Chemistry Unit 1: Section1 - Elements, Compounds, & Mixtures

PURE SUBSTANCES

A pure substance is called an **element**. An element is a pure substance because it cannot be separated into any other substances. Currently, a total of 118 elements have been identified with 92 of them known to exist in nature. All matter consists of one or more of these elements.

Elements are represented by **chemical symbols** as seen in a periodic table. Some chemical symbols consist of only one capital letter, such as C for carbon or H for hydrogen. Other symbols consist of two letters with the first being capital and the second lower case. Examples include Na for sodium and Cl for chlorine.

Some elements are very common; others are relatively rare. The most common element in the universe is hydrogen (H), which is part of Earth's atmosphere and a component of water. The most common element in Earth's atmosphere is nitrogen (N), while the most common element in Earth's crust is oxygen (O).

Living things, like all matter, are made of elements. Carbon (C) is the most common element in living things. It has the unique property of being able to combine with many other elements as well as with itself. This allows carbon to form a huge number of different substances.

ELEMENTAL PROPERTIES

Each element has a unique set of properties that is different from the set of properties of any other element. For example, the element iron (Fe) is a solid that is attracted by a magnet and can be made into a magnet, like a compass needle. The element neon (Ne), on the other hand, is a gas that gives off a red glow when electricity flows through it. The lighted sign at right contains neon.

Do you know properties of any other elements? For example, what do you know about helium? Helium (He) is a gas that has a lower density than air. That's why helium balloons have to be weighted down so they won't float away.

PARTICLES OF ELEMENTS

The smallest particle of an element that still has the properties of that element is the **atom**. Atoms actually consist of smaller particles, including **protons** and **electrons**, but these smaller particles are the same for all elements.

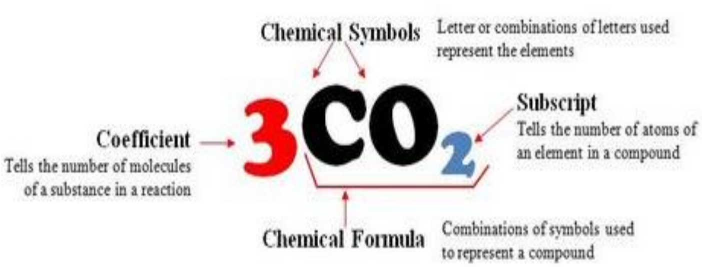
All the atoms of an element are like one another, and are different from the atoms of all other elements. The identity of an element is determined by the number of protons it has. All carbon atoms have six protons. They also have six electrons. All carbon atoms are the same whether they are found in a lump of coal or a teaspoon of table sugar (**Figure** below). On the other hand, carbon atoms are different from the atoms of hydrogen, which are also found in coal and sugar. Each hydrogen atom has just one proton and one electron.

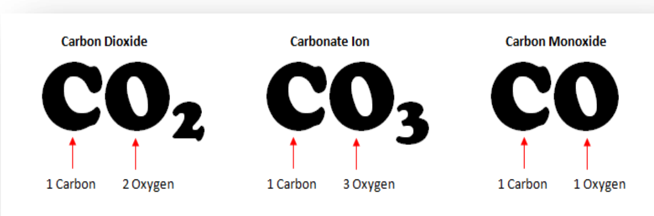
Carbon is the main element in coal (left). Carbon is also a major component of sugar (right).

*Why do you think coal and sugar are so different from one another when carbon is a major component of each substance? Coal and sugar differ from one another because they contain different **proportions** of carbon and other elements. C**oal** is about 85 percent carbon, whereas **table sugar** is about 42 percent carbon. Both coal and sugar also contain the elements hydrogen and oxygen but in different proportions. In addition, coal contains the elements nitrogen and sulfur.*

WHAT IS A COMPOUND?

Some types of matter are elements, or pure substances that cannot be broken down into simpler substances mentioned above. Many other types of matter are **compounds**, which form when two or more elements combine chemically. Compounds are represented by **chemical formulas**, which are combinations of chemical symbols and subscripts. The **subscript** is used to show the number of atoms of a specific element in a compound.





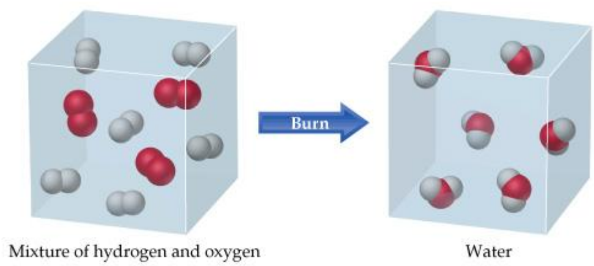
Compounds have the same elements in the same proportions and have the same composition throughout. Water (H_2O) is formed as two atoms of hydrogen bond with one atom of oxygen. Other examples are shown in the diagram below carbon dioxide (CO_2) always has two atoms of oxygen for each atom of carbon, while other carbon-containing compounds may have three oxygen atoms or only one.

The properties of a compound are different from the properties of the elements that form them — sometimes very different. That's because elements in a compound combine chemically and become an entirely different substance with its own unique properties.

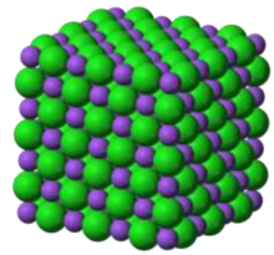
> ***Example 1**: Do you put salt on your food? Table salt is the compound sodium chloride (NaCl). It contains one sodium (Na) atom and one chlorine (Cl) atom. As shown in the **Figure** below, sodium is a solid that reacts explosively with water, and chlorine is a poisonous gas. But together in table salt, sodium and chlorine form a harmless compound that you can safely eat.*

Sodium and chlorine combine to form sodium chloride, or table salt.

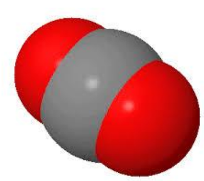
> ***Example 2**: What are the properties for the elements that form water? Hydrogen and oxygen are both gases, but when chemically combined they form a liquid.*



STRUCTURE OF COMPOUNDS



Compounds like sodium chloride form structures called **crystals**, which is a rigid framework of many ions locked together in a repeating pattern. Ions are electrically charged forms of atoms. You can see a crystal of sodium chloride in the figure at right. It is made up of many sodium and chloride ions.



A **molecule** is the smallest particle of a compound that still has the compound's properties. It consists of two or more atoms bonded together. Compounds such as carbon dioxide (at right) and water form molecules instead of crystals.

WHAT IS A MIXTURE?

A **mixture** is a combination of two or more substances in any proportion. This is different from a compound, which consists of substances in fixed proportions. The substances in a mixture also do not combine chemically to form a new substance. Instead, they just intermingle and keep their original properties.

The lemonade pictured is a mixture because it doesn't have fixed proportions of ingredients. It could have more or less lemon juice, for example, or more or less sugar, and it would still be lemonade.

HOMOGENEOUS OR HETEROGENEOUS?

The lemonade in the opening picture is an example of a **homogeneous** mixture. A homogeneous mixture has the same composition throughout. Another example of a homogeneous mixture is salt water. If you analyzed samples of ocean water in different places, you would find that the proportion of salt in each sample is the same: 3.5 percent.

A **heterogeneous** mixture, such as a cup of trail mix or Big Mac, varies in its composition. The components are not evenly distributed and you can usually see the different parts of the mixture.

TYPES OF MIXTURES

Mixtures have different properties depending on the size of their particles, which is how they are classified into three **types** of mixtures. The table below describes **solutions**, **suspensions**, and **colloids**, which are the three main types of mixtures.

Type of Mixture	Description
Solutions 	A **solution** is a homogeneous mixture in which one substance is dissolved in another. The particles are too small to see and also too small to settle or be filtered out of the mixture. In salt water, the salt (**solute**) is dissolved in the water (**solvent**). When the salt is thoroughly mixed into the water in this glass, it will form a solution. The salt will no longer be visible in the water, and it won't settle to the bottom of the glass. Solutions may also be made up of solids and gases. An example of a **gaseous** solution is air, which is oxygen and other gases dissolved in nitrogen. An **alloy** is a mixture of metals or a mixture of a metal and another element. Examples of alloys are steel, bronze, brass, pewter.

Type of Mixture	Description
Colloids 	A **colloid** is a homogeneous mixture with medium-sized particles. The particles are large enough to see but not large enough to settle or be filtered out of the mixture. Gelatin is a colloid. It looks red because you can see the red gelatin particles in the mixture. However, the particles are too small to settle to the bottom of the dish. Some other examples of colloids are fog or clouds, whipped cream, mayonnaise, milk, butter, jelly, muddy water, plaster, and colored glass. The milk you buy in the supermarket has gone through a process called **homogenization**. This process breaks up the cream in the milk into smaller particles. As a result, the cream doesn't separate out of the milk no matter how long it sits on the shelf. Milk is a colloid with particles that are large enough to see—that's why milk is white instead of clear like water, which is the main component of milk. However, the particles are not large enough to settle out of the mixture.
Suspensions 	A **suspension** is a heterogeneous mixture with large particles. The particles are large enough to see and also to settle or be filtered out of the mixture. The salad dressing in the bottle is a suspension. It contains oil, vinegar, herbs, and spices. If the bottle sits undisturbed for very long, the mixture will separate into its component parts. Other examples include dust or soot in the air, paint, red blood cells suspended in blood plasma, sand, clay, or dirt in water, and algae suspended in pond water.

SEPARATING MIXTURES

The components of a mixture keep their own identity when they combine, so they retain their physical properties. Examples of physical properties include boiling point, ability to dissolve, and particle size. When components of mixtures vary in physical properties such as these, processes such as boiling, dissolving, or filtering can be used to separate them.

The water in the Great Salt Lake in Utah is a solution of salt and water. Water has a lower boiling point than salt, and it evaporates in the heat of the sun. With its higher boiling point, the salt doesn't get hot enough to evaporate, so it is left behind.