CHAPTER 2

AP Chemistry

Laws

- Law of Conservation of Mass
- Law of Definite Proportions (constant comp)
- Law of Multiple Proportions: ratios of masses can always be reduced to small whole #s.
  - CO = 1 g C combines with 1.33g O
  - CO_2 = 1 g C combines with 2.66g O

Dalton's Atomic Theory 1

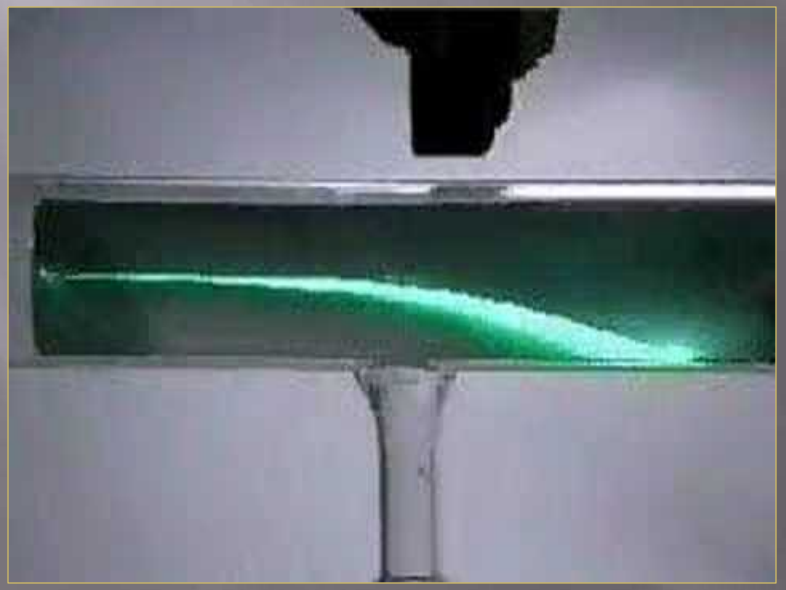
- All elements are composed of tiny indivisible particles called atoms.
- Atoms of the same element are identical.

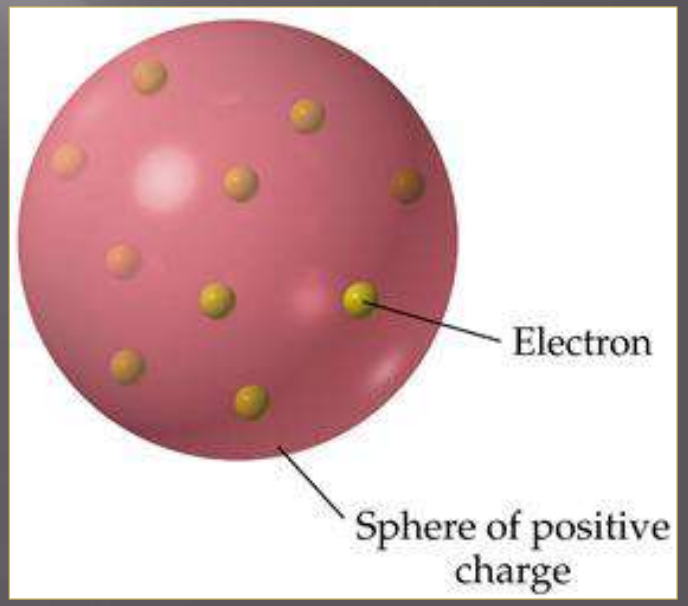
Dalton's Atomic Theory 2

- Atoms of different elements can combine with one another in whole number ratios to form molecules.
- Chemical reactions occur when atoms are separated, joined, or rearranged.

J.J.Thomson

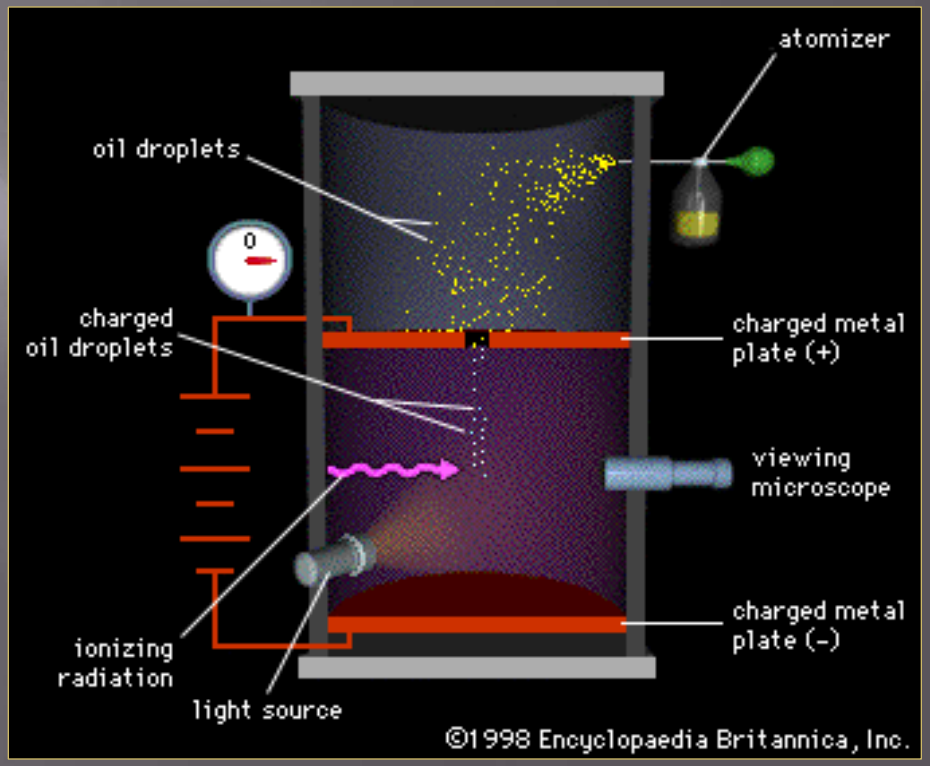
- Found the existence of negatively charged particles in atoms.
- Called these particles electrons.
- Designed the Plum Pudding Model





Robert Millikan

- Used charged oil droplets to find the mass of an electron.
- 9.11×10^{-31} kilograms



Radioactivity

- Alpha:
  - Positively charged helium nucleus
- Beta
  - High energy electron
- Gamma
  - High energy ray/light

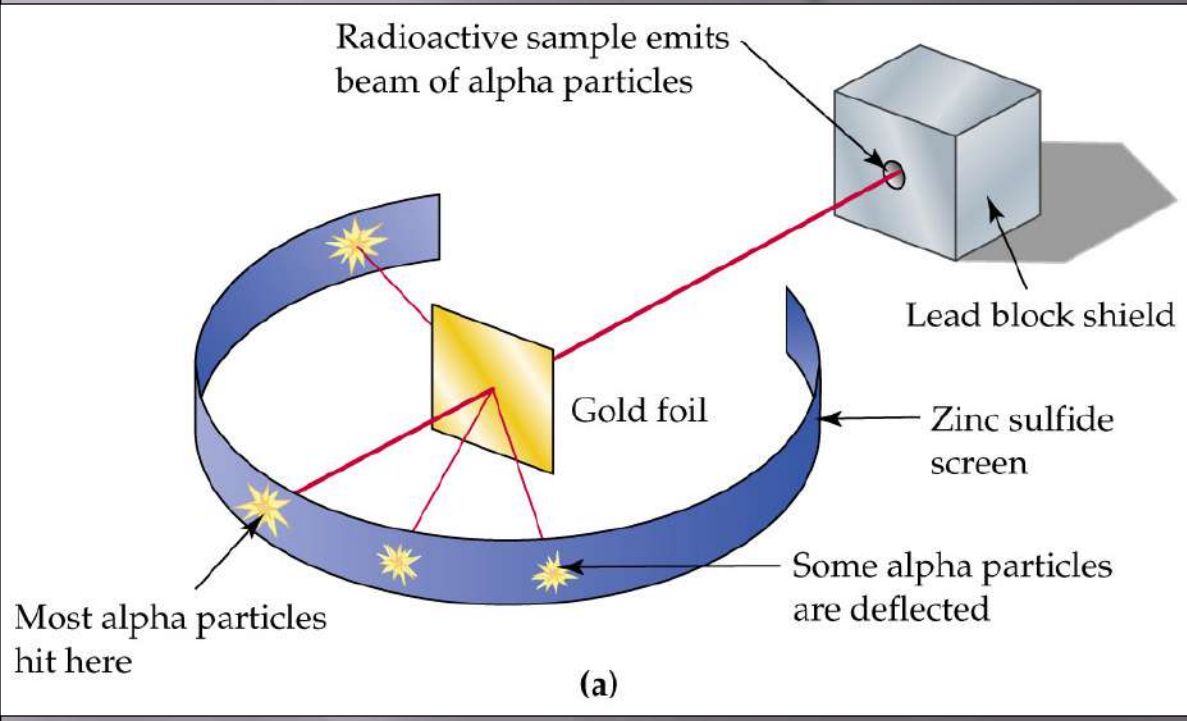
Ernest Rutherford

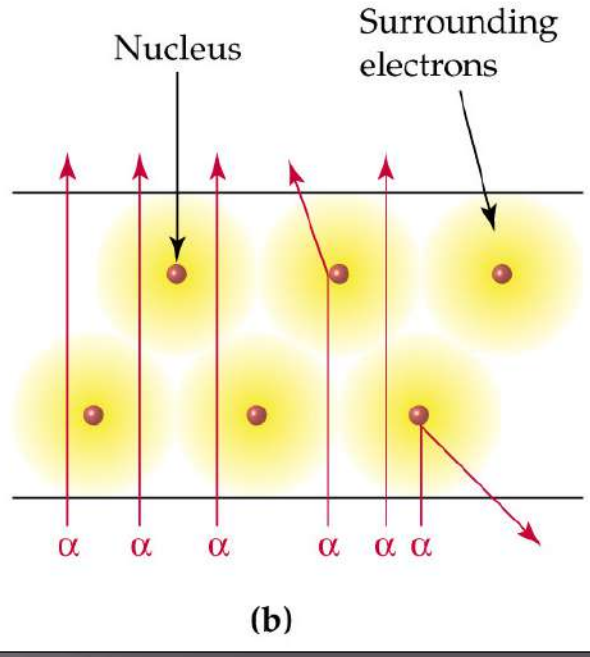
- Designed an experiment to test Thomson's Plum Pudding Model.

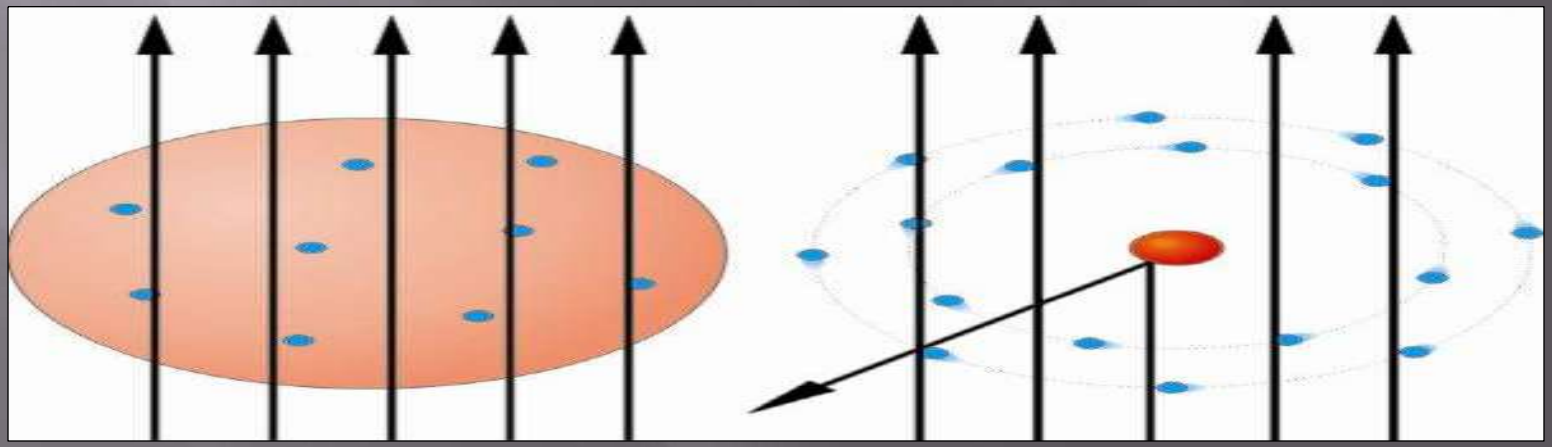
- Shot alpha radiation at gold foil.
- If Thomson is right, alpha particles will pass straight thru.

- What do you think he found?

Rutherford's Gold Foil Experiment







Nucleus

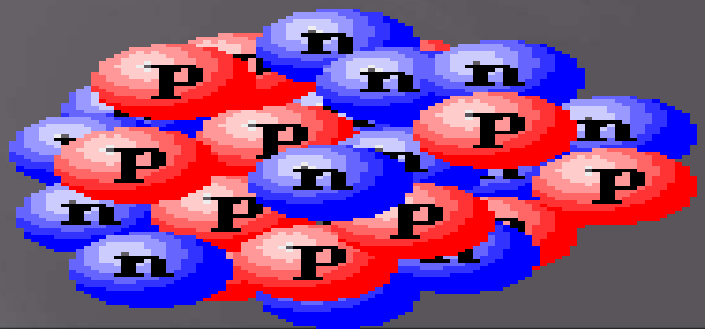
- The **nucleus** is a very dense cluster of protons and neutrons that takes up very little space but accounts for over 99% of the mass of an atom.
- The nucleus is held together by the **strong nuclear force**.

Protons

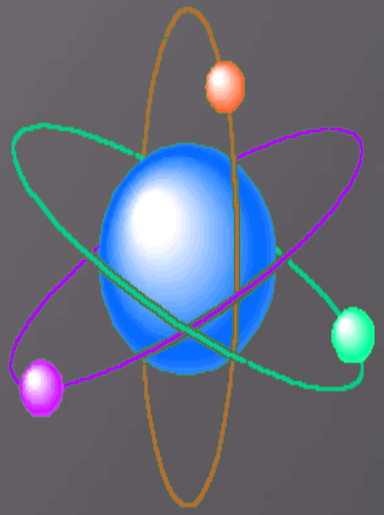
- **Protons** are positively charged particles found in the nucleus.
- The mass of a proton is about 1 atomic mass unit (amu).

Neutrons

- **Neutrons** are neutral particles found in the nucleus.
- They shield the protons from one another to serve as a buffer.
- The mass of a neutron is about 1 amu.



Electrons



- **Electrons** are negatively charged particles found moving at different distances from the nucleus.
- The mass of an electron is only about 0.000545 amu.

Atomic Number (Z)

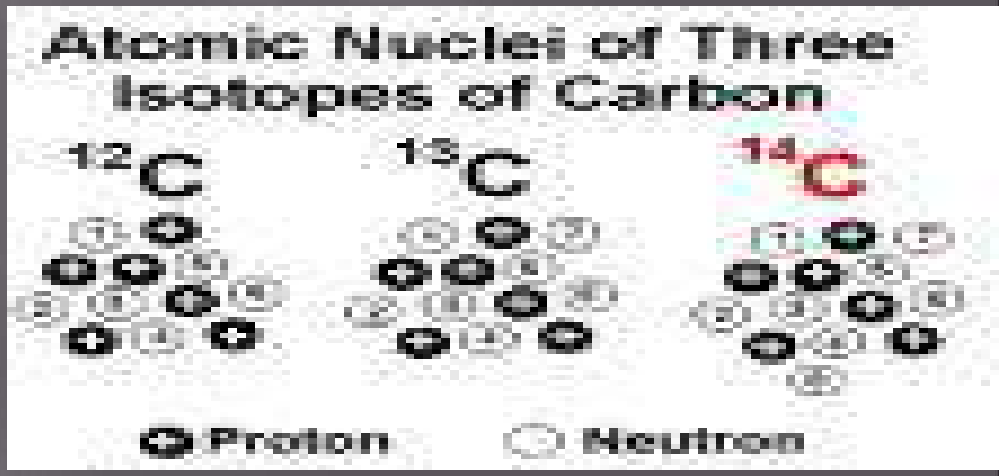
- The number of protons found in atoms of a particular element are unique and specific for that element.
- The **atomic number** is the number of protons found in the nucleus of an atom.

Atomic Number 2

- The number of protons identifies the type of atom.
- The atomic number also indicates the number of electrons found in the atom when it is neutral.

Isotopes

- Atoms that have the same number of protons but different numbers of neutrons are called **isotopes**.



Mass Number (A)

- The sum of the protons and neutrons in an atom is called the **mass number**.

Carbon 12

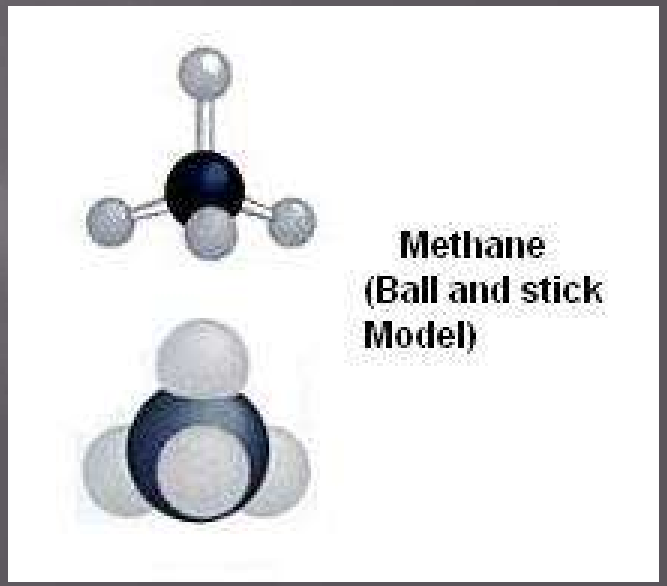
Carbon 13

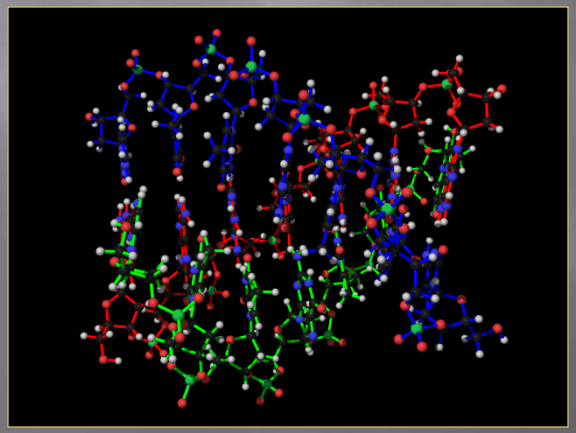
Chemical Bonds Preview

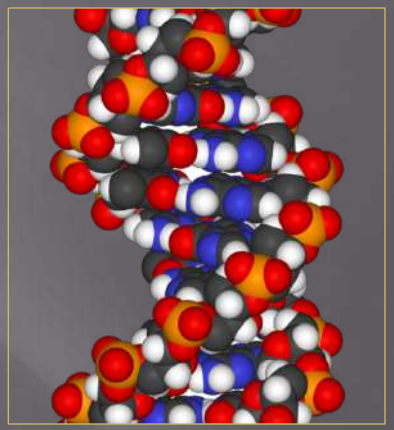
- The forces that hold atoms together in compounds are called Chemical Bonds.
- Covalent Bonds: Atoms share electrons
- Molecule: Collection of atoms held together with covalent bonds. (sharing e^-)

Representing Molecules

- Chemical Formula: Simplest and least useful
  - $H_2OCO_2CH_4$
- Structural Formula: Shows the bonds
  - H-O-H O=C=O
- Space-Filling Model: 3D
- Ball-and-Stick Model: 3D







Ion

- An **ion** is an atom that has gained or lost one or more electrons in order to obtain the octet.
- There is no longer a balance between electrons and protons, leaving a charge.

More About Ions

- Anions
  - Atoms gain electrons and become negatively charged.
- Cations
  - Atoms lose electrons and become positively charged.

How Many Electrons Are There?

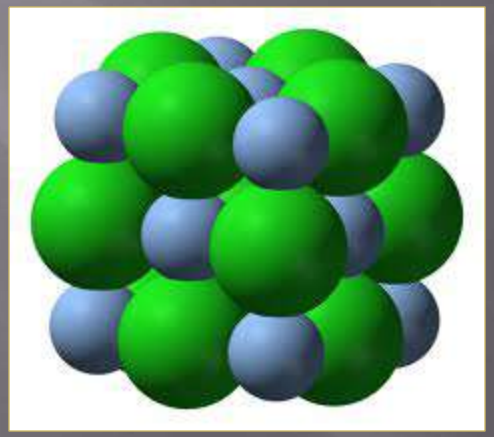
- #protons - #electrons = charge

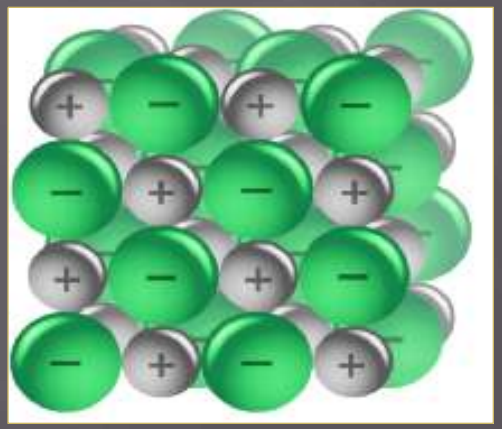
  OR

- #protons – charge = # electrons
- Example:
  - Al^{+3}
  - Br^{-1}
  - Ca^{+2}

Ionic Bonds

- Ionic Bond: bond formed due to the transfer of electrons from one or more atoms to one or more atoms.
- Since they have opposite charges, anions and cations are attracted to each other.
- Ionic Solid (Salt): Collection of oppositely charged ions.





Periodic Table

- The **periodic table** is an arrangement of the elements according to atomic number and similarities in their properties.

Period / Group (Family)

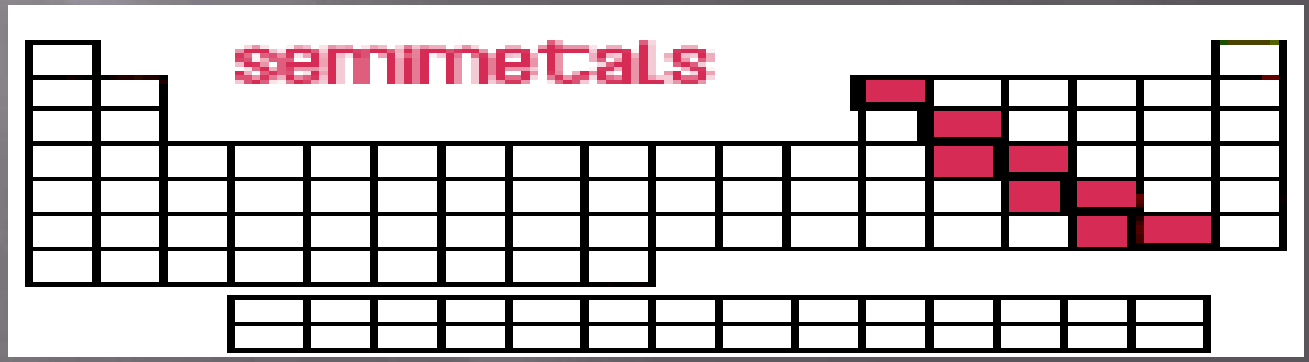
- The 7 horizontal rows of the periodic table are called **periods**.
- The 18 vertical columns of the periodic table are called **groups** or **families**.

Periodic Table Regions

- The periodic table is divided into 3 main regions:
- Metals on the left.
- Semimetals or metalloids.
- Non-metals on the right.

Semimetals (Metalloids)

- The elements to the immediate right and left of the heavy stepped line except for aluminum are the **semimetals**.



Semimetal Characteristics

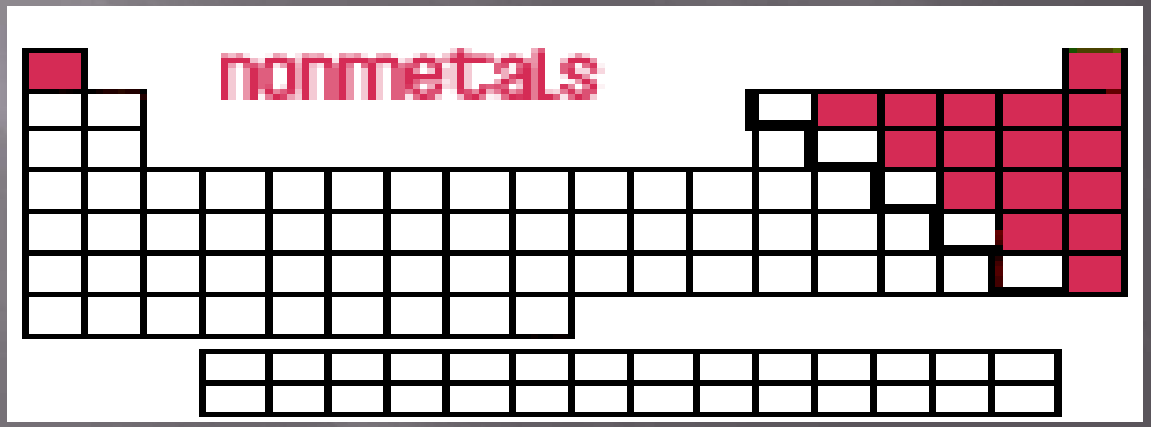
- Semimetals have properties that are intermediate between metals and nonmetals.

Metals

- The elements to the left of the semimetals and at the bottom of the table are called **metals**.
- Metals are good conductors, shiny, malleable (can be hammered into sheets), and ductile (can be pulled into wires).

Non Metals

- The elements to the right of the semimetals and hydrogen are the **non metals**.



Valence Electrons

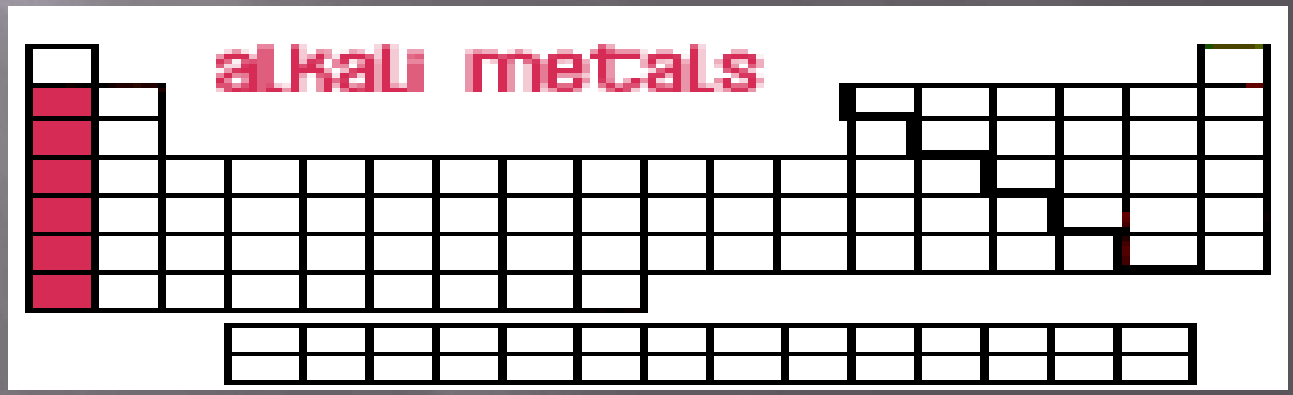
- The group number indicates the number of electrons that are able to participate in a chemical bond.
- These outer electrons are called the **valence electrons**.

Octet

- All atoms want to have 8 valence electrons.
- This **octet** is responsible for making atoms stable.

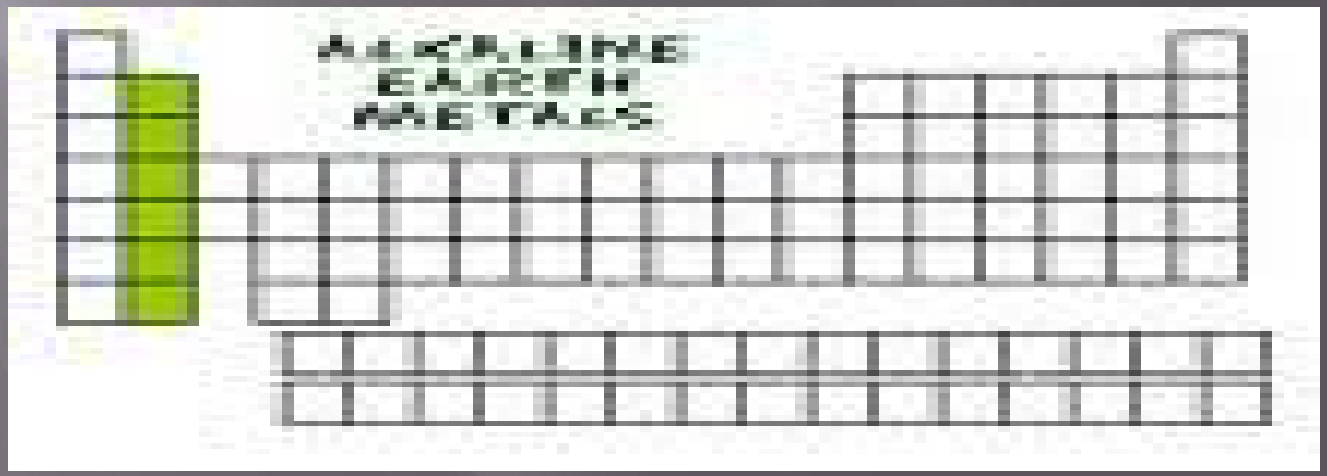
Alkali Metals

- The **alkali metals** are found in group one of the metals.
- The alkali metals are extremely reactive.



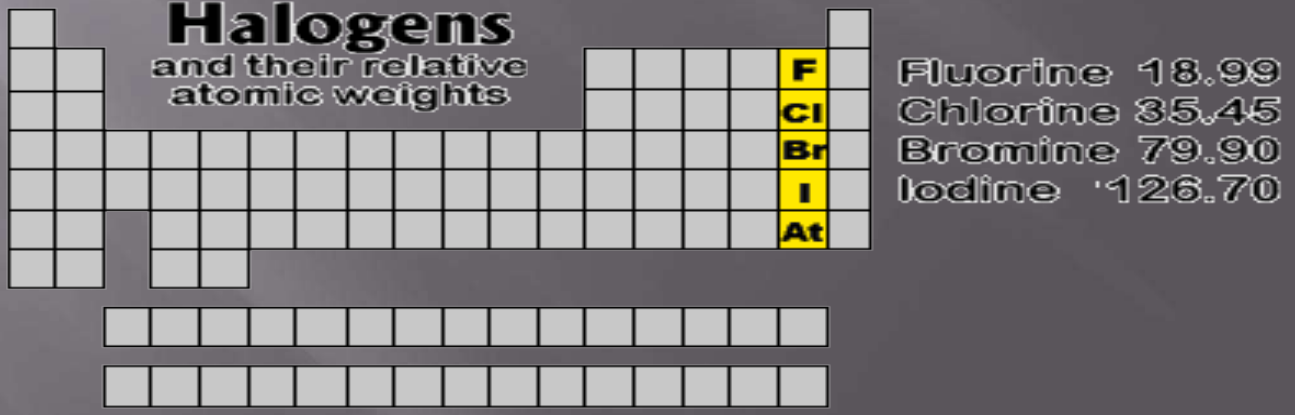
Alkaline Earth Metals

- The **alkaline earth metals** are found in group 2.
- They are not quite as reactive as the alkali metals.



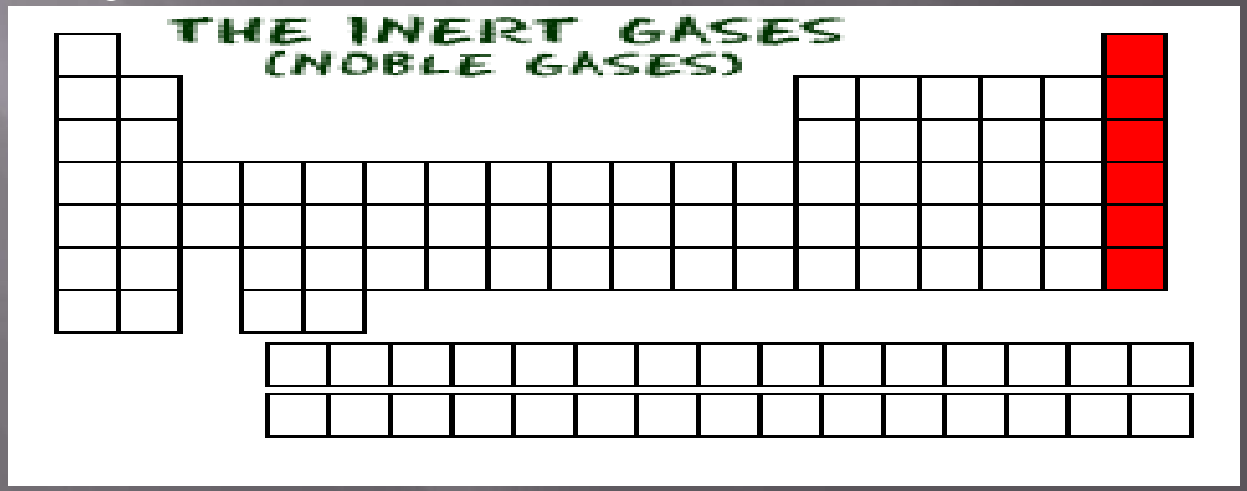
Halogens

- The **halogens** are group 17 in the non metal portion of the periodic table. These elements are very reactive.



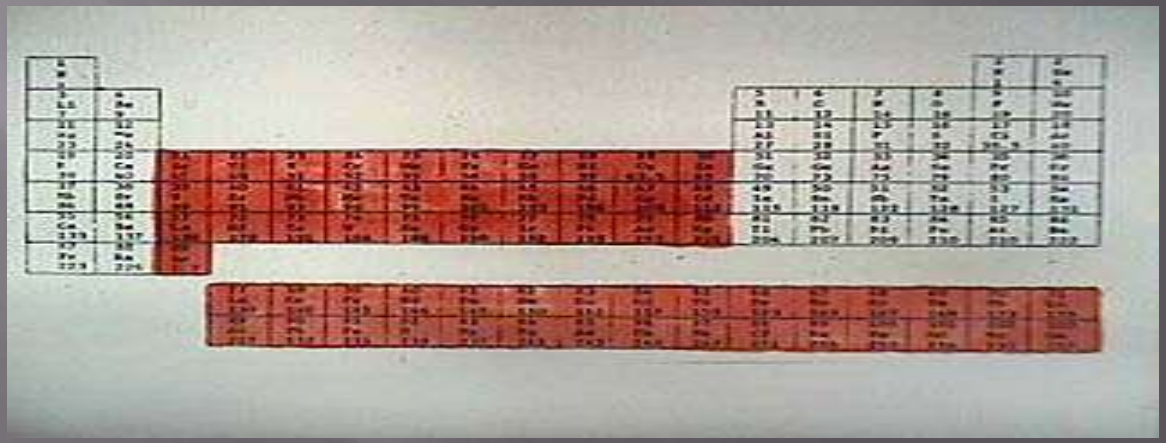
Noble Gases

- The noble gases are group 18 in the non metal portion of the periodic table. They are largely non reactive.



Transition Metals

- The **transition metals** include groups 3 through 12 as well as the lanthanides and actinides.



Diatomic Gases or Molecules

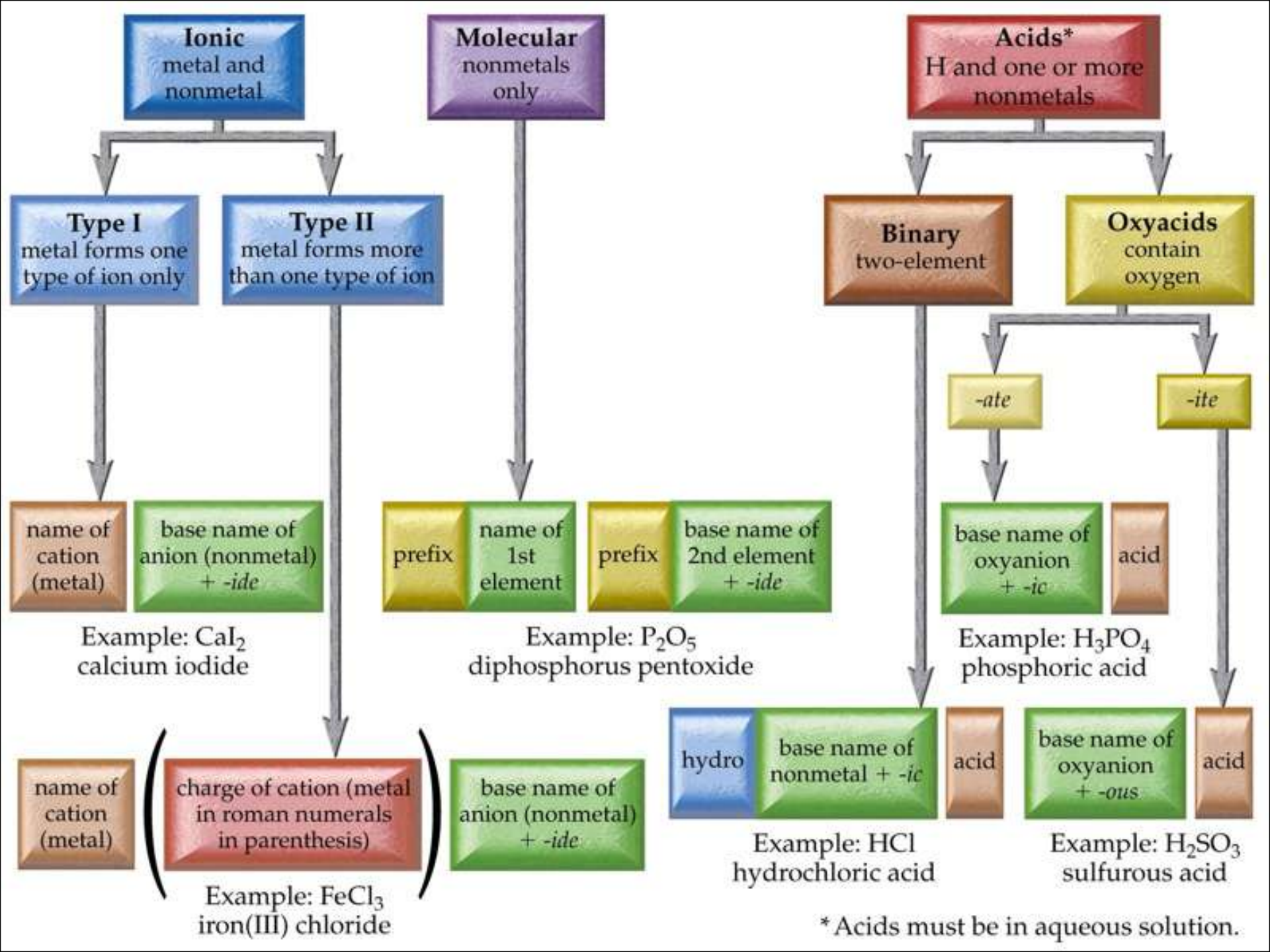
- Elemental forms that are made up of two molecules bonded together.

- H O F Br I N Cl
- Triple 7's
- At F O N H ome

- Noble Gases are always atomic gases.

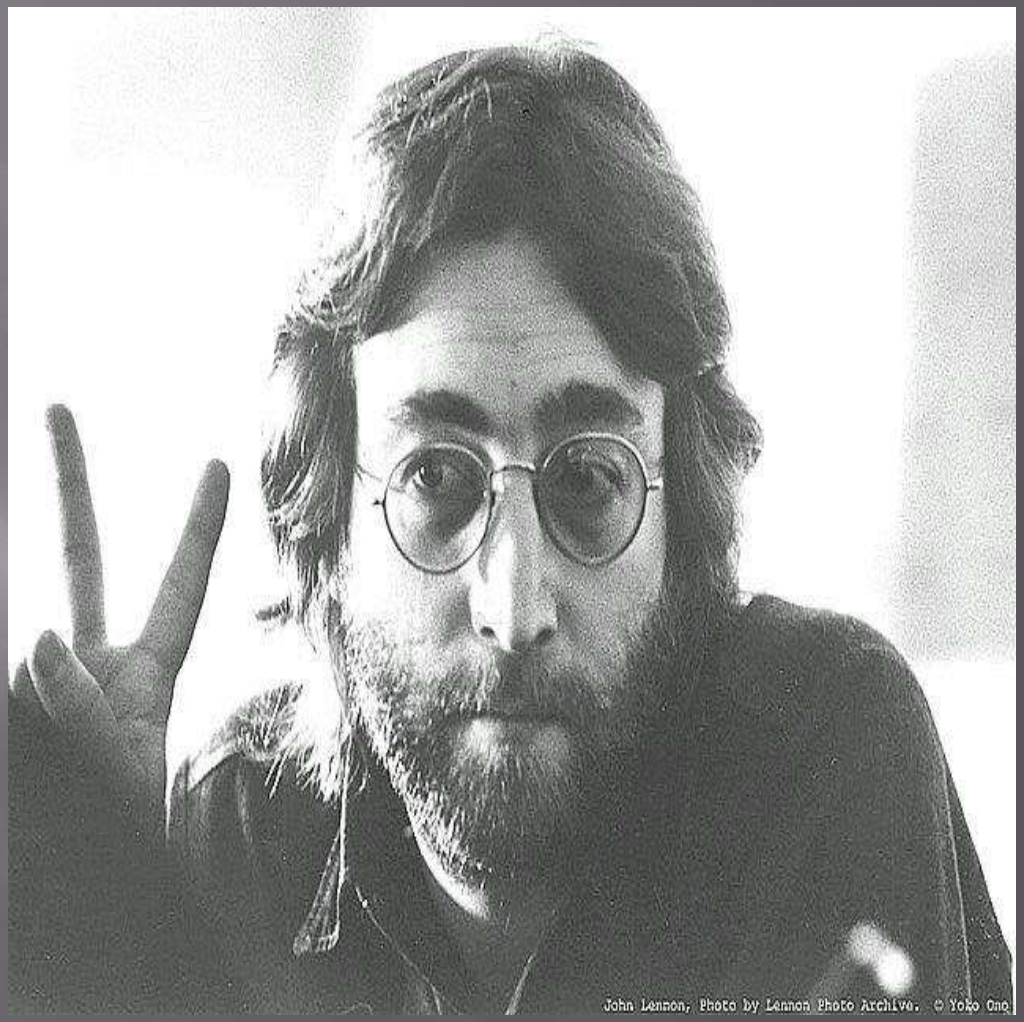
Chapter Questions/Homework

#44, 46, 47, 50, 54


Ionic
metal and nonmetal
Molecular
nonmetals only
Acids*
H and one or more nonmetals
Type I
metal forms one type of ion only
Type II
metal forms more than one type of ion
Binary
two-element
Oxyacids
contain oxygen
-ate
-ite
name of cation (metal)
base name of anion (nonmetal) + -ide
prefix
name of 1st element
prefix
base name of 2nd element + -ide
base name of oxyanion + -ic
acid
Example: CaI2
calcium iodide
Example: P2O5
diphosphorus pentoxide
Example: H3PO4
phosphoric acid
name of cation (metal)
charge of cation (metal in roman numerals in parenthesis)
base name of anion (nonmetal) + -ide
hydro
base name of nonmetal + -ic
acid
base name of oxyanion + -ous
acid
Example: FeCl3
iron(III) chloride
Example: HCl
hydrochloric acid
Example: H2SO3
sulfurous acid
*Acids must be in aqueous solution.

- Binary Compound

  A compound made of **two** elements
- 2 Types
  - Metal and Nonmetal
  - 2 Nonmetals



Don't Forget

- Metals tend to lose electrons and become positively charged ions.
- Nonmetals tend to gain electrons and become negatively charged ions.
- These bond together to form binary ionic compounds.

TABLE 4.1

Common Simple Cations and Anions

Cation	Name	Anion	Name*
H^+	hydrogen	H^-	**hydr**ide
Li^+	lithium	F^-	**fluor**ide
Na^+	sodium	Cl^-	**chlor**ide
K^+	potassium	Br^-	**brom**ide
Cs^+	cesium	I^-	**iod**ide
Be^{2+}	beryllium	O^{2-}	**ox**ide
Mg^{2+}	magnesium	S^{2-}	**sulf**ide
Ca^{2+}	calcium		
Ba^{2+}	barium		
Al^{3+}	aluminum		
Ag^+	silver		

*The root is given in color.

TABLE 4.2

Common Type II Cations

Ion	Systematic Name
Fe^{3+}	iron(III)
Fe^{2+}	iron(II)
Cu^{2+}	copper(II)
Cu^+	copper(I)
Co^{3+}	cobalt(III)
Co^{2+}	cobalt(II)
Sn^{4+}	tin(IV)
Sn^{2+}	tin(II)
Pb^{4+}	lead(IV)
Pb^{2+}	lead(II)
Hg^{2+}	mercury(II)
Hg_2^{2+}*	mercury(I)

*Mercury(I) ions always occur bound together in pairs

You Try It!

- CsF
- $AlCl_3$
- MgI_2
- Rb_2O

You Try It!

- CsF
- *cesium fluoride*
- $AlCl_3$
- *aluminum chloride*
- MgI_2
- *magnesium iodide*
- Rb_2O
- *rubidium oxide*

Type II Binary Ionic Compounds

- Some cations can form more than one charge
  - Type II
- Ex: iron can form 2+ ***and*** 3+ ions
- We use roman numerals to distinguish between the ions

TABLE 4.2

Common Type II Cations

Ion	Systematic Name	Older Name
Fe^{3+}	iron(III)	ferric
Fe^{2+}	iron(II)	ferrous
Cu^{2+}	copper(II)	cupric
Cu^{+}	copper(I)	cuprous
Co^{3+}	cobalt(III)	cobaltic
Co^{2+}	cobalt(II)	cobaltous
Sn^{4+}	tin(IV)	stannic
Sn^{2+}	tin(II)	stannous
Pb^{4+}	lead(IV)	plumbic
Pb^{2+}	lead(II)	plumbous
Hg^{2+}	mercury(II)	mercuric
Hg_2^{2+*}	mercury(I)	mercurous

*Mercury(I) ions always occur bound together in pairs to form Hg_2^{2+}.

Naming type II Binary Ionic Compounds

1. Determine the charge on the cation (metal).
2. Name the compound like a type I ionic compound.
3. Include a roman numeral that represents the charge between the cation and anion.

Name of cation (metal) (Charge of cation (metal) in roman numerals in parenthesis) Base name of anion (nonmetal) + -ide

Practice

- $CoBr_2$
- *cobalt(II) bromide*
- $CrCl_3$
- *chromium(III) chloride*
- SnO_2
- *tin (IV) oxide*
- $CaCl_2$
- *calcium chloride*

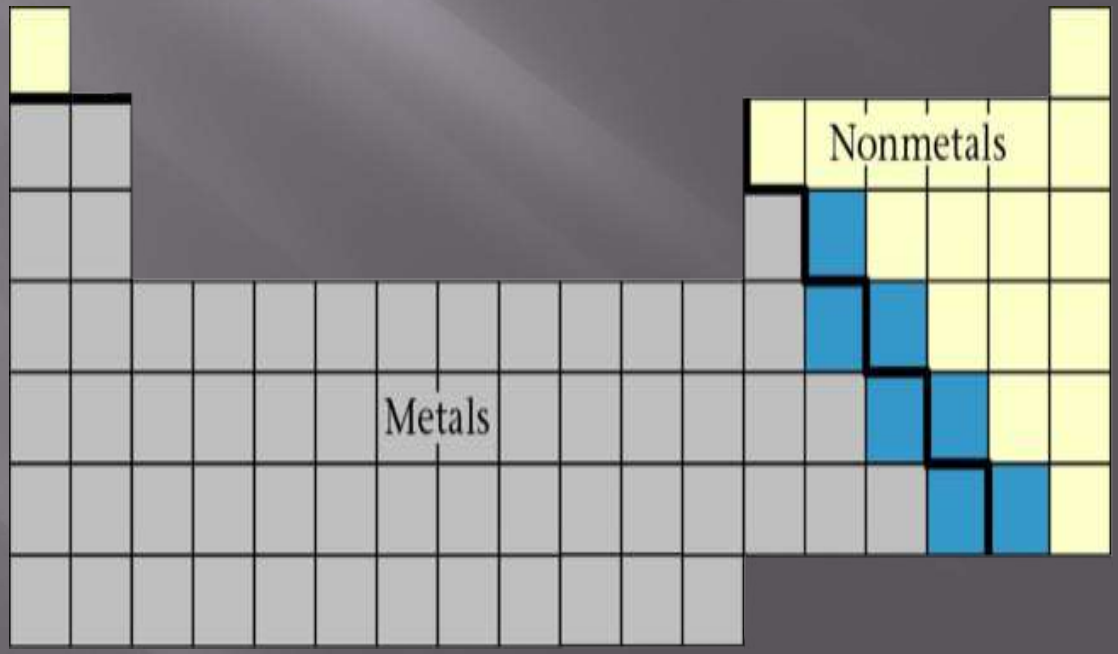
4.2 naming binary compounds that contain only nonmetals (Type III)

TABLE 4.3

Prefixes Used to Indicate Numbers in Chemical Names

Prefix	Number Indicated
mono-	1
di-	2
tri-	3
tetra-	4
penta-	5
hexa-	6
hepta-	7
octa-	8

- **Type III** contain only nonmetals



Examples

TABLE 4.3

Prefixes Used to Indicate Numbers in Chemical Names

Prefix	Number Indicated
mono-	1
di-	2
tri-	3
tetra-	4
penta-	5
hexa-	6
hepta-	7
octa-	8

- BF_3
- boron trifluoride
- NO
- nitrogen monoxide
- N_2O_5
- dinitrogen pentaoxide

Practice

- P_4O_6
- PCl_5
- S_3O_2

Practice

- P_4O_6
- Tetraphosphorus hexaoxide
- PCl_5
- Phosphorus pentachloride
- S_3O_2
- Trisulfur dioxide

4.4 Naming compounds that contain polyatomic ions (non-binary)

These compounds are named just like type I or type II binary ionic compounds but the name of the polyatomic ion must be used.

TABLE 4.4

Names of Common Polyatomic Ions

Ion	Name	Ion	Name
NH_4^+	ammonium	CO_3^{2-}	carbonate
NO_2^-	nitrite	HCO_3^-	hydrogen carbonate (bicarbonate is a widely used common name)
NO_3^-	nitrate		
SO_3^{2-}	sulfite		
SO_4^{2-}	sulfate	ClO^-	hypochlorite
HSO_4^-	hydrogen sulfate (bisulfate is a widely used common name)	ClO_2^-	chlorite
		ClO_3^-	chlorate
		ClO_4^-	perchlorate
OH^-	hydroxide	$C_2H_3O_2^-$	acetate
CN^-	cyanide	MnO_4^-	permanganate
PO_4^{3-}	phosphate	$Cr_2O_7^{2-}$	dichromate
HPO_4^{2-}	hydrogen phosphate	CrO_4^{2-}	chromate
$H_2PO_4^-$	dihydrogen phosphate	O_2^{2-}	peroxide

- Ammonium is the only polyatomic cation (positive ion).
- All the rest are anions (negative ion).

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HSO_4^-	hydrogen sulfate (bisulfate is a widely used common name)	ClO_2^-	chlorite
		ClO_3^-	chlorate
		ClO_4^-	perchlorate
OH^-	hydroxide	$C_2H_3O_2^-$	acetate
CN^-	cyanide	MnO_4^-	permanganate
PO_4^{3-}	phosphate	$Cr_2O_7^{2-}$	dichromate
HPO_4^{2-}	hydrogen phosphate	CrO_4^{2-}	chromate
$H_2PO_4^-$	dihydrogen phosphate	O_2^{2-}	peroxide

Practice

- $Ca(OH)_2$
- Na_3PO_4
- $KMnO_4$
- $Co(ClO_4)_2$
- $Cu(NO_2)_2$

TABLE 4.4

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		ClO_3^-	chlorate
		ClO_4^-	perchlorate
OH^-	hydroxide	$C_2H_3O_2^-$	acetate
CN^-	cyanide	MnO_4^-	permanganate
PO_4^{3-}	phosphate	$Cr_2O_7^{2-}$	dichromate
HPO_4^{2-}	hydrogen phosphate	CrO_4^{2-}	chromate
$H_2PO_4^-$	dihydrogen phosphate	O_2^{2-}	peroxide

Practice

TABLE 4.4

Names of Common Polyatomic Ions

Ion	Name	Ion	Name
NH_4^+	ammonium	CO_3^{2-}	carbonate
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		ClO_4^-	perchlorate
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CN^-	cyanide	MnO_4^-	permanganate
PO_4^{3-}	phosphate	$Cr_2O_7^{2-}$	dichromate
HPO_4^{2-}	hydrogen phosphate	CrO_4^{2-}	chromate
$H_2PO_4^-$	dihydrogen phosphate	O_2^{2-}	peroxide

- $Ca(OH)_2$
- *calcium hydroxide*
- Na_3PO_4
- *sodium phosphate*
- $KMnO_4$
- *potassium permanganate*
- $Co(ClO_4)_2$
- *cobalt(II) perchlorate*
- $Cu(NO_2)_2$
- *copper(II) nitrite*

Rules for naming acids

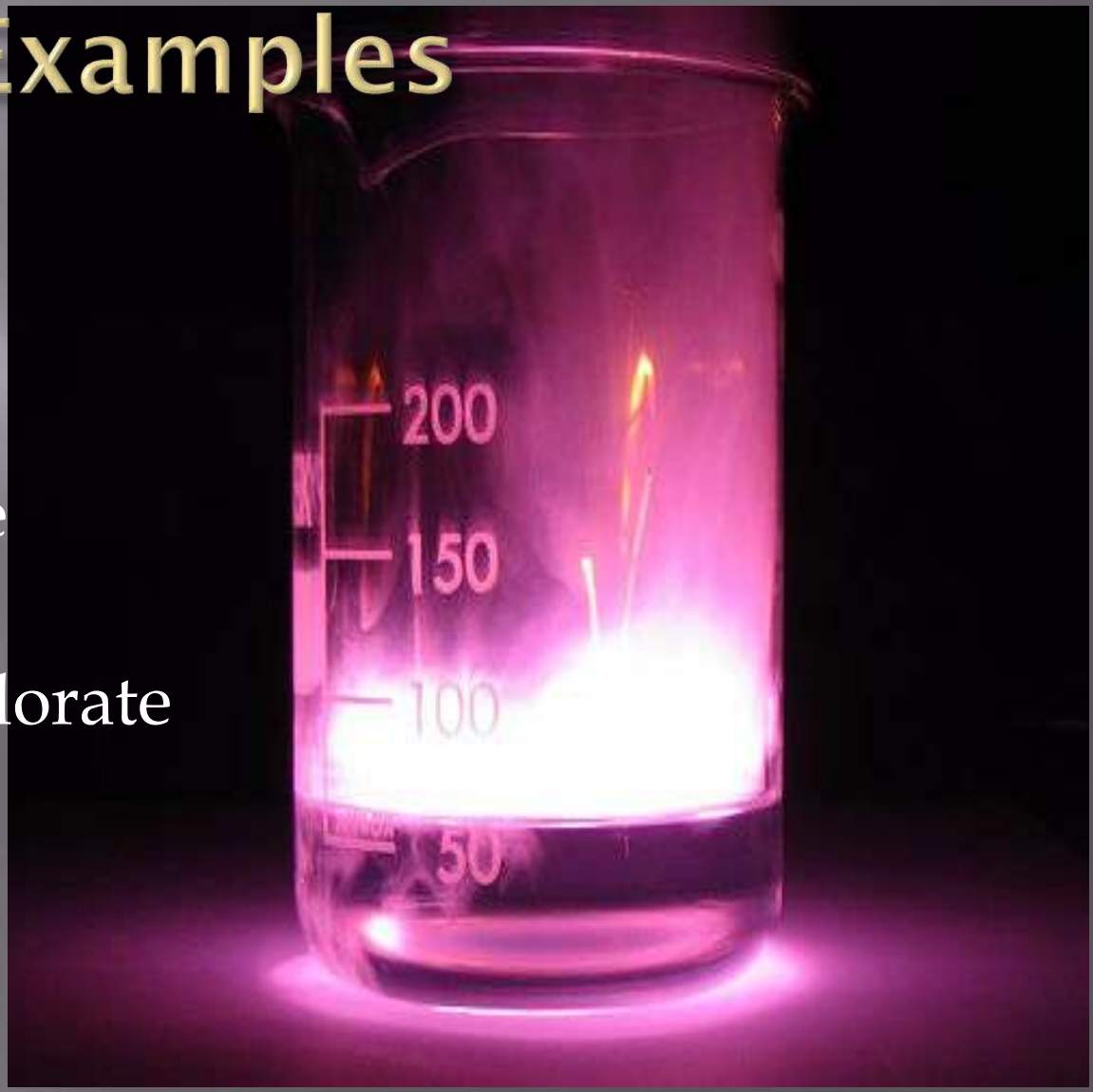
1. If the anion doesn't contain oxygen, then the prefix *hydro-* and suffix *-ic* is added to the root name of the element.
2. If the anion does contain oxygen, then the suffix *-ic* or *-ous* is added to the root name of the anion.
   - If the anion ends in *–ate* the suffix *–ic* is used.
   - If the anion ends in *–ite* the suffix *–ous* is used.
3. *acid* is added to the end of the name.

You Try It!

- H_2SO_3
- sulfurous acid
- HBr
- hydrobromic acid
- HI (this is an I eye)
- hydroiodic acid
- H_2CO_3
- carbonic acid
- H_3PO_4
- phosphoric acid
- HCN
- hydrocyanic acid

Examples

- cesium fluoride
- CsF
- carbon disulfide
- CS_2
- nickel (II) perchlorate
- $Ni(ClO_4)_2$
- Nitrous acid
- HNO_2

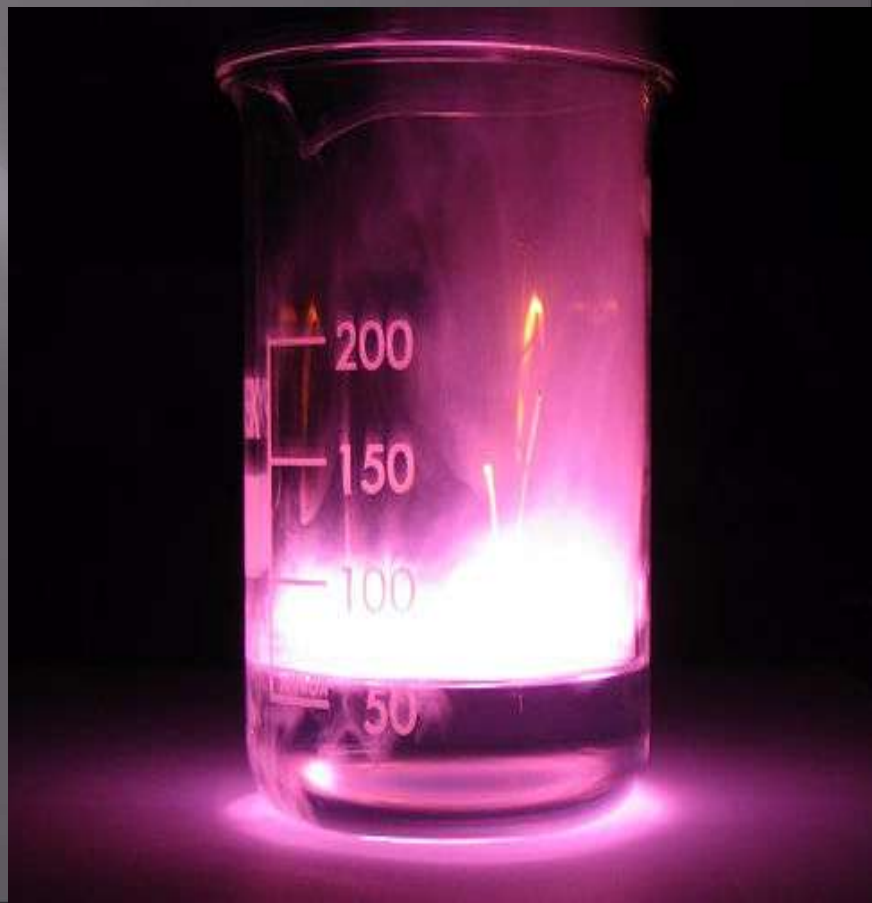


Practice

- potassium hydroxide
- tin (IV) oxide
- nitric acid
- dinitrogen pentoxide

Practice

- potassium hydroxide
- KOH
- tin (IV) oxide
- SnO_2
- nitric acid
- HNO_3
- dinitrogen pentoxide
- N_2O_5



Chapter Questions/Homework

#63, 64, 75, 79,