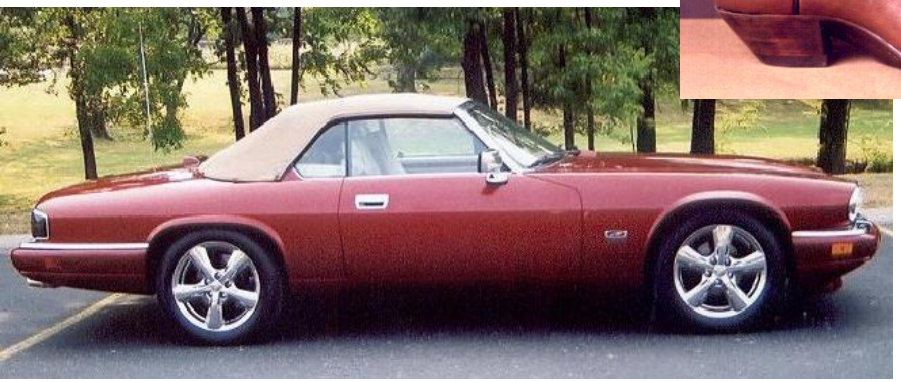
What’s in a name?

- When two people use different names for the same thing, misunderstood words are apt to happen.
- The British and Americans often get confused!

Find the bonnet.

Find the boot.



Chemical Nomenclature!

Systematic way to name chemical compounds!

Now you will be looking at labels differently!

Centrum Multi-Vitamin

Ingredients: ascorbic acid, beta carotene, biotin, calcium pantothenate, calcium phosphate, carnauba wax, chromium chloride, crospovidone, cupr*ic* sulfate, cyanocobalamin, dl-alpha tocopheryl acetate, FD & C blue no. 2 aluminum lake, hydroxypropyl cellulose, ferrous fumarate, hydroxypropyl methylcellulose, lactose, Magnesium oxide, magnesium stearate, manganese sulfate, microcrystalline cellulose,niacinamide, nickel sulfate, phytonandione, polyethylene glycol, potassium chloride, potassium citrate, potassium iodide, povidone, pyridoxine hydrochloride, riboflavin, silica gel, sodium borate, sodium metavanadate, sodium molybdate, sodium selenate, stann*ous* chloride, stearic acid, thiamin mononitrate, titanium dioxide, triacetin, vitamin A acetate, vitamin D_3, zinc oxide. PC7563-46-00

Warning: Accidental overdose of iron-containing products is a leading cause of fatal poisoning in children under 6. Keep this product out of reach of children. In case of accidental overdose, call a doctor or poison control immediately.

Chemical Bonds

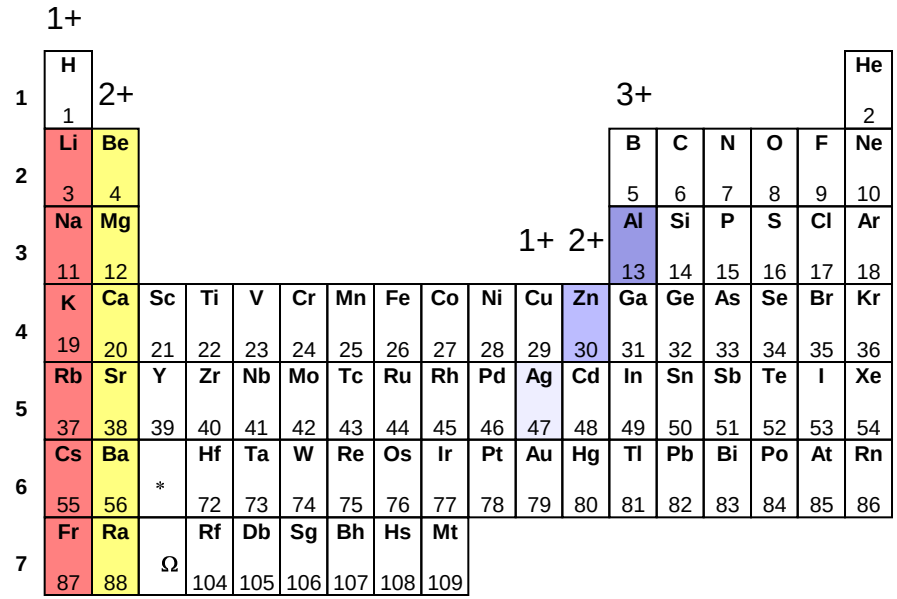
- Attractive force that holds atoms or ions together
- Three main types of chemical bonds
  - **Ionic – Metal and a Non-Metal**
  - **Covalent – 2 or more Non-Metals**
  - **Metallic – Between Metals**
- Type of chemical bond will determine the physical and chemical properties of the substance
- All chemical bonds result from obtaining a full outer shell of electrons.
  - The Octet Rule is the tendency of atoms to gain or lose electrons in order to have eight valence electrons
    - All noble gases have 8 valence electrons except for Helium which has only two.

Type ONE

- Simple Binary Compounds
- Only Two Elements
- Monovalent metal and a non-metal
- State metal then non-metal change ending to ide

Binary Compounds

Binary compounds that contain a metal of fixed oxidation number (group 1, group 2, Al, Zn, Ag, etc.), and a non-metal.



To name these compounds, give the name of metal followed by the name of the non-metal, with the ending replaced by the suffix –**ide**.

Examples:

NaCl	sodium chloride	(Na^{1+} Cl^{1-})
CaS	calcium sulfide	(Ca^{2+} S^{2-})
AlI_3	aluminum iodide	(Al^{3+} $3\,I^{1-}$)

Cations and Anions

Common Simple Cations and Anions

Cation	Name	Anion	Name*
H^{1+}	hydrogen	H^{1-}	hydride
Li^{1+}	lithium	F^{1-}	fluoride
Na^{1+}	sodium	Cl^{1-}	chloride
K^{1+}	potassium	Br^{1-}	bromide
Cs^{1+}	cesium	I^{1-}	iodide
Be^{2+}	beryllium	O^{2-}	oxide
Mg^{2+}	magnesium	S^{2-}	sulfide
Al^{3+}	aluminum		
Ag^{1+}	silver		

*The root is given in color.

“Perhaps one of you gentlemen would mind telling me just what is outside the window that you find so attractive..?”

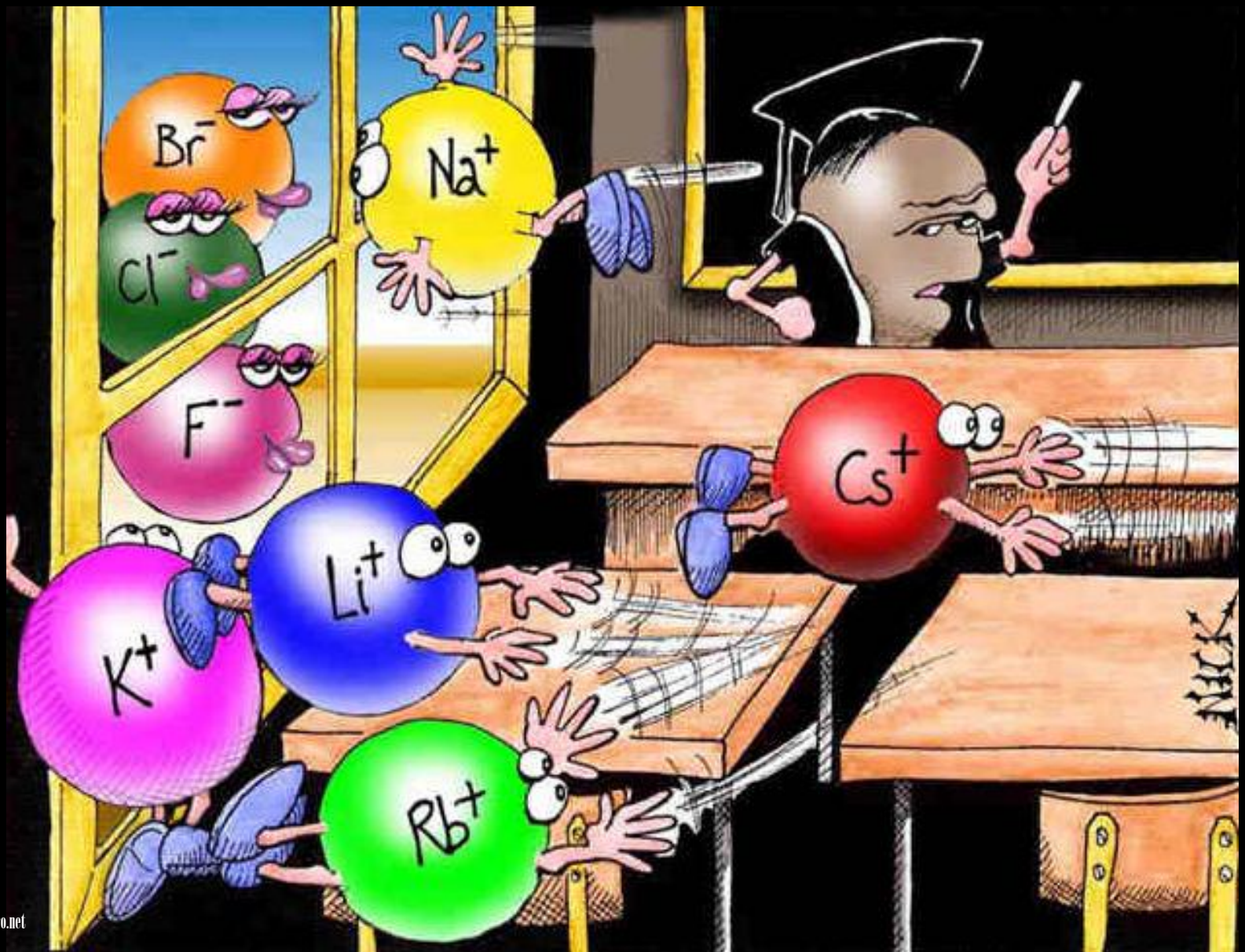
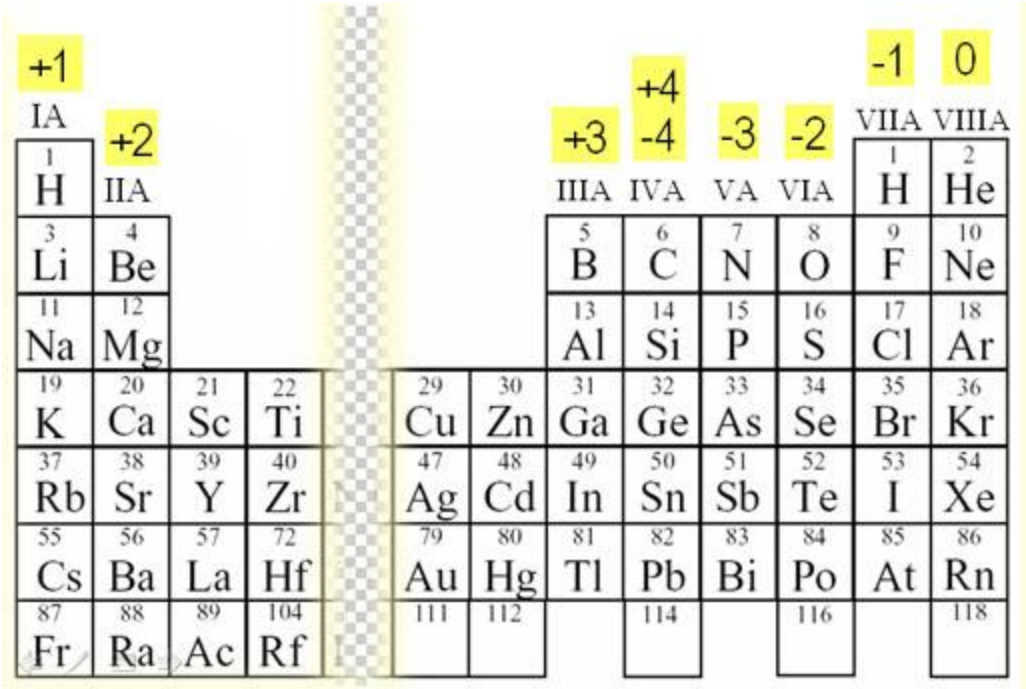


Image courtesy NearingZero.net

To make formula from the name

Use the crisscross rule!



Criss-Cross Rule

Example: Aluminum Chloride

Step 1:

write out name with space

Step 2:

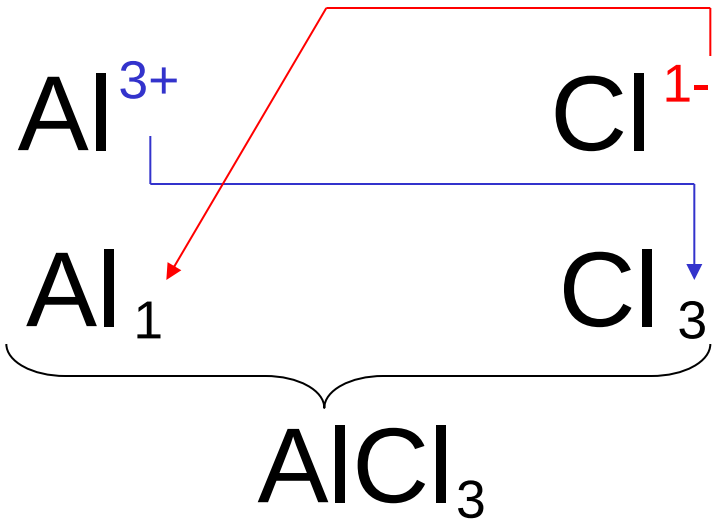
write symbols & charge of elements

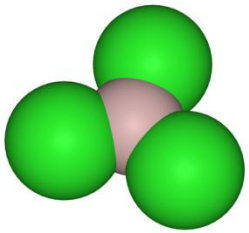
Step 3:

criss-cross charges as subsrcipts

Step 4:

combine as formula unit
("1" is never shown)

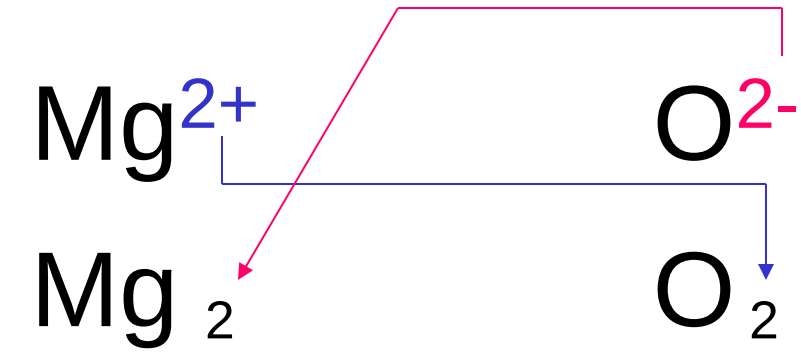




Criss-Cross Rule with Reduction

Example: Magnesium Oxide

Step 1: Magnesium Oxide



Step 4: Mg_2O_2

Step 5: MgO

Criss-Cross Rule

criss-cross rule:

charge on cation / anion

"becomes" subscript of anion / cation

** Warning: Reduce to lowest terms 

Al^{3+} and O^{2-}

$Al_2 O_3$

Al_2O_3

aluminum oxide

Ba^{2+} and S^{2-}

$Ba_2 S_2$

BaS

barium sulfide

In^{3+} and Br^{1-}

$In_1 Br_3$

$InBr_3$

indium bromide

Writing Formulas of Ionic Compounds

chemical formula:

has neutral charge;
shows types of atoms and how many of each

To write an ionic compound's formula, we need:

1. the two types of ions
2. the charge on each ion

Na^{1+}	and	F^{1-}	NaF	sodium fluoride
Ba^{2+}	and	O^{2-}	BaO	barium oxide
Na^{1+}	and	O^{2-}	Na_2O	sodium oxide
Ba^{2+}	and	F^{1-}	BaF_2	barium fluoride

Naming Binary Compounds

	Formula	Name
1	BaO	barium oxide
2	NaBr	sodium bromide
3	MgI_2	magnesium iodide
4	KCl	potassium chloride
5	SrF_2	strontium fluoride
6	CsF	cesium fluoride

Type Two Binary Compounds

Containing a Polyvalent Metal

To name these compounds, give the name of the metal (Type II cations) followed by Roman numerals in parentheses to indicate the oxidation number of the metal, followed by the name of the nonmetal, with its ending replaced by the suffix **–ide.**

Examples	Stock System	Traditional (OLD) System
$FeCl_2$	Iron (II) chloride	Ferrous chloride
$FeCl_3$	Iron (III) chloride	Ferric chloride
SnO	Tin (II) oxide	Stannous oxide
SnO_2	Tin (IV) oxide	Stannic oxide

("ic" ending = higher oxidation state; "ous" is lower oxidation state)

Type three

Polyvalent Metals with Elemental Anions

Pb^{2+}/Pb^{4+},
Sn^{2+}/Sn^{4+},
transition elements (not Ag or Zn)

A. To name, given the formula:

1. Figure out charge on cation.
2. Write name of cation.
3. Write Roman numerals in ( ) to show cation's charge.

Stock System of nomenclature

4. Write name of anion.

FeO	Fe^{2+}	O^{2-}	iron (II) oxide
Fe_2O_3	$2\ Fe^{3+}$	$3\ O^{2-}$	iron (III) oxide
CuBr	Cu^{1+}	Br^{1-}	copper (I) bromide
$CuBr_2$	Cu^{2+}	$2\ Br^{1-}$	copper (II) bromide

Periodic Table with charges

Single-charge cations
Multiple-charge cations
Elemental anions

	1+												3+		3-	2-	1-	
1	H 1	2+															H 1	He 2
2	Li 3	Be 4											B 5	C 6	N 7	O 8	F 9	Ne 10
3	Na 11	Mg 12									1+	2+	Al 13	Si 14	P 15	S 16	Cl 17	Ar 18
4	K 19	Ca 20	Sc 21	Ti 22	V 23	Cr 24	Mn 25	Fe 26	Co 27	Ni 28	Cu 29	Zn 30	Ga 31	Ge 32	As 33	Se 34	Br 35	Kr 36
5	Rb 37	Sr 38	Y 39	Zr 40	Nb 41	Mo 42	Tc 43	Ru 44	Rh 45	Pd 46	Ag 47	Cd 48	In 49	Sn 50	Sb 51	Te 52	I 53	Xe 54
6	Cs 55	Ba 56	*	Hf 72	Ta 73	W 74	Re 75	Os 76	Ir 77	Pt 78	Au 79	Hg 80	Tl 81	Pb 82	Bi 83	Po 84	At 85	Rn 86
7	Fr 87	Ra 88	Ω	Rf 104	Db 105	Sg 106	Bh 107	Hs 108	Mt 109									

La 57	Ce 58	Pr 59	Nd 60	Pm 61	Sm 62	Eu 63	Gd 64	Tb 65	Dy 66	Ho 67	Er 68	Tm 69	Yb 70	Lu 71
Ac 89	Th 90	Pa 91	U 92	Np 93	Pu 94	Am 95	Cm 96	Bk 97	Cf 98	Es 99	Fm 100	Md 101	No 102	Lr 103

Polyvalent Metal Cations

Common Type II Cations

Ion	Stock System	Traditional System
Fe^{3+}	iron (III)	ferric
Fe^{2+}	iron (II)	ferrous
Cu^{2+}	copper (II)	cupric
Cu^{1+}	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 are always bound together in pairs to form Hg_2^{2+}

Traditional (OLD) System of Nomenclature

…used historically (and still some today) to name compounds w/multiple-charge cations

To use:

1. Use Latin root of cation.
2. Use ***-ic*** ending for higher charge; (“icky” food is good for you!)
   “ ***-ous*** “ “ lower “ ; (“delici*ous”* food is not good for you!)
3. Then say name of anion, as usual.

Element	Latin root	***-ic***	***-ous***
gold, Au	*aur-*	Au^{3+}	Au^{1+}
lead, Pb	*plumb-*	Pb^{4+}	Pb^{2+}
tin, Sn	*stann-*	Sn^{4+}	Sn^{2+}
copper, Cu	*cupr-*	Cu^{2+}	Cu^{1+}
iron, Fe	*ferr-*	Fe^{3+}	Fe^{2+}

Find the oxidation State of the polyvalent metal

Subscript Metal (X) + Subscript Nonmetal (Ox #) = 0

State metal, use Roman Numeral for oxidation state, state nonmetal and change ending to ide.

Name this compound!

Cu_3P_2

1. Find oxidation number of the metal :

$$(3)\ (x) + 2\ (-3) = 0$$

$$X = +2$$

2. state the metal
3. state the value of the Roman Numeral
4. state non-metal change ending to ide

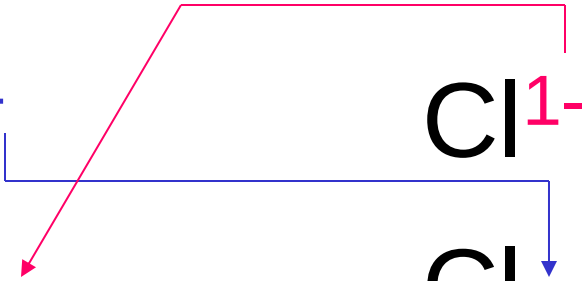
Copper II Phosphide

Chromium II Chloride

RECALL: Chromium has multiple oxidation states.
Name with STOCK system.
Assume Chromiun (II).

Step 1: Chromium (II) Chloride

Step 2: Cr^{2+} Cl^{1-}



Step 3: Cr_1 Cl_2

Step 4: Cr_1Cl_2

Step 5: $CrCl_2$

Return to Centrum Bottle

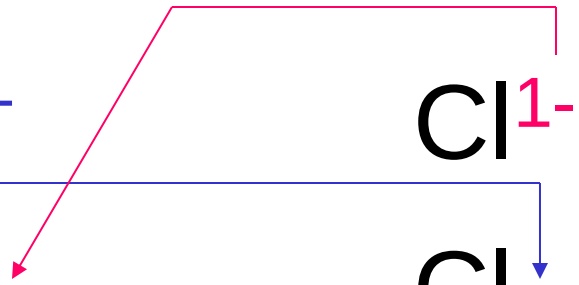
Tin IV Chloride Stannic Chloride

RECALL: “ic” higher oxidation & “ous” lower oxidation

Sn^{4+} (higher) Sn^{2+} (lower)

Step 1: Stannic (tin) Chloride

Step 2: Sn^{4+} Cl^{1-}



Step 3: Sn_1 Cl_4

Step 4: $SnCl_4$

Return to Centrum Bottle

Chromium (III) Chloride

RECALL: Chromium forms oxides in which metal exhibits oxidation states of +3 and +2. STOCK system indicates oxidation state of compound. Assume Cr^{3+} (chromium (III) chloride).

Step 1: Chromium (III) Chloride

Step 2: Cr^{3+} Cl^{1-}

Step 3: Cr_1 Cl_3

Step 4: $CrCl_3$

Return to Centrum Bottle

Write formulas:

copper I sulfide
Cu^{1+} S^{2-} Cu_2S

auric nitride
Au^{3+} N^{3-} AuN

gold (III) nitride

ferrous fluoride

Fe^{2+} F^{1-} FeF_2

iron (II) fluoride

Write names:

Pb_3P_4 3 $Pb^{?}$ 4 P^{3-}

plumbic phosphide

lead (IV) phosphide

Pb_3P_2 3 $Pb^{?}$ 2 P^{3-}

plumbous phosphide

lead (II) phosphide

$SnCl_4$ $Sn^{?}$ 4 Cl^{1-}

stannic chloride

tin (IV) chloride

Naming Binary Compounds

	Formula	Name
1	Hg_2O	mercury (I) oxide
2	HgO	mercury (II) oxide
3	CuF_2	copper (II) fluoride
4	Cu_2S	copper (I) sulfide
5	Cr_2O_3	chromium (III) oxide
6	PbO_2	lead (IV) oxide

Molecular Compound

A compound containing atoms of two or more elements that are bonded together by sharing electrons.



Silicon dioxide, SiO_2, is a molecular compound. It is also a mineral called quartz (left). Quartz is found in nearly every type of rock. Most sand grains (center) are bits of quartz. Glass is made from sand.

Type Five
Writing Formulas of Covalent Molecules

- ***Covalent Molecules***

  contain two types of nonmetals

  Key: FORGET CHARGES

What to do:

Use Greek prefixes to indicate how many atoms of each element, but don't use "mono" on first element.

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

Greek Prefixes for Two Nonmetals

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

Writing Formulas of Covalent Molecules

EXAMPLES:

carbon dioxide	CO_2
CO	carbon monoxide
dinitrogen trioxide	N_2O_3
N_2O_5	dinitrogen pentoxide
carbon tetrachloride	CCl_4
NI_3	nitrogen triiodide

Binary Compounds

Containing Two Nonmetals

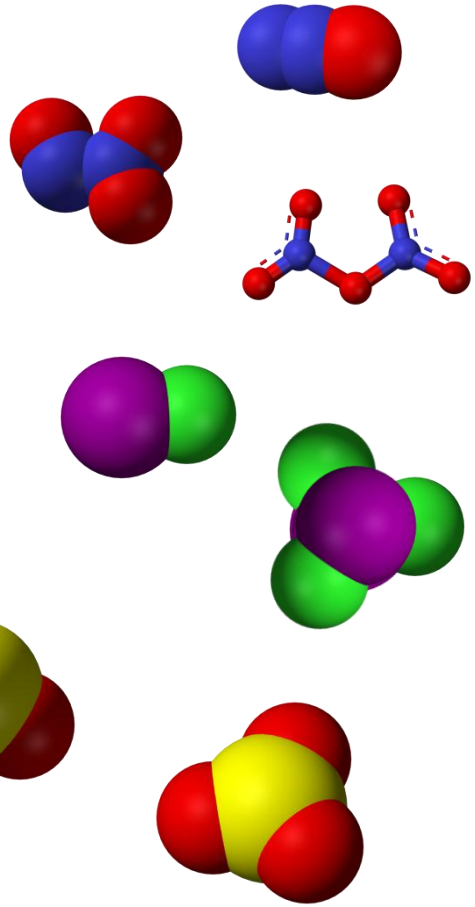
To name these compounds, give the name of the less electronegative element first with the Greek prefix indicating the number of atoms of that element present, followed by the name of the more electronegative non-metal with the Greek prefix indicating the number of atoms of that element present and with its ending replaced by the suffix –**ide**.

Prefixes you should know:

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

Binary Molecular Compounds

N_2O	dinitrogen monoxide
N_2O_3	dinitrogen trioxide
N_2O_5	dinitrogen pentoxide
ICl	iodine monochloride
ICl_3	iodine trichloride
SO_2	sulfur dioxide
SO_3	sulfur trioxide



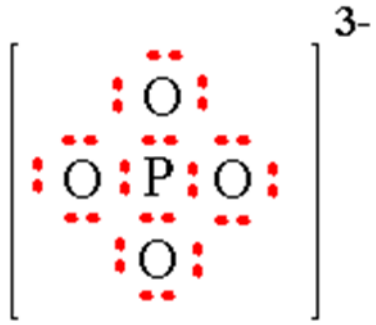
Binary Compounds

Containing Two Nonmetals

1.	As_2S_3	diarsenic trisulfide
2.	SO_2	sulfur dioxide
3.	P_2O_5	diphosphorus pentoxide
4.	CO_2	carbon dioxide
5.	N_2O_5	dinitrogen pentoxide
6.	H_2O	dihydrogen monoxide

Polyatomic Ions

Group of atoms that are covalently bonded that carry a charge



Polyatomic Ions - Memorize

Eight "-ATE's"

PO_4^{3-} ..... phosphATE

SO_4^{2-} ..... sulfATE

CO_3^{2-} ..... carbonATE

ClO_3^{1-} ..... chlorATE

NO_3^{1-} ..... nitrATE

Exceptions:

NH_4^{1+} ..... ammonium

OH^{1-} ..... hydroxide

CN^{1-} ..... cyanide

Polyatomic Ion:

a group of atoms that stay together and have a single, overall charge.

BrO_4^{1-} **Perbrom*ate* ion**	BrO_3^{1-} **Brom*ate* ion**	BrO_2^{1-} **Brom*ite* ion**	BrO^{1-} **Hypobrom*ite* ion**
CO_4^{2-}	CO_3^{2-} **Carbon*ate* ion**	CO_2^{2-}	CO^{2-}
ClO_4^{1-}	ClO_3^{1-} **Chlor*ate* ion**	ClO_2^{1-}	ClO^{1-}
IO_4^{1-}	IO_3^{1-} **Iod*ate* ion**	IO_2^{1-}	IO^{1-}
NO_4^{1-}	NO_3^{1-} **Nitr*ate* ion**	NO_2^{1-}	NO^{1-}
PO_5^{3-}	PO_4^{3-} **Phosph*ate* ion**	PO_3^{3-}	PO_2^{3-}
SO_5^{2-}	SO_4^{2-} **Sulf*ate* ion**	SO_3^{2-}	SO_2^{2-}
1 more oxygen	**“normal”**	**1 less oxygen**	**2 less oxygen**

Rules for Parentheses

Parentheses are used *only* when the following two condition are met:

1. There is a radical (polyatomic ion) present and…
2. There are two or more of that radical in the formula.

Examples:

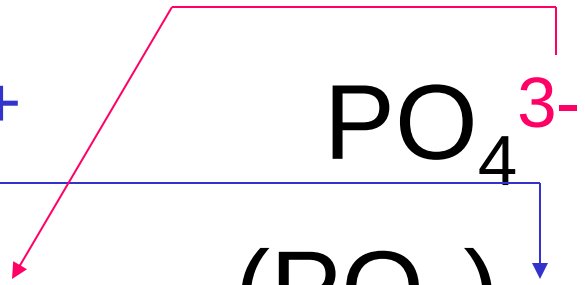
$NaNO_3$	NO_3^{1-} is a radical, but there is only one of it.
$Co(NO_3)_2$	NO_3^{1-} is a radical and there are two of them
$(NH_4)_2SO_4$	NH_4^{1+} is a radical and there are two of them; SO_4^{2-} is a radical but there is only one of it.
$Co(OH)_2$	OH^{1-} is a radical and there are two of it.
$Al_2(CO_3)_3$	CO_3^{2-} is a radical and there are three of them.
$NaOH$	OH^{1-} is a radical but there is only one of it.

Calcium Phosphate

Cross and Drop! Reduce if You Can

Step 1: Calcium Phosphate

Step 2: Ca^{2+} PO_4^{3-}



Step 3: Ca_3 $(PO_4)_2$

Step 4: $Ca_3(PO_4)_2$

Return to Centrum Bottle

Given the formula state the name of the metal and the name of the polyatomic ion

$LiNO_3$	Lithium Nitrate
$Sr_3(PO_4)_2$	Strontium Phosphate
$Al(OH)_3$	Aluminum Hydroxide

Type Two Cont
Monovalent metals w/Polyatomic Ions

Parentheses are required *only* when you need more than one "bunch" of a particular polyatomic ion.

Ba^{2+}	and	SO_4^{2-}	$BaSO_4$	barium sulfate
Mg^{2+}	and	NO_3^{1-}	$Mg(NO_3)_2$	magnesium nitrate
NH_4^{1+}	and	ClO_3^{1-}	NH_4ClO_3	ammonium chlorate

Type Four: Polyvalent metal and a Polyatomic Ion

Find the oxidation State of the polyvalent metal with a polyatomic ion

Subscript Metal (X) + Subscript polyatomic ion(Ox #) = 0

State metal, use Roman Numeral for oxidation state, state polyatomic name

Name This Compound!

$Cu_3(PO_4)_2$

1. Find Oxidation state of metal

$$3(x) + 2(-3) = 0$$

X= +2 Value II

2. State metal
3. State value of R.N.
4. Name the polyatomic ion

Copper II Phosphate

Name That Compound!

Compound | Ox # of Metal | state metal R.N. Polyatomic

1. $Pb(SO_4)_2$ $1(?) + 2(-2) = 0$ Lead IV Sulfate

? = +4

2. $Co_2(SO_4)_3$ $2(?) + 3(-2) = 0$ Cobalt III Sulfate

? = + 3

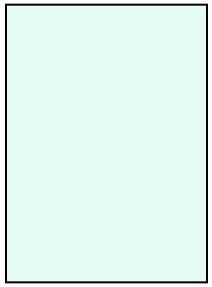
Type Four Making the compounds polyvalent metals w/Polyatomic Ions Cross and Drop Reduce if Possible

Parentheses are required *only* when you need more than one "bunch" of a particular polyatomic ion.

tin (IV) sulfate	Sn^{4+}	and	SO_4^{2-}	$Sn(SO_4)_2$
iron (III) dichromate	Fe^{3+}	and	$Cr_2O_7^{2-}$	$Fe_2(Cr_2O_7)_3$

B. To find the formula, given the name: Cross the value of the roman numeral and the oxidation of the non-metal

1. Write symbols for the two types of ions.



2. Cross and Drop Reduce if Possible!

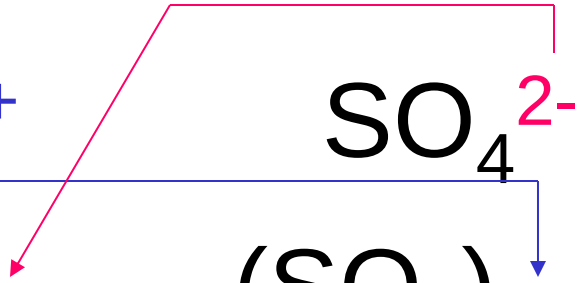
cobalt (III) chlorate	Co^{3+} ClO_3^{1-}	$Co(ClO_3)_3$
tin (IV) sulfate	Sn^{4+} SO_4^{2-}	$Sn(SO_4)_2$
tin (II) Carboante	Sn^{2+} CO_3^{2-}	$SnCO_3$

Copper II Sulfate

RECALL: “ic” higher oxidation & “ous” lower oxidation
Cu^{2+} (higher) Cu^{1+} (lower)

Step 1: Cupric Sulfate

Step 2: Cu^{2+} SO_4^{2-}



Step 3: Cu_2 $(SO_4)_2$

Step 4: $Cu_2(SO_4)_2$

Step 5: $CuSO_4$

Return to Centrum Bottle

Compounds Containing Polyatomic Ions

Insert name of ion where it should go in the compound's name.
Cross and Drop Reduce if you can!

Write formulas:

iron (III) nitrate	Fe^{3+}	$3\ NO_3^{1-}$	$Fe(NO_3)_3$
Copper I phosphate	$3\ Cu^{1+}$	$PO_4 3^-$	Cu_3PO_4
Silver chlorate	Ag^{1+}	ClO_3^{1-}	$AgClO_3$
Nickel II phosphate	$3\ Ni^{2+}$	$2\ PO_4^{3-}$	$Ni_3(PO_4)_2$
lead (II) permanganate	Pb^{2+}	$2\ MnO_4^{1-}$	$Pb(MnO_4)_2$

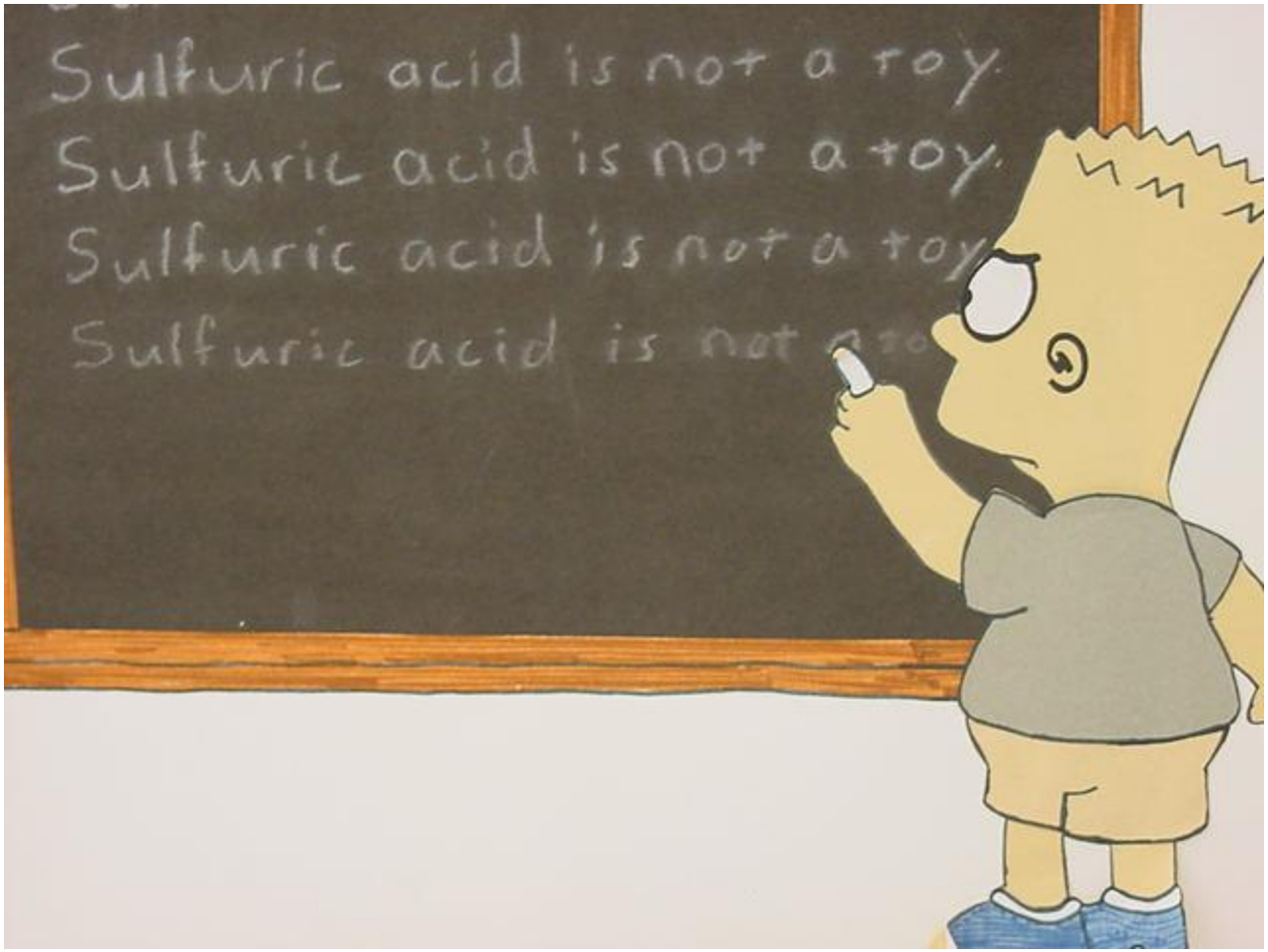
Type Six Acids
Hydrogen Containing Compounds

If it is binary HX use the prefix hydro state nonmetal change ending to ic acid

HBr Hydrobromic Acid

To make the formula cross and drop charges!

Oxy Acids: HXO_n



2. Oxy Acids

- Hydrogen _____Oxygen H___O_x
- Prefix and ending indicate number of oxygens present

+ 2 oxygens Hyper ___ic acid $HClO_5$ Hyperchloric Acid

+1 oxygen per____ic acid $HClO_4$ PerChloric Acid

Normal Poly # (ate ending) ____ic acid $HClO_3$ Chloric Acid

-1 oxygen ____ous acid $HClO_2$ Chlorous Acid

-2 oxygens Hypo ____ous acid HClO Hypochlorous Acid

Finding an Empirical Formula from Experimental Data

1. Find # of g of each element.
2. Convert each g to mol.
3. Divide each "# of mol" by the smallest "# of mol."
4. Use whole number ratio to find formula.

A compound is 45.5% yttrium and 54.5% chlorine. Find its empirical formula.

$$45.5\ \text{g Y}\left(\frac{1\ \text{mol Y}}{88.9\ \text{g Y}}\right) = 0.512\ \text{mol Y} \div 0.512 \rightarrow 1$$

$$54.5\ \text{g Cl}\left(\frac{1\ \text{mol Cl}}{35.5\ \text{g Cl}}\right) = 1.535\ \text{mol Cl} \div 0.512 \rightarrow 3$$

YCl_3

A ruthenium/sulfur compound is 67.7% Ru.
Find its empirical formula.

$$67.7\ \text{g}\,\text{Ru}\left(\frac{1\ \text{mol Ru}}{101.1\ \text{g}\,\text{Ru}}\right) = 0.670\ \text{mol Ru} \div 0.670 \rightarrow 1$$

$$32.3\ \text{g}\,\text{S}\left(\frac{1\ \text{mol S}}{32.1\ \text{g}\,\text{S}}\right) = 1.006\ \text{mol S} \div 0.670 \rightarrow 1.5$$

Multiply each by 2
to get to next
whole number

→ Ru_2S_3

To find molecular formula…

A. Find empirical formula.

B. Find molar mass of empirical formula.

C. Find $n = \frac{\text{mm molecular}}{\text{mm empirical}}$

D. Multiply all parts of empirical formula by n.

(How many empiricals “fit into” the molecular?)

A carbon/hydrogen compound is 7.7% H and has a molar mass of 78 g. Find its molecular formula.

$$7.7\ \text{g H}\left(\frac{1\ \text{mol H}}{1.0\ \text{g H}}\right) = 7.7\ \text{mol H} \div 7.69 \rightarrow 1$$

$$92.3\ \text{g C}\left(\frac{1\ \text{mol C}}{12.0\ \text{g C}}\right) = 7.69\ \text{mol C} \div 7.69 \rightarrow 1$$

emp. form. → CH

$$\text{mm}_{\text{emp}} = 13\ \text{g} \longrightarrow \frac{78\ \text{g}}{13\ \text{g}} = 6 \longrightarrow \boxed{C_6H_6}$$

A compound has 26.33 g nitrogen, 60.20 g oxygen, and molar mass 92 g. Find molecular formula.

$$26.33\ \text{g N}\left(\frac{1\ \text{mol N}}{14.0\ \text{g N}}\right) = 1.881\ \text{mol N} \div 1.881 \rightarrow 1$$

$$60.20\ \text{g O}\left(\frac{1\ \text{mol O}}{16.0\ \text{g O}}\right) = 3.763\ \text{mol O} \div 1.881 \rightarrow 2$$

$$\underline{NO_2}$$

$$mm_{emp} = 46\ \text{g} \longrightarrow \frac{92\ \text{g}}{46\ \text{g}} = 2 \longrightarrow \boxed{N_2O_4}$$