DESCRIPTIVE CHEMISTRY

PROPERTIES OF SELECTED ELEMENTS

METALLIC ELEMENTS:

The majority of elements on the periodic table are metals. Most are solids (except Hg).

In general, metals are: **malleable** (they can be hammered into useful shapes)
ductile (they can be pulled into thin wires)
good **conductors** of heat and electricity

Most metals (several exceptions) will react with acids to release hydrogen, e.g.:

$Mg + 2\,HCl \rightarrow MgCl_2 + H_2$

Metals are isolated (extracted) from naturally occurring substances called **ores**.

Silver, copper, and gold sometimes occur as metals in nature.

Several metals (the less reactive ones) can be extracted by heating their ores:

$2\,HgO \rightarrow 2\,Hg + O_2$; $2\,Ag_2O \rightarrow 4\,Ag + O_2$

Many more metals can be recovered if carbon is used as a "reducing agent":

$2\,CuO + C \rightarrow 2\,Cu + CO$

$2\,FeO + 3\,C \rightarrow 4\,Fe + 3\,CO$ (requires higher temperature)

The more reactive metals (those of groups I and II) cannot be recovered from their ores by the above procedures. Historically, they were first isolated using **electrolysis** (passsing a strong electric current through a melted compound).

Group I metals ("alkali metals") include Li, Na, K, Rb, Cs, Fr.

They are all soft (can be cut with a knife) and melt easily, usually below 100^o C.

They are very reactive, so they are never found uncombined in nature.

These metals occur most often as chlorides and other halide compounds, which are generally white, crystalline compounds with simple shapes.

These metals react with water to produce hydroxide compounds and release hydrogen:

$2\,Na + 2\,H_2O \rightarrow 2\,NaOH + H_2$

Oxides of these metals combine with water to form hydroxides:

$2NaO + H_2O \rightarrow 2\,NaOH$

Group II metals ("alkaline earth metals") include Be, Mg, Ca, Sr, Ba, Ra.

They have melting points between 600^o - 900^o C (higher for Be, around 1280^o C).

They are very reactive, so they are never found uncombined in nature.

These metals occur most often as carbonates, or sometimes as sulfates, all of which are white, crystalline compounds (like chalk, $CaCO_3$).

The oxides can be obtained by heating the carbonates:

$CaCO_3 \rightarrow CaO + CO_2$

The oxides all react with water to form hydroxides, which are basic:

$CaO + H_2O \rightarrow Ca(OH)_2$

Other metals ("transition metals") have higher melting points (usually), but are easier to extract from their ores, which are often oxides.

The oxides do not always react with water, but they are basic when they do.

NONMETALLIC GASES:

Hydrogen (H_2) can be prepared by reacting metals with acids (see metals, above).

Hydrogen burns in air; the only product is water:

$2\ H_2 + O_2 \dashrightarrow 2\ H_2O$

Hydrogen is the lightest substance known.

Its physical properties are those of a nonmetal, but its chemical properties resemble the metallic elements, and solid hydrogen (at very low temperature) behaves as a metal.

Hydrogen is a constituent of all acids and all organic compounds.

Oxygen (O_2) makes up about 21% of air. It supports combustion and also animal respiration.

Lavoisier proved that combustion in air consists of something combining with oxygen.

Nearly all other elements can combine with oxygen, but in different proportions.

Oxygen is the most abundant element on earth.

Nitrogen (N_2) makes up about 78% of air.

If oxygen is removed from air, then the gas that remains is mostly nitrogen.

Nitrogen is not very reactive; most naturally occuring nitrogen exists as N_2.

Nitrate compounds with the NO_3^- ion are also quite common.

Nitrogen and hydrogen can combine to form ammonia, NH_3.

Chlorine (Cl_2) and the other halogens are very reactive and never occur alone in nature.

They occur most often as white crystalline salts, in combination with group I metals.

Pure halogens are all strongly colored and all are poisonous.

F_2 is a yellow-green gas; Cl_2 is a green gas; Br_2 is a foul-smelling orange liquid; I_2 is a very dark purple solid that sublimes to a purple vapor with no liquid phase.

All halides react violently with metals to form ionic halide compounds.

Halogen elements form acids (like HCl, hydrochloric acid).

Halogens were first isolated by electrolysis.

The inert gases ("noble gases") include He, Ne, Ar, Kr, Xe, Rn.

They are so unreactive that no compounds exist in nature, but a few unstable compounds have been made (only with the most reactive elements). The noble gases were not known before 1900.

NONMETALLIC SOLIDS:

Boron (B) is a brownish solid that occurs in nature mostly in borates.

Carbon (C) occurs in several allotropic forms: diamond, graphite, buckminsterfullerine.

It occurs in some ionic carbide compounds, formed at high temperatures and pressures.

Most carbon compounds are covalent and are called <u>organic compounds</u> because all living organisms are made of them. Carbon also forms two oxides (CO and CO_2).

Silicon (Si) is the second most abundant element on earth.

The most abundant compound is SiO_2 (sand, or quartz). Most rocks are made of silicates.

Phosphorus (P) burns easily in air, giving off light, and is therefore used in matches.

It exists in 3 allotropic forms: white, red, and black.

Phosphate minerals make up our bones and various mineral deposits.

Phosphorus occurs in DNA, so crops need phosphorus to make seeds.

Sulfur (S) is a low-melting, yellow solid, known in ancient times, used by Romans as a fungicide.

H_2S, SO_2 and SO_3 are bad-smelling poisonous gases often found near volcanoes

Sulfate minerals are quite common. Sulfuric acid is the most commonly manufactured chemical.