States of Matter

Solids, Liquids, and Gases

**Before You Read**

**What do you think?** Read the two statements below and decide whether you agree or disagree with them. Place an A in the Before column if you agree with the statement or a D if you disagree. After you’ve read this lesson, reread the statements to see if you have changed your mind.

<table>
<thead>
<tr>
<th>Before</th>
<th>Statement</th>
<th>After</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>1. Particles moving at the same speed make up all matter.</td>
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<td></td>
<td>2. The particles in a solid do not move.</td>
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**Read to Learn**

**Describing Matter**

Picture yourself blowing bubbles by the seaside. Do you see matter in this scene? The three most common forms, or states, of matter on Earth are solids, liquids, and gases. The bubbles you blow hold air, which is a mixture of gases. The soap mixture used to make the bubbles and the ocean water are liquids. The sand, your shoes, and nearby seashells are a few of the solids you might see by the seaside.

There is a fourth state of matter, plasma. Plasma is high-energy matter made up of particles that have positive and negative charges. Plasma is the most common state of matter in space. Plasma also is in lightning flashes, fluorescent lights, and stars, such as the Sun.

Matter can be described in many ways. You can describe matter using your senses. You can describe its state, color, texture, and smell. You also can describe matter using measurements, such as mass, volume, and density. Mass is the amount of matter in an object. The units for mass are often grams (g) or kilograms (kg). Volume is the amount of space that a sample of matter takes up. The units for liquid volume are usually liters (L) or milliliters (mL). The units for solid volume are usually cubic centimeters (cm\(^3\)) or cubic meters (m\(^3\)). Density is a quantity calculated by dividing an object’s mass by its volume. The units of density are usually g/cm\(^3\) or g/mL.

**Key Concepts**

- How do particles move in solids, liquids, and gases?
- How are the forces between particles different in solids, liquids, and gases?

**Make a Table** with three columns to contrast solids, liquids, and gases. Label one column Particle Motion and Forces. Label the second column Definite Shape? Label the third column Definite Volume? Complete the table as you read this lesson.

**Reading Check**

1. Name the four states of matter.

   __________
   __________
   __________
Particles in Motion

Have you ever wondered what makes something a solid, a liquid, or a gas? Two main factors that determine the state of matter are particle motion and particle forces.

Atoms, ions, or molecules make up all matter. These particles can move in different ways. In some matter, they are close together and vibrate back and forth. In other matter, the particles are farther apart. Sometimes, they slide past each other. At other times, they move freely and spread out. It does not matter how close the particles are to each other. All particles have random motion. Random motion is movement in all directions and at different speeds. If particles are free to move, they move in straight lines until they collide with something. Collisions usually change the speed and direction of the particles’ movements.

Forces Between Particles

Recall that atoms that make up matter have positively charged protons and negatively charged electrons. These opposite charges attract each other. They create attractive forces between any two particles. Attractive forces pull particles together.

Strong attractive forces hold slow-moving particles close together, as shown in the figure below. As the motion of particles gets faster, particles move farther apart. When they get farther apart, the attractive forces between particles have a weaker effect. The spaces between them increase. This bigger space lets other particles slip past. As the motion of particles gets even faster, particles move even farther apart. In time, the distance between particles is so great that there is little or no attractive force between them. The particles move randomly and spread out.

Visual Check

3. Draw Circle the particles that show the weakest attractive forces between them.

**Particle Motion**

- Particles move slowly and can only vibrate in place. Therefore, the attractive forces between particles are strong.
- Particles move faster and slip past each other. The distance between particles increases. Therefore, the attractive forces between particles are weaker.
- Particles move fast. The distance between the particles is great, and therefore, the attractive forces between particles are very weak.
Solids

If a skateboard moves from one place to another, its shape and volume do not change. A skateboard’s shape and volume do not change because a skateboard is a solid. *A solid is matter that has a definite shape and a definite volume.*

Particles in a Solid

Why doesn’t a solid change shape or volume? Remember that the particles in a solid are close together. The particles are touching neighboring particles. The attractive forces between them are strong. Their strong attractive forces and slow motion hold the particles tightly in their positions. The particles still move, but they do not get away from each other. They simply vibrate back and forth in place. This arrangement gives solids a definite shape and volume.

Types of Solids

All solids are not the same. For example, a diamond and a piece of charcoal do not look alike. However, they are both solids made of carbon atoms. They both have particles that strongly attract each other and vibrate in place. What makes them different is the arrangement of their particles. A diamond is a crystalline solid. It has particles arranged in a specific, repeating order. Charcoal is an amorphous solid. It has particles that are arranged randomly. Different particle arrangements give these materials different properties. For example, a diamond is a hard material. Charcoal is brittle.

Liquids

Have you ever seen a waterfall flowing into a riverbed? Water is a liquid. *A liquid is matter with a definite volume but no definite shape.* Liquids flow and can take the shape of their containers. Water from a waterfall takes the shape of the riverbed that it fills.

Particles in a Liquid

How can liquids change shape? The particle motion in liquids is faster than the particle motion in solids. This faster motion causes the particles to move slightly farther apart. As they move farther apart, the effect of the attractive forces between them decreases. The faster motion also causes gaps to form between the particles. The gaps allow particles to slip past each other. The slightly weaker attractive forces and gaps between particles let liquids flow and take the shape of their containers.
**Viscosity**

If you have ever poured or dipped honey, you know what a liquid with a high viscosity is like. *Viscosity* (vihs KAW sih tee) is *a measurement of a liquid's resistance to flow*. Honey has high viscosity. Water, on the other hand, has low viscosity. This property of a liquid is due to the strength of attraction between particles, particle mass, and particle shape.

- Strong forces between particles slow particle movement as particles slip past each other. In general, the stronger the forces are between particles, the higher the viscosity. For many liquids, viscosity decreases as the liquid becomes warmer.
- The mass of a particle also affects its ability to slip past other particles. More massive particles tend to move more slowly.
- Particles with complex shapes, such as long chains, also have high viscosity. Such long particles have difficulty slipping past other particles.

**Surface Tension**

Have you ever seen an insect that can walk on water? Believe it or not, some insects can do this because of the forces between molecules.

Water molecules below the surface of water are surrounded on all sides by other water molecules. Therefore, they have attractive forces, or pulls, in all directions. The attraction between similar molecules, such as water molecules, is called cohesion.

Water molecules at the surface of a liquid do not have liquid water molecules above them. As a result, there is a greater downward pull on the molecules. This downward pull causes the surface particles of water to become tightly stretched like the head of a drum. Molecules at the surface of a liquid have *surface tension*, the uneven forces acting on the particles on the surface of a liquid. Surface tension makes it possible for some insects to walk on water. In general, the stronger the attractive forces are between particles, the greater the surface tension of the liquid.

Think about the bubbles you were blowing in the imaginary scene at the beginning of the lesson. The thin water-soap film surrounding the bubbles formed because of surface tension between the particles.
Gases

Think about a beach ball. To make it big and round, you have to fill it with a gas. A gas is matter that has no definite volume and no definite shape.

It is not easy to identify the gas in a beach ball because you cannot see it. In fact, there are gas particles inside and outside a beach ball. Air is all around us all the time. Air is a mixture of gases, including nitrogen, oxygen, argon, and carbon dioxide.

Particles in a Gas

Why don’t gases have definite volumes or definite shapes? Compared to the particles in the solid and the liquid states, the particles in gases are very far apart.

The distances between the particles in a solid are small. The particles touch each other. The distances between the particles in a liquid are greater, and the particles can slip past each other. The distances between the particles in a gas differ from those in solids and liquids. In a gas, the forces of attraction between the particles are not strong enough to keep the particles close together. As a result, distances between particles are greater in the gas state.

Forces Between Particles

Particles in the gas state have greater motion than the same particles in the solid or liquid state. Because the particles are moving quickly, the distances between particles increase. As the distances increase, the attractive forces between particles have less of an effect.

The distances are so great and the effect of the attractive forces so small that gas particles act like they have little or no attraction to each other. As a result, the particles spread out to fill their container. Gases have no definite shape or volume.

Vapor

Have you ever heard the term vapor? The gas state of a substance that is normally a solid or a liquid at room temperature is called vapor. For example, water is normally a liquid at room temperature. When it is a gas, such as in air, it is called water vapor. Other substances that can form a vapor are rubbing alcohol, grain alcohol, iodine, mercury, and gasoline.

Reading Check
10. Identify What is a gas, and what is another object that contains a gas?

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Key Concept Check
12. Describe How do particles move and interact in a gas?
Mini Glossary

gas: matter that has no definite volume and no definite shape

liquid: matter with a definite volume but no definite shape

solid: matter that has a definite shape and a definite volume

surface tension: the uneven forces acting on the particles on the surface of a liquid

vapor: the gas state of a substance that is normally a solid or a liquid at room temperature

viscosity (vihs KAW sih tee): a measurement of a liquid's resistance to flow

1. Review the terms and their definitions in the Mini Glossary. Write a sentence that explains the differences between liquids and gases.

2. Using what you have learned about the states of matter, draw lines to connect two characteristics (shown in ovals) to each state of matter (shown in boxes).

3. Which state of matter is a vapor? From what states of matter does a vapor form?

What do you think NOW?
Reread the statements at the beginning of the lesson. Fill in the After column with an A if you agree with the statement or a D if you disagree. Did you change your mind?