3.3: Composition of Matter

Learning Objectives

- Explain the difference between a pure substance and a mixture.
- Explain the difference between an element and a compound.
- Explain the difference between a homogeneous mixture and a heterogeneous mixture.

One useful way of organizing our understanding of matter is to think of a hierarchy that extends down from the most general and complex to the simplest and most fundamental (Figure 3.3.1). Matter can be classified into two broad categories: pure substances and mixtures. A **pure substance** is a form of matter that has a constant composition (meaning that it is the same everywhere) and properties that are constant throughout the sample (meaning that there is only one set of properties such as melting point, color, boiling point, etc. throughout the matter). A material composed of two or more substances is a **mixture**. Elements and compounds are both examples of pure substances. A substance that cannot be broken down into chemically simpler components is an **element**. Aluminum, which is used in soda cans, is an element. A substance that can be broken down into chemically simpler components (because it has more than one element) is a **compound**. For example, water is a compound composed of the elements hydrogen and oxygen. Today, there are about 118 elements in the known universe. In contrast, scientists have identified tens of millions of different compounds to date.

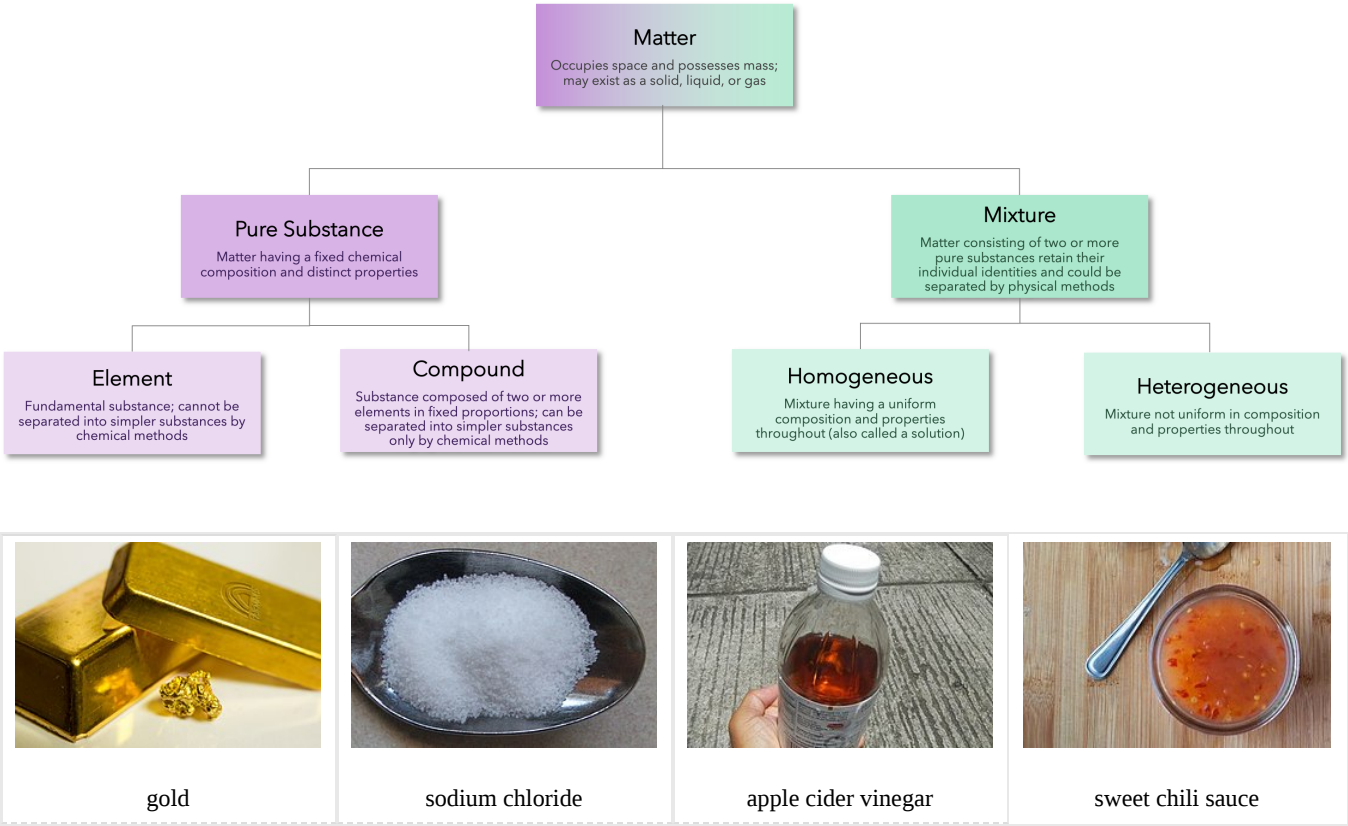

Figure 3.3.1: Relationships between the types of matter and the methods used to separate mixtures.

Ordinary table salt is called sodium chloride. It is considered a **pure substance** because it has a uniform and definite composition. All samples of sodium chloride are chemically identical. Water is also a pure substance. Salt easily dissolves in water, but salt water cannot be classified as a pure substance because its composition can vary. You may dissolve a small amount of salt or a large amount into a given amount of water. A mixture is a physical blend of two or more components, each of which retains its own

identity and properties in the **mixture**. Only the form of the salt is changed when it is dissolved into water. It retains its composition and properties.

A **homogeneous mixture**, also called a **solution**, is a mixture in which the composition is uniform throughout the mixture. The salt water described above is homogeneous because the dissolved salt is evenly distributed throughout the entire salt water sample. Often it is easy to confuse a homogeneous mixture with a pure substance because they are both uniform. The difference is that the composition of the pure substance is always the same. The amount of salt in the salt water can vary from one sample to another. All solutions are considered homogeneous because the dissolved material is present in the same amount throughout the solution.

A **heterogeneous mixture** is a mixture in which the composition is not uniform throughout the mixture. Vegetable soup is a heterogeneous mixture. Any given spoonful of soup will contain varying amounts of the different vegetables and other components of the soup.

⚡ Phase

A phase is any part of a sample that has a uniform composition and properties. By definition, a pure substance or a homogeneous mixture consists of a single phase. A heterogeneous mixture consists of two or more phases. When oil and water are combined, they do not mix evenly, but instead form two separate layers. Each of the layers is called a phase.

✅ Example 3.3.1

Identify each substance as a compound, an element, a heterogeneous mixture, or a homogeneous mixture (solution).

A. filtered tea
B. freshly squeezed orange juice
C. a compact disc
D. aluminum oxide, a white powder that contains a 2:3 ratio of aluminum and oxygen atoms
E. selenium

Given: a chemical substance

Asked for: its classification

Strategy:

- Decide whether a substance is chemically pure. If it is pure, the substance is either an element or a compound. If a substance can be separated into its elements, it is a compound.
- If a substance is not chemically pure, it is either a heterogeneous mixture or a homogeneous mixture. If its composition is uniform throughout, it is a homogeneous mixture.

Solution

A. Tea is a solution of compounds in water, so it is not chemically pure. It is usually separated from tea leaves by filtration. Because the composition of the solution is uniform throughout, it is ***a homogeneous mixture***.
B. Orange juice contains particles of solid (pulp) as well as liquid; it is not chemically pure. Because its composition is not uniform throughout, orange juice is ***a heterogeneous mixture***.
C. A compact disc is a solid material that contains more than one element, with regions of different compositions visible along its edge. Hence, a compact disc is not chemically pure. The regions of different composition indicate that a compact disc is ***a heterogeneous mixture.***
D. Aluminum oxide is a single, chemically pure ***compound***.
E. Selenium is one of the known ***elements***.

✏️ Exercise 3.3.1

Identify each substance as a compound, an element, a heterogeneous mixture, or a homogeneous mixture (solution).

A. white wine
B. mercury

C. ranch-style salad dressing
D. table sugar (sucrose)

Answer A

homogeneous mixture (solution)

Answer B

element

Answer C

heterogeneous mixture

Answer D

compound

✅ Example 3.3.2

How would a chemist categorize each example of matter?

A. saltwater
B. soil
C. water
D. oxygen

Solution

A. Saltwater acts as if it were a single substance even though it contains two substances – salt and water. Saltwater is a homogeneous mixture, or a solution.
B. Soil is composed of small pieces of a variety of materials, so it is a heterogeneous mixture.
C. Water is a pure substance. More specifically, because water is composed of hydrogen and oxygen, it is a compound.
D. Oxygen, a pure substance, is an element.

✏️ Exercise 3.3.2

How would a chemist categorize each example of matter?

A. coffee
B. hydrogen
C. an egg

Answer A

a homogeneous mixture (solution), assuming it is filtered coffee

Answer B

element

Answer C

heterogeneous mixture

Summary

- Matter can be classified into two broad categories: pure substances and mixtures.
- A pure substance is a form of matter that has a constant composition and properties that are constant throughout the sample.
- Elements and compounds are both examples of pure substances.

- Elements are the simplest substances made up of only one type of atom. Compounds are substances that are made up of more than one type of atom.
- Mixtures are physical combinations of two or more elements and/or compounds. Mixtures can be classified as homogeneous or heterogeneous.

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