TOPIC 2 Changes in Matter

Every kind of matter has properties that can be used to identify the matter. Properties are the characteristic ways in which a substance behaves. Examples of properties include the strength of the ice on a skating rink, the smooth surface of writing paper, and the taste of chlorinated water. However, properties can change. Ice can melt and lose its ability to support skaters. Paper can burn and become useless for writing. Chlorinated water, left overnight, can lose its strong taste.

Chemists classify changes in matter into two categories: physical changes and chemical changes. During a **physical change** a substance changes in form but not in chemical composition. No new substances are formed. Ice melting is an example of a physical change. The new properties are temporary because a change of state can be reversed. The liquid water can easily be converted into solid ice again.

The taste of the chlorinated water is also the result of a physical change. The taste is caused by chlorine dissolved in the water. If the solution stands overnight, it separates and most of the dissolved chlorine escapes. The chlorine particles still exist, with all of their properties unchanged, but they are now dissolved in the surrounding air instead of being dissolved in the water.

A **chemical change** causes one or more new substances to be formed. A chemical change may be difficult or impossible to reverse (see Figure 2.8). Burning paper is an example of a chemical change. The smoke that escapes and the black solid that is left behind cannot be recombined again to form paper — the change cannot be reversed. You will observe physical and chemical changes in the next investigation.

Figure 2.6 Are brilliant colours in leaves the result of physical or chemical change?

Figure 2.7 Hockey players can move quickly over the ice because the ice melts under the pressure of the skate blades and reduces friction. The melted ice resolidifies quickly on the sheet of ice.

Figure 2.8 How is the change shown in this picture different from the change shown in Figure 2.7? Which change is physical, and which is chemical? How do you know?

INQUIRY

INVESTIGATION 2-A

SKILL CHECK
- Initiating and Planning
- Performing and Recording
- Analyzing and Interpreting
- Communication and Teamwork

Physical and Chemical Changes in Ancient Alberta

Did you know that Alberta was covered by ocean water in its ancient past? Many physical and chemical changes occurred in and around these bodies of water. Alberta's present landscape and mineral resources are partly a result of the changes. For example, much of the rock exposed in the mountains contains carbonates, such as dolomite and limestone. In this investigation you will duplicate the chemical changes that created carbonates in the rocks. You will test the results using hydrochloric acid, a standard test for carbonates in rocks.

Question

What physical and chemical changes occur when two solutions are mixed together?

Safety Precautions

- Avoid contact of the acid with your skin. If you accidentally spill acid on your skin, wash it off immediately with lots of cool water and inform your teacher.

Apparatus

2 test tubes
2 rubber stoppers for test tube
10 mL graduated cylinder
funnel
beaker
medicine dropper
balance
retort stand
ring clamp or burette clamp
tongs
watch glass
hot plate
evaporating dish
test tube rack
scoopula

Materials

water
sodium carbonate
calcium chloride
filter paper
dilute hydrochloric acid (1 mol/L)

Procedure

1. Make an observation chart like the example shown below.
2. **Label** the test tubes A and B.
3. Put on your safety goggles and apron. Leave them on for the entire investigation.

	Observations
Part 1	
Part 2	
Part 3	

Part 1

4. **Measure** 10 mL of water into test tubes A and B.
5. Add 1 g of sodium carbonate to the water in test tube A. Stopper the test tube and shake it until all the chemical has dissolved. Place the test tube in a test tube rack.
6. Add 1 g of calcium chloride to the water in test tube B. Stopper and shake the test tube until all of the chemical has dissolved.
7. Pour the contents of test tube A into test tube B. Stopper it and shake it a few times. If you have a jelly-like substance, add a small amount of water to the test tube.
8. **Observe** the results. **Record** your observations in the chart. Save your mixture.

Part 2

Procedure

1. Fold the filter paper. Place the folded filter paper in the funnel and dampen it with water to hold it in place.
2. Hold the funnel over the beaker or attach it to the retort stand with a clamp.

3. Pour the mixture from test tube B into the funnel. Allow all of the mixture to filter through the filter paper into the beaker. Save both the filtrate (liquid that passed through the filter) and the residue (material trapped in the filter paper).
4. Place the filter paper and residue on a watch glass.
5. Use the dropper to add five drops of dilute hydrochloric acid (1 mol/L) to the residue on the filter paper. **Observe** the results.
6. **Record** your observations.

Part 3

Procedure

1. Be sure the hot plate is in a safe place. Plug it in.
2. Pour some of the filtrate (liquid in the beaker) into the evaporating dish.
3. Put the evaporating dish on the hot plate.
4. Heat the liquid until almost all of it has evaporated. **Observe** carefully. As the liquid evaporates, it may "spit" small particles out of the dish.
5. Use tongs to remove the evaporating dish from the hot plate just before all of the liquid has evaporated. Unplug the hot plate.
6. **Observe** the results. **Record** your observations.
7. Clean all equipment and return it to the proper location. Dispose of chemicals as directed by the teacher.

Analyze

1. What happened when you poured the two solutions together in Part 1?
2. Describe what happened when the hydrochloric acid was added to the residue in Part 2. What did this tell you about the residue?
3. Describe the residue left in the evaporating dish. What substance did it appear to be?

Conclude and Apply

4. Describe the chemical change(s) in this investigation.
5. Describe the physical change(s) in this investigation.
6. Sometimes when solutions are mixed together an insoluble substance is formed called a precipitate. Which of the steps created a precipitate?

Extend Your Knowledge

7. Did this simulation illustrate how Alberta's carbonate rocks were formed? Why or why not?
8. What connection might there be between the calcium carbonate rocks in Alberta and the large deposits of salt in Saskatchewan?

INTERNET CONNECT

www.mcgrawhill.ca/links/sciencefocus9

To find out more about ancient chemical and physical changes, go to the web site above, and click on Web Links to find out where to go next. Use the information you find to create an events chain.

Find Out ACTIVITY

What's in the Bag?

What kinds of changes can matter undergo?

Safety Precautions

- Open the bag carefully in steps 2 and 4. Point the opening away from anyone's face. If any solution comes in contact with your skin, wash it off immediately with lots of cool water. Inform your teacher of the accident.

Materials

20 mL warm water
5 mL phenol red solution
resealable plastic bag
5 mL calcium chloride
5 mL baking soda

Procedure Performing and Recording

1. Pour 20 mL warm water and 5 mL phenol red solution into the bag. Seal the bag. Gently shake the bag. Feel the outside of the bag.
2. Carefully open the bag. Add 5 mL calcium chloride. Seal the bag and gently shake it. Feel the outside of the bag.
3. Record your observations.
4. Carefully open the bag. Add 5 mL baking soda. Seal the bag and gently shake it. Feel the outside of the bag.
5. Record your observations.

What Did You Find Out? Analyzing and Interpreting

1. List the starting materials. Describe their properties.
2. What happened to the starting materials? Describe the changes in properties that you observed.
3. Were the changes physical or chemical? How can you tell?

Can You Ever Be Sure About Changes?

It can be difficult to decide if a change is physical or chemical. Here is a rule that can help you: If you make two or more of the following observations, then a chemical change has *probably* taken place.

- Heat is produced or absorbed.
- The starting material is used up.
- There is a change in colour.
- A material with new properties forms.
- Gas bubbles form in a liquid.
- A precipitate forms in a liquid.
- The change is difficult to reverse.

Why does the rule say *probably*? Changes in properties can be misleading. You cannot be sure that a chemical change has occurred unless you are certain that a new substance has been formed. You cannot be certain that a new substance has been formed unless you do careful tests both before and after the change.

Figure 2.9 Has this watermelon just undergone a physical or a chemical change?

Properties: Chemical or Physical?

If you want to understand the changes that matter undergoes, you need to know the properties of the matter. For example, Canadian aerospace engineers need to know everything about the materials used in the construction of Canadarm and how the materials might change. Will the materials melt in extreme heat, become brittle in the cold, or react with other materials? Chemists classify properties to gain a better understanding of matter. Table 2.1 shows some properties of two pure substances: helium and hydrogen.

Table 2.1 Properties of Helium and Hydrogen

Properties	Helium	Hydrogen
colour	colourless	colourless
density	low (0.18 g/L)	very low (0.09 g/L)
combustibility	does not burn	burns explosively

To survive the fierce heat of re-entering Earth's atmosphere, the space shuttle uses a system of heat-resistant tiles. These tiles can be removed from an oven at 1200°C and put straight into cold water without cracking. The tiles are made from silica and ceramic bonding materials.

Any property that can be observed or measured without forming a new substance is a physical property. Density is the amount of matter that occupies a certain space, or in other words, the mass per unit volume of a substance. Density can be measured without forming a new substance, so density is a physical property.

Suppose you had one balloon filled with hydrogen, and another balloon filled with helium (see Figure 2.10). How could you tell which was which? If you could see inside the balloons, both gases would be colourless, so you could not distinguish the gases by colour. Both balloons would float in air, since both gases have a low density.

There would be a difference, however, if each gas were exposed to a flame. Helium would not burn at all. Hydrogen would burn explosively. The ability of a substance to burn in oxygen is called combustibility. Combustibility is not a physical property because combustion creates new substances.

Any property that describes how a substance reacts with another substance when forming a new substance is a chemical property. Combustibility is therefore a chemical property. Hydrogen burns in oxygen, so it has the property of combustibility. Helium does not burn in oxygen, so it does not have the property of combustibility. Knowing that something is not combustible may be just as important as knowing that it is.

Figure 2.10 How could you tell if these balloons contained hydrogen or helium?

Word CONNECT

Are you familiar with the words "ductility," "malleability," and "viscosity"? Use a regular or science dictionary or the Internet to discover their meanings. Write a definition of each in your notebook.

Physical properties are often further classified as either qualitative or quantitative (see Table 2.2 and Figure 2.11). A qualitative physical property is a characteristic of a substance that can be described but might not be measured (a quality). A quantitative physical property is a characteristic of a substance that can be measured numerically (a quantity).

Table 2.2 Classification of Properties

Chemical Properties	Physical Properties	
	Qualitative	Quantitative
reacts with water	colour	melting temperature
reacts with air	texture	boiling temperature
reacts with pure oxygen	taste	density
reacts with acids	smell	viscosity
reacts with other pure substances	state	solubility
toxicity	crystal shape	electrical conductivity
stability	malleability	heat conductivity
combustibility	ductility	

Copper reacts with substances in air to form a green coating.

Gold has the property of malleability, so it can be hammered into thin sheets and different shapes.

Sulfur reacts with oxygen to form a new substance, sulfur dioxide.

Iron melts at the extremely high temperature of 1535°C.

A solid that is ductile can be stretched to form a wire.

Figure 2.11 Which of these properties are qualitative? Which are quantitative?

DidYouKnow?

Some of the first people to experiment with chemicals were the Egyptians. They observed the properties of chemicals and what happened when the chemicals interacted. One of their most famous technologies was the invention of mummification. To create a mummy, the religious leaders removed the soft organs and covered the body with a natural salt called natron. The salt was left on the body for 70 days to prevent decomposition. The body was then wrapped in cloth bandages, smeared with natural gum, and sealed in an air-tight container. The process was so effective that 3000-year-old mummies still have soft and elastic skin on the soles of their feet. Scientists have recently duplicated this process with authentic tools in hopes of learning more about mummification. Search the Internet to study more recent discoveries about this ancient technology.

TOPIC 2 Review

1. Name seven observations that may indicate a chemical change has occurred.

2. Which of the following are physical changes, and which are chemical changes? How do you know?
   - **(a)** Sugar dissolves in water.
   - **(b)** A steak is well cooked.
   - **(c)** The filament of a light bulb glows when an electric current flows through it.
   - **(d)** A piece of chalk is crushed.
   - **(e)** A plant grows taller.

3. **Apply** Water and gasoline are both clear liquids at room temperature. Describe one physical property and one chemical property that might be used to distinguish between them.

4. **Thinking Critically** State two quantitative physical properties that change when antifreeze is dissolved in water.

5. **Thinking Critically** Examine the photograph of "the ice man" in Figure 2.12. Which physical and chemical changes do you think his remains have undergone in the past 5300 years? Do you think scientists established the age of the remains based on physical evidence or on chemical evidence? Why?

Figure 2.12 This is a photo of the oldest human remains ever found intact. A hiker found this body frozen in a glacier. Scientists established that the body is of a man who lived 5300 years ago.