

Properties of Matter

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CONCEPT

1

Properties of Matter

Lesson Objectives

- Classify properties of materials as extensive, intensive, chemical, or physical. Give examples of each.
- Describe the concepts of intensive and extensive properties and be able to describe these properties in a given material.
- Describe the concepts of physical properties and chemical properties and be able to describe these properties for a given material.
- Explain the concept of density as it relates to other physical properties of matter.

Lesson Vocabulary

- **chemical properties:** Properties that describe matter's reactions with other substances.
- **physical properties:** Properties of matter that can be observed without changing the matter's composition.
- **intensive properties:** Physical properties that are independent on the amount of a substance present.
- **extensive properties:** Physical properties that depend on the amount of a substance present.

Check Your Understanding

- What are some ways that you can distinguish different substances from each other?
 - For example, what is different between sand and sugar?

Introduction

All substances have special properties by which they can be identified. For instance, substances have unique colors, densities, and boiling points. They also behave in unique ways with other substances. For example, they may react with air, water, or acids. In chemistry, we study these properties and use them to identify and categorize matter.

Chemical Properties

All types of matter exhibit **chemical properties**. Chemical properties are the properties that describe matter's reactions with other substances. We can determine these chemical properties by seeing what happens to a substance when it is placed in the presence of the following:

- air
- water
- an acid

- a base
- other chemicals

Chemical properties indicate how the composition of a substance will change when exposed to various other substances. You can observe many chemical properties in the objects around you. For example, the metal frame of a bicycle will become rusty over time. The process of the frame becoming rusty can be described by a chemical property of iron, one of the metals in the frame. The iron will react with the oxygen in the air to form iron oxide, or rust.

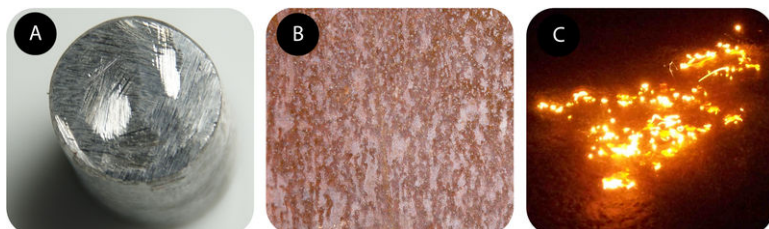


FIGURE 1.1

(A) Elemental iron. (B) Oxidized iron plate. (C) Iron “burning.”

In the **Figure 1.1** we can observe the difference in color between pure iron, which is a lustrous dark gray color, and rusted iron, which is cinnamon colored. We can also observe the reaction that takes place when iron is heated by a flame, in which the hot air reacts more rapidly with the pure iron. The changes that iron undergoes when exposed to air show us some of iron’s chemical properties and help us to classify iron as specific type of matter.

Example 2.1

Which of the following would be examples of a chemical property?

- Most metals will react with acids.
- Water can be a solid, liquid, or a gas.
- Water mixes well with ethanol.

Answer: A is an example of chemical properties. Statement B does not reflect chemical properties; these are physical characteristics of water. The process described in answer C would not be a chemical property because no reaction takes place. There are no changes in the composition of either the water or the ethanol as a result of the mixing, and both components can be separated from one another using physical processes.

Physical Properties

Matter also exhibits **physical properties**. Physical properties are used to observe and describe matter. Physical properties can be observed or measured without changing the composition of matter. These are properties such as mass, weight, volume, and density. Density calculations will be discussed later on in chapter three, but for now just remember that density is a physical property.

Intensive Properties

Physical properties that do not depend on the amount of substance present are called **intensive properties**. Intensive properties do not change with changes of size, shape, or scale. Examples of intensive properties are as follows in the **Table 1.1**.

TABLE 1.1:

Intensive Properties	Example
color	Aluminum metal is gray colored.
taste	Lemon juice (citric acid) is sour.
melting point	Aluminum has melting point of 660°C.
boiling point	Water has a boiling point of 100°C.
density	Water has a density of 1 g/mL.
luster	Metals are lustrous (shiny).
hardness	Diamond is the hardest substance known.

Extensive Properties

Physical properties that do depend on the amount of substance present are called **extensive properties**. Examples of extensive properties include:

- Mass
- Volume
- Length

Example 2.2

Which of the following is an intensive property of a box of crackers?

- A. Calories per serving.
- B. Total grams.
- C. Total number of crackers.
- D. Total calories.

Answer: A. Calories per serving. Total grams, total crackers, and total number of calories are extensive properties. A larger amount of crackers would have more grams, crackers, and total calories but the same number of calories per serving.

Example 2.3

Which of the following is an extensive property?

- A. The color of charcoal is black.
- B. Gold is shiny.
- C. The volume of orange juice is 25 mL.

Answer: C. The volume of orange juice is 25 mL. Charcoal's black color and gold's luster are intensive properties, and are not dependent on how much charcoal or gold is present. However if you had more or less orange juice, its volume would not stay the same. So, this is an extensive property.

Lesson Summary

- Matter is anything that has mass and takes up space.
- The properties of matter can be classified as either chemical or physical.
- Chemical properties describe the reactions that can occur when matter is treated with other substances, such as how a substance reacts with air or with an acid.

- Physical properties, such as mass, volume, density, and color, can be observed without changing the identity of the matter.
- We can further categorize the physical properties of matter as either intensive or extensive.
- Intensive properties do not depend on the amount of the substance present. Some examples of intensive properties are color, taste, and melting point.
- Extensive properties vary according to the amount of matter present. Examples of extensive properties include mass, volume, and length.

Review Questions

1. Compare and contrast physical properties and chemical properties.
2. Which of these is a chemical property?
 - (a) Oxygen is a gas at 25°C.
 - (b) Helium is very nonreactive.
 - (c) Ice melts at 0°C.
 - (d) Sodium is a soft, shiny metal.
3. Indicate whether each of the following is a chemical property or a physical property. If it is a chemical property, indicate whether it is an intensive or extensive property.
 - (a) Water boils at 100°C.
 - (b) Diamonds are the hardest known substance.
 - (c) Salt is capable of dissolving in water.
 - (d) Vinegar reacts with baking soda.
 - (e) Most metals are lustrous.
 - (f) Most metals react with acids.
 - (g) A given sample of lead weighs 4.5 g.
 - (h) The length of a piece of aluminum foil is 12.2 cm.
 - (i) Gold conducts electricity.

Further Reading / Supplemental Links

- Examples of laboratory techniques used for separating mixtures: <http://sciencepark.etacude.com/projects/>

Points to Consider

- How could you categorize types of matter based on differing chemical and physical properties?

References

1. (A) Hi-Res Images of Chemical Elements; (B) Jordan McCullough; (C) Jo Naylor. (A) <http://images-of-elements.com/iron.php>; (B) <http://www.flickr.com/photos/ambientideas/3297063530/>; (C) http://www.flickr.com/photos/pandora_6666/3454172058/. (A) CC-BY 3.0; (B) CC-BY 2.0; (C) CC-BY 2.0