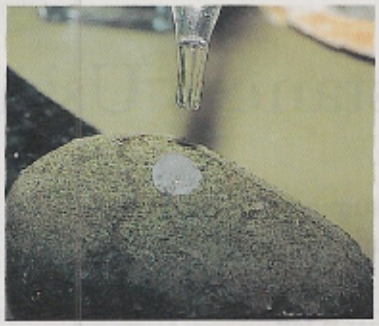
Reaction with Acid



When magnesium metal is added to acid, it produces bubbles of gas and the metal quickly disappears. However, when gold is added to acid, no visible change occurs. The ability of a substance to react with acid is a chemical property. For example, geologists use acid to test samples of rock. A chemical property of limestone is that it reacts with acid to produce bubbles of gas.

Using the Properties of Matter

Matter can be grouped as metals and nonmetals. Metals are suitable for different uses because of their special properties.

Metals have been used by people for thousands of years: first copper, then bronze, iron, and steel. Now, many different mixtures of metals, called **alloys**, are used. Whatever the purpose, whether for airplane parts, the bottoms of cooking pots, or braces for teeth, the metal chosen has properties useful for the job.

The metals used in the braces in **Figure 2**, for instance, must have specific chemical properties: they must not react with saliva or chemicals in food. They must also have specific physical properties. Some of these are shown in **Table 2**.

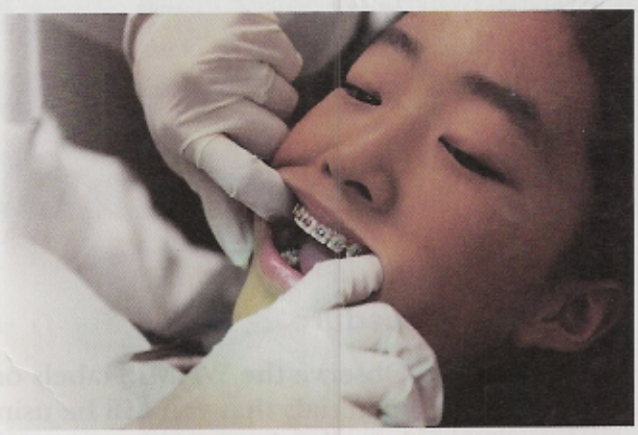


Figure 2
Braces should not be made from toxic metals!

Table 2 **Physical Properties of Some Metals Used in Braces**

Metal	Stiffness	Springiness	How easily does it bend?	How easy is it to join?
stainless steel	high	good	fair	fair
gold alloy	medium	fair	fair	easy
nickel/titanium alloy	low	excellent	poor	difficult

Understanding Concepts

1. What property is described by each of the following statements?
   - **(a)** Copper metal can be bent into different shapes.
   - **(b)** A steel blade can scratch glass.
   - **(c)** Alcohol boils at 60°C.
   - **(d)** Under a magnifying glass, sugar appears to be made of tiny cubes.
   - **(e)** A nickel coin is shiny.
2. Make a chart listing physical properties that you can observe qualitatively by using your senses or by doing some simple tests.

Qualitative Observations

Using Senses	Doing Tests
?	?
?	?

3. Distinguish between a physical property and a chemical property.

Exploring

4. Think of one use of metal. (3A) Research the suitability of two different metals for that use, considering the advantages and possible risks. Explain.

Reflecting

5. What are some other properties of matter that were not discussed in this section? For example, do any substances change when they are exposed to air? Can any substances carry electricity?
6. Look at the list of adjectives that you made for Getting Started (1) on page 12. Do any of these adjectives represent the properties in this section? What other properties are suggested in your list?

Challenge

List the materials used in some everyday products, and identify their useful physical and chemical properties. How would you display this information?

SKILLS MENU
○ Questioning ● Conducting ● Analyzing
○ Hypothesizing ● Recording ● Communicating
○ Planning

Identifying Substances Using Properties

Have you ever confused the salt and sugar in your home? Because they look the same, you must use other properties to distinguish between them. A mechanic working on a car uses many different solutions. Gasoline, oil, transmission fluid, antifreeze, and brake fluid are just a few of these solutions. Different colours are added to these solutions to make it easier to identify leaks. For example, antifreeze is often green and transmission fluid is red. Physical and chemical properties are the key to identifying substances.

In this investigation, you will determine the identities of five unknown substances, using your laboratory skills. The substances are all white solids, but have other different properties that are described in **Table 1**.

Materials

- safety goggles
- apron
- original containers for salt, baking soda, chalk, sodium nitrate, and sodium thiosulphate
- numbered samples of five unknown solids
- toothpicks
- hand lens
- spot plate or microtray
- medicine dropper
- small beaker with distilled water
- small beaker with dilute hydrochloric acid (3–5%)

Acids are corrosive. Spills of any of these solutions on the skin, in the eyes, or on clothing should be washed immediately with cold water. Inform your teacher of any spills. Similarly, no solid chemicals should contact the skin or be left on bench tops.

Never use your sense of taste to identify substances—they may be poisonous.

Table 1 **Data About Solids**

Property	Salt	Baking Soda	Chalk	Sodium Nitrate	Sodium Thiosulphate
state (at room temperature)	solid	solid	solid	solid	solid
colour	white	white	white	white	white
clarity	clear	opaque	opaque	clear	clear
crystal shape	small cubes	powder	powder	granular	hexagons
behaviour in water	soluble	soluble	insoluble	soluble	soluble
behaviour in acid	dissolves	fizzes and dissolves quickly	fizzes and some dissolves	dissolves	turns cloudy yellow

Question

How can physical and chemical properties be used to identify substances?

Hypothesis

An unknown substance can be identified by testing its properties and comparing them with those of known substances.

Procedure

1. Observe the WHMIS labels on the materials that you will be using in this investigation.

(a) Record the information for each substance.

2. Make a table in your notebook similar to **Table 2** to record your observations.

3. Put on your apron and safety goggles.

Table 2 Data Table for Identifying Substances

Property	Unknown Substance				
	1	2	3	4	5
state	?	?	?	?	?
colour	?	?	?	?	?
clarity	?	?	?	?	?
crystal shape	?	?	?	?	?
behaviour in water	?	?	?	?	?
behaviour in acid	?	?	?	?	?
identity of solid	?	?	?	?	?

4 Obtain a small sample of each of the five unknown solids on separate numbered scraps of paper.

5 Look at the samples using a hand lens. Describe their appearance.

(a) Record your description of state, colour, clarity, and crystal shape in your table.

(b) Without specific directions from your teacher, which of your five senses is the only one you can use for your observations? Why?

6 Using the hand lens and a toothpick, count out roughly 20 crystals of whichever solid appears to be salt. Measure out roughly equal amounts of each of the other solids. Place each sample in a different well of the spot plate or microtray. Make sure you have numbered the samples 1 to 5.

7 Using a medicine dropper, add two drops of water to each sample. Observe what happens to the solids.

Step 7

(a) Record your observations in the table.

(b) What kinds of solids dissolved or mixed with water faster?

8 Rinse and dry the spot plate. Repeat steps 6 and 7, using dilute hydrochloric acid in the medicine dropper instead of water.

(a) Record your observations in the table.

9 Dispose of the contents of your spot plate and put away your materials as directed by your teacher. Clean up your work station. Wash your hands.

Analysis and Communication

10 Analyze your observations by answering the following questions:

(a) What was the identity of each of the five solids? Record their names in your data table. Do your results support your hypothesis?

(b) For each of the five solids, explain how you decided on its identity.

(c) Which physical properties did you examine in this activity?

(d) Which chemical properties did you examine?

(e) Which samples were the most difficult to identify? Explain.

11 Write your investigation as a lab report. 8A

Understanding Concepts

1. Describe three everyday situations in which it would be useful to identify unknown substances. Explain how you would identify the substances.

Exploring

2. At home, collect five small samples of white powder. Choose from flour, cornstarch, icing sugar, baking powder, cream of tartar, citric acid, powdered milk, and coffee whitener. Put each sample in a small bottle and label the bottles A to E. Keep a list of your samples, labelled with the correct letters. Trade samples with a friend and design an experiment to identify each other's samples.

Do not use your sense of taste when you identify these substances.

In Search of Safer Paint

What does an artist have in common with a house painter? Both work with paints—mixtures of substances that have been carefully chosen for their special physical and chemical properties. These properties include not just colour but also the ability to flow and stick to the canvas, walls, or other surfaces. People who work with these chemicals also have to consider safety issues.

You may have noticed a strong smell in a freshly painted room. This odour means that particles of solvent—the liquid part of the paint—have evaporated into the air and entered your nose. The solvent is just one of many different substances that have been mixed together to make the paint.

As the solvent evaporates into the air, the solid components of paint are left behind to coat the wall or other surface. Unfortunately, when some solvents evaporate, their fumes are more than just strong or unpleasant—they are dangerous. These fumes may burn, or even explode if concentrated in a poorly ventilated room. Many solvents are also toxic and can poison a person who inhales large amounts.

(a) What are two problems associated with solvents in paint?

Inside a Can of Paint

Paint is a mixture of pigments, resins, and solvent. Each substance in the mixture is chosen for its physical and chemical properties. The components of paint are summarized in **Table 1**.

(b) What are the three components of paint and the purpose of each?

Table 1 **Inside a Can of Paint**

What Is in Paint	Comes from	Properties	Possible Hazards
pigment	soil, metals, other coloured substances	long-lasting colour	some components harmful if consumed 
resin	plant or insect secretions, plastics (alkyds, acrylics, urethanes)	forms hard film that sticks	some components harmful if consumed 
solvent	water, mineral spirits, turpentine (from plants)	dissolves other parts of paint	fumes may be toxic  fumes may burn easily (combustible) 

Latex Paints

Water is the major solvent in latex paint, so the fumes from latex paint are harmless. However, water is not very good at dissolving resins, the part of paint that provides strength and durability. As a result, latex paint contains less resin than alkyd paint, and is less strong and durable. Latex paints are not as sticky and so cannot be used on all surfaces. The water in latex paints damages some surfaces. On the other hand, latex paints dry very quickly and you can use water to clean the brushes or rollers.

(c) What are two advantages and two disadvantages of latex paint?

Alkyd Paints

Alkyd paint does not contain water as a solvent. Instead it uses mineral spirits and/or turpentine. These solvents are able to dissolve the resins that make this type of paint useful. Alkyd paint is strong and durable. These properties make it useful on surfaces that are often washed, such as kitchen cabinets. It sticks to metal and other surfaces. But the solvent fumes are hazardous, so very good

ventilation is necessary when painting. Cleaning up requires the same solvents, adding more fumes to the air.

(d) *What are two advantages and two disadvantages of alkyd paint?*

Choosing a Paint

Think about the decisions you would have to make if you had to do some painting. Painters need to choose products that have the properties they require. Examine the label for "Colour Depot Enviro-safe Paint," shown in **Figure 1**. The label makes claims about the paint that you may or may not agree with.

(e) In a group, list the advantages of Enviro-safe Paint that are claimed in the advertisement.

(f) Discuss these claims. Consider the following questions:

- What evidence is presented to support each claim?
- What evidence would you need to be convinced the claim is accurate?
- Are there any confusing or incorrect statements in the advertisement? If so, why do you think this has happened?

(g) Rank the claims as very important, less important, or not important to health and safety.

(h) Rank the claims as very important, less important, or not important to the function of the paint (colouring and protecting a wall).

Figure 1

Understanding Concepts

1. What are three types of physical properties that are important for paint?
2. When is paint most hazardous to human health: while it is in the can, while it is being applied, or after it is dry? Explain your reasons.

Making Connections

3. Which paint would you buy for painting each of the following areas? Explain your choice.
   - **(a)** the walls of a hospital
   - **(b)** the walls of a school hallway
   - **(c)** the window sills in a home
4. What WHMIS or Hazardous Household Product Symbols would you expect to see on a can of (a) latex paint? (b) alkyd paint?
5. Would you prefer to use Enviro-safe Paint or regular latex paint if you were painting your room? Why? If you are not sure, what other issues are important in making this decision?

Exploring

6. Research some of the changes that scientists (3A) have made to make paints safer. For example, paint used to contain lead. Why? Now it does not. Why? What replaces the lead and why is it better? Can you think of any ways to make paint safer still?

Challenge

What are the health and environmental issues related to the substance you are marketing?

SKILLS MENU
- Questioning
- Conducting
- Analyzing
- Hypothesizing
- Recording
- Communicating
- Planning

Identifying Substances Using Density

Which is heavier: a kilogram of feathers or a kilogram of lead? Once you think about it, the answer is obvious. They have the same mass but very different volumes and therefore different densities. As you have learned earlier, density is a physical property of matter (**Figure 1**). Each substance has its own characteristic density. Look at **Table 1** to see the densities of some common solids, liquids, and gases.

Density is the amount of matter per unit volume of that matter. Density can be expressed as a formula:

$$\text{Density } (D) = \frac{\text{Mass } (m)}{\text{Volume } (V)}$$

If you know the value of any two of the three variables (D, m, or V) in this formula, you can solve for the third. For example, if a metal has a mass of 30 g and occupies a volume of 6 cm^3, its density can be calculated as

$$D = \frac{m}{V} = \frac{30\ g}{6\ cm^3} = 5.0\ g/cm^3$$

In this investigation, you will use density calculations to identify unknown liquids.

Table 1

Approximate Densities of Some Common Materials

Substance	Density	
	kg/m^3	g/cm^3
gold	19 300	19.3
silver	10 500	10.5
aluminum	2700	2.7
ice	920	0.92
wood (birch)	660	0.66
wood (cedar)	370	0.37
glycerol	1260	1.26
distilled water	1000	1.0
vegetable oil	920	0.92
isopropanol	790	0.79

Materials

- samples of glycerol, vegetable oil, and isopropanol, labelled Unknown A, Unknown B, and Unknown C
- 3 beakers, each 100 mL
- balance
- graduated cylinder

Isopropanol (rubbing alcohol) is flammable and toxic.

Question

1 The labels have fallen off three bottles of liquid. The liquids are glycerol, vegetable oil, and isopropanol. Write a testable question for determining the identity of the unknown liquids.

Hypothesis

2 The densities of the unknown liquids can be compared with the known densities of...
The unknown densities can be calculated if experimental measurements are made of...

(a) Copy these statements into your notebook and complete the sentences.

Experimental Design

3 You will be given samples of three liquids, identified as Unknown A, Unknown B, and Unknown C.

4 Design an experiment to determine the identity of the three unknown liquids, using the materials in the list above.

(a) Write out the design as a series of numbered sentences.

5 Include with your design a fully labelled data table to record your observations.

(a) Make a ruled table for observations.

6 Note that your design must include suggestions on appropriate safety procedures.

SKILLS HANDBOOK: 2A Controlled Experiments

(1B) (a) Make a list of safety precautions that you will follow.

7 Show your procedure, data table, and safety suggestions to your teacher.

Procedure

8 When your design has been approved by your teacher, obtain the necessary materials and perform your experiment.

(a) Record observations in your data table.

9 Calculate the densities of the unknown liquids.

(a) Show calculations, including formula, substitution, and units.

(b) Record your results on a class data sheet, if your teacher suggests you do so.

Analysis and Communication

10 Analyze your observations by answering the following questions:

(a) What were the identities of Unknowns A, B, and C?

(b) What other physical properties might have helped you decide what the unknown liquids were?

(c) List any difficulties that you experienced when making measurements.

(d) How would you modify your experimental design to improve it?

(e) Determine the average of all the density values obtained by the groups in your class. How does your class average compare with the expected values for glycerol, vegetable oil, and isopropanol?

11 Write your investigation as a lab report. (8A)

Making Connections

1. You are designing a new transparent bottle for an oil and vinegar salad dressing. Vinegar is mostly water. Some spices dissolve into the oil, some into the vinegar, and some spices remain separate. Look for the densities of oil and water in **Table 1**. Where in the bottle would you expect to find the oil layer? How would this affect the design of your bottle? Explain, using a sketch of your bottle design and label.
2. Calculate the densities of the following substances, given mass and volume information:
   - **(a)** mass = 200 g and volume = 40 cm^3
   - **(b)** mass = 4 g and volume = 3.20 cm^3
   - **(c)** mass = 36 g and volume = 54 cm^3
3. The density formula can be used to calculate mass or volume if density is given. Use the densities of substances given in **Table 1** to calculate:
   - **(a)** the mass of 100 cm^3 of silver
   - **(b)** the volume of 270 g of aluminum
   - **(c)** the mass of a 20 cm^3 block of birch wood
4. An unknown metal has a volume of 20 cm^3 and a mass of 54 g. Use **Table 1** and calculations to guess the likely identity of the unknown metal.
5. Which do you think is more dense: an (2A) unpeeled orange or a peeled orange? You may be surprised to find that one floats in water and the other does not. Design and perform an experiment, using "home apparatus," to determine their densities.

Challenge

Identify two instances in which an understanding of density is important in our lives. Consider how to include these examples in your display.

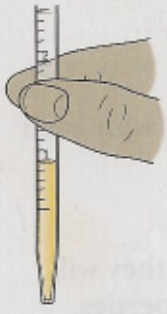


Figure 1
Although these three substances all have the same volume, their masses are very different.

1 cm^3 gold | 1 cm^3 birch | 1 cm^3 vegetable oil

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

Chemical Magic

A chemical property, such as combustibility, describes the ability of a substance to interact with another substance. These interactions result in change. Change can be subtle—a leaf slowly changes colour from green to yellow in the fall. Change can be dramatic—gasoline explodes in a fireball. Experimenting with different substances and recording observations have led scientists to form new hypotheses to classify some of these changes. This investigation will allow you to identify some changes in chemical properties as new substances are formed. It may also lead you to hypothesize about what kinds of changes you observe.

Materials

- safety goggles
- apron
- 2 small test tubes
- test-tube rack
- 4 labelled medicine droppers
- 2 mL distilled water
- indicator solution (phenolphthalein) in a dropper bottle
- 2 mL of Solution A (0.5% sodium hydroxide)
- 2 mL of Solution B (2.0% sulfuric acid)
- 2 mL of Solution C (2.0% calcium chloride)
- 2 cm^2 of aluminum foil
- 10-mL graduated cylinder
- 2 mL of Solution D (2.0% copper (II) chloride)

Solutions A–D are corrosive. Specifically, Solutions A, B, and C are drain cleaner, car battery acid, and de-icing salt, respectively. Spills of any of these solutions on the skin, in the eyes, or on clothing should be washed immediately with cold water. Inform your teacher of any spills.

Phenolphthalein solution is flammable and harmful if ingested. Inform your teacher of any spills.

Question

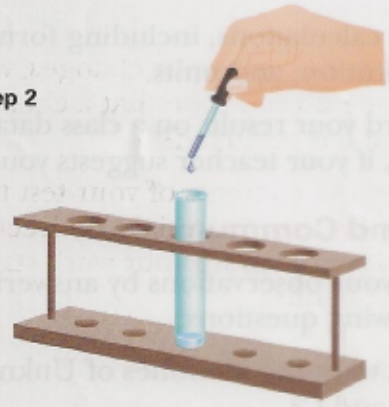
How do various substances interact with each other?

Hypothesis

When some substances are mixed, they will form new substances with new properties.

Procedure

1. Put on your apron and safety goggles.
2. Obtain a test tube and put it in a test-tube rack. Use one of the medicine droppers to add 5 drops of water to the test tube. Then add 2 drops of indicator solution to the water. (6A)


Step 2

(a) Record your observations.

(b) Is there any evidence that a new substance was produced? Explain.

3. Use a second dropper to add 5 drops of Solution A to the water/indicator solution.

(a) Record your observations.

(b) Is there any evidence that a new substance was produced? Explain.

4. Use a third dropper to add 5 drops of Solution B to the solution.

(a) Record your observations.

(b) Is there any evidence that a new substance was produced? Explain.

5. Use the fourth dropper to add 5 drops of Solution C to the solution.

(a) Record your observations.

(b) Is there any evidence that a new substance was produced? Explain.

6 Crumple a small piece of aluminum foil and place it in a second test tube. Place the test tube in a rack. Using a graduated cylinder, measure 2 mL of Solution D and add it to the test tube.

(a) Describe the initial colour of Solution D.

(b) Describe the colour of the solution after 3 min.

(c) Describe the change in the aluminum foil.

(d) Other than any colour changes, what evidence do you have that a chemical change has occurred?

7 Dispose of the contents of your test tubes and put away your materials as directed by your teacher. Clean up your work station. Wash your hands.

Analysis and Communication

8 Analyze your observations by answering the following questions:

(a) How could you tell when a new substance was produced?

(b) Describe two particular physical properties of substances that changed during this activity.

9 Write a summary paragraph explaining to others how you can tell when a new substance is produced.

Challenge

How would you display the information in your summary paragraph so that it makes sense to a younger audience?

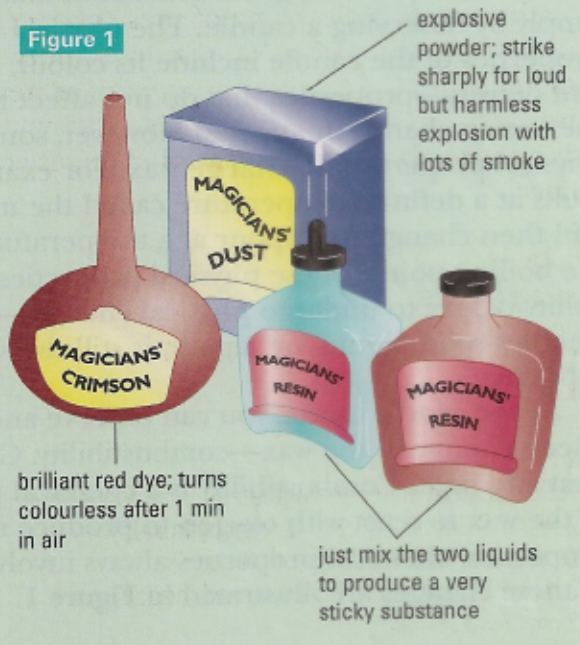
Understanding Concepts

1. List all the changes in matter you can think of that might occur in a kitchen. Do any of the products of these changes have new properties? Explain.

Making Connections

2. Imagine that you are a magician and that you want to design a new magic trick to amaze your audience. You go to a magicians' supply store and discover three new products, illustrated in **Figure 1**. Write a script describing how you could use any or all of these products to create a magic trick.

Figure 1



Exploring

3. In the investigation you just completed, what would happen if you changed the order in which water, indicator, and Solutions A, B, and C were mixed? Design an experiment to test this idea, and predict the observations you would expect. Check your design and predictions with your teacher before mixing any substances. Compare your results with your predictions.

Reflecting

4. After observing different kinds of changes, can you suggest a way of categorizing changes in matter?

Physical and Chemical Changes

Some of the most useful and powerful properties of matter are those related to how and why matter changes. There are countless changes in matter that affect us every day: for example, applying heat to an egg, burning gasoline, freezing water, and mixing oil and vinegar, to name a few. Understanding and categorizing kinds of change are an important first step to making use of change.

You can discover a great deal about matter simply by observing a candle. The physical properties of the candle include its colour, texture, and density—properties that do not affect the ability of the wax to change in any way. However, some other physical properties do change wax. For example, the wax melts at a definite temperature called the melting point and then changes to vapour at a temperature called the boiling point. These physical properties affect the ability of wax to undergo physical change—the wax, whether solid, liquid, or vapour, is still the same substance.

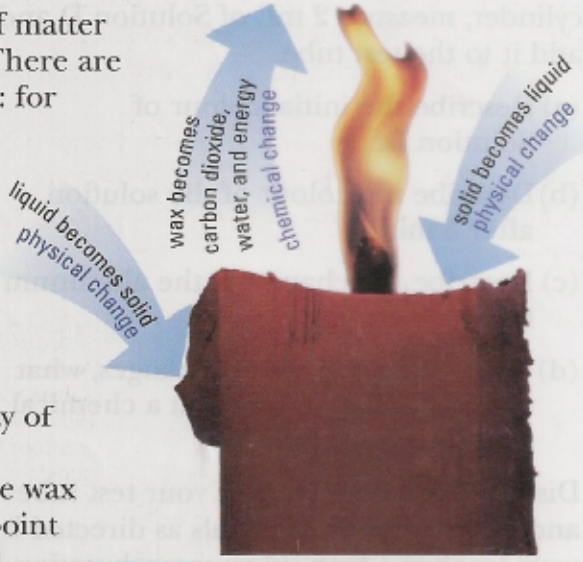


Figure 1
The wax of this candle is undergoing both physical and chemical changes. Which change results in new substances? Which does not?

As the candle burns, you can observe another kind of property that affects change in the wax—combustibility. Candle wax burns, producing heat and light. Combustibility is a chemical property: it describes the ability of the wax to react with oxygen to produce new substances. Unlike physical properties, chemical properties always involve change in a substance. Some of these changes are illustrated in **Figure 1**.

Physical Change

In a **physical change**, the substance involved remains the same substance, even though it may change state or form. When the candle wax has melted or vaporized, it is still wax.

Changes of state—melting, boiling, freezing, condensation, sublimation—are physical changes (**Figure 2**). You can see a physical change when you pour melted chocolate over ice cream. Liquid chocolate forms a thin, even coating over the ice cream. The chocolate becomes solid as the ice cream cools it, but once it's in your mouth, it tastes the same in both states because its particles have not changed.

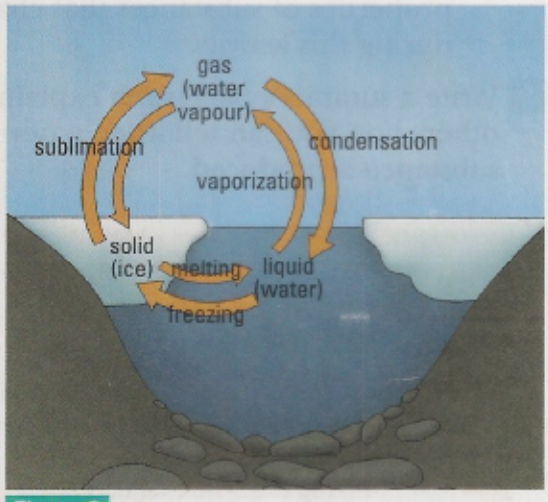


Figure 2
Changes of state

Dissolving is also a physical change. When you dissolve sugar in water, the sugar particles spread out, but they are still there, as sugar particles. You can reverse the process by evaporating the water and collecting the sugar. Most physical changes are easy to reverse.