ACTIVITY 2– ELEMENTS AND THEIR PROPERTIES

Background Information

History has shown that the idea of what an element is has changed over the years. What are the properties that are necessary for a substance to be classified as an element? We define an element as a substance that contains only one kind of atom. A compound is a substance that consists of at least two different kinds of atoms. A molecule can exist as a compound or as an element. Water is an example of a compound whereas oxygen exists in nature as a diatomic molecule.

The current definition of an element is: An element is material that cannot be broken down into new material that is stable or simpler through chemical reactions.

After the periodic table was developed, the discovery of elements increased quite rapidly as chemists developed quantitative methods of analyzing substances. Students will learn that a family of elements will have similar physical and chemical properties.

Group 1A elements (**alkali metals**) include Li, Na, K, Rb, Cs, and Fr. These are very reactive metals, so much so that they must be protected from air and water to prevent them from reacting. These are shiny solids that conduct heat and electricity well. The 1A metals are soft, lightweight, and have low melting points. They always occur in nature as 1+ ions rather than as free metals.

The **alkaline earth metals** are members of **Group 2A** (Be, Mg, Ca, Sr, Ba, and Ra). Compared with transition metals (B-Groups), the 2A elements are soft and lightweight, but they are harder and denser than the 1A elements. The 2A elements (all except Be, which forms polar covalent compounds) tend to form ions with a 2+ charge.

The magnesium in this activity reacts with acid to liberate hydrogen gas:

$$Mg_{(s)} + 2\ H^{+}_{(aq)} \longrightarrow Mg^{2+}_{(aq)} + H_{2(g)}$$

Group 3A elements (B, Al, Ga, In, Tl) are sometimes called the boron family, and exhibit a wide range of chemical behaviors. Boron is a black, hard metalloid with a high melting point. Aluminum is a metal; shiny, low density, and low melting point.

Aluminum only forms ions with a 3+ charge. When aluminum reacts with HCl, the following reaction occurs:

$$2\ Al_{(s)} + 6\ H^{+}_{(aq)} \longrightarrow 2\ Al^{3+}_{(aq)} + 3\ H_{2(g)}$$

Group 4A is comprised of C, Si, Ge, Sn, and Pb. Carbon is found in fossil fuels and in all living matter. The largest natural sources of carbon are the carbonate minerals limestone and dolomite. Silicon, a metalloid, is second only to oxygen as the most abundant element in Earth's crust, occurring as silica (SiO_2) and silicates (various complexes with SiO_4^{4-} as the building unit).

The first three elements of **Group 6A** are *nonmetals* (oxygen, sulfur, and selenium) and the last two are metalloids (tellurium and polonium). Oxygen exists as a diatomic gas O_2, and sulfur and selenium exist in the form S_8 and Se_8. These elements tend to form ions with a 2– charge.

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Group 7A elements are called the halogens and exist as diatomic molecules with the general formula X_2, where X denotes either F, Cl, Br, I, or At (Astatine is a radioactive, artificial element; its chemical properties are not well known). These nonmetal elements are very reactive and are not naturally occurring in their elemental state, that is, they will never be found in an uncombined form. The halogens tend to form ions with a 1– charge, thus when they combine with Group 1A metals, the compounds have the formula MX. If they combine with Group 2A metals they form compounds with the formula MX_2.

Copper, iron, and zinc are metals that are members of different **Group B elements**, the **transition elements**.

Physical properties of substances are those that can be measured and observed without the substance undergoing any change in composition. Examples include color, odor, texture, density, melting and boiling points.

If the identity of a substance changes when a property is demonstrated, the property is a **chemical property**. Examples include flammability, tendency to rust, and explosiveness.

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