CHAPTER 6

Matter can be classified.

KEY IDEAS

- All matter can be classified as pure substances or mixtures.
- Pure substances can be classified as elements or compounds.
- Mixtures can be classified as mechanical mixtures, suspensions, or solutions.
- Mixtures can be separated by a variety of methods.
- Solutions can be measured by concentration, solubility, and acidity.

Matter is made up of many different substances. Some of these substances are similar to each other, and some are very different. You can see and feel most substances. You can also describe them, based on what you see and feel—for example, gold is solid, hard, and shiny.

The properties of matter that you studied in Chapter 4 can be used to classify matter. Classifying matter helps you predict properties of similar substances. For example, silver has many of the same properties as gold and, like gold, is used to make jewellery. Classifying matter also helps you predict how substances will behave when they are mixed with other substances. The gold that is used in jewellery is not pure gold. It is mixed with other metals to make it stronger. In this chapter, you will learn some of the ways that scientists classify matter.

Pure Substances and Mixtures

6.1

As you have already learned, all matter is made up of particles. There are many different kinds of particles. Different substances have different properties because they contain different kinds of particles.

Pure Substances

A substance that contains only one kind of particle is called a **pure substance.** There are millions of pure substances, but only a few can be found in nature. For example, water is a pure substance, but pure water is difficult to find in nature. Even the clearest spring water contains dissolved minerals. In nature, pure substances tend to mix with other substances. Diamonds are one of the few exceptions (**Figure 1**). They are formed deep within Earth, in only a very few areas.

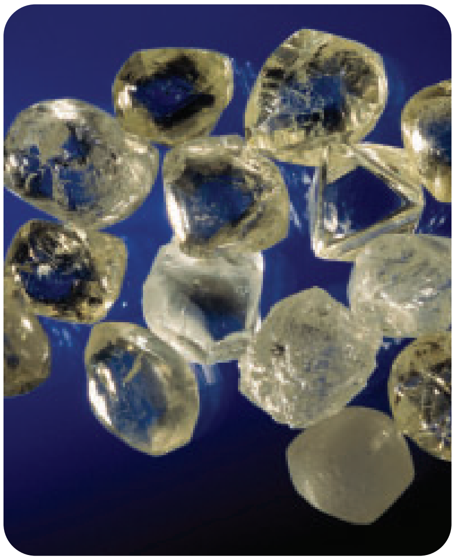


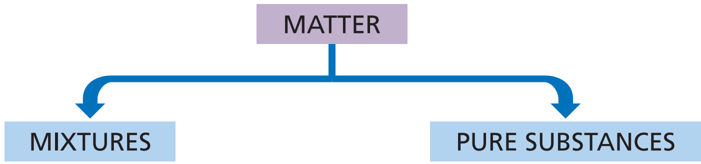
Figure 1
A diamond is an example of a pure substance. All the particles in a diamond are the same.

Most of the pure substances that you encounter in your daily life have been made pure by people through refining. Aluminum foil is a pure substance, and so is table sugar (**Figure 2**).

Figure 2
Aluminum foil and sugar are pure substances.

LEARNING TIP

Before you read this chapter, begin a graphic organizer that shows how different types of matter can be classified. The first level in your organizer will look like the diagram to the right. As you work through this chapter, add more levels to your organizer.



All samples of a pure substance have the same properties, no matter what size the samples are or where in the world the samples are found. For instance, all samples of pure gold have the same melting and boiling points and the same density. Because every sample of a pure substance has the same properties, scientists have made reference lists of pure substances and their properties. These reference lists can help you to identify an unknown substance based on its properties.

Mixtures

Almost all the natural substances and manufactured products in the world are mixtures of pure substances. A **mixture** contains two or more pure substances, as shown in **Figure 3**.

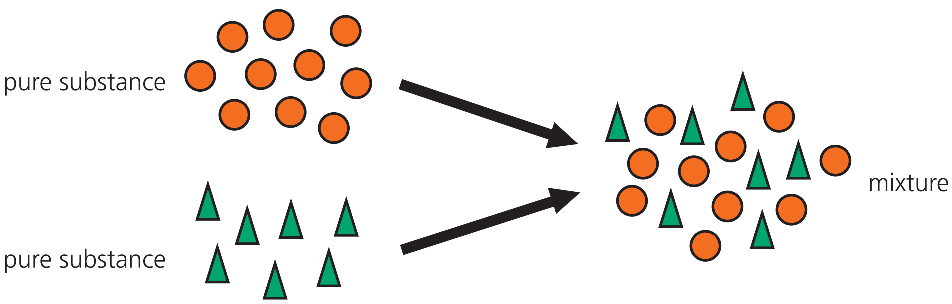


Figure 3
Most substances that you encounter are mixtures. Mixtures contain at least two pure substances.

Mixtures can be any combination of solids, liquids, and gases. For example, soft drinks are mixtures made from liquid water, solid sugar, and carbon dioxide gas (**Figure 4**).

Figure 4
Soft drinks may look like pure substances, but they are mixtures.

Breads are mixtures of yeast, flour, sugar, water, air, and other chemicals (**Figure 5**). The properties of mixtures may be different in different samples because there may be more or less of the different kinds of particles. For example, breads do not always have the same number of yeast or sugar particles in them.

Figure 5
Bread is a mixture of different substances.

TRY THIS: *TEST INK*

Skills Focus: observing, interpreting data

1. Cut a "tongue" in a piece of filter paper.
2. About 1 cm from the end of the tongue, draw a large dot with a black water-soluble marker.
3. Put the filter paper on top of a 250-mL beaker, with the tongue bent down into the beaker.
4. Carefully add water until it touches the filter paper tongue but does not touch the dot. Observe what happens as the water soaks into the filter paper. Is ink a pure substance or a mixture?

CHECK YOUR UNDERSTANDING

1. Explain the difference between a pure substance and a mixture, using examples of each.
2. Explain the difference between a pure substance and a mixture, using the particle model.
3. Give three examples of pure substances and three examples of mixtures.

6.2 Elements and Compounds

> **LEARNING TIP**
>
> The key vocabulary words on the next two pages are illustrated with both photographs and drawings that show you the particles. If you are having trouble remembering the difference between elements and compounds, use the illustrations for clarification.

There are millions of pure substances. Can anyone expect to learn about all of them? How would you start? How would you find out which ones are safe? How would you find out which ones are useful?

People have investigated pure substances for thousands of years. Ten thousand years ago, people learned how to extract copper from rocks by heating the ore. In medieval times, alchemists [AL-ku-mists] tried to break down metals, such as copper, to make gold. They dissolved and mixed various substances, filtered, and heated. None of the alchemists ever succeeded in making gold. They discovered, however, that some pure substances can be broken down into other pure substances, while others cannot. For this reason, pure substances are classified into two types: elements and compounds.

Elements

Elements are pure substances that cannot be broken down into any other pure substances. After many investigations, scientists found that there are only about 104 pure substances that are elements.

Elements are composed of only one kind of particle. For instance, aluminum foil is made of the element aluminum. It is composed of only particles of aluminum (**Figure 1**).

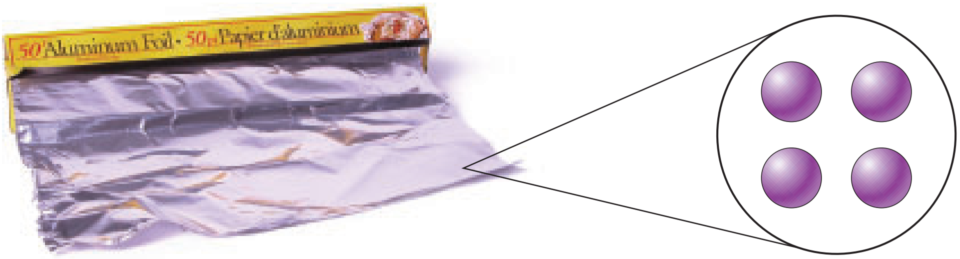


Figure 1
The element aluminum in aluminum foil is composed of aluminum particles.

Some elements, such as iron, aluminum, and oxygen, are common in nature, although they are usually found mixed with other substances. Other elements, such as krypton, are extremely rare. Some elements are considered safe. Other elements, such as sodium and chlorine, are explosive or poisonous.

Compounds

Elements can combine with other elements to form new pure substances, called compounds. **Compounds** are pure substances that are made up of two or more different elements. Compounds are related to elements in the same way that words are related to the letters of the alphabet. Thousands of words can be made from the 26 letters of the English alphabet. Similarly, millions of compounds can be made by combining the 104 elements.

Compounds can be solids, liquids, or gases. One example of a compound is water. Water is made up of the elements hydrogen and oxygen (**Figure 2**). Thus, a particle of water contains both hydrogen and oxygen. Every particle of water is the same as every other particle of water. At one time, scientists thought that water was made up of particles that could not be broken down further. Scientists now know, however, that water can be broken down into hydrogen and oxygen.

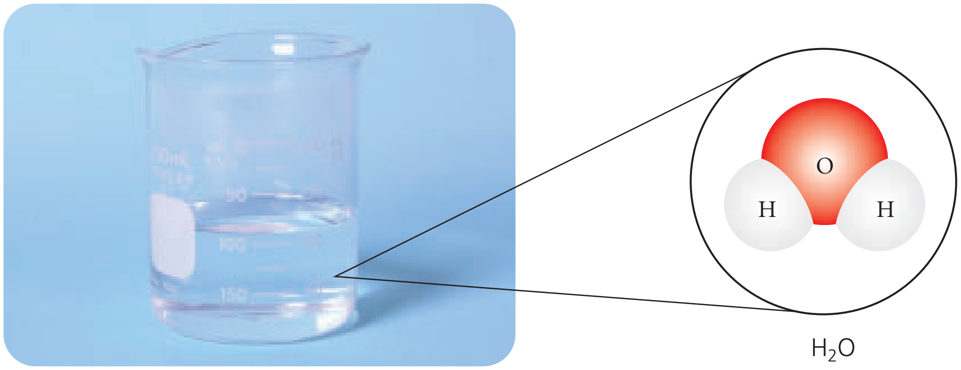


Figure 2
Water is a compound composed of hydrogen and oxygen particles.

The elements in some common compounds are listed in **Table 1**.

Table 1 Elements in Some Common Compounds

Compound	Elements combined in compound
water	hydrogen and oxygen
table salt (sodium chloride)	sodium and chlorine
carbon dioxide	carbon and oxygen
sugar (any type)	carbon, hydrogen, and oxygen
alcohol (any type)	carbon, hydrogen, and oxygen
chalk (calcium carbonate)	calcium, carbon, and oxygen
baking soda	sodium, hydrogen, carbon, and oxygen

Different elements have different properties because they have different particles. In the same way, different compounds have different properties because they have different combinations of elements. The properties of a compound can be very different from the properties of the elements that make it up. Table salt (**Figure 3**) is made of two elements, called sodium and chlorine. Sodium on its own is a soft, silvery metal that is poisonous and reacts violently with water (**Figure 4**). Chlorine is a greenish-yellow gas that is extremely poisonous (**Figure 5**). Each of these elements could be fatal if consumed on its own—for example, if you breathed in too much chlorine or swallowed a large quantity of sodium. When sodium and chlorine combine, however, they form table salt (sodium chloride), which you can safely eat and need in your diet.

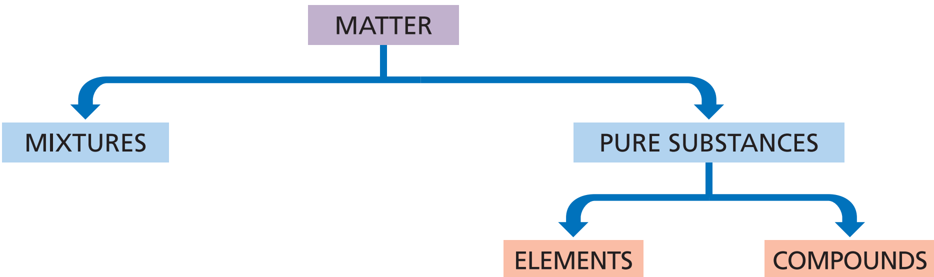
Figure 3
Table salt

Figure 4
Sodium metal

Figure 5
Chlorine gas

LEARNING TIP

Go back to the graphic organizer you started in section 6.1. Add "elements" and "compounds" under "pure substances." Your graphic organizer should now look like this: ↵



TRY THIS: CLASSIFY MODELS OF MATTER

Skills Focus: creating models, classifying

Copy your graphic organizer onto a large piece of paper.
Your teacher will give you eight jars, containing the following items (**Figure 6**):

1. five nuts
2. five bolts, five nuts, and five washers
3. five bolts with nuts attached
4. five bolts with a nut attached and five bolts with a washer and a nut attached
5. five bolts
6. five nuts and five washers
7. five bolts with a washer and a nut attached
8. five washers

Figure 6

Each jar is a model, representing a different type of matter. Each bolt, nut, and washer represents a different type of particle. Classify the eight models of matter as elements, compounds, or mixtures by placing them in the appropriate places on your graphic organizer.

LEARNING TIP

If you are having difficulty remembering the differences between mixtures, pure substances, elements, and compounds, scan the text for the information you need and make notes on your graphic organizer before you try to classify the models.

CHECK YOUR UNDERSTANDING

1. Explain the difference between an element and a compound, using examples of each.
2. Explain the difference between an element and a compound, using the particle model.
3. State whether each pure substance is an element or a compound. Explain your reasoning.
   a) a clear, colourless liquid that can be split into two gases with different properties
   b) a yellow solid that always has the same properties and cannot be broken down
   c) a colourless gas that burns to produce carbon dioxide and water

6.3 Mixtures

Most of the substances you use in your daily life are not pure substances. For example, hand lotion, shampoo, and soap are made of many substances, such as colouring and perfumes, mixed together. Foods contain preservatives and other additives. Even fruit juice that is labelled "100% pure" is actually a mixture of water, citric acid, and other substances (**Figure 1**).

Figure 1
This "pure" apple juice is a mixture.

Classifying Mixtures

If you were asked to name some pure substances, you might think of common substances such as sugar, water, salt, and oxygen gas. Other substances you might think of may seem to be pure, even though they are not. 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. One way that scientists classify mixtures is to group them according to their appearance.

LEARNING TIP

Before you read further, look at the subheadings on the next two pages. Predict how many categories scientists use to classify mixtures.

Mechanical Mixtures

A **mechanical mixture** is a mixture in which two or more different parts can be seen with the unaided eye. Granola cereal is an example of a mechanical mixture (**Figure 2**). Concrete is another example.

Figure 2
This cereal is a mechanical mixture. What other foods can you classify as mechanical mixtures?

Suspensions

A **suspension** is a cloudy mixture in which clumps of a solid or droplets of a liquid are scattered throughout a liquid or gas. Muddy water and tomato juice are suspensions. The parts of a suspension may separate into layers if the suspension is not stirred.

Farm-fresh milk is a suspension. If the milk is left standing, the fatty part (the cream) floats to the top and the watery part sinks to the bottom (**Figure 3**). Commercially available milk does not separate. It is a special kind of suspension, called an **emulsion,** which has been treated to keep it from separating. In a process called homogenization, the milk is sprayed through very small openings. This breaks down the fat into droplets that are so tiny they stay suspended.

Figure 3
Cream floats to the top of farm-fresh milk.

Solutions

A **solution** is a mixture that appears to be only one substance. The parts of a solution are so completely mixed that they cannot be seen, even under a microscope. This is because the particles of the substance that dissolves fill in the spaces between the particles of the substance it dissolves in. Clear apple juice (a liquid) (**Figure 4**), clean air (a gas), and stainless steel (a solid mixture of metals) are all solutions.

Figure 4
Apple juice is a solution.

LEARNING TIP

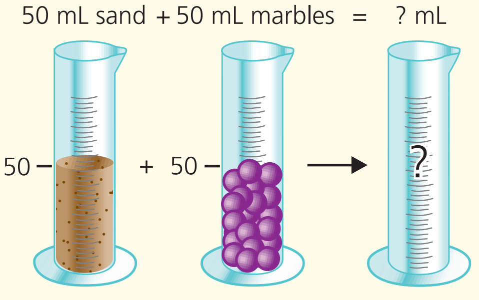
For a review on models, see "Creating Models" in the Skills Handbook.

TRY THIS: MODEL A SOLUTION

Skills Focus: modelling, predicting, observing

You can make a model to show how particles mix in a solution. The advantage of making a model is that you can observe a process you would not normally be able to see.

1. Half fill a clear plastic container with marbles. On the outside of the container, mark the level of the marbles with a marker. Then half fill a second, identical container with sand.
2. Predict the total volume that will result when you combine the marbles and the sand by marking the level you think will result.
3. Carefully pour the sand into the container with the marbles, and shake gently. How accurate was your prediction of the total volume? Explain.
4. How is the container of sand and marbles like a solution? How is it different?

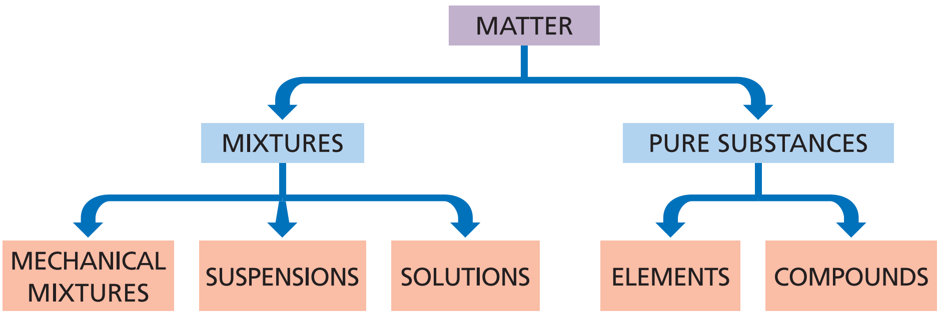


Examples of Mixtures

Table 1 gives examples of mechanical mixtures, suspensions, and solutions. Can you explain the classification of each substance listed?

Table 1 Examples of Mechanical Mixtures, Suspensions, and Solutions

Mechanical mixtures	Suspensions	Solutions
snow falling through the air	foggy air	clean air
salad	salad dressing	vinegar
cornflakes and milk	orange juice	tea
concrete (cement, sand, and gravel)	muddy water	tap water
abrasive skin cleanser	hand lotion	clear shampoo



LEARNING TIP

Go back to the graphic organizer you started in section 6.1. Complete it by adding "mechanical mixtures," "suspensions," and "solutions" under "mixtures." Your graphic organizer should now look like the one on the left.

CHECK YOUR UNDERSTANDING

1. List at least three mechanical mixtures and three solutions from your everyday life that were not mentioned in this section.
2. State whether each substance is a mechanical mixture, a suspension, or a solution. Explain your reasoning.
   a) green relish
   b) freshly squeezed orange juice
   c) soda pop in a glass
   d) bubble tea
   e) trail mix
   f) traditional Aboriginal paint, made of red ochre and grease
   g) vegetable soup
3. How are suspensions and solutions similar? How are they different?
4. Suppose that you dissolve 250 mL of drink crystals in 1000 mL of water. You get 1175 mL of drink rather than 1250 mL. How can you use the particle model of matter to explain this?

6.4 Separating Mixtures

▶ **LEARNING TIP**

Before reading this section, "walk" through it, looking at the headings. What ways of separating mixtures do you think you will learn about?

Does your family have a "junk drawer" somewhere, maybe in the kitchen or near the door (**Figure 1**)? Have you ever tried to sort out all the items that have collected in the drawer? In everyday life, there are many situations in which people want to separate the parts of a mixture. For example, you do not want to drink water that contains algae or fish, or dissolved chemicals from factories. You prefer to have these removed from the water before it is pumped to your home. Harmful or toxic substances from factories must be removed from any waste products before the waste products can be released into the environment.

Figure 1

How could the boy separate the items in the drawer?

Depending on the mixture involved, separating the parts can be easy or difficult. In this section, you will learn about some ways to separate different types of mixtures.

Picking Apart

You would probably separate the mixture in a junk drawer by simply taking out the different items—tools, elastic bands, scrap paper, and so on. You would use observable properties, such as shape and colour, to separate the mixture. If the pieces in a mixture are smaller, you might have to use a magnifier and forceps. Picking apart works when you can easily see the different pieces (**Figure 2**). It only works well for small quantities of mixtures. It is too time-consuming to use for large quantities.

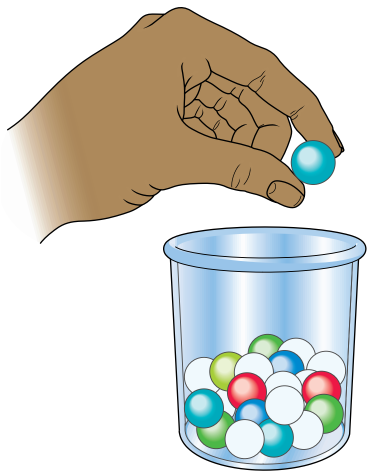


Figure 2

Picking apart a mixture

Filtering

You can remove solid pieces of matter from a liquid or gas by passing the mixture through a device that allows smaller particles to pass through but holds back larger particles. This is called filtering (**Figure 3**). Drinking water is an example of a mixture that is filtered. The water passes through a filter, which allows the liquid through but holds back larger particles. The liquid that passes through is called the filtrate and the solid material that is held back by the filter is called the residue.

There are many other examples of filtration. Air is filtered in car engines and factory smokestacks. Window screens act as filters to keep flies and mosquitoes out of homes. Workers who use spray paint wear facemasks so that they do not breathe in droplets of paint. Tea bags keep tea leaves out of tea, and coffee filters keep coffee grounds out of coffee.

Even very small pieces of substances can be removed from mixtures by filtration if the holes in the filter are small enough. Thus, filters can be used to separate solids from mechanical mixtures or suspensions. Filters cannot be used, however, to separate parts of solutions.

Figure 3
Filtering a mixture

Using Density

Density can also be used to separate mixtures. If the substances in a mechanical mixture have different densities, one substance may float and another may settle to the bottom (**Figure 4**). For example, density can be used to separate a mixture of sand and wood chips. If water is added to the mixture, the wood chips float and the sand sinks, making the mixture easy to separate.

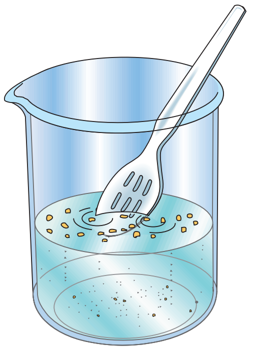


Figure 4
Using density to separate a mixture

Using Magnetism

Magnetism can be used to separate a mechanical mixture if one of the substances in the mixture is attracted to a magnet (**Figure 5**). This works well for a mixture of iron filings in sand.

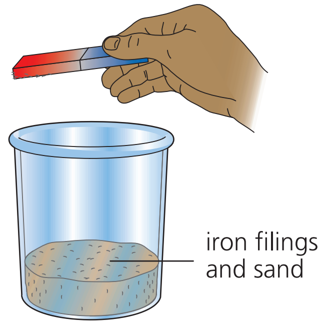


Figure 5
Using magnetism to separate a mixture

Figure 6
Dissolving one of the substances in a mixture

Dissolving

You can sometimes **dissolve** one of the substances in a mixture. When a substance dissolves, it mixes completely with another substance. For example, if you add water to a mixture of sand and salt, the salt dissolves. This makes the undissolved sand easier to separate out of the mixture by filtering (**Figure 6**).

Evaporating

You can also evaporate part of a solution to get a substance dissolved in it (**Figure 7**). For example, you can evaporate the water from a cup of tea. The solid that remains is the tea. Sometimes, the solid that remains crystallizes. For example, when the water evaporates from a salt-water solution, the salt crystallizes.

Figure 7
Evaporating one of the substances in a mixture

CHECK YOUR UNDERSTANDING

1. Describe the method you would use to separate each mixture in **Figure 8**.

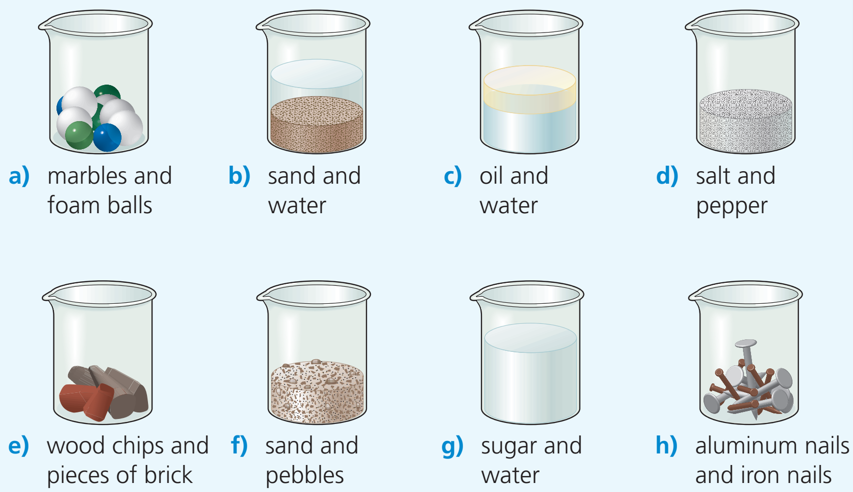


Figure 8

2. List several different filters in your home and school. What is the purpose of each filter?

Separating a Mystery Mixture

Often, scientists do not know exactly what substances are in a mixture before they try to separate it. Sometimes they have to separate something out of a mixture to use in a different test. In this activity, you will be provided with a mystery mixture. You must determine what the different substances in the mixture are.

LEARNING TIP

For more information on the steps in problem solving, see the "Solving a Problem" in the Skills Handbook.

Problem

For this activity, your teacher will give you a mystery mixture to separate.

Task

Your task is to separate the substances in the mixture using methods you learned in section 6.4. You should be able to identify six different substances.

Criteria

To be successful, your procedure must

- allow you to separate all six of the substances in the mixture
- be clear enough for someone else to follow and get the same results

Plan and Test

1. Look at your mixture. Are there any easily observable properties that give you clues about how to proceed? What separation methods can you use? In what order will you use them?
2. Design a procedure to separate your mystery mixture. Remember the different ways to separate a mixture: picking apart, filtering, using density, using magnetism, dissolving, and evaporating.
3. Decide what materials you will need. Draw a diagram to show how you will set up the equipment. Your diagram should be at least half a page in size.
4. Submit your list of materials, diagram, and procedure to your teacher for approval. Your procedure must include any safety precautions and an observation table.
5. Carry out your procedure.

Evaluate

6. Were you able to separate your mystery mixture into six separate substances? What substances did you find in your mixture?

LEARNING TIP

For more information on how to create a flow chart, see "Using Graphic Organizers" in the Skills Handbook.

Communicate

7. Draw a flow chart to show how you separated your mystery mixture. Post your flow chart, and compare it with the flow charts that your classmates have drawn.

CHECK YOUR UNDERSTANDING

1. Did any of the methods you tried fail to separate a substance from your mixture? If so, why?
2. What physical properties did you use to separate each substance from your mixture?
3. Are there any other methods you could have used to separate your mixture?
4. Do you think you recovered all of each substance in your mixture? How might you improve your procedure to recover as much as possible of each substance?

Measuring the Concentration and Solubility of Solutions

6.6

Concentration

When a solid dissolves in a liquid, the liquid that does the dissolving is called the solvent. The solid that dissolves is called the solute. For example, in a solution of orange-drink crystals and water, the water is the solvent and the orange-drink crystals are the solute (**Figure 1**).

Figure 1
The drink on the right has more solute than the drink on the left. How can you tell?

Have you ever made a drink by dissolving drink crystals in water and found that it tasted watery? This happens when you do not have the right concentration of solute in the solvent. **Concentration** [kon-suhn-TRAY-shun] is the amount of solute that is dissolved in a given quantity of solvent or solution.

Solutions that are made with the same substances may contain different amounts of each substance. A solution with a low concentration of solute is said to be **dilute** [die-LOOT]. A solution with a higher concentration of solute is said to be more concentrated. For example, lemonade with a small amount of dissolved sugar is a more dilute solution than lemonade with a lot of dissolved sugar. The lemonade with more sugar is a more concentrated solution. It tastes sweeter than the more dilute solution.

LEARNING TIP

The key vocabulary words on this page are illustrated. If you are having trouble with these vocabulary words, look at **Figure 1** for clarification.

LEARNING TIP

Make a web to show what you already know about substances that dissolve in water.

Solubility

You can make orange drink because the orange-drink crystals dissolve in water. Another way to say that a substance dissolves in water is to say that it is soluble in water. Can you think of some other substances that are soluble in water? If the orange-drink crystals did not dissolve in water, you would not be able to make the drink. An insoluble substance is a substance that does not dissolve. Can you think of some substances that are insoluble in water? Can a substance that is insoluble in water be dissolved in another solvent?

TRY THIS: OBSERVE DIFFERENT SOLVENTS

Skills Focus: predicting, observing, classifying

Predict whether salt, sugar, butter, and wax will dissolve in water and in ethanol. Now try to dissolve each of these solutes in the two different solvents (**Figure 2**). Record your results.

Observe Different Solvents

	Dissolves in water?	Dissolves in ethanol?
salt		
sugar		
butter		
wax		

Figure 2

Adding sugar to ethanol to see if the sugar dissolves

Saturated and Unsaturated Solutions

Even if a substance is soluble in a solvent, there is usually a limit to how concentrated the solution can become. For example, there is a limit to how many orange-drink crystals you can dissolve in a glass of water. Imagine that you add more and more drink crystals to a glass of water, stirring constantly. Eventually, the drink crystals will just stay at the bottom of your glass (**Figure 3**). The drink solution will not be able to dissolve any more drink crystals because it is saturated with them. A solution is **saturated** with a solute when no more of the solute can be dissolved in it. A solution is **unsaturated** with a solute when more of the solute can be dissolved in it.

Figure 3
How much sugar do you think can be dissolved in this lemonade?

The ability of a substance to dissolve in a solute is called **solubility.** You can measure the exact amount of solute that is required to form a saturated solution in a certain solvent at a certain temperature. Temperature is important because you can generally dissolve more solute in warm water than in cold water.

Solubility is different for each combination of solute and solvent. The amounts of different solutes that are needed to saturate a certain volume of solvent varies enormously. For example, more sugar than salt is needed to saturate 100 mL of water at room temperature (20°C) (**Table 1**).

Table 1 Solubilities of Common Substances in Water

Solute	Temperature (°C)		
	0	**20**	**50**
baking soda	6.9 g/100 mL	9.6 g/100 mL	14.5 g/100 mL
table salt	35.7 g/100 mL	36.0 g/100 mL	36.7 g/100 mL
sugar	179 g/100 mL	204 g/100 mL	260 g/100 mL

TRY THIS: ***DISSOLVE SOLUTES***

Skill Focus: predicting, observing

1. Make a saturated solution of water and salt by stirring small amounts of salt into about 100 mL of water until no more salt will dissolve.
2. Now that the water is saturated with salt, do you think you will be able to dissolve anything else in the water? Make a prediction.
3. Test your prediction by trying to dissolve sugar in your saturated salt solution.

Supersaturation

A very few solid solutes can be used to create a solution that is more than saturated. A solution that contains more of the solute than can be found in a saturated solution is called a **supersaturated** solution.

You can make a supersaturated solution by starting with a saturated solution at high temperature and then allowing the solution to cool slowly. Normally, as a solution cools, the solute particles lose energy. Some of the solute particles draw together and form the crystal pattern of the solid. In a supersaturated solution, the solute particles are not able to get into a crystal pattern. As a result, the solution remains liquid even when it is at a temperature at which it would normally be a solid.

If the supersaturated solution is not disturbed, all the solute may remain dissolved. If you strike the container lightly with a stirring rod or a spoon, however, the resulting vibrations may cause some of the solute particles to move into a crystal pattern. Immediately, the rest of the extra solute will fall out of solution and join the crystal. You can produce a similar effect by adding a seed crystal of the solute for the excess solute particles to build on (**Figure 3**).

LEARNING TIP

Pause and think. Ask yourself, "What did I just read? What did it mean?" Try to reword the information on supersaturation in your own words.

Figure 3

Adding a seed crystal causes the rapid formation of crystals in a supersaturated solution of sodium acetate.

CHECK YOUR UNDERSTANDING

1. Identify the solute and the solvent in the photo to the right.
2. List two liquid solutions that do not contain water.
3. Suppose that you add one teaspoon of sugar to your cup of tea. A friend adds four teaspoons of sugar to his cup of tea. Whose tea is a more concentrated sugar solution?
4. Is the solubility of all solutes the same? Explain.
5. Describe how you can tell the difference between an unsaturated solution and a saturated solution.

LEARNING TIP

Locate the information needed to answer these questions by scanning the text for key words.

6.7 Design Your Own Experiment

SKILLS MENU

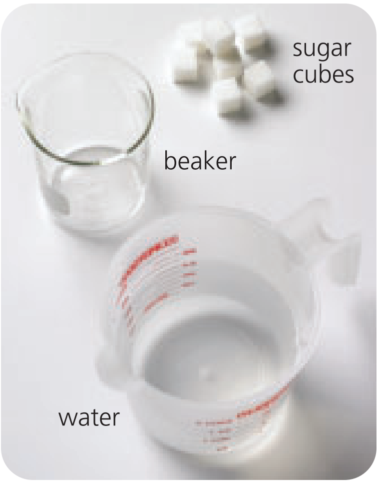
○ Questioning	● Observing
● Predicting	● Measuring
● Hypothesizing	○ Classifying
● Designing Experiments	○ Inferring
● Controlling Variables	● Interpreting Data
○ Creating Models	● Communicating

Factors That Affect the Rate of Dissolving

Imagine that you are trying to make a cold drink, such as lemonade, in a hurry. All that you have to sweeten your drink are sugar cubes, and they seem to be taking forever to dissolve. When you add sugar to a drink, several factors affect how quickly the sugar dissolves. Based on your experiences, you probably have some ideas about what these factors are. But have you ever tested your ideas?

LEARNING TIP

For help in writing hypotheses, controlling variables, or writing up your experiment, see the Skills Handbook sections "Hypothesizing," "Controlling Variables," and "Writing a Lab Report."



Question

What factors affect how quickly a solute dissolves in a solvent?

Hypothesis

You will be testing at least three variables in this experiment. Write a hypothesis for each variable that you plan to test. Use the form "If … then the sugar will dissolve more quickly."

Materials

- sugar cubes
- beakers
- water

List any other materials that you will need to perform this experiment.

Procedure

- This is a controlled experiment to investigate factors that affect the rate of dissolving. Design a procedure for the experiment. For each part of your procedure, determine
  - what variable(s) will change
  - what variable(s) will stay the same
- Submit your procedure, including any safety precautions, to your teacher for approval. Also submit a diagram, at least half a page in size, showing how you will set up your experiment.

Data and Observations

Create a table to record your observations. Record your observations as you carry out your experiment.

Analysis

1. Compare your results with your classmates' results. Were your results similar?
2. Use the particle model of matter to explain why each factor affected the rate of dissolving.

Conclusion

Were your hypotheses correct? Did your observations support, partly support, or not support your hypotheses? Write a conclusion for your experiment.

LEARNING TIP

For help in writing a conclusion, see the example and explanation in the "Writing a Lab Report" section of the Skills Handbook.

Applications

1. A soup recipe calls for bouillon to be added. You find both bouillon powder and bouillon cubes in your kitchen cupboard. Which form of bouillon will speed up the soup-making process? Explain your answer.
2. Most brands of soda pop are solutions of water, dissolved sugar, and dissolved carbon dioxide gas. When you remove the cap from a cold bottle of pop, you hear a faint whoosh as the gas escapes. When you remove the cap from a warm bottle, however, the whoosh is much louder. What effect do temperature and pressure have on the rate that carbon dioxide gas comes out of a pop bottle?
3. Give three examples of situations in which speeding up or slowing down the rate of dissolving might be important. How do you think this could be done in each situation?

CHECK YOUR UNDERSTANDING

1. What were the independent and dependent variables in each part of your procedure?
2. Suggest at least two factors that you think would have no effect on the rate of dissolving. Explain why you think they would have no effect.

6.8 Measuring the Acidity of Solutions

Have you ever wondered what makes lemon juice sour (**Figure 1**)? Lemon juice is a solution that contains dissolved compounds. Scientists classify some compounds by the properties of the solutions they form.

Figure 1
Lemon juice has a sour taste.

LEARNING TIP

Check your understanding of the properties of acids and bases. Work with a partner and take turns describing the properties.

Acids are compounds that form solutions with the following properties:

- have a sour taste
- react with (corrode) metals
- can cause serious burns on skin

Many acidic solutions, such as lemon juice and vinegar, are harmless. They can be used to give foods a tangy flavour. Other acidic solutions are extremely dangerous. Hydrochloric acid, for example, is used to etch concrete and would make holes in your skin or clothing.

Bases are compounds that form solutions with the following properties:

- have a bitter taste
- feel slippery
- react with (break down) fats and oils
- can cause serious burns on skin

Some basic solutions are harmless. You can drink a solution of baking soda and water to calm an upset stomach. Other basic solutions, such as drain cleaner, should be used with extreme care. They should never be allowed even to touch your skin.

You often use the properties of acidic and basic solutions in your daily life. Some common acids and bases are shown in **Figure 2**.

Figure 2
Common acids (left) and bases (right)

LEARNING TIP

Make connections between what you are learning about the properties of acids and bases in this section and what you already knew about the products in **Figure 2**. Ask yourself, "Did I already know these products had these properties?"

Identifying Acids and Bases

Because many acids and bases are not safe to taste, scientists use other properties to identify them. One property that is safe to use is their effect on a dye called litmus [LIHT-muhs]. Acidic solutions turn blue litmus paper red. Basic solutions turn red litmus paper blue. Litmus is called an indicator because it indicates whether a solution is acidic or basic (**Figure 3**).

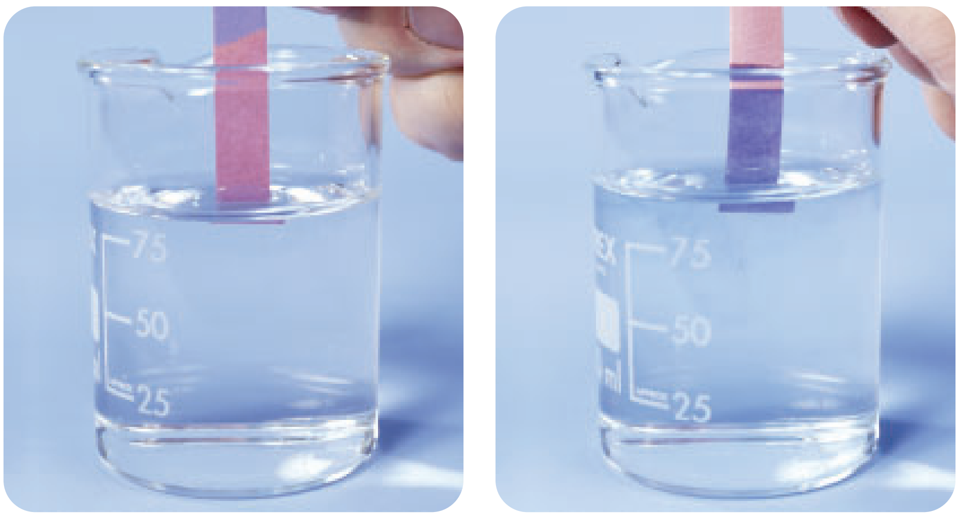


Figure 3
Blue litmus paper turns red in an acidic solution (left). Red litmus paper turns blue in a basic solution (right).

Scientists measure acidity on the **pH** scale—a scale of numbers running from 0 to 14 (**Figure 4**). If a compound is neither an acid nor a base, it is **neutral** and has a pH of 7.0. Pure water, for example, is neutral. **Acidic** solutions have pH values that are below 7. The more acidic a solution, the lower its pH value is. A solution with a pH between 0 and 3 is very acidic. **Basic** solutions have pH values that are above 7. The more basic a solution, the higher its pH value is. Very basic solutions, such as drain cleaners, have pH values that are close to 14.

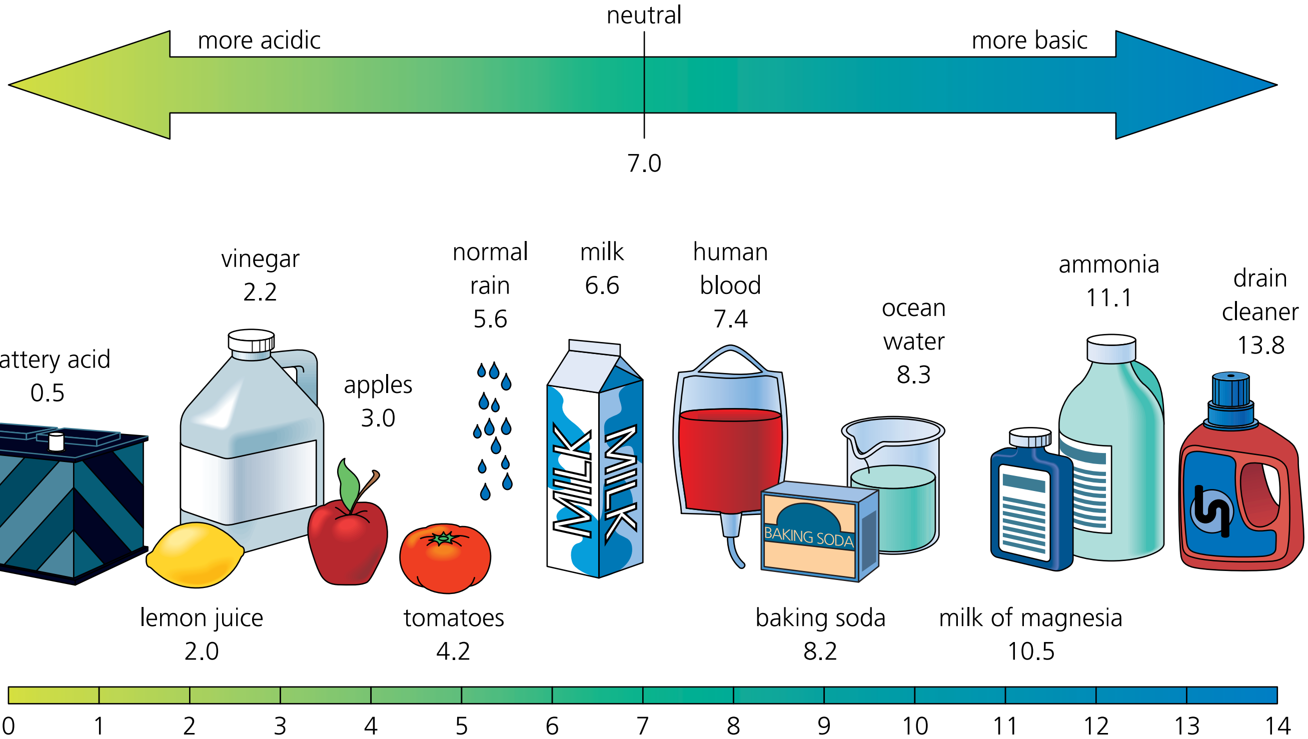


Figure 4
The pH values of some common substances

CHECK YOUR UNDERSTANDING

1. Make a Venn diagram to compare acids and bases. Include at least two examples for each.
2. When might you need to know whether a solution is acidic or basic?
3. Dishwasher detergent, oven cleaner, and drain cleaner are all basic solutions with high pH values. What property of basic solutions makes these products useful?

Measuring the pH of Household Products

SKILLS MENU	
○ Questioning	● Observing
● Predicting	● Measuring
○ Hypothesizing	● Classifying
○ Designing Experiments	○ Inferring
○ Controlling Variables	○ Interpreting Data
○ Creating Models	● Communicating

Acids and bases can be distinguished from one another by the colours they turn certain indicators. The pH paper you will use in this investigation is a universal indicator. It contains several indicators, which turn different colours in solutions with different pH values (**Figure 1**). You will also use an indicator that you will make yourself and develop a colour scale for this indicator.

Figure 1
pH paper turns different colours.

Question

What is the pH of some common products around your home?

Materials

- red cabbage
- 400-mL beaker
- hot plate
- apron
- safety goggles
- several clean beakers or glass jars
- several household products that are solutions, such as lemon juice, apple juice, baking-soda solution, vinegar, milk, coffee, tea, and shampoo
- samples of different types of water, such as tap water, rainwater, swimming-pool water, hot-tub water, and water from a lake or stream
- wide-range pH indicator paper
- medicine dropper

Acids and bases are harmful to eyes and skin. Always wear safety goggles and an apron.

Procedure

1 Slice the red cabbage, and put it in the 400-mL beaker. Add water to cover the cabbage. Boil the cabbage on a hot plate for about half an hour while you continue with the other steps. After half an hour, turn off the heat and let the cabbage cool.

Be careful when using the hot plate.

2 In your notebook, draw a data table like the one below.

Data Table for Investigation 6.9

Substance tested	Prediction: acid, base, or neutral?	pH
lemon juice		
baking-soda solution		

3 Before you test the solutions, predict whether each solution will be acidic, basic, or neutral. Record your predictions in the second column of your table.

4 Put on your apron and safety goggles.

5 Put about 20 mL of a different household product or different type of water in each beaker.

There is the risk that acids and bases may irritate eyes and skin. If you get any acid or base in your eyes or on your skin, immediately rinse the area with water for 15 to 20 min, and tell your teacher.

6 Test the pH of each solution by dipping a strip of pH paper into the beaker. Compare the colour that results with the colour scale on the dispenser. If the colour that results is in between two colours on the scale, estimate the pH. Record the pH for each solution in your data table.

7 Add 5 drops of red cabbage juice to each solution you tested in step 6. Record the colours. Use the information from the data table you completed in step 6 to develop a red cabbage indicator scale. Set up your indicator scale in a table like the one below.

Red Cabbage Indicator Scale

pH	Colour of red cabbage indicator
1	
2	
3	
4	
5	
6	

8 After you have completed your tests, wash your hands.

Analyze and Evaluate

1. Which solutions were acidic? Which were basic? Which were neutral?
2. Which solution was the most acidic? Which was the most basic?
3. Why do different samples of water have different pH values?

Apply and Extend

4. Samples of water are taken from two swimming pools. One sample has a pH of 4. The other sample has a pH of 5. Which is more acidic?
5. Some people like to squeeze a few drops of lemon juice into their tea (**Figure 2**). When they add the lemon juice, the tea changes colour. Use what you know about acids and bases to explain why this happens. What other substances might cause the colour of tea to change?

Figure 2
What happens to tea when lemon juice is squeezed into it?

CHECK YOUR UNDERSTANDING

1. Did you have any surprises in your predictions about acids and bases? What have you learned that would help you make more accurate predictions if you were given a new set of samples?

LEARNING TIP

For a review of what is involved in making predictions in science, see "Predicting" in the Skills Handbook.

6.10 Explore an Issue

LEARNING TIP

For more information on the steps in exploring an issue, see "Exploring an Issue" in the Skills Handbook.

Should Salt Be Used on a Walkway?

Different substances have different properties because every pure substance is made up of different kinds of particles. Each pure substance has its own melting point and boiling point. Adding a solute to a substance changes the melting point or boiling point of the substance.

In winter, snow and ice can make driving and walking dangerous (**Figure 1**). To melt the ice and reduce the danger, salt (sodium chloride) is often spread on roads and walkways. Why is this done? What does salt do to the snow and ice to help make the roads and walkways safer?

Figure 1
How could spreading salt on this road make it safer for drivers?

Salting roads and walkways makes driving and walking safer, but it also causes some serious problems. What are these problems? Are there alternatives to using salt on roads and walkways?

The Issue

It is the middle of winter and the walkway in front of your school has completely frozen over. You are worried that someone might slip on the ice. What should you do? Should you spread salt on the ice? How does this help? What are the benefits of spreading salt on the ice? What are the drawbacks? Are there alternatives to salt? What are the benefits and drawbacks of these alternatives?

Background to the Issue

Gather Information

Work in pairs to learn more about spreading salt on walkways. Where can you find more information? If you are doing an Internet search, what key words can you use?

www.science.nelson.com GO

LEARNING TIP

For more information about how to do this research, see "Researching" in the Skills Handbook.

Identify Solutions

You may wish to use the following questions to help you identify solutions:

- What does salt do to ice and snow? (*Hint*: Think in terms of chemistry—melting point, solutions, and so on.)
- What are the drawbacks of using salt on walkways?
- What are some alternatives to using salt?
- How much does each alternative cost?
- What are the benefits and drawbacks of each alternative?
- What are the environmental impacts of salt and each of the alternatives?

Make a Decision

What will you use on the walkway? What criteria did you use to decide?

Communicate Your Decision

Write a position paper about why salt should or should not be used on the walkway. If you decide that salt should not be used, explain why. Then discuss alternatives to salt. Explain which alternative(s) you would use, and why.

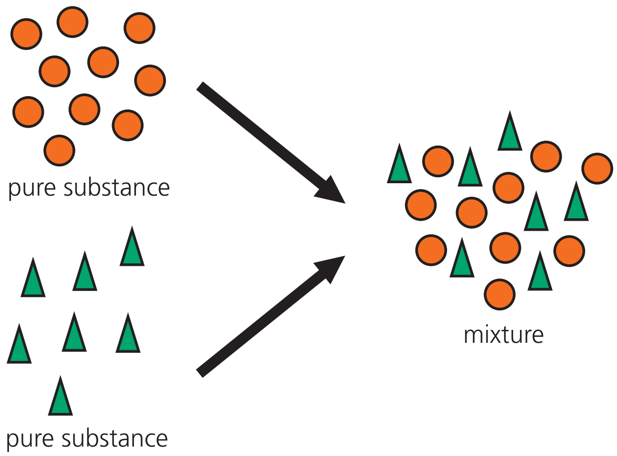
CHECK YOUR UNDERSTANDING

1. How did you come up with your position? Are there things you could have done differently? Explain.
2. Why should you always be prepared to consider alternatives?
3. Why should you always be prepared to defend your position on an issue?

6 Chapter Review

Matter can be classified.

Key Idea: **All matter can be classified as pure substances or mixtures.**

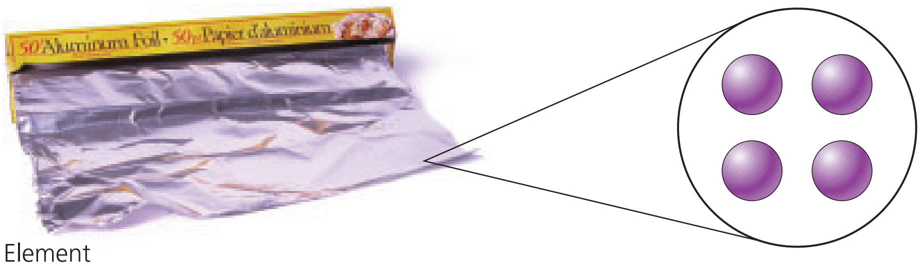


Vocabulary

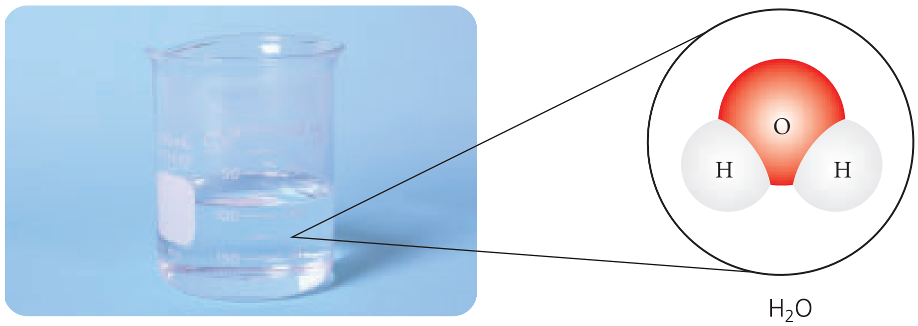
pure substance p. 137

mixture p. 138

Key Idea: **Pure substances can be classified as elements or compounds.**



Element



Compound

Vocabulary

elements p. 140

compounds p. 141

Key Idea: **Mixtures can be classified as mechanical mixtures, suspensions, or solutions.**


Mechanical Mixture


Suspension

Solution

Vocabulary

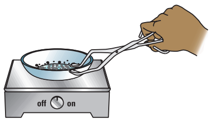
mechanical mixture p. 145

suspension p. 145

emulsion p. 145

solution p. 146

Key Idea: **Mixtures can be separated by a variety of methods:**



Evaporating


Using density


Filtering


Dissolving


Picking apart


Using magnetism

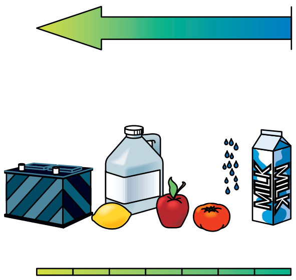
Vocabulary

dissolve p. 150

Key Idea: **Solutions can be measured by concentration, solubility, and acidity.**


Concentration


Solubility


Acidity

Vocabulary

concentration p. 153

dilute p. 153

saturated p. 155

unsaturated p. 155

solubility p. 155

supersaturated p. 156

acids p. 160

bases p. 160

pH p. 162

neutral p. 162

acidic p. 162

basic p. 162

Review Key Ideas and Vocabulary

When answering the questions, remember to use vocabulary from the chapter.

1. What is the difference between a pure substance and a mixture? Give two examples of each.
2. What is the difference between an element and a compound? Give two examples of each.
3. Identify each of the following as a mechanical mixture, a suspension, or a solution. Explain your reasoning.
   a) granola
   b) orange juice
   c) tap water
   d) a toonie
   e) farm-fresh milk
   f) homogenized milk
   g) concrete
   h) clear apple juice
   i) hand lotion
   j) cereal and milk
4. Describe how you would separate the parts of each mixture. What property of matter makes the separation method work? Explain.
   a) sand and salt
   b) dust in a fluffy blanket
   c) sawdust and sand
   d) pebbles and sand
   e) flour and water
5. Read the following statements. Rewrite any statements that are incorrect so that they are correct.
   a) If a solution is saturated at 20°C, it will also be saturated at 25°C.
   b) When some solvent evaporates, a solution becomes more saturated.
   c) When a saturated solution is cooled, some crystals begin to appear in the solution. The solution is now unsaturated.
   d) A solvent is a liquid that dissolves sugar.
   e) A solute is always a solid.
   f) Oil is insoluble.
6. Five solutions have pH values of 3, 5, 7, 9, and 11. State which solution(s) is (are)
   a) acidic
   b) most acidic
   c) neutral
   d) basic
   e) sour tasting
   f) most helpful in breaking down oils and fats

Use What You've Learned

7. Mixtures and compounds both contain two or more elements. How do mixtures differ from compounds?
8. Screens and filters work in the same way. The screens on your windows and doors separate insects (such as flies and mosquitoes) from the air. Make a table like the one below. In the first column, list different types of filters and screens that can be found in your home and school, and in a car. In the second and third columns, identify what is let through and what is held back.

#8.

Screen or filter	What is let through	What is held back

9. Imagine that you have spilled a whole bottle of expensive perfumed oil into a bath. What steps could you take to recover as much of the oil as possible?

10. How could you use a flashlight to distinguish between a solution and a suspension?

11. a) Make a table that has three columns. In the first column, list 10 liquids in your home. Determine the substances in each liquid by reading the label on the container.
    b) In the second column of your table, identify the liquids that meet the definition of a solution.
    c) In the third column, list the solvent and the solute(s) in each solution.

#11.

Liquids in home	Is it a solution?	Solvent and solute

12. The label on a large bottle of liquid laundry detergent states that the bottle contains enough detergent to wash 100 loads of laundry. The label on a different brand, in a smaller bottle, also states that the bottle contains enough detergent to wash 100 loads of laundry. Both claims are true. Explain how this is possible.

13. Using what you know about solutions, predict three ways that you could shorten the time a sugar cube takes to dissolve in a drink. Explain your predictions.

14. Oil spills that occur near shorelines are often cleaned up with the help of powerful detergents. What properties of oil and a detergent solution make this work?

Think Critically

15. Is ocean water a saturated or unsaturated saltwater solution? Explain your answer.

16. "A chemical that can dissolve in water is more dangerous than a chemical that cannot." Do you agree with this statement? Explain.

Reflect on Your Learning

17. Print the following terms on sticky notes: suspension, element, matter, mechanical mixture, compound, pure substance, solution, mixture. Arrange the sticky notes on a piece of paper. Draw lines between them to show how scientists classify matter. Check your work by comparing it with the graphic organizer you drew in section 6.3.