

# Properties of Matter

When you choose your clothes, your lunch, or your shampoo, you are making choices based on the properties of matter. Considering how important these properties are to our daily lives, it's not surprising that people have always been curious about matter and how it changes. Through observation, scientists have found it useful to categorize properties as physical or chemical.

## Physical Properties

When you observe matter—whether you see it, touch it, hear it, smell it, or taste it—you are observing its characteristics, called physical properties. A **physical property** is a characteristic or description of a substance that may help to identify it. Unlike a chemical property, a physical property does not involve a substance becoming a new substance. For instance, colour is a physical property. A substance simply has a certain colour: its colour has no relationship to the substance's ability to change into new substances.

Some physical properties that can be observed by using your senses are summarized in **Table 1**. Pick one of the materials shown in **Figure 1** and describe it, mentioning all of the properties listed in **Table 1**.

There are other physical properties you might choose to describe. Simple tests and measurements can aid your senses in observing these properties.

Table 1

Physical Properties Observed with the Senses

Property	Describing the Property
colour	Is it black, white, colourless, red, blue, greenish-yellow...?
texture	Is it fine, coarse, smooth, gritty...?
odour	Is it odourless, spicy, sharp, burnt...?
lustre	Is it shiny, dull...?
clarity	Is it clear, cloudy, opaque...?
taste	Is it sweet, sour, salty, bitter...?

Figure 1



## The States of Matter

One of the physical properties of matter is its state—whether it is solid, liquid, or gas at room temperature.

### Solid

Example



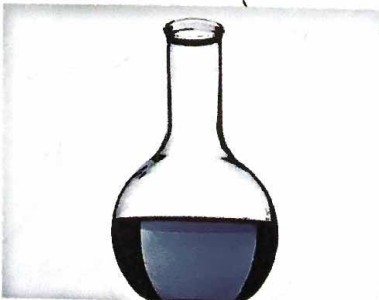
Shape

Definite: has a fixed (unchanging) shape.

Volume

Definite: has a fixed volume.

### Liquid



Indefinite: always takes the shape of its container.

Definite: has a fixed volume.

### Gas



Indefinite: always takes the shape of its container.

Indefinite: always fills the entire container.

## Hardness

Because they are harder than glass, diamonds are used to cut glass. **Hardness** is a measure of the resistance of a solid to being scratched or dented. A harder material will scratch or dent a softer one. For instance, a diamond stylus is used to cut a large sheet of glass into different sizes. Rank the following substances by hardness: steel nails, chalk, glass, diamond.



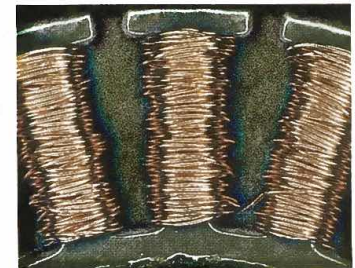
## Malleability

Gold can be hammered into thin sheets, so it is said to be **malleable**. If a solid is malleable, it can be hammered or bent into different shapes. Aluminum foil is malleable, which makes it useful for wrapping food as it cooks. Many materials, glass for example, are not malleable. Instead of flattening out when hammered, they shatter. **Brittle** objects shatter easily.



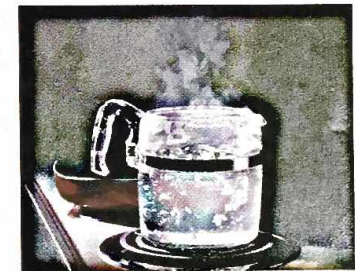
## Ductility

One of the reasons copper is used for electrical wiring is that it can be drawn out into long, thin wires. If a solid is **ductile**, it can be pulled into wires. What other materials can you think of, besides copper, that are ductile?



## Melting and Boiling Points

The temperatures at which substances change state are characteristic physical properties. For example, under controlled conditions, water always changes from solid ice to liquid water at  $0^{\circ}\text{C}$ —its melting point is  $0^{\circ}\text{C}$ . Similarly, the boiling point of water, when it changes from liquid to vapour, is  $100^{\circ}\text{C}$ .



## Crystal Form

Solids can exist in different forms. **Crystals** are the solid forms of many minerals in which you can see a definite structure of cubes or blocks with a regular pattern. For example, when you look closely at salt crystals, you can see that they are tiny cubes.



## Solubility

When salt and pepper are added to water, the salt dissolves but the pepper does not. **Solubility** is the ability of a substance to dissolve in a solvent such as water. Salt is described as soluble and pepper as insoluble. Drink mixes, for example, contain powdered substances that are soluble in water.



## Viscosity

Maple syrup is "thicker" than water—it flows more slowly than water when you pour it. **Viscosity** refers to how easily a liquid flows: the thicker the liquid, the more viscous it is.



## Density

When people describe lead as “heavier” than feathers, what they really mean is that lead is more dense than feathers.

**Density** is the amount of matter per unit volume of that matter. This is usually expressed in kilograms per cubic metre ( $\text{kg}/\text{m}^3$ ) or grams per cubic centimetre ( $\text{g}/\text{cm}^3$ ). For example, the density of water is  $1.0 \text{ g}/\text{cm}^3$ . (It can also be expressed as  $\text{g}/\text{mL}$  and  $\text{g}/\text{L}$ .)

## Chemical Properties

In nature, substances often combine or react with each other. When one substance can interact with another, that characteristic behaviour can be called a chemical property. For example, dynamite explodes when exposed to a flame because the dynamite combines with oxygen in the air. This reaction produces new substances. A **chemical property** describes the behaviour of a substance as it becomes a new substance.

## Combustibility

Combustibility is a property that describes the ability of a substance to react with oxygen to produce carbon dioxide, water, and energy. When a flame is brought close to a mixture of gasoline and air, the gasoline ignites and burns. However, water not only does not burn, but can be used to put out some fires. If a substance is **combustible** or **flammable**, it will burn when exposed to a flame. A substance that will not burn is described as nonflammable. What other materials can you think of that are combustible?



### Did You Know ?

**C**ombustible, flammable, and inflammable all mean the same thing! A substance that will not burn is described as nonflammable or noncombustible.



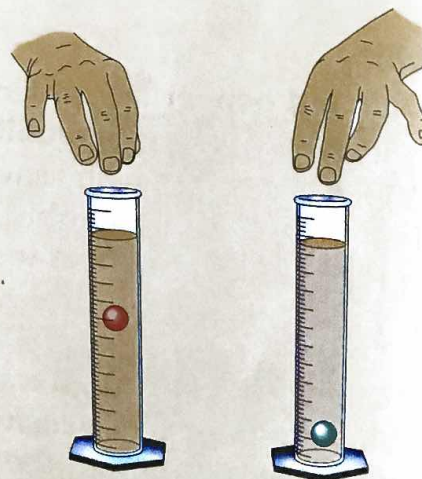
## Try This

### Just How Thick—Comparing Viscosity

You will need an apron, safety goggles, rubber gloves, a stopwatch, a marble, and a graduated cylinder to compare the viscosity of water, several cooking oils, syrups, and liquid detergents.

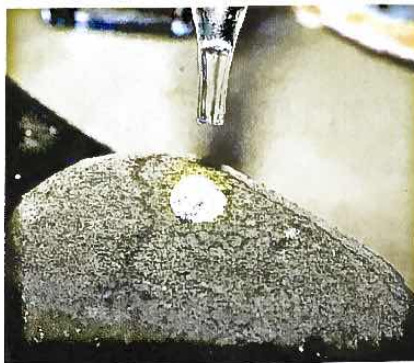
As a measure of viscosity, you can time how long it takes the marble to fall from the top of each cylinder to the bottom when the cylinder is filled with each of the liquids. (If you use water in your first trial, that will give you a standard for comparing the other liquids.)

1. Before you get started, which liquid do you think has the highest viscosity? Comment on the accuracy of your prediction: which liquid is the “thickest”?
2. Could you identify a liquid based on your data? Try it out: ask a friend to bring you an unidentified liquid, and then use the marble test to identify the liquid.



## 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.

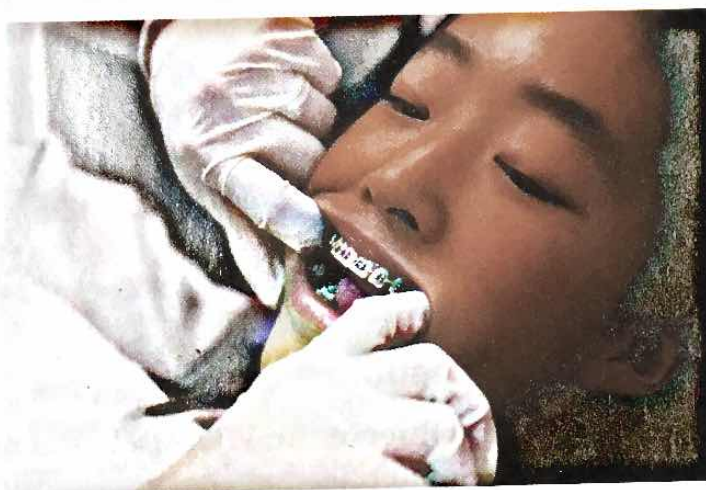


## Using the Properties of Matter

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

- What property is described by each of the following statements?
  - Copper metal can be bent into different shapes.
  - A steel blade can scratch glass.
  - Alcohol boils at  $60^{\circ}\text{C}$ .
  - Under a magnifying glass, sugar appears to be made of tiny cubes.
  - A nickel coin is shiny.
- 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
?	?
?	?

- Distinguish between a physical property and a chemical property.

## Exploring

- 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

- 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?
- 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?