

Nomenclature

A logical system for naming substances.

This is an endless subject, we're just going to take on a small but useful part of it.



A naming system for...

→ Stuff made of 1 element:

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

▶ Stuff made of 2 elements:

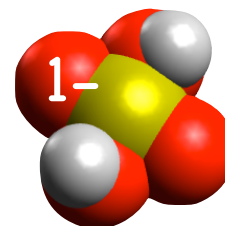
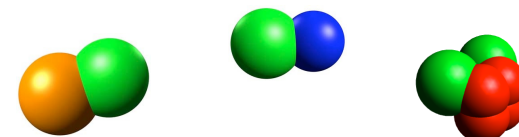
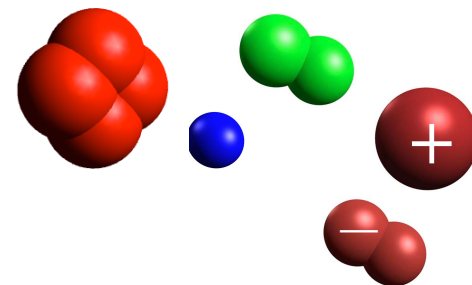
- ▶ When it's a non-metal and a metal
- ▶ When it's a non-metal and a metal w/ more than one possible charge
- ▶ When both elements are non-metals

▶ 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)
- ▶ Use them just like monatomic ions

▶ Hydrogen is a wild card (Acids):

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

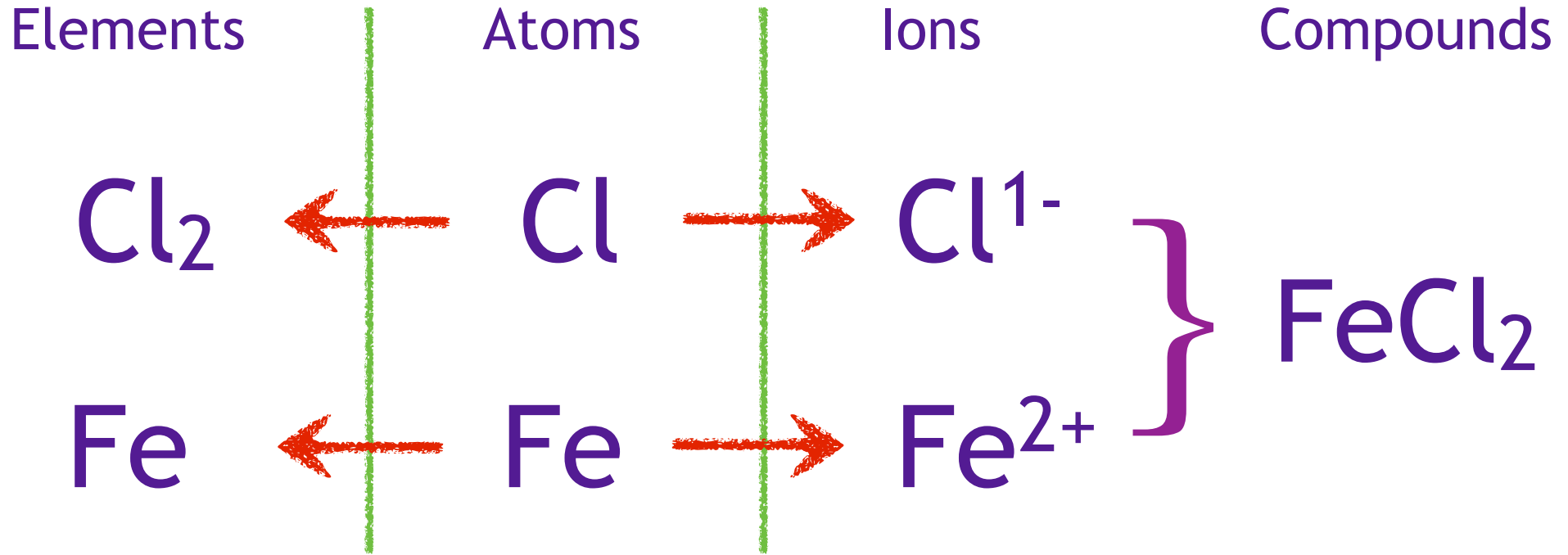


HELLO
my name is

Ferric Chloride

You can call me "FeCl₃"

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

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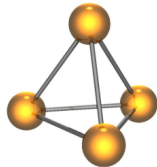
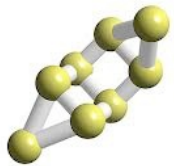
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Naming Elements

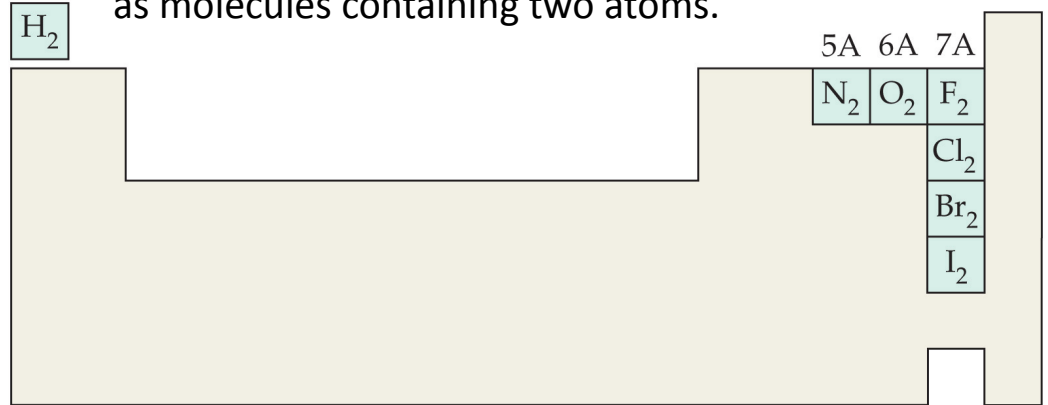
The name for any substance that contains atoms of only one element, is just the name of that element. The formula is also easy:

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

Sulfur, S_8 and Phosphorous, P_4



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

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

Mg^{2+} 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

N^{3-} is nitride ion

C^{4-} 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!

Ion charge trends: +1 +2 (left side), +3 +4 (top right), -3 -2 -1 0 (right side).

1A 1 1 H	2A 2 2 Li Be	3A 13 3 B	4A 14 4 C	5A 15 5 N	6A 16 6 O	7A 17 7 F	8A 18 8 He											
3 11 Na	4 12 Mg	3B 3 21 Sc	4B 4 22 Ti	5B 5 23 V	6B 6 24 Cr	7B 7 25 Mn	8B 8 26 Fe	9 27 Co	10 28 Ni	1B 11 29 Cu	2B 12 30 Zn	13 13 31 Ga	14 14 32 Ge	15 15 33 As	16 16 34 Se	17 17 35 Br	18 18 36 Kr	
4 19 K	20 20 Ca	21 39 Y	22 40 Zr	23 41 Nb	24 42 Mo	25 43 Tc	26 44 Ru	27 45 Rh	28 46 Pd	29 47 Ag	30 48 Cd	31 49 In	32 50 Sn	33 51 Sb	34 52 Te	35 53 I	36 54 Xe	
5 37 Rb	38 38 Sr	39 71 Lu	40 72 Hf	41 73 Ta	42 74 W	43 75 Re	44 76 Os	45 77 Ir	46 78 Pt	47 79 Au	48 80 Hg	49 81 Tl	50 82 Pb	51 83 Bi	52 84 Po	53 85 At	54 86 Rn	
6 55 Cs	56 88 Ba	57 87 Fr	58 88 Ra	103 103 Lr	104 104 Rf	105 105 Db	106 106 Sg	107 107 Bh	108 108 Hs	109 109 Mt	110 110 Ds	111 111 Rg	112 112 Cn	113 113 Nh	114 114 Fl	115 115 Mc	116 116 Lv	118 118 Og
Metals		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			
Metalloids		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			
Nonmetals																		

Cr Fe Co +2/+3

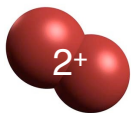
Cu Hg +1/+2

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 Chromous and Chromic ions
- ▶ For 11 metal elements the symbol and in some cases the stem are based on the latin name.
- ▶ Example:
 - ▶ Copper produces the Cupric and Cuprous ions
 - ▶ Tin produces the Stannic and Stannous ions

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

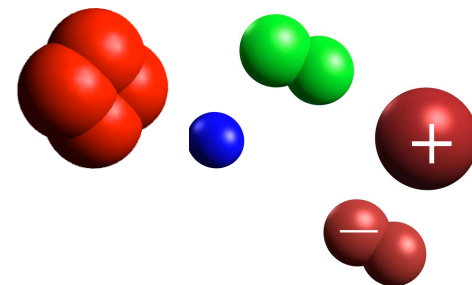
• Stannic Ion or
Tin (IV) Ion

• Manganous Ion or
Manganese (II) Ion

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▶ Stuff made of 2 elements:

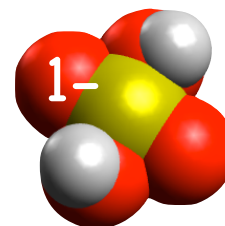
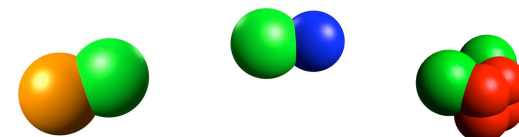
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- ▶ Binary compounds with Hydrogen & Binary Acids
- ▶ Some Oxy-ions with Hydrogen
- ▶ Some Oxy-Ion Acids



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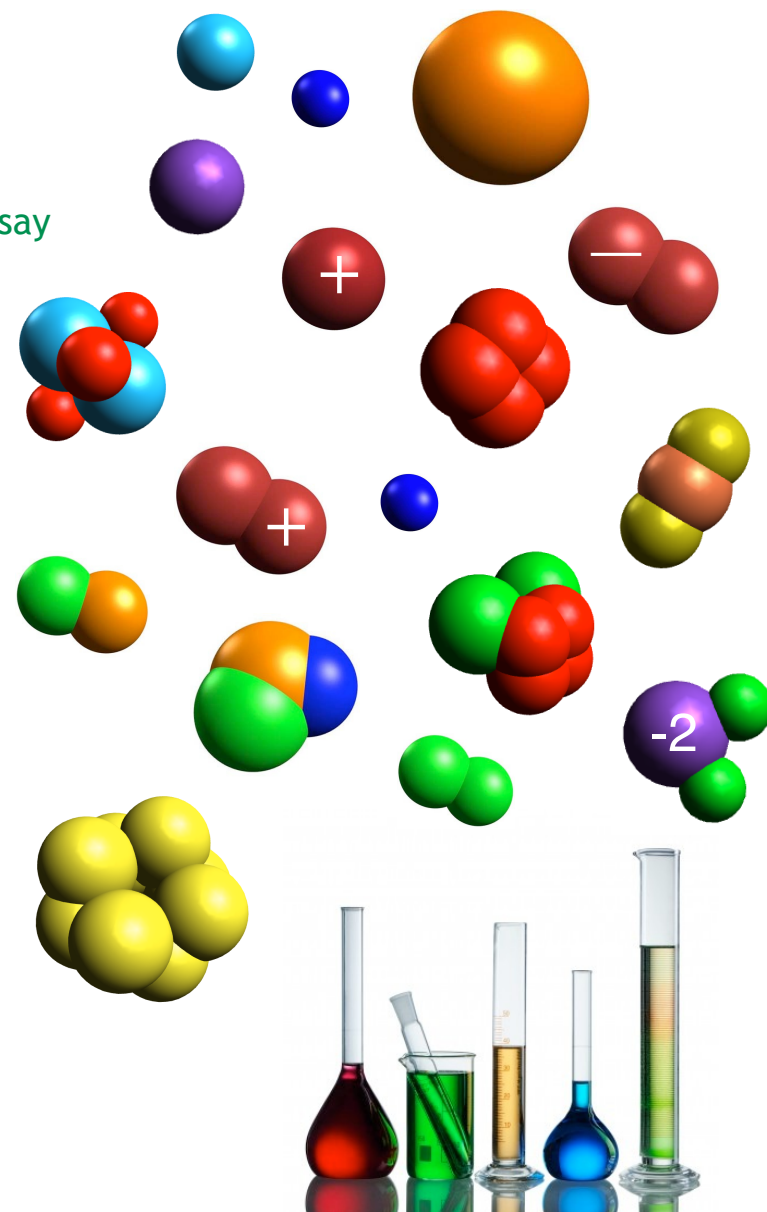
You can call me "FeCl₃"

An Overview of Atomic Particles

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

This slide will reappear a lot.
in chapters 1,2 & 3.

- ▶ 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

	1A 1																			8A 18						
1	1 H	2A 2																			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															118

Metals	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
Metalloids	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
Nonmetals														

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

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

Metals, Non-metals, and Metalloids

1A 1	1	2A 2									3A 13	4A 14	5A 15	6A 16	7A 17	8A 18 2		
1	H															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	112	113	114	115	116		118

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Metalloids	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
Nonmetals														

Metals are on the left side of the periodic table.

Metals, Non-metals, and Metalloids

1A 1	2A 2											3A 13	4A 14	5A 15	6A 16	7A 17	8A 18
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4 19 K	20 20 Ca	21 21 Sc	22 22 Ti	23 23 V	24 24 Cr	25 25 Mn	26 26 Fe	27 27 Co	28 28 Ni	29 29 Cu	30 30 Zn	31 31 Ga	32 32 Ge	33 33 As	34 34 Se	35 35 Br	36 36 Kr
5 37 Rb	38 38 Sr	39 39 Y	40 40 Zr	41 41 Nb	42 42 Mo	43 43 Tc	44 44 Ru	45 45 Rh	46 46 Pd	47 47 Ag	48 48 Cd	49 49 In	50 50 Sn	51 51 Sb	52 52 Te	53 53 I	54 54 Xe
6 55 Cs	56 56 Ba	71 71 Lu	72 72 Hf	73 73 Ta	74 74 W	75 75 Re	76 76 Os	77 77 Ir	78 78 Pt	79 79 Au	80 80 Hg	81 81 Tl	82 82 Pb	83 83 Bi	84 84 Po	85 85 At	86 86 Rn
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Nonmetals																	

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

Metals, Non-metals, and Metalloids

1A 1																				8A 18
1 H	2A 2											3A 13	4A 14	5A 15	6A 16	7A 17	2 He			
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3 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			
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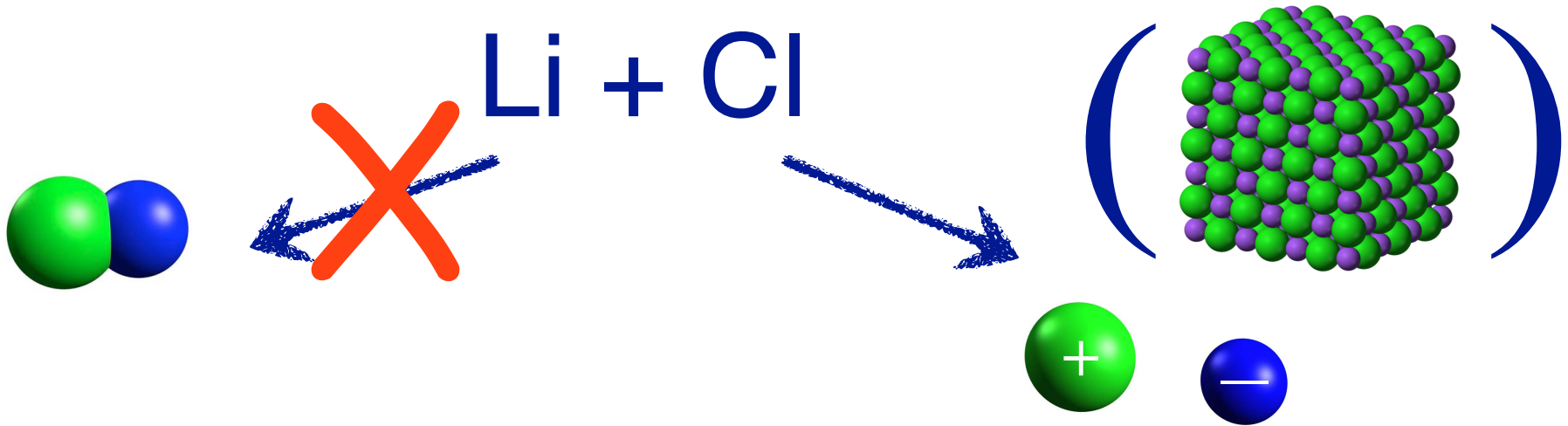
Metalloids
 are not metals.
 We don't distinguish
 between metalloids
 and non-metals
 in naming!

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.

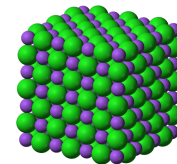
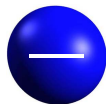
Metal + NonMetal Binary Compounds



- ▶ 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...

- ② FeCl_3 Ferric Chloride or Iron (III) Chloride
- ② SnS Stannous Sulfide or Tin (II) Sulfide
- ② CrN Chromic Nitride or Chromium (III) Nitride
- ② CuBr Cuprous Bromide or Copper (I) Bromide
- ② Hg_2F_2 Mercurous Fluoride or Mercury (I) Fluoride
- ② HgF_2 Mercuric Fluoride or Mercury (II) Fluoride
- ② CoS Cobaltous Sulfide or Cobalt (II) Sulfide
- ② MgCl_2 Magnesium Chloride (Mg has only one charge!)
- ② SnS_2 Stannic Sulfide or Tin (IV) Sulfide
- ② 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⁺



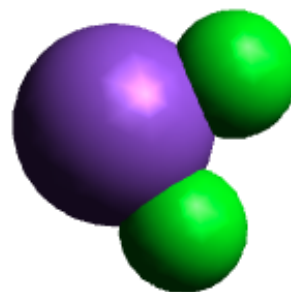
Cl⁻



Magnesium Chloride

2+

2x 1-



MgCl₂

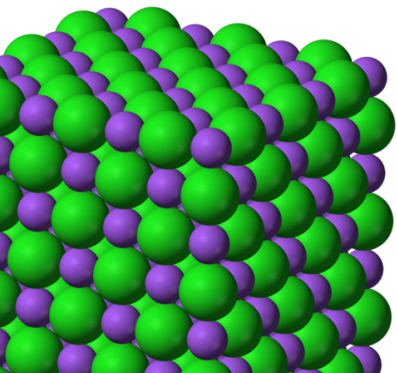
Total Charge

0

+2

-2

0

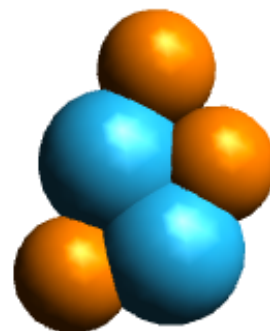


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Barium Phosphide



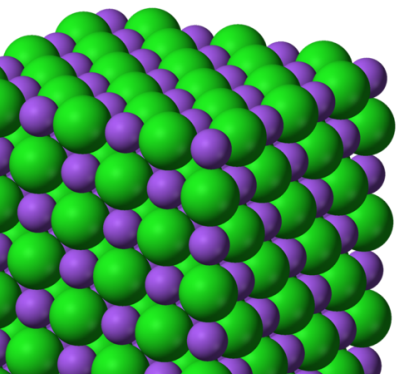
Total Charge

0

+6

-6

0

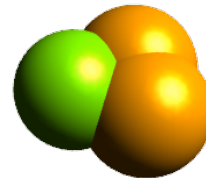


Metal + NonMetal Binary Compounds

- ▶ 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.



Tin (IV) Sulfide



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

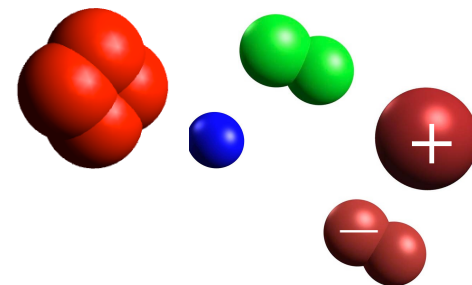
Name or provide the formula for...

• 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

A naming system for...

▶ Stuff made of 1 element:

- ▶ Elements (atoms or molecules)
- ▶ Ions (charged atoms—monatomic ions)
 - ▶ Ions with 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

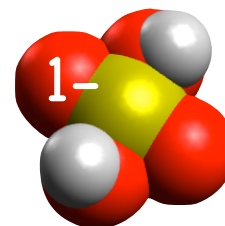
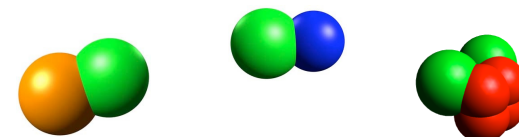


▶ Some Stuff made of more than 2 elements:

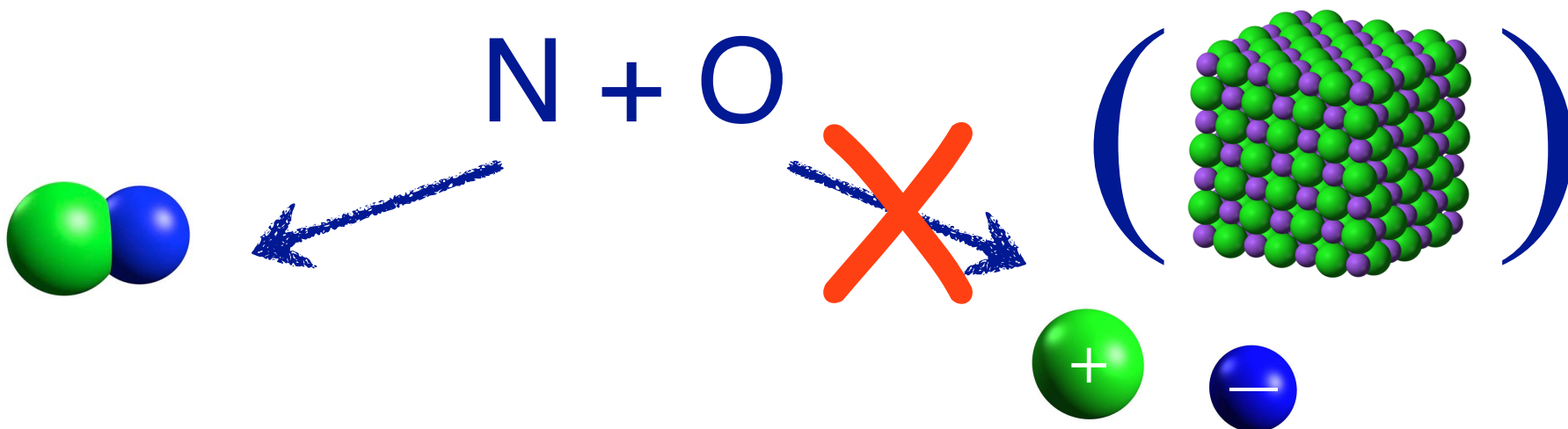
- ▶ Some Oxy-ions (oxygen + one other element)
- ▶ Some other ions (some stuff that you'll run into a lot)
- ▶ Use them just like monatomic ions

▶ Hydrogen is a wild card (Acids):

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



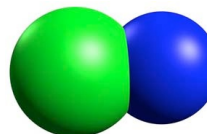
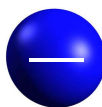
Two NonMetal Binary Compounds



- ▶ 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.

The periodic table shows the relative positions of elements. A red arrow points from Fluorine (F) to Nitrogen (N) and Oxygen (O). A blue arrow points from F to Carbon (C). A purple arrow points from F to Silicon (Si). A green arrow points from F to Chlorine (Cl). A vertical list on the right side of the table lists the following elements from top to bottom: F, O, Cl, N, Br, I, S, C, P, B, Si.

1A 1 1 H	2A 2 2 He	3A 13 3 Li	4A 14 4 Be	5A 15 5 B	6A 16 6 C	7A 17 7 N	8A 18 8 O	9A 19 9 F	10A 20 10 Ne																								
11 Na	12 Mg	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	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
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	117	118	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		

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
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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

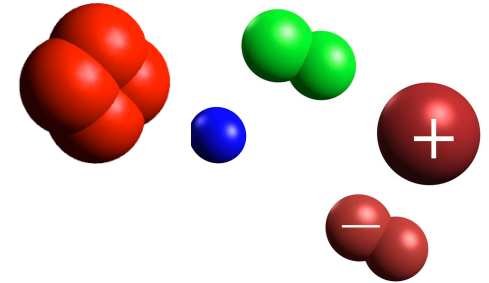
☉ Nitrogen Oxide

NO (should be nitrogen monoxide!)

A naming system for...

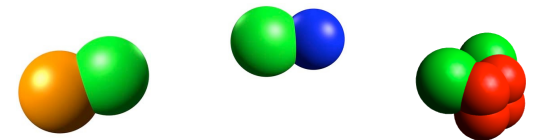
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- ▶ When both elements are non-metals



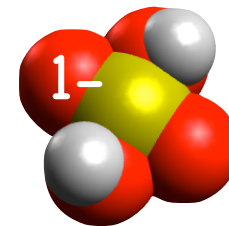
→ ▶ Some Stuff made of more than 2 elements:

- ▶ Some Oxy-ions (oxygen + one other element)
- ▶ Some other ions (some stuff that you'll run into a lot)
- ▶ Use them just like monatomic ions



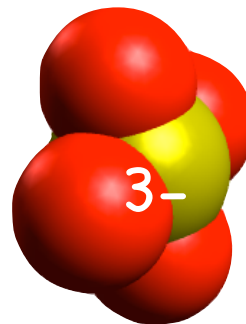
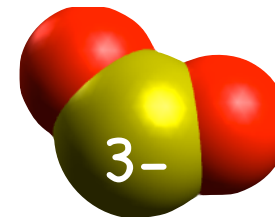
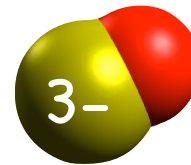
▶ Hydrogen is a wild card (Acids):

- ▶ 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.



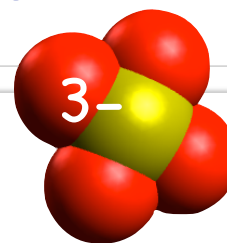
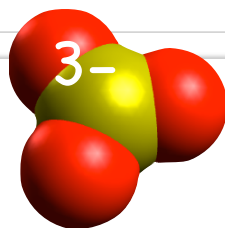
							He
		5 B	6 C	7 N	8 O	9 F	10 Ne
		13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
9 u	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
7 g	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
9 u	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
11 a	112 Cn	113 Uut	114 Fl	115 Uup	116 Lv	117 Uus	118 Uuo

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

Element	Chg the element prefers	Chg of the ion	Oxygens	Formula	Name
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

Element	Chg the element prefers	Chg of the ion	Oxygens	Formula	Name
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-}	<i>Per</i> brom ate ion
			3 oxygens	BrO_3^{1-}	Brom ate ion
			2 oxygens	BrO_2^{1-}	Brom ite ion
			1 oxygen	BrO_1^{1-}	<i>Hypo</i> brom ite ion

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

- ▶ 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-} .



Ammonium ion

Hydroxide ion

Acetate Ion

Cyanide Ion

HELLO
my name is

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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

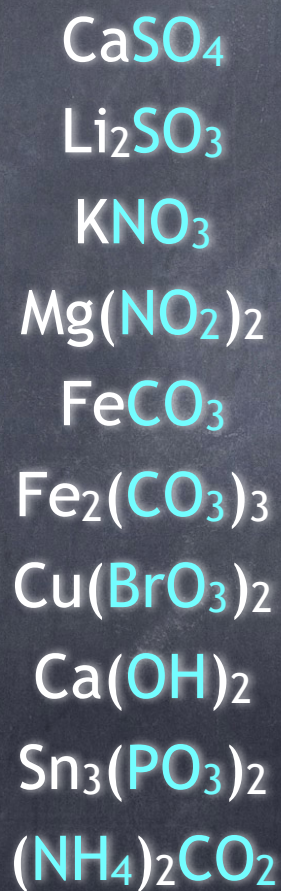


Ammonium Phosphate

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

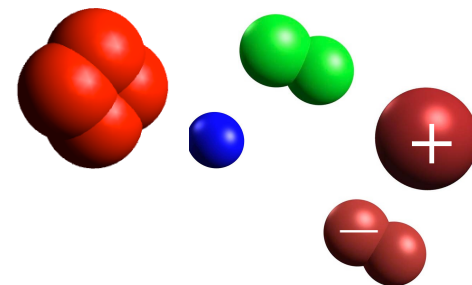


P	-3	4	PO_4^{3-}
		3	PO_3^{3-}
S	-2	4	SO_4^{2-}
		3	SO_3^{2-}
C	-2	3	CO_3^{2-}
		2	CO_2^{2-}
N	-1	3	NO_3^{1-}
		2	NO_2^{1-}
Cl, Br, I	-1	4	ClO_4^{1-}
		3	ClO_3^{1-}
		2	ClO_2^{1-}
		1	ClO^{1-}
			NH_4^+
			OH^-
			O_2^{2-}
			CN^-

A naming system for...

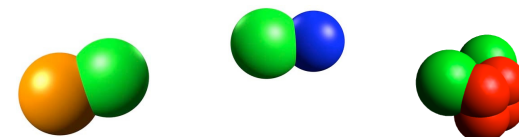
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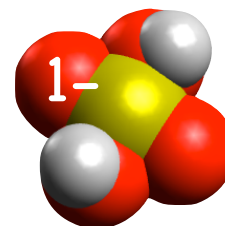
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- ▶ Binary compounds with Hydrogen & Binary Acids
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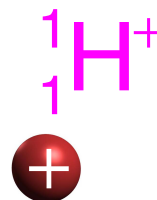
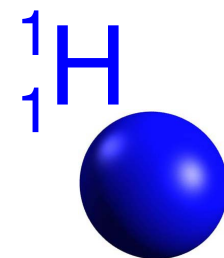
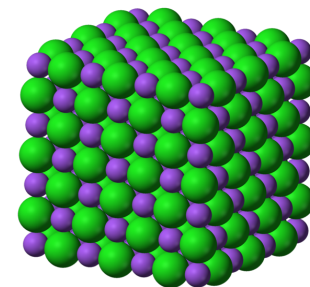
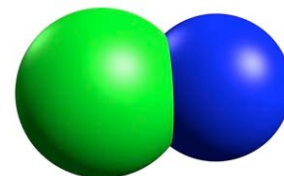
Acids

- ▶ **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.



DANGER
Acid

What's the name or formula?

Hydrogen Bromide
Hydrobromic Acid
Hydroiodic Acid

HF
HCl (aq)

Answer:

HBr
HBr (aq)
HI (aq)

Hydrogen Fluoride
Hydrochloric Acid



HELLO
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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	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-}	<i>Per</i> brom ate ion
			3 oxygens	BrO_3^{1-}	Brom ate ion
			2 oxygens	BrO_2^{1-}	Brom ite ion
			1 oxygen	BrO_1^{1-}	<i>Hypo</i> brom ite ion

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Ammonium ion

Hydroxide ion

Acetate Ion

Cyanide Ion

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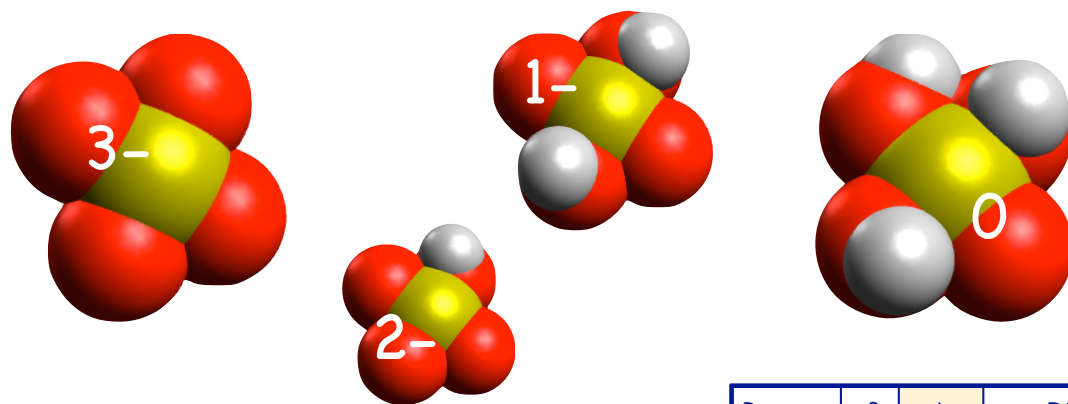
HELLO
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Hydrogen with Polyatomic Ions

- ▶ 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	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-}



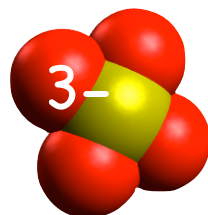
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You can call me "FeCl₃"

Hydrogen with Polyatomic Ions

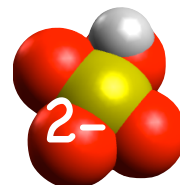
- ▶ Polyatomic ions with a charge larger than 1- can add a hydrogen and still be an ion.
- ▶ We name them by just adding “hydrogen” or “dihydrogen” to the name of the oxy-ion.
- ▶ Then we treat them as any other ion in naming compounds that contain them.
- ▶ Ions of sulfur and carbon have a common name (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.

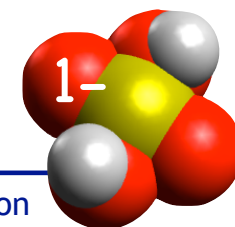
PO₄³⁻ is phosphate ion
 HPO₄²⁻ is hydrogen phosphate ion
 H₂PO₄⁻ is dihydrogen phosphate ion
 H₃PO₄ is **not an ion** — it’s an acid.

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

Nick Name

S	SO ₄ ²⁻ SO ₃ ²⁻	Sulf ate ite ion Sulf ate ite ion	HSO ₄ ¹⁻ HSO ₃ ¹⁻	Hydrogen Sulf ate ite ion Hydrogen Sulf ate ite ion	Bisulf ate ite ion Bisulf ate ite ion
C	CO ₃ ²⁻ CO ₂ ²⁻	Carbon ate ite ion Carbon ate ite ion	HCO ₃ ¹⁻ HCO ₂ ¹⁻	Hydrogen Carbon ate ite ion Hydrogen Carbon ate ite ion	Bicarbon ate ite ion Bicarbon ate ite ion

Hydrogen with Polyatomic Ions

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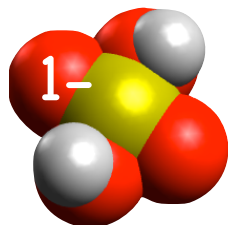
SO₄²⁻ is sulfate ion
 HSO₄⁻ is hydrogen sulfate ion
 H₂SO₄ is **not an ion** — it’s an acid.

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

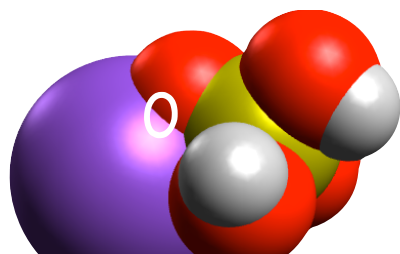
P	PO ₄ ³⁻ PO ₃ ³⁻
S	SO ₄ ²⁻ SO ₃ ²⁻
C	CO ₃ ²⁻ CO ₂ ²⁻

What’s the name or formula?

Hydrogen Sulfate Ion
 HPO₄²⁻
 HPO₃²⁻
 HCO₃¹⁻



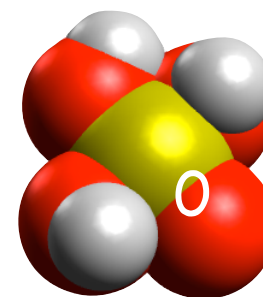
Potassium Hydrogen Sulfate
 Lithium Dihydrogen Phosphite
 MgHPO₄
 NaH₂PO₄
 LiHSO₃
 NaHCO₃



Answer:

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”)

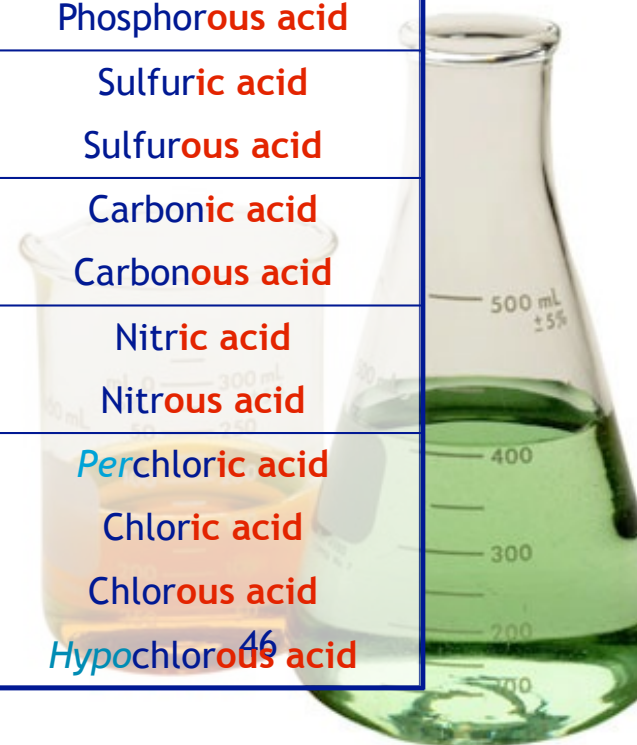


Polyatomic Ions form Oxy-Acids

- ▶ 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	Phosphoric acid
	PO_3^{3-}	Phosph ite ion	H_3PO_3	Phosphorous acid
S	SO_4^{2-}	Sulf ate ion	H_2SO_4	Sulfuric acid
	SO_3^{2-}	Sulf ite ion	H_2SO_3	Sulfurous acid
C	CO_3^{2-}	Carbon ate ion	H_2CO_3	Carbonic acid
	CO_2^{2-}	Carbon ite ion	H_2CO_2	Carbonous acid
N	NO_3^{1-}	Nitr ate ion	HNO_3	Nitric acid
	NO_2^{1-}	Nitr ite ion	HNO_2	Nitrous acid
Cl, Br, I	ClO_4^{1-}	Perchlor ate ion	HClO_4	Perchloric acid
	ClO_3^{1-}	Chlor ate ion	HClO_3	Chloric acid
	ClO_2^{1-}	Chlor ite ion	HClO_2	Chlorous acid
	ClO^{1-}	Hypochlor ite ion	HClO	Hypochlorous 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:

- ▶ H_3PO_4 Phosphoric Acid
- ▶ H_2SO_3 Sulfurous Acid
- ▶ HClO_3 Chloric Acid
- ▶ HClO_4 Perchloric Acid

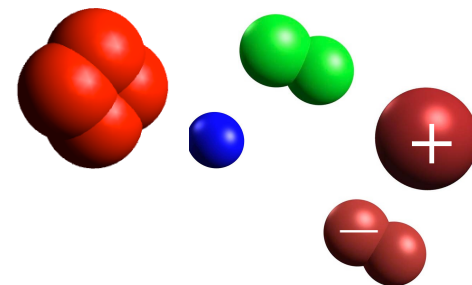
- ▶ Nitric Acid HNO_3
- ▶ Carbonous Acid H_2CO_2
- ▶ Sulfuric Acid H_2SO_4
- ▶ Bromic Acid HBrO_3

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-}

A naming system for...

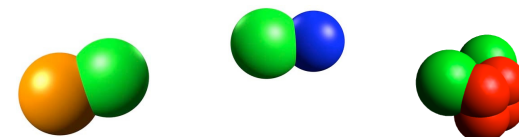
▶ Stuff made of 1 element:

- ▶ Elements (atoms or molecules)
- ▶ Ions (charged atoms—monatomic ions)
 - ▶ Ions with 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



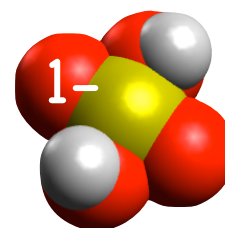
▶ Some Stuff made of more than 2 elements:

- ▶ Some Oxy-ions (oxygen + one other element)
- ▶ Some other ions (some stuff that you'll run into a lot)
- ▶ Use them just like monatomic ions



▶ Hydrogen is a wild card (Acids):

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



HELLO
my name is

Ferric Chloride

You can call me "FeCl₃"

Questions?

HELLO
my name is



Ferric Chloride

You can call me "FeCl₃"