Types of Matter

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CHAPTER 1 Types of Matter

Lesson Objectives

- Describe elements and atoms.
- Describe compounds, molecules, and crystals.
- Define mixture, and identify types of mixtures.

Vocabulary

- atom
- colloid
- compound
- crystal
- element
- mixture
- molecule
- solution
- suspension

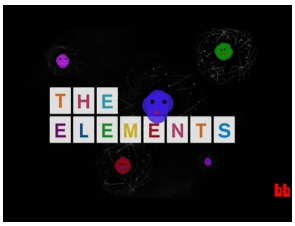
Introduction

The properties of matter, both physical and chemical, depend on the substances that matter is made of. Matter can exist either as a pure substance or as a combination of different substances.

Elements

An **element** is a pure substance. It cannot be separated into any other substances. There are more than 90 different elements that occur in nature. Some are much more common than others. Hydrogen is the most common element in the universe. Oxygen is the most common element in Earth's crust. **Figure** 1.1 shows other examples of elements. Still others are described in the video below.

http://www.youtube.com/watch?v=d0zION8xjbM (3:47)



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Properties of Elements

Each element has a unique set of properties that make it different from all other elements. As a result, elements can be identified by their properties. For example, the elements iron and nickel are both metals that are good conductors

FIGURE 1.1

Each of the elements described here has different uses because of its properties.

of heat and electricity. However, iron is attracted by a magnet, whereas nickel is not. How could you use this property to separate iron objects from nickel objects?

History of Elements

The idea of elements is not new. It dates back about 2500 years to ancient Greece. The ancient Greek philosopher Aristotle thought that all matter consists of just four elements. He identified the elements as earth, air, water, and fire. He thought that different kinds of matter contain only these four elements but in different combinations.

Aristotle's ideas about elements were accepted for the next 2000 years. Then, scientists started discovering the many unique substances we call elements today. You can read when and how each of the elements was discovered at the link below. Scientists soon realized that there are far more than just four elements. Eventually, they discovered a total of 92 naturally occurring elements. http://www.nndc.bnl.gov/content/origindc.pdf

Elements and Atoms

The smallest particle of an element that still has the element's properties is an **atom**. All the atoms of an element are alike, and they are different from the atoms of all other elements. For example, atoms of gold are the same whether they are found in a gold nugget or a gold ring (see **Figure** 1.2). All gold atoms have the same structure and properties.

Compounds

There are millions of different substances in the world. That's because elements can combine in many different ways to form new substances. In fact, most elements are found in compounds. A **compound** is a unique substance that forms when two or more elements combine chemically. An example is water, which forms when hydrogen and oxygen combine chemically. A compound always has the same components in the same proportions. It also has the same composition throughout. You can learn more about compounds and how they form by watching this video:

FIGURE 1.2
Gold is gold no matter where it is found because all gold atoms are alike.

http://www.youtube.com/watch?v=-HjMoTthEZ0 (3:53).

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Properties of Compounds

A compound has different properties than the substances it contains. For example, hydrogen and oxygen are gases at room temperature. But when they combine chemically, they form liquid water. Another example is table salt, or sodium chloride. It contains sodium and chlorine. Sodium is a silvery solid that reacts explosively with water, and chlorine is a poisonous gas (see **Figure** 1.3). But together, sodium and chlorine form a harmless, unreactive compound that you can safely sprinkle on food.

FIGURE 1.3
Table salt is much different than its components. What are some of its properties?

Molecules and Crystals

The smallest particle of a compound that still has the compound's properties is a **molecule**. A molecule consists of two or more atoms that are joined together. For example, a molecule of water consists of two hydrogen atoms joined to one oxygen atom (see **Figure** 1.4). You can learn more about molecules at this link: http://www.nyhallsci.org/marvelousmolecules/marveloussub.html .

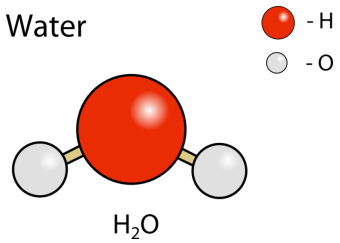

FIGURE 1.4
Water is a compound that forms molecules. Each water molecule consists of two atoms of hydrogen (white) and one atom of oxygen (red).

Some compounds form crystals instead of molecules. A **crystal** is a rigid, lattice-like framework of many atoms bonded together. Table salt is an example of a compound that forms crystals (see **Figure** 1.5). Its crystals are made up of many sodium and chloride ions. Ions are electrically charged forms of atoms. You can actually watch crystals forming in this video: http://www.youtube.com/watch?v=Jd9C40Svt5g .

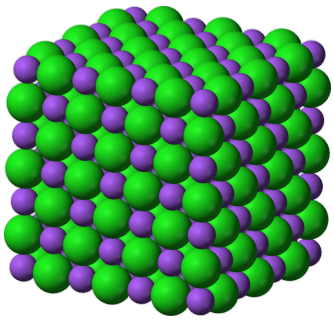

FIGURE 1.5
A crystal of table salt has a regular, repeating pattern of ions.

Mixtures

Not all combined substances are compounds. Some are mixtures. A **mixture** is a combination of two or more substances in any proportion. The substances in a mixture may be elements or compounds. The substances don't combine chemically to form a new substance, as they do in a compound. Instead, they keep their original properties and just intermix. Examples of mixtures include salt and water in the ocean and gases in the atmosphere. Other examples are pictured in **Figure** 1.6.

Homogeneous and Heterogeneous Mixtures

Some mixtures are homogeneous. This means they have the same composition throughout. An example is salt water in the ocean. Ocean water everywhere is about 3.5 percent salt.

Some mixtures are heterogeneous. This means they vary in their composition. An example is trail mix. No two samples of trail mix, even from the same package, are likely to be exactly the same. One sample might have more raisins, another might have more nuts.

This lemonade is mixture of water, lemon juice, and sugar.

This rock is a mixture of smaller rocks and minerals.

This salad dressing is a mixture of olive oil, vinegar, herbs, and spices.

This package contains a mixture of seeds of several types of wildflowers.

FIGURE 1.6

All these substances are mixtures. How do they differ from compounds?

Particle Size in Mixtures

Mixtures have different properties depending on the size of their particles. Three types of mixtures based on particle size are described below. **Figure** 1.7 shows examples of each type. You can watch videos about the three types of mixtures at these links:

http://www.youtube.com/watch?v=q96ljVMHYLo (4:35)

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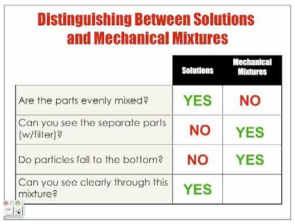
http://www.youtube.com/watch?v=96OOIL6atXs (6:13)



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- A **solution** is a homogeneous mixture with tiny particles. An example is salt water. The particles of a solution are too small to reflect light. As a result, you cannot see them. That's why salt water looks the same as pure water. The particles of solutions are also too small to settle or be filtered out of the mixture.

- A **suspension** is a heterogeneous mixture with large particles. An example is muddy water. The particles of a suspension are big enough to reflect light, so you can see them. They are also big enough to settle or be filtered out. Anything that you have to shake before using, such as salad dressing, is usually a suspension.
- A **colloid** is a homogeneous mixture with medium-sized particles. Examples include homogenized milk and gelatin. The particles of a colloid are large enough to reflect light, so you can see them. But they are too small to settle or filter out of the mixture.

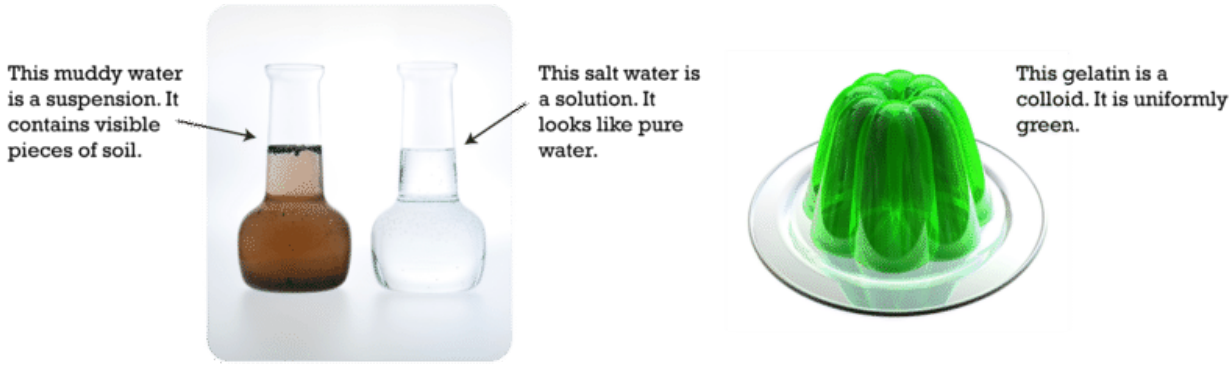

FIGURE 1.7

These three mixtures differ in the size of their particles. Which mixture has the largest particles? Which has the smallest particles?

Separating Mixtures

The components of a mixture keep their own identity when they combine. Therefore, they usually can be easily separated again. Their different physical properties are used to separate them. For example, oil is less dense than water, so a mixture of oil and water can be separated by letting it stand until the oil floats to the top. Other ways of separating mixtures are shown in **Figure** 1.8 and in the videos below.

- http://www.youtube.com/watch?v=jWdu_RVy5_A (2:30)

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- http://www.youtube.com/watch?v=UsouAlL-YZU (2:41)

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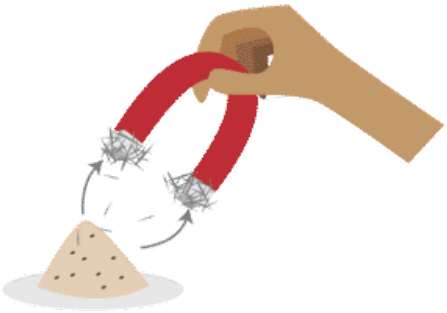
The sun heats salt water in this lake. This causes some of the water to evaporate, leaving the salt behind.

A coffee filter lets water but not coffee grounds pass through into the pot below.



A magnet can be used to separate iron filings from sand. Can you explain why?

FIGURE 1.8

Separating the components of a mixture depends on their physical properties. Which physical property is used in each example shown here?

Lesson Summary

- Elements are pure substances with unique properties. There are more than 100 different elements (92 of which occur naturally). The smallest particles of elements are atoms.
- Compounds are unique substances that form when two or more elements combine chemically. The smallest particles of compounds are molecules. Some compounds form crystals instead.

Lesson Review Questions

Recall

1. What is an element? Give three examples.
2. Describe compounds.
3. Identify molecules and crystals.
4. What are mixtures?

Apply Concepts

5. How could you use water and a coffee filter to separate a mixture of salt and sand?

6. Homogenized milk is a colloid. It has been treated to prevent its different components from separating when it stands. When non-homogenized milk stands, the cream rises to the top because it is less dense than the rest of the milk. Which type of mixture is non-homogenized milk? Explain your answer.

Think Critically

7. Create a table comparing and contrasting compounds and mixtures. Include an example of each.
8. How are atoms related to molecules?

Points to Consider

The properties of matter are not fixed. In fact, matter is always changing.

- What are some ways you have seen matter change?
- What do you think caused the changes?

References

1. Balloon: LeAnn E. Crowe (Flickr:technicolor76); Red panda: Matthijs Koster; Neon signs: Dane A. Penland; Iron: Courtesy of NASA. Balloon: http://www.flickr.com/photos/86044507@N00/3705507804; Red panda: http://www.flickr.com/photos/matthijskoster/746427079/; Neon signs: http://www.flickr.com/photos/publicresourceorg/493866748/; Iron: http://commons.wikimedia.org/wiki/File:Widmanstatten_IronMet.JPG . Balloon: CC BY 2.0; Red panda: CC BY 2.0; Neon signs: CC BY 2.0; Iron: Public Domain
2. Nugget: Eden, Janine and Jim (Flickr:edenpictures); Ring: Flickr:certified su. Nugget: http://www.flickr.com/photos/edenpictures/9769105003/; Ring: http://www.flickr.com/photos/certified_su/2940891731/ . CC BY 2.0
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6. Lemonade: Flickr:momentcaptured1; Rock: James St. John (Flickr:jsj1771); Salad dressing: Image copyright Charles Brutlag, 2013; Flower seeds: Forest Kim Starr. Lemonade: http://www.flickr.com/photos/pat_ossa/4991556821/; Rock: http://www.flickr.com/photos/jsjgeology/8475805063/; Salad dressing: http://www.shutterstock.com; Flower seeds: http://commons.wikimedia.org/wiki/File:Starr_080117-1842_Calendula_officinalis.jpg . Lemonade and Rock: CC BY 2.0; Salad dressing: Used under licenses from Shutterstock.com; Flower seeds: CC BY 3.0
7. Muddy and salt water: Image copyright Alena Brozova, 2013; Gelatin: Image copyright Jan Kaliciak, 2013. http://www.shutterstock.com . Used under licenses from Shutterstock.com
8. Lake: User:xta11/Wikimedia Commons; Coffee filter: Robert S. Donovan; Magnet: Christopher Auyeung. Lake: http://commons.wikimedia.org/wiki/File:DeadSeaIsrael3.jpg; Coffee filter: http://www.flickr.com/photos/booleansplit/7181874752/; Magnet: CK-12 Foundation . Lake: Public Domain; Coffee filter: CC BY 2.0; Magnet: CC BY-NC 3.0