Historical use of Chemistry- Harnessing of Chemical Changes

1000 BC
- processing ore into metal
- embalming

400 BC
- Greeks attempt to explain reason for chemical changes
- propose all matter is composed of 4 fundamental substances
    - Fire
    - Water
    - Wind/Air
    - Earth
- this is the earliest attempt to define an "element"

Next 2000 years (400 BC – 1600 AD)

Dominated by Alchemy

Alchemy- making and exploring substances
- turning cheap metals into gold
- Creating fountain of youth potion
- Discovery of mercury, sulfur and antimony
- Learn to make acids

Robert Boyle
- experimentation very important
- scientific process
- Definition of an Element
    - ELEMENT- any substance that cannot be further broken down into two or more simpler substances.

An element can be present as a single atom, or an entire truck load.

There are 115 elements.

88 are naturally occurring
27 are man made elements

The most abundant elements on earth are found on page 84
The most abundant elements in the human body are found on page 85

You should know the first few from each list, you do not have to know percentages.

Element symbols are a short hand or symbolic representation of the elements.

They originate from the first few letters of the element name.

Element symbols are either one or two letters long.

The first letter of the symbol is always capitalized.

If the symbol is two letters long then the second letter is **not** capitalized.

Sometimes the symbol originates from the old name of the element

Example:

Tungsten = W, wolfram was the old name
Gold = Au, aurium was the old name

You should be familiar with the elements found on page 87 in the textbook.

John Dalton

Dalton's Atomic Theory – 1808

1. Elements are made of tiny particles called atoms.
2. All atoms of a given element are identical.
3. All atoms of a given element are different from all atoms of any other elements.
4. Atoms of one element can combine with atoms of another element to form compounds. A given compound always contains the same relative numbers and types of atoms (fixed ratio).
5. Atoms are indivisible in a chemical reaction. They cannot be created or destroyed, only regrouped.

From #4 in Dalton's Atomic Theory we get LAW OF CONSTANT COMPOSITION:

A given compound always contains the same proportion by mass of its elements.

Definition of a COMPOUND: a distinct substance composed of atoms of two or more elements combined in a fixed ratio.

CHEMICAL FORMULA: expression of types and number of atoms present in a compound.

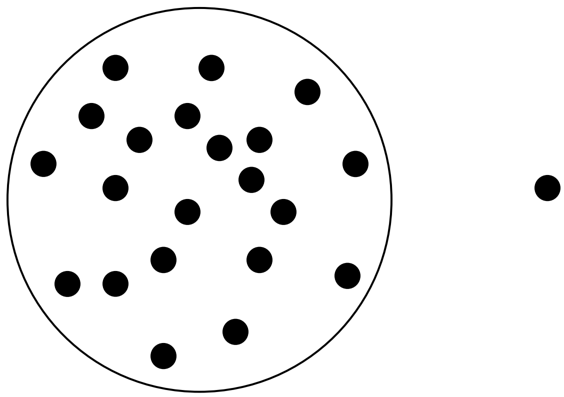
Atoms are represented by element symbols, number of each atom present is represented by a subscript (located to the lower right of the symbol it is modifying).

Example: A compound with six carbon atoms, twelve hydrogen atoms and six oxygen atoms = $C_6H_{12}O_6$

Structure of the Atom

JJ Thomson- discovered the electron in late 1890's

Developed the "PLUM PUDDING MODEL" of the Atom

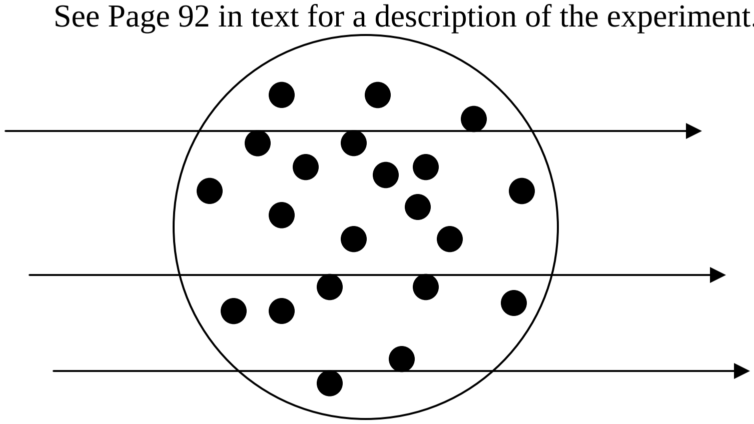


Negative particles scattered throughout a positively charged atom

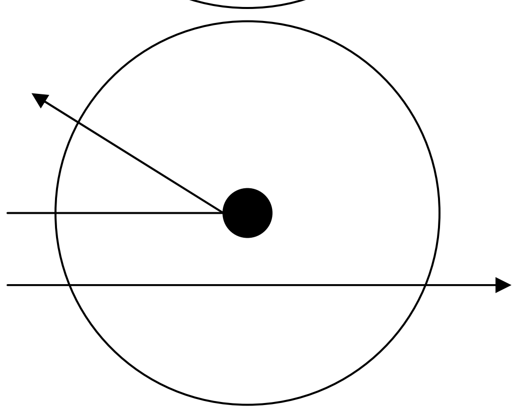
Thomson knew that overall the atom was neutral, so if there were negative particles, the rest of the atom must be positive to cancel out the negative charge.

Ernest Rutherford – discovered the proton in 1911, "GOLD FOIL EXPERIMENT"

See Page 92 in text for a description of the experiment.



If the "Plum Pudding Model" were true Rutherford's results should have looked like this.



Rutherford's actual results show the presence of a dense center of positive charge.

The NUCLEAR MODEL of the atom is developed and positive charged particles known as protons are found to be at the center of this nucleus.

James Chadwick- discovers the NEUTRON in 1932.

The neutron is located in the nucleus and has NO CHARGE.

The following table summarizes the subatomic particles listed in order of discovery:

Particle	Relative Mass	Relative Charge	Location
Electron	1	-1, negative	Surrounding the nucleus
Proton	1836	+1, positive	In the nucleus
Neutron	1839	0, neutral	In the nucleus

With the discovery of the neutron, it was also discovered that atoms could contain varied numbers of neutrons.

Dalton's atomic theory has to be modified to reflect this discovery.

Dalton's Atomic Theory – 1808

#2 All atoms of a given element are identical.

#2 is modified to: All atoms of a given element contain the same number of protons, but may contain different numbers of neutrons.

ISOTOPE: atoms with the same number of protons (same element) but with different numbers of neutrons.

When dealing with isotopes the following symbol is used:

$$^{A}_{Z}X$$

This is known as the atomic symbol.
X is the element symbol
A is the atomic mass
Z is the atomic number

Atomic Mass is equal to the number of protons plus the number of neutrons.
Atomic Number is equal to the number of protons.

In a neutral atom the number of electrons equals the number of protons.

The atomic symbol can be used to describe the subatomic particles in an atom.

If an atom has 11 protons and 12 neutrons the atomic symbol would be:

$$^{23}_{11}\text{Na}$$

If the atomic symbol of an atom is:

$$^{40}_{20}\text{Ca}$$

Then the atom would contain 20 protons, 20 neutrons and 20 electrons.

Note: WHEN DEALING WITH ISOTOPES, DO NOT GET THE MASS NUMBER FROM THE PERIODIC TABLE. THAT NUMBER REPRESENTS AN AVERAGE OF ALL ISOTOPES!! YOU MUST CALCULATE THE MASS BY ADDING PROTONS AND NEUTRONS!!

Periodic Table: a chart with all known elements

Contains a great deal of information.

At minimum periodic tables contain element symbols and atomic numbers.

Many include mass numbers (atomic mass) as well.

Some even indicate other properties of the elements such as state of matter or if the element is natural or man-made.

The atomic number is most always located above the element symbol (sometimes it may be off to the right or left a bit, but it is above the symbol)

The most recently discovered elements have a 3 letter name. It is a temporary name until it is officially named by UPAC- Union of Pure and Applied Chemists.

The periodic table is arranged by increasing atomic number and it has a specific shape so that there is meaning to the horizontal and vertical rows (we will get into this more later)

The periodic table was developed in 1869 by Dmitri Mendeleev.

The vertical columns represent GROUPS. Groups on the periodic table have very similar chemical properties.

The horizontal rows are called PERIODS.

There are special FAMILY names for some of the groups on the periodic table.

Group 1 = ALKALI METALS
Group 2 = ALKALI EARTH METALS
Group 7 = HALOGENS
Group 8 = NOBLE GASES
Center columns = TRANSITION METALS

The majority of the elements on the periodic table are METALS.
Metals are located on the left hand side of the periodic table.
Most metals are solid at room temperature.

Exceptions: Mercury is a liquid and Cesium and Gallium melt just above room temperature at about 30°C.

Metals have the following characteristics:

1. Conductors of heat and electricity
2. Malleable- can be hammered into a thin sheet
3. Ductile- can be drawn into a wire
4. Lustrous- shiny

The right hand side of the periodic table contains the NONMETALS.
Only a few nonmetals are solids.

Bromine is a LIQUID.

Hydrogen, nitrogen, oxygen, fluorine, chlorine, helium, neon, argon, krypton, xenon and radon are all GASES.

boron, carbon, phosphorus, sulfur, selenium, iodine, astatine are SOLIDS

Nonmetals have the following characteristics:

1. Insulators from heat and electricity
2. Brittle
3. Dull

There are a few elements on the periodic table that are located along a stair-step line that divides the metals from the nonmetals. These few elements are known as METALLOIDS.

Metalloids have properties of both a metal and a nonmetal.

Metalloids are often semiconductors, can be somewhat shiny/dull, and are usually somewhat brittle.

The metalloids are: silicon, germanium, arsenic, antimony, and tellurium

Most elements are not found in pure form in nature.

Exceptions are the noble gases and the noble metals (gold, silver, platinum)

Some elements in pure form do not exist as a single atom. These are known as DIATOMIC MOLECULES (di= 2, atomic = atoms; two atoms)

DIATOMIC MOLECULES: molecules made up of two atoms of the same element

The diatomic molecules are: hydrogen, nitrogen, oxygen, fluorine, chlorine, bromine, iodine.

An element can also have different forms. Carbon for example has 3 ALLOTROPES.

ALLOTROPE: a different physical formation of the same element

Carbons 3 allotropes are diamond, graphite and buckminsterfullerene or “buckey ball”

An atom has a zero net charge. The number of protons equals the number of electrons.

A charged entity can be produced by adding or removing electrons from an atom.

ION: a charged particle created by adding or removing electrons from an atom.

CATION: a positively charged particle created by removing electrons from an atom.

ANION: a negatively charged particle created by adding electrons to an atom.

Metals tend to lose electrons and become positively charged ions (CATIONS)
Nonmetals tend to gain electrons and become negatively charged ions (ANIONS)

IONS ARE ONLY CREATED BY ADDING OR REMOVING ELECTRONS, NEVER BY CHANGING THE NUMBER OF PROTONS!!!!

A cation is called by the name of the element plus the word ion.

Example: Aluminum atom loses 3 electrons to become the Aluminum ion with a +3 charge.

An anion is called by the root of the element name plus the ending –IDE plus the word ion

Example: Fluorine atom gains 1 electron to become the Fluoride ion with a -1 charge.

Atoms do not just randomly gain and lose electrons. There is a patter to how it occurs, certain elements gain or lose certain amounts of electrons. This can be predicted in part by the periodic table.

Group 1 = form plus 1 cations by losing 1 electron
Group 2 = form plus 2 cations by losing 2 electrons

Group 6 = form minus 2 anions by gaining 2 electrons
Group 7 = form minus 1 anions by gaining 1 electron

Aluminum, Gallium and Indium form plus 3 cations by losing 3 electrons

Transition metals form cations with various charges, some with more than one.
(We will not concern ourselves with this at this time)

Positive and negative ions combine to form compounds.

Most compounds that contain a metal and a nonmetal are an ionic compound

IONIC COMPOUNDS: compounds that are formed from positive and negative ions joining.

CHARACTERISTICS OF IONIC COMPOUNDS

1. Very high melting points
2. Conduct electricity in molten or dissolved form. (will not conduct in solid form because the ions need to be free to move around, thus molten (liquid) or dissolved form is needed)

In order to have an ionic compound:

1. There must be at least one (or more) cation and one (or more) anion.
2. The numbers of cations and anions must be such that the net charge is zero.

#2 is the one that is likely to give you problems.

Example:

Na^{+1} and Cl^{-1} combine to form NaCl; the plus one of the Na^{+1} cation is cancelled out by the minus 1 of the Cl^{-1}anion.

Mg^{+2} and Cl^{-1} combine to form $MgCl_2$; the plus two of the Mg^{+2} cation require two Cl^{-1} anions to cancel out the charge.

Li^{+1} and N^{-3} combine to form Li_3N; this compound requires three of the Li^{+1} cation to cancel out the minus 3 charge from the N^{-3} anion.

Key: OVERALL THE NET CHARGE ON AN IONIC COMPOUND MUST BE ZERO!!!