TOPIC 2.2

What are some ways to describe matter?

Key Concepts

- Matter can be described by its physical properties.
- Matter can be described by its chemical properties.
- Matter can be described based on physical and chemical changes.
- Matter can be classified based on how it responds to physical and chemical changes.

Curricular Competencies

- Identify a question to answer or a problem to solve through scientific inquiry.
- Make predictions about the findings of your inquiry.
- Demonstrate an understanding and appreciation of evidence (qualitative and quantitative).

Do these images look like they have been digitally enhanced? They haven't been. This ghostly looking material is called silica aerogel. Compared with any other solid of the same size and shape, it is extremely light. That is why it almost appears to float above this person's fingers. A cube of silica aerogel measuring 1 cm on each side is about the same size as a mini-marshmallow but is 30 times lighter.

Silica aerogel has some unique properties. Despite seeming so fragile, it has an amazing ability to insulate against heat. Even a thin piece can protect a delicate flower from the full heat of a laboratory burner. Its applications range from common consumer products such as paint thickener to out-of-this-world uses such as insulation for spacesuits.

Starting Points

Choose one, some, or all of the following to start your exploration of this Topic.

1. **Identifying Preconceptions** Describe three properties of silica aerogel. Do you think these are physical properties, chemical properties, or examples of both? Explain your reasoning.
2. **Analyzing Information** Come up with three applications that silica aerogel could be used for. Explain why it would be an ideal material to use in each case.
3. **Processing Information** Assume you have been asked to develop an environmentally friendly bicycle tire.
   a) Identify important properties the material should have to meet that need.
   b) What are other important points to consider when developing a new product made of different material?

Key Terms

There are seven key terms that are highlighted in bold type in this Topic:

- physical property
- density
- physical change
- mass
- chemical property
- chemical change
- volume

Flip through the pages of this Topic to find these terms. Add them to your class Word Wall along with their meaning. Add other terms that you think are important and want to remember.

CONCEPT 1

Matter can be described by its physical properties.

Activity

Observing Properties

Choose an object in the classroom. Write down as many of its properties as you can. Then trade your description with a partner and see if you can identify the object. Afterwards, reflect on which properties helped to make the object more or less difficult to identify.

All matter has different characteristics that can be used to describe it. A **physical property** of matter is a characteristic that can be observed or measured without changing its chemical identity (the type of matter that it is).

physical property characteristic of matter that can be observed or measured without changing its chemical identity

Physical Properties

Qualitative Physical Properties

These berries, all B.C. crops, each have distinct colours, flavours, and odours due to a variety of substances in each fruit.

Texture is a physical property that describes how the surface of a substance feels. This sandpaper has a rough texture.

This gold ring was made by Haisla artist Barry Wilson. Gold is popular for jewellery because it is lustrous (shiny) and malleable (easy to shape). Diamond is prized for its sparkle and hardness.

Oxygen is a gas at room temperature. The state of a substance—gas, liquid, or solid—is a physical property.

Figure 2.5 shows examples of physical properties of matter. *Qualitative physical properties* can be described and compared using words, such as “red,” “sweet-smelling,” or “shiny.” You do not need to use an instrument to make measurements when observing qualitative physical properties. However, many physical properties have numerical values associated with them. Those properties that can be measured and assigned a value are called *quantitative physical properties*.

Figure 2.5 Matter can have a variety of physical properties.

Quantitative Physical Properties

The temperature at which a substance melts is called the melting point. The melting point of most chocolates is between 30°C and 32°C, which is less than normal human body temperature.

The boiling point is the temperature at which a liquid becomes a gas. The boiling point of water is 100°C.

Solubility is the amount of matter that dissolves in another kind of matter. The solubility of table salt in water is 0.4 g of salt in 1 mL of water.

Tlingit Haida master carver Nathan Jackson uses the difference in hardness between wood and steel in his work. Various hardness scales are used to associate a number with the hardness of a material.

Viscosity describes the rate at which a material flows. Molasses has a high viscosity, which means it flows very slowly. Depending on the type, molasses is 5000 to 10 000 times as viscous as water.

Mass and Volume

mass quantity of matter in an object or sample

All matter has two things in common: mass and volume. **Mass** is the quantity of matter in a sample that is being measured. A balance is used to measure mass, and there are a variety of different types. Figure 2.6 shows two electronic digital balances in use. Some common units for measuring mass are the kilogram (kg), gram (g), and milligram (mg).

volume amount of space a substance takes up

Volume is the amount of space that a material takes up. Most often, the volume of a solid is measured in cubic units, such as cubic metres (m^3) or cubic centimetres (cm^3). The volume of a gas or liquid is measured in litres (L). Small volumes are often recorded as millilitres (mL). The unit used to measure the volume of a solid is related to the unit of volume used to measure liquids and gases. One cubic centimetre is the same volume as one millilitre ($1\ cm^3 = 1\ mL$).

Density—A Physical Property Related to Mass and Volume

Suppose you have two identical shopping bags. One is filled with loaves of bread and hotdog buns, and the other is filled with containers of juice and milk. Which would be easier to lift? Even though both bags are the same size, the second bag would be much heavier because it contains more mass in the same volume. This example describes a quantitative physical property called density.

density quantity of mass in a certain volume of material

Density is the mass of a material that occupies a certain volume. Common units of density are grams per cubic centimetre (g/cm^3) for solids and grams per millilitre (g/mL) for liquids and gases. Figure 2.6 compares two items with different densities.

Figure 2.6 The grape and foam have the same mass but different volumes. **Which substance has the greater density? Explain why.**

Determining Density

You do not usually measure density directly. Instead, you measure the mass and volume of a sample and then calculate density using this equation:

Density Equation

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

For example, jet fuel is tested to ensure it meets certain standards. One standard is density. If a sample of jet fuel has a mass of 8.30 g and a volume of 10.3 mL, what is its density?

mass = 8.30 g

volume = 10.3 mL

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

$$= \frac{8.30\ \text{g}}{10.3\ \text{mL}}$$

$$= 0.806\ \text{g/mL}$$

The density of water is about 1 g/mL. Therefore, the density of the jet fuel is less than the density of water. Jet fuel and water do not mix, so when jet fuel is added to water, it forms a layer that floats on top of the water. Figure 2.7 shows how liquids with different densities can form layers in a container.

Figure 2.7 These liquids have different densities. (Dyes were added to the liquids to help you see the layers.) **List the liquids in the order of most dense to least dense.**

Activity

Finding Density

Your teacher will provide you and a partner with a set of cubes of different materials.

- Using a ruler, measure the volume of each cube. What units will you use?
- Measure the mass of each cube. What units will you use?
- Determine the density of each cube. Make sure to report it in the correct units.

Which material was the densest? Which material was the least dense?

Before you leave this page . . .

1. What is a physical property? Give three examples as part of your answer.
2. What is the difference between a qualitative property and a quantitative property?

AT ISSUE How can small floating cards help in the study of oil spills?

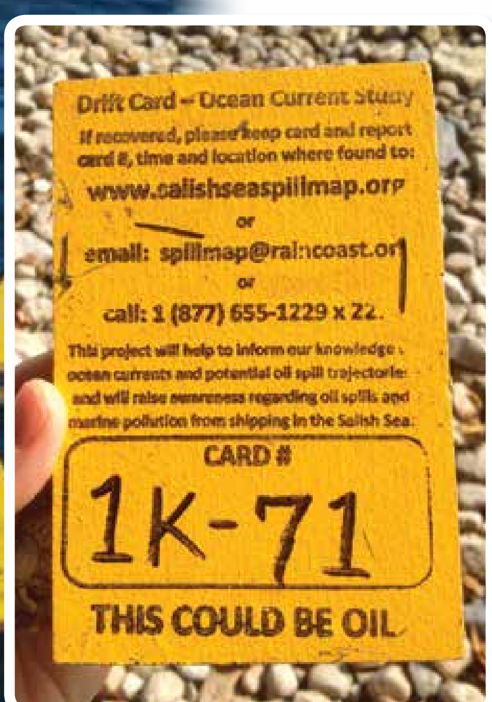
What's the Issue?

"This could be oil" was the warning that Andy Rosenberg printed on 400 yellow plywood cards. Then in October 2013 and again in August 2014, Rosenberg, a biologist with Raincoast Conservation, dumped the cards over the side of a boat. He dropped 400 into British Columbia's lower Fraser River, 600 into the Burrard Inlet, and about 3000 others in various locations off the coast of B.C.

Why would a biologist do this?

In 2013, 300 000 barrels of gas and oil were shipped every day through a vast pipeline running from the oil sands in Alberta to refineries and terminals in Vancouver, B.C., and in Washington, in the United States. Then the pipeline company decided it wanted to expand its project by adding a new pipeline. A segment of this new pipeline would carry oil under the Fraser River, in B.C. The addition of a new pipeline would increase the amount of gas and oil transported each day to 890 000 barrels.

In years past, the oil was mainly kept for local use. Now, the plan was for oil tankers to carry the oil to other destinations. The tankers would travel along many kilometres of coastline through the Strait of Georgia, Puget Sound, and the Strait of Juan de Fuca, which together are known as the Salish Sea, before reaching the Pacific Ocean. The new pipeline would increase the number of tankers moving through the Salish Sea from 4 to 35 per month.



When Andy Rosenberg, the biologist, learned of this, he was concerned. What if there were a leak in the pipeline under the Fraser River or in any of the oil tankers moving along the coastal waters? Because oil does not mix with water and is less dense than salt water, spilled oil floats and spreads out very thinly on the surface of the water. The spills can cover large areas and travel great distances. Rosenberg wanted to determine how far and where oil might spread.

Getting the Public Involved

Rosenberg created the floating drift cards as stand-ins for the spilled oil. He distributed them at key locations in local waters, in different seasons. Rosenberg also set up a website showing a map of the area, including where he'd dropped the drift cards. He encouraged the public to log on and report the finding of any cards, including their location and the date and time of the recovery. This would assist him in creating maps to show possible results of different spill scenarios.

As of April 2016, members of the public have reported the locations of more than 1800 drift cards—from the Salish Sea all the way up to Alaska. Raincoast Conservation is working to analyze the findings.

Dig Deeper

Collaborate with your classmates to explore one or more of these questions—or generate your own questions of interest to explore.

1. Why did Rosenberg make his drift cards out of plywood? What other kinds of materials are used to make drift cards, and why?
2. Substances in oil can be poisonous. They can cause harm inside the body. They can damage skin or irritate eyes. They can coat fur or feathers.
   a) How does the density of oil determine what kind of organisms are affected most by oil spills?
   b) Not all oil being carried in pipelines is alike. Find out how diluted bitumen is different from conventional oil. Compare the effects of a spill of each type.
3. Alexandra Woodsworth campaigns for a B.C.-based environmental group. She believes another benefit of the drift cards is that they engaged the public in a key issue: oil spills.
   a) Do you think that public involvement in scientific studies is important? Why or why not?
   b) How could the Internet encourage more public involvement in studies overall?

CONCEPT 2

Matter can be described by its chemical properties.

Activity

What's a Chemical Property?

Which of these situations do you think describes a chemical property and why?

- The flesh of an apple turns brown when exposed to air.
- Copper wire can be bent to form a coil.

chemical property ability of matter to react with another substance to form one or more new substances

A **chemical property** describes the ability of matter to react with another substance to form one or more new substances with different properties. Chemical properties can only be observed when a substance chemically interacts, or reacts, with another substance. Some examples of chemical properties are shown in **Figure 2.8**.

Figure 2.8 Chemical properties are only observed when substances chemically interact to form new substances—or when they fail to do so.

Chemical Properties

Combustibility describes the ability of a material to catch fire and burn in air. We can burn wood and other fuels, such as natural gas and propane, because of their combustibility.

Reactivity with acids is a chemical property. Some substances react vigorously with acids and others do not. Here, a gas forms when baking soda is mixed with vinegar, which is an acid.

Reactivity with oxygen is a chemical property. Substances in foods such as avocadoes, apples, and bananas react with oxygen when exposed to air. Different substances are formed that give the exposed food a brown colour.

Lack of reactivity is another chemical property. Substances that do not react with other substances are called "inert." Helium, used to fill balloons for parties and parades, is one example of an inert substance.

Before you leave this page . . .

1. What is the main difference between physical and chemical properties?
2. Explain why melting point is not a chemical property.

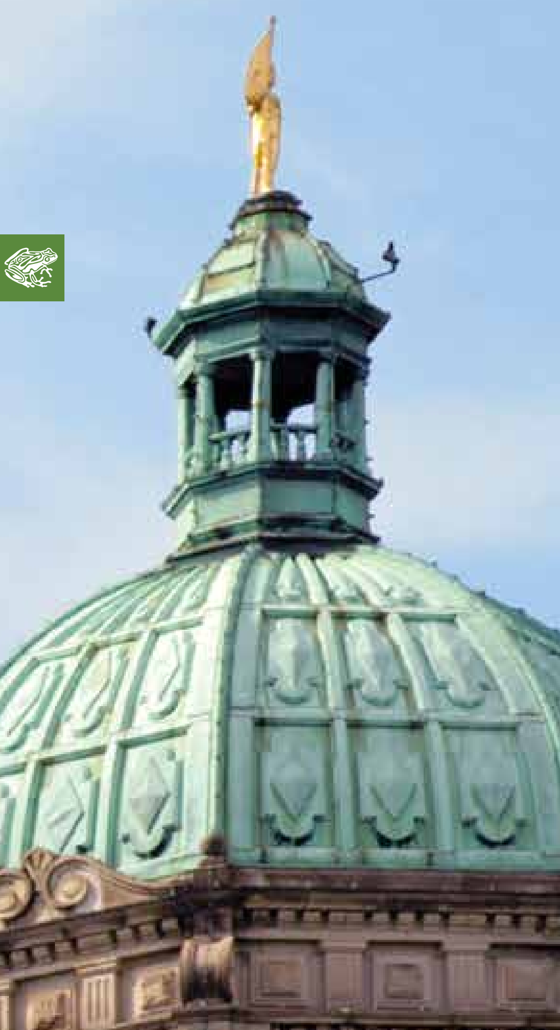
AT ISSUE

How do we measure the worth of copper?

What's the Issue?

The physical and chemical properties of copper have made it valuable throughout history. Copper can be flattened and shaped without breaking. It was first used in coins as far back as 8000 B.C.E. For the Haida, Tlingit, Kwakwaka'wakw, Tsimshian, and Bella Coola, coppers such as the one below signified wealth as well as natural and supernatural power.

Copper's ability to conduct heat and electricity makes it useful in the home and industry. Its chemical properties include the ability to combine with oxygen in air and rain to form a green layer for the B.C. parliament buildings.



Copper is used in almost everything that touches our lives, and the demand for the metal continues to increase. British Columbia produces more copper than any other province. A mine planned for northwest B.C. would make the province home to the largest copper mine in the world.

Dig Deeper

Collaborate with your classmates to explore one or more of these questions—or generate your own questions of interest to explore.

1. Research the physical and chemical properties of copper. Also find out the different uses for copper. How do its physical and chemical properties relate to the ways people use copper?
2. Describe the Seabridge Gold Inc. plan to build a combined gold and copper mine in northwest B.C. What approvals did the company need? What controversies have been associated with this project, and why?
3. Copper is mined in B.C. by open-pit mining. What is open-pit mining and what are some concerns that are associated with it? How do mining companies try to reduce the risks? In your opinion, are the benefits worth the risks?

CONCEPT 3

Matter can be described based on physical and chemical changes.

Activity

What Changes Are Happening?

Your teacher will give you and a partner a test tube with water and part of an Alka-Seltzer® tablet. The tablet contains baking soda and citric acid. Make a list of the physical properties of the water and tablet. Predict what will happen when the tablet is added to the water. Add the tablet to the water and observe what happens. Which changes do you think are physical changes? Which are chemical changes? Explain.

Physical Changes

physical change change of matter that does not alter its chemical identity or composition

A **physical change** is a change that alters a substance without changing its chemical identity or composition. Crumpling a sheet of aluminum foil into a ball or folding a piece of paper into the shape of a bird are examples of physical changes. The crumpled ball of foil is still aluminum and the folded paper is still paper. Figure 2.9 shows a familiar physical change.

Figure 2.9 Freezing is a physical change.

The freezing of water to form ice is also an example of a physical change—the frozen, solid water is still water. Substances can exist in gas, liquid, or solid forms. These forms are called states. For example, you are most familiar with gold in its solid state. But gold can exist as a liquid or even a gas. However, extreme conditions are needed to change gold into its gas state, because its boiling point is 2856°C, which is hotter than most furnaces can get.

When a substance changes from one state to another, the physical change is known as a *change of state*.

Chemical Changes

chemical change change of matter that produces new substances

During a **chemical change**, or *chemical reaction*, one type of matter changes to produce one or more different types of matter. The matter that is produced has a different identity and different properties from the original matter. The substances that take part in a chemical change are called the *reactants*. The substances that are formed by the chemical change are called the *products*. Figure 2.10 shows some physical and chemical changes involved in preparing food.

Connect to Investigation 2-C on pages 126–127

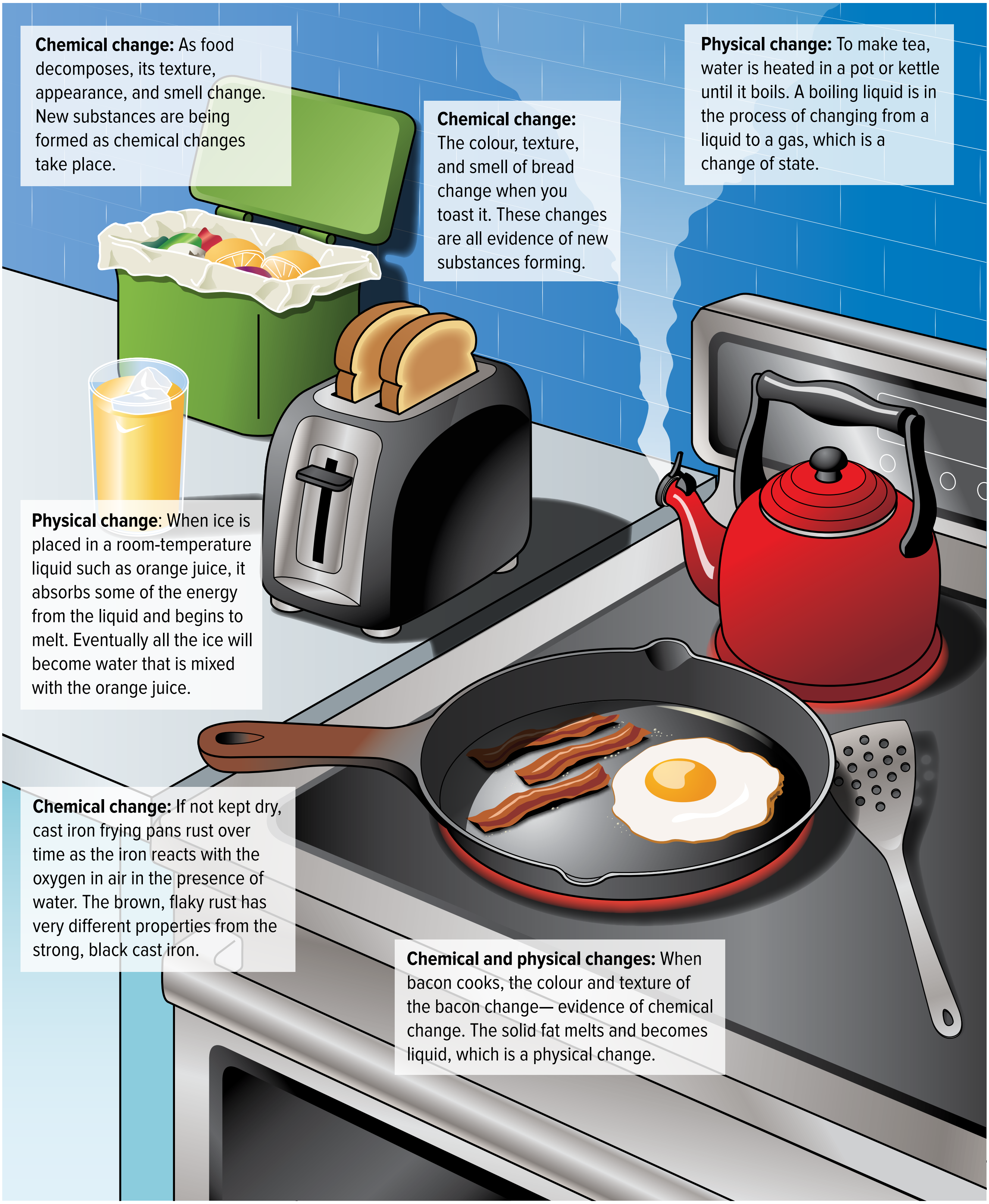


Figure 2.10 Even a simple task like preparing a meal involves many physical and chemical changes. **What are some other chemical or physical changes that take place in a kitchen? List one of each not shown in the illustration.**

Law of Conservation of Mass

Early scientists experimented with chemical changes by heating, burning, and mixing matter. These studies included measuring the masses of substances before and after chemical changes had occurred.

French scientist Antoine Lavoisier (1743–1794) and his wife Marie-Anne carried out many chemical reactions, measuring the mass of substances before (the *reactants*) and after (the *products*). **Figure 2.11** shows an example of one of these experiments. Over and over again, the Lavoisiers observed that mass did not change when a chemical reaction took place. The mass of the reactants was always equal to the mass of the products. This observation was summarized as the *law of conservation of mass*. According to this scientific law, mass is neither created nor destroyed during a chemical reaction—it is conserved.

Connect to Investigation 2-D on pages 128–129

The Law of Conservation of Mass

mass of reactants = mass of products

In any chemical reaction, the total mass of the products is the same as the total mass of the reactants.

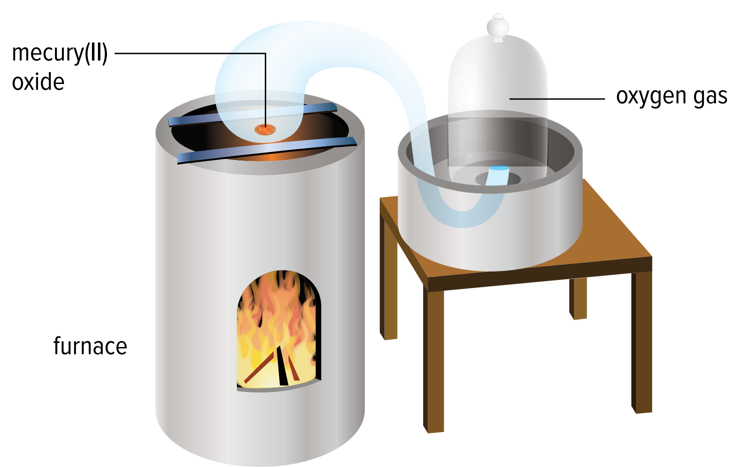


Figure 2.11 Lavoisier sealed a powdery, red-coloured chemical called mercury(II) oxide in a container. After intense heating, the red powder was changed to silvery liquid mercury and oxygen gas. The mass after the reaction was the same as the mass before the reaction.

Before you leave this page . . .

1. What is the main difference between a physical change and a chemical change?
2. State the law of conservation of mass in your own words.
3. In Lavoisier's experiments, why was it important that the container be sealed? Explain your answer.

AT ISSUE

How does B.C. snowmaking compare with other parts of the world?

What's the Issue?

B.C. is a paradise for skiers and snowboarders, with its huge mountains and wide spaces. But the ski and snowboard industries are important for more than the fun that they provide. They employ about 14 000 people, account for 8 percent of the province's total tourism revenues year-round, and bring in more tourism dollars than any other sector in the winter.

However, snowfall is unpredictable and varies from year to year. In the winter of 2014, El Niño brought warmer temperatures to the west coast, and this brought more rain than snow to the hills. Fourteen percent fewer skiers visited B.C. ski resorts that year. There is also the threat of climate change reducing annual snowfalls.

Owners of many ski resorts in British Columbia and around the world have invested millions of dollars to purchase snowmaking machines so they can make their own snow. By using snowmakers, resorts can ensure ski runs have lots of snow throughout the season. The resorts can also extend the ski season beyond what would be possible if they relied on natural snowfall alone. During the 2010 Winter Olympics, held in Vancouver, snowmakers were essential to ensuring events could run as planned. The benefits are clear, but are there financial and environmental costs associated with snowmaking?

Dig Deeper

Collaborate with your classmates to explore one or more of these questions—or generate your own questions to explore.

1. How does snow form naturally? Describe the process in four or five steps. Then find out about the process of snowmaking. Describe one system of snowmaking in four or five steps. Compare the two processes, including the amount of energy each requires. Why is it important to do this comparison?
2. How are the crystals that snow machines make different from natural snow crystals? Explain whether you would call them "artificial snow" or not.
3. Where do ski resorts in Canada get the water they use for making snow? How does this compare with other parts of the world? What are possible effects on the local and global environment of using these sources of water for making snow?

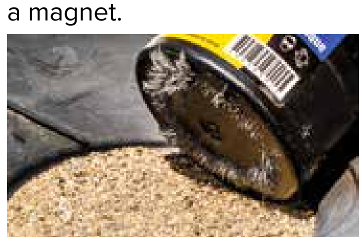
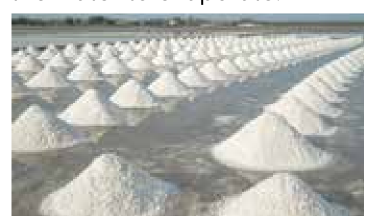
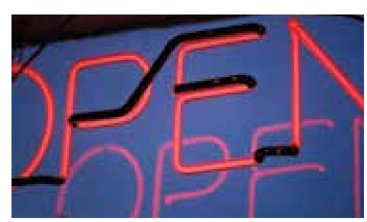
CONCEPT 4

Matter can be classified based on how it responds to physical and chemical changes.

Connect to Investigation 2-E on pages 130–131

Matter can be classified based on how it can be separated or broken down using physical and chemical changes. As you can see in **Table 2.1**, matter can be either a mixture or a pure substance. A pure substance can be either a compound or an element. The rest of the unit will focus on pure substances and the models and theories that help explain their properties and changes.

Table 2.1 Classifying Matter Based on Physical and Chemical Changes

Type of Matter	Description	Examples	
Mixtures	Can be separated into parts by physical changes.	A mixture of iron filings and sand can be separated using a magnet. 	A solution of salt and water can be separated by allowing the water to evaporate. 
Pure substances	Compounds: Can be broken down into two or more elements by chemical changes but not physical changes.	Passing an electric current through water produces the elements hydrogen and oxygen.	
	Elements: Cannot be separated or broken down by physical or chemical changes.	These lights contain neon gas, an element.	

Before you leave this page . . .

1. Classify each of the following as a mixture or a pure substance.

a) oxygen **b)** lemonade **c)** mercury(II) oxide

Check Your Understanding of **Topic 2.2**

QP Questioning and Predicting   PC Planning and Conducting   PA Processing and Analyzing   E Evaluating
AI Applying and Innovating   C Communicating

Understanding Key Ideas

1. Define volume and give two examples of units used to express it. PA C

2. Define mass and give two examples of units used to express it. PA C

3. Explain how density is related to mass and volume. PA C

4. For each image below, give a physical property and a chemical property that is shown in the image. Describe each property. PA

   a) 

   b) 

5. Read the three descriptions below. Which is a physical change? Which is a chemical change? Explain your answers.
   a) Salt can be extracted from salt water by heating it. The water evaporates into the air and the salt stays behind.
   b) Many cake recipes include baking powder because, when it mixes with water, it produces carbon dioxide gas that helps batter to rise.
   c) When you bend a light stick, the materials inside it are allowed to mix, and light is given off. PA E

6. Iron pyrite is commonly called fool's gold because of its golden colour. Suppose you found a golden solid that has a mass of 25.04 g and a volume of 4.99 cm^3. Use the data in the table below to determine if you have found iron pyrite or gold. QP PA E

Material	Density g/cm^3
gold	19.3
iron pyrite	5.02

Connecting Ideas

7. A student argues that a sample of sugar water is a pure substance because it contains only sugar and water, nothing else. Do you agree with this classification? Why or why not? How would you respond to this argument? C QP

Making New Connections

8. Many First Peoples of British Columbia, as well as throughout North America, are expert canoe-makers.
   a) What understandings about properties and changes of matter do you think First Peoples developed to perfect the science and art of canoe-making?
   b) How is the making of canoes connected with the spiritual/cultural life of First Peoples? QP PA E AI

9. The law of conservation of mass is more than 200 years old. It is still accepted by scientists today. How can they be so confident about it? Use scientific understanding to explain your reasoning. AI PA

INVESTIGATION

2-C

GUIDED INQUIRY

Testing Physical and Chemical Properties of Matter

Skills and Strategies

- Questioning and Predicting
- Planning and Conducting
- Processing and Analyzing
- Evaluating
- Applying and Innovating
- Communicating

Safety

What You Need

- samples of matter to test (e.g., paper, cork, baking soda, copper, aluminum strips, table salt, sugar, carbon [graphite], cooking oil)
- water
- dilute acid
- test tubes
- test tube rack
- marker

In this investigation, you will develop your own questions that will guide your study of the properties of matter.

Procedure

1. Your teacher will give you two samples of matter to study. Write out any questions you have about the properties of these samples.
2. Decide which questions you will investigate. Make predictions about the answers to your questions.
3. Plan a procedure that you will follow to answer your questions. A description of how to perform different tests is provided in the table on the opposite page.

   You can use the questions below to help guide your procedure:

   - What physical and chemical properties will I investigate?
   - How will I record and organize the observations I make? For properties that need to be rated, how will I do it? For example, how do I rate the lustre of a substance?
   - What procedure will I need to follow to study a particular property?
4. Have your teacher approve your procedure.
5. Carry out your plan once your teacher has approved it.
6. Dispose of any chemicals according to your teacher's instructions.

Evaluate

1. Did you determine the answers to your questions? If so, what are they? If not, why were you not able to? What other evidence would you need to answer your questions?

2. Share your results with your teacher, who will record them in a class chart. Reflect on the properties for all the substances that were studied.
   - Look for patterns you can use to group the substances according to common physical or chemical properties.
   - What groupings of substances can you make? Explain what these groupings are based on.

Apply and Innovate

3. Think about how each substance you studied is used. How do you think the physical and/or chemical properties of each substance are related to its function?

Tests for Properties

Properties	Test
Physical Properties	
colour, state, lustre	Describe the appearance.
malleability	Try to bend the solid material.
density	Calculate based on mass and volume.
texture	Feel the surface.
odour	**Never inhale directly.** Waft the air above the sample toward you and very gently inhale.
solubility in water	**1.** Place 1 mL of water in a test tube. **2.** Place a small amount of the sample being tested in the water. **3.** Gently tap the bottom of the tubes with your finger while holding the tube in the other hand. **4.** Look to see if all, part, or none of the sample dissolves.
Chemical Properties	
reactivity with water	**1.** Place 1 mL of water in a test tube. **2.** Place a small amount of the sample being tested in the water. **3.** Gently tap the bottom of the tube with your finger to mix the contents. **4.** Look for evidence of one or more new substances forming.
reactivity with acid	**1.** Place 1 mL of dilute acid in a test tube. **2.** Place a small amount of the sample being tested in the test tube. **3.** Look for evidence of one or more new substances forming.

INVESTIGATION

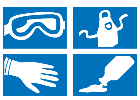
2-D

STRUCTURED INQUIRY

Skills and Strategies

- Processing and Analyzing
- Evaluating
- Communicating

Safety



What You Need

- 1 mL measuring scoop
- test tubes and stoppers
- test tube rack
- resealable plastic bag
- beakers
- water
- ice
- matches
- sand
- baking soda
- citric acid
- table salt
- 0.1 mol/L potassium iodide
- 0.1 mol/L lead(II) nitrate
- vinegar

Physical and Chemical Changes

In this investigation, you will observe the results of physical and chemical changes.

Question

What observations help to determine if a chemical or physical change has occurred?

Procedure

1. The procedures you will carry out are described in the table on the opposite page. Read them and predict what you think will happen in each case.
2. Design a table with headings like the ones below to record your observations.

Station Number	Procedure Summary	Observations			Type of Change
		Before	During	After	

3. Begin at the station assigned by your teacher. Move to the next station when directed by your teacher.
4. Each station has instructions for the procedure and how to dispose of the materials. Be sure to follow these instructions.
5. Wash your hands as soon as you have finished the investigation.

Process and Analyze

1. What physical changes did you observe? For each one, describe the observations that provide evidence of a physical change.
2. What chemical changes did you observe? For each one, describe the observations that provide evidence of a chemical change.
3. How did your predictions compare with your observations?

Evaluate and Communicate

4. Which changes were difficult to classify, and why? What further tests would have helped?
5. Summarize the types of evidence that someone can use to identify physical changes and chemical changes.
6. One of the substances in the materials list for this Investigation has lead in it. Your teacher may have used a different chemical instead of this one. Do research to find out why lead is a particular concern, and why disposing of it must be done in a special manner.

Chemical and Physical Changes

Station	Procedure
Station 1: baking soda and citric acid	• Place a 1 mL scoop of baking soda into one corner of a resealable plastic bag. • Add 1 mL scoop of citric acid in the same corner of the bag. Observe the bag for changes. • Twist the corner of the bag so that the solid chemicals are isolated. Add 3 mL of water in the other corner of the bag. Press the air out of the bag and seal the bag. • Untwist the corner of the bag and mix the contents.
Station 2: salt water	• Fill the bottom of a test tube with salt. • Add water to about one-third of the test tube, stopper the tube, and gently shake.
Station 3: ice	• Put 2 or 3 small pieces of ice into a 100 mL beaker, and cup the beaker in the palm of your hand.
Station 4: matches	• Strike a match and watch as it burns.
Station 5: potassium iodide and lead(II) nitrate	• Add 5 drops of potassium iodide solution into a test tube. • Add 5 drops of lead(II) nitrate solution **Due to the presence of a lead compound, it is very important for your teacher to follow the disposal instructions when you are done.**
Station 6: water and sand	• Add about 1 mL of water to a test tube. • Add a scoop of sand to the test tube, stopper the tube, and gently shake.
Station 7: water and vinegar	• Add about 1 mL of water to a test tube. • Add about 1 mL of vinegar to the test tube, stopper the tube, and gently shake.

INVESTIGATION
2-E

STRUCTURED INQUIRY

Skills and Strategies

- Processing and Analyzing
- Evaluating
- Communicating

Safety

What You Need

- 400 mL beaker
- filter paper with ink dot about 1.5 cm from end
- water
- plastic straw
- tape
- paper towel

Separating a Mixture by Paper Chromatography

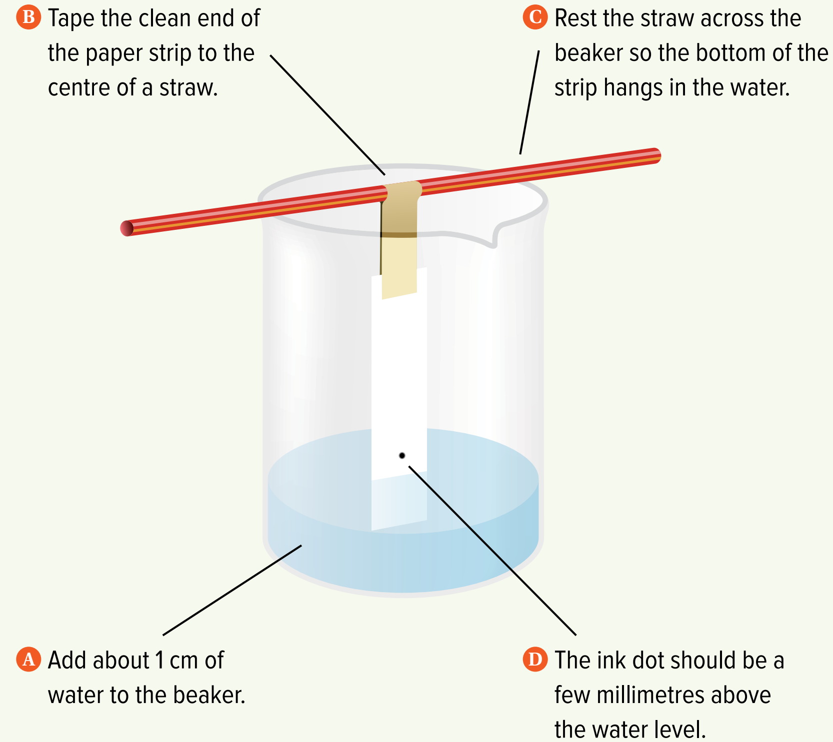
If you want to know what is in a mixture, there are a variety of ways to separate and identify its component substances by using their different properties. In this Investigation, you will separate a mixture of ink using a method called paper chromatography.

Question

How can you separate the components of ink?

Procedure

1. Set up a beaker as shown below.



2. Leave the beaker undisturbed until the ink has moved a few centimetres up the strip and you can clearly detect some separation of the ink into more than one colour. Then remove the strip and let it dry on some paper towel.
3. Clean up your work area and dispose of waste as instructed by your teacher.

Process and Analyze

1. Sketch and describe what you observed on the paper strip.
2. How many different colours can you see? How do you explain what you see?

Communicate and Apply

3. How do the physical properties of the different substances in the ink relate to this method of separating a mixture?
4. Predict what would happen if you repeated this Investigation using permanent ink.
5. Find out more about the technique of chromatography.
   - **a)** In addition to paper chromatography, what other types of chromatography are there? How do these types of chromatography work?
   - **b)** What kinds of jobs make use of chromatography?
   - **c)** How is chromatography used in each of the following applications?
     - forensics
     - analysis of food and drink
     - drug testing
     - airport security

Gas chromatography is an important tool used to separate mixtures and identify the substances in them.