

From Particles to Solutions

Matter is anything that has mass and takes up space. Chemistry is the study of matter and the changes it undergoes. In this section, you will briefly review some of the important concepts you learned in earlier grades about what matter is made of and how it is classified.

The Particle Theory of Matter

All matter is made of tiny particles. Different kinds of matter are made of different kinds of particles. For example, the particles that make up water are different from the particles that make up the glass containing it (Figure 1).

The **particle theory of matter** summarizes what scientists have learned about the particles that make up matter. The main ideas of the particle theory are

1. All matter is made up of tiny particles that have empty spaces between them.
2. Different substances are made up of different kinds of particles.
3. Particles are in constant random motion.
4. The particles of a substance move faster as its temperature increases.
5. Particles attract each other.

According to the particle theory, particles are attracted to each other and are always moving. Particles of a substance form a solid when these forces of attraction are strong enough to hold the particles close together in a rigid shape. When heated, particles gain energy and begin moving faster. When they have enough thermal energy, the particles start sliding past each other because the attraction between particles can no longer hold them together. This is the liquid state. The particles are still very close together, but they are able to flow past one another. If heating continues, the particles gain so much energy that they literally fly apart. The substance is now in the gaseous state, and the particles are so far apart that their forces of attraction have little effect on their behaviour (Figure 2).

particle theory of matter a theory that describes the composition and behaviour of matter

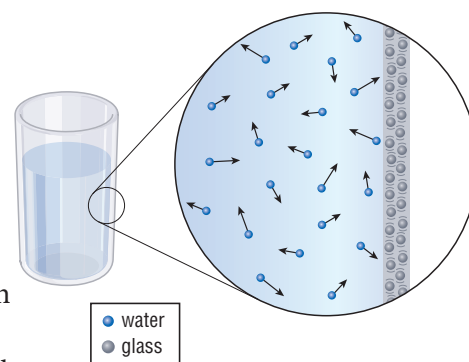


Figure 1 All matter is made up of particles.

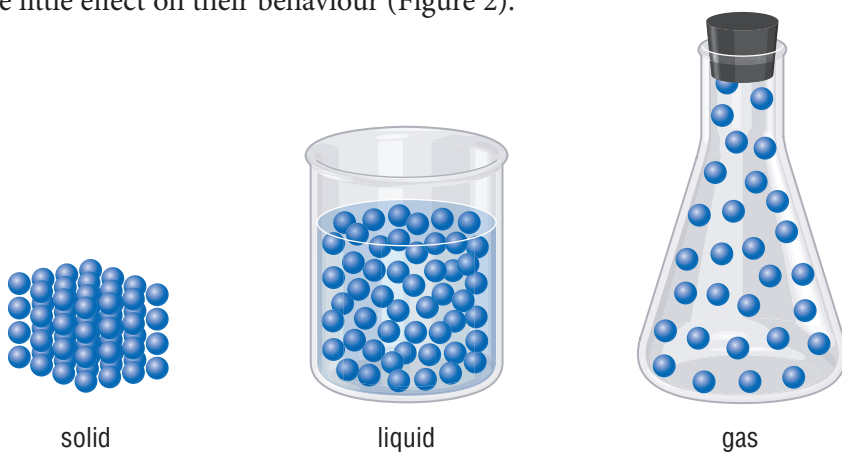


Figure 2 The particle theory describes the different behaviours of solids, liquids, and gases.

Pure Substances

Matter can be made up of many different types of particles. Some types of matter, however, are made up of only one type of particle. For example, pure or distilled water contains only water particles. Distilled water is an example of a **pure substance**—a type of matter that consists of only one type of particle. Water from your tap is not a pure substance because it contains water particles as well as other types of particles, such as dissolved gases.

pure substance a substance that is made up of only one type of particle



Figure 3 Granola bars are mixtures because they are made up of more than one type of particle.

mixture a substance that is made up of at least two different types of particles

mechanical mixture a mixture in which you can distinguish between different types of matter

solution a uniform mixture of two or more substances

Mixtures

When you add a pinch of salt to a glass of distilled water, the salt dissolves and the water tastes salty. The water in the glass is no longer a pure substance but a mixture because it contains salt particles and water particles. A **mixture** contains more than one type of particle. Mixtures can be solids, liquids, or gases. Solid mixtures include cellphones and granola bars (Figure 3). Examples of liquid mixtures are tea and juice. Air is a mixture of different types of gases.

Mechanical Mixtures and Solutions

There are two different kinds of mixtures: mechanical mixtures and solutions. A **mechanical mixture** is a mixture in which the substances in it are distinguishable from each other, either with the unaided eye or with a microscope. Breakfast cereal is an example of a mechanical mixture (Figure 4). A **solution** looks like a pure substance but it contains more than one type of particle. You cannot visually distinguish between the different types of particles in a solution. Clear apple juice is an example of a solution (Figure 5).



Figure 4 When you eat cereal for breakfast, you are eating a mechanical mixture.



Figure 5 Clear apple juice is a solution because you cannot visually distinguish between the different types of particles in it.

There is an easy way to tell whether a liquid or gas mixture is a solution or a mechanical mixture: all liquid and gas solutions are clear! If a liquid or gas mixture appears murky or opaque, it is a mechanical mixture. Fog, milk, and orange juice are examples of mechanical mixtures.

ALLOYS

Tin and lead are pure metals. Each metal by itself is a pure substance because it is made of only one type of particle. When two or more metals are mixed together, the resulting metal is called an **alloy**. An alloy is an example of a solution.

Tin and lead are combined to make a metal alloy commonly called solder (pronounced “sodder”). Solder is used to join together metal components, such as wires in electrical circuits and copper pipes in plumbing. Like glue, solder needs to be fluid so that it can be applied to a joint and fill the spaces in it. It also needs to quickly solidify to firmly hold the parts together. Lead is ideal for this purpose—it is fluid at high temperatures but solidifies quickly.

alloy a solid solution of two or more metals

There is increasing awareness, however, that lead poisoning causes irreversible damage to the brain, kidneys, heart, and reproductive organs, especially in growing children. Many uses of lead have been reduced or eliminated because of this increased awareness. Leaded gasoline and lead bullets used for hunting, as well as lead pipes and leaded solder, have been replaced by less hazardous materials (Figure 6).



Figure 6 A blow torch is used to melt solder. Lead-free solder consists of non-toxic metals such as tin, copper, and silver.

DID YOU KNOW?

Lead Poisoning

Before the toxic effects of lead were understood, the seams of metal cans for preserving food were sealed using lead solder. When the cans were heated, a high level of lead leached into the food, particularly if the contents were acidic, such as tomatoes or citrus fruits. It is likely that sailors suffered from lead poisoning on long trips. Fresh meat and vegetables were not available, so sailors ate mostly canned foods. Even today, you should never drink hot water directly from the tap, in case there is lead solder in the plumbing that may be absorbed into the hot water.



TRY THIS HOW STRETCHY IS YOUR SOLDER?

SKILLS: Predicting, Controlling Variables, Performing, Observing, Analyzing, Evaluating, Communicating

SKILLS HANDBOOK
3.B.2, 3.B.3

Have you heard the story about two brothers fighting over a copper penny and neither of them would let go? They ended up holding on to the ends of a copper wire. Metal can be stretched. This property of copper and other metals, called ductility, can be demonstrated using a piece of solder (Figure 7).

Equipment and Materials: marker; ceiling hook or ladder; heavy mass (e.g., bag of books or rocks); tape measure; 1 m long piece of solder

1. Obtain a piece of solder approximately 1 m long.
2. Tie one end of the solder to a ceiling hook or to the top rung of a ladder.
3. Tie the other end around a heavy mass, such as a bag of books or rocks.
4. Use a marker to draw a line near each end of the solder. Measure the distance between the lines. Allow the solder to remain suspended overnight.
5. Measure the length of the solder between the two marked lines again, and compare with the previous length.



Figure 7 Solder is used to form solid connections between wires and copper pipes. You will be measuring the ductility of solder.

- A. Did the solder stretch while suspended overnight? How much? **T/I**
- B. Predict whether the solder would stretch more or less if the temperature were increased. **T/I**
- C. Design a way to test your prediction. If possible, test your prediction. **T/I**
- D. What avoidable or unavoidable problems did you encounter in this activity? What improvements could you make to your procedure? **T/I**

The tree diagram in Figure 8 summarizes the classification of matter you studied in this section.

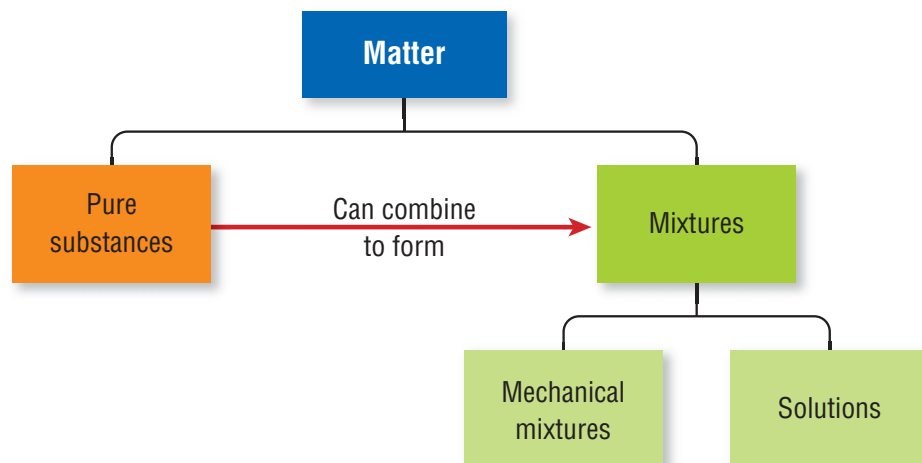


Figure 8 The classification of matter

IN SUMMARY

- The particle theory of matter describes the composition and behaviour of matter.
- A pure substance is made up of only one type of particle.
- A mixture is made up of at least two different types of particles.
- A mechanical mixture contains more than one type of particle, and the different types of particles are visible.
- A solution contains more than one type of particle but the different types of particles cannot be distinguished visually.
- An alloy is a solution composed of two or more metals.

CHECK YOUR LEARNING

1. List the five main ideas of the particle theory. [K/U](#)
2. Use the particle theory to explain why water changes from a solid to a liquid when it is heated. [K/U](#)
3. Give three examples of a pure substance. [K/U](#)
4. Give three examples of a mixture. [K/U](#)
5. Describe a mechanical mixture. [K/U](#)
6. Describe a solution. [K/U](#)
7. Use a Venn diagram to compare mechanical mixtures and solutions (Figure 9). [C](#)
8. Identify each of the following as a mechanical mixture or a solution: [K/U](#)
 - (a) a pane of clear glass
 - (b) chocolate chip ice cream
 - (c) clear apple juice
 - (d) a pizza
 - (e) garbage in a garbage can
9. What kind of alloy makes an effective solder material? Explain. [K/U](#)
10. Lead is not often used in solder anymore. Explain why not. [K/U](#)

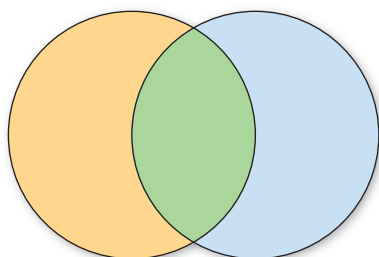


Figure 9 Sample Venn diagram