

# The Particle Model of Matter

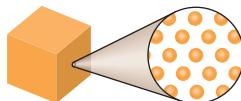
5.1

More than 2000 years ago in Greece, a philosopher named Democritus suggested that matter is made up of tiny particles too small to be seen. He thought that if you kept cutting a substance into smaller and smaller pieces, you would eventually come to the smallest possible particles—the building blocks of matter.

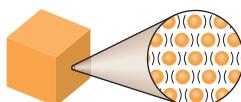
Many years later, scientists came back to Democritus' idea and added to it. The theory they developed is called the **particle model** of matter.

There are four main ideas in the particle model:

1. All matter is made up of tiny particles.



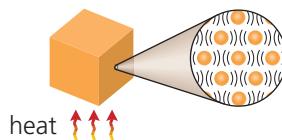
2. The particles of matter are always moving.



3. The particles have spaces between them.



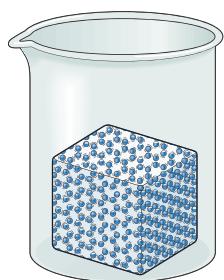
4. Adding heat to matter makes the particles move faster.



Scientists find the particle model useful for two reasons. First, it provides a reasonable explanation for the behaviour of matter. Second, it presents a very important idea—the particles of matter are always moving. Matter that seems perfectly motionless is not motionless at all. The air you breathe, your books, your desk, and even your body all consist of particles that are in constant motion. Thus, the particle model can be used to explain the properties of solids, liquids, and gases. It can also be used to explain what happens in changes of state (**Figure 1** on the next page).

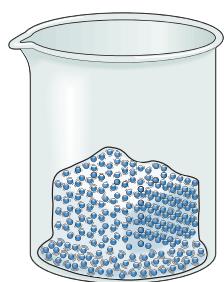
## LEARNING TIP

Are you able to explain the particle model of matter in your own words? If not, re-read the main ideas and examine the illustration that goes with each.



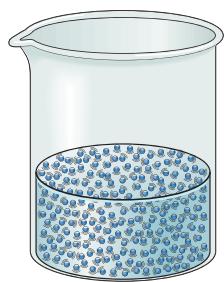
The particles in a solid are held together strongly. The spaces between the particles are very small.

A **solid** has a fixed shape and a fixed volume because the particles can move only a little. The particles vibrate back and forth but remain in their fixed positions.



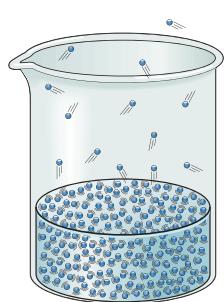
As a solid is heated, the particles vibrate faster and faster until they have enough energy to break away from their fixed positions. When this happens, the particles can move about more freely. The change from a solid to a liquid is called **melting**.

The reverse of melting is called **freezing** or solidification. This is the change from a liquid to a solid. As a liquid cools, the particles in the liquid lose energy and move more and more slowly. When they settle into fixed positions, the liquid has frozen or solidified.



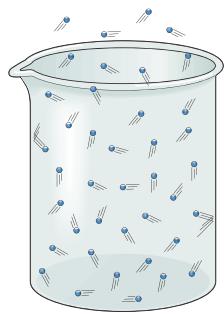
The particles in a liquid are separated by spaces that are large enough to allow the particles to slide past each other.

A **liquid** takes the shape of its container because the particles can move around more freely than they can in a solid. They are held close together, however. Therefore, a liquid has a fixed volume, like a solid.



When a liquid absorbs heat energy, the particles move about more and more quickly. Some of the particles gain enough energy to break free of the other particles. When this happens, the liquid changes to a gas. The change from a liquid to a gas is called **evaporation**.

The reverse process—the change from a gas to a liquid—is called **condensation**. As a gas cools, the particles in the gas lose energy and move more and more slowly until the gas condenses to a liquid.



The particles in a gas are separated by much larger spaces than the particles in a liquid or a solid. Therefore, a gas is mostly empty space.

A **gas** always fills whatever container it is in. Since the particles are moving constantly in all directions, they spread throughout their container, no matter what volume or shape their container is.

**Figure 1**

Explaining changes of state using the particle model

## Sublimation: A Special Change of State

Some solids can change directly to a gas without first becoming a liquid. This change of state is called **sublimation** [sub-luh-MAY-shun]. In sublimation, individual particles of a solid gain enough energy to break away completely from the other particles, forming a gas.

For example, sublimation occurs as the solid material in a room deodorizer gradually “disappears” into the air. Sublimation also occurs as a block of dry ice (frozen carbon dioxide) in an ice-cream cart “disappears” (**Figure 2**). If you live in a cold climate, you may have seen wet laundry hung outside in the winter go from frozen solid to dry because of sublimation.



**Figure 2**

Dry ice (frozen carbon dioxide) seems to disappear as it changes directly from a solid to a gas.

## All States Have Fixed Mass

When matter changes state, it does not lose or gain mass. The mass of water vapour that is produced by melting an ice cube and then boiling the water is the same as the mass of the original ice cube.



When a liquid is poured from one container to a different-shaped container, its shape changes, but its mass does not change (**Figure 3**). If a volume of a gas is squeezed into a smaller volume, its mass does not change (**Figure 4**). We say that the mass of a specific amount of a solid, liquid, or gas is fixed.

### ► LEARNING TIP

Look at these photos and read the captions. Then check for understanding. Ask yourself, “What is the main idea here?”



**Figure 3**

Even though the shape of water changes as it is poured from one container to another, the mass of the water stays the same.



**Figure 4**

Gases can be squeezed into smaller containers, but the mass of the gas does not change.

### ► CHECK YOUR **UNDERSTANDING**

1. Copy **Table 1** in your notebook. Complete the table by writing “yes” or “no” in each space.

**Table 1** Summary of States

State	Fixed mass?	Fixed volume?	Fixed shape?
solid			
liquid			
gas			

2. Use diagrams and words to explain what happens to the particles of matter in each of the following situations. Are the particles moving faster or slower? Are they getting farther apart or closer together?
  - a) Butter is warmed on a stove.
  - b) Water vapour cools and forms raindrops.
  - c) Liquid wax hardens.
  - d) Water boils.
  - e) Frost forms on a window.