Matter, Atoms, Elements

I. MATTER, ELEMENTS, ATOMS

A. Definitions

0. Matter- any material that occupies space and has mass.

1. Elements - all matter are made of elements, over 100 elements are known. Elements include O, Au, Ag, N, H, C and have a unique, and identifiable atomic structure.

a. Refer to periodic table/handout

(1) 92 naturally occurring elements

(2) 11 man-made elements (103 total)

2. Compounds - combination of two or more elements joined together at the atomic level.

3. Atom - the smallest recognized particle of matter that retains the properties of a given element. Atoms of elements are combined together to form compounds.

B. Atomic Structure - Theory of atoms and atomic structure are based on experimental evidence and mathematical models. Atoms are generally too small to observe directly even with the most powerful microscope, but they can be observed indirectly by modeling.

1. Nucleus - central portion of an atom which contains even smaller sub-atomic particles called protons and neutrons.

a. Protons - very dense, positively charged subatomic particles in the nucleus of an atom.

b. Neutrons - dense, neutrally charged subatomic particles in the nucleus of an atom.

2. Electrons - negatively charged particles that orbit very rapidly about the nucleus of an atom. Generally considered that electrons are moving so fast, that it is difficult to locate their position at any given moment....view electrons as a cloud of charged particles hovering about the nucleus.

a. Electron clouds are organized at certain distances from the nucleus in regions called energy level shells. Each energy level shell at a given distance from the nucleus can only hold a certain number of electrons at any given time. An important fact with regards to attraction and bonding together of atoms to form compounds...our concern since it relates to the construction of minerals and rocks.

3. Atomic number - is the number of protons located in the nucleus, each element has its own unique atomic number making it distinct from other elements (e.g. C a.n. = 6, O a.n. = 8)

b. Isotope: same number of protons, variable no. of neutrons

(1) e.g. O^{18}/O^{16}: 8 protons but 10 and 8 neutrons respectively

(2) Deuterium = hydrogen with proton + neutron: atomic no. = 2 (instead of one for common hydrogen with one proton)

(3) Tritium = hydrogen with 1 proton and 2 neutrons: atomic no. =3.

4. Atomic charge balance - all atoms contain the same number of negative electrons as positive protons, thus as neutrons have no charge, then net positive charges = net negative charges (protons = electrons)

Elements can be considered to be large collection of electrically neutral atoms, having the same atomic number or no. of protons.

5. Electron energy level shells - the lst principle shell holds 2 electrons, while each of the higher shells holds 8 or more electrons, but the outermost shell will contain a maximum of only eight electrons... an important phenomena in that the configuration of 8 electrons in the outermost shell tends to be a stable occurrence in nature.

C. Atomic Bonding - Chemical bonding between atoms occur when two or more elements join to form a compound (e.g. Na and Cl atoms typically bond to form NaCl or table salt). The forces that bring atoms or ions (electrically charged atoms) together are electrical in nature and the configuration of the electrons in the outer energy shell are important in relation to bonding characteristics of a given element.

1. Octet Rule - atoms combine in order that each may attain an electron arrangement of eight in the outer energy level (the stable configuration that naturally occurs in Noble Gases).

a. Noble gases= stable/inert as outer shell filled with octet configuration

1) helium (2), neon (8), argon, xenon and radon.

In order to satisfy the octet rule, an atom can either gain, lose, or share electrons with one or more atoms. The electrons form an electrical glue which hold atoms together

2. Valence electrons - the electrons present in the outer energy level that are available for atomic bonding. The no. of valence electrons an element has determines the number of bonds it will form.

e.g. Si has 4 valence electrons and tends to form 4 bonds in the process of obtaining the stable configuration of 8 electrons in the outer energy level. Oxygen has 6 electrons in outer shel, and forms two bonds to complete to 8. Hydrogen has one electron in its first shell, thus only needs one bond to complete the stable configuration of 2 electrons in the first shell.

3. Ionic Bonds - bonding in which one or more valence electrons are transferred from one atom to another. One atoms becomes stable by giving up an electron (to obtain a stable no. in outer energy shell) the other atom becomes stable by accepting one electron into its outer energy shell. The result is oppositely charged ions attracting to one another to produce an electrically neutral stable compound.

e.g. NaCl - Na has an atomic no. of 11, and thus contains 11 electrons around the nucleus (2 in first energy level, 8 in second energy level, and 1 in valence or outer energy level); Cl has an atomic no. of 17 and thus 17 electrons about its nucleus (2 in first level, 8 in second level, 7 in outer level). Thus Na needs to lose 1 electron from outer shell to obtain stable configuration, and Cl needs to gain 1 electron in outer shell to obtain stable configuration.... tendancy for ionic bonding to form NaCl.

a. Ions - electrically charged atoms.

1) positive ions - tend to lose electrons during bonding (e.g. Na in its native state has an atomic no. of 11, thus 11 positive protons in nucleus, and 11 negative electrons about the nucleus making it electrically neutral. When it loses one electron during bonding it then has 11 positive protons and 10 negative electrons and thus has a net +1 positive charge.

2) negative ions - tend to gain electrons during bonding. Cl on the other hand has an atomic no. of 17 with 17 +protons and 17-electrons in its native state, it tends to gain 1 electron during bonding thus results in 17+protons and 18 - electrons and a net charge imbalance of -1. Na +1 and Cl -1 attract one another as they have opposite and equal charges.

Thus two elements with different properties combine together to form a compound with yet different properties. Cl is a green poisonous gas, Na is a silvery reactive metal, but together they form NaCl or table salt also known as the mineral Halite.

4. Covalent Bonds - not all atoms combine by transferring/losing electrons to form ions. It is more beneficial in some cases for atoms to share valence electrons as opposed to transferring them to obtain a stable configuration.

Covalent Bonds - bond produced by sharing of electrons to obtain stable arrangement of 8 electrons in outer energy shell

e.g. Cl_2 or chlorine gas - occurs as 2 atoms of chlorine share their outer electrons ... see page 21....as stated previously, Cl has 7 electrons in its outer shell, thus if it lossed any electrons it would become more unstable, so in the case of two cl atoms they simply share their to valence shell electrons

a. Metallic bonding - extreme case of electron sharing in which electrons move freely from atom to atom. Metallic bonding accounts fo the high electrical conductivity of metals and other special properties.