Chapter 2

Atoms, Molecules, and IONS

Chapter 2: Atoms, Molecules, and Ions

2.1 The Atomic Theory

2.2 The Structure of Atoms

2.3 Atomic Number, Mass Number, AND Isotopes.

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2.1:The Structure of the Atom
Definitions for Components of Matter

Element - the simplest type of substance with unique physical and chemical properties. *An element consists of only one type of atom (Very small and Indivisible Particles).* It cannot be broken down into any simpler substances by physical or chemical means.

Molecule - a structure that consists of two or more atoms that are chemically bound together and thus behaves as an independent unit.

A Atoms of an element

B Molecules of an element

Definitions for Components of Matter

Compound - a substance composed of two or more elements which are chemically combined.

C Molecules of a compound

D Mixture of two elements and a compound

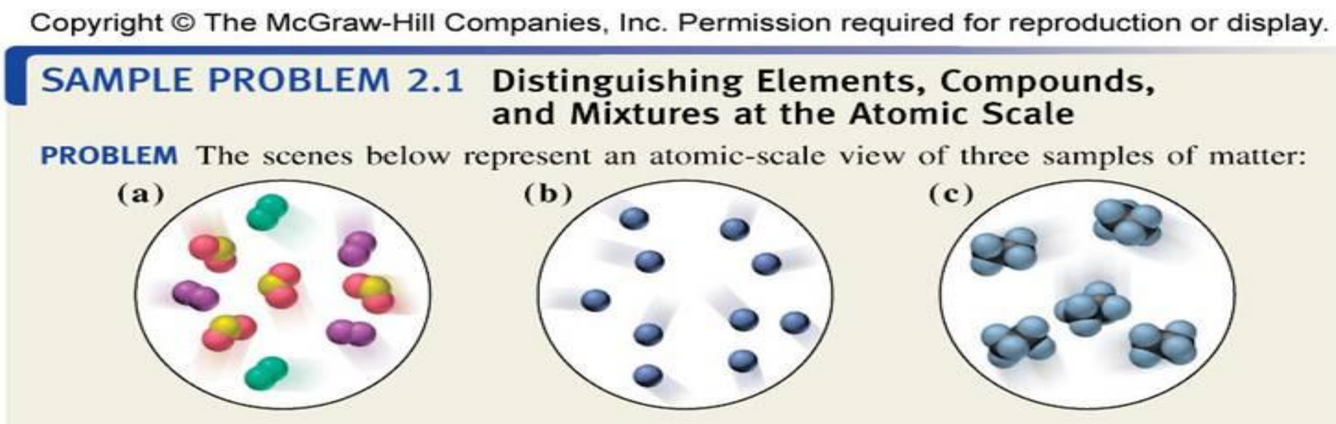
Mixture - a group of two or more elements and/o compounds that are physically intermingled.

Table 2.1 Some Properties of Sodium, Chlorine, and Sodium Chloride

Property	Sodium +	Chlorine →	Sodium Chloride
			
Melting point	97.8°C	–101°C	801°C
Boiling point	881.4°C	–34°C	1413°C
Color	Silvery	Yellow-green	Colorless (white)
Density	0.97 g/cm^3	0.0032 g/cm^3	2.16 g/cm^3
Behavior in water	Reacts	Dissolves slightly	Dissolves freely

Distinguishing Elements, Compounds, and Mixtures at the Atomic Scale

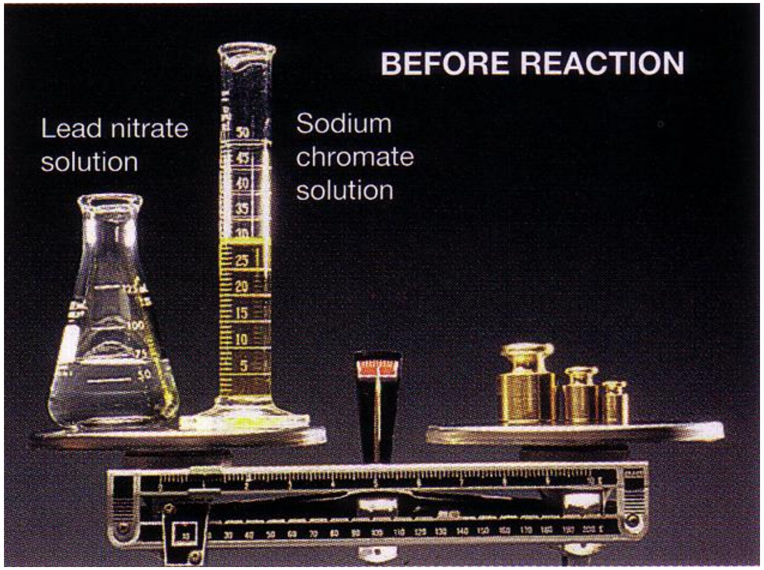
PROBLEM: Theses scenes represent an atomic-scale view of three samples of matter. Describe each sample as an element, compound, or mixture.

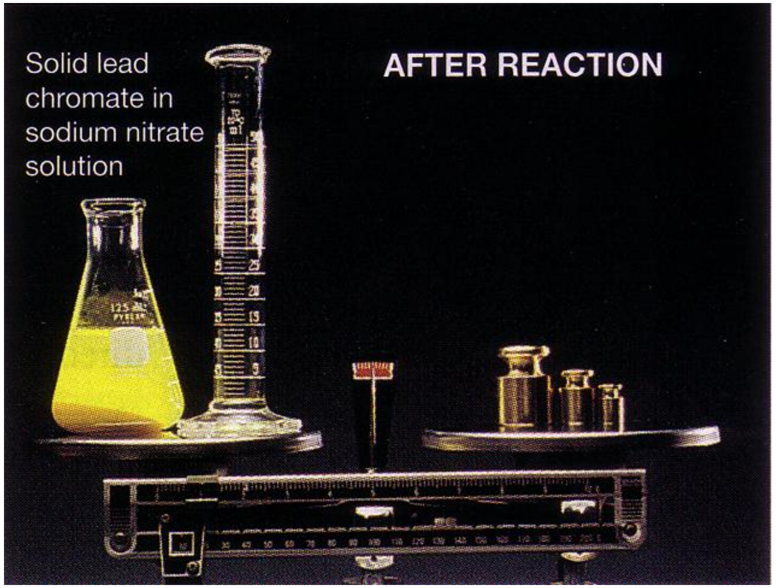


PLAN: Samples that contain one type of matter are either an element or a compound. An element contains only one type of particle and a compound contains two or more. Mixtures contain more than one type of matter.

SOLUTION: (a) mixture (b) element (c) compound

The law of mass conservation:
mass remains constant during a chemical reaction.





Law of Mass Conservation

The total mass of substances does not change during a chemical reaction.

reactant 1 + reactant 2 ⟶ product

total mass = *total mass*

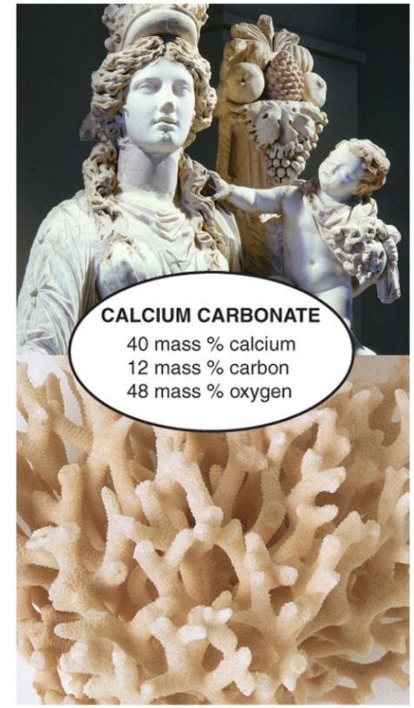
calcium oxide + carbon dioxide ⟶ calcium carbonate

$$CaO + CO_2 \longrightarrow CaCO_3$$

56.08 g + 44.00 g ⟶ 100.08 g

Law of Definite (or Constant) Composition

No matter the source, a particular compound is composed of the same elements in the same parts (fractions) by mass.



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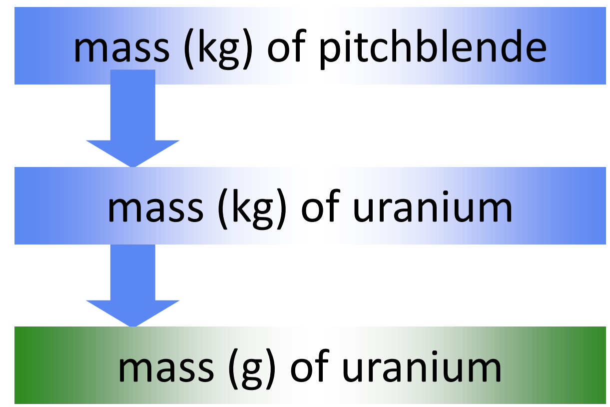
Calcium carbonate

Analysis by Mass (grams/20.0 g)	Mass Fraction (parts/1.00 part)	Percent by Mass (parts/100 parts)
8.0 g calcium	0.40 calcium	40% calcium
2.4 g carbon	0.12 carbon	12% carbon
9.6 g oxygen	0.48 oxygen	48% oxygen
20.0 g	1.00 part by mass	100% by mass

Sample Problem   Calculating the Mass of an Element in a Compound

PROBLEM: Analysis of 84.2 g of the uranium containing compound pitchblende shows it is composed of 71.4 g of uranium, with oxygen as the only other element. How many grams of uranium can be obtained from 102 kg of pitchblende?

PLAN: The mass ratio of uranium/pitchblende is the same no matter the source. We can use the ratio to find the answer.



SOLUTION:

mass (kg) of uranium =

$$\text{mass (kg) pitchblende} \times \frac{\text{mass (kg) uranium in pitchblende}}{\text{mass (kg) pitchblende}}$$

$$= 102\ \cancel{\text{kg}}\ \text{pitchblende} \times \frac{71.4\ \text{kg uranium}}{84.2\ \cancel{\text{kg}}\ \text{pitchblende}} = 86.5\ \text{kg uranium}$$

$$86.5\ \cancel{\text{kg}}\ \text{uranium} \times \frac{1000\ \text{g}}{\cancel{\text{kg}}} = 8.65 \times 10^{4}\ \text{g uranium}$$

2.2: The Structure of the Atom

Dalton’s Atomic Theory

The Postulates:

1. All matter consists of atoms.

2. Atoms of one element *cannot* be converted into atoms of another element.

3. Atoms of an element are identical in mass and other properties and are different from atoms of any other element.

4. Compounds result from the chemical combination of a specific ratio of atoms of different elements.

Dalton's Atomic Theory

explains the mass laws

Mass conservation

Atoms cannot be created or destroyed *postulate 1*

or converted into other types of atoms. *postulate 2*

Since every atom has a fixed mass, *postulate 3*

during a chemical reaction atoms are combined differently, and therefore, there is no mass change overall.

Dalton's Atomic Theory

explains the mass laws

Definite composition

Atoms are combined in compounds in specific ratios *postulate 4*

and each atom has a specific mass. *postulate 3*

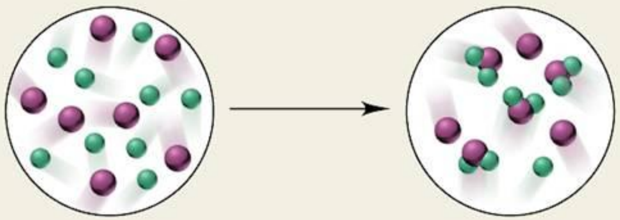
Each element has a fixed fraction of the total mass in a compound.

Visualizing the Mass Laws

PROBLEM: Theses scenes represent an atomic-scale view of a chemical reaction. Which of the mass laws: mass conservation or definite composition is (are) illustrated?

SAMPLE PROBLEM 2.3 **Visualizing the Mass Laws**

PROBLEM The scenes below represent an atomic-scale view of a chemical reaction:



PLAN: Mass conservation illustrated if number of each atom before and after reaction remains constant. Definite composition illustrated by formation of compounds that always have the same atom ratio.

SOLUTION: Seven purple and nine green atoms in each circle, mass conserved. One compound formed has one purple and two green, definite composition. Law of multiple proportions does not apply.

General features of the atom today.

- The atom is an electrically neutral, spherical entity composed of a positively charged central nucleus surrounded by one or more negatively charged electrons.
- The atomic nucleus consists of protons and neutrons.

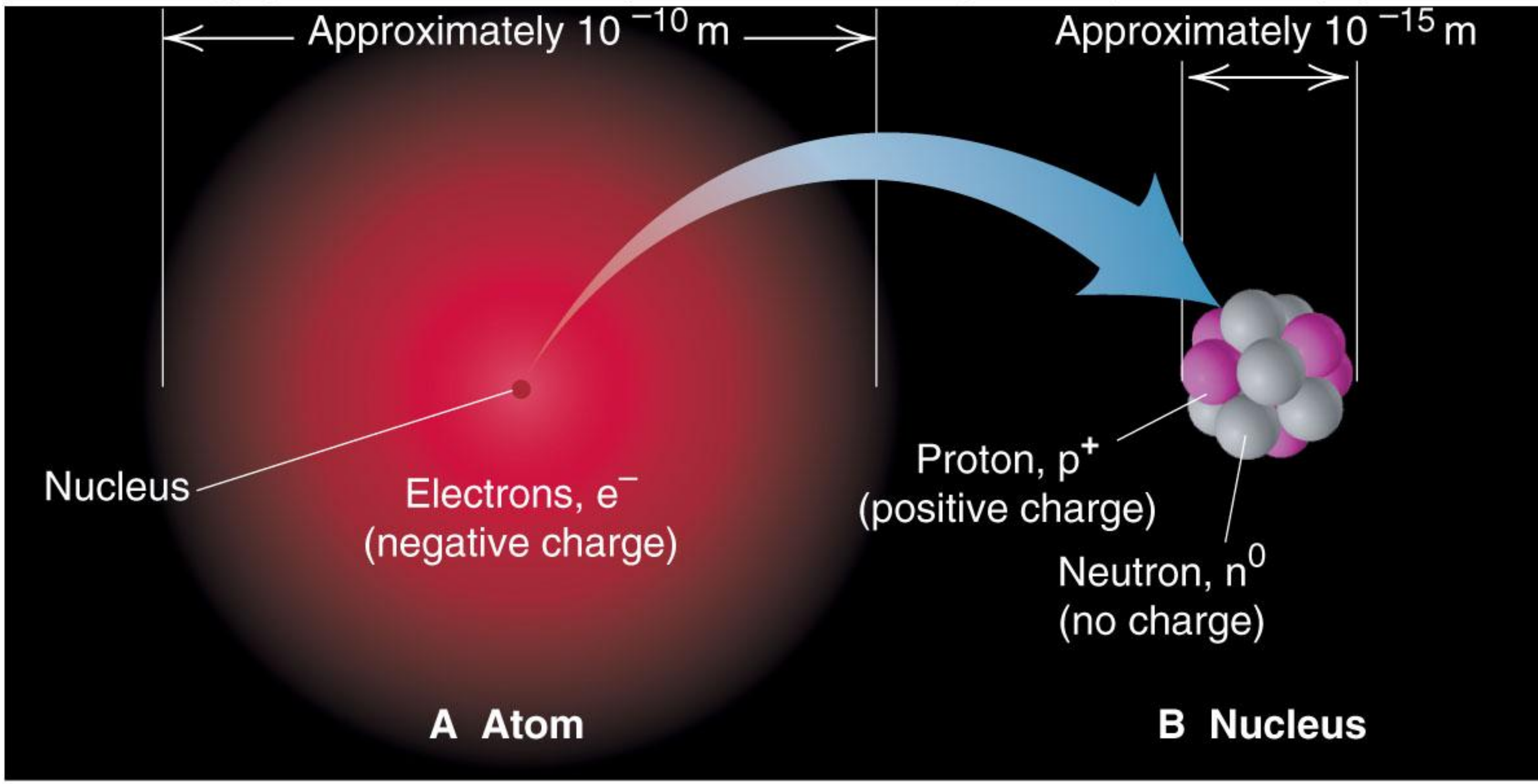


Table 2.2 Properties of the Three Key Subatomic Particles

	Charge		Mass		
Name(Symbol)	Relative	Absolute(C)*	Relative(amu)†	Absolute(g)	Location in the Atom
Proton (p^+)	1+	$+1.60218 \times 10^{-19}$	1.00727	1.67262×10^{-24}	Nucleus
Neutron (n^0)	0	0	1.00866	1.67493×10^{-24}	Nucleus
Electron (e^-)	1-	-1.60218×10^{-19}	0.00054858	9.10939×10^{-28}	Outside Nucleus

* The coulomb (C) is the SI unit of charge.

† The atomic mass unit (amu) equals 1.66054×10^{-24} g.

2.3 (P 44): Atomic Number, Mass Number, and Isotopes

${}^{A}_{Z}X$ = The symbol of the atom or isotope

X = Atomic symbol of the element

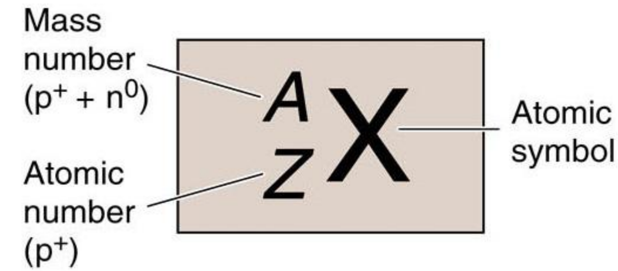
A = mass number; A = Z + N

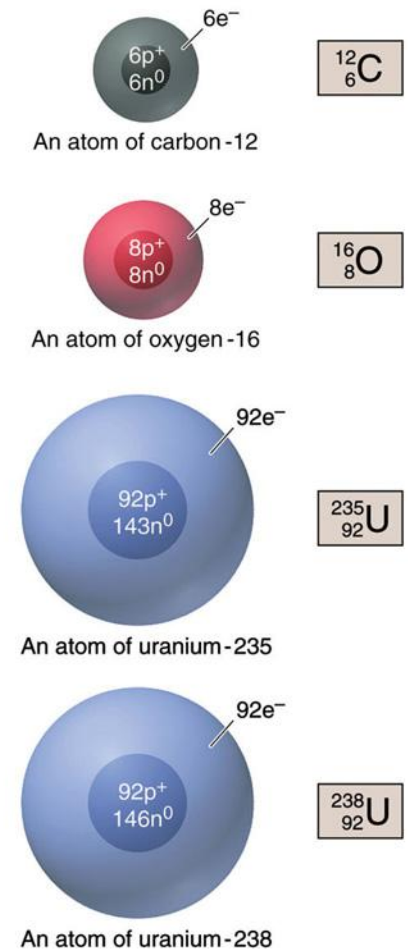
Z = atomic number

(the number of protons in the nucleus)

N = number of neutrons in the nucleus

Isotope = atoms of an element with the same number of protons, but a different number of neutrons





Determining the Number of Subatomic Particles in the Isotopes of an Element

PROBLEM: Silicon (Si) has three naturally occurring isotopes: ^{28}Si, ^{29}Si, and ^{30}Si. Determine the number of protons, neutrons, and electrons in each silicon isotope. Given that the Atomic Number of Si is 14

PLAN: Mass number (A), protons + neutrons, is given for the listed isotopes. Atomic number (Z), number of protons, for each element is given in the periodic table and equal to the number of electrons. Number of neutrons is determined using equation 2.2.

SOLUTION: The atomic number of silicon is 14. Therefore

^{28}Si has $14p^+$, $14e^-$ and $14n^0$ (28-14)

^{29}Si has $14p^+$, $14e^-$ and $15n^0$ (29-14)

^{30}Si has $14p^+$, $14e^-$ and $16n^0$ (30-14)

2.4: The periodic Table

The Modern Reassessment of the Atomic Theory

1. *All matter is composed of atoms.* The atom is the smallest body that *retains the unique identity* of the element.

2. *Atoms of one element cannot be converted into atoms of another element in a chemical reaction.* Elements can only be converted into other elements in nuclear reactions.

3. *All atoms of an element have the same number of protons and electrons, which determines the chemical behavior of the element.* Isotopes of an element differ in the number of neutrons, and thus in mass number. A sample of the element is treated as though its atoms have an *average* mass.

4. *Compounds are formed by the chemical combination of two or more elements in specific ratios.*

-Chemist noted that the physical and chemical prosperities of certain groups of elements were similar to one another. These similarities with the need to arrange the large volume of available information about the structure and prosperities of elements led to the Development of the Periodic Table.

-Elements are arranged in the Periodic Table By Atomic Number in horizontal rows called PERIODS.

-and the Elements are arranged according to their Physical and Chemical Properties in columns called GROUPS.

The modern periodic table.

- Metals (main-group)
- Metals (transition)
- Metals (inner transition)
- Metalloids
- Nonmetals

MAIN–GROUP ELEMENTS | TRANSITION ELEMENTS | MAIN–GROUP ELEMENTS

Period	1A (1)	2A (2)	3B (3)	4B (4)	5B (5)	6B (6)	7B (7)	8B (8)	8B (9)	8B (10)	1B (11)	2B (12)	3A (13)	4A (14)	5A (15)	6A (16)	7A (17)	8A (18)
1	1 **H** 1.008																	2 **He** 4.003
2	3 **Li** 6.941	4 **Be** 9.012											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
3	11 **Na** 22.99	12 **Mg** 24.31											13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.07	17 **Cl** 35.45	18 **Ar** 39.95
4	19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.88	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.39	31 **Ga** 69.72	32 **Ge** 72.61	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.80
5	37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.94	43 **Tc** (98)	44 **Ru** 101.1	45 **Rh** 102.9	46 **Pd** 106.4	47 **Ag** 107.9	48 **Cd** 112.4	49 **In** 114.8	50 **Sn** 118.7	51 **Sb** 121.8	52 **Te** 127.6	53 **I** 126.9	54 **Xe** 131.3
6	55 **Cs** 132.9	56 **Ba** 137.3	57 **La** 138.9	72 **Hf** 178.5	73 **Ta** 180.9	74 **W** 183.9	75 **Re** 186.2	76 **Os** 190.2	77 **Ir** 192.2	78 **Pt** 195.1	79 **Au** 197.0	80 **Hg** 200.6	81 **Tl** 204.4	82 **Pb** 207.2	83 **Bi** 209.0	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
7	87 **Fr** (223)	88 **Ra** (226)	89 **Ac** (227)	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (266)	107 **Bh** (262)	108 **Hs** (265)	109 **Mt** (266)	110 (269)	111 (272)	112 (277)		114 (285)				

Period

INNER TRANSITION ELEMENTS

6	Lanthanides	58 **Ce** 140.1	59 **Pr** 140.9	60 **Nd** 144.2	61 **Pm** (145)	62 **Sm** 150.4	63 **Eu** 152.0	64 **Gd** 157.3	65 **Tb** 158.9	66 **Dy** 162.5	67 **Ho** 164.9	68 **Er** 167.3	69 **Tm** 168.9	70 **Yb** 173.0	71 **Lu** 175.0
7	Actinides	90 **Th** 232.0	91 **Pa** (231)	92 **U** 238.0	93 **Np** (237)	94 **Pu** (242)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (260)

The elements in the Periodic Table can be categorized as

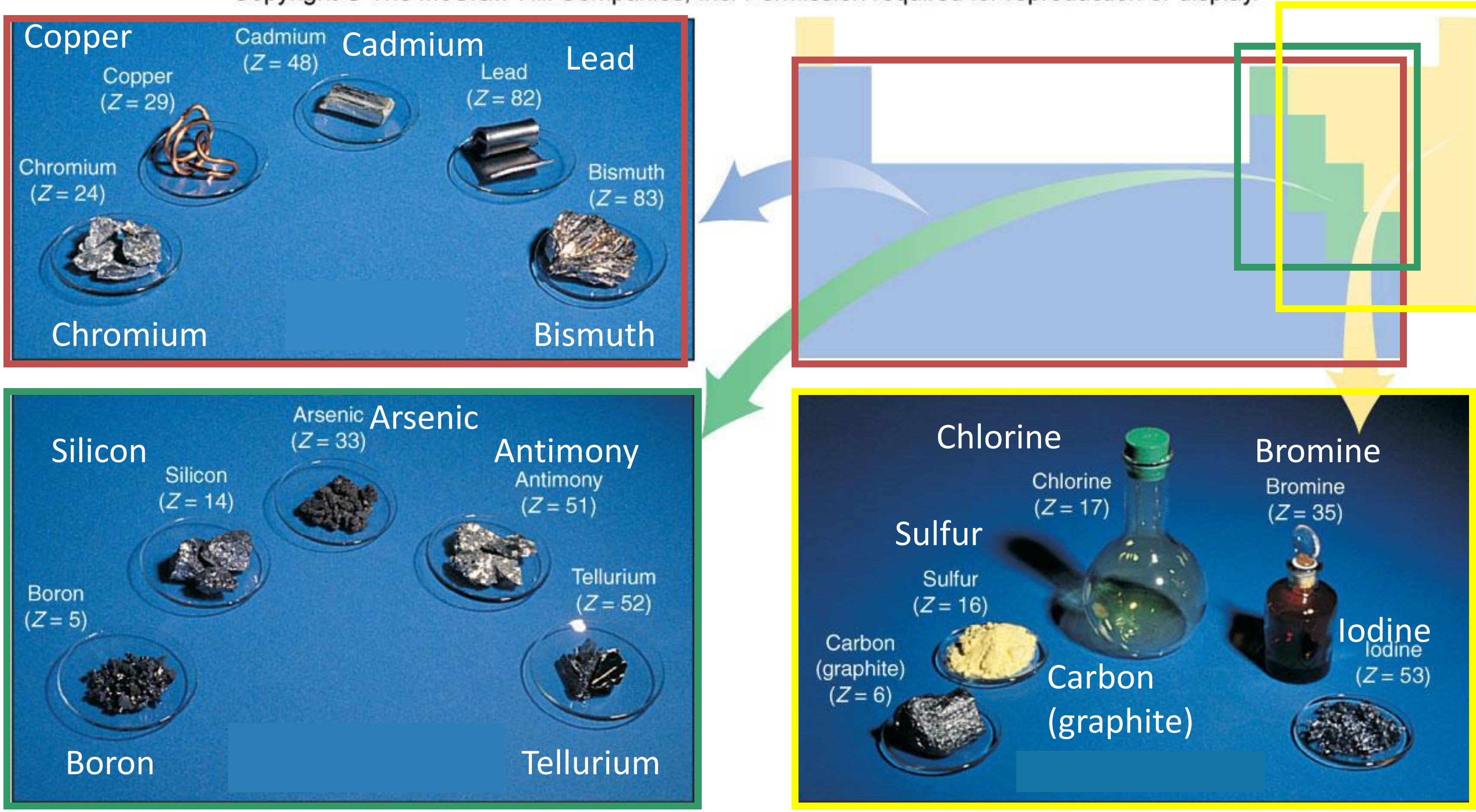
METALS, NON METALS, and METALLOIDS.

-Metals: are good conductors of heat and electricity.

Nonmetals: are poor conductors of heat and electricity.

Metalloids: have properties that are intermediate between metals and nonmetals.

Metals, metalloids, and nonmetals.



Problem: Which of the Following series of elements lists a nonmetal, metal, and a metalloid?

a) Ca, Cu, Si
b) K, Mg, B
c) Br, Ba, Ge
d) O, Na, S,
e) Ag, Cr, As

Answer: **c**

Br: Nonmetal, Ba: Metal, Ge: Metalloid

Problem: which of the following elements would you expect have properties similar to those of Cl:

a) Cu b) F c) Na d) Cr

Answer: b

Because both Cl and Br are from the same Group.

2.5: The Atomic Mass Scale and The Average Atomic Mass:

-We cannot weigh single atom but It is Possible to determine experimentally the mass of one atom relative to another.

-Atomic Mass: is the mass of an atom in atomic mass unit (*amu*)

-The mass of Carbon atom is used as standard.

-

-The Mass of one Carbone atom is exactly 12 *amu*

-One *amu* = 1/12 the mass of one Carbon atom.

-The mass of Carbon atom in the Periodic table is reported as 12.01 amu not 12 Because Carbon (like some elements) has more than one Isotope (which is different in mass). So we are measure the Average Atomic Mass of the naturally occurring mixture of Isotopes.

-The Average Atomic Mass of any Element=(Natural Abundance of Isotop1x Mass of Isotope 1) + (Natural Abundance of Isotop2x Mass of Isotope 2) + ...etc

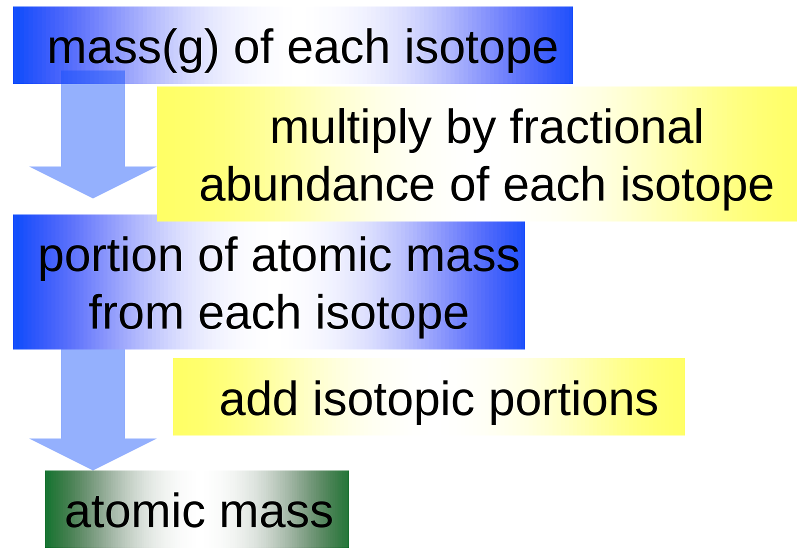
-**Carbon has tow Isotopes Carbon 12 (98.93 %) and Carbon 13 (1.07%) and has a mass of 13.003355 amu.**

-So the AVERAGE ATOMIC MASS of Carbon =
(12.00000 x 0.9893) + (0.0107 x 13.003355) = 12.01 amu

PROBLEM: Silver's(Ag: Z = 47) naturally occurring isotopes, ^{107}Ag and ^{109}Ag, give this mass spectrometric data, calculate the atomic mass of Ag:

Isotope	Mass(amu)	Abundance(%)
^{107}Ag	106.90509	51.84
^{109}Ag	108.90476	48.16

PLAN: Find the weighted average of the isotopic masses.



SOLUTION:

mass portion from ^{107}Ag =
106.90509 amu x 0.5184 = 55.42 amu

mass portion from ^{109}Ag =
108.90476amu x 0.4816 = 52.45amu

atomic mass of Ag = 55.42amu + 52.45amu = 107.87amu

2.6: Molecules and Molecular Compounds:

Types of Chemical Formulas

A chemical formula is comprised of element symbols and numerical subscripts that show the type and number of each atom present in the smallest unit of the substance.

- **An empirical formula** indicates the relative number of atoms of each element in the compound. It is the simplest type of formula.

  The empirical formula for hydrogen peroxide is HO.

- **A molecular formula** shows the actual number of atoms of each element in a molecule of the compound.

  The molecular formula for hydrogen peroxide is H_2O_2.

- **A structural formula** shows the number of atoms and the bonds between them, that is, the relative placement and connections of atoms in the molecule.

  The structural formula for hydrogen peroxide is H-O-O-H.

Naming Molecular Compounds:

1.Naming Binary Compounds: Binary Compounds are those compounds which consist of just tow types of elements (Most Compose of tow nonmetals).

A. Naming Binary Compounds with tow elements (one atom only of each element)

We first name the element which appears first in the formula, followed by that of the second element changing the end of its name by ***ide***.

Ex. The Name of HCl is: Hydrogen Chlor***ide***

Ex. *Calcium and bromine form calcium brom**ide**.*

Ex. Name of SiC is: Silicon Carb***ide***

B. Naming Binary Compounds with tow elements (At least one of them has more than one atom)

-We first name the element which appears first in the formula, followed by that of the second element changing the end of its name by ***ide***.

-We use the Greek Perfixes to donate the number of each atoms of each element present

Perfix	Meaning
Mono	1
Di	2
Tri	3
Tetra	4
Penta	5
Hexa	6
Hepta	7
Octa	8
Nona	9
Deca	10

-The Perfix Mono is Generally Omitted for the first element.

EXAMPLE: Write the name of the following compounds:

-**CO_2 :** Carbon Dioxide Not Monocarbon Dioxide

-CO: Carbon Monoxide

-**-SO_2:** Sulfur Dioxide

-**-SO_3:** Sulfur Trioxide

-**-NO_2:** Nitrogen Dioxide

-NO: Nitrogen Monoxide

-**-N_2O_5:** Dinitrogen Pentoxide

-**NF3:** Nitrogen Trifluoride

-**Cl_2O_5:** Dichlorine Pentoxide

EXAMPLE: Write the Chemical Formula for the following compounds:

-Boron trichloride: BCl_3

-Sulfur tetrafluoride: SF_4

-Tetraphosphorus DecaSulfide: P_4S_{10}

-Carbon tetrachloride: CCl_4

<u>C. Exceptions: Some molecular compounds containing hydrogen do not usually conform to the nomenclature gaudiness.</u>

Ex.:
B_2H_6: Diborane

SiH_4: Silane

NH_3: Ammonia

PH_3: Phosphine

H_2O: Water

H_2S: Hydrogen sulfide.

D. Naming of Binary Acids:

Binary acids solutions form when certain gaseous compounds dissolve in water.

For example, when gaseous hydrogen chloride (HCl) dissolves in water, it forms a solution called hydrochloric acid.

Prefix *hydro-* + anion nonmetal *root* + suffix *-ic* + the word *acid* -

hydro + chlor + ic + acid

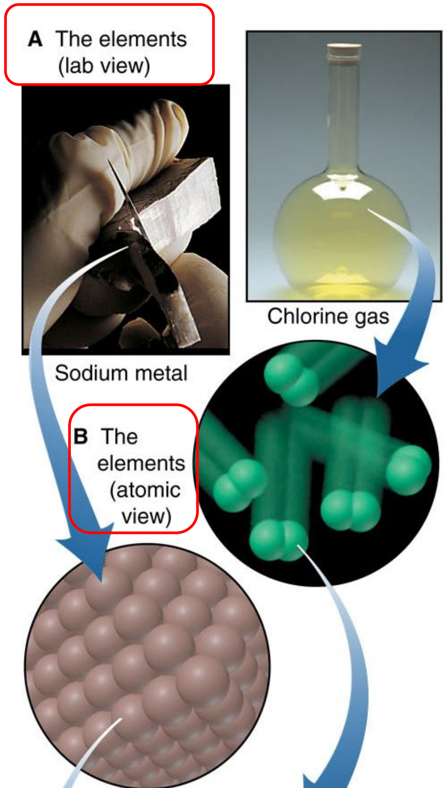
hydrochloric acid

Formula	Binary Compound Name (Systematic Name)	Acid Name
HF	Hydrogen Fluoride	Hydrofluoric Acid
HBr	Hydrogen Bromide	Hydrobromic Acid
HI	Hydrogen Iodide	Hydroiodic Acid
HCl	Hydrogen Chloride	Hydrochloric Acid
HCN*(Not Binary)	Hydrogen Cyanide	Hydrocyanic Acid

2.Naming Organic Compounds: **Organic Compounds are those compounds which contain carbon atoms. The simplest class of Organic Compounds are *Hydrocarbons* which consist of Carbon and Hydrogen. Among Hydrocarbons the simplest form are compounds known as *Alkanes*. The name of alkanes depends on the number of carbon atoms in molecule.**

Chemical Formula	Name	Empirical Formula
CH_4	Methane	CH_4
C_2H_6	Ethane	CH_3
C_3H_8	Propane	C_3H_8
C_4H_{10}	Butane	C_2H_5
C_5H_{12}	Pentane	C_5H_{12}
C_6H_{14}	Hexane	C_3H_7
C_7H_{16}	Heptane	C_7H_{16}
C_8H_{18}	Octane	C_4H_9
C_9H_{20}	Nonane	C_9H_{20}
$C_{10}H_{22}$	Decane	C_5H_{11}

2.7 (P 58): Ions and Ionic Compounds

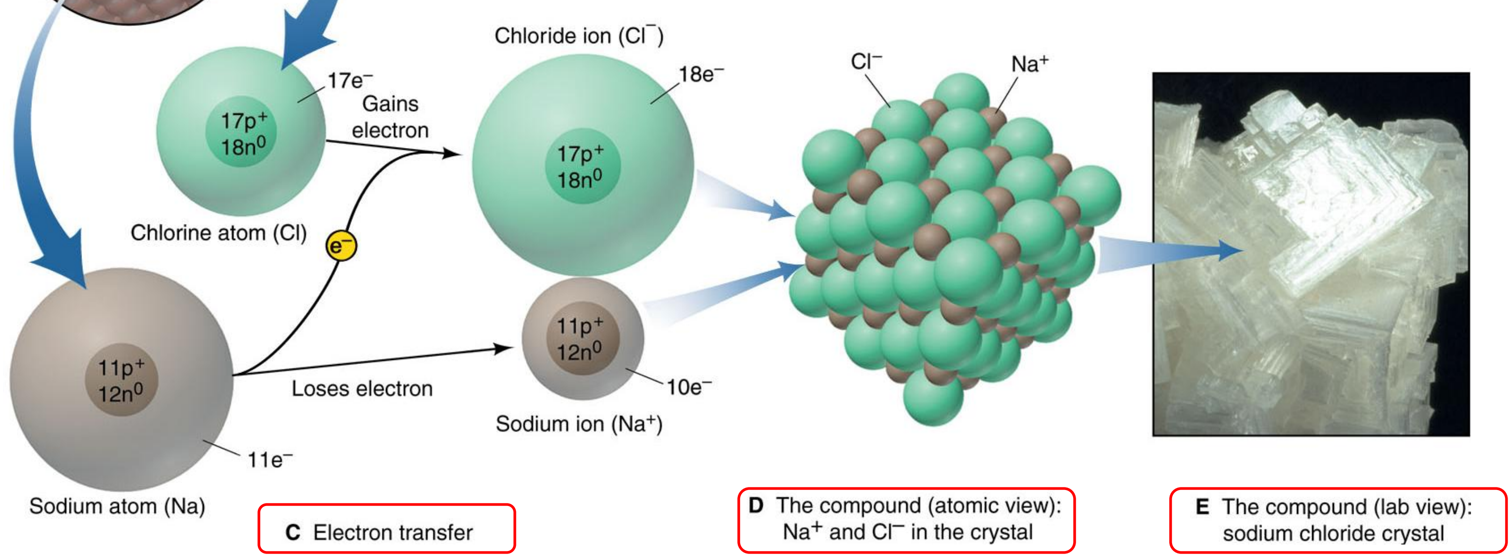


<u>The formation of an ionic compound:</u> the negatively charged electrons may be lost or gained to form Ions.

-Atoms that gain electrons will form negatively charged ions called ***Anions*** (Nonmetals)

-Atoms that lose electrons will form positively charged ions called ***Cataions*** (Metals)

Transferring electrons from the atoms of one element to those of another results in an ionic compound ***(Metal bonded with Nonmetal).***



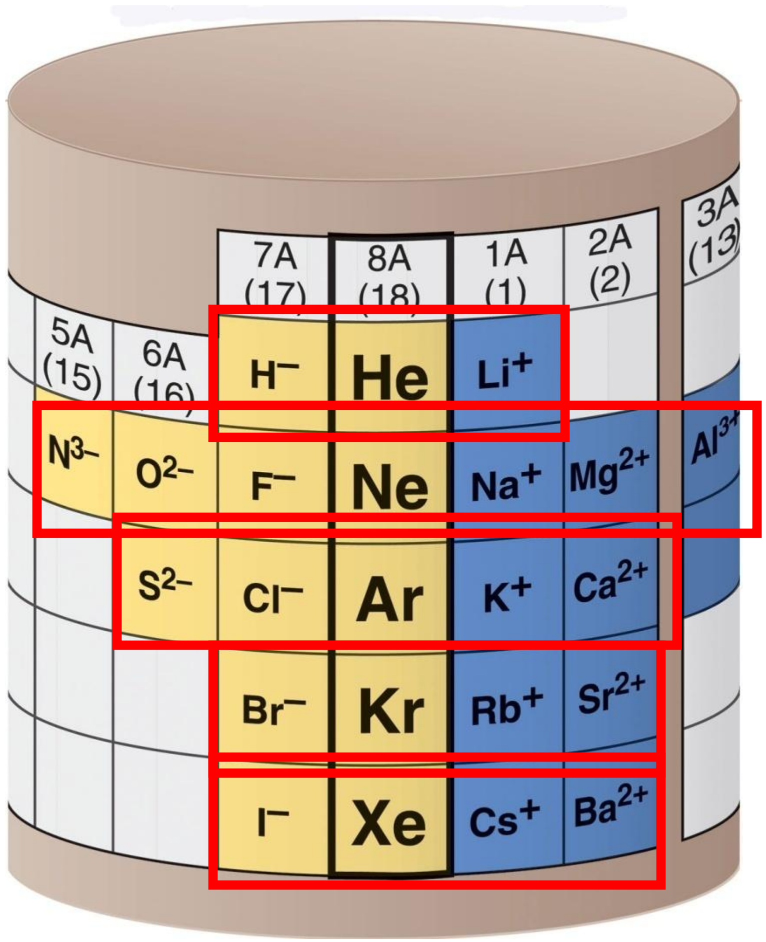
-Monatomic ions: are ions that consist of just one atom of positive or negative charge.

-How can we Indicate the Charge of monatomic ions?????

-Because ***Nobel Gases*** are stable during to their electronic distribution as we will discuss in the coming chapters, metals try to lose electrons to have the same number of electrons of the corresponding ***NOBEL GAS***. While Nonmetals try to gain electrons to get the same number of electrons of their corresponding ***NOBEL GAS***.

-The relation between atoms and their corresponding Nobel Gas is shown in the next figure.

The relationship between ions formed and the nearest noble gas.



Some common monatomic ions of the elements.

Can you see any patterns?

-The Charge of Cations formed by atoms Group 1A, 2A, and 3A equals the Number of their group.

-The Charge of Anions formed by atoms in Group 4A through 7A equals their group number minus 8.

-Transition elements (B groups) could

Have more than one charge of their cations

Period	1A (1)	2A (2)	3B (3)	4B (4)	5B (5)	6B (6)	7B (7)	8B (8)	(9)	(10)	1B (11)	2B (12)	3A (13)	4A (14)	5A (15)	6A (16)	7A (17)	8A (18)
1	H^+																H^-	
2	Li^+														N^{3-}	O^{2-}	F^-	
3	Na^+	Mg^{2+}											Al^{3+}			S^{2-}	Cl^-	
4	K^+	Ca^{2+}				Cr^{2+} Cr^{3+}	Mn^{2+}	Fe^{2+} Fe^{3+}	Co^{2+} Co^{3+}		Cu^+ Cu^{2+}	Zn^{2+}					Br^-	
5	Rb^+	Sr^{2+}									Ag^+	Cd^{2+}		Sn^{2+} Sn^{4+}			I^-	
6	Cs^+	Ba^{2+}										Hg_2^{2+} Hg^{2+}		Pb^{2+} Pb^{4+}				
7																		

Predicting the Ion and Element Forms

PROBLEM: What monatomic ions do the following elements form?

(a) Iodine (Z = 53) (b) Calcium (Z = 20) (c) Aluminum (Z = 13)

PLAN: Use Z to find the element. Find its relationship to the nearest noble gas. Elements occurring before the noble gas gain electrons and elements following lose electrons.

SOLUTION:

$\boxed{I^-}$ Iodine is a nonmetal in Group 7A(17). It gains one electron to have the same number of electrons as $_{54}Xe$.

$\boxed{Ca^{2+}}$ Calcium is a metal in Group 2A(2). It loses two electrons to have the same number of electrons as $_{18}Ar$.

$\boxed{Al^{3+}}$ Aluminum is a metal in Group 3A(13). It loses three electrons to have the same number of electrons as $_{10}Ne$.

-Positive Ions are have the same name of the elment.

Example: the name of Na^+ is Sodium ion

Mg^{+2} is Magnesium ion …………..

-Some Transition metals (B groups) could have more than one posibility for their ions.

-Example:

- Fe^{+2}: Ferrous ion, while Fe^{+3}: Ferric ion.

-Or you can use the Roman numerals to indicate the charge.

-Example:

Fe^{+2}: Iron (II) ion while Fe^{+3}: Iron (III) ion

Mn^{+3}: Mnaganese (III) ion, while Mn^{+4} : Mnaganese (IV) ion.

-Negative Ions are named by replacing the end of the name by *ide*

Example: Cl^- : Chloride, O^{-2}: Oxide

Common Monoatomic Ions

Common ions are in red.

Cations

Charge	Formula	Name
+1	H^+	hydrogen
	Li^+	lithium
	Na^+	sodium
	K^+	potassium
	Cs^+	cesium
	Ag^+	silver
+2	Mg^{2+}	magnesium
	Ca^{2+}	calcium
	Sr^{2+}	strontium
	Ba^{2+}	barium
	Zn^{2+}	zinc
	Cd^{2+}	cadmium
+3	Al^{3+}	aluminum

Anions

Charge	Formula	Name
-1	H^-	hydride
	F^-	fluoride
	Cl^-	chloride
	Br^-	bromide
	I^-	iodide
-2	O^{2-}	oxide
	S^{2-}	sulfide
-3	N^{3-}	nitride

Some Metals That Form More Than One Monatomic Ion

Element	Ion Formula	Systematic Name	Common Name
Cobalt	Co^{+2}	cobalt(II)	
	Co^{+3}	cobalt (III)	
Copper	Cu^{+1}	copper(I)	cuprous
	Cu^{+2}	copper(II)	cupric
Iron	Fe^{+2}	iron(II)	ferrous
	Fe^{+3}	iron(III)	ferric
Lead	Pb^{+2}	lead(II)	
	Pb^{+4}	lead(IV)	
Tin	Sn^{+2}	tin(II)	stannous
	Sn^{+4}	tin(IV)	stannic

(partial table)

Polyatomic Ions:

Ions that consist of a combination of more than one atom.

You must know their names, formulas, and their charges.

Naming oxoanions

Prefix	Root	Suffixes	Examples	
per	*root*	ate	ClO_4^-	perchlorate
	root	ate	ClO_3^-	chlorate
	root	ite	ClO_2^-	chlorite
hypo	*root*	ite	ClO^-	hypochlorite

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

Some Common Polyatomic Ions

Formula	Name	Formula	Name
	Cations		
NH_4^+	ammonium	H_3O^+	hydronium
	Common Anions		
CH_3COO^-	acetate	CO_3^{-2}	carbonate
CN^-	cyanide	CrO_4^{-2}	chromate
OH^-	hydroxide	$Cr_2O_7^{-2}$	dichromate
ClO_3^-	chlorate	O_2^{-2}	oxide
NO_2^-	nitrite	PO_4^{-3}	phosphate
NO_3^-	nitrate	SO_4^{-2}	sulfate
MnO_4^-	permanganate		

(partial table)

Formulas of Ionic Compounds:

In order to write the chemical formula of Ionic Compound you must make the total charge of the compounds equals zero (Electrically neutral)

To do so……the following equation must be satisfied:

(Number of cationic atoms x their charge) + (Number of anionic atoms x their charge) =0

Example: The chemical formula of the ionic compound formed by the combination between Mg^{+2} and Cl^{-1} is $MgCl_2$

$(1x2)+(2x-1)=0$

Determining Formulas of Binary Ionic Compounds

PROBLEM: Write empirical formulas for the compounds named in Sample Problem 2.7:

(a) magnesium nitride (b) cadmium iodide

(c) strontium fluoride (d) cesium sulfide

PLAN: Compounds are neutral. We find the smallest number of each ion which will produce a neutral formula. Use *subscripts* to the *right* of the element symbol.

SOLUTION:

(a) Mg^{2+} and N^{3-}; three Mg^{2+}(6+) and two N^{3-}(6-); Mg_3N_2

(b) Cd^{2+} and I^-; one Cd^{2+}(2+) and two I^-(2-); CdI_2

(c) Sr^{2+} and F^-; one Sr^{2+}(2+) and two F^-(2-); SrF_2

(d) Cs^+ and S^{2-}; two Cs^+(2+) and one S^{2-} (2-); Cs_2S

Naming Ionic Compounds:

-An Ionic Compound is named using the cation name followed by the name of the anion eliminating the word ion from each.

-Because cations and anions have known charges; there is no need to the Greek Prefixes. (the name of $LiCO_3$ is Lithium carbonate not dilithium carbonate).

-If the metal cation may have more than one charge recall that the charge is indicated in the name of the positive ion by using the Roman numerical system. (the name of $FeCl_2$ is Iron(II) Chloride).

Problem 2.10: **name the following compounds:**

-MgO -$Al(OH)_3$ -$Fe_2(SO_4)_3$ -$Ni(NO_3)_2.6H_2O$

Answer :

-Magnesium Oxide.

-Aluminium Hydroxide.

Iron(II) sulfate.

-Ni(II) nitrate hexahydrate.

Problem 2.11: **Deduce the formula of the following compounds:**

-Mercury(I)Chloride

-Lead(II) Chromate

-Potassium Hydrogen phosphate

Answer:

-Hg_2Cl_2

-$PbCrO_4$

-K_2HPO_4

PROBLEM: Something is wrong with the second part of each statement. Provide the correct name or formula.

(a) $Ba(C_2H_3O_2)_2$ is called barium diacetate.

(b) Sodium sulfide has the formula $(Na)_2SO_3$.

(c) Iron(II) sulfate has the formula $Fe_2(SO_4)_3$.

(d) Cesium carbonate has the formula $Cs_2(CO_3)$.

SOLUTION: (a) Barium is always a +2 ion and acetate is -1. The "di-" is unnecessary.

(b) An ion of a single element does not need parentheses. Sulfide is S^{2-}, not SO_3^{2-}. The correct formula is Na_2S.

(c) Since sulfate has a 2- charge, only 1 Fe^{2+} is needed. The formula should be $FeSO_4$.

(d) The parentheses are unnecessary. The correct formula is Cs_2CO_3.

Homework #3: (P 70-72)

2.22

2.38

2.46

2.60

2.63

2.70

2.78