Chem 101 Chapter 3: Elements and Compounds Week 2 pgs. 43 - 60

Atoms vs. Molecules

Atoms are the smallest components of elements. Atoms of hydrogen, helium, lithium, beryllium, boron, etc. are each unique and have differing properties. Molecules are the smallest component of compounds. Molecules of water, carbon dioxide, chlorine (an element that exists as a molecule), sulfuric acid, etc. are the chemical combination of atoms into new substances.

The Elements

Elements are the "building blocks of matter." These substances compose all of matter and are each unique in physical and chemical properties. The **periodic table** displays all of the known elements. The number of protons (atomic number, above the symbol) denotes the identity of the element. All elements above 92 are synthetic and are not found in nature and a few elements (4) below 92 (such as technetium (43) and astatine (85)) exist only very briefly in nature or are synthetic. The smallest particle of an element is an atom.

Elements are found in differing abundances in differing places on the earth. The **most abundant element is oxygen**. It occurs in the atmosphere and combined with hydrogen in water as well as in the earth's crust with silicon (sand, quartz, chalcedony).

Interestingly, only **4 elements are liquids at our body temperature**. These are **mercury, cesium, gallium, and the non-metal bromine**. **11 are gases** at ordinary pressures and temperatures, while the **remainder are solids** and most of these are metals. The human body contains several elements.

Element names come from Latin, Greek, German, (See Table 3.2 pg. 52) etc. and can be the names of people such as fermium or even named for a country (americium and germanium).

Symbols

Element symbols are short hand ways of writing them. The first letter is capitalized and the second and possibly third letter is **lowercase**. Be careful not to confuse Co with CO as one is a metal while the other is a toxic gas (carbon monoxide).

You should know the symbols of the most common elements given in Table 3.3, pg. 47.

Metals, Non-metals, and Metalloids

Metals, non-metals, and metalloids or semi-metals each have unique chemical and physical properties.

METALS

Metals are the most abundant form of element in the periodic table. They have the following properties:

a. Most are solids (cesium, mercury, and gallium are exceptions)

b. Malleable: can be rolled or hammered into thin sheets

c. Ductile: formed into wires

d. Usually have a high melting point and boiling point. Exceptions: the alkali metals; mercury, and gallium

e. Do not react readily with each other to form compounds

f. Some exist in nature as the element (gold, silver, mercury, bismuth, copper) while others combine readily with other elements to form rocks and minerals.

NON-METALS

Physical Properties: can be solids, liquids (Br), or gases at room T and P; brittle, low-reflectivity (not shiny); poor conductors of heat and electricity

Chemical Properties: Combine readily with each other to form compounds (smallest particle or called a molecule). Exs.: C and O combine to form CO (carbon monoxide) or CO_2 (carbon dioxide), H and Cl combine to form HCl (hydrogen monochloride)

Some non-metals are **diatomic** (consist of 2 atoms bonded to each other): **H_2, N_2, O_2, F_2, Cl_2, Br_2, I_2** (7 total), see Table 3.4 p. 56

METALLOIDS (SEMI-METALS): Have properties of both; located along stair-step line on periodic table; used in semi-conductors

Exs.: B, Si, Ge

Allotropes: Differing forms of the same element that exist due to differences in chemical bonding. Exs.: white and red phosphorus; graphite, diamond, and buckminsterfullerenes (bucky balls) all forms of C; oxygen (O_2) and ozone (O_3)

Compounds

A compound is a new substance formed when 2 or more elements combine chemically. The compound usually has properties completely different than the elements that make it up (more than 9 million (9×10^6) known).

When forming compounds, elements combine in whole number (1, 2, 3, etc.) ratios such as 1:1 (NaCl), 1:2 (CO_2), 1:3 (SO_3), 2:3 (N_2O_3), 3:2 (Ca_3P_2), etc. but NEVER fractions!

Molecules vs. Ions

A **molecule** is formed when 2 or more non-metals combine chemically; a bond forms as a result and this is termed a ***covalentbond***.

Ions: An ion is formed when an atom gains (a negative ion N-, called an *anion*) or loses (a positive ion N+, called a *cation*) one or more electrons. An ***ionic bond*** occurs between a metal and non-metal. Exs.:Ca + Cl_2 combine to produce $CaCl_2$, CsBr, Al_2O_3, KI

Chemical Formulas

Consist of element symbols and subscripts which indicate the element and how many of each is found in that compound.

Exs.: P_4O_{10}: 4 atoms of P and 10 atoms of O; $H_2C_2O_4$: 2 atoms of H, 2 atoms of C, and 4 atoms of O

If no subscripts are present, there is one element present. Ex. KI: 1 atom of K and 1 atom of I

Some compounds have parentheses in them. This indicates the elements inside the parentheses must be multiplied by the subscript outside the parentheses.

Example 1: $C_3H_5(NO_3)_3$ has 3 atoms of C, 5 atoms of H, 3 atoms of N (1 x 3), and 9 atoms of O (3 x 3).

Example 2: $KAl(SO_4)_2 \cdot 12\ H_2O$ has 1 atom of K, 1 atom of Al, 2 atoms of S, a total of 20 atoms of O, and 24 atoms of H.