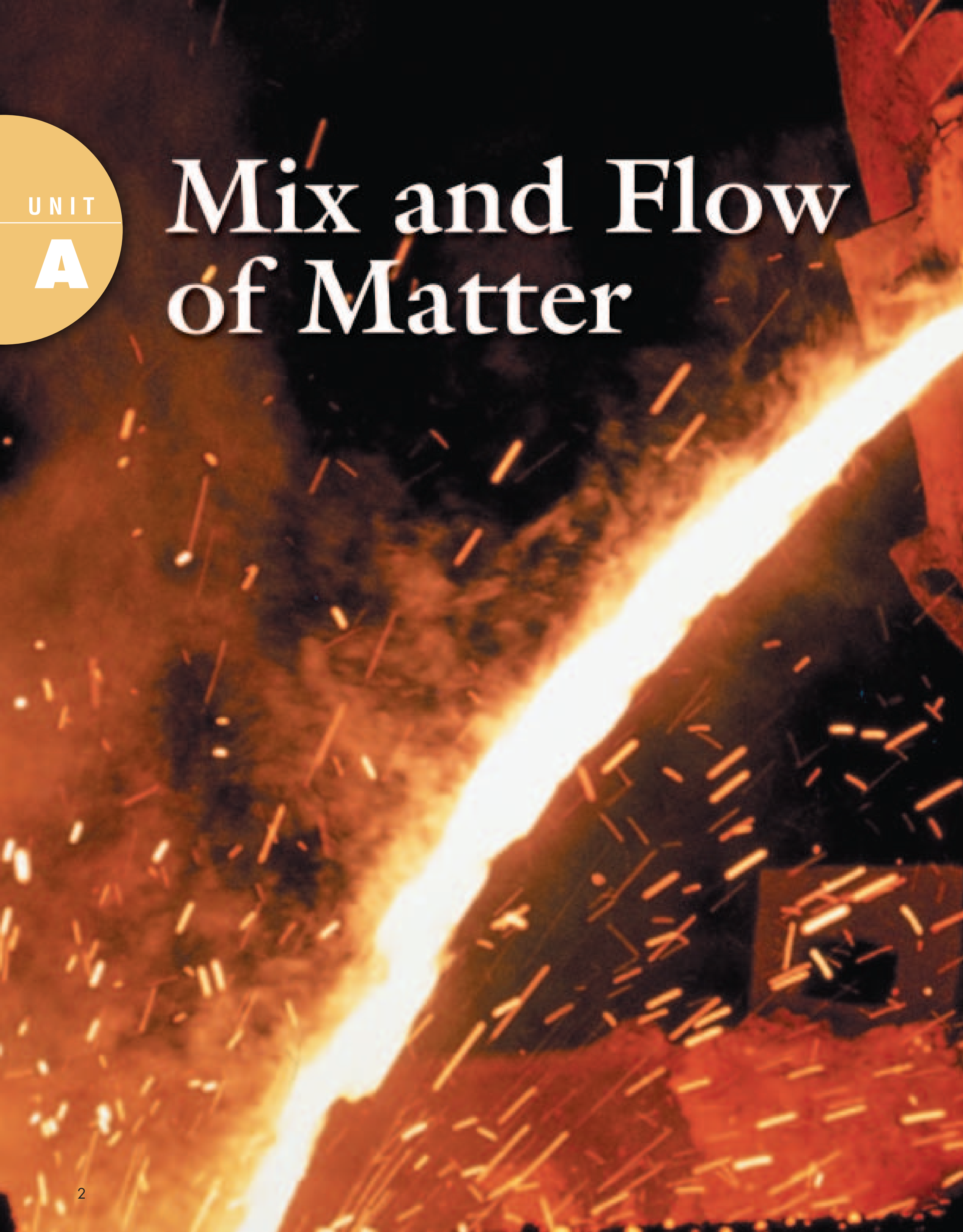
UNIT A

Mix and Flow of Matter



In this unit, you will cover the following sections:

1.0

Fluids are used in technological devices and everyday materials.

1.1 WHMIS Symbols and Safety Procedures

1.2 The Many Uses of Fluids

2.0

The properties of mixtures and fluids can be explained by the particle model of matter.

2.1 Pure Substances and Mixtures

2.2 Concentration and Solubility

2.3 Factors Affecting Solubility

2.4 The Particle Model of Matter and the Behaviour of Mixtures

3.0

The properties of gases and liquids can be explained by the particle model of matter.

3.1 Viscosity and the Effects of Temperature

3.2 Density of Fluids

3.3 Density, Temperature, and Buoyancy

3.4 Compression of Fluids

3.5 Pressure in Fluids—Pascal's Law

4.0

Many technologies are based on the properties of fluids.

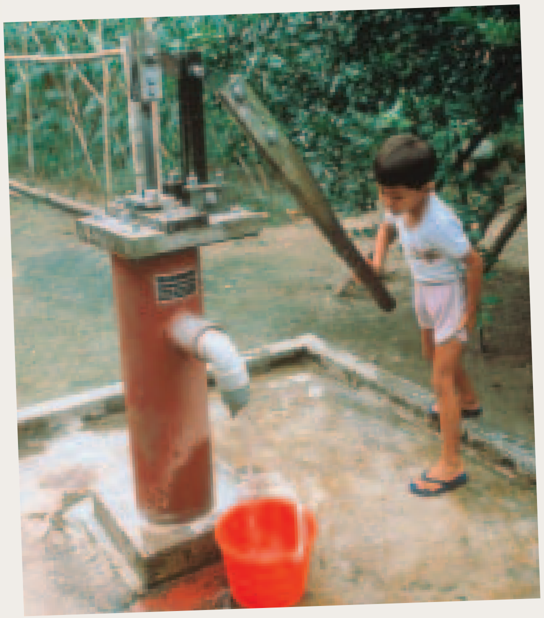
4.1 Technologies Based on Solubility

4.2 Technologies Based on Flow Rates and Moving Fluids

4.3 Designing a Working Model of a Fluid-Using Device

Exploring

Canadian Invention Brings Water to African Villages



RESEARCHERS AT THE University of Waterloo in southern Ontario have developed a low-cost, shallow-well pump that can easily be used in developing countries.

Since the early 1980s, many African and Southeast Asian communities have utilized the pump to bring clean drinking water to their villages.

Now, with the help of the International Development Research Centre in Ottawa, these inexpensive pumps are being made all over the developing world.

USING SCIENCE AND TECHNOLOGY TO SOLVE PROBLEMS

In 1978, two Canadian scientists, Alan Plumtree and Alfred Rudin, invented a reliable hand-operated water pump suitable for use in developing countries. The new pump had to meet the following criteria:

- It had to be durable enough to work continuously for 18 hours a day.

- It had to be cheap enough for people in poorer countries to afford.
- It had to be simple enough for villagers to maintain and repair themselves.
- It had to be designed so that it could be manufactured within developing countries. This would create jobs and ensure that spare parts would be available.

New Technology from Old

When the two scientists were researching pump designs, they noticed a pump at a Mennonite community in southern Ontario. It was practical and reliable and had been used for generations. With this pump as a model, they designed a hand pump with a tubing made out of a plastic called polyvinyl chloride (PVC). In the past, pumps were made of iron and steel, materials that are scarce and costly in many developing countries. PVC is inexpensive and available everywhere around the world. Plus, PVC doesn't rust! The new PVC pump was light, sturdy, cheap to build, and easy to install and maintain.

Adapting the Technology

Thanks to these Canadian inventors, villagers in developing countries are building and maintaining their own water pumps. Over 11 000 pumps are being used in 13 developing nations.

Of course, the basic pump design can be modified for local conditions. For example, in Sri Lanka, they decided to use a leather washer instead of a plastic one. The advantage of the leather one is that it can be made locally. In Malawi, the spigot on the pump has to be made out of black metal because hyenas ate the original white plastic ones. The hyenas thought the white spigots looked like bones and kept chewing them off the pumps!

Mennonites in southern Ontario have used hand pumps like this one for generations.

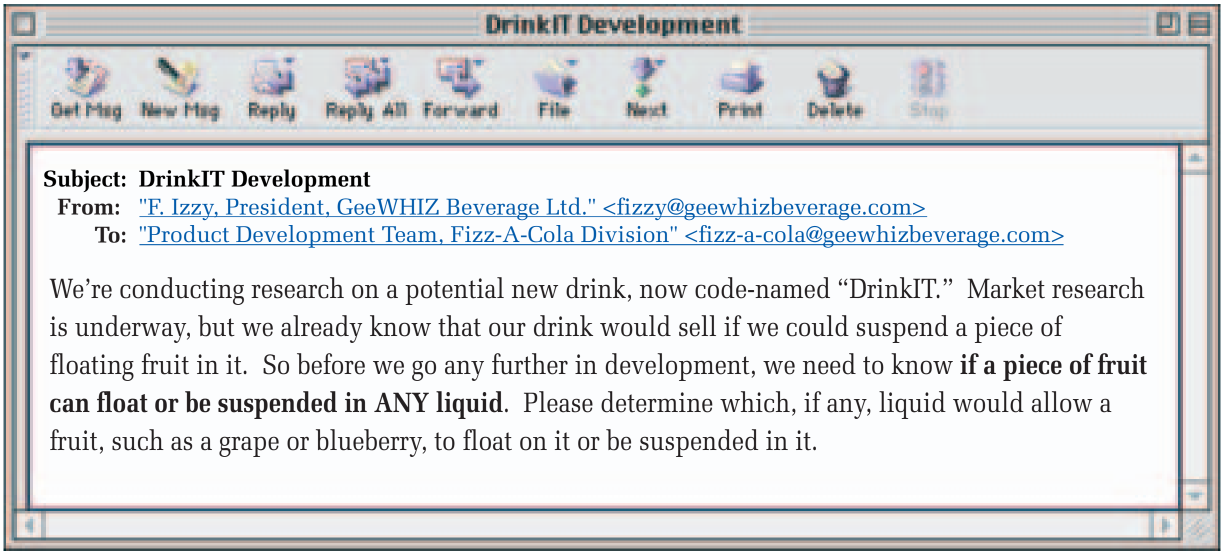
These villagers in Thailand are being trained to maintain and repair a Canadian-invented hand pump.

The PVC water pump is a good example of the importance of understanding a concept so that you can apply that understanding to different situations. In this case, the inventors knew about the properties of fluids and how a water pump operates. They applied this knowledge to develop a better pump that would work reliably for long hours and be easy to fix. In this unit, you will learn about the properties of fluids and see how they can be used to solve a variety of practical problems.

Give it a TRY ACTIVITY

THE NEW DRINK

Now you have an opportunity to use what you already know about fluids and develop your problem-solving skills. You and your product development team have to find a solution to the following problem.



Subject: DrinkIT Development
From: "F. Izzy, President, GeeWHIZ Beverage Ltd." <fizzy@geewhizbeverage.com>
To: "Product Development Team, Fizz-A-Cola Division" <fizz-a-cola@geewhizbeverage.com>

We're conducting research on a potential new drink, now code-named "DrinkIT." Market research is underway, but we already know that our drink would sell if we could suspend a piece of floating fruit in it. So before we go any further in development, we need to know **if a piece of fruit can float or be suspended in ANY liquid**. Please determine which, if any, liquid would allow a fruit, such as a grape or blueberry, to float on it or be suspended in it.

Test a variety of liquids to determine if a piece of fruit floats, sinks, or can be suspended in any of them.

A variety of liquids will be available for you to test. You may use any one of these liquids or a combination of them. Design a procedure that will allow you to collect the necessary data. Have your teacher approve your design before you start.

Prepare a reply to the president of the company that summarizes your results.

Focus On SCIENCE AND TECHNOLOGY

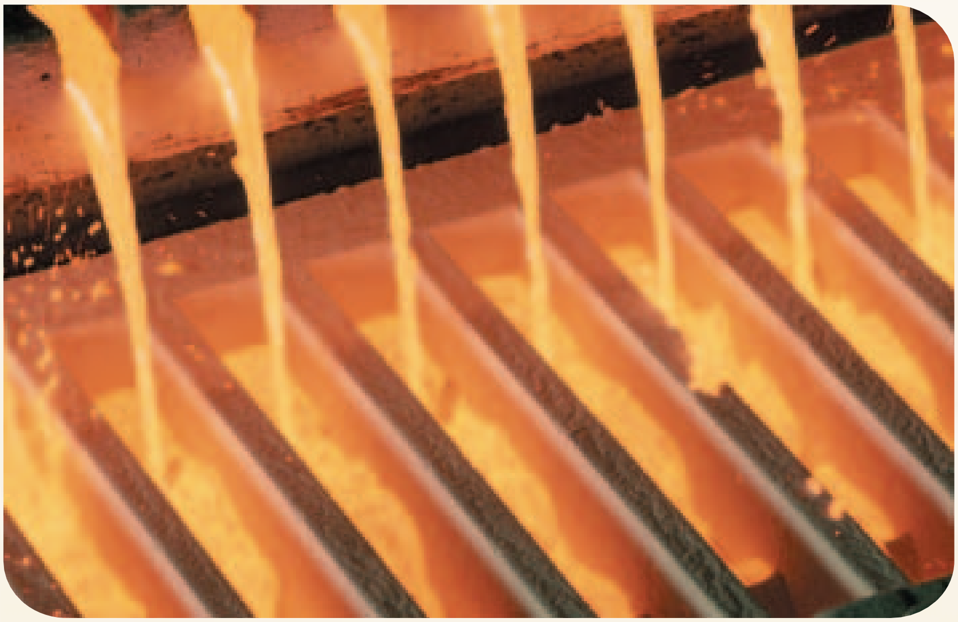
As you work through this unit, you will be reading about mixtures and fluids and doing activities that focus on science and technology. Science attempts to explain the phenomena in our world. The goal of technology is to provide solutions to practical problems.

In this unit, one of your main tasks is to practise your problem-solving skills. The scientific knowledge you gain throughout this unit will help you develop these skills. Remember that many technological problems have many different solutions. There may be no one right way to solve the problem. These three steps can help you in your problem solving:

- clearly define your need
- develop appropriate plans and designs
- test and evaluate these designs

You will be learning about the role of the properties of mixtures and fluids in both scientific research and technological developments. Use the following questions to guide your reading.

1. **What are the properties of fluids?**
2. **Why are these properties and their interactions important?**
3. **What technologies have been designed to use the interactions between fluids and other materials?**



1.0 Fluids are used in technological devices and everyday materials.

Key Concepts

In this section, you will learn about the following key concepts:

- WHMIS symbols
- properties of fluids

Learning Outcomes

When you have completed this section, you will be able to:

- explain WHMIS and other safety symbols
- describe safety precautions for using substances
- identify examples of fluids in products and devices
- describe examples of fluids used to transport, process, or use materials
- identify important properties of fluids

The ladder on this truck helps firefighters save lives in tall buildings. But without fluids, firefighters wouldn't be able to use it. It would take many people working together to put up a huge, heavy ladder like this one. But with the push of a button, a hydraulic system can raise and lower it easily. A **hydraulic system** uses fluids under pressure to move loads. It is just one of many technologies that use fluids to make our lives easier and safer. Fluids are substances that flow. Both liquids and gases are fluids.

In this section, you'll begin to learn about fluids and how and why they are used in technological devices and everyday materials. The first step in investigating fluids is learning how to work with them safely in the lab.

 For Web links relating to 1.0, visit **www.pearsoned.ca/scienceinaction**

1.1 WHMIS Symbols and Safety Procedures

Before you begin your study of mixtures and fluids, you need to review some safety rules and basic lab skills. Figure 1.1 shows a science class performing a science activity. Unfortunately, some of the students are not following proper safety procedures. Work with a partner to identify and list the problem actions. Then suggest a better, safer way to perform each action. After you have finished, share your observations with the class.

Figure 1.1 What are these students doing wrong? What are they doing right?

WHMIS AND OTHER HAZARD SYMBOLS

You will be doing many activities in this unit. Before you do an activity, read through it and watch for "Caution!" notes that will tell you if you need to take extra care. There are two areas of special consideration when working in the lab—understanding warning labels and following safety procedures.

Some of the materials you will use in the lab are hazardous. Always pay attention to the warning labels described on the next page, and follow your teacher's instructions for storing and disposing of these materials. If you are using cleaning fluids, paint, or other hazardous materials at home, look on the labels for special storage and disposal advice.

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Symbol Shapes

These shapes and their colours indicate how dangerous the substances are.

All hazardous materials have a label showing a hazard symbol. The **hazard symbol** has a safety warning and a shape to indicate how hazardous the material is. You may have already seen these labels on fluids you find at home, such as bleach or oven cleaner. There are two separate pieces of information for each symbol. The first is the shape of the symbol, shown in the *info*BIT. A yellow triangle means "caution," an orange diamond means "warning," and a red octagon means "danger."

The second piece of information is a picture inside the shape that indicates the type of hazard. There are seven pictures of common hazards shown in Figure 1.2.

Figure 1.2 These pictures tell you what type of hazard to watch out for.

Figure 1.3 shows some of the WHMIS symbols. **WHMIS** stands for Workplace Hazardous Materials Information System. This is another system of easy-to-see special symbols on hazardous materials. These symbols were designed to help protect people who use potentially harmful materials at work.

Figure 1.3 WHMIS symbols

Understanding the Rules

When performing a science investigation, it is very important that you follow the lab safety rules.

Lab Safety Rules

1. Read all written instructions before doing an activity.
2. Listen to all instructions and follow them carefully.
3. Wash your hands carefully after each activity and after handling chemicals.
4. Wear safety goggles, gloves, or an apron as required.
5. Think before you touch. Equipment may be hot and substances may be dangerous.
6. Smell a substance by fanning the smell toward you with your hand. Do not put your nose close to the substance.
7. Do not taste anything in the lab.
8. Tie back loose hair and roll up loose sleeves.
9. Never pour liquids into containers held in your hand. Place a test tube in a rack before pouring substances in it.
10. Clean up any spilled substances immediately as instructed by your teacher.
11. Never look into test tubes or containers from the top. Always look through the sides.
12. Never use cracked or broken glassware. Make sure you follow your teacher's instructions when getting rid of any broken glass.
13. Label any container you put chemicals in.
14. Report all accidents and spills immediately to your teacher.
15. If there are WHMIS (Workplace Hazardous Materials Information System) safety symbols on any chemical you will be using, make sure that you understand all the symbols. See Toolbox 1 at the back of this book.

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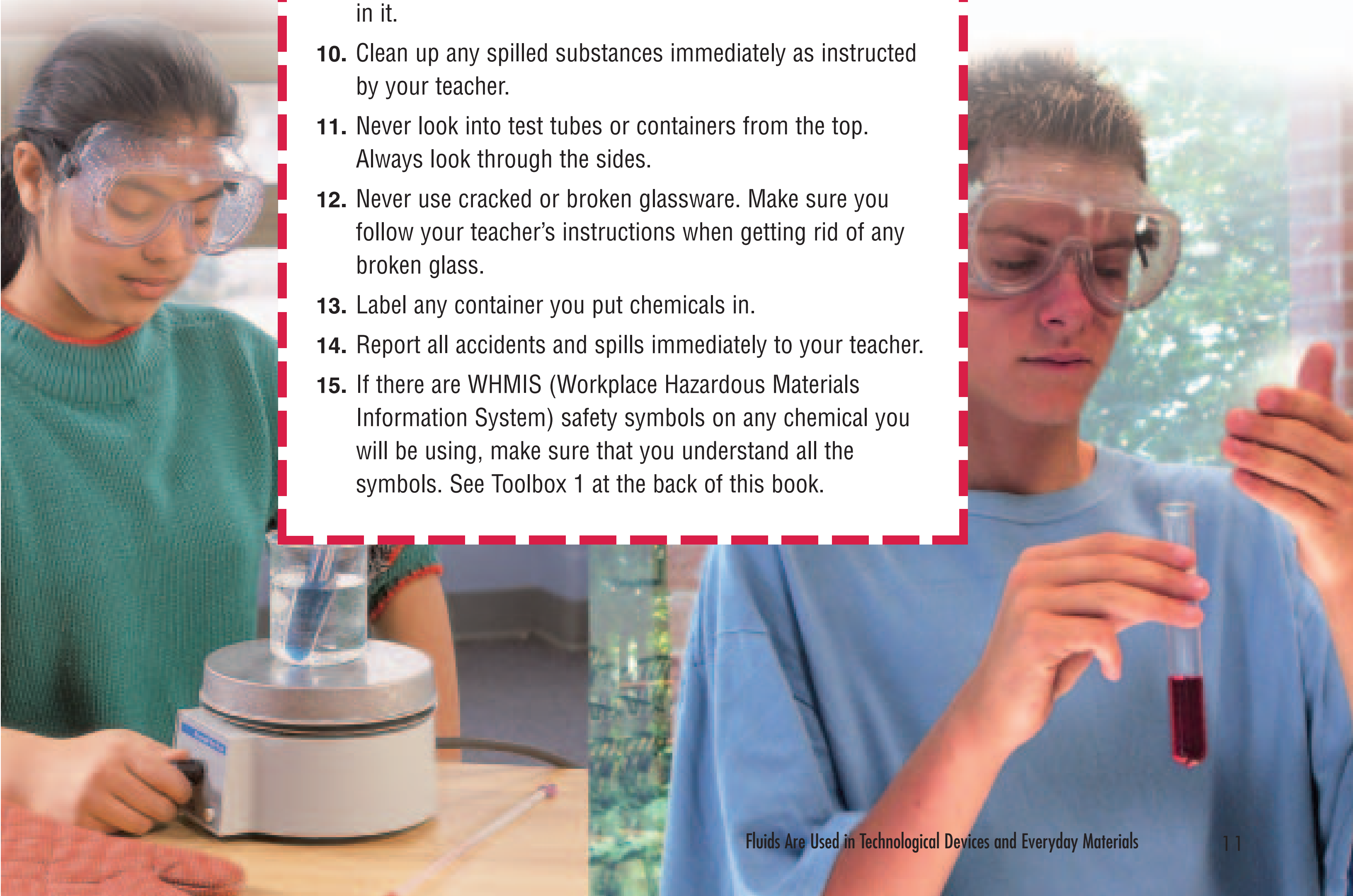
WHMIS Symbols at School

Check around your school for WHMIS symbols. Try the art room or a cleaning room. Make a map showing where the different hazardous materials are located in your school.



Safety Begins with You

Not following one or more of the lab safety rules could result in injury to you or your classmates. Follow the list of 15 safety rules to ensure that you work in a safe manner. Your teacher will also discuss any specific rules that apply to your classroom. After you have read the rules here, you can read more about safety in Toolbox 1 at the end of the book.

Remember that safety in a science class begins with you. Before you start any activity, you should be prepared to

- follow the safety instructions outlined by your teacher and this text
- keep an eye open for possible hazards, and report them immediately
- show respect and concern for your own safety and the safety of your classmates and teachers

Check and Reflect

1. What does each hazard warning label mean on the fluids shown in Figure 1.4?

Figure 1.4 Warning labels on hazardous products

2. Choose five of the lab safety rules given on page 11. For each one, explain briefly why it's important to follow it. Give an example of what could happen to a student who didn't follow that rule.
3. Make your own chart of hazard warning symbols. When you go home, check for each symbol on materials where you live or at your local grocery store. List two or three substances or items to which the symbol applies.

1.2 The Many Uses of Fluids

A **fluid** is anything that has no fixed shape and can flow. Usually it is a liquid or a gas. Look at Figure 1.5. How many different examples of fluids being used can you observe? Make a list of the fluids you see there and how they are being used. Include one additional use for each fluid. Remember to note uses by other living things besides humans. After you have made your list, group the examples into four different categories. Label each category with a title that makes sense to you.

Figure 1.5 How are fluids being used?

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Agrifoam Cold Crop Protector

Frost damage is a big risk for farmers who grow fruit. To help farmers protect their crops, Canadians Dr. D. Siminovitch and J.W. Butler invented Agrifoam Cold Crop Protector. Agrifoam is a shaving-cream-like material that can be sprayed onto plants to protect them from freezing.

Fluids Make It Easier to Use Materials

It's easy to think of many fluids you use every day, such as water, soft drinks, and detergents. One of the reasons that fluids are so useful is that they make it easier to transport, process, and use different kinds of materials, even if these materials are solids.

Figure 1.6 Because it's a fluid, the water can carry the sand and other solids away.

Slurries

Think about washing off a sidewalk or driveway with a hose. If you had a coating of mud or sand on your driveway, you could turn your hose on it. The water would wash or carry the mud or sand off the driveway. This mixture of water and solids is called a *slurry*. Slurry technology—the transport of solids in water—is important in many applications. One of these is in mining oil sands. Syncrude in Alberta is the world's largest producer of oil from oil sands. Syncrude started out by using conveyor belts to move the oil sands from the mine to the processing plant. But this technology proved to be very expensive. Now Syncrude creates an oil-sand slurry at the mine site and pumps this slurry through pipelines to the processing plant.

Fluids Become Solids

Fluids are easy to move, and they take the shape of containers. Because of these properties, many of the things we see and use as solids were originally prepared as fluids. Glass, for example, is manufactured by heating a mixture of substances that includes sand, limestone, and other carbonates. Other materials can be added to give the glass colour or special qualities. The mixture is heated in a furnace at 1000°C until it becomes a fluid. This allows it to be shaped into the form needed for particular uses, such as bottles, windows, or fibre-optic strands.

Figure 1.7 Glass bottles being formed

Steel is another example of the use of fluids as a stage in processing materials. Steel consists of a mixture of iron, carbon, and small quantities of other substances. This mixture is heated to 1650°C to melt everything together, and to add more materials. The fluid steel is then shaped into the desired forms and allowed to cool.

Fluids Can Hold Other Materials

The ability of fluids to spread or flow and to carry other materials makes them useful in many applications. Toothpaste is an example that you may not have thought of. Most toothpaste contains powdered materials, such as bauxite, to polish your teeth. It also contains a detergent to clean your teeth, and fluoride to keep your teeth strong. Substances called binders, made from wood pulp, keep the paste mixed. Colouring and flavouring are added to make the mixture more agreeable.

Useful Properties of Fluids

From the information you have learned so far in this section, you can begin to appreciate the importance of fluids in our world. You've seen some examples of the different ways that fluids are involved in transporting, processing, and using materials. Fluids can be used in all these ways because of their properties.

By understanding the properties of fluids, people can design technological devices that use these properties. Later in this unit, you will be exploring these properties: viscosity, density, buoyancy, and compressibility. Figures 1.8 to 1.12 on the next page show how these properties can be important in choosing and using fluids in different applications.

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Froth Flotation

A common method of processing mineral ore is called froth flotation. How are fluids used in this process?

Give it a TRY — ACTIVITY

Another Property of Fluids

In this activity, you will observe a situation that uses two liquids—detergent and water. You have a pan of water with some pepper floating on it. Add a couple of drops of liquid detergent. What happens?

Suggest a situation where what you observed could be used in a practical way. Present your ideas to the class either orally or as a short written description.

Figure 1.8 Your bicycle starts to make grinding noises as you pedal. What do you do? You use oil on your bicycle or in a car to make sure that the parts operate smoothly together. The viscosity of the oil that you use is important. Viscosity describes how easily a fluid flows. You will learn more about viscosity in section 3.0.

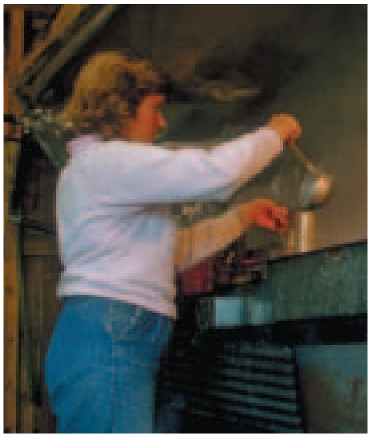


Figure 1.9 In making maple syrup, you have to determine when the mixture reaches the right concentration of sugar. A device called a **hydrometer** is used to measure the density of the syrup to find out if there is enough sugar in it. You will learn more about density in section 3.0.

Figure 1.10 This ship floats because of the buoyant force of the water acting on it. You will learn more about buoyancy in section 3.0.

Figure 1.12 The hovercraft operates by directing air downward so it floats on a fluid cushion over the waves.

Figure 1.11 This jackhammer is pneumatic. Systems that use compressed air are called **pneumatic systems**. **Hydraulic systems** use liquids to lift or move things. You will learn more about pneumatic and hydraulic systems when you learn about the compression of fluids in sections 3.0 and 4.0.

Check and Reflect

1. Review the list of fluids and their uses that you made at the beginning of this subsection when you looked at Figure 1.5. Are there any changes you would make based on what you have learned? Add at least three other examples, and make one new category for your list.
2. Describe an example where materials are prepared as fluids so they can be moved more easily.
3. Explain why it is important for steel to go through a fluid phase as it is being produced.

Assess Your Learning

1. What labels would you expect to find on containers of the following materials?
   a) oven cleaner in a spray can
   b) bleach
   c) paint thinner
   d) unknown bacteria
2. Describe the process for getting rid of broken glass in your class.
3. What protective measures must you take when you work around an open flame?
4. Describe an example where materials are prepared as fluids to make it easier to use them.
5. Describe two technologies that require a specific property of a fluid to function properly.

Focus On SCIENCE AND TECHNOLOGY

The goal of technology is to provide solutions to practical problems. For example, toothpaste is a technology to solve the problem of tooth decay. It was invented to keep teeth clean and strong. It also freshens your breath. Think back to what you learned in this section.

1. What were some practical problems that you read about?
2. What technologies were used to solve these problems?
3. Did it seem to you there would be more than one way to solve some of these problems?

2.0 The properties of mixtures and fluids can be explained by the particle model of matter.

Key Concepts

In this section, you will learn about the following key concepts:

- pure substances, mixtures, and solutions
- solute and solvent
- concentration
- solubility and saturation points
- particle model of matter

Learning Outcomes

When you have completed this section, you will be able to:

- distinguish between pure substances and mixtures
- define concentration and solubility
- identify factors that affect solubility and rate of dissolving
- relate the behaviour of mixtures to the particle model of matter

All the objects in the pictures on this page have at least one thing in common. They are all examples of matter. Matter may be hard, soft, rough, smooth, round, square, hot, or cold. It may be smaller than a cell or larger than the sun. Matter may have colour or it may be colourless. Matter is what makes up everything in our universe.

Matter can be organized in different ways. You already know one way: matter can be classified as solid, liquid, or gas. In this section, you will look at another classification system. This system classifies matter as pure substances or mixtures. You will also learn about a model that you can use to describe the nature of matter. This model will help you understand fluids and their properties.

For Web links relating to 2.0, visit **www.pearsoned.ca/scienceinaction**

2.1 Pure Substances and Mixtures

All matter is either a pure substance or a mixture. A **pure substance**, such as sugar, is made up of only one kind of matter. A **mixture**, such as soil, is made up of a combination of different substances.

Give it a **TRY** ACTIVITY

CLASSIFYING PURE SUBSTANCES AND MIXTURES

You can find examples of pure substances and mixtures all around you. Work with a partner to make a list of 20 different things you have used in the last day or two. Try to include at least two solids, two liquids, and two gases.

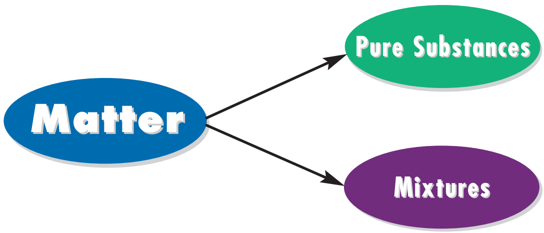
Classify the items in your list as either pure substances or mixtures. If you are not sure into which grouping an item fits, make a third grouping.

Review your groupings and answer the following questions in your notebook or in a class discussion:

- Could you tell pure substances and mixtures apart?
- Which were the hardest items to classify?
- Did some items seem to be neither a pure substance nor a mixture?

PURE SUBSTANCES

A pure substance is made up of one type of matter and has a unique set of characteristics or properties. For example, aluminum foil, baking soda, and distilled water are all pure substances. You cannot separate them into different substances.



MIXTURES

Mixtures are two or more substances combined together. In a mixture, each substance keeps its properties, but it may be difficult to identify these properties. For example, you may not see the sugar in a drink of soda pop, but you can certainly taste it. Sometimes it is easy to identify the different substances in the mixtures. For example, you can see the different vegetables in a package of mixed vegetables.

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What Are Pennies Made Of?

Until 1997, pennies were made of a pure substance—copper. Since then, other substances have been added so pennies are now a mixture of metals. Mixtures of metals are called *alloys*.

Mechanical Mixtures and Solutions

If you think about pure substances, you might list common examples such as sugar, water, salt, and oxygen gas. Some other examples you might think of may seem to be pure substances, but aren't. For example, how would you classify vinegar—is it a pure substance or a mixture? To be able to classify matter, you need to know more about mixtures.

In a **mechanical mixture**, you can see the different substances that make up the mixture. Soil and mixed vegetables are both mechanical mixtures. This type of mixture is sometimes called a **heterogeneous mixture**. In other mixtures, you can't see the different substances that make them up. These mixtures may be solutions, suspensions, or colloids. A **solution** looks as if it is all one substance. It is called a **homogeneous mixture**. Sometimes it is difficult to tell the difference between a pure substance and a solution without performing some tests. You can learn more about suspensions and colloids on the next page. The chart in Figure 2.1 summarizes the classification of matter as pure substance, mechanical mixture, solution, suspension, or colloid.

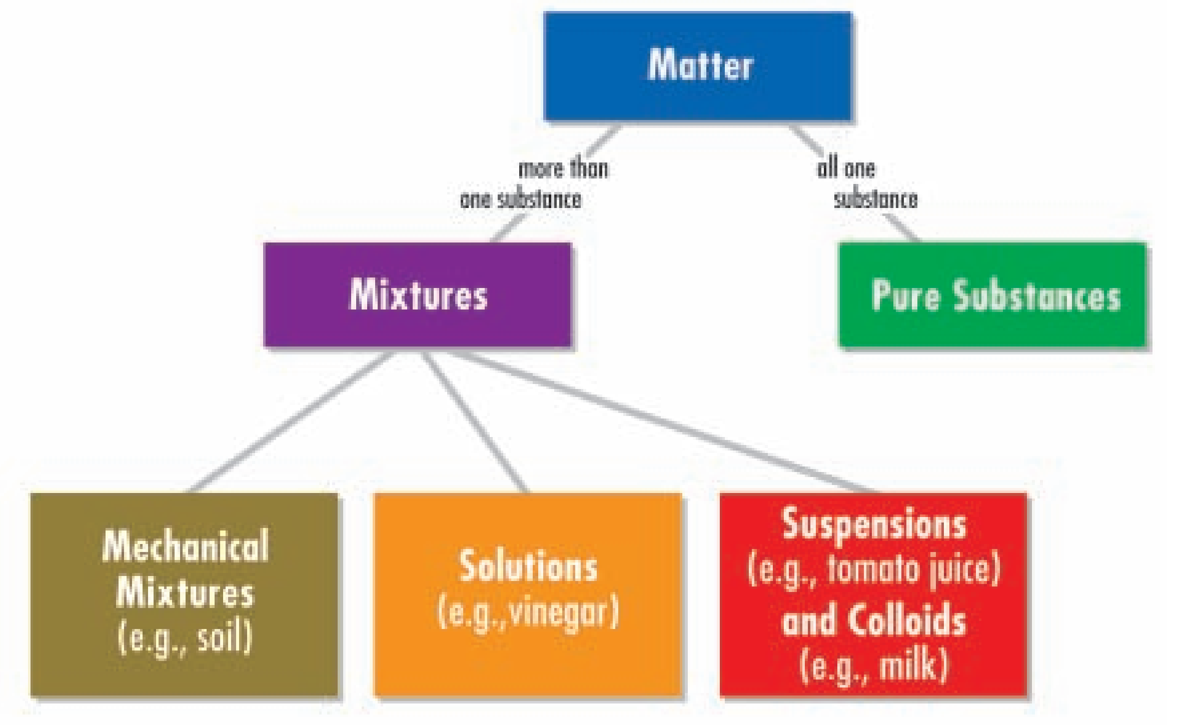

Figure 2.1 Matter classification chart

Suspensions and Colloids

A **suspension** is a cloudy mixture in which droplets or tiny pieces of one substance are held within another substance. If you leave a suspension undisturbed, its parts will usually separate out. Muddy water is an example of a suspension. A **colloid** is also a cloudy mixture but the droplets or tiny pieces are so small that they do not separate out easily. Homogenized milk is a colloid of tiny cream droplets in whey.

Figure 2.2 A *foam* is a colloid of a gas in a liquid. The foam in this photo is used for insulation. It comes out of the can as a fluid, and then hardens in place to seal cracks.

Pure Substance or Solution?

Look at the list of different fluids in this table. Answer the following questions.

- Are these fluids pure substances or solutions?
- How would you determine if your classification is correct?

Copy the table into your notebook. In your table, mark ✔ in the column to which each fluid belongs.

Fluid	Pure Substance	Solution
soda pop		
hot chocolate		
water		
apple juice		
windshield washer fluid		

Paper Chromatography

For some fluids, the *paper chromatography* test can be used to determine if they are pure substances or solutions. A piece of filter paper is placed partly in a solution. If the fluid is a pure substance, it will move up a strip of filter paper to one level. If the fluid is a solution, the different substances in it will move up the paper to different levels. This is a powerful technique for separating several substances mixed together.

Inquiry Activity

PAPER CHROMATOGRAPHY

The Question

Is the black ink in a marker pen a pure substance or a solution?

The Hypothesis

TOOLBOX

Write a hypothesis stating whether the marker pen's ink is a pure substance or a solution. (See Toolbox 2 if you need help with this.)

Materials & Equipment

- filter paper or coffee filters
- pencil
- 250-mL beaker
- black, water-soluble marker pen
- paper towels
- water

Figure 2.3 Step 1. Cut a piece of filter paper slightly larger than the width and height of the beaker.

Figure 2.4 Step 6. Curve the paper so it will stand up by itself in the beaker.

Procedure

1. Cut a piece of filter paper so that it is slightly larger than the width and height of the beaker. This will become your chromatogram.
2. Using a pencil, draw a horizontal line 1 cm from one end of the paper.
3. Put 2 large dots of black ink on the filter paper along the horizontal line. Make sure that the dots aren't too close to each other.
4. Pour water into the beaker to a depth of 0.5 cm.
5. Predict what will happen to the ink dots when you put the paper in the water.
6. Curve the paper so that it can stand up by itself in the beaker. Be sure the bottom edge is touching the bottom of the beaker. The line of dots should be just above the water. Do NOT allow the water to touch the line of dots.
7. The water will move up as it soaks into the paper. When the water almost reaches the top of the paper, take the paper out and place it on a paper towel. Allow it to dry.

Collecting Data

8. Record your observations. Be sure to include or draw your strip of paper.

Analyzing and Interpreting

9. What happened to the original colour of the black dots?

Forming Conclusions

10. Is the ink in a marker a pure substance or a solution? Support your answer with your data.

Applying and Connecting

Chromatography has many uses, including identifying forged cheques. In one recent case, a greedy man changed the dollar amount on a will from $1000 to $10 000 simply by adding an extra 0. Using chromatography and comparing the ink from the different digits, investigators determined that the ink from one of the zeros came from a different pen. The man was convicted of forgery.

Extending

What would happen if you tested coloured markers? Try it and find out.

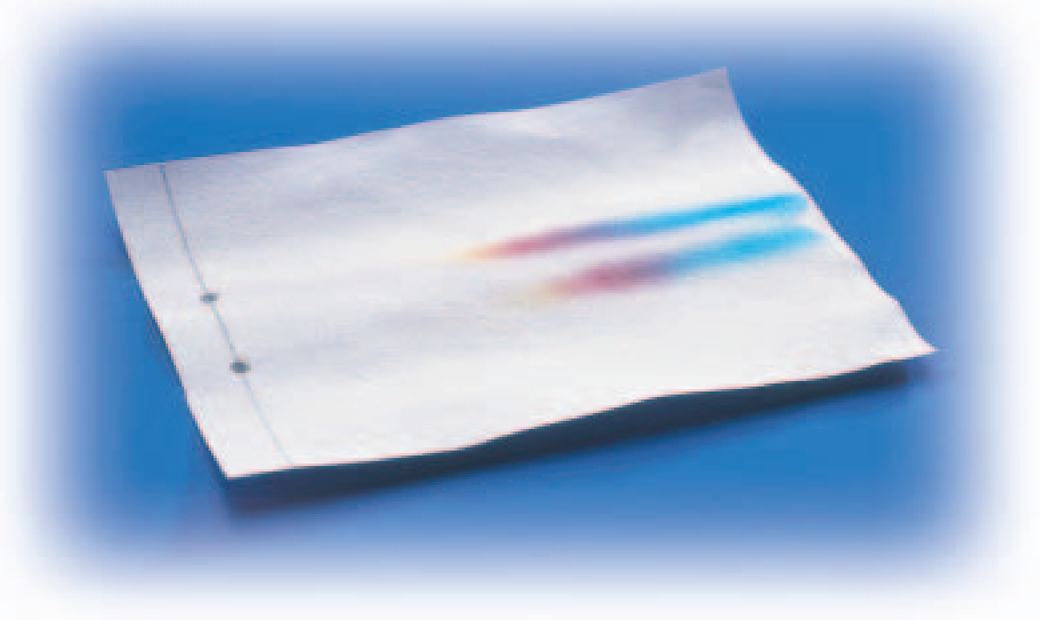

Figure 2.5 You can see from this chromatogram that the ink is not a pure substance. How many substances are mixed together in this kind of ink?

Reading Chromatograms

The filter paper used to test the substance is called a *chromatogram*. Figure 2.5 shows a filter paper with two spots of ink from a black marker on it after it was placed in water. The water soaked into the paper and eventually dissolved the ink spots. Notice how the different substances making up the ink separated at different levels on the chromatogram. The distance a substance moves depends on its attraction to the paper. Some substances are more strongly attracted to the paper. Those with the strongest attraction to the paper don't move very far. Those with the weakest attraction move farthest.

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Separating Mixtures

Methods of separating mixtures can be classified as either destructive or non-destructive. Use print or electronic resources to find examples of methods and what they are used for. Try to find examples other than chromatography.

Check and Reflect

1. What is the difference between a mixture and a pure substance?
2. Below is a list of some examples of matter. Classify each example as a heterogeneous mixture, a homogeneous mixture, or a pure substance. Explain your classification in each case.
   a) chocolate chip cookies
   b) coffee with cream
   c) aluminum foil
   d) potting soil
   e) gold medal
3. Create a flowchart that would help you classify matter into heterogeneous mixtures, homogeneous mixtures, or pure substances. Hint: Review the flowchart on page 20. Test your flowchart using the examples in question 2.
4. What practical uses can you think of for chromatography?

2.2 Concentration and Solubility

Dissolving one substance into another makes a solution. The substance that dissolves is called the **solute**. The substance that does the dissolving is called the **solvent**.

In a concentrated solution, there are large amounts of solute in the solvent. For example, you may have made orange juice from frozen juice concentrate. The concentrate has a large amount of orange solids (solute) in a small amount of water (solvent). You add water to make a diluted solution. A diluted solution has small amounts of solute in the solvent. So the orange juice you drink is actually a diluted solution.

Measuring Concentration

Concentrated and *diluted* are not exact terms. They don't tell you the actual amount of solute in the solvent. The **concentration** of a solution tells you the amount of solute dissolved in a specific amount of solvent. For example, a solution with 50 g of solute dissolved in 100 mL of water has a concentration of 50 g/100 mL of water. This is read as "fifty grams per one hundred millilitres."

Another common way of describing concentration is to state the number of grams of solute per 100 mL of *solution*. A concentration of 50 g/100 mL of solution means that 100 mL of the *solution* has 50 g of solute dissolved in it. Sometimes you will see concentrations stated in other ways. For example, the label on a juice box may say "5% real juice." Very low concentrations may be stated in parts per million (ppm).

*info***BIT**

The Smell of Chlorine
A concentration of one part per million of chlorine in a swimming pool can be detected by the human nose.

Give it a **TRY** — **Activity**

Comparing Solutions

You have three drinks in front of you. You know how they were made, but are unsure which one has the highest concentration of juice crystals. The first drink has 10 g of juice crystals dissolved in 50 mL of water. The second drink has 15 g of juice crystals dissolved in 100 mL of water. The third drink has 6 g of juice crystals dissolved in 25 mL of water.

Work with a partner to make a plan to figure out the concentration of each drink.

What was the most concentrated drink? How did you determine this since all three drinks had different amounts of solvent?

Comparing Concentrations

To compare the concentrations of two solutions, you need to know the amount of solute in the same volume of solvent for each solution. For example, you have two solutions. One has 10 g of salt in 50 mL of water (10 g/50 mL). The other has 25 g in 100 mL (25 g/100 mL). Which one is more concentrated?

For a comparison, the volume of solvent must be the same for both solutions. In our example, this means doubling the 10 g/50 mL to 20 g/100 mL. So now you are comparing the amount of salt per 100 mL of water in both solutions. The solution with the most solute in the same amount of water is the most concentrated: the solution with 25 g/100 mL is more concentrated than the one with 20 g/100 mL.

mathLink

A cleaning solution is made of 5.25 g of a chemical called sodium hypochlorite in 100 mL of water. If you had a solution of 21 g of sodium hypochlorite in 100 mL of water, how would you make the cleaning solution?

Saturated and Unsaturated Solutions

You have just learned how to state the concentration of a solute in a solvent. You know that you can make a very diluted solution by adding a small amount of juice crystals to water. If you add more juice crystals, the solution becomes more concentrated. As long as the juice crystals keep dissolving, you have an **unsaturated solution**. An unsaturated solution is one in which more solute can dissolve.

What would happen if you kept adding juice crystals until no more would dissolve? You would now have a **saturated solution**. A saturated solution is a solution in which no more solute can dissolve at a given temperature. **Solubility** is the maximum amount of solute you can add to a fixed volume of solvent at a given temperature. In our example, the solubility of the juice crystals would be the maximum amount of juice crystals that you could dissolve in water at that temperature. Every solution has a **saturation point** at a given temperature. This occurs when no more solute can be dissolved in a fixed volume of solvent at that temperature.

Figure 2.6 When you drink juice made from concentrate, you have mixed water with the concentrate to make a diluted solution. The water is the solvent and the part of the concentrate that dissolves is the solute.