Unit#1

AP Chem
Topic#2
Atoms - Molecules

Atoms-Molecules
Topic#2

Foundational Laws

Law of Constant (definite) Composition

- a given compound always has a fixed ratio between its constituent elements and does not depend on its source (origin) or method of preparation.

Law of Conservation of Mass

- mass cannot be created or destroyed (mass in = mass out)

Law of Conservation of Energy

- energy cannot be created or destroyed only transformed (energy in = energy out)

Law of Conservation of Charge

- chargers in solution must be conserved (remains constatnt)
- total charge in an isolated system never changes

Foundational Laws

Law of Multiple Proportions

Law of Multiple Proportions Demonstrated with Oxygen and 1.00 gram of Nitrogen

Compound	Mass of Nitrogen	Mass of Oxygen
N_2O	1.00 grams	0.571 grams
NO	1.00 grams	1.14 grams
NO_2	1.00 grams	2.28 grams
NO_4	1.00 grams	4.57 grams

($NO_{1/2}$)

Ratio of Compounds	Ratio of Masses	Ratio	Ratio Small Number
NO_4:NO_2	4.57:2.28	2:1	2
NO_4:NO	4.57:1.14	4:1	4
NO_4:N_2O	4.57:0.571	8:1	8
NO_2:NO	2.28:1.14	2:1	2
NO_2:N_2O	2.28:0.571	4:1	4
NO:N_2O	1.14:0.571	2:1	2
NO_4:NO_2:NO:N_2O	4.57:2.28:1.14:0.571	8:4:2:1	1

Foundational Laws

Sample WS#1 - Definite Proportions

1. A sample of H_2SO_4 contains 2.02g hydrogen, 32.07g sulfur, and 64.00g oxygen. How many grams of sulfur and grams of oxygen are present in a second sample of H_2SO_4 containing 7.27g of hydrogen? (Ans: 115g S and 230.g O)

Foundational Laws

2. Sulfur and oxygen can react to form both sulfur dioxide and sulfur trioxide. In sulfur dioxide there are 32.06g sulfur and 32.00g oxygen. In sulfur trioxide there are 32.06g sulfur combined with 48.00g oxygen. What is the ratio of the weights of oxygen that combine with 32.06g sulfur?

(Ans: 2:3)

Atomic Theory

Dalton's Atomic Theory

Dalton's Atomic Theory

1.) All matter is made up of tiny particles called atoms.
2.) All atoms of a given element are alike, but are different from the atoms of any other element.
3.) Compounds are formed when atoms of different elements combine in fixed proportions.
4.) A chemical reaction involves a rearrangement of atoms, not a change in the atoms themselves.

Atoms-Molecules
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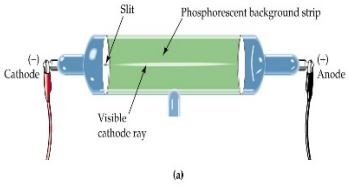
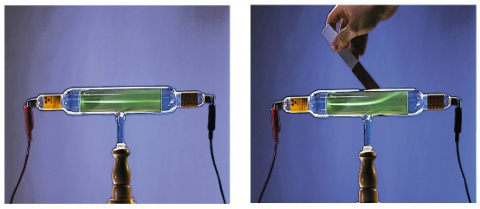
Inside the Atom

The Electron

- JJ Thomson (discovered electron)
  - Cathode Ray tube
- Robert Millikan (measured the charge of an electron)
  - Oil drop experiment



(a)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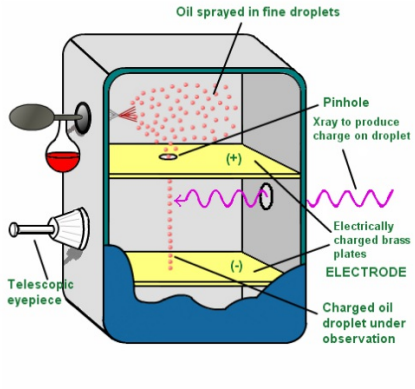
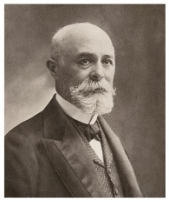


Inside the Atom

Radioactivity

- Wilhelm Conrad Rontgen (Roentgen) - discovered x-rays (1895)

- Henri Becquerel - first to discover evidence of radioactivity (1986)



- Marie Curie - discovered Polonium and radium
  - First woman to win Nobel and only to win it twice

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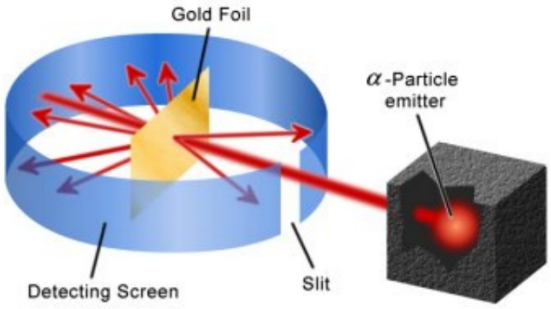
Inside the Atom

The Nuclear Atom

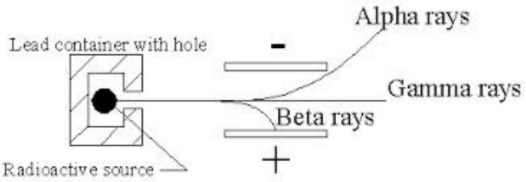
- Rutherford
  - Gold Foil
    - alpha particle ($^4_2He^{2+}$)



Particle	Relative Mass	Relative Charge	Charge / C	Mass / kg
Protons	1	+ 1	$+ 1.6 \times 10^{-19}$	1.67×10^{-27}
Neutrons	1	neutral	0	1.67×10^{-27}
Electrons	0.0005	- 1	$- 1.6 \times 10^{-19}$	9.11×10^{-31}

Alpha Radiation: $^4_2He^{2+}$

Beta Radiation: $n^0 \rightarrow p^+ + e^-$



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Isotopes

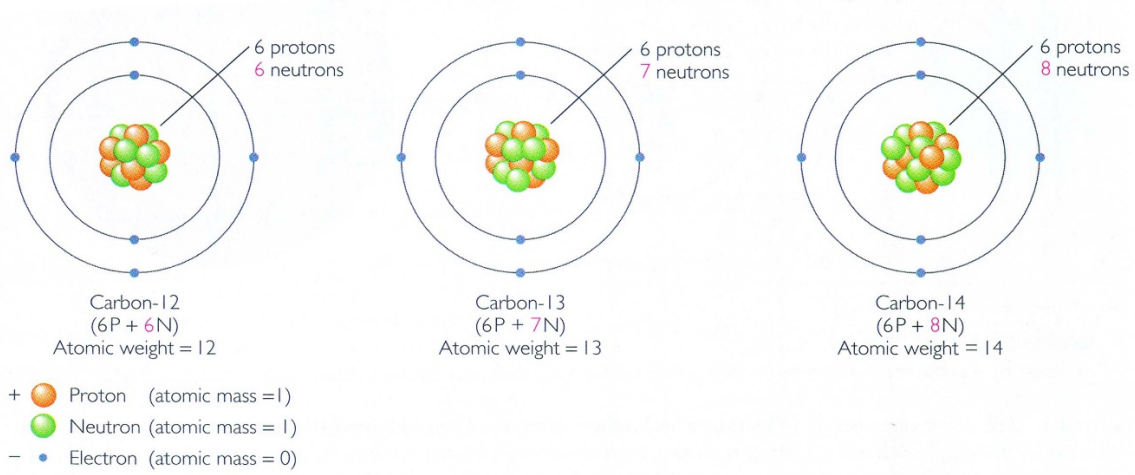

FIGURE 2.3 These three carbon isotopes all have the same number of protons and thus the same atomic number, 6. Their atomic masses differ, however, because they have slightly different numbers of neutrons. The atomic mass of any element is the average of the weighted sum of the atomic masses of its various isotopes. One isotope of an element—for example, carbon-12—is far more abundant than the others because natural processes favor that particular isotope.

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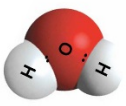
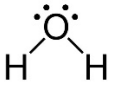
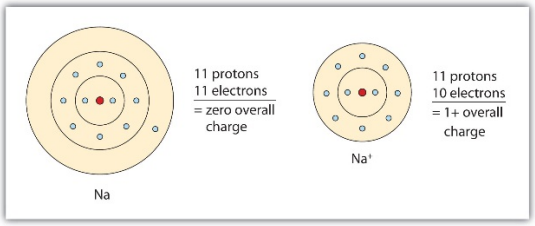
Ions

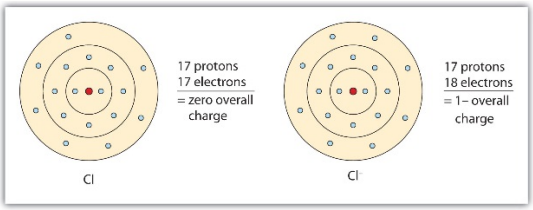
Cations - loses electrons to form a positive ion where the $\#p^+ > \#e^-$
- metals ($Na \rightarrow Na^+ + 1e^-$)
- loses electrons to form an inner octet

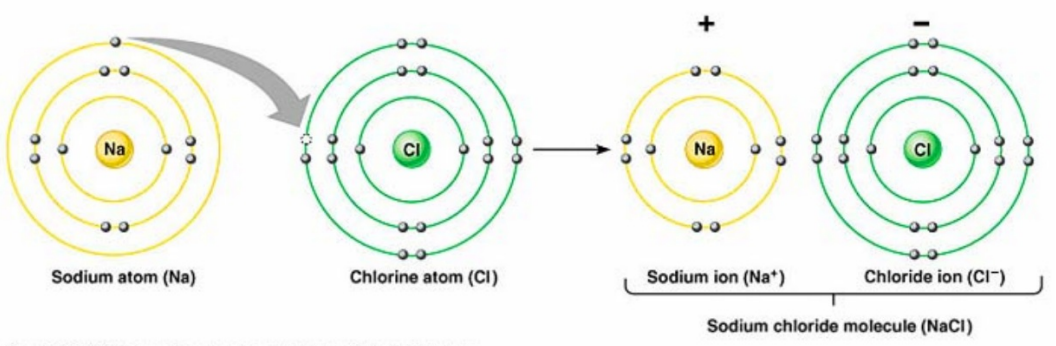
Anions - gain electrons for form a negative ion where $\#e^- > \#p^+$
- nonmetals ($F + 1e^- \rightarrow F^{1-}$)
- gains electrons to form an octet











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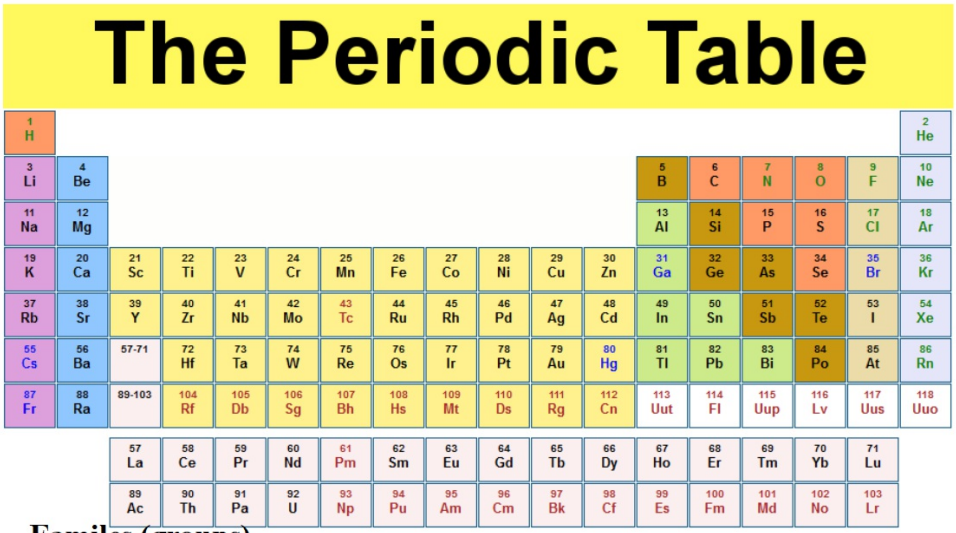
Periodic Table



Element	Symbol	Latin Name
Antimony	Sb	Stibium
Copper	Cu	Cuprum
Gold	Au	Aurum
Iron	Fe	Ferrum
Lead	Pb	Plumbum
Mercury	Hg	Hydrargyrum
Potassium	K	Kalium
Silver	Ag	Argentum
Sodium	Na	Natrium
Tin	Sn	Stannum
Tungsten	W	Wolfram

Familes (groups)
Period (rows/energy levels)
Metals
Nonmetals
Metalloids
Alkali metals/alkaline earth metals/halogens/noble gases/tranistion metals/inner-transtion metals (rare earth's)

Nuclear Symbols

Atomic (nuclear) symbol

A is the mass number

Z is the atomic number

A - *Z* = n^0

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

Complete chemical symbol

Charge = protons - electrons

$$ {}^{A}_{Z}\mathbf{X}^{C} $$

Sample Problems - Nuclear (Atomic) Symbols

3. Write the atomic (nuclear) or complete atomic (nuclear) symbol.

a. uranium – 238 b. #e = 80, #p = 84, and #n = 105 c. #e = 18, #p = 17, and #n = 20

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Type I Nomenclature

Type I Binary Ionic Compounds (NO transition metals)

	1st name - name of metal	**2nd name - root of nonmetal + ide**	**Name**
NaCl	sodium	chlor + ide	sodium chloride
KI	potassium	iod + ide	potassium iodide
CaS	calcium	sulf+ide	calcium sulfide
Li_3N	lithium	nitr+ide	lithium nitride
BaO			
Sr_3P_2			

Formulas

	Write Symbols and Charge	**Criss-Cross**	**Simplify**
cesium bromide	Cs^{1+} and Br^{1-}	Cs_1Br_1	CsBr
magnesium oxide	Mg^{2+} and O^{2-}	Mg_2O_2	MgO
lithium hydride			
barium chloride			

Type II Nomenclature

Type II Binary Ionic Compounds (transition metals)

	1st name - metal name/Roman numeral	2nd name - root of nonmetal + ide	Name
$CuCl_2$	copper (II)	chloride	copper(II) chloride
$FeCl_3$	iron (III)	chloride	iron (III) chloride
CoO	cobalt (II)	oxide	cobalt (II) oxide
CuCl			
HgO			
Fe_2O_3			

i.e. TiO_2

Formulas

	Write Symbols and Charge	Criss-Cross	Simplify
copper (II) sulfide	Cu^{2+} and S^{2-}	Cu_2S_2	CuS
silver (I) bromide	Ag^{1+} and Br^{1-}	Ag_1Br_1	AgBr
chromium (III) oxide	Cr^{3+} and O^{2-}	Cr_2O_3	Cr_2O_3
manganese (IV) oxide			
lead (II) chloride			

Type III Nomenclature

Polyatomic Ions to Memorize

1+

ammonium	NH_4^{1+}

1-

acetate	$C_2H_3O_2^{1-}/CH_3COO^{1-}$
bicarbonate (hydrogen carbonate)	HCO_3^{1-}
bisulfide	HS^{1-}
cyanide	CN^{1-}
hydroxide	OH^{1-}
nitrate	NO_3^{1-}
nitrite	NO_2^{1-}
perchlorate	ClO_4^{1-}
chlorate	ClO_3^{1-}
chlorite	ClO_2^{1-}
hypochlorite	ClO^{1-}
permanganate	MnO_4^{1-}

2-

carbonate	CO_3^{2-}
chromate	CrO_4^{2-}
dichromate	$Cr_2O_7^{2-}$
oxalate	$C_2O_4^{2-}$
peroxide	O_2^{2-}
sulfate	SO_4^{2-}
sulfite	SO_3^{2-}

3-

phosphate	PO_4^{3-}

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Type III Nomenclature

Type III Ionic Compounds (polyatomic ions; ternary compounds)

	1st name metal/Roman numeral/ammonium	2nd name - ide/polyatomic ion name	Name
$CuCO_3$	copper (II)	carbonate	copper (II) carbonate
$(NH_4)_2S$	ammonium	sulfide	ammonium sulfide
Na_2SO_4			
$Mn(OH)_2$			
K_2SO_3			
$(NH_4)_3PO_4$			

Formulas

	Write Symbols and Charge	Criss-Cross	Simplify
copper (II) acetate	Cu^{2+} $C_2H_3O_2^{1-}$	$Cu_1(C_2H_3O_2)_2$	$Cu(C_2H_3O_2)_2$
sodium hydrogen carbonate			
ammonium oxalate			
potassium cyanide			

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Type I Nomenclature (Binary Molecular)

Binary molecular compounds are ALWAYS written in their MOLECULAR formul while ionic compounds are written in their empirical form.

Simplification of Type I binary - molecular involves ONLY the disappearenc of the subscript 1.

Prefixes

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

Type I - Binary Molecular (Covalent) Compounds

	1st name - nonmetal name with prefix (subscript ≥ 2)	2nd name - prefix and ide suffix		Name
N_2O	dinitrogen	mono	oxide	dinitrogen monoxide
NO	nitrogen	mono	oxide	nitrogen monoxide
N_2O_5	dinitrogen	penta	oxide	dinitrogen pentoxide
PCl_5				
SO_2				

Formulas

	Write Element Name and Subscript	Simplify
sulfur hexafluoride	S_1F_6	SF_6
tetraphosphorus decoxide	P_4O_{10}	P_4O_{10}