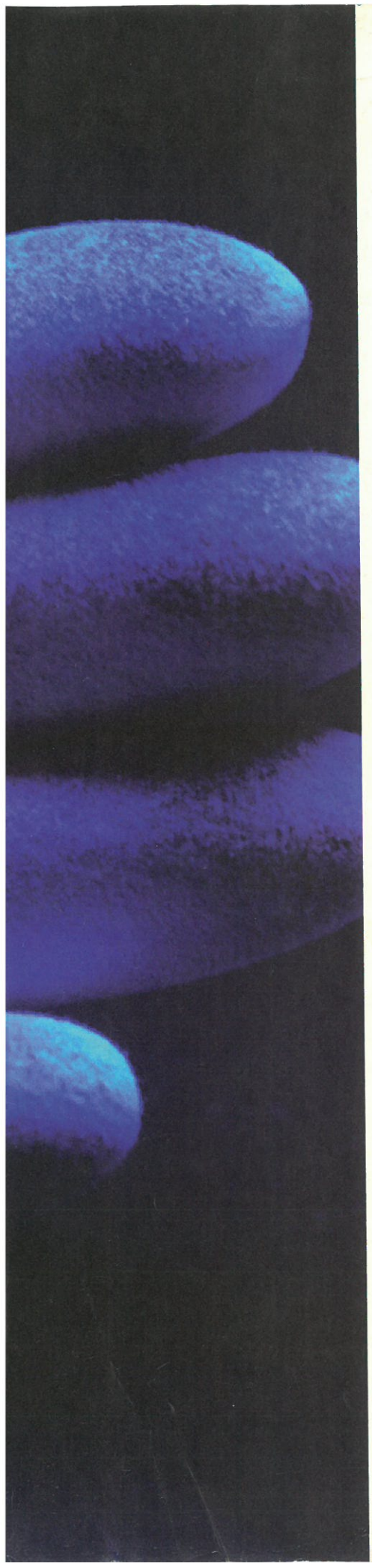


Chemical Processes

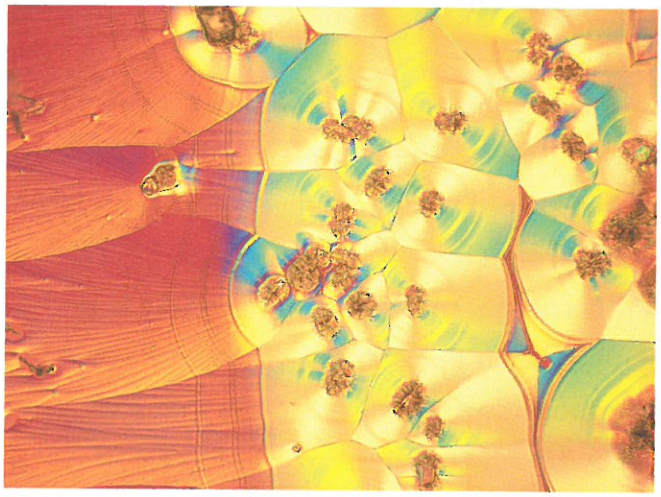
Chemical processes have a role in almost every aspect of everyday life. The clothes we wear, the food we eat, and the places where we live, work, and learn all contain the products of chemical reactions. The chemical industry that makes these products is a major driving force in our economy. Understanding chemical compounds and the reactions that they can undergo is key to developing new products and solutions to social and environmental problems.

Unit 2 Overview

Overall Expectations

In this unit, you will be able to

- describe chemical reactions and the symbolic systems used to describe them;
- investigate types of reactions and the factors that control their rates;
- develop an awareness of societal issues related to chemical compounds and their reactions.



Chapter 5
Chemicals in Action

Chemical compounds can be classified as ionic or molecular. These compounds can be represented with chemical formulas and naming systems. Both ionic and molecular compounds include naturally occurring and synthetic materials that can be used in a variety of products.

In this chapter, you will be able to

- recognize the relationships among chemical formulas, composition, and names;
- write the chemical formulas for ionic and molecular compounds, and name these compounds using appropriate vocabulary;
- perform chemical tests, including those to identify common gases, safely and accurately.

Chapter 6
Understanding Chemical Reactions

Chemical reactions can be classified according to the types of reactants involved. These reactions can be represented using word and balanced chemical equations. Chemical reactions can produce useful new products, but can also produce toxic substances that may affect the environment.

In this chapter, you will be able to

- apply the Law of Conservation of Mass to balance chemical equations;
- recognize and predict the products of different types of chemical equations;
- represent chemical reactions using word equations and balanced chemical equations;
- obtain qualitative and quantitative data to analyze patterns in chemical reactions, to compare theoretical and empirical values, and to calculate experimental errors;
- describe how an understanding of chemical reactions has led to the production of new consumer products and technological processes.

Chapter 7
Controlling Chemical Reactions

The speed or rate of chemical reactions can be affected by several factors, including temperature and concentration of reactants. Factors that affect rates of reaction can apply to laboratory experiments, to the production of chemicals in industry, and to common reactions around the home.

In this chapter, you will be able to

- explain how factors affect rates of chemical reaction;
- design and perform controlled experiments to gather experimental data and to investigate variables that affect rates of chemical reactions;
- identify everyday examples of ways in which rates of reaction are controlled.

Chapter 8
Acids and Bases

Acids and bases are compounds of particular interest because of their reactivity. They can be produced through the reaction of metals and nonmetals with oxygen and the reaction of their oxides with water. Acids and bases are important in many industrial reactions that produce both useful materials and pollutants.

In this chapter, you will be able to

- describe and experimentally investigate the relationships among metals, nonmetals, acidic oxides, basic oxides, acids, bases, and salts;
- describe acid-base neutralization and how the pH scale relates to the acidity of a solution;
- conduct experiments to identify the relative acidity or pH of common substances;
- explain how environmental challenges, such as acid rain, can be understood and addressed through a knowledge of acids and bases.

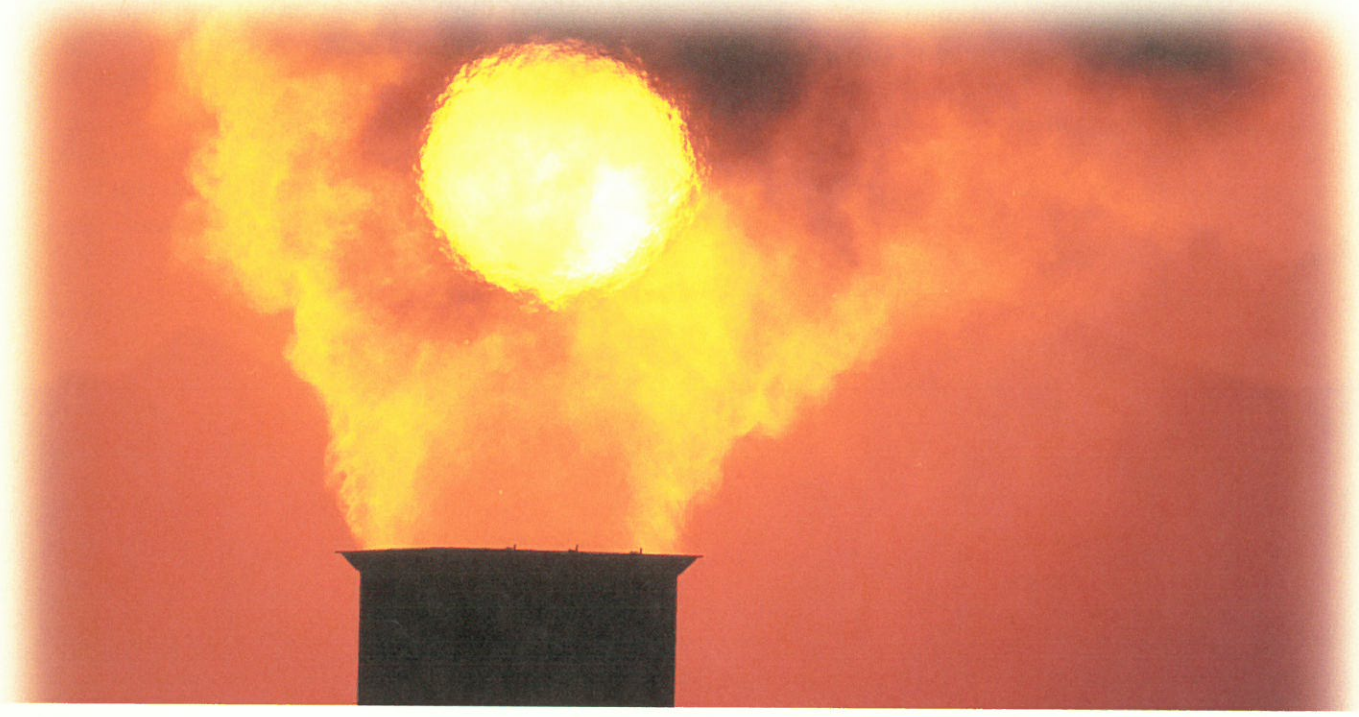
Chemistry and Society

Chemistry is the study of substances and their reactions. An understanding of chemical reactions allows us to invent new materials that have properties not dreamed of only a few decades ago. But understanding brings with it a responsibility to use these materials wisely.

You can practise chemistry by simply performing laboratory experiments; that way you will learn how chemicals interact. But the effects of science extend beyond the school walls. Learning about chemistry involves not only mixing substances in test tubes and researching specific topics, but also applying and extending the depth of your knowledge. As you learn about chemical processes, you will become more aware of the ways in which chemistry-related issues affect people's lives and our society as a whole.

As a citizen, you make personal choices and influence public decisions. Your growing knowledge of chemical processes will help you make informed decisions about issues that affect you in your home and community: Which products are most appropriate for a given use? Should tax dollars be spent on pollution control? Should the use of some chemicals be banned because of their effects on the environment? Should we be burning fossil fuels when these same fuels can be used to manufacture plastics? As a "chemistry-literate" citizen, you have the opportunity to help make better decisions as an individual and as a member of society.

As you work on one of the Challenges in this unit, you will learn in greater depth how our use and understanding of chemical processes benefit us, and how they require us to take responsibility for our actions.



CHAPTER

5 Chemicals in Action

Getting Started

WHAT IS CHEMISTRY?

Chemistry is the study of matter, its properties, and its changes or transformations. **Matter** is anything that has mass and takes up space. All types of matter have physical and chemical properties. One physical property is the state of matter (solid, liquid, or gas) at room temperature. Other physical properties include colour, odour, lustre, solubility, and melting and boiling points. A piece of solid granite found on a shoreline may be grey, hard, and crystalline. Hand lotions are opaque, white liquids at room temperature. The carbon dioxide gas that we exhale with every breath is colourless and odourless. Every day we use hundreds of different types of matter.

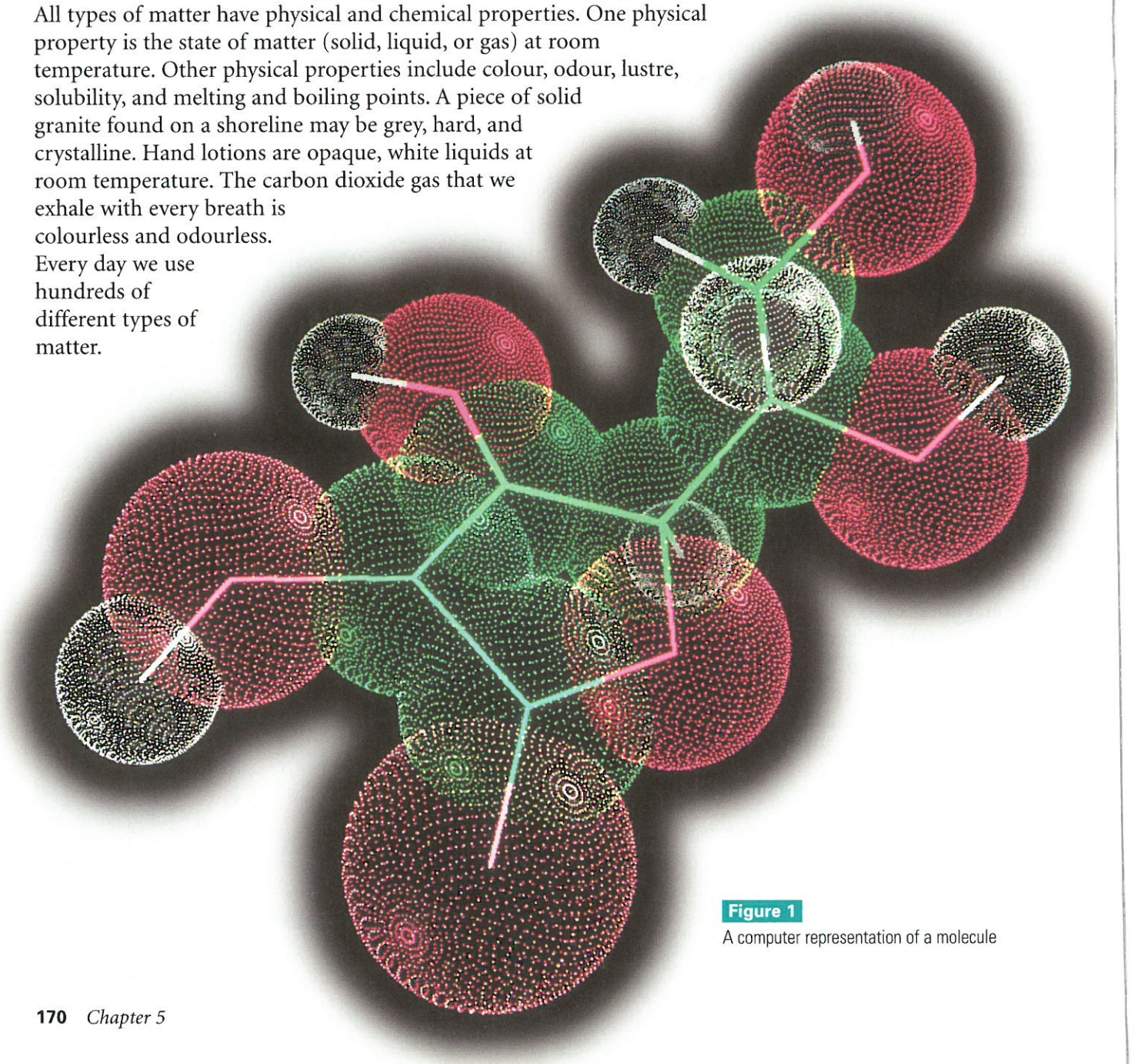
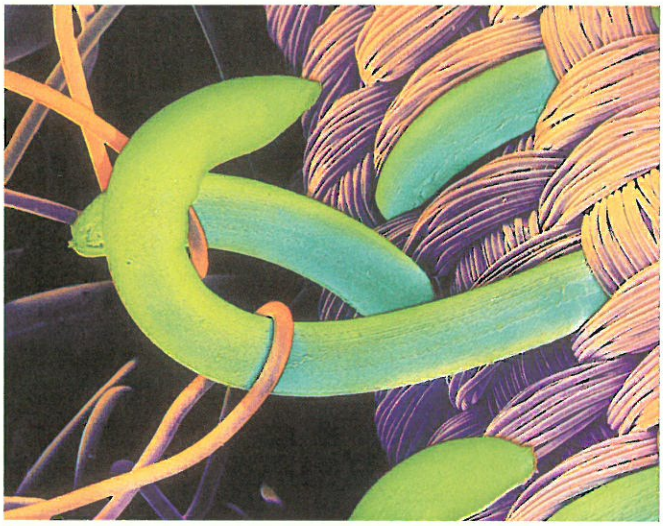


Figure 1
A computer representation of a molecule

Challenge

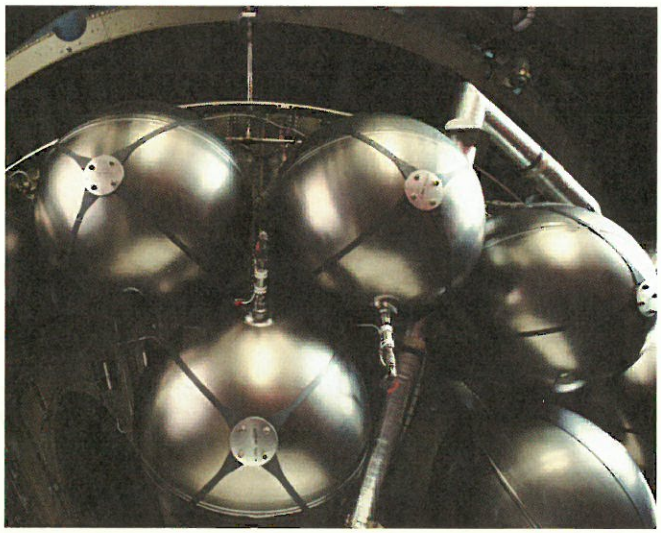
Assessing the Effects of Chemical Processes

As you learn about chemical processes, you will develop an awareness of the ways in which they may be applied and their impact on society.



1 Making a Consumer Product

The consumer products that we use today are made of a much wider variety of synthetic substances than those of 40 years ago. Choose a product and identify the materials that it is made of. Find out where the raw materials come from, and identify the chemical processes used to transform the raw materials into the product. Finally, assess the effects these processes have on society.



2 Marketing Alternative Fuels

Chemical reactions are used to propel most of our vehicles, even battery-powered toys. Research the substances and chemical processes that are used to power vehicles today. Then research alternative sources of chemical energy, such as hydrogen power, fuel cells, or more efficient batteries. Choose one of these sources and prepare a marketing proposal in which you promote your choice as the fuel of the future.

3 Acid Rain Action Plan

Acid rain is a product of our lifestyles. The demand for electricity and, in particular, our consumption of fossil fuels create huge amounts of air pollutants. Create an education plan that explains to people how their lifestyle decisions affect the production of acid rain. Then develop an action plan that could be used in your school or community to change people's attitudes and encourage them to adopt more "environment-friendly" habits.

Record your ideas for your Challenge as you progress through this unit, and when you see

Challenge

Why are some chemicals safe and others dangerous to use? Chemists are trained to work safely with a variety of substances. Corrosive acids, reactive metals, and poisonous powders must all be used and disposed of safely. More importantly, everybody needs to understand the chemical properties of substances because they determine the changes or transformations that substances may undergo. Some substances, such as salt, simply dissolve when added to water. Other substances, such as household cleaners contain "active ingredients" that cause chemical reactions and should be used with caution.

How does chemistry affect our everyday life? Everything in the world involves chemistry because everything in the world is made of matter. Water, sand, and the oxygen in the air are substances that have always existed. Other molecules, such as DNA, have always existed, but have only been recently understood. Still other substances have been created in the last few years by chemists. "Bucky-balls" and "super-magnetic" ceramics have existed for only a few years. Scientists are constantly developing new drugs that fight cancer and other diseases.

Reflect on your Learning

1. Make a list of what you think are the 10 most important examples of matter that you encounter in a typical day.
2. What are five examples of substances that you might encounter in and around the home that need to be treated with care?
3. Make a table with two columns. In the first column, list chemical substances that you think have always existed; in the second column, list substances that you think have been developed and produced by people in the past 50 years.

Try This Activity Household Substances

We live in a world full of chemicals, and many of those chemicals are found in the home. The labels on household products, including foods and cleaners, often provide important information.

- With an adult's permission, find 5 to 10 household products that have labels. (Do not open the containers.) The information presented on the label can be qualitative (a list of ingredients) or quantitative (the percentage concentration of an ingredient). Note that product labels list the most abundant material first and the least abundant last.
- Make a table that summarizes the information, using the following questions as a guide:

(a) Describe the products you chose. Was there an "active ingredient" in each product? If the label listed a number of substances, what was the major ingredient?

(b) Was any quantitative information provided? For example, was the percentage concentration of an ingredient given?

(c) List any safety information or safety symbols that the labels provided. For example, was there a reference to daily use if the substance was a food? Were there any warnings, such as suggestions not to add the product to certain other materials?

(d) Describe any patterns in the amount and type of information that you noticed in certain groups of products: for example, were there similarities in the cleaning products?

5.1

Chemicals and Chemical Change

How can we make sense of the different types of matter that make up our world? Scientists classify matter either as pure substances or as mixtures (**Figure 1**). **Figure 2** shows the classification of matter.

Figure 1

A pizza and a soft drink are examples of mixtures of pure substances. Mixtures can be either solutions (homogeneous mixtures) or heterogeneous mixtures. Which one is a solution, and which one is a heterogeneous mixture?

Classifying Pure Substances

How do we know that a sample of matter is a pure substance? You have studied John Dalton's atomic model, which proposed that all matter is made up of particles. A **pure substance** is one in which all the particles that make up the substance are the same. As a result, the substance has constant properties. For example, pure water is a clear, colourless substance that freezes at exactly 0°C and boils at 100°C.

Chemists tend to classify pure substances on the basis of the particles of which they are made. In this system, pure substances are classified as elements or compounds. **Elements** are pure substances that cannot be broken down into simpler substances. Oxygen, hydrogen, iron, and mercury are elements because each contains only one kind of atom.

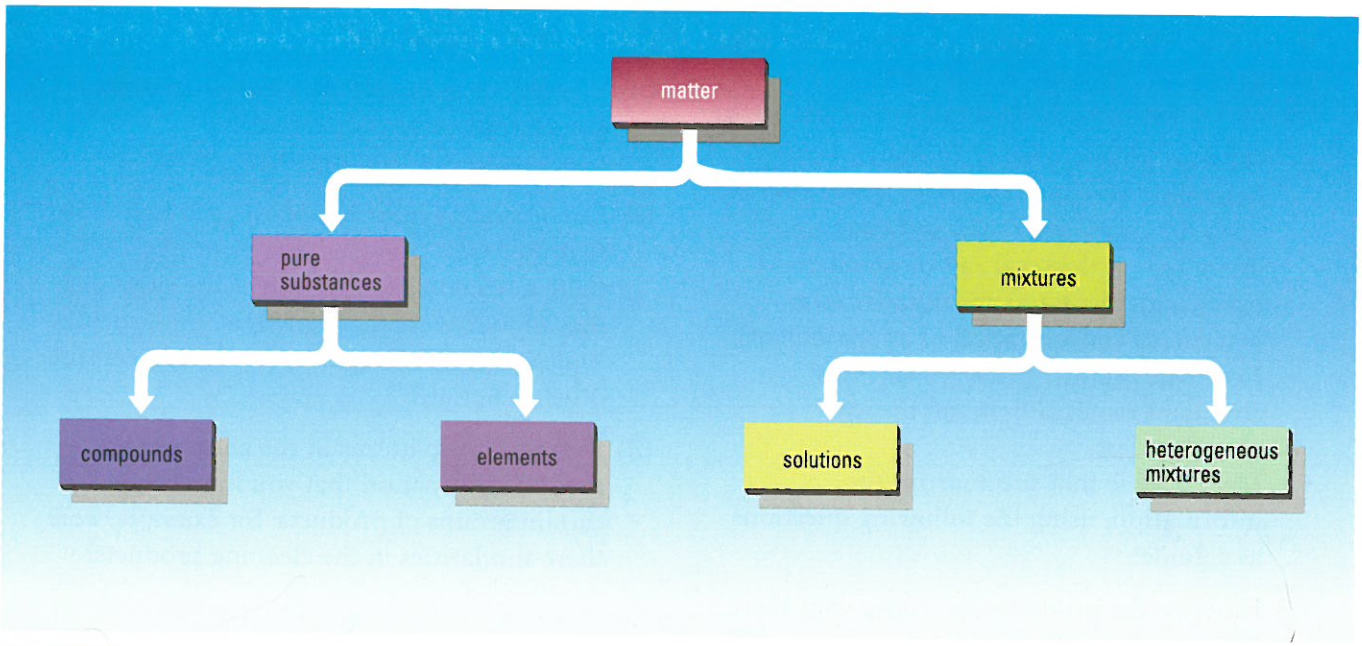


Figure 2

The classification of matter. Mixtures contain two or more pure substances. Solutions have only one visible component. Heterogeneous mixtures contain two or more visible components.

Elements can be identified with a chemical symbol. Pure gold (symbol Au) is completely made up of atoms of gold. All elements are listed in the periodic table (shown at the back of this text). Some elements consist of molecules, which are formed when two or more atoms join together; for example, the element oxygen (O) occurs in nature as pairs of oxygen atoms, or molecules of oxygen (O_2).

Compounds are pure substances that contain two or more different elements in a fixed proportion. Compounds can be identified with chemical formulas. For example, carbon dioxide (formula CO_2) is a compound. Each molecule of carbon dioxide is composed of one carbon atom and two oxygen atoms (**Figure 3**). Water (H_2O), carbon monoxide (CO), sodium chloride (NaCl or salt), and calcium carbonate ($CaCO_3$) are also compounds.

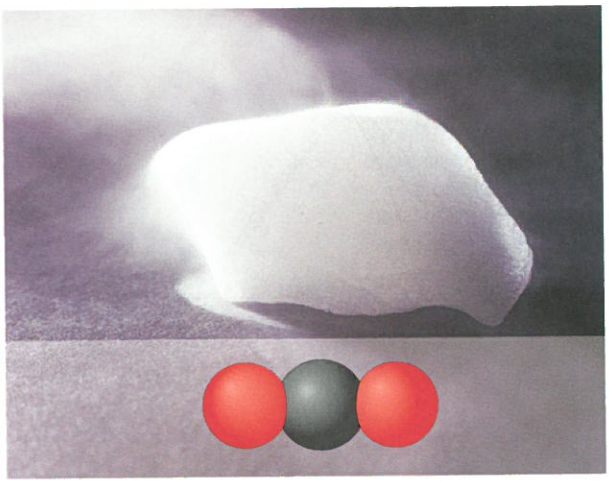


Figure 3

Each particle in dry ice, or solid carbon dioxide, is a molecule made up of one carbon atom and two oxygen atoms. It has the formula CO_2.

Properties of Matter

All matter has physical and chemical properties. The state of matter at room temperature, hardness, melting and boiling points, odour, solubility, and colour are all physical properties. A **physical property** is a characteristic of a substance. For example, baking soda is a pure substance that has a number of physical properties. It is a white, crystalline solid at room temperature that dissolves readily in water to form a solution. A change (such as dissolving or melting) in the size or form of a substance, which does not change the chemical properties of the substance, is called a **physical change**.

A **chemical property** is a characteristic behaviour that occurs when a substance changes to a new substance. The change itself is called a **chemical change** (**Figure 4**). For example, when baking soda is added to acid, a new substance, carbon dioxide gas, is formed. This reaction with acid is a chemical property of baking soda. When an iron nail is left out in the rain, it undergoes a chemical change: the iron combines with the oxygen in the air to form a new substance, iron(III) oxide (rust). The starting materials in such a change are called **reactants**, and the new materials produced are called **products**. For example, iron and oxygen are reactants and iron(III) oxide is a product.

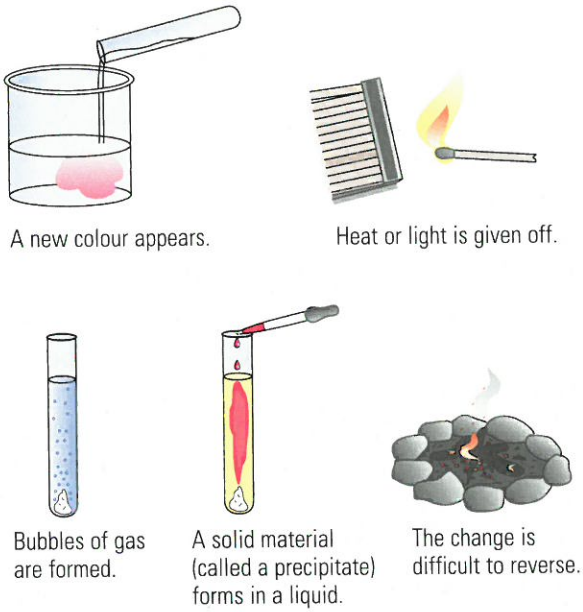


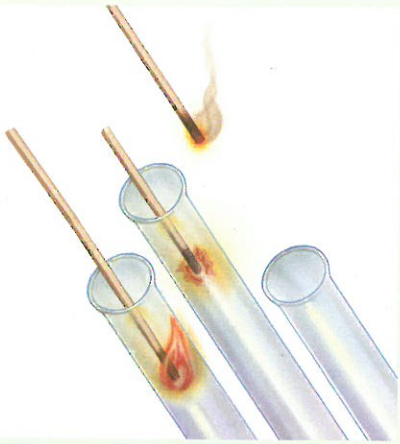
Figure 4

Clues that a chemical change has happened

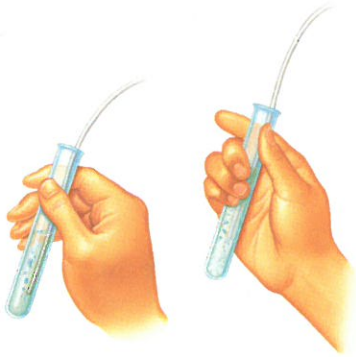
Chemical Tests

How are chemical changes useful? Chemical changes can be used to make new substances. They can also be used to identify unknown substances. For example, a geologist can add an acid to an unknown sample of rock. If bubbles of carbon dioxide gas are formed, the rock is probably limestone. As you work through this unit, you will encounter chemical reactions that can also be used to identify gases. For example, suppose that

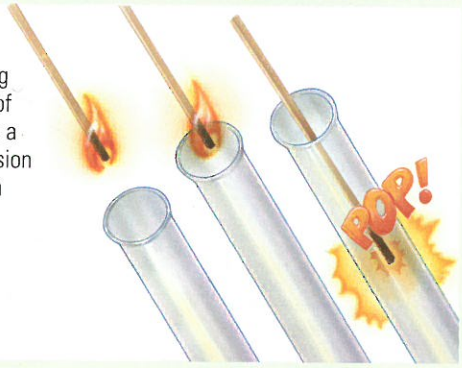
Oxygen gas is indicated if a glowing splint bursts into flame when placed in the gas. The more concentrated oxygen in test tube makes the combustion of the splint go faster.



Carbon dioxide gas is indicated if limewater solution turns milky when the gas is bubbled into it. The limewater undergoes a chemical change to form an insoluble white precipitate. A flaming splint, held at the mouth of the tube, is extinguished.



Hydrogen gas is indicated if a flaming splint at the mouth of the test tube causes a "pop" or small explosion in the gas. Hydrogen is highly flammable.



Water vapour is indicated if cobalt chloride test paper changes from blue to pink.

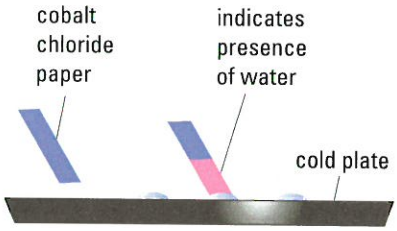


Figure 5
Testing for gases

you did an experiment in which an odourless, colourless gas was produced. How would you know what the gas was? Oxygen, hydrogen, carbon dioxide, and water vapour are all odourless, colourless gases. However, they differ in the ways they interact with other chemicals. Chemists can use **chemical tests**, or distinctive chemical reactions, to identify unknown gases or other substances (**Figure 5**).

Chemicals and Safety

Imagine that you plan to work with a chemical in the school lab, at home, or in the workplace. How do you know what its properties are? How do you know what chemical reactions may occur if you mix the chemical with another substance? You may not have time to perform chemical tests to find out. Is there a way to predict a chemical's properties before opening the container?

Many chemicals can be hazardous to human health or to the environment if they are not handled safely. There are a variety of symbols that are used to identify hazardous chemicals. Many household products are labelled with Hazardous Household Product Symbols (HHPS). Dangerous materials in the workplace are labelled using the Workplace Hazardous Materials Information System (WHMIS). Every chemical that is ordered for use in your school arrives with a Materials Safety Data Sheet (MSDS). This sheet describes the hazards that are associated with the chemical, the protective clothing that should be worn when handling the chemical, and steps that should be taken if the chemical is spilled.

Challenge

1 What are the names of the chemical compounds that make up your consumer product?

SKILLS HANDBOOK: (B) Safety in the Laboratory

Understanding Concepts

1. Classify each of the following as a pure substance or a mixture. Explain your choices.
   - **(a)** soapy water
   - **(b)** hydrogen gas
   - **(c)** sodium chloride
2. Classify each of the following as an element or a compound. Explain your choices.
   - **(a)** hydrogen
   - **(b)** potassium carbonate
   - **(c)** water
   - **(d)** Mg
3. Draw sketches to represent 10 particles of the following:
   - **(a)** an element
   - **(b)** a compound
   - **(c)** a mixture
4. Classify each of the following as a physical property or a chemical property. Explain your choices.
   - **(a)** Gasoline is a clear pink solution.
   - **(b)** Gasoline burns in air.
   - **(c)** Water boils at 100°C.
   - **(d)** Electric current can split water into hydrogen and oxygen gases.
5. When aluminum metal is added to hydrobromic acid, hydrogen gas and an aluminum bromide solution are formed.
   - **(a)** What kind of change has occurred? Explain.
   - **(b)** Which substances are the reactants and which are the products?
6. In your own words describe the chemical tests that can be used to identify the following gases:
   - **(a)** hydrogen
   - **(b)** oxygen
   - **(c)** carbon dioxide
   - **(d)** water vapour
7. When sodium carbonate is added to water, the sodium carbonate dissolves. When hydrochloric acid is added to the solution, the solution fizzes. What kinds of changes have occurred? Explain.
8. **(a)** Why does a glowing splint burst into flame when oxygen gas is tested?
   - **(b)** When you test for hydrogen gas, another gas is involved as a reactant. What is this gas?

Making Connections

9. Two bottles of materials, as shown in **Figure 6**, are found in a laboratory.

Figure 6

   - **(a)** What hazard is indicated on each bottle?
   - **(b)** What safety precautions would you take if handling these materials?
10. Obtain a sample MSDS sheet from your teacher. Use the sheet to answer the following questions:
    - **(a)** Write the name and formula of the substance.
    - **(b)** Describe one physical property of the substance.
    - **(c)** What fire or explosion hazard data are provided?
    - **(d)** What health hazards are associated with the substance?

Reflecting

11. Which of the two hazard warning systems do you think is more effective: HHPS or WHMIS? Explain.
12. Discuss why it is necessary to have a system like WHMIS in the workplace. How does it benefit the employee or employer?

Try This **Activity**

A Lab Safety Concept Map

Make a laboratory safety concept map to place at the front of your notebook.

(a) Write "Lab Safety" in the middle of a sheet of (B) paper. Draw lines out from the centre and, at the end of each line, write a word or phrase that summarizes a lab safety idea.

(b) Draw a map of your science classroom (A) indicating the location of safety equipment.

(A) Safety Conventions and Symbols

5.2 Case Study

Hazardous Household Chemicals

In Section 5.1 you reviewed how to use properties to classify substances. You also learned how symbols can be used to identify hazardous materials. How can you apply your knowledge to chemicals that you encounter in your home?

Household products, like everything else in the world, are made of substances that have their own particular properties. Many of these products are unreactive. You would not want a plastic container to react with the food inside it. Nor would you want an aluminum pan to catch on fire or react with food while you were making dinner! The less reactive many household products are, the better.

(a) Name five household products that are not reactive.
(b) For each product, describe the properties that make it useful.

Other household products are useful because they do interact with other materials. For example, some cleaning solutions dissolve grease in a physical change. Other cleaners contain bleach, which actually reacts with a stain in a chemical change to remove its colour. Household products can be toxic (poisonous), flammable, explosive, or corrosive (reactive). Product labels often identify these hazards using the Hazardous Household Product Symbols. Hazardous products must be used safely, and any waste must be disposed of properly so as not to damage the environment. Household products can be categorized according to where they are used: the garage, the kitchen and bathroom, the walls, and the garden.

(c) Give an example of a household product that works using a physical change and an example of a product that works using a chemical change.
(d) What are the four categories of Hazardous (A) Household Product Symbols that might be on a label?

Figure 1
Car maintenance requires chemicals. Antifreeze, oil, and transmission fluids contain hazardous chemicals.

Chemicals in the Garage

Automobiles use many different chemicals in various engine components. Gasoline, a mixture of molecules called hydrocarbons, burns in the engine and produces mainly carbon dioxide and water vapour, but also pollutants. Many other products used in cars contain hazardous chemicals and produce hazardous waste materials (**Figure 1**, and **Table 1**).

Table 1 **Automobile Products**

Chemical product	Hazardous ingredient(s)	Hazard
antifreeze	ethylene glycol	
transmission fluids	hydrocarbons	
brake fluids	glycol ethers	
used oils	hydrocarbons	
batteries	sulfuric acid, lead	

SKILLS HANDBOOK: (A) Safety Conventions and Symbols

Concerns about the environment have led to the development of two approaches to dealing with chemicals in the garage. One possibility is finding alternative products to use. For automobile products, the main alternative to the use of chemicals is to not use the car at all! The second possibility is to improve waste management by finding safe ways of disposing of or recycling products used in cars. Service stations use such large amounts of these materials that they have systems for recycling most automobile products.

(e) What are some alternatives to using a car?
(f) Which waste product would you expect to be produced in greater quantities in Canada compared to warmer parts of the world? Explain.

Figure 2
Cleaners contain a wide range of chemicals.

Chemicals in the Kitchen and Bathroom

Cleaning products are used throughout the home (**Figure 2**). However, the greatest quantities of cleaners are used in the kitchen and bathroom. These products generally work in one of two ways. Many contain solvents (substances that can dissolve other substances) or detergents that dissolve grease and dirt (a physical change). Others contain substances that chemically react with dirt and stains. Many cleaners contain hazardous chemicals (**Table 2**).

There are numerous alternatives to using cleaning products that contain toxic chemicals. Blocked drains can be cleared using boiling water and plungers. Dissolving either baking soda or vinegar in water makes an effective cleaning solution, and borax dissolved in water is a practical disinfectant. A mixture of lemon juice and vegetable oil can be used as furniture polish.

The disposal of cleaners can create a hazard to the environment. The best approach to disposing of waste cleaners is to use up as much of the substance as possible so that there is a minimum of waste.

(g) What are the main hazards associated with cleaners?
(h) What safety precautions should you take when handling these substances?

Table 2 **Cleaning and Related Products**

Chemical product	Hazardous ingredient(s)	Hazard
abrasive cleaners	trisodium phosphate	
window cleaner	ammonia	
mothballs	naphthalene	
bleach cleaners	hydrogen peroxide, sodium hypochlorite	
floor/furniture polishes	petroleum distillates	
rug cleaners	perchloroethylene, oxalic acid	
drain cleaners	sodium hydroxide, sulfuric acid	
disinfectants	diethylene glycol	
toilet cleaners	oxalic acid, calcium hypochlorite	
oven cleaners	sodium hydroxide, ammonia	

Chemicals on the Walls

Have you ever felt dizzy when working with paints in an enclosed space? Paints and solvents make you feel this way because they contain hazardous chemicals

(Figure 3). All paints contain pigments (for colour), resin (for stickiness), and solvents (to dissolve the components of the mixture). Some of the substances in paint and related products are described in **Table 3.**

(i) Which type of hazard is most prevalent in these products?

Alternatives to paints are limited, although water-based products are less hazardous. Waste management includes fully using the products, storing any unused materials in tightly sealed containers, and straining solid waste through mesh to save any solvents. There are also often municipal programs for recycling paints and solvents.

Figure 3
Paint products are a major source of hazardous household waste.

Chemicals in the Garden

Chemicals used for lawns and gardens include fertilizers and pesticides. Fertilizers are generally not a major concern as long as they are used in appropriate amounts and properly stored. The compounds in pesticides and other yard products are extremely poisonous (**Table 4** and **Figure 4**). Pesticides are discussed in detail in Chapter 2.

(j) Which type of hazard is most prevalent in these products?

Alternatives to pesticides include the use of insecticidal soaps, predator insects such as ladybugs, and insect and mouse traps, as well as the removal of debris from gardens.

Waste management is important due to the toxicity of these products. Pesticides should be disposed of properly. Some communities hold special curbside collection days when pesticides and other hazardous wastes are collected.

Table 3 **Paint Products**

Chemical product	Hazardous ingredient(s)	Hazard
oil-based paints	pigments, hydrocarbons	
water-based paints	pigments, resins, glycol ethers	
thinners and solvents	acetone, petroleum distillates	
wood preservatives	chlorinated phenols, creosote	
stains, finishes	halogenated hydrocarbons, mineral spirits	

Table 4 **Pesticides and Other Yard Products**

Chemical product	Hazardous ingredient(s)	Hazard
fungicides	captan, folpet	
insecticides	malathion	
general pesticides	pyrethrins, aldrin	
pet flea collars	carbamates, pyrethrins	
roach and ant killers	carbamates, pyrethrins	
rat and mouse poison	coumarins	
herbicides	2,4-D, prometon	
pool chemicals	hydrochloric acid, sodium hypochlorite	

Figure 4
Appropriate protective gear should be worn when using pesticides.

Understanding Concepts

1. **(a)** In what ways are household wastes hazardous?
   (b) Which type of hazard is posed by the largest number of products?
2. Give an example of a hazardous substance that might be found
   (a) in the garage
   (b) in the kitchen
   (c) in the bathroom
   (d) in the garden
3. Give two examples each of the physical changes and the chemical changes involved in the use of household products.
4. Where in the house do you find the highest concentration of hazardous compounds? Why do you think this is so?
5. Find five household products that have suggestions for first-aid treatment on the labels. What general suggestions are made?

Making Connections

6. Which automobile products does your local service station recycle? Which products do they dispose of? What government regulations apply to this process? Phone your nearest service station to find out the answers to these questions.
7. How does your local greenhouse or plant nursery deal with hazardous waste? Phone your nearest garden centre to find out the answer to this question.
8. Disposing of chemical products, whether hazardous or not, can cause problems. Research and report on the meanings of the following terms and how they relate to the disposal of chemical wastes:
   (a) nonbiodegradable
   (b) landfill
   (c) runoff
   (d) incinerator

5.3 Investigation

INQUIRY SKILLS MENU

○ Questioning	○ Planning	● Analyzing
○ Hypothesizing	● Conducting	○ Evaluating
○ Predicting	● Recording	● Communicating

Testing Properties of Substances

How can you investigate a chemical substance in the laboratory? As you have seen, labels, WHMIS symbols, and the MSDS can provide some information about the physical and chemical properties of substances. You can also use chemical tests to investigate the properties of a substance.

Physical properties that can be tested for in the laboratory include solubility in water and the ability to conduct an electrical current. An **electrolyte** is a substance whose water solution can conduct electricity. A nonelectrolyte is a substance whose water solution does not conduct electricity.

Chemical properties can also be investigated in the laboratory. For example, the characteristic chemical reaction of a substance with an acid is a chemical property because it results in the production of a new substance, usually a gas. Often, the gas itself can be identified through observation of its properties. In this investigation, you will have the opportunity to review some basic lab skills as you investigate the properties of substances.

Question

How can the physical and chemical properties of substances be determined?

Design

In this investigation, you will test the solubility and electrical conductivity of several substances. You will also investigate the reactions of some substances with acid, and use chemical tests to determine the identity of gases formed as products.

(a) Read the Procedure and make a table to record your observations. For Parts 1 and 2, possible headings could be *Substance tested*, *Solubility in water*, and *Conductivity of solution*. For Part 3, possible headings could be *Starting materials*, *Observations during change*, and *Observations during gas test*.

Materials

- apron
- safety goggles
- sodium chloride (salt)
- sodium bicarbonate (baking soda)
- calcium carbonate powder (chalk)
- potassium bromide
- calcium chloride
- copper(II) sulfate
- glucose
- sucrose (table sugar)
- scoopula or toothpicks
- large-well "comboplate" microtray or 11 50-mL beakers
- distilled water
- tap water
- vegetable oil
- conductivity apparatus
- mossy zinc
- hydrochloric acid solution (10% or 1.0 mol/L)
- 3 small test tubes
- test tube holder
- wooden splints
- limewater (calcium hydroxide) solution (0.02 mol/L)
- rubber stopper or cork

Copper(II) sulfate and potassium bromide are poisonous and are irritants. Report any spills to your teacher.

Hydrochloric acid is corrosive. Any spills on the skin, in the eyes, or on clothing should be washed immediately with plenty of cold water. Report any spills to your teacher.

SKILLS HANDBOOK: K7 Preparing Tables of Evidence