Chapter 2
Matter and Change

2.1 Properties of Matter

2.2 Mixtures
2.3 Elements and Compounds
2.4 Chemical Reactions
Why are windows made of glass?

In this lesson, you will learn how properties can be used to classify and identify matter.
Why do all samples of a substance have the same intensive properties?
What you observe when you look at a particular sample of matter is its properties.

- Is a solid shiny or dull?
- Does a liquid flow quickly or slowly?
- Is a gas odorless, or does it have a smell?
Properties used to describe matter can be classified as extensive or intensive properties.
2.1 Properties of Matter > Describing Matter

Extensive Properties

Recall that matter is anything that has mass and takes up space.

- The **mass** of an object is a measure of the amount of matter the object contains.

  - The mass of a basketball is greater than the mass of a golf ball.
Extensive Properties

The **volume** of an object is a measure of the space occupied by the object.

- The volume of a basketball is greater than the volume of a golf ball.
Extensive Properties

Mass and volume are both examples of extensive properties.

- An **extensive property** is a property that depends on the amount of matter in a sample.
Intensive Properties

There are properties to consider when selecting a basketball besides mass and volume.

- The outer covering may be made of leather, rubber, or a synthetic composite.
  - Each of these materials has different properties that make the basketballs suitable for different playing situations.
Intensive Properties

For example, leather balls are suitable for indoor play but not outdoor play.

- Leather balls absorb water and dirt more than rubber balls do.
Intensive Properties

Absorbency is an example of an intensive property.

• An **intensive property** is a property that depends on the type of matter in a sample, not the amount of matter.
Identifying a Substance

Each object in this figure has a different chemical makeup, or composition.

- The soda can is mainly aluminum.
- The watering can is mainly copper.
Identifying a Substance

Matter that has a uniform and definite composition is called a substance.

- Aluminum and copper are examples of substances, which are also referred to as pure substances.
Identifying a Substance

Every sample of a given substance has identical intensive properties because every sample has the same composition.
Identifying a Substance

Aluminum and copper have some properties in common, but there are differences besides their distinctive colors.

- Aluminum is highly reflective and is often used in silver paint.
- Pure copper can scratch the surface of aluminum because copper is harder than aluminum.
- Copper is a conductor of heat or electric current.
- Copper and aluminum are both malleable, which means they can be hammered into sheets without breaking.
Identifying a Substance

Hardness, color, conductivity, and malleability are examples of physical properties.

- A **physical property** is a quality or condition of a substance that can be observed or measured without changing the substance’s composition.
This table lists physical properties for some substances.

<table>
<thead>
<tr>
<th>Substance</th>
<th>State</th>
<th>Color</th>
<th>Melting point (°C)</th>
<th>Boiling point (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neon</td>
<td>Gas</td>
<td>Colorless</td>
<td>−249</td>
<td>−246</td>
</tr>
<tr>
<td>Oxygen</td>
<td>Gas</td>
<td>Colorless</td>
<td>−218</td>
<td>−183</td>
</tr>
<tr>
<td>Chlorine</td>
<td>Gas</td>
<td>Greenish-yellow</td>
<td>−101</td>
<td>−34</td>
</tr>
<tr>
<td>Ethanol</td>
<td>Liquid</td>
<td>Colorless</td>
<td>−117</td>
<td>78</td>
</tr>
<tr>
<td>Mercury</td>
<td>Liquid</td>
<td>Silvery-white</td>
<td>−39</td>
<td>357</td>
</tr>
<tr>
<td>Bromine</td>
<td>Liquid</td>
<td>Reddish-brown</td>
<td>−7</td>
<td>59</td>
</tr>
<tr>
<td>Water</td>
<td>Liquid</td>
<td>Colorless</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Sulfur</td>
<td>Solid</td>
<td>Yellow</td>
<td>115</td>
<td>445</td>
</tr>
<tr>
<td>Sodium chloride</td>
<td>Solid</td>
<td>White</td>
<td>801</td>
<td>1413</td>
</tr>
<tr>
<td>Gold</td>
<td>Solid</td>
<td>Yellow</td>
<td>1064</td>
<td>2856</td>
</tr>
<tr>
<td>Copper</td>
<td>Solid</td>
<td>Reddish-yellow</td>
<td>1084</td>
<td>2562</td>
</tr>
</tbody>
</table>

- The states of the substances are given at room temperature.
Identifying a Substance

Physical properties can help chemists identify substances.

• For example, a colorless substance that was found to boil at 100°C and melt at 0°C would likely be water.

• A colorless substance that boiled at 78°C and melted at –117°C would definitely not be water. It would likely be ethanol.
Glass is often used to make windows, while copper is often used in electrical wires. What properties of glass make it a desirable material to use for windows?

Glass is transparent, so it can be seen through; hard, so it stays in place within window frames; and heat resistant, so it helps prevent the transfer of heat between outside and inside.
You want to compile a list of properties of a substance, but you don’t have a way to measure mass or volume. What kinds of properties can you determine without knowing the amount of matter in the sample?

You can determine the sample’s intensive properties.
States of Matter

What are three states of matter?
Depending on the circumstances, you use three different words to refer to water—water, ice, and steam.

- Water, which is a common substance, exists in three different physical states.
  - So can most other substances.
Three states of matter are solid, liquid, and gas.
Solids

A **solid** is a form of matter that has a definite shape and volume.

- The shape of a solid doesn’t depend on the shape of its container.
Solids

A **solid** is a form of matter that has a definite shape and volume.

- The shape of a solid doesn’t depend on the shape of its container.
- The particles in a solid are packed tightly together, often in an orderly arrangement.
Solids

A **solid** is a form of matter that has a definite shape and volume.

- As a result, solids are almost incompressible; that is, it is difficult to squeeze a solid into a smaller volume.
- In addition, solids expand only slightly when heated.
Liquids

The particles in a liquid are in close contact with one another, but the arrangement of particles in a liquid is not rigid or orderly.

- Because the particles in a liquid are free to flow, a liquid takes the shape of the container in which it is placed.
Liquids

The particles in a liquid are in close contact with one another, but the arrangement of particles in a liquid is not rigid or orderly.

• However, the volume of the liquid doesn’t change as its shape changes.
Liquids

The volume of a liquid is fixed or constant.

- Thus, a **liquid** is a form of matter that has an indefinite shape, flows, and yet has a fixed volume.
  - Liquids are almost incompressible.
  - However, they tend to expand slightly when heated.
Gases

• Like a liquid, a gas takes the shape of its container.

• But, unlike a liquid, a gas can expand to fill any volume.
Gases

A gas is a form of matter that takes both the shape and volume of its container.

- The particles in a gas are usually much farther apart than the particles in a liquid.
- Because of the space between particles, gases are easily compressed into a smaller volume.
The words *vapor* and *gas* are sometimes used interchangeably. But there is a difference.

- The term *gas* is used for substances, like oxygen, that exist in the gaseous state at room temperature.

- **Vapor** describes the gaseous state of a substance that is generally a liquid or solid at room temperature, as in *water vapor*.
A substance is in a state in which it takes the shape of its container. What state or states could it be in?

The substance could be either a liquid or a gas, as each takes the shape of its container.
Physical Changes

How can physical changes be classified?
The melting point of gallium metal is 30°C. The figure at left shows how the heat from a person’s hand can melt a sample of gallium.
2.1 Properties of Matter > Physical Changes

The shape of the sample changes during melting as the liquid begins to flow, but the composition of the sample does not change.

- Melting is a physical change.
- During a **physical change**, some properties of a material change, but the composition of the material does not change.
• Words such as *boil*, *freeze*, *melt*, and *condense* are used to describe physical changes.

• So are words such as *break*, *split*, *grind*, *cut*, and *crush*.
  – There is a difference between these two sets of words. Each set describes a different type of physical change.
Physical changes can be classified as reversible or irreversible.

- Melting is an example of a reversible physical change.
  - If a sample of liquid gallium cools below its melting point, the liquid will become solid.
All physical changes that involve a change from one state to another are reversible.

- Cutting hair, filing nails, and cracking an egg are examples of irreversible physical changes.
Water boils and becomes water vapor. Is this a reversible or irreversible physical change?

*It is a reversible physical change because it involves a change from one state to another.*
Every sample of a given substance has identical intensive properties because every sample has the same composition.

Three states of matter are solid, liquid, and gas.

Physical changes can be classified as reversible or irreversible.
2.1 Properties of Matter

Glossary Terms

- **mass**: a measure of the amount of matter that an object contains; the SI base unit of mass is the kilogram
- **volume**: a measure of the space occupied by a sample of matter
- **extensive property**: a property that depends on the amount of matter in a sample
- **intensive property**: a property that depends on the type of matter in a sample, not the amount of matter
Glossary Terms

- **substance**: matter that has a uniform and definite composition; either an element or a compound; also called pure substance

- **physical property**: a quality or condition of a substance that can be observed or measured without changing the substance’s composition

- **solid**: a form of matter that has a definite shape and volume

- **liquid**: a form of matter that flows, has a fixed volume, and has an indefinite shape
• **gas**: a form of matter that takes the shape and volume of its container; a gas has no definite shape or volume

• **vapor**: describes the gaseous state of a substance that is generally a liquid or solid at room temperature

• **physical change**: a change during which some properties of a material change, but the composition of the material does not change
Chemistry as the Central Science

Physical properties, such as melting point and boiling point, are used to describe matter.