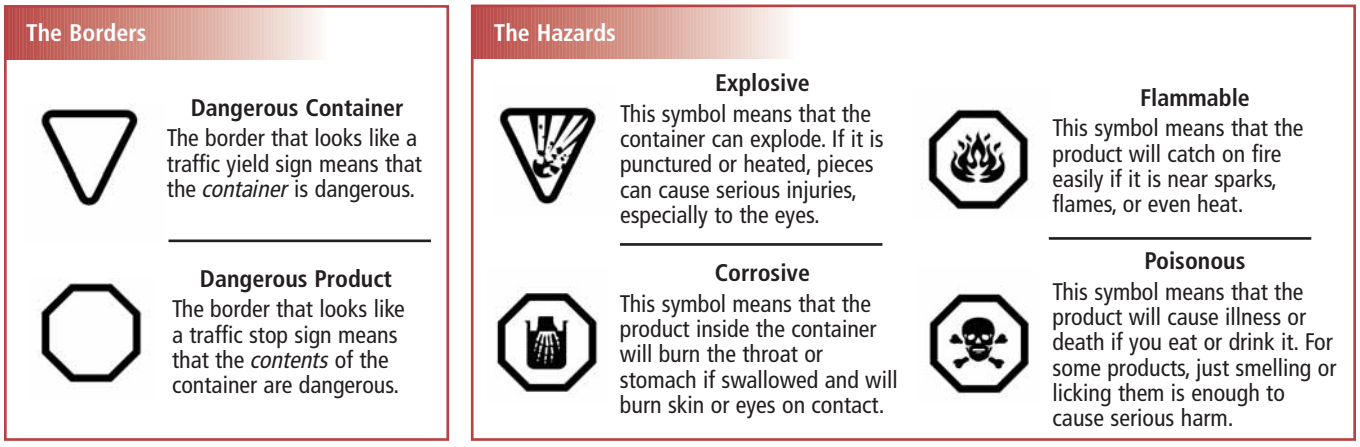


Figure 1.5 Watch for these symbols on products you use at home as well as those you see in the lab.

Reading Check

1. What does WHMIS stand for?
2. Name the hazard that each WHMIS symbol below identifies.

(a)  (b)  (c) 

3. Identify each of the following hazard symbols.

(a)  (b)  (c) 

Explore More

There is a Material Safety Data Sheet (MSDS) for every chemical used in school classrooms. Find out what an MSDS is. Read the MSDS for bleach or another chemical of your choice. Start your research at **www.bcscience9.ca**.

1-1B Safety Guidelines for Your Lab

Think About It

In this activity, you will select a safety rule listed on pages 10 and 11 or one provided by your teacher and create a poster illustrating the rule. Share your poster with your classmates and then develop safety guidelines customized for your classroom.

What to Do

Part 1

1. Select a safety rule. Think about a way to show the rule visually, such as using an image similar to direction signs in airports or using a short phrase.
2. On a sheet of paper, draw a poster that has strong visual impact and will be a good reminder of one particular rule. Make sure the poster can be read from at least 3 m away.
3. Present your poster to the class, explaining the rule and your choice of illustration.

Part 2

4. Work in pairs or small groups to develop a set of safety guidelines that could be used as a safety contract for the students in your classroom. Your guidelines should incorporate the following.
   - information from the class posters and *BC Science 9*
   - information specific to your class about location of safety equipment and procedures for evacuation
   - other information to ensure safe and responsible ways of working in your class
5. Share your contract with several other groups.

What Did You Find Out?

1. How could you improve your safety poster?
2. (a) How could you improve your safety contract based on what other groups have included in their contracts?
   (b) Make your refinements and sign your contract.

Science Watch

Chemistry in a House Fire

Your school has fire drills so you can practise fire safety. But fire safety is important in the home as well. Fire departments around the province recommend that your family have a fire safety plan for your home.

How can you make your home as safe as possible? Keep flammable clutter out of hallways, have functioning smoke and carbon monoxide detectors, and keep fire extinguishers in the kitchen, laundry room, and garage. You should also plan and practise escape from every room in your house.

If trouble should occur, flesh burns are not the only worry. When a home burns, many hot gases are generated. These are collectively called toxic fumes. "Toxic" means poisonous, and simply breathing toxic gases can cause you to lose consciousness long before the flames reach you.

When wood catches fire, carbon dioxide gas is the main product. It is not poisonous, but it replaces oxygen and can suffocate you. Burning wood also creates poisonous gases, the most dangerous being carbon monoxide. But the carbon monoxide released in a fire can also save your life. How? Carbon monoxide moves faster than the fire and can trigger a carbon monoxide detector alarm. Early detection means you can be alerted to the fire before the flames get near you.

The chemicals in paint, furniture fabric, carpeting, and insulation are considered safe under normal conditions. However, when these materials are heated in a fire they release poisons that can quickly make a person lose consciousness.

If a fire does break out in your house, you need to get out immediately using an escape plan you have practised. Do not run. If your clothes catch fire, STOP! DROP! and ROLL! To exit through smoke, crawl low with your face near the floor so you breathe in the cleanest and coolest air. Meet other family members outside and check that everyone is safe. Never go back into a burning house. And if you have not already done so, call your local fire department!

Questions

1. List four ways to make your home safer from fire.
2. Describe the safest way to move through smoke.
3. List two dangers from toxic fumes.

Check Your Understanding

Checking Concepts

1. For each of the following statements, decide whether it is true or false. If it is false, change the statement to make it true.
   (a) Broken or chipped glassware should be disposed of in the garbage.
   (b) If there is a fire, immediately ask the teacher for permission to use the fire extinguisher.
   (c) If the label on a chemical container is not readable or is missing, put it back where it was and do not use it.
   (d) Leftover chemicals should be returned to their original containers to prevent waste.
   (e) It is safe to leave an open flame to do something else if you get someone else to watch it for you.
   (f) Gum chewing is permitted in the lab.
2. Write the description of the WHMIS label that matches each of the following WHMIS hazard symbols.
   (a) a test tube with lines coming out of it superimposed on a large capital R
   (b) a skull and crossbones
   (c) a stylized T that looks like an exclamation mark (!)
   (d) two test tubes pouring liquid onto a hand and an object
   (e) a cylinder
   (f) a flame coming out of a flat line
3. What does each of the following warning labels mean?
   (a) 
   (b) 
   (c) 
   (d) 

Understanding Key Ideas

4. Explain the difference between knowledge of safety procedures and awareness of safety hazards.
5. List any safety rules your teacher has given you that relate specifically to your classroom.
6. List the steps you would take to deal with each of the following situations.
   (a) While you are using a hot plate to heat up a liquid, the fire alarm sounds.
   (b) You are heating a test tube in the flame of a Bunsen burner when you notice that your test tube has a chip near the top.
   (c) While you are using an open flame, the shirt of someone near you catches fire.
7. Make a sketch of your science lab or classroom showing the location of emergency exits, eyewash stations, fire extinguishers, and any other emergency equipment.

Pause and Reflect

Safety symbols are designed to protect people who work with chemicals. Why do commercial products such as bleach or drain cleaner not have WHMIS labels, but similar chemicals used in your science activities do have WHMIS labels?