

Ch06

Compounds

Building with atoms.

Ionic and molecular compounds.



version 1.5

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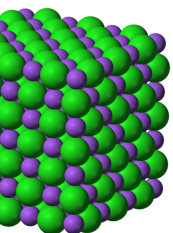


Compounds



What are compounds?

- ▶ Compounds are not mixtures.
- ▶ Chemical Bonding
 - ▶ covalent vs ionic bonds
 - ▶ molecular vs ionic compounds

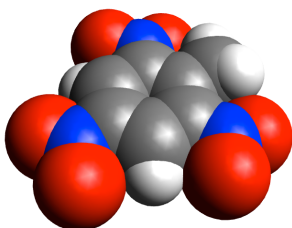


Chemical Formula

- ▶ Symbols in Formulas
- ▶ Kinds of chemical formula
 - ▶ Identification, Composition

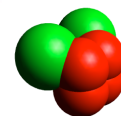
Stuff made of 1 element:

- ▶ Elements (atoms or molecules)
- ▶ Ions (charged atoms—monatomic ions)
 - ▶ Ions can have more than one possible charge:
 - ▶ Classical System (historical)
 - ▶ Stock System (you'll like this one better)



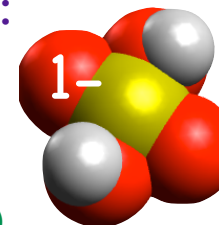
Stuff made of 2 elements:

- ▶ When it's a non-metal and a metal
- ▶ When it's a non-metal and a metal w/ more than one possible charge
- ▶ When both elements are non-metals



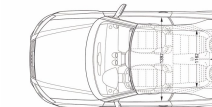
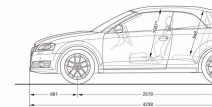
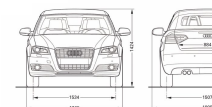
Stuff made of more than 2 elements:

- ▶ Some Oxy-ions (oxygen + one other element)
- ▶ Some other Polyatomic Ions (some stuff that you'll run into a lot)



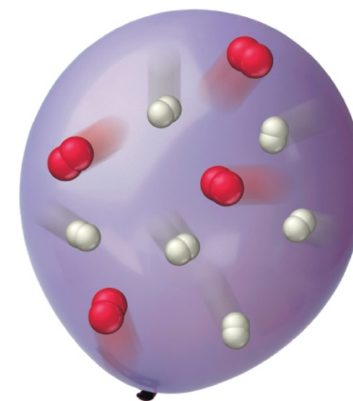
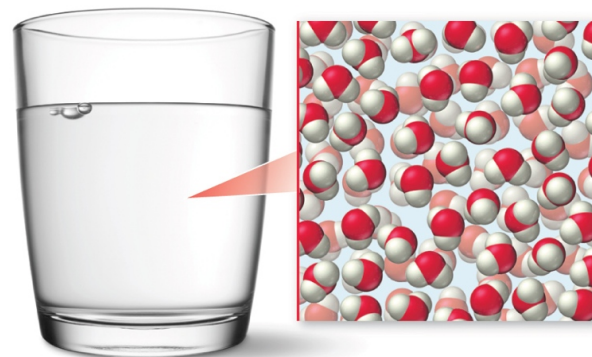
Hydrogen is a wild card (Acids):

- ▶ Binary compounds with Hydrogen & Binary Acids
- ▶ Some Oxy-ions with Hydrogen
- ▶ Some Oxy-Ion Acids



Chemical Bonding

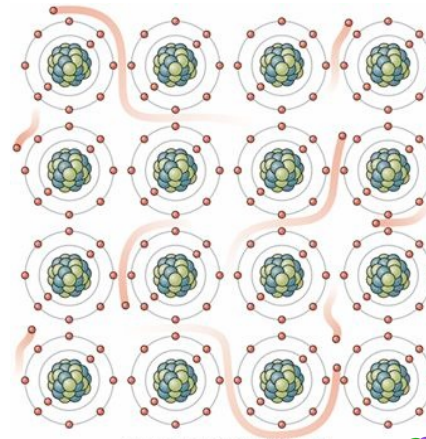
- ▶ Bringing elements together to form new compounds.
- ▶ Not a mixture, but bonding the elements at the atomic level.
- ▶ When you mix hydrogen and oxygen, you don't have a new substance — no new properties are observed.
 - ▶ Mixtures are useful, but it's not a reaction.
 - ▶ It's just stirring up the particles.
- ▶ When you react hydrogen and oxygen, you have a new substance — you see new properties.
 - ▶ Water is a compound
 - ▶ won't burn
 - ▶ liquid at room temperature
 - ▶ causes sodium to burn
- ▶ The compound forms because the atoms bond to each other.
- ▶ All chemical bonding uses electrons to glue atoms to each other
- ▶ There are different types of bonding.
 - ▶ metallic
 - ▶ ionic
 - ▶ covalent



Chemical Bonds

▶ Metallic Bonding (only metals)

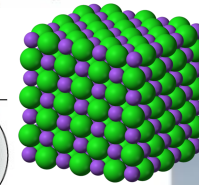
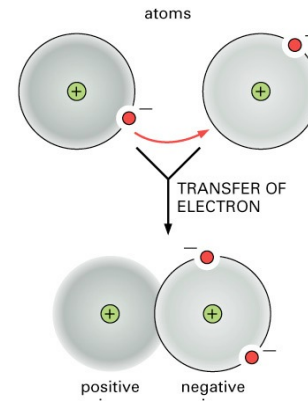
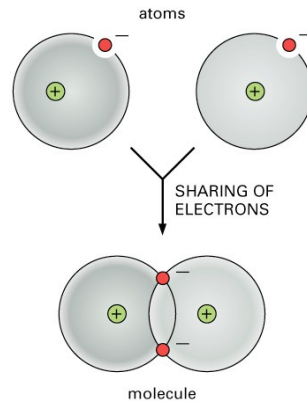
- ▶ In pure metals (Fe, Au, Co) or alloys (mixtures of metals) electrons break off and float between the atoms.
- ▶ These free flowing electrons make metals extremely good conductors of electricity.
- ▶ Metal atoms pull on the electrons flowing between them causing the mass to stick together.
- ▶ Metallic bonding does not form compounds.



Magnesium
Gold
Copper

▶ Ionic Bonding (metal with non-metal)

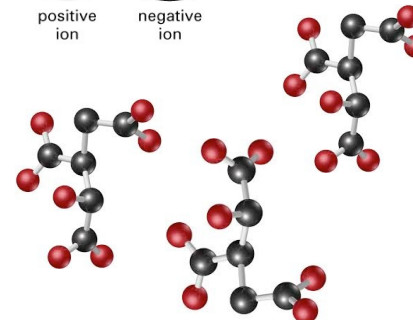
- ▶ When you mix metals and non-metals electrons break off from metals and are captured by non-metals.
- ▶ This creates positively and negatively charged particles.
- ▶ The particles attract each other, this is an ionic bond.
- ▶ Ionic bonds are extremely strong.
- ▶ These ions clump together in simple, large complexes.
- ▶ Compounds made from ionic bonds are ionic compounds.



Magnesium oxide
Potassium dichromate
Nickel(II) oxide

▶ Covalent Bonding (only non-metals)

- ▶ Nonmetals pull on each others electrons.
- ▶ If neither non-metal pulls hard enough to remove the electron from the other, the two end up sharing a pair of electrons.
- ▶ The shared electrons are localized between two atoms, creating a bond between just those two atoms.
- ▶ This produces discrete microscopic structures built of atoms.
- ▶ Particles made of covalent bonds are molecules.
- ▶ Compounds made from covalent bonds are molecular compounds.

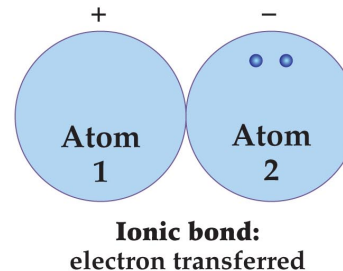
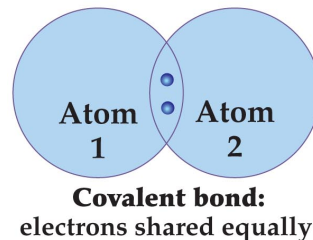
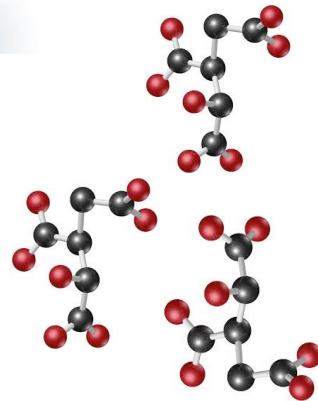
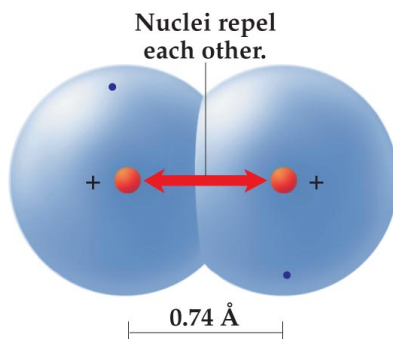
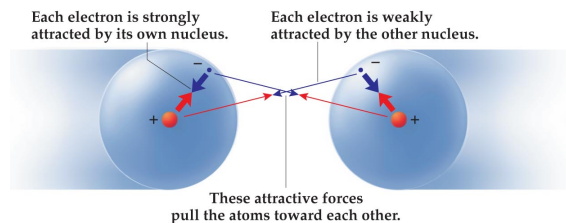


Bromine
Sulfur
Sucrose

Chemical Bonding in Compounds

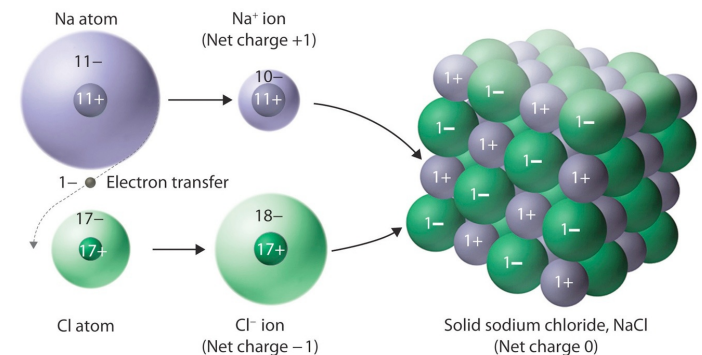
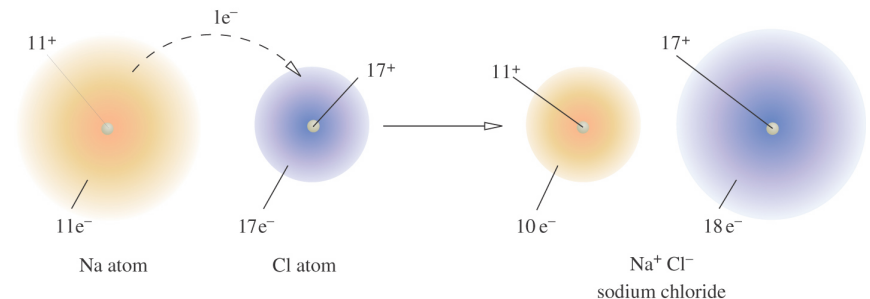
► Covalent Bonding (only non-metals)

- Nonmetals pull on each others electrons.
- The shared electrons are localized between two atoms, creating a bond between just those two atoms.
- Covalent bonding produces discrete microscopic structures built of atoms.
- Particles made of covalent bonds are **molecules**.
- Compounds made from covalent bonds are **molecular compounds**.



► Ionic Bonding (metal with non-metal)

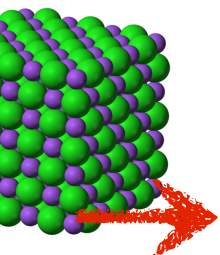
- Ionic bonding creates positively and negatively charged particles.
- The particles attract each other, this is an ionic bond.
- These ions clump together in simple, large complexes.
- Compounds made from ionic bonds are **ionic compounds**.



Compounds

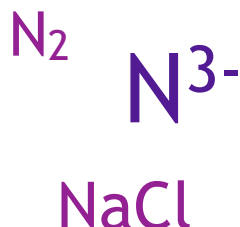
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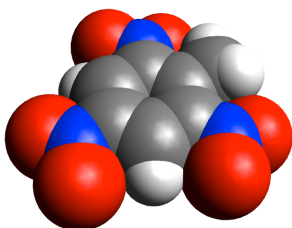
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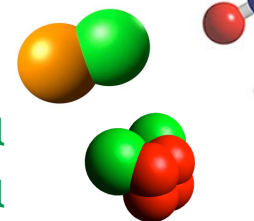
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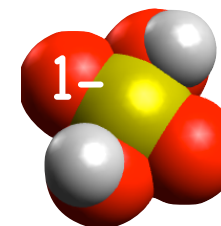
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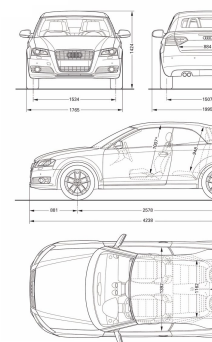
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- Some other Ions (some stuff that you'll run into a lot)



Hydrogen is a wild card (Acids):

- Binary compounds with Hydrogen & Binary Acids
- Some Oxy-ions with Hydrogen
- Some Oxy-Ion Acids



Chemical Formulas

- ▶ We use symbols to represent elements and also to represent atoms of that element.
 - ▶ You must memorize the symbols of the first 18 elements! (this is easier than it sounds)
- ▶ The order of elements goes from the most metal-like element to the least. Na before C before H before F, etc (we'll talk more about this later)
- ▶ We use subscripts to indicate the number of atoms of that element.
 - ▶ Subscripts of 1 are omitted.
 - ▶ Omitted subscripts mean 1.
- ▶ We use superscripts to indicate the net charge (if any) on the entire particle.
 - ▶ Superscripts of 0 (charge 0) are omitted.
 - ▶ Omitted superscripts are assumed to mean 0 (no charge).

Au

AlBr₃

CH₄

Cl⁻

Na⁺

HF

Br₂

NO₂⁻

Al³⁺

Sn

C₆H₈NO₄

PO₄²⁻



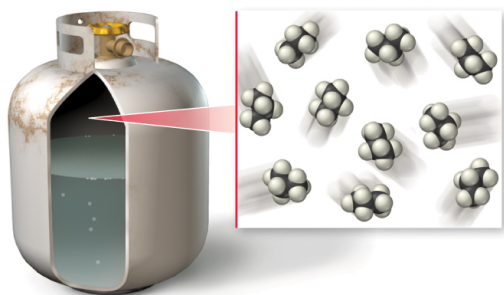
Water is a **binary compound**, it is a **polyatomic molecule** composed of 2 hydrogen atoms and 1 oxygen atom. It has a charge of zero.



Sulfate is a **binary ion**, it is a **polyatomic ion** composed of 1 sulfur atom and 4 oxygen atoms. It has a charge of minus two.

Chemical Formula

A Molecular Compound



Butane

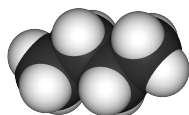
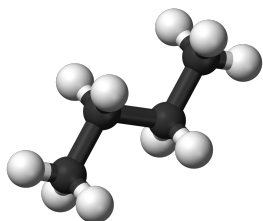
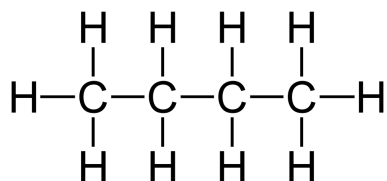
Empirical



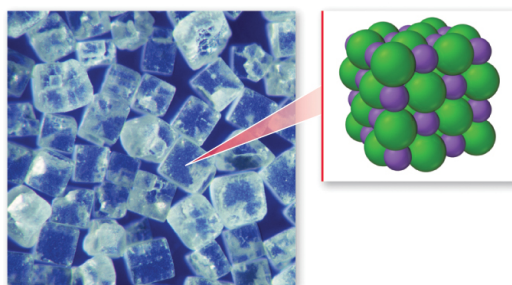
Molecular



Structural



An Ionic Compound

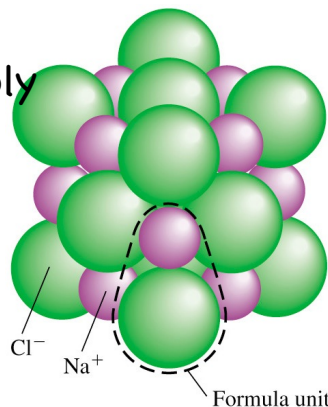


Salt



does not apply

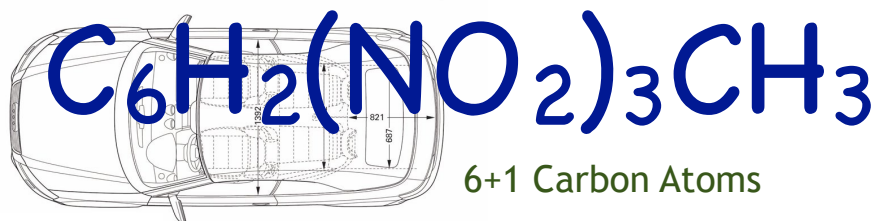
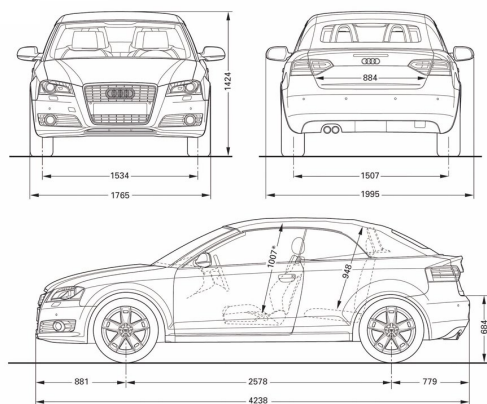
does not apply



- ▶ We use chemical formulas to describe both types of compound.
- ▶ There are three kinds of chemical formulas.
- ▶ **Empirical formulas** describe the ratio of elements in the compound.
 - ▶ Empirical formulas can describe either molecular or ionic compounds.
 - ▶ The smallest whole number ratio of elements is also called a **formula unit**.
- ▶ **Molecular formulas** describe the number of atoms in each molecule.
 - ▶ Molecular formulas can only be used to describe molecular compounds.
- ▶ **Structural formulas** graphically describe the connectivity between atoms.
 - ▶ Structural formulas can only be used to describe molecular compounds.
 - ▶ We will talk more about these shortly.



Molecular Formulas



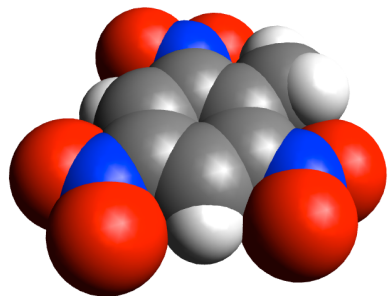
6+1 Carbon Atoms

2+3 Hydrogen Atoms

3 NO_2 Groups

3 (3x1) Nitrogen Atoms

6 (3x2) Oxygen Atoms



- ▶ Chemical Formulas Identify Compounds
 - ▶ We use them as shorthand to name of a substance (“Pass me the H_2O ”)
- ▶ Chemical Formulas indicate the composition of a substance.
 - ▶ Each element is indicated with it’s symbol.
 - ▶ The a subscript indicates the total number of atoms of that element.
 - ▶ Subscripts of 1 are omitted.
 - ▶ Omitted subscripts mean 1.
 - ▶ Parenthesis are used to indicate groups of atoms.
- ▶ Chemical Formulas **may** contain hints of the connectivity of the atoms.
- ▶ Chemical Formulas **may** show a CH_3 group of atoms and three NO_2 groups of atoms are bonded to a C_6H_2 group by writing:



instead of: $C_7H_5N_3O_6$



Compounds

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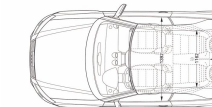
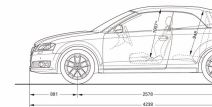
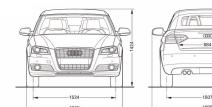
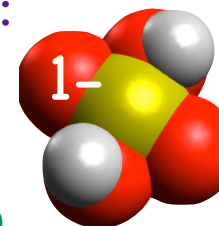
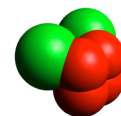
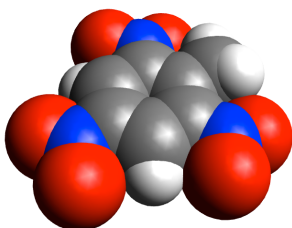
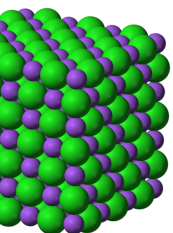
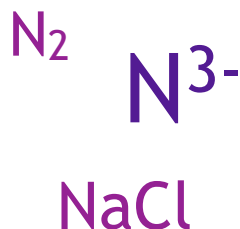
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Stuff made of more than 2 elements:

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- Some other Polyatomic Ions (some stuff that you'll run into a lot)

Hydrogen is a wild card (Acids):

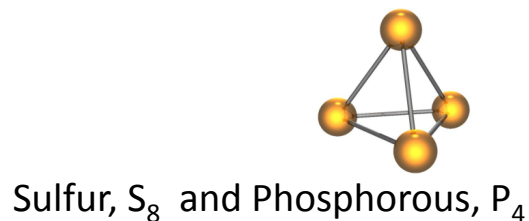
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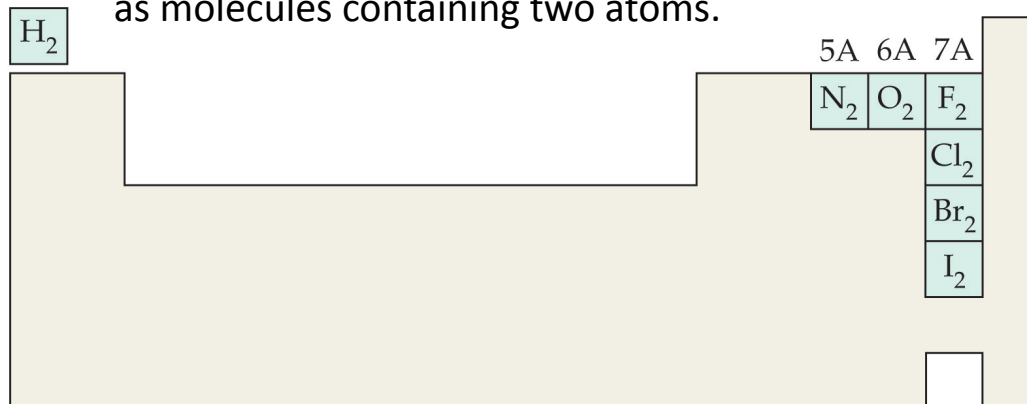
Naming Elements

The name for any substance that contains atoms of only one element, is just the name of that element. The formula is also easy:

- ▶ Most elements are monatomic.
- ▶ Seven elements are diatomic.
- ▶ Two elements are polyatomic.

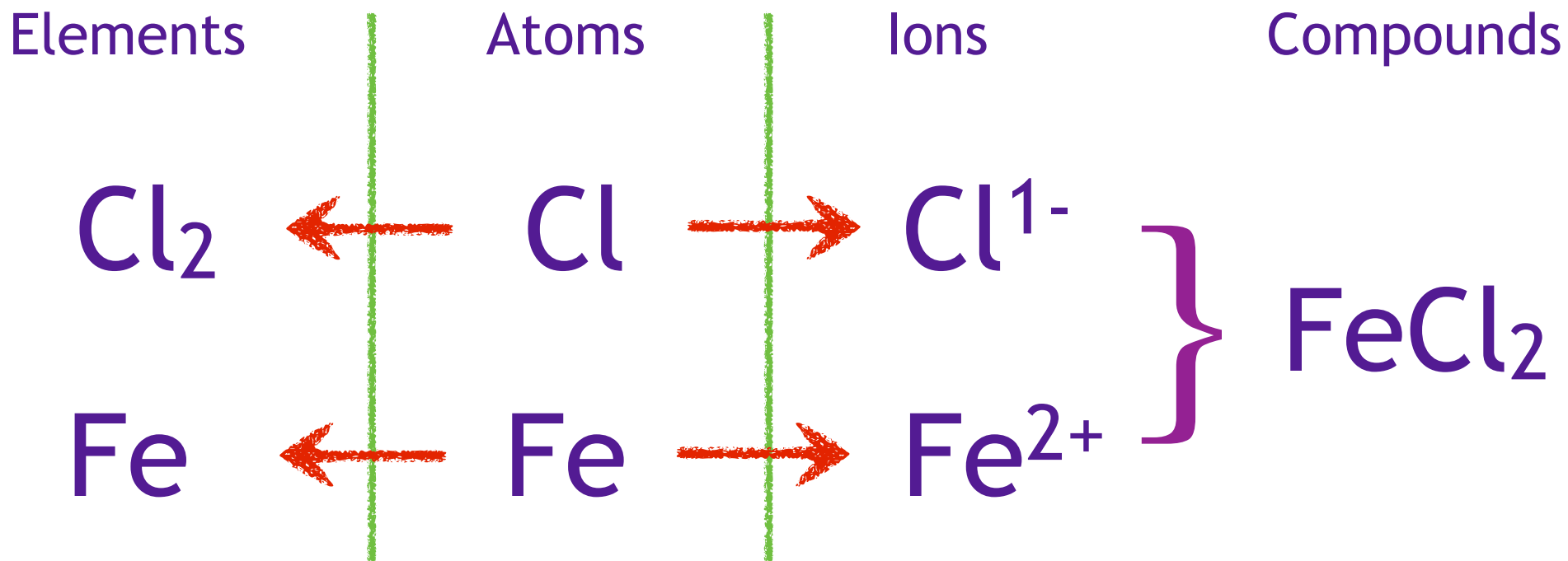


These seven elements occur naturally as molecules containing two atoms.



Everything else is monatomic and the formula is just the symbol of the element: Au, C, Na, Ne, etc

Don't Confuse Elements vs Ions



Substances are elements and compounds.

Substances are large groups of molecules and ions.

Molecules are built from atoms and ions.

HELLO
my name is

Ferric Chloride

You can call me "FeCl₃"

Naming Monatomic Ions

Most Monatomic Ions are easy to name.

- ▶ Positively charged atoms are **cations**. (CA+ION)
- ▶ Negatively charged atoms are **anions**.

- ▶ Cations—just add “ion” to the element name:

Na⁺ is sodium ion

Mg²⁺ is magnesium ion

- ▶ Anions—just add “-ide ion” to the stem of the element:

(The stem is usually the first syllable of the element name)

Cl⁻ is chloride ion

N³⁻ is nitride ion

C⁴⁻ is carbide ion



Use the Periodic Table to predict ion charges

- ▶ Cations can be predicted reliably with only the transition metals causing exceptions.
- ▶ Hydrogen can be either +1 or -1
— it's a wild card.
- ▶ Carbon can be either +4 or -4.
- ▶ Non-metals can only be predicted reliably when teamed up with a metal.

DO NOT RELY ON THIS TRICK IF THE COMPOUND HAS MORE THAN ONE NON-METAL!

+1 +2
+3 +4
-3 -2 -1 0

1A 1																	3A 13	4A 14	5A 15	6A 16	7A 17	8A 18							
1 H																	5 B	6 C	7 N	8 O	9 F	10 Ne							
3 Li	4 Be											11 Na	12 Mg	3B 3	4B 4	5B 5	6B 6	7B 7	8B 8 9 10			1B 11	2B 12	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr												
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe												
55 Cs	56 Ba	71 Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn												
87 Fr	88 Ra	103 Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112	113	114	115	116		118												

Metals
 Metalloids
 Nonmetals

Cr Fe Co +2/+3

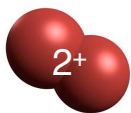
Cu Hg +1/+2

Sn Pb Mn +2/+4

Some Metals have more than one cation.

- ▶ Chromium (Cr^{2+} , Cr^{3+})
- ▶ Iron (Fe^{2+} , Fe^{3+})
- ▶ Cobalt (Co^{2+} , Co^{3+})
- ▶ Copper (Cu^{+} , Cu^{2+})
- ▶ Mercury (Hg_2^{2+} , Hg^{2+})
- ▶ Tin (Sn^{2+} , Sn^{4+})
- ▶ Lead (Pb^{2+} , Pb^{4+})
- ▶ Manganese (Mn^{2+} , Mn^{4+})

(better table on next slide)



Hg_2^{2+}
mercury (I) ion



Hg^{2+}
mercury (II) ion

- ▶ For these you need to do something extra, to show which ion you're talking about.
- ▶ These are all cations. They are all transition metals.
- ▶ You are only responsible for these 8, but be aware there are others.
- ▶ There are two methods (you need to know both):
- ▶ **Classical System**
 - ▶ —name the ion “classic stem+ous” for smaller ion
ex: ferrous ion (Fe^{2+}), cuprous ion (Cu^{+})
 - ▶ —name the ion “classic stem+ic” for the larger ion
ex: ferric ion (Fe^{3+}), cupric ion (Cu^{2+})remember: think of a third wheel on a date:
2 < 3 two's company “us”; three's a crowd “ick”
- ▶ **Stock System**
 - ▶ —name the ion “element name (charge) ion”
ex: iron (II) ion (Fe^{2+}), copper (I) ion (Cu^{+})
ex: iron (III) ion (Fe^{3+}), copper (II) ion (Cu^{2+})

Classic Stems for Ancient Metals

- ▶ For most elements the stem is simply the first syllable of the elements name.
- ▶ Example:
 - ▶ Chromium produces the Chrom**ous** and Chrom**ic** ions.
 - ▶ Manganese produces Mangan**ous** and Mangan**ic** ions.
 - ▶ Mercury produces the Mercur**ous** and Mercur**ic** ions.
 - ▶ Cobalt produces the Cobalt**ous** and Cobalt**ic** ions.
- ▶ For 11 metal elements the symbol and (in 4 cases) the stem is also based on the latin name (when using the classic system).
 - ▶ Copper produces the Cupr**ic** and Cupr**ous** ions.
 - ▶ Tin produces the Stann**ic** and Stann**ous** ions.
 - ▶ Iron produces the Ferr**ic** and Ferr**ous** ions.
 - ▶ Lead produces the Plumb**ic** and Plumb**ous** ions.
- ▶ On the next slide you'll see the ions of the eight elements whose classical names you are responsible for.

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

Metals that form more than one cation.

	Element	Ion	Classical Name	Stock Name
Cr Fe Co +2/+3	Chromium	Cr ²⁺	Chromous ion	Chromium (II) ion
		Cr ³⁺	Chromic ion	Chromium (III) ion
	Iron	Fe ²⁺	Ferrous ion	Iron (II) ion
		Fe ³⁺	Ferric ion	Iron (III) ion
	Cobalt	Co ²⁺	Cobaltous ion	Cobalt (II) ion
		Co ³⁺	Cobaltic ion	Cobalt (III) ion
Cu Hg +1/+2	Copper	Cu ⁺	Cuprous ion	Copper (I) ion
		Cu ²⁺	Cupric ion	Copper (II) ion
	Mercury	Hg ₂ ²⁺	Mercurous ion	Mercury (I) ion
		Hg ²⁺	Mercuric ion	Mercury (II) ion
Sn Pb Mn +2/+4	Tin	Sn ²⁺	Stannous ion	Tin (II) ion
		Sn ⁴⁺	Stannic ion	Tin (IV) ion
	Lead	Pb ²⁺	Plumbous ion	Lead (II) ion
		Pb ⁴⁺	Plumbic ion	Lead (IV) ion
	Manganese	Mn ²⁺	Manganous ion	Manganese (II) ion
		Mn ⁴⁺	Manganic ion	Manganese (IV) ion

Name or provide the formula for...

• Sulfur

• S_8

• Bromine

• Br_2

• Bromide Ion

• Br^-

• Iron (II)

• Fe^{2+}

• Aluminum Ion

• Al^{3+}

• Cuprous Ion

• Cu^+

• Stannic Ion

• Sn^{4+}

Name or provide the formula for...



• Calcium Ion

• Fluoride Ion

• Iron (III) Ion or
Ferric Ion

• Stannic Ion or
Tin (IV) Ion

• Manganous Ion or
Manganese (II) Ion

Compounds

▶ What are compounds?

- ▶ Compounds are not mixtures.
- ▶ Chemical Bonding
 - ▶ covalent vs ionic bonds
 - ▶ molecular vs ionic compounds

▶ Chemical Formula

- ▶ Symbols in Formulas
- ▶ Kinds of chemical formula
 - ▶ Identification, Composition

▶ Stuff made of 1 element:

- ▶ Elements (atoms or molecules)
- ▶ Ions (charged atoms—monatomic ions)
 - ▶ Ions can have more than one possible charge:
 - ▶ Classical System (historical)
 - ▶ Stock System (you'll like this one better)



Stuff made of 2 elements:

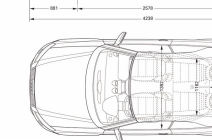
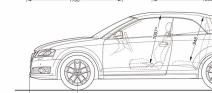
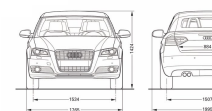
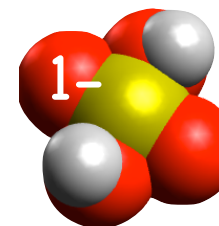
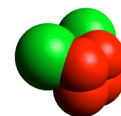
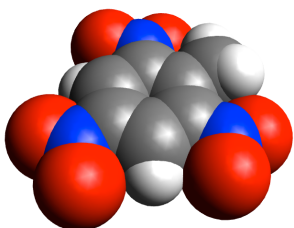
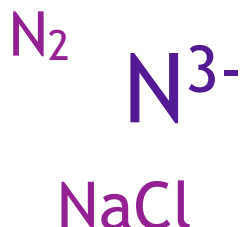
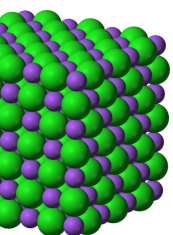
- ▶ When it's a non-metal and a metal
- ▶ When it's a non-metal and a metal w/ more than one possible charge
- ▶ When both elements are non-metals

▶ Some Stuff made of more than 2 elements:

- ▶ Some Oxy-ions (oxygen + one other element)
- ▶ Some other Ions (some stuff that you'll run into a lot)

▶ Hydrogen is a wild card (Acids):

- ▶ Binary compounds with Hydrogen & Binary Acids
- ▶ Some Oxy-ions with Hydrogen
- ▶ Some Oxy-Ion Acids

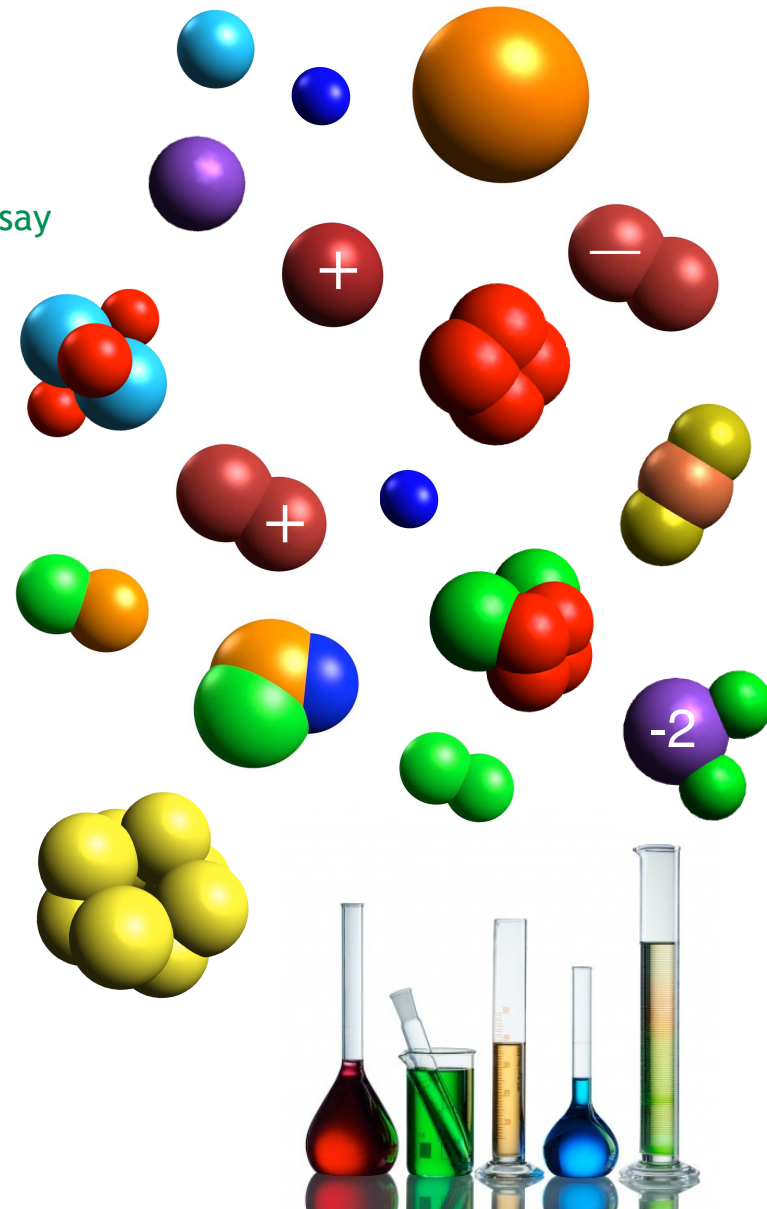


An Overview of Atomic Particles

We will discuss the details of these differences in many chapters. For now, I just want to share the “big picture” with you.

This slide will reappear a lot.

- ▶ Matter is made up of particles.
 - ▶ **Particle** is a generic term for small pieces of matter. We say particle when we want to be vague or comprehensive.
- ▶ Matter is made up of either ions or molecules.
 - ▶ **Ions** are charged particles (+ or -).
 - ▶ **Molecules** are neutral particles (no charge).
- ▶ Ions and molecules are made up of atoms.
 - ▶ **Monatomic** particles are just a single atom.
 - ▶ **Diatomic** particles are particles made of two atoms.
 - ▶ **Polyatomic** particles are made of more than two atoms.
- ▶ Atoms come in 118 flavors (**elements**).
 - ▶ If a sample of matter contains only one flavor atom, we say that sample is an **element**.
 - ▶ Yes, we use the word element two ways!
 - ▶ If a sample of matter contains two elements we say it is a **binary compound** or just a **compound**.
 - ▶ If a sample of matter contains more than two elements we say that sample of matter is a **compound**.



Metals, Non-metals, and Metalloids

[illegible]

All elements are either metals, non-metals, or metaloids.

For naming we just worry whether something is a metal or not a metal.

Metals, Non-metals, and Metalloids

1A 1	2A 2											3A 13	4A 14	5A 15	6A 16	7A 17	8A 18
1 1 H																	2 He
2 3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3 11 Na	12 Mg	3B 3	4B 4	5B 5	6B 6	7B 7	8B 8 9 10			1B 11	2B 12	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4 19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5 37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6 55 Cs	56 Ba	71 Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7 87 Fr	88 Ra	103 Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg		113	114	115	116		118
		<div>Metals</div> <div>Metalloids</div> <div>Nonmetals</div>															
		57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb		
		89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No		

Metals are on the left side of the periodic table.

Metals, Non-metals, and Metalloids

[illegible]

Nonmetals are on the right side of the periodic table (with the exception of H).

Metals, Non-metals, and Metalloids

1A 1	2A 2																				3A 13	4A 14	5A 15	6A 16	7A 17	8A 18
1 H																					5 B	6 C	7 N	8 O	9 F	10 Ne
2 Li	4 Be																				13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
3 Na	12 Mg	3B 3	4B 4	5B 5	6B 6	7B 7	8B 8 9 10			1B 11	2B 12										31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
4 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn										49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
5 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd															
6 Cs	56 Ba		71 Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn								
7 Fr	88 Ra	103 Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112	113	114	115	116										118	

Metals

Metalloids

Nonmetals

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

Metalloids
are not metals.
We don't distinguish
between metalloids
and non-metals
in naming!

The 7 Metalloids:

B, Si, Ge, As, Sb, Te & At

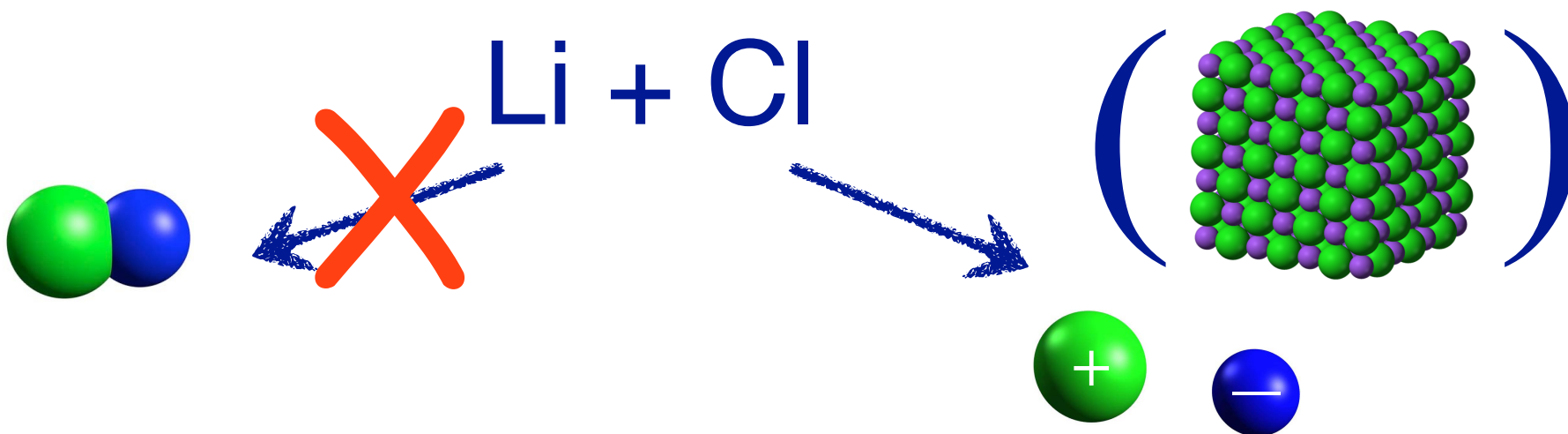
border the stair-step line

(Al is not a metalloid)

Metals, Nonmetals, and Metalloids

- Metals
 - With the exception of mercury, all metals are solids at room temperature.
 - Metals have high luster and are good conductors of electricity and heat.
 - Metals are malleable (can be rolled or hammered into sheets) and are ductile (can be drawn into wires).
 - Most metals have a high melting point and a high density.
 - Metals tend to form cations.
 - Often form ions with easily predictable charges (exception is transition metals).
- Nonmetals
 - Not lustrous.
 - Have low melting pts. and densities.
 - Poor conductors of heat and electricity.
 - Are brittle.
 - Have lower boiling point, melting point, and density.
 - Nonmetals tend to form anions.
- Metalloids
 - Have properties that are intermediate between those of metals and those of non-metals.
 - For naming we don't distinguish between metalloids and non-metals.

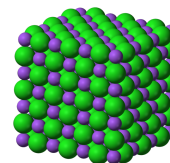
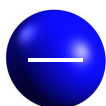
Metal + NonMetal Binary Compounds



- ▶ A binary compound of a metal and a non-metal forms ions – not a molecule.
- ▶ The ions collect into a huge ionic mass.
- ▶ We still write the formula as the ratio of the two ions in the compound (e.g. **LiCl**, MgCl_2 , Li_3N , etc)
- ▶ We name binary compounds by just writing the names of the two ions:

Lithium ion + chloride ion = lithium chloride

The cation
always goes first!



Name or provide the formula for...



Sodium Bromide



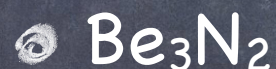
Magnesium Chloride



Potassium Sulfide



Aluminum Fluoride



Beryllium Nitride



Hydrogen Chloride



Lithium Hydride (hydrogen is a wild card)



Cesium Phosphide



Sodium Carbide



Potassium Oxide

Metal + NonMetal Binary Compounds

- Some cations can have more than one charge.

- Iron, Cobalt, Mercury, Tin, Copper, etc.

- You can use known charge on the anion, to read the charge of the cation from a formula.

- If the cation has a variable charge, you must indicate that charge in its name.

- When you have a choice, use the stock system.



Ferrous Chloride ?

Ferric Chloride ?



Chloride Ion

3x Chloride Ion

Fe must be

Ferrous Ion is +2 Ferric Ion is +3

FeCl_3 is Ferric Chloride
also called Iron (III) Chloride

Total Charge

0

-1

-3

+3

0

Name or provide the formula for...

- | | |
|---------------------------|----------------------------------------------|
| • FeCl_3 | Ferric Chloride or Iron (III) Chloride |
| • SnS | Stannous Sulfide or Tin (II) Sulfide |
| • CrN | Chromic Nitride or Chromium (III) Nitride |
| • CuBr | Cuprous Bromide or Copper (I) Bromide |
| • Hg_2F_2 | Mercurous Fluoride or Mercury (I) Fluoride |
| • HgF_2 | Mercuric Fluoride or Mercury (II) Fluoride |
| • CoS | Cobaltous Sulfide or Cobalt (II) Sulfide |
| • MgCl_2 | Magnesium Chloride (Mg has only one charge!) |
| • SnS_2 | Stannic Sulfide or Tin (IV) Sulfide |
| • FeO | Ferrous Oxide or Iron (II) Oxide |

Metal + NonMetal Binary Compounds

- ▶ To write the formula, you need to know the ratio of atoms. — It's not always one to one.
- ▶ Molecules always have a net charge of zero.
- ▶ Use the known charge of the atoms to figure out the **smallest whole number ratio** of atoms.

Mg²⁺



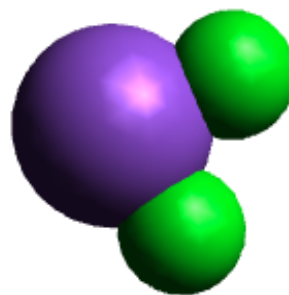
Cl⁻



Magnesium Chloride

2+

2x 1-



MgCl₂

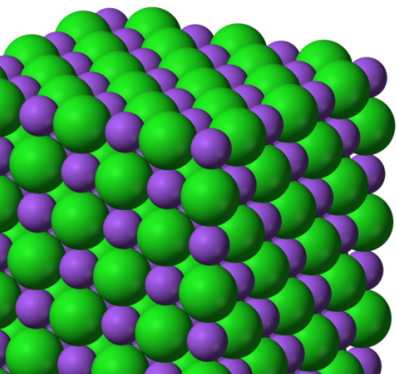
Total Charge

0

+2

-2

0



Metal + NonMetal Binary Compounds

- ▶ To write the formula, you need to know the ratio of atoms. — It's not always one to one.
- ▶ Molecules always have a net charge of zero.
- ▶ Use the known charge of the atoms to figure out the **smallest whole number ratio** of atoms.

Ba²⁺



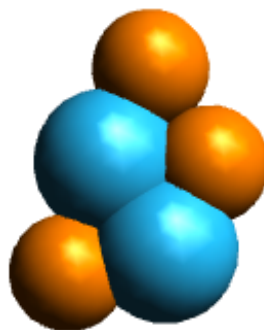
P³⁻



Barium Phosphide

3x 2+

2x 3-



Ba₃P₂

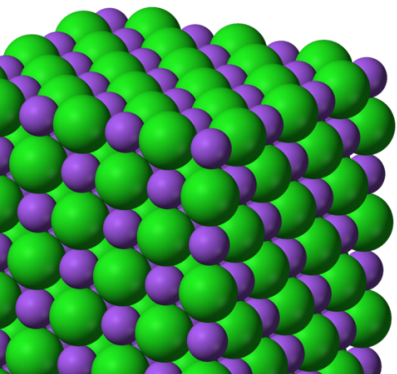
Total Charge

0

+6

-6

0



Metal + NonMetal Binary Compounds

- ▶ To write the formula, you need to know the ratio of atoms. — It's not always one to one.
- ▶ Molecules always have a net charge of zero.
- ▶ Use the known charge of the atoms to figure out the **smallest whole number ratio** of atoms.

Sn^{4+}



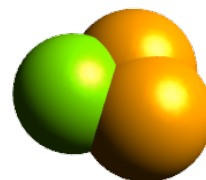
S^{2-}



Tin (IV) Sulfide

4+

2x 2-



SnS_2

Total Charge

0

+4

-4

0

Don't just use the charge of one atom as the subscript for the other. If you do, you may get something silly like: Sn_2S_4

Name or provide the formula for...

• Beryllium Sulfide	BeS
• Calcium Chloride	CaCl ₂
• Potassium Sulfide	K ₂ S
• Aluminum Fluoride	AlF ₃
• Magnesium Nitride	Mg ₃ N ₂
• Hydrogen Chloride	HCl
• Cesium Phosphide	Cs ₃ P
• Calcium Carbide	Ca ₂ C
• Aluminum Oxide	Al ₂ O ₃
• Calcium Hydride	CaH ₂

Compounds

What are compounds?

- Compounds are not mixtures.
- Chemical Bonding
 - covalent vs ionic bonds
 - molecular vs ionic compounds

Chemical Formula

- Symbols in Formulas
- Kinds of chemical formula
 - Identification, Composition

Stuff made of 1 element:

- Elements (atoms or molecules)
- Ions (charged atoms—monatomic ions)
 - Ions can have more than one possible charge:
 - Classical System (historical)
 - Stock System (you'll like this one better)

Stuff made of 2 elements:

- When it's a non-metal and a metal
- When it's a non-metal and a metal w/ more than one possible charge



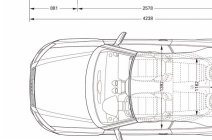
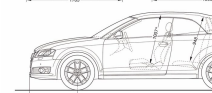
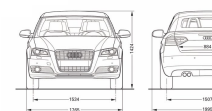
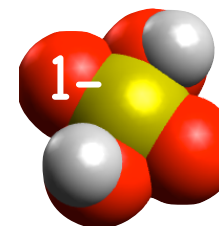
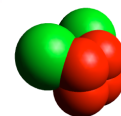
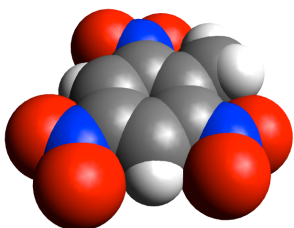
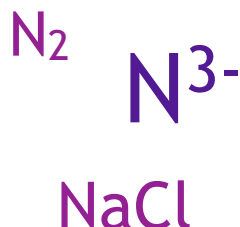
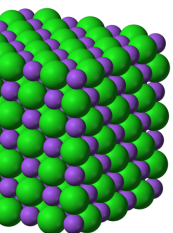
When both elements are non-metals

Some Stuff made of more than 2 elements:

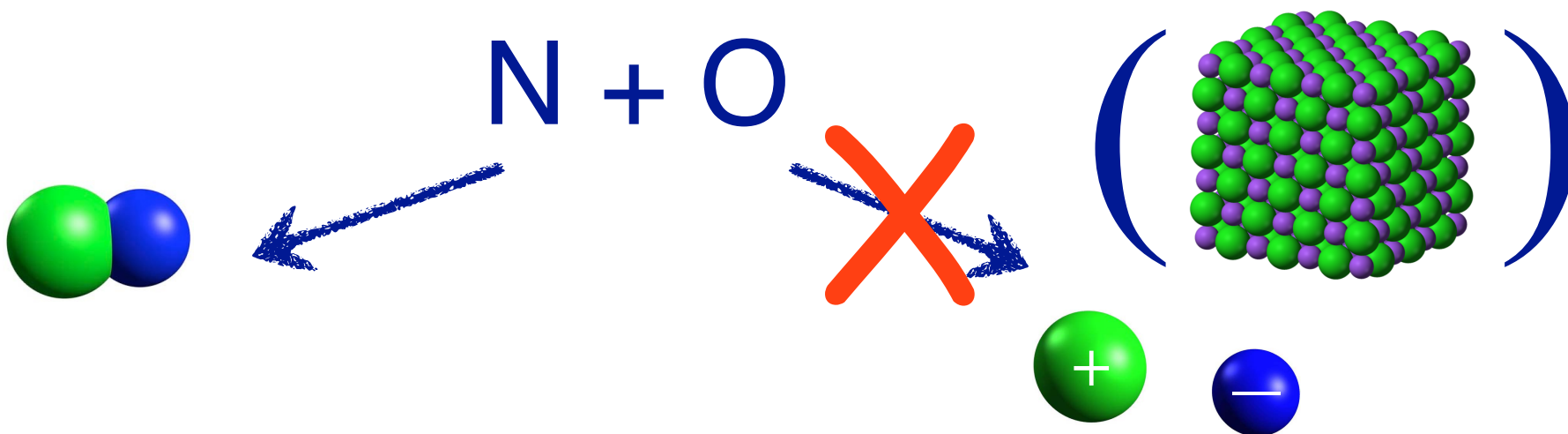
- Some Oxy-ions (oxygen + one other element)
- Some other Ions (some stuff that you'll run into a lot)

Hydrogen is a wild card (Acids):

- Binary compounds with Hydrogen & Binary Acids
- Some Oxy-ions with Hydrogen
- Some Oxy-Ion Acids



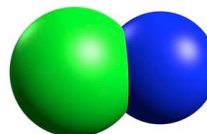
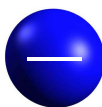
Two NonMetal Binary Compounds



- ▶ A binary compound of two non-metals form a molecule – not ions.
- ▶ To name it though, we treat the binary compound as if it were two ions.
- ▶ We choose the **most anion-like thing** and call it the **anion**. Oxide ion.
- ▶ We choose the **most cation-like thing** and call it the **cation**. Nitrogen ion.
- ▶ We name it by just writing the names of the two *imaginary* ions:

Nitrogen ion + oxide ion = nitrogen oxide

The cation
always goes first!



Two NonMetal Binary Compounds

Which one is “anion”-like?

- ▶ F is the king.
- ▶ As you get farther away from F, on the PT you get less “anion”-like.

N or O

— oxygen forms the anion

Nitrogen Oxide

O or F

— fluorine forms the anion

Oxygen Fluoride

C or Br

— bromine forms the anion

Carbon Bromide

Si or Cl

— chlorine forms the anion

Silicon Chloride

P or S

— sulfur forms the anion

Phosphorus Sulfide

F is the king.

1A

1

1

H

2A

2

2

He

3A

13

5

B

4A

14

6

C

5A

15

7

N

6A

16

8

O

7A

17

9

F

8A

18

10

Ne

3

Li

4

Be

11

Na

12

Mg

3B

3

4B

4

5B

5

6B

6

7B

7

8B

8

9

10

1B

11

2B

12

13

Al

14

Si

15

P

16

S

17

Cl

18

Ar

19

K

20

Ca

21

Sc

22

Ti

23

V

24

Cr

25

Mn

26

Fe

27

Co

28

Ni

29

Cu

30

Zn

31

Ga

32

Ge

33

As

34

Se

35

Br

36

Kr

37

Rb

38

Sr

39

Y

40

Zr

41

Nb

42

Mo

43

Tc

44

Ru

45

Rh

46

Pd

47

Ag

48

Cd

49

In

50

Sn

51

Sb

52

Te

53

I

54

Xe

55

Cs

56

Ba

71

Lu

72

Hf

73

Ta

74

W

75

Re

76

Os

77

Ir

78

Pt

79

Au

80

Hg

81

Tl

82

Pb

83

Bi

84

Po

85

At

86

Rn

87

Fr

88

Ra

103

Lr

104

Rf

105

Db

106

Sg

107

Bh

108

Hs

109

Mt

110

Ds

111

Rg

112

113

114

115

116

118

57

La

58

Ce

59

Pr

60

Nd

61

Pm

62

Sm

63

Eu

64

Gd

65

Tb

66

Dy

67

Ho

68

Er

69

Tm

70

Yb

89

Ac

90

Th

91

Pa

92

U

93

Np

94

Pu

95

Am

96

Cm

97

Bk

98

Cf

99

Es

100

Fm

101

Md

102

No

Metals

Metalloids

Nonmetals

F

O

Cl

N

Br

I

S

C

P

B

Si

We're not done...

the ions don't really exist, so you can't use charge to figure out how many atoms are in the formula!

Summary: Naming Binary Compounds

- ▶ Lithium + Chlorine forms LiCl
 - always (this is a metal and nonmetal)
- ▶ Iron + Chlorine forms FeCl_2 or FeCl_3
 - so we have to differentiate (multiple charge metal and nonmetal)
- ▶ Phosphorus + Chlorine forms PCl_2 , PCl_3 , PCl_5 , P_2Cl_7 ...
 - so we *really* have to differentiate (this is two nonmetals)

Prefix to indicate number of atoms of each element

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

*mono is omitted for the cation, but is required for the anion
example: CO is carbon monoxide

Lithium Chloride

Iron (II) Chloride

or

Iron (III) Chloride

Phosphorus Dichloride

or

Phosphorus Trichloride

or

Phosphorus Pentachloride

or

Diphosphorus Heptachloride

Name or provide the formula for...

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



Nitrogen Monoxide



Oxygen Monofluoride



Nitrogen Trioxide



Dinitrogen Pentoxide



Triboron Hexachloride



Phosphorus (what's the other polyatomic element?)



Tetraphosphorus Decoxide



Diboron Triphosphide



Dichlorine monoxide



Chlorine (what are the 7 diatomic elements?)

Name or provide the formula for...

• Carbon Tetrachloride

CCl_4 (common solvent)

• Dioxygen Monofluoride

O_2F

• Nitrogen Dioxide

NO_2

• Diphosphorus Nonachloride

P_2Cl_9

• Hexabromine Dinitride

Br_6N_2

• Disulfur Tetrabromide

S_2Br_4

• Silicon Dioxide

SiO_2 (sand)

• Dinitrogen Pentoxide

N_2O_5

• Nitrogen Trioxide

NO_3

• Nitrogen Oxide

NO (should be nitrogen monoxide!)

Compounds

What are compounds?

- Compounds are not mixtures.
- Chemical Bonding
 - covalent vs ionic bonds
 - molecular vs ionic compounds

Chemical Formula

- Symbols in Formulas
- Kinds of chemical formula
 - Identification, Composition

Stuff made of 1 element:

- Elements (atoms or molecules)
- Ions (charged atoms—monatomic ions)
 - Ions can have more than one possible charge:
 - Classical System (historical)
 - Stock System (you'll like this one better)

Stuff made of 2 elements:

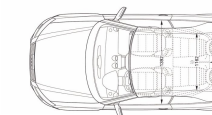
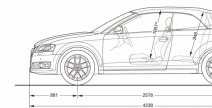
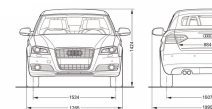
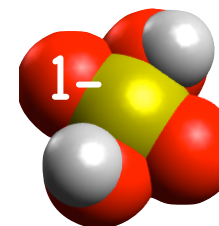
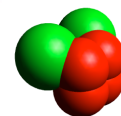
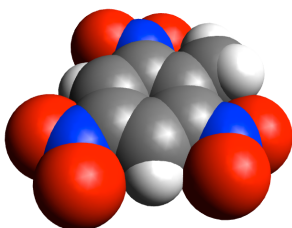
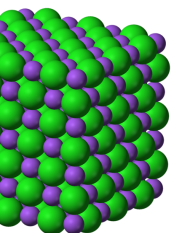
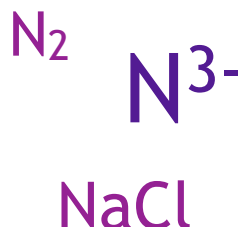
- When it's a non-metal and a metal
- When it's a non-metal and a metal w/ more than one possible charge
- When both elements are non-metals

Some Stuff made of more than 2 elements:

- Some Oxy-ions (oxygen + one other element)
- Some other Ions (some stuff that you'll run into a lot)

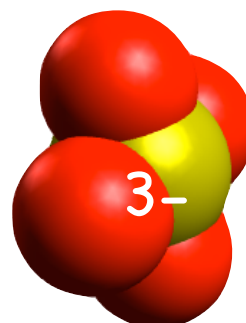
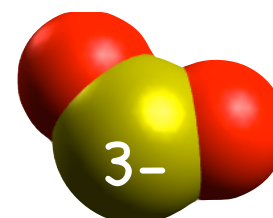
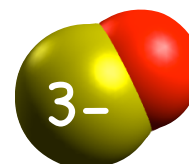
Hydrogen is a wild card (Acids):

- Binary compounds with Hydrogen & Binary Acids
- Some Oxy-ions with Hydrogen
- Some Oxy-Ion Acids



Oxy-ions are Polyatomic Ions

- ▶ Most of the polyatomic ions you will be responsible for are oxy-ions.
- ▶ Oxy-ions are elements with some number of oxygen atoms clustered around them with a charge on the whole package.
- ▶ Basically a dog pile on one atom, with oxygen pulling at it's electrons.
 - ▶ C, N, P, S, and the halogens Cl, Br, and I form oxy-ions.
 - ▶ Fluorine is the king, he's never on the bottom of the dog pile!
- ▶ Oxy-ions will vary by:
 - ▶ The element of the central atom.
 - ▶ The number of oxygen atoms.
 - ▶ The charge on the central atom.
- ▶ There are other polyatomic ions you will be responsible for, but most will be oxy-ions.



							He
		5 B	6 C	7 N	8 O	9 F	10 Ne
		13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
9 u	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
7 g	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
9 u	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
11 a	112 Cn	113 Uut	114 Fl	115 Uup	116 Lv	117 Uus	118 Uuo

HELLO
my name is

Ferric Chloride

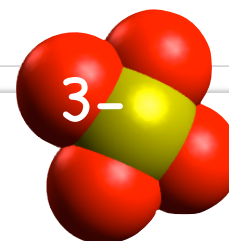
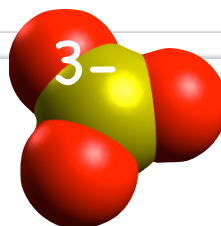
You can call me "FeCl₃"

Naming Oxy-ions

The Element at
the center
of the ion

Chg the
element
prefers

Chg of
the ion



3/4 ions

P	-3	-3	4 oxygens 3 oxygens	PO_4^{3-} PO_3^{3-}	Phosph ate ion Phosph ite ion
S	-2	-2	4 oxygens 3 oxygens	SO_4^{2-} SO_3^{2-}	Sulf ate ion Sulf ite ion

2/3 ions

C	-4/+4	-2	3 oxygens 2 oxygens	CO_3^{2-} CO_2^{2-}	Carbon ate ion Carbon ite ion
N	-3	-1	3 oxygens 2 oxygens	NO_3^{1-} NO_2^{1-}	Nitr ate ion Nitr ite ion
Cl, Br, I	-1	-1	4 oxygens 3 oxygens 2 oxygens 1 oxygen	BrO_4^{1-} BrO_3^{1-} BrO_2^{1-} BrO_1^{1-}	Per brom ate ion Brom ate ion Brom ite ion Hypo brom ite ion

Think of a party, and
remember: I "ate more". The ate ion
has more oxygens.



Ammonium ion

Hydroxide ion

Acetate Ion

Cyanide Ion

- ▶ All 20 oxy-ions have the same charge as their central atom normally prefers — except carbon and nitrogen
- ▶ P and S oxy-ions have 3 or 4 oxygens.
- ▶ C, N, Cl, Br, and I oxy-ions have 2 or 3 oxygens.
- ▶ The "ite" ion is always the one with less oxygens.
- ▶ The "ate" ion is always the one with more oxygens.
- ▶ The 3 halogens can **super** size: 4 oxygens = **per**chlorate ion
- ▶ The 3 halogens can also have a really small ion: 1 oxygen = **hypo**chlorite ion
- ▶ There are four misc polyatomic ions you should also know:
 NH_4^{1+} , OH^{1-} , OAc^{1-} , and CN^{1-} .

HELLO
my name is

Ferric Chloride

You can call me "FeCl3"

Using Polyatomic Ions

- ▶ Lithium + Chlorine forms LiCl
 - always (this is a metal and nonmetal)
- ▶ Iron + Chlorine forms FeCl_2 or FeCl_3
 - so we have to differentiate (multiple charge metal and nonmetal)

Lithium Chloride

Iron (II) Chloride
or

Iron (III) Chloride

Use polyatomic ions like you used monoatomic ions:

- ▶ Lithium + Nitrate Ion (NO_3^{1-}) forms LiNO_3
 - polyatomic anions are just like monoatomic anions.
- ▶ Iron + Nitrate Ion (NO_3^{1-}) forms $\text{Fe}(\text{NO}_3)_2$ or $\text{Fe}(\text{NO}_3)_3$
 - if the metal can have more than one charge, specify the charge.
 - use parenthesis for multiple polyatomic ions in a compound.
- ▶ Ammonium Ion (NH_4^{1+}) + Chlorine forms NH_4Cl
 - polyatomic cations are just like monoatomic cations.

Lithium Nitrate

Iron (II) Nitrate
or

Iron (III) Nitrate

Ammonium Chloride

Name or provide the formula for...



Carbonate Ion



Sulfite Ion



Nitrate Ion



Lithium Nitrate



Magnesium Carbonite



Magnesium Nitrite



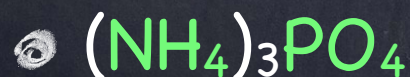
Calcium Cyanide



Potassium Bromate



Potassium *Per*bromate

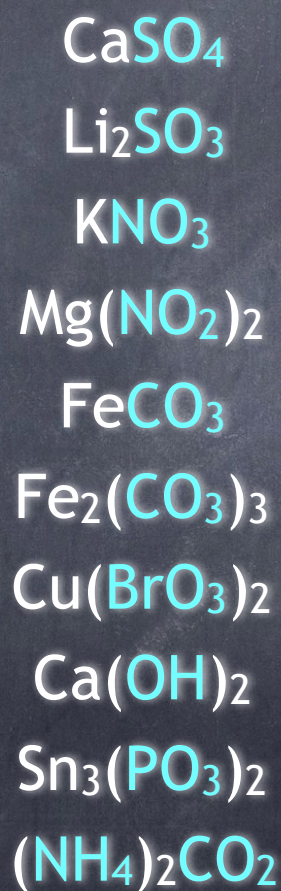


Ammonium Phosphate

P	-3	4	PO_4^{3-}
		3	PO_3^{3-}
S	-2	4	SO_4^{2-}
		3	SO_3^{2-}
C	-2	3	CO_3^{2-}
		2	CO_2^{2-}
N	-1	3	NO_3^{1-}
		2	NO_2^{1-}
Cl, Br, I	-1	4	ClO_4^{1-}
		3	ClO_3^{1-}
		2	ClO_2^{1-}
		1	ClO^{1-}
			NH_4^+
			OH^-
			O_2^{2-}
			CN^-

Name or provide the formula for...

- ☉ Calcium Sulfate
- ☉ Lithium Sulfite
- ☉ Potassium Nitrate
- ☉ Magnesium Nitrite
- ☉ Iron (II) Carbonate
- ☉ Iron (III) Carbonate
- ☉ Cupric Bromate
- ☉ Calcium Hydroxide
- ☉ Tin (II) Phosphite
- ☉ Ammonium Carbonite



P	-3	4 3	PO_4^{3-} PO_3^{3-}
S	-2	4 3	SO_4^{2-} SO_3^{2-}
C	-2	3 2	CO_3^{2-} CO_2^{2-}
N	-1	3 2	NO_3^{1-} NO_2^{1-}
Cl, Br, I	-1	4	ClO_4^{1-}
		3	ClO_3^{1-}
		2	ClO_2^{1-}
		1	ClO^{1-}
			NH_4^+
			OH^-
			O_2^{2-}
			CN $^-$

Compounds

What are compounds?

- Compounds are not mixtures.
- Chemical Bonding
 - covalent vs ionic bonds
 - molecular vs ionic compounds

Chemical Formula

- Symbols in Formulas
- Kinds of chemical formula
 - Identification, Composition

Stuff made of 1 element:

- Elements (atoms or molecules)
- Ions (charged atoms—monatomic ions)
 - Ions can have more than one possible charge:
 - Classical System (historical)
 - Stock System (you'll like this one better)

Stuff made of 2 elements:

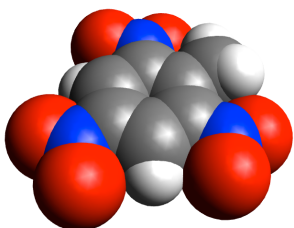
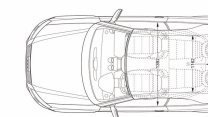
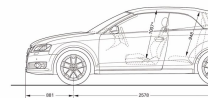
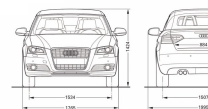
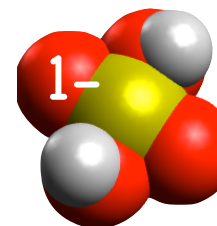
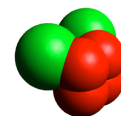
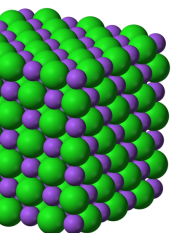
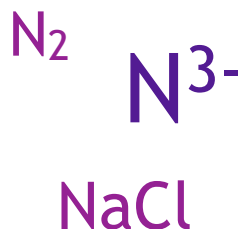
- When it's a non-metal and a metal
- When it's a non-metal and a metal w/ more than one possible charge
- When both elements are non-metals

Some Stuff made of more than 2 elements:

- Some Oxy-ions (oxygen + one other element)
- Some other Ions (some stuff that you'll run into a lot)

Hydrogen is a wild card (Acids):

- Binary compounds with Hydrogen & Binary Acids
- Some Oxy-ions with Hydrogen
- Some Oxy-Ion Acids



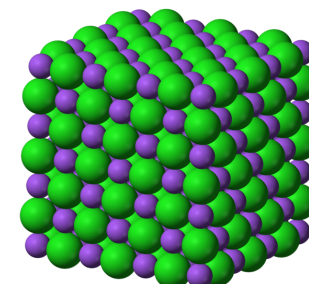
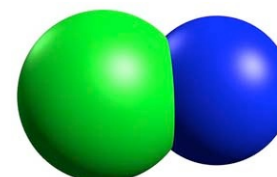
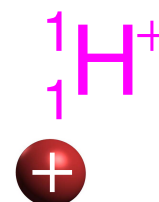
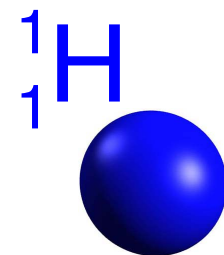
Acids

- ▶ **Acids** are compounds which release hydrogen ions (H^+)
 - ▶ Hydrogen ions are simply free protons.
 - ▶ They are the most concentrated source of a positive charge chemists know of – acids can be dangerous.
- ▶ Binary compounds where one of the two non-metals is hydrogen are not acids. But some become acids when they're dissolved in water.
 - ▶ Binary compounds only release protons into water.
- ▶ The binary compounds that become acids are: HF , HCl , HBr , and HI
- ▶ We indicate something is dissolved in water by putting "(aq)" after it's formula. Aqueous is Latin for "with water."
- ▶ To name a binary acid add "-ic acid" to the anion and prefix the name with "hydro".

HBr is hydrogen bromide. It's not an acid.

HBr (aq) is **hydrobromic acid**.

HCl (aq) is **hydrochloric acid**, a very powerful acid.



What's the name or formula?

Answer:

Hydrogen Bromide
Hydrobromic Acid
 Hydroiodic Acid

HBr
 HBr (aq)
 HI (aq)

HF
 HCl (aq)

Hydrogen Fluoride
Hydrochloric Acid



Naming Oxy-ions

	The Element at the center of the ion	Chg the element prefers	Chg of the ion			
3/4 ions	P	-3	-3	4 oxygens	PO_4^{3-}	Phosph ate ion
				3 oxygens	PO_3^{3-}	Phosph ite ion
	S	-2	-2	4 oxygens	SO_4^{2-}	Sulf ate ion
				3 oxygens	SO_3^{2-}	Sulf ite ion
2/3 ions	C	-4/+4	-2	3 oxygens	CO_3^{2-}	Carbon ate ion
				2 oxygens	CO_2^{2-}	Carbon ite ion
	N	-3	-1	3 oxygens	NO_3^{1-}	Nitr ate ion
				2 oxygens	NO_2^{1-}	Nitr ite ion
	Cl, Br, I	-1	-1	4 oxygens	BrO_4^{1-}	Per brom ate ion

Think of a party, and remember: I "ate more". The ate ion has more oxygens.

NH_4^{1+} Ammonium ion
 OH^{1-} Hydroxide ion
 OAc^{1-} ($\text{CH}_3\text{CO}_2^{1-}$) Acetate ion
 CN^{1-} Cyanide ion

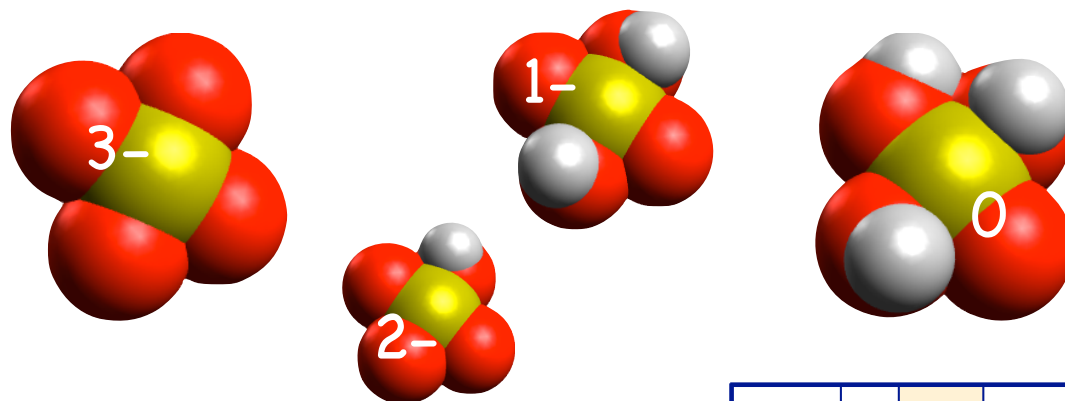
- ▶ All 20 oxy-ions have the same charge as their central atom normally prefers – except carbon and nitrogen
- ▶ P and S oxy-ions have 3 or 4 oxygens.
- ▶ C, N, Cl, Br, and I oxy-ions have 2 or 3 oxygens.
- ▶ The "ite" ion is always the one with less oxygens.
- ▶ The "ate" ion is always the one with more oxygens.
- ▶ The 3 halogens can **super** size: 4 oxygens = **per**chlorate ion
- ▶ The 3 halogens can also have a really small ion: 1 oxygen = **hypo**chlorite ion
- ▶ There are four misc polyatomic ions you should also know:
 NH_4^{1+} , OH^{1-} , OAc^{1-} , and CN^{1-} .

HELLO
my name is

Ferric Chloride
You can call me "FeCl₃"

Hydrogen with Polyatomic Ions

- ▶ Hydrogen ion is a wild card, it changes a lot of things.
- ▶ Some polyatomic ions have extra hydrogen ions attached to them, but are still ions. That changes their names slightly.
- ▶ An **acid** is a compound that releases hydrogen ions.
(we'll talk more about acids next chapter)
- ▶ Polyatomic ions with enough hydrogens on them to neutralize their charge are acids.
- ▶ Monatomic ions with a hydrogen ion attached to them **are not acids** — but some become acids in water.



SO_4^{2-} is sulfate ion
 HSO_4^- is hydrogen sulfate ion
 H_2SO_4 is **not an ion** — it's an acid.

PO_4^{3-} is phosphate ion
 HPO_4^{2-} is hydrogen phosphate ion
 H_2PO_4^- is dihydrogen phosphate ion
 H_3PO_4 is **not an ion** — it's an acid.

HNO_3 is an acid.

HClO_4 is an acid.

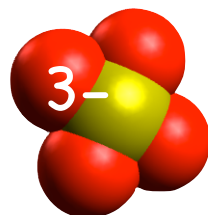
... the acids name is derived from the name of the ion.

P	-3	4 3	PO_4^{3-} PO_3^{3-}
S	-2	4 3	SO_4^{2-} SO_3^{2-}
C	-2	3 2	CO_3^{2-} CO_2^{2-}
N	-1	3 2	NO_3^{1-} NO_2^{1-}
Cl, Br, I	-1	4 3 2 1	ClO_4^{1-} ClO_3^{1-} ClO_2^{1-} ClO^{1-}



Hydrogen with Polyatomic Ions

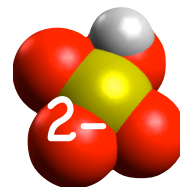
- ▶ Polyatomic ions with a charge larger than 1- can add a hydrogen and still be an ion.
- ▶ We name them by just adding “hydrogen” or “dihydrogen” to the name of the oxy-ion.
- ▶ Then we treat them as any other ion in naming compounds that contain them.
- ▶ Ions of sulfur and carbon have a common name (nick name). Because we need twice as much of the -1 ion to do the work of a -2 ion, we call them “bi”carbonate.



SO₄²⁻ is sulfate ion
 HSO₄⁻ is hydrogen sulfate ion
 H₂SO₄ is **not an ion** — it's an acid.

PO₄³⁻ is phosphate ion
 HPO₄²⁻ is hydrogen phosphate ion
 H₂PO₄⁻ is dihydrogen phosphate ion
 H₃PO₄ is **not an ion** — it's an acid.

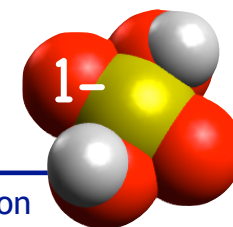
P	PO ₄ ³⁻ PO ₃ ³⁻
S	SO ₄ ²⁻ SO ₃ ²⁻
C	CO ₃ ²⁻ CO ₂ ²⁻



Add 1H

Add 2H

P	PO ₄ ³⁻ PO ₃ ³⁻	Phosph ate ion Phosph ite ion	HPO ₄ ²⁻ HPO ₃ ²⁻	Hydrogen Phosph ate ion Hydrogen Phosph ite ion	H ₂ PO ₄ ¹⁻ H ₂ PO ₃ ¹⁻	Dihydrogen Phosph ate ion Dihydrogen Phosph ite ion
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Add 1H

Nick Name

S	SO ₄ ²⁻ SO ₃ ²⁻	Sulf ate ion Sulf ite ion	HSO ₄ ¹⁻ HSO ₃ ¹⁻	Hydrogen Sulf ate ion Hydrogen Sulf ite ion	Bisulfate ion Bisulfite ion
C	CO ₃ ²⁻ CO ₂ ²⁻	Carbon ate ion Carbon ite ion	HCO ₃ ¹⁻ HCO ₂ ¹⁻	Hydrogen Carbon ate ion Hydrogen Carbon ite ion	Bicarbonate ion Bicarbonite ion

Hydrogen with Polyatomic Ions

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 HPO₄²⁻ is hydrogen phosphate ion
 H₂PO₄⁻ is dihydrogen phosphate ion
 H₃PO₄ is **not an ion** — it's an acid.

P	PO ₄ ³⁻ PO ₃ ³⁻
S	SO ₄ ²⁻ SO ₃ ²⁻
C	CO ₃ ²⁻ CO ₂ ²⁻

What's the name or formula?

Answer:

Hydrogen Sulfate Ion

HPO₄²⁻

HPO₃²⁻

HCO₃¹⁻

Potassium Hydrogen Sulfate

Lithium Dihydrogen Phosphite

MgHPO₄

NaH₂PO₄

LiHSO₃

NaHCO₃

HSO₄¹⁻

Hydrogen Phosphate Ion

Hydrogen Phosphite Ion

Hydrogen Carbonate Ion (aka “Bicarbonate Ion”)

KHSO₄

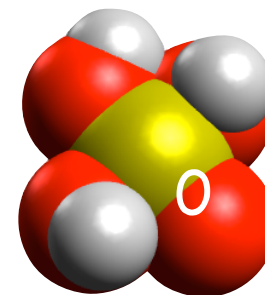
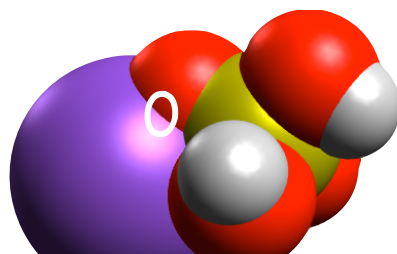
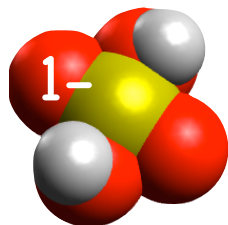
LiH₂PO₃

Magnesium Hydrogen Phosphate

Sodium Dihydrogen Phosphate

Lithium Hydrogen Sulfite (“Lithium Bisulfite”)

Sodium Hydrogen Carbonate (“Sodium Bicarbonate”)

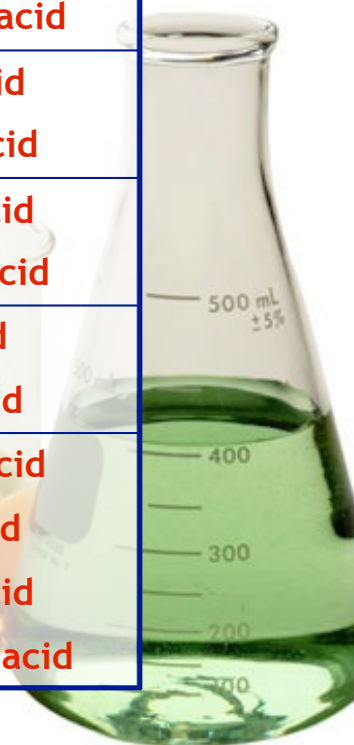


Polyatomic Ions form Oxy-Acids

- ▶ Polyatomic ions with enough hydrogens on them to neutralize their charge become acids.
- ▶ Oxy acids do not need to be in water to be acids, they are acids with or without (aq).

- ▶ To name acids of oxy-ions, replace
 - ▶ the “-ate ion” with “-ic acid”
 - ▶ the “-ite ion” with “-ous acid”

P	PO_4^{3-}	Phosph ate ion	H_3PO_4	Phosphor ic acid
	PO_3^{3-}	Phosph ite ion	H_3PO_3	Phosphor ous acid
S	SO_4^{2-}	Sulf ate ion	H_2SO_4	Sulfur ic acid
	SO_3^{2-}	Sulf ite ion	H_2SO_3	Sulfur ous acid
C	CO_3^{2-}	Carbon ate ion	H_2CO_3	Carbon ic acid
	CO_2^{2-}	Carbon ite ion	H_2CO_2	Carbon ous acid
N	NO_3^{1-}	Nitr ate ion	HNO_3	Nitr ic acid
	NO_2^{1-}	Nitr ite ion	HNO_2	Nitr ous acid
Cl, Br, I	ClO_4^{1-}	Perchlor ate ion	HClO_4	Perchlor ic acid
	ClO_3^{1-}	Chlor ate ion	HClO_3	Chlor ic acid
	ClO_2^{1-}	Chlor ite ion	HClO_2	Chlor ous acid
	ClO^{1-}	Hypochlor ite ion	HClO	Hypochlor ous acid



Polyatomic Ions form Oxy-Acids

- ▶ To name acids of oxy-ions, replace
- ▶ the “-ate ion” with “-ic acid”
- ▶ the “-ite ion” with “-ous acid”

▶ Write the name or formula for these oxy-acids:



Phosphoric Acid



Sulfurous Acid



Chloric Acid



Perchloric Acid

▶ Nitric Acid



▶ Carbonous Acid



▶ Sulfuric Acid



▶ Bromic Acid

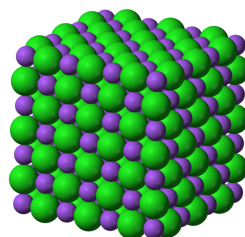


P	-3	4 3	PO_4^{3-} PO_3^{3-}
S	-2	4 3	SO_4^{2-} SO_3^{2-}
C	-2	3 2	CO_3^{2-} CO_2^{2-}
N	-1	3 2	NO_3^{1-} NO_2^{1-}
Cl, Br, I	-1	4 3 2 1	ClO_4^{1-} ClO_3^{1-} ClO_2^{1-} ClO^{1-}

Compounds

► Molecules & Compounds

- Compounds are not mixtures.
- Chemical Bonding
 - covalent vs ionic bonds
 - molecular vs ionic compounds

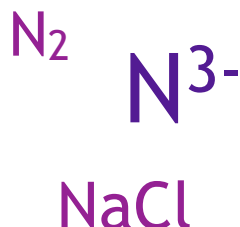


► Chemical Formula

- Symbols in Formulas
- Kinds of chemical formula
 - Identification, Composition

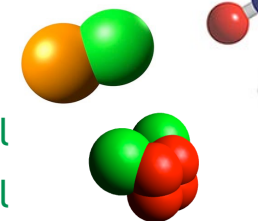
► Stuff made of 1 element:

- Elements (atoms or molecules)
- Ions (charged atoms—monatomic ions)
 - Ions can have more than one possible charge:
 - Classical System (historical)
 - Stock System (you'll like this one better)



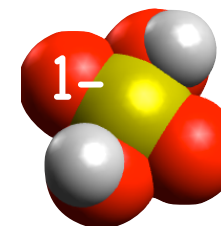
► Stuff made of 2 elements:

- When it's a non-metal and a metal
- When it's a non-metal and a metal w/ more than one possible charge
- When both elements are non-metals



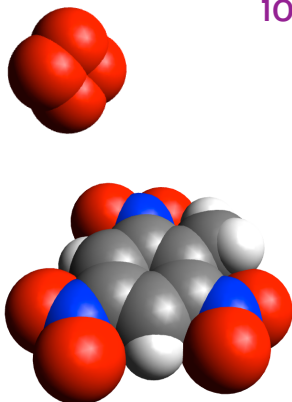
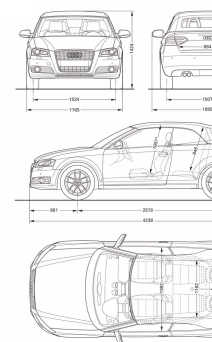
► Some Stuff made of more than 2 elements:

- Some Oxy-ions (oxygen + one other element)
- Some other Ions (some stuff that you'll run into a lot)



► Hydrogen is a wild card (Acids):

- Binary compounds with Hydrogen & Binary Acids
- Some Oxy-ions with Hydrogen
- Some Oxy-Ion Acids



Compounds

▶ What are compounds?

- ▶ Compounds are not mixtures.
- ▶ Chemical Bonding
 - ▶ covalent vs ionic bonds
 - ▶ molecular vs ionic compounds

▶ Chemical Formula

- ▶ Symbols in Formulas
- ▶ Kinds of chemical formula
 - ▶ Identification, Composition

▶ Stuff made of 1 element:

- ▶ Elements (atoms or molecules)
- ▶ Ions (charged atoms—monatomic ions)
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▶ Stuff made of 2 elements:

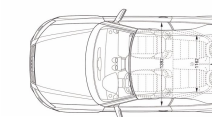
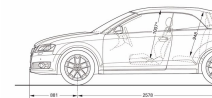
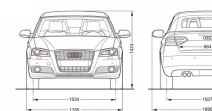
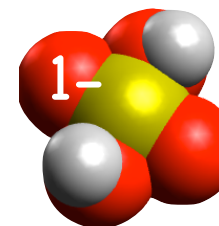
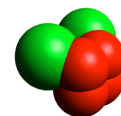
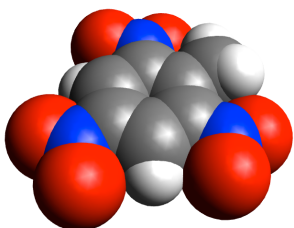
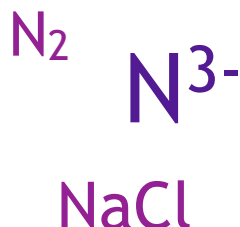
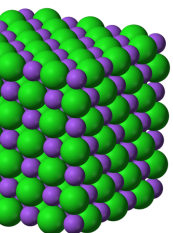
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Questions?

