Physical Properties

5.2

If you have ever lost a piece of luggage at the airport, you know how important it is to provide a good description of its appearance. You need to report its colour, shape, size, and any other identifiable features, such as the colourful name tag that you could use to distinguish your luggage from hundreds of other items (Figure 1). When you describe your luggage in this way, you are reporting the physical properties of your lost item.

Figure 1 Colour, shape, and size are physical properties that help identify objects and substances. Some of these pieces of luggage are easy to identify because of their physical properties.

WRITING TIP

Condensing the Original Text

When writing a summary, find ways to condense the original text. Sometimes several specific words can be replaced by a general word. For example, "colour, shape, size, and any other identifiable features" can be shortened to "physical properties."

Physical properties give us information about what the substance is like. You can determine a physical property by simply observing the substance using your five senses and measuring instruments. Determining physical properties does not involve changing the composition of the substance.

physical property a characteristic of a substance that can be determined without changing the composition of that substance

We make direct observations when we are asked to determine the physical properties of a substance. For example, you might describe the substance in Figure 2 as white, odourless, and powdery. These descriptions tell us something about the appearance of the substance—in this case, how it looks, smells, and feels. We make these observations using our five senses. Any property that does not provide numerical information about the substance is called a **qualitative property**. Further, we may take some measurements and note that the substance has a mass of 10.0 g and is at a temperature of 25 °C. These measured physical properties give us numerical information about the substance. These types of information are **quantitative properties** of the substance (Figure 3).

qualitative property a property of a substance that is not measured and does not have a numerical value, such as colour, odour, and texture

quantitative property a property of a substance that is measured and has a numerical value, such as temperature, height, and mass

Figure 2 Physical properties include qualitative observations such as colour, odour, and texture.

Figure 3 Temperature is a quantitative property that tells us about the energy of particles in a substance.

Figure 4 A bicycle has both quantitative and qualitative physical properties.

Observations that a bicycle has a mass of 10 kg and is 2.0 m long are quantitative physical properties of the bicycle because they include a measurement. Qualitative physical properties of the bicycle are not measured and include that it is red, shiny, and rigid (Figure 4).

So far, we do not have any information about what will happen if we leave this bike out in the rain or whether a cola drink would effectively remove rust from the bike. These properties are chemical properties of the bike, which involve changing the bike's composition. Chemical properties are discussed in Section 5.3.

TRY THIS CLOSE-UP OF A RUNNING SHOE

SKILLS: Observing, Analyzing, Evaluating, Communicating

SKILLS HANDBOOK 3.B.6.

Do you spend time and effort shopping for the ultimate running shoe (Figure 5)? What physical factors influence your decision? Perhaps comfort and support take priority over breathability and weight. Of course, style and colour are important as well.

In this activity, you will closely examine a running shoe. You will note how the physical properties of the different materials in it determine their specific function in the shoe.

Equipment and Materials: running shoe

Figure 5 A running shoe has important physical properties that enhance its function.

1. Make a table with three columns and record the following information:
   (a) In the first column, list all the different materials used to make each part of the shoe; for example, rubber soles.
   (b) In the second column, record the physical properties of each material listed; for example, waterproof, flexible.
   (c) In the third column, describe the function of each physical property you listed in part (b); for example, keeps the shoe dry, allows the foot to bend.
2. List at least five different quantitative properties of your shoe.

A. Of the physical properties that you listed, which are the most useful in the running shoe? A

B. From what you know about the different materials that make up a running shoe, which ones might present a problem to the environment when the shoes are eventually discarded? Explain your answer. A C

C. There are different brands of running shoes, and they vary in price. What factors might influence the various prices? Compare the physical properties of the materials of several different brands of running shoes. Do they vary significantly? What other factors determine the retail price of running shoes? How important should these other factors be when choosing a pair of running shoes? Make a priority list of factors you will take into consideration when choosing your next pair of running shoes. A

WRITING TIP

Restating the Main Idea

When you restate the author's main idea in the topic sentence of your summary, you say it in words that you understand. For example, if the author says that "some physical properties are particularly useful in describing and categorizing substances," you might restate this main idea by saying "physical properties are used to describe substances."

Some physical properties are particularly useful in describing and categorizing substances. Common qualitative physical properties include colour, odour, taste, and texture. Some of the other physical properties of matter are

- lustre—shininess or dullness; many silver objects have a high lustre (Figure 6), whereas a rusty nail has low lustre
- optical clarity—the ability to allow light through (Figure 7); thin blue glass is clear and transparent, frosted glass is translucent, and a brick wall is opaque
- brittleness—breakability or flexibility; glass is brittle (Figure 8) whereas modelling clay is flexible
- **viscosity**—the ability of a substance to flow or pour readily; molasses is viscous (Figure 9) whereas water is less viscous

viscosity the degree to which a fluid resists flow

- hardness—the relative ability to scratch or be scratched by another substance (Figure 10); wax is low on the hardness scale, whereas diamonds are high on the scale because they scratch nearly all other substances
- malleability—the ability of a substance to be hammered into a thinner sheet or molded (Figure 11); silver is malleable whereas glass breaks easily
- ductility—the ability of a substance to be drawn (pulled) into a finer strand; pieces of copper can be drawn into thin wires and are considered ductile (Figure 12)
- electrical conductivity—the ability of a substance to allow an electric current to pass through it; copper wires have high conductivity, whereas plastics do not (Figure 13)

Figure 6 This shiny kettle has high lustre.

Figure 7 The optical clarity of this window allows a lot of sunlight into the room.

Figure 8 Glass is brittle and cracks easily.

Figure 9 Molasses is viscous.

Figure 10 The dark crystal is hard.

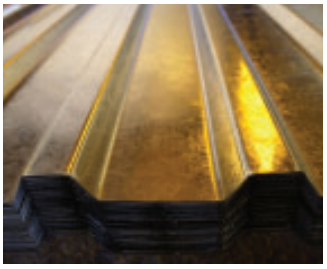

Figure 11 This metal is malleable because it can be made into sheets.

Figure 12 Copper wire is considered ductile.

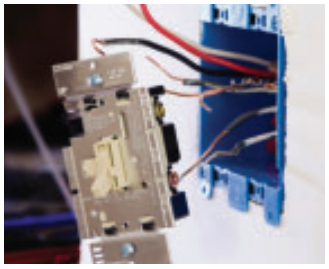

Figure 13 The copper wires have high conductivity but the plastic switch does not.

As you will learn in Section 5.6, several quantitative physical properties are easy to measure and provide a useful method for identifying a substance. These properties include melting point and boiling point, as well as density.

Physical Changes

If you take a piece of paper and fold it into a paper crane, does the paper undergo a chemical or a physical change? It is true that the paper crane appears to be a new object, but the composition of the paper is not changed. It is still paper, although with a different shape and size (Figure 14). This change is a **physical change**. In a physical change, the composition of the substance remains exactly the same. No new substances are made.

Consider a change of state. If you heat an ice cube until it melts, does it undergo a chemical or a physical change? The ice cube was a cold solid, and now it has changed into a cold liquid. Was a new substance produced?

Figure 14 It's a bird! It's a plane! Yes, but it's still paper.

physical change a change in which the composition of the substance remains unaltered and no new substances are produced

Figure 15 Wax is wax, whether it is solid or melted.

Recall from the particle theory that all matter is made up of particles that are in constant motion. In the case of melting ice, a new substance was not produced because the particles that make up water did not change. Only the arrangement of the water particles changed. If you were to put the water in a freezer rather than heat it, the water would turn back into ice. A change of state is a physical change—a change in how closely the particles are packed together (Figure 15). Many substances that undergo a physical change can be returned to their original state.

What happens when something dissolves? If you add a teaspoon of sugar to a large pot of hot water and stir, does the sugar undergo a chemical change or a physical change? The sugar seems to have disappeared into the water, which may lead you to think that its composition has changed. All the particles of sugar are close together in the solid state. When they are dissolved, the sugar particles become separated, spread out among the water particles, and are no longer visible in solution. If you taste the water, you can tell that the sugar is still there because the solution tastes sweet. If you allow all the water to evaporate, the sugar reappears at the bottom of the pot. Therefore, dissolving is a physical change.

UNIT TASK Bookmark

You can apply what you learned in this section about physical properties to the Unit Task described on page 286.

IN SUMMARY

- A physical property is a characteristic of a substance that can be determined without changing the composition of that substance. It may be qualitative or quantitative.
- Qualitative physical properties are not measured and include hardness, malleability, and electrical conductivity.
- Quantitative physical properties are measured and include temperature, height, and mass.
- A physical change is a change in which the composition of the substance remains unaltered and no new substances are produced. Examples of physical change are a change of size or shape, a change of state, and dissolving.

CHECK YOUR LEARNING

1. Explain the difference between a qualitative property and a quantitative property. K/U
2. A student recorded the following observations about a T-shirt. Classify each observation as a qualitative property or a quantitative property, and give reasons for your answers. K/U
   (a) It is red and grey in colour.
   (b) It is 60 cm long.
   (c) It is soft and stretchable.
   (d) It will shrink in 70 °C water.
3. What physical properties are important for the materials used to make mountain bikes? A
4. List four physical properties of each of the following: K/U
   (a) a piece of copper wire
   (b) 500 g of butter
   (c) a glass of milk
   (d) a candle
   (e) a piece of aluminum foil
   (f) a spoonful of sugar
   (g) toothpaste
5. In each of the situations below, it seems that a new substance may have been produced. Explain why each situation represents a physical change. K/U
   (a) A tailor makes a new suit out of a piece of fabric.
   (b) A chef makes a salad out of lettuce, tomatoes, and cucumbers.
   (c) A mechanic builds a boat engine out of a lawnmower.
   (d) A chemist boils salt water until only salt crystals are left.
   (e) A child makes juice by adding water to juice concentrate.