Pearson

1.2: Classifying Matter: A Particulate View

Key Concept Video **Classifying Matter**

In the previous section, we saw that matter is anything that occupies space and has mass. A specific instance of matter—such as air, water, or sand—is a **substance**. We can begin to understand the particulate view of matter by classifying matter based on the particles that compose it. The first classification—the **state** of matter—depends on the *relative positions* of the particles and *how strongly they interact* with one another (relative to temperature). The second classification—the **composition** of matter—depends on the *types* of particles.

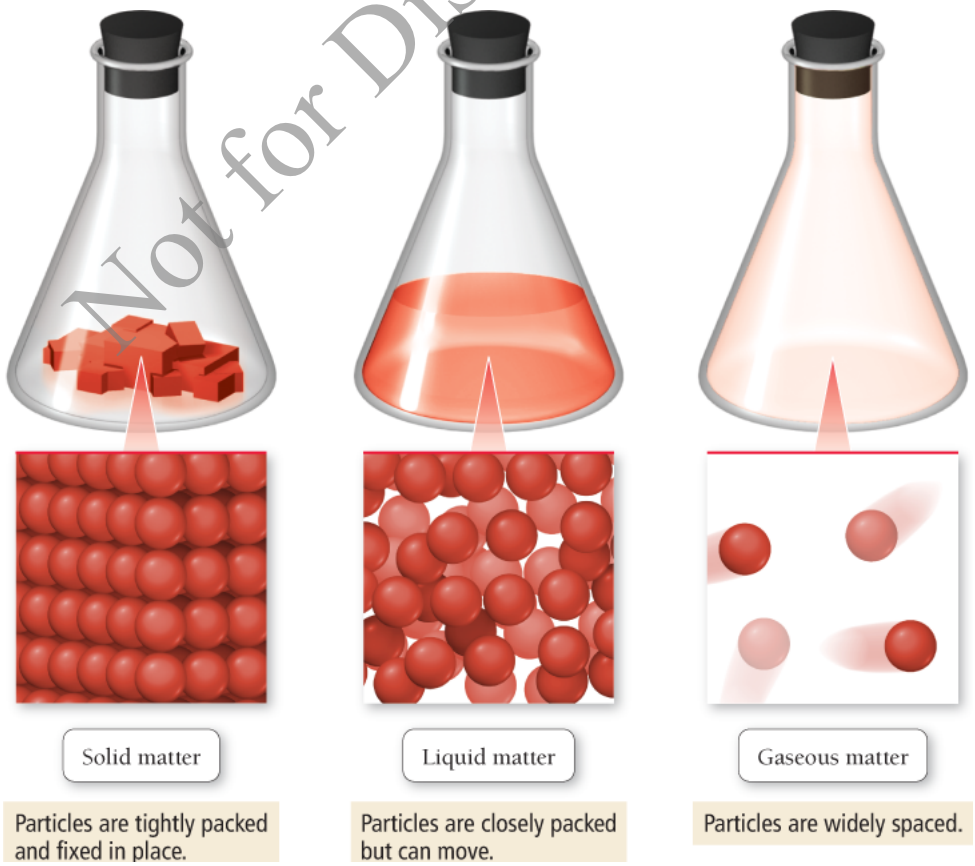
> The state of matter changes from solid to liquid to gas with increasing temperature.

The States of Matter: Solid, Liquid, and Gas

Matter can exist in three different states: **solid**, **liquid**, and **gas** (Figure 1.1). The particles that compose *solid matter* attract one another strongly and therefore pack closely to each other in fixed locations. Although the particles vibrate, they do not move around or past each other. Consequently, a solid has a fixed volume and rigid shape. Ice, aluminum, and diamond are good examples of solids.

Figure 1.1 **The States of Matter**

In a solid, the composite particles are fixed in place and can only vibrate. In a liquid, although the particles are closely packed, they can move past one another, allowing the liquid to flow and assume the shape of its container. In a gas, the particles are widely spaced, making gases compressible as well as fluid (able to flow).

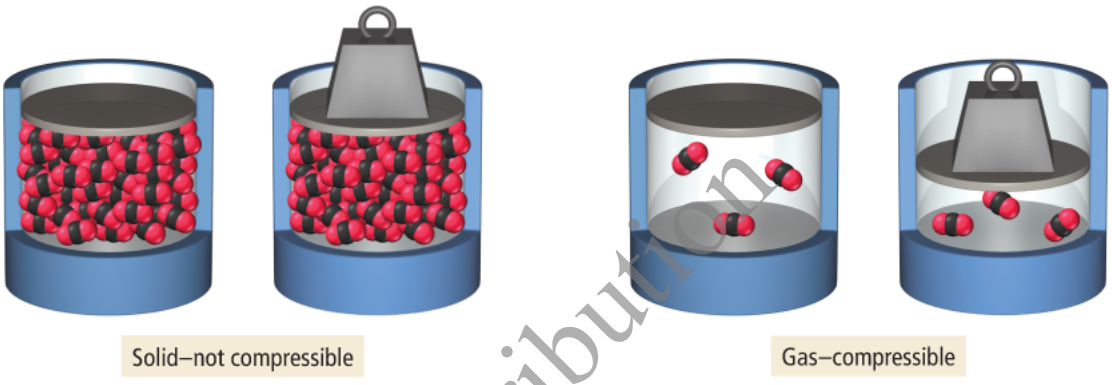


The particles that compose *liquid matter* pack about as closely as particles do in solid matter, but slightly weaker attractions between the particles allow them to move relative to each other, giving liquids a fixed volume but not a fixed shape. Liquids assume the shape of their container. Water, alcohol, and gasoline are examples of substances that are liquids at room temperature.

The particles that compose *gaseous matter* attract each other only very weakly—so weakly that they do not clump together as particles do in a liquid or solid. Instead the particles are free to move large distances before colliding with one another. The large spaces between the particles make gases *compressible* (Figure 1.2). When you squeeze a balloon or sit down on an air mattress, you force the gas particles into a smaller space, so that they are closer together. Gases always assume the shape *and* volume of their container. Substances that are gases at room temperature include helium, nitrogen (the main component of air), and carbon dioxide.

Figure 1.2 The Compressibility of Gases

Gases can be compressed—squeezed into a smaller volume—because there is so much empty space between atoms or molecules in the gaseous state.

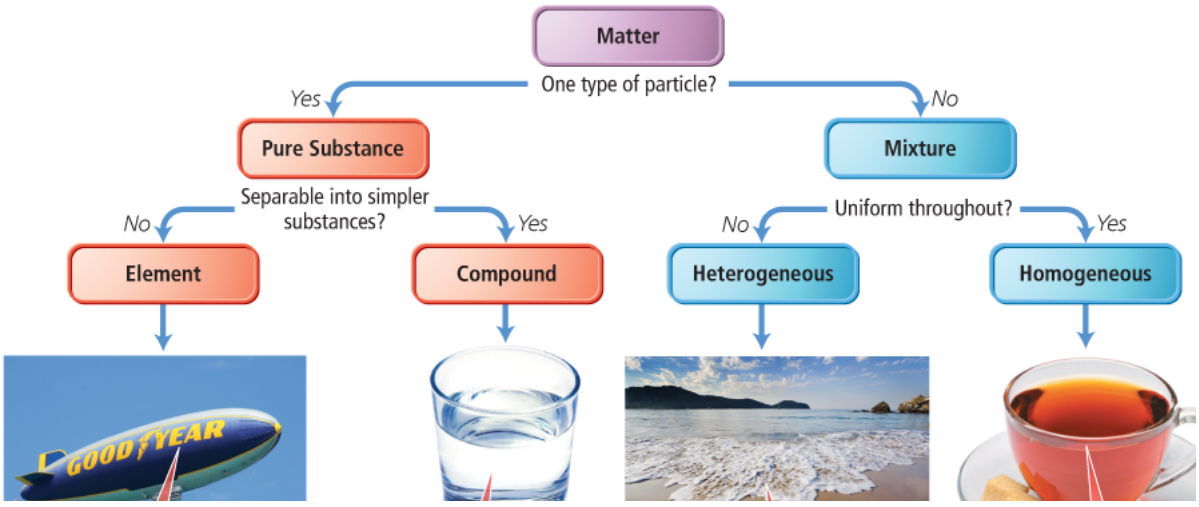


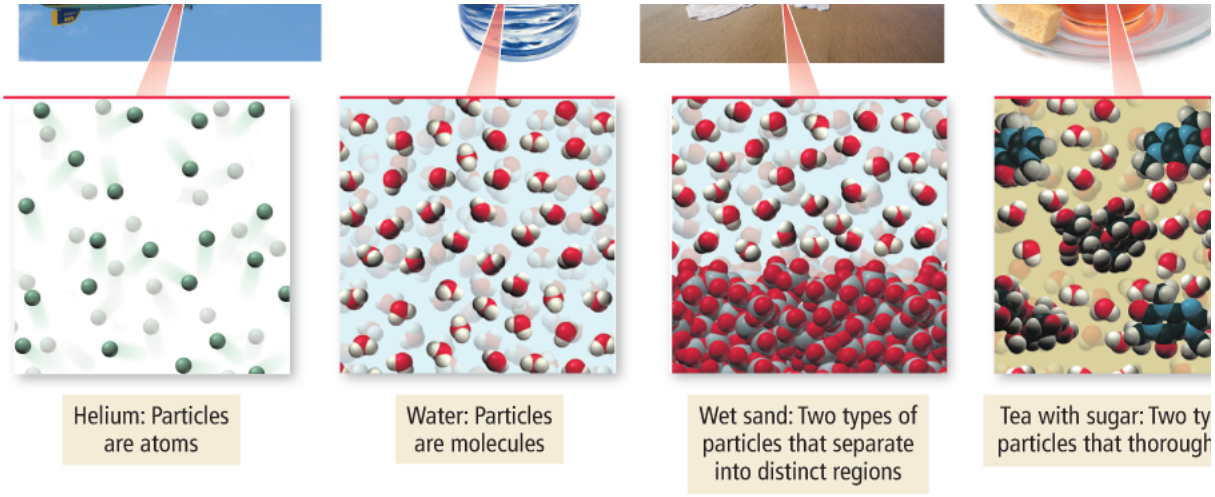
Elements, Compounds, and Mixtures

In addition to classifying matter according to its *state*, we can classify it according to *the types of particles that compose it* (its composition), as shown in Figure 1.3. In other words, in our quest to understand the particulate nature of matter, we must determine the *types* of particles in the matter and *whether there is only one type or more than one type*. The first division in this scheme is between a *pure substance* and a *mixture*.

Figure 1.3 The Classification of Matter According to Its Composition

Sweetened tea is mostly sugar and water but also contains a few other substances in much smaller amounts. In addition, the tea is assumed to not contain any solid impurities.





A **pure substance** is made up of only one type of particle (one component), and its composition is invariant (it does not vary from one sample to another). The particles that compose a pure substance can be individual atoms, or groups of atoms joined together. For example, helium, water, and table salt (sodium chloride) are all pure substances. Each of these substances is made up of only one type of particle: Helium is made up of helium atoms; water is made up of water molecules; and sodium chloride is made up of sodium chloride units. The composition of a pure sample of any one of these substances is always exactly the same.

A **mixture**, by contrast, is a substance composed of two or more particles in proportions that can vary from one sample to another. For example, sweetened tea, composed primarily of water molecules and sugar molecules (with a few other substances mixed in), is a mixture. It can be slightly sweet (a small proportion of sugar to water) or very sweet (a large proportion of sugar to water) or any level of sweetness in between.

A pure substance can be either an *element* or a *compound*, depending on whether or not it can be broken down (or decomposed) into simpler substances. Helium, which we just noted is a pure substance, is also a good example of an **element**, a substance that cannot be chemically broken down into simpler substances. Water, also a pure substance, is a good example of a **compound**, a substance composed of two or more elements (in this case hydrogen and oxygen) in fixed, definite proportions. On Earth, compounds are more common than pure elements because most elements combine with other elements to form compounds.

A mixture can be either heterogeneous or homogeneous, depending on how *uniformly* the particles that compose the mixture combine. Water and sand is a **heterogeneous mixture**, one in which the composition varies from one region of the mixture to another—the different particles that compose water and sand *do not* mix uniformly. Sweetened tea is a **homogeneous mixture**, one with the same composition throughout—the particles that compose sweetened tea mix uniformly.

Classifying a substance according to its composition is not always obvious and requires that you either know the true composition of the substance or are able to test it in a laboratory. For now, we will focus on relatively common substances that you are likely to have encountered. During this course, you will gain the knowledge to understand the composition of a larger variety of substances.

Conceptual Connection 1.1 Pure Substances and Mixtures

Interactive