# Atoms, Molecules and Ions

- Atomic Theory of Matter
- Modern Atomic Theory
- Relation to Periodic Table
- Isotopes & Mass Number
- Periodic Table
- Ionic Compounds
- Molecular Compounds
- Acid Compounds

# The Atomic Theory of Matter

Atom - the smallest particle of an element that retains the chemical identity of that element.

Dalton's Principles (1803)

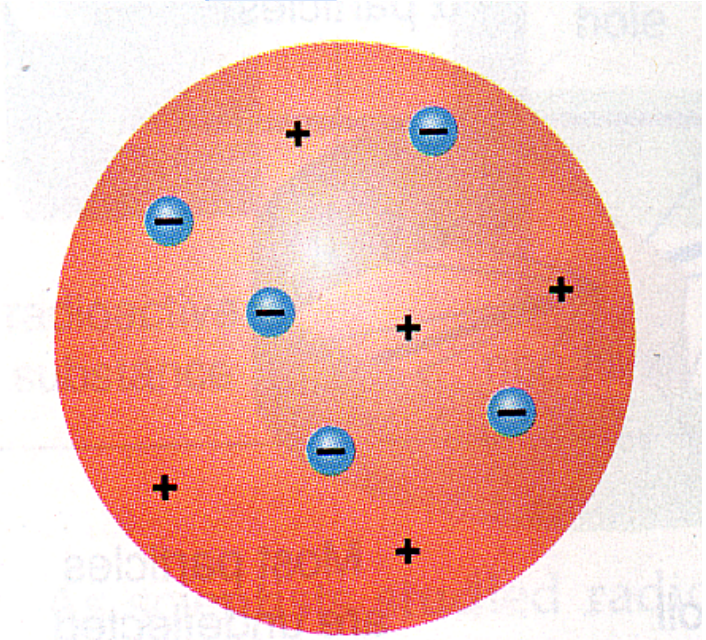
- Each element is composed of extremely small particles called atoms
- All atoms of a given element are identical, but differ from every other element.
- Atoms are neither created nor destroyed in a chemical reaction.
- A given compound always has the same relative number and kinds of atoms.

# Laws from Dalton's Principles

- Law of constant composition - In a given compound, the relative number and kinds of atoms are constant
- Law of conservation of mass - The total mass of materials present after a chemical reaction is the same as the total mass before the reaction.
- Law of multiple proportions - If two elements A and B can form more than 1 compound, the ratio of masses of A to B are small, whole numbers.

# Thomson's electron

Using a cathode ray tube with a fluorescent screen, Thomson measured the deflection of a cathode ray by a magnetic field. Because he could measure the charge per gram of the "ray", he concluded that the "ray" was actually a particle (la called the electron).



This produced a slight change in the model of the atom.

# Radioactivity

1896 - Becquerel discovered that some materials spontaneously give off high-level energy.

Early 1900's - Rutherford discovers three types of radiation emitted from an atom

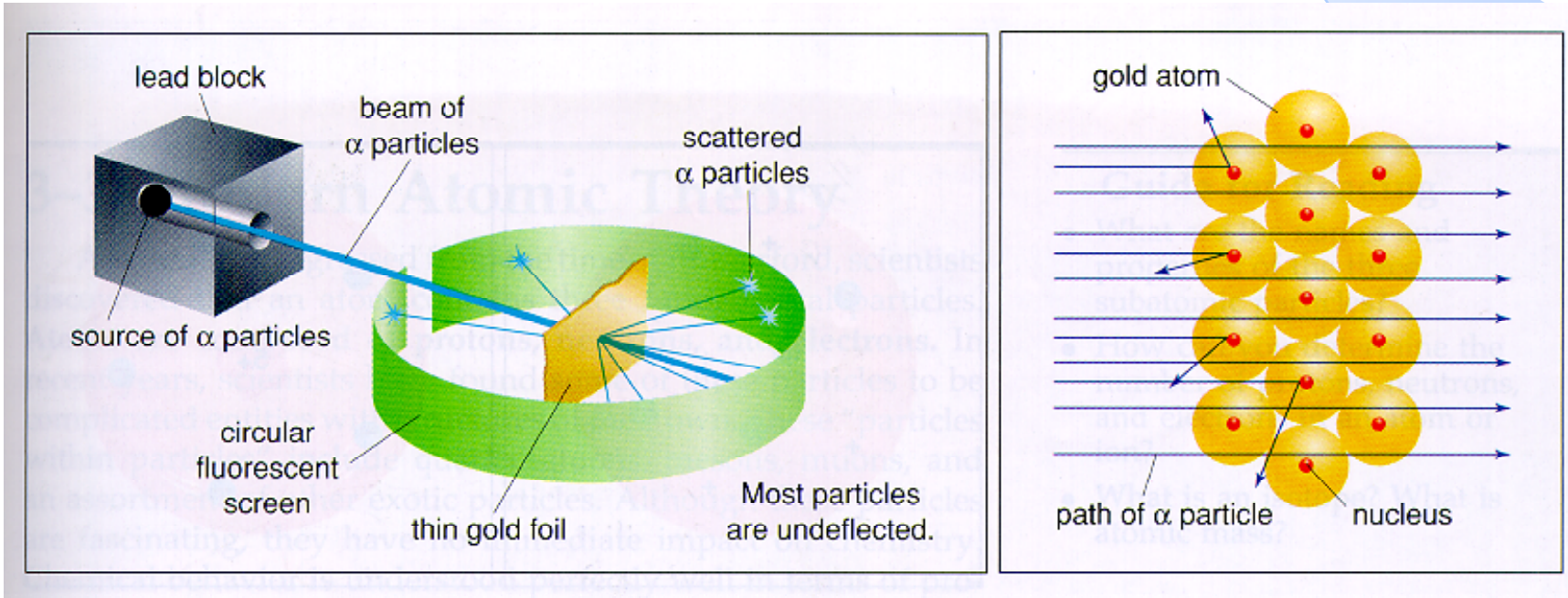
Alpha - positively charged He nucleus

Beta - essentially a cathode ray (electron)

Gamma - High energy radiation similar to x-rays

# Rutherford's Gold Foil Exp.

1911 - Rutherford claims that the results of his experiment suggest a positive center to the atom (nucleus).

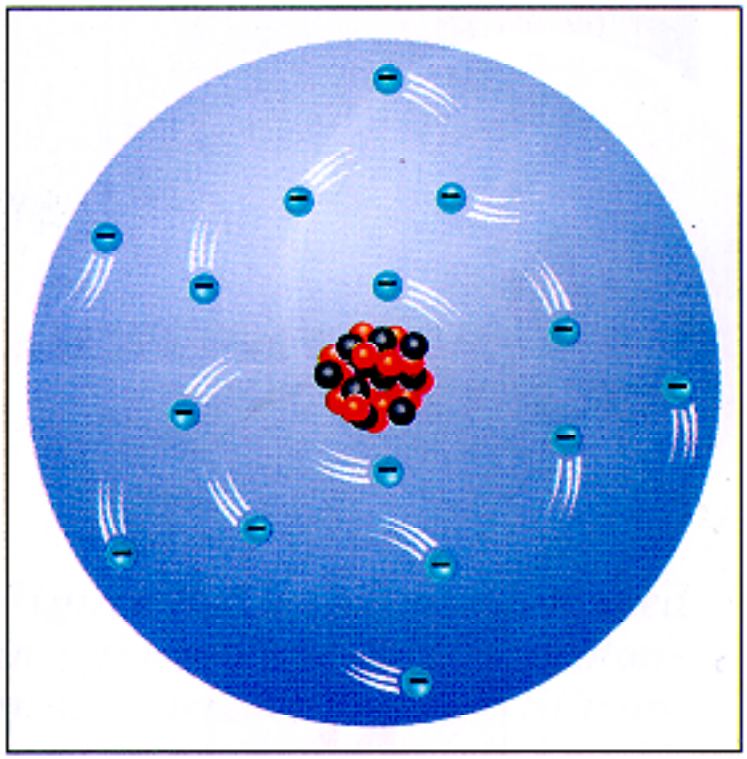


# Other discoveries

1919 - Rutherford discovers the proton, a positively charged mass within the nucleus.

1932 - Chadwick discovers the missing mass of the nucleus, a non-charged neutron.

# Modern Atomic Theory



Atoms are composed of:

1) protons - positively charged particles located within the nucleus.
2) neutrons - uncharged particles located within the nucleus.
3) electrons - negatively charged particles which orbit the nucleus.

# Size and Charge of Sub-atomic Particles

Size of sub-atomic particles:

- proton -> $1.673 \times 10^{-24}$ g (1 amu)
- neutron -> $1.675 \times 10^{-24}$ g ~ (1 amu)
- electron -> $9.11 \times 10^{-28}$ g ~ (1/2000 amu)

Charge of sub-atomic particles:

- proton -> $+1.602 \times 10^{-19}$ C - (+1)
- neutron -> 0 C - (0)
- electron -> $-1.602 \times 10^{-19}$ C - (-1)

Every atom has a neutral charge.

# Relation to the periodic table

- Atomic Number - tells the number of protons in an atom. In a neutral atom, the number of protons must equal the number of electrons.
- Atomic Mass - tells the total mass of the atom (protons and neutrons).

# Origins of the Periodic Table

In 1869, approximately 62 elements were known to exist. Scientists wanted a convenient way to look at these elements. Dmitri Mendeleev proposed a periodic table of elements. It was arranged by increasing mass number and similar properties.

Later, Henry Mosley working with X-ray radiation discovered that the amount of positive charge in the atom (protons) was the proper way to order the elements.

# The Periodic Law

- Periodic Law - when elements are arranged in order of increasing atomic number, their physical and chemical properties show a periodic pattern.

# Periodic Table Setup

- Groups or Families - vertical columns
  - (numbered 1 - 18)
- Periods - horizontal rows
  - (numbered 1 - 7)

# Special Names

- Group Names
  - Group 1 - Alkali Metals
  - Group 2 - Alkali Earth Metals
  - Groups 3 - 12 - Transition Metals
  - Group 17 - Halogens
  - Group 18 - Noble Gases
- Period Names
  - 4f - Lanthanide series
  - 5f - Actinide series
  - both technically in group 3 (inner transition metals)

# Types of Elements

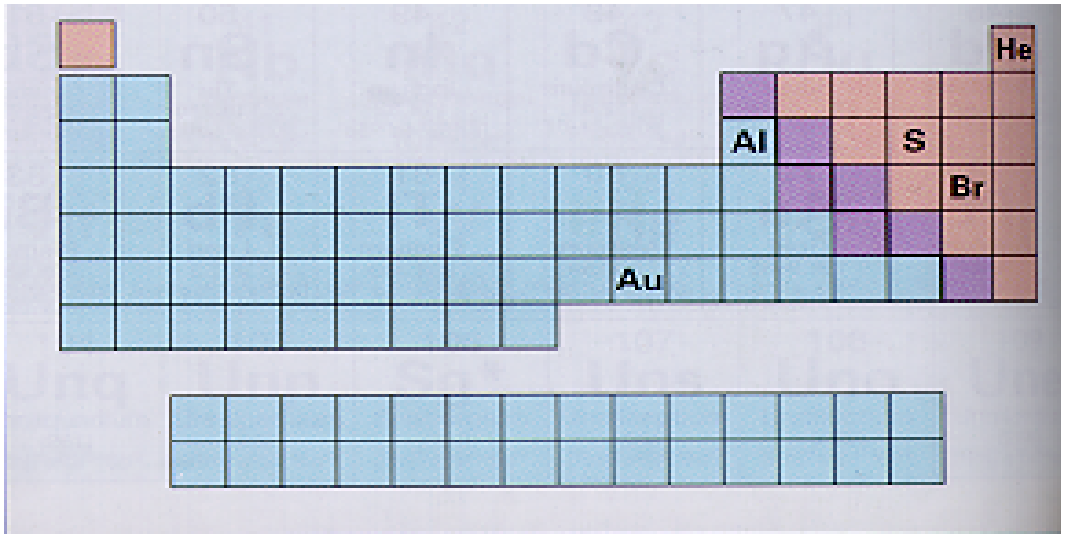
Metal Properties

- luster or shine
- good conductors of heat/electricity
- most are solids at room temp.
- malleable

Nonmetal Properties

- no luster
- poor conductors
- not malleable
- Can be solid, liquid or gas at room temp.

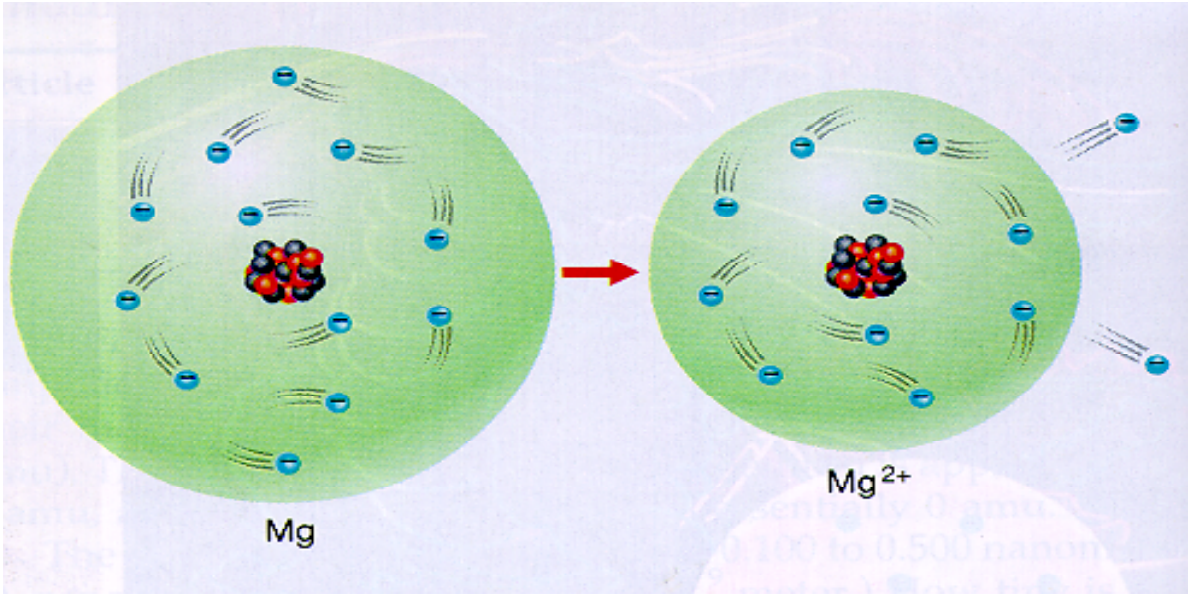
Metalloids - properties of both



# Ions

Ions - When an atom gains or loses one or more electrons, it acquires an electrical charge.

- If it loses electrons, it becomes more positive, and this is called a cation. (positive charge)
- If it gains electrons, it becomes more negative, and this is called an anion. (negative charge)



# Determining ionic charge

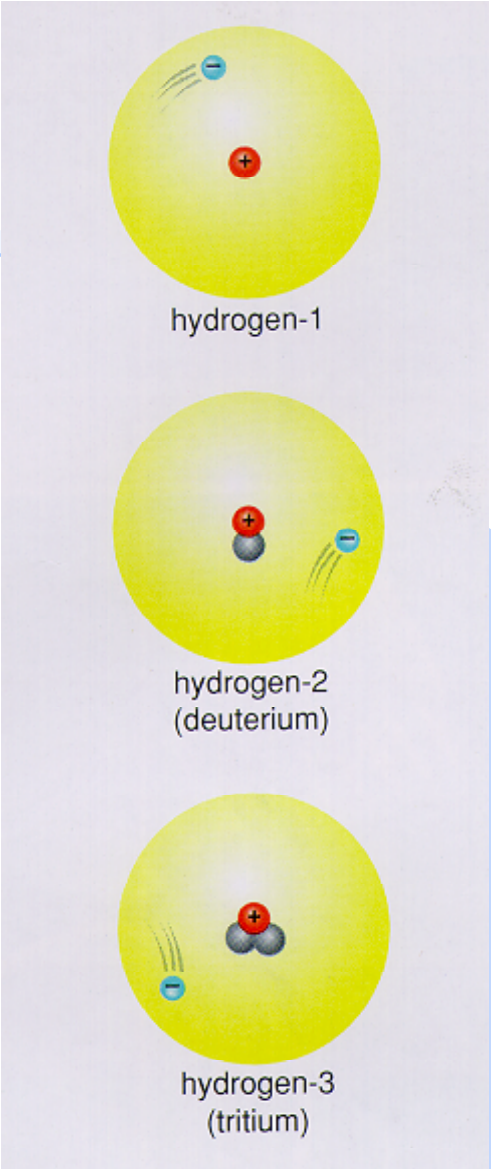
A neutral atom has equal numbers of protons and electrons, giving it a zero charge

An ion's charge can be determined by the following formula:

Charge of ion = # of protons - # of electrons

# Isotopes and Mass Number

- Every atom of a given element has the same number of protons. However, like the electrons, the amount of neutrons in any atom of that element can be different.
- The chemical properties of each isotope are identical, except the number of neutrons within the nucleus.



# Isotopes and Mass Number

- To identify the different isotopes, scientist add a mass number after the element's name. The mass number is the sum of the number of protons and neutrons (rounded off to the nearest whole number).
- The average mass (in amu) of a group of atoms of the same element is used to find the average atomic mass.

# Writing Ionic Compound Formulas

There are 4 steps in writing chemical formulas:

1) Determine the ions listed in the name.

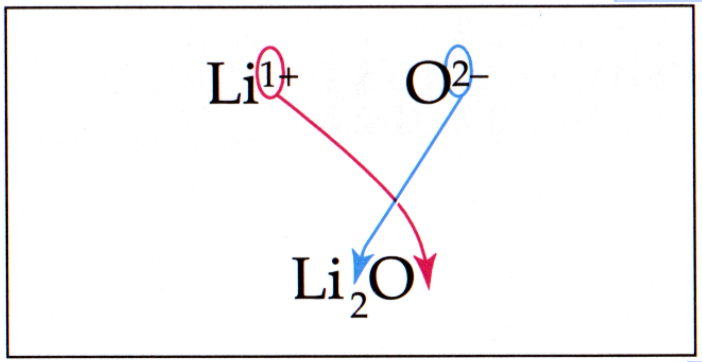
2) Write the symbols with the charges next to it. (Cation comes first)

3) Balance the charges so that the total charge is zero for the compound

   - determine the number of each ions needed to add up to zero charge.

   - write the number of each ion as a subscript following the symbol.

4) Criss-cross method.



# Polyatomic Ions

Frequently, atoms can combine to form polyatomic ions.

These are groups of atoms that have an overall charge that needs to be balanced.

They act the same as monatomic ions (one atom ions).

# Naming Ionic Compounds

There are 3 steps in writing the chemical names of formulas:

1) Determine which elements (or groups) are in your compound.

2) List the name of the cation as it is.

3) Then follow it by the element anion and replace the last syllable with -ide, unless it is a group, which remains the same

***If the cation can form more than one charge, follow the name of the cation with a roman numeral telling the size of the cation charge.

# Special Naming

- When an element can only form 2 charges, the traditional naming system does not use roman numerals but slightly different names:
- Ex.

| Formula | Name | Traditional Name |
|---|---|---|
| $FeCl_2$ | Iron (II) chloride | Ferrous Chloride |
| $FeCl_3$ | Iron (III) chloride | Ferric Chloride |

# Special Naming

- Polyatomic anions with the same root but different numbers of oxygens will change their names slightly to show the difference:
- Ex.

| Ion | Name |
|---|---|
| $ClO_4^-$ | Perchlorate (1 more O) |
| $ClO_3^-$ | chlorate |
| $ClO_2^-$ | Chlorite (1 less O) |
| $ClO^-$ | Hypochlorite (2 less O) |

# Molecular Compounds

A molecular compound is a compound comprised of only non-metal and metalloid elements. These compounds are connected by covalent bonds.

When naming these compounds, we use Greek prefixes to tell how many of each element we have.

# Naming Molecular Compounds

When naming these compounds, we use special rules:

1) Name the first element in the compound. If there is more than one of this element, signify this with the appropriate Greek prefix.

2) Follow this with the second element with the appropriate prefix and an -ide ending.

*** The prefix mono- is not needed on the first element if it is single, however, it must be placed on the second element of the compound.***

**Numerical Prefixes**

| | |
|---|---|
| *mono-* | 1 |
| *di-* | 2 |
| *tri-* | 3 |
| *tetra-* | 4 |
| *penta-* | 5 |
| *hexa-* | 6 |
| *hepta-* | 7 |
| *octa-* | 8 |
| *nona-* | 9 |
| *deca-* | 10 |

# Acids

Acids are molecular and ionic compounds that increase the pH of liquids in solution. They always begin with the H+ ion.

Monatomic Acids - compounds of hydrogen and one other atom.

Polyatomic Acids - compounds of hydrogen and a polyatomic ion group

Acids are named differently than other compounds:

# Naming Monatomic Acids

1) Prefix “Hydro-”, followed by
2) Root “-anion name-”, followed by
3) Suffix “-ic”, all in one word
4) Followed by the word “acid”

Ex. HF

Answer : Hydroflouric Acid

# Naming Polyatomic Acids

1) Root "Anion name-", followed by

2a) Suffix "-ic" for ions with -ate or -ide ending,

***or***

2b) Suffix "-ous" for ions with -ite ending

3) Followed by the word "acid"

(no hydro prefix on polyatomic acids)

Ex. $HNO_3$

Answer : Nitric acid

Ex. $HClO_2$

Answer : Chlorous acid

# Diatomic Elements

Some elements cannot exist by themselves, even when they are isolated from any other type of atom.

Elements of this nature will combine with atoms of the same element in order to be stable. There are eight elements that form diatomic molecules:

Three Hints: “7 that make a 7 and hydrogen” or “sneeze HNOF↓“ or think “GEN-u-INE”.