Science 10 Unit A: Chemistry

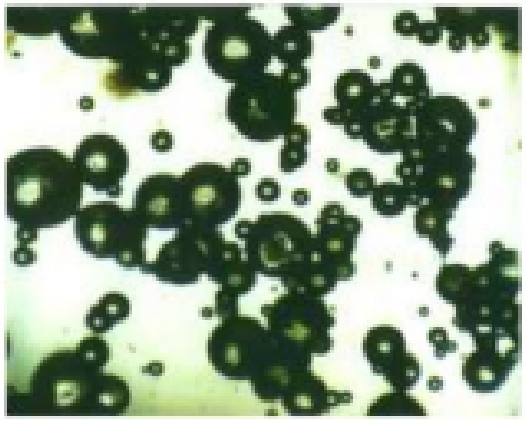
Nomenclature of Ionic Compounds

POS Checklist:

- ☐ recall principles for assigning names to ionic compounds.
- ☐ recall principles for naming molecular substances.
- ☐ explain how an ionic bond results from the simultaneous attraction of oppositely charged ions.

What's in a name?

The scientific world has adopted a standard method for naming any and all chemical compounds. This is called the IUPAC system (International Union of Pure and Applied Chemistry) of naming.



There are three main types of naming:

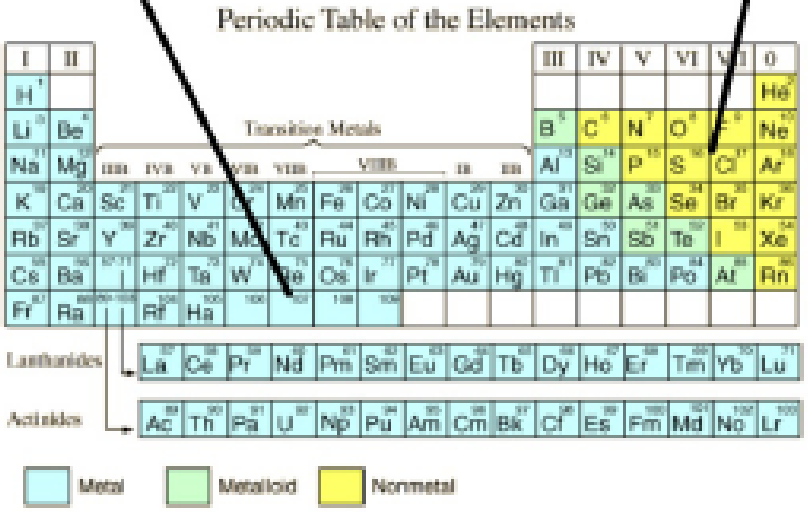
1. **Ionic**
2. **Molecular**
3. **Naming Acids**
4. **Organic Naming (Covered in Chem 30)**

1. Writing formulas for Binary Ionic Compounds

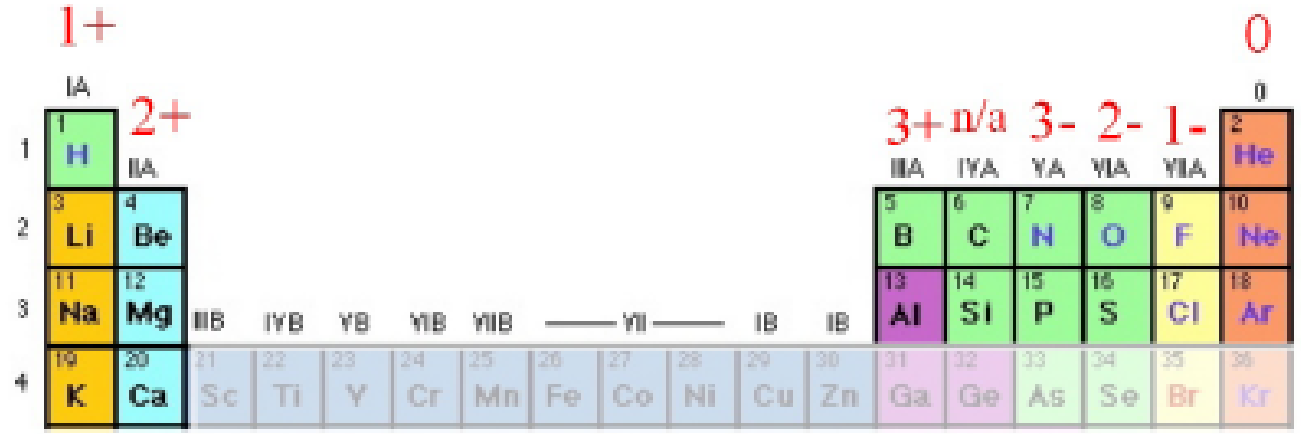
A binary ionic compound is made up of only two (binary means "two") elements: one metal element and one non-metal element

Metals include all the elements left of the staircase. These elements have positive charges.

Nonmetals live on the right of the staircase and have negative charges.

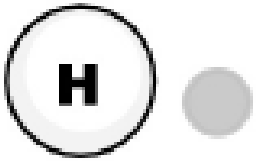


The table is arranged according to charge. Let's look at the first 20 elements.

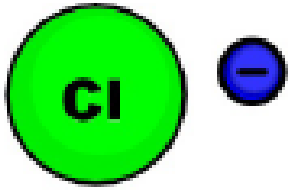


The positive metals ions are attracted to the negative nonmetals ions. The ions bond in a way so that the overall charge in the final compound is neutral.

For example, let's bond a hydrogen ion and a chlorine ion.

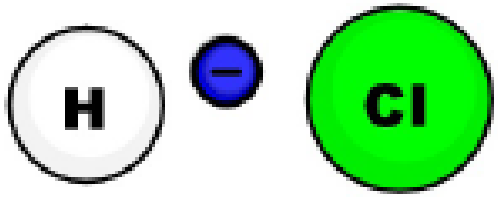


The hydrogen ion is H+. This means it is missing 1 electron (indicated by the grey circle).



The chlorine ion is Cl^-. This means it has one extra electron (in blue).

If we put the two together, the Cl^- will give up its one electron to the H+. The electron forms a bond, represented by the black line. The result is the binary ionic compound HCl. This compound is neutral.



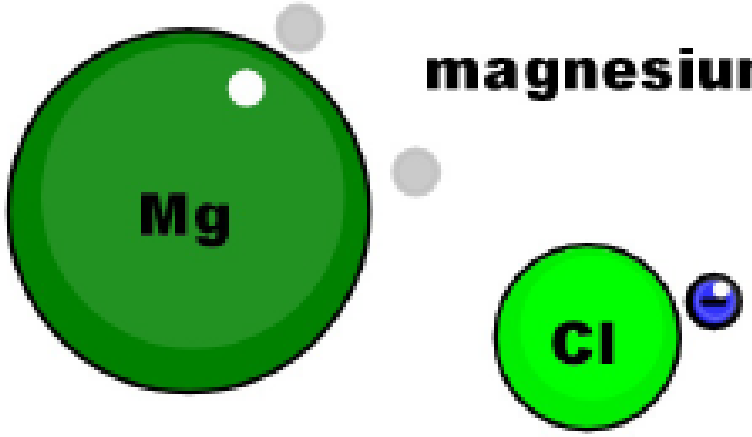
The chemical equation would look like this:

$$H^+ + Cl^- \longrightarrow HCl$$

*Note: the product is always neutral (no + or - signs on it).

The product is called hydrogen chloride.

Let's try something else...magnesium and chlorine.

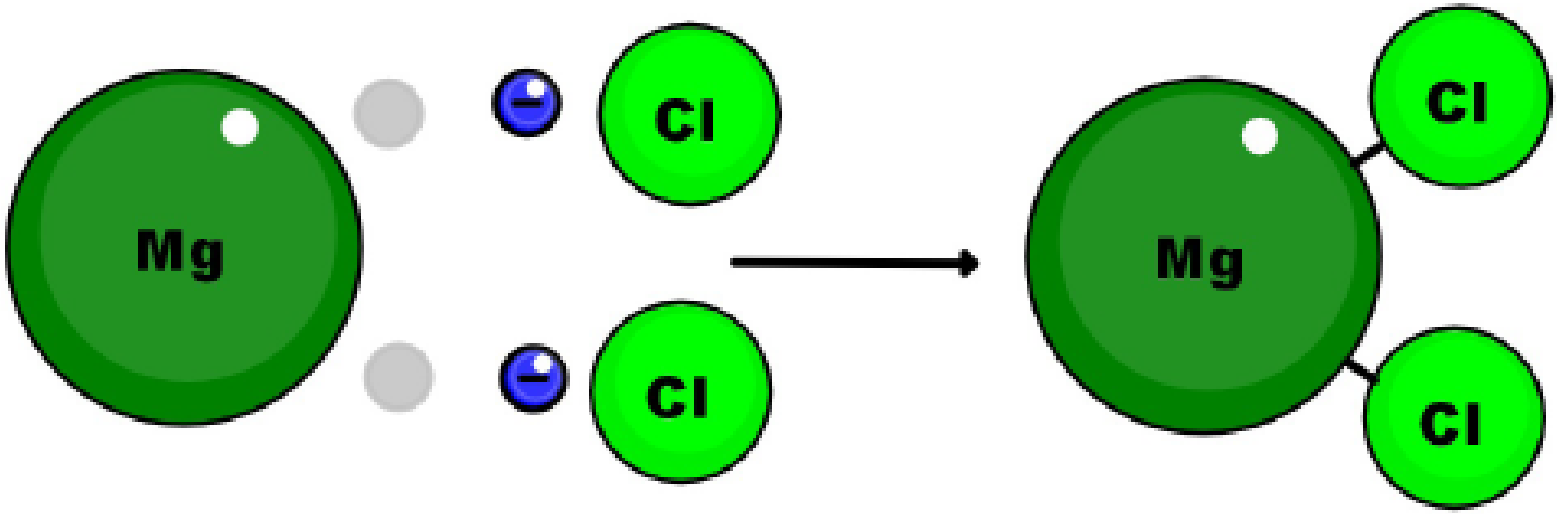


magnesium has a charge of 2+

chlorine has a charge of 1-

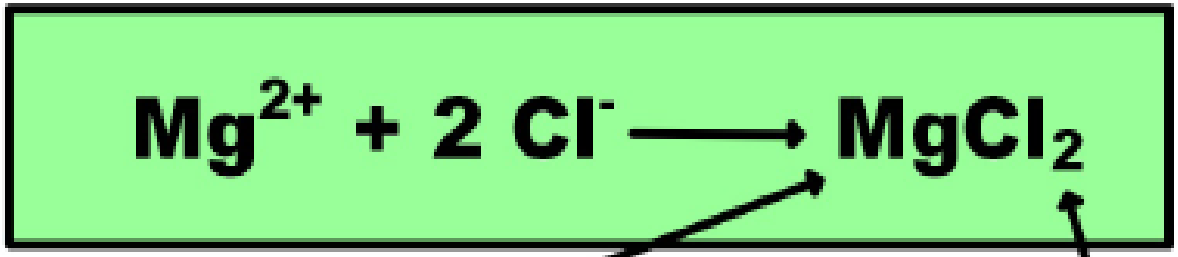
What will happen if we try to bond these two ions?

We need two chlorine ions to fill the holes in magnesium.



This explains the chemical formula:

$$Mg^{2+} + 2\ Cl^{-} \longrightarrow MgCl_2$$

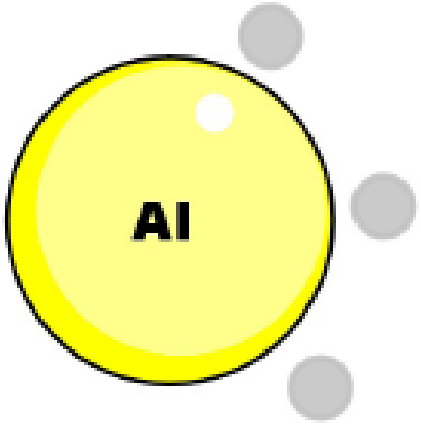


The name of this product is magnesium chloride.

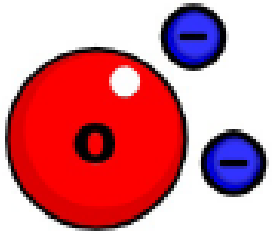
The 2 in subscripts means that there are two chlorine ions.

Notice how the formula, $MgCl_2$, can be created by crossing the charges on the products.

Let's try aluminum and oxygen...



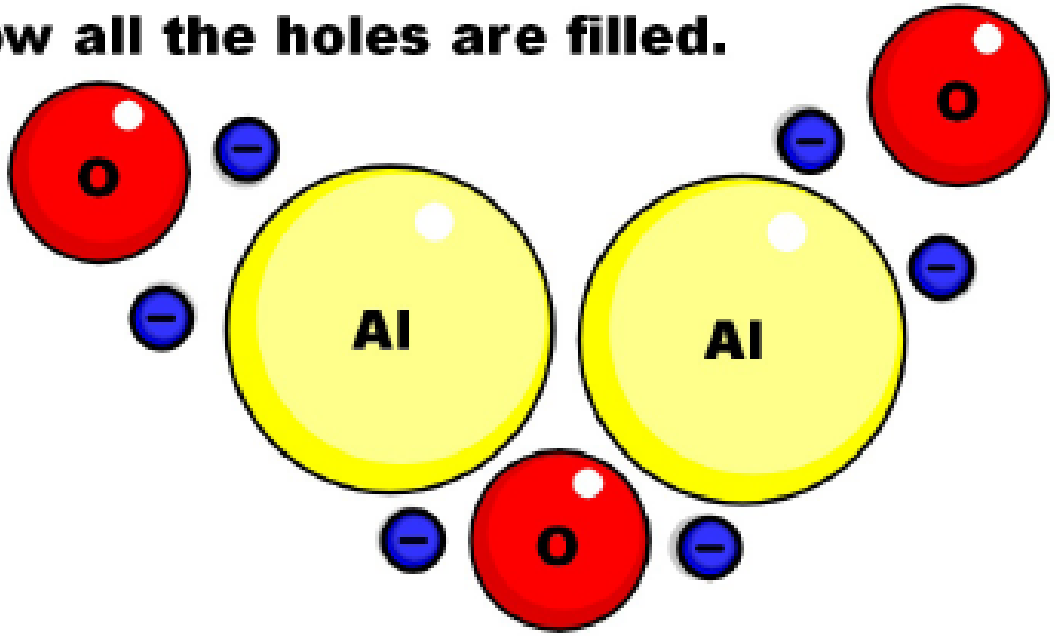
aluminum (Al^{3+})



oxygen (O^{2-})

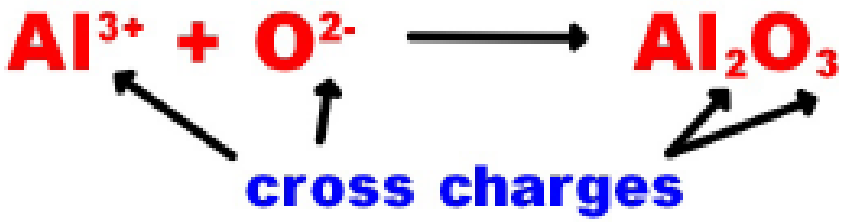
One oxygen ion and one aluminum ion can't bond. We need two aluminum ions and three oxygen ions.

Now all the holes are filled.



[1]Note: this compound actually forms into a crystal, so it wouldn't look exactly like this structure, but then again, it's not made up of yellow and red balls either.

For writing the formula for aluminum oxide or another binary ionic compound, cross the charges:



If the two subscripts have a common factor, divide each subscript by the common value.

ex. magnesium oxide

$$Mg^{2+} + O^{2-} \longrightarrow Mg_2O_2 \longrightarrow MgO$$

common factor of 2 reduce

Weird: two exceptions to the rule are H_2O_2 (hydrogen peroxide) and Na_2O_2 (sodium peroxide)

Naming Binary Ionic Compounds

When naming compounds, the metal ion is named first, followed by the nonmetal ion.

The nonmetal ion changes suffix to end in "ide".

ex) #2 from worksheet:

Formula	Compound Name
NaI	

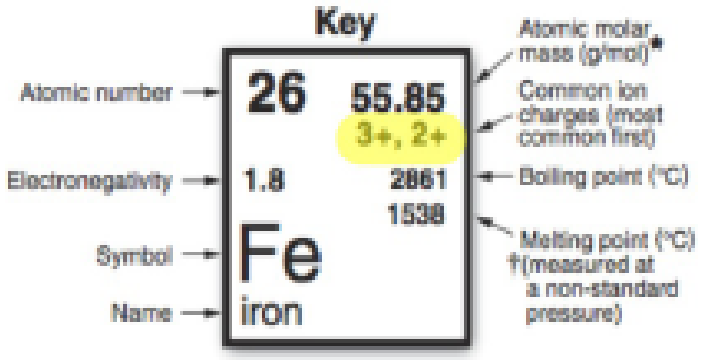
*Hint: Use your periodic table to find out the name of Na and the name of I, then change the ending to "ide".

Practice: try the next four examples.

Formula	Compound Name
NaI	sodium iodide
MgCl	
ZnO	
$AlBr_3$	
BaS	

Naming and writing formulas for ions with multiple charges

Note that some metal ions can form ions with different charges.



Iron is a good example. It can form the Fe^{2+} ion or the Fe^{3+} ion.

In order to distinguish between the two ions, we use roman numerals.

ex. Write the formula for iron (II) oxide.

The roman numeral II indicates the ion with a charge of +2 is used.

$Fe^{2+} + O^{2-} \longrightarrow FeO$

ex. Write the formula for iron (III) oxide.

Ex. What is the name of SnI_4?

Warning: forgetting the roman numerals is one of the most common mistakes in beginners chemistry (not unlike sig-digs in physics...). Be careful, I can pull marks off for mistakes like this at any time!

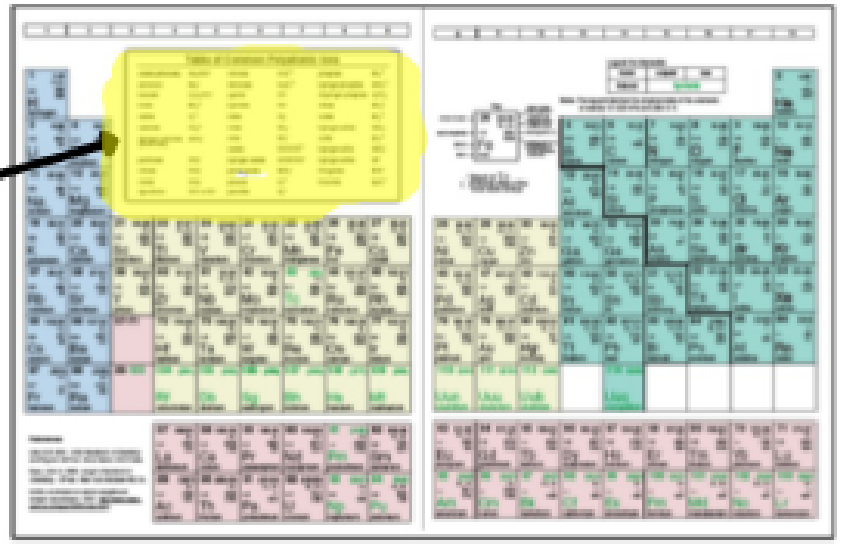
Practice: try these questions

Formula	Metal Ion Charge	Non-Metal Ion Charge	Name
$NiCl_3$			
MnO			
Cr_2O_3			
$CuCl_2$			
PbO_2			

Naming and writing formulas for complex (polyatomic) ions

Complex ions are groups of atoms bonded together that carry a collective charge. They are listed on the data table of your period table.

These guys up here = often used



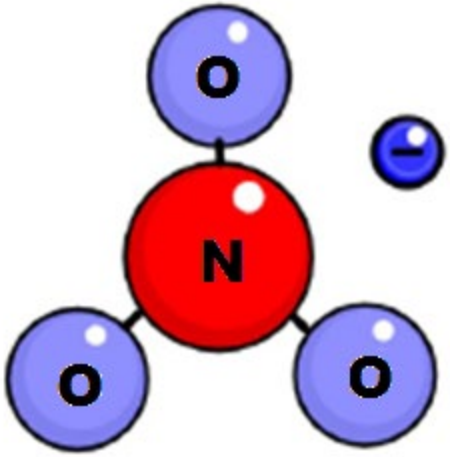
You will often encounter these ions. If you are having trouble naming a compound, it often contains a complex ion which you forgot about, so familiarize yourself with these names!

Table of Common Polyatomic Ions

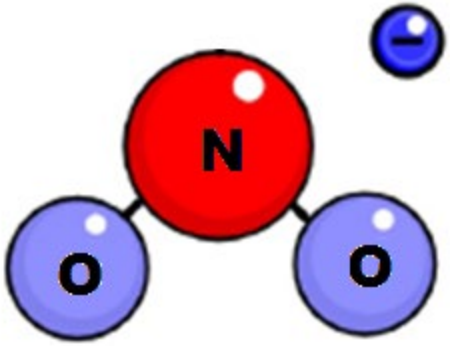
acetate (ethanoate)	CH_3COO^-	chromate	CrO_4^{2-}	phosphate	PO_4^{3-}
ammonium	NH_4^+	dichromate	$Cr_2O_7^{2-}$	hydrogen phosphate	HPO_4^{2-}
benzoate	$C_6H_5COO^-$	cyanide	CN^-	dihydrogen phosphate	$H_2PO_4^-$
borate	BO_3^{3-}	hydroxide	OH^-	silicate	SiO_3^{2-}
carbide	C_2^{2-}	iodate	IO_3^-	sulfate	SO_4^{2-}
carbonate	CO_3^{2-}	nitrate	NO_3^-	hydrogen sulfate	HSO_4^-
hydrogen carbonate (bicarbonate)	HCO_3^-	nitrite	NO_2^-	sulfite	SO_3^{2-}
		oxalate	$OOCCOO^{2-}$	hydrogen sulfite	HSO_3^-
perchlorate	ClO_4^-	hydrogen oxalate	$HOOCCOO^-$	hydrogen sulfide	HS^-
chlorate	ClO_3^-	permanganate	MnO_4^-	thiocyanate	SCN^-
chlorite	ClO_2^-	peroxide	O_2^{2-}	thiosulfate	$S_2O_3^{2-}$
hypochlorite	ClO^- or OCl^-	persulfide	S_2^{2-}		

(On your periodic table in your data booklet.)

Most negative complex ions end in "ite" or "ate".



An example of a complex ion, nitrate.

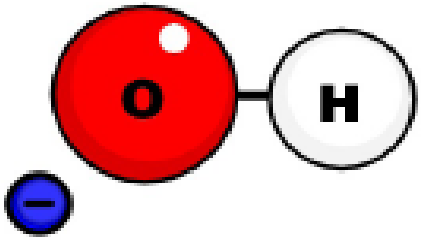


An example of a complex ion, nitrite.

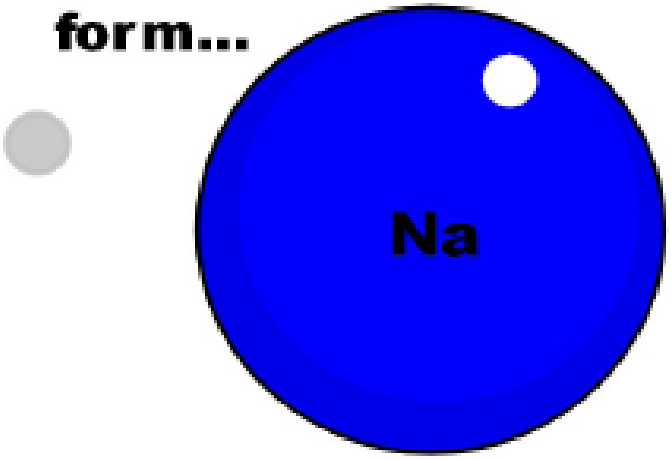
These ions bond like any other, but if more than one complex ion is present, the formula of the complex ion must be bracketed.

Let's create an ionic compound with the complex ion, hydroxide.

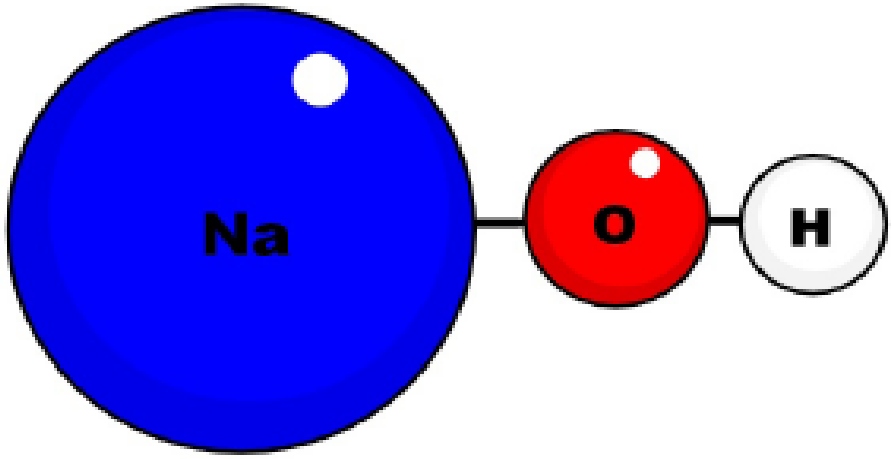
The hydroxide ion, OH-



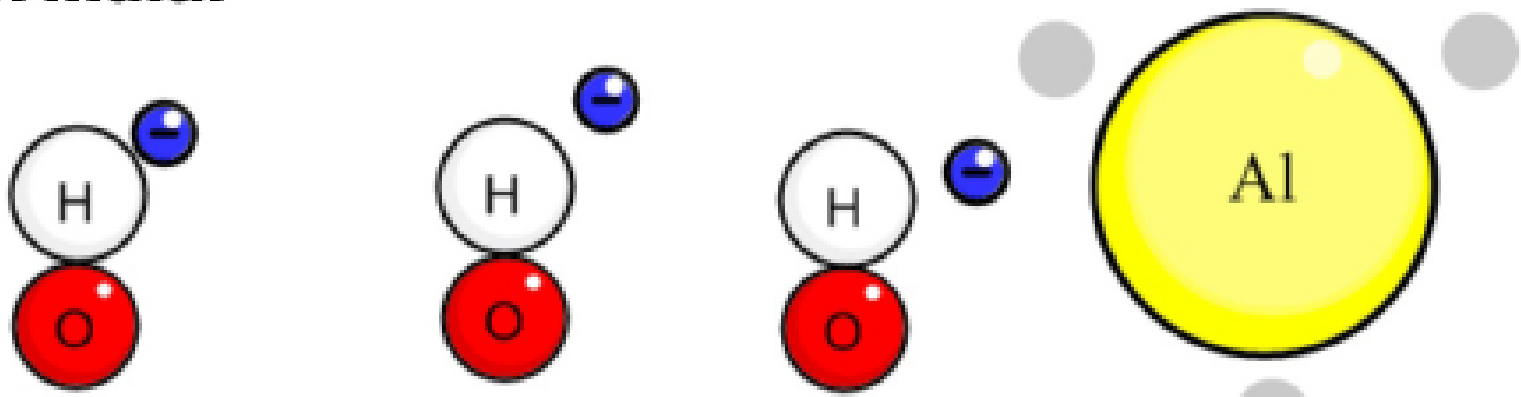
...and the sodium ion, Na^+ form...



sodium hydroxide, NaOH.



In the case of a compound that has more than one complex ion, put the complex ion in brackets in the formula.



The hydroxide ion, OH-

aluminum ion, Al^{3+}

This aluminum ion will need three hydroxide ions to form a compound.

The equation for aluminum hydroxide is

$$Al^{3+} + OH^{-} \longrightarrow Al(OH)_3$$

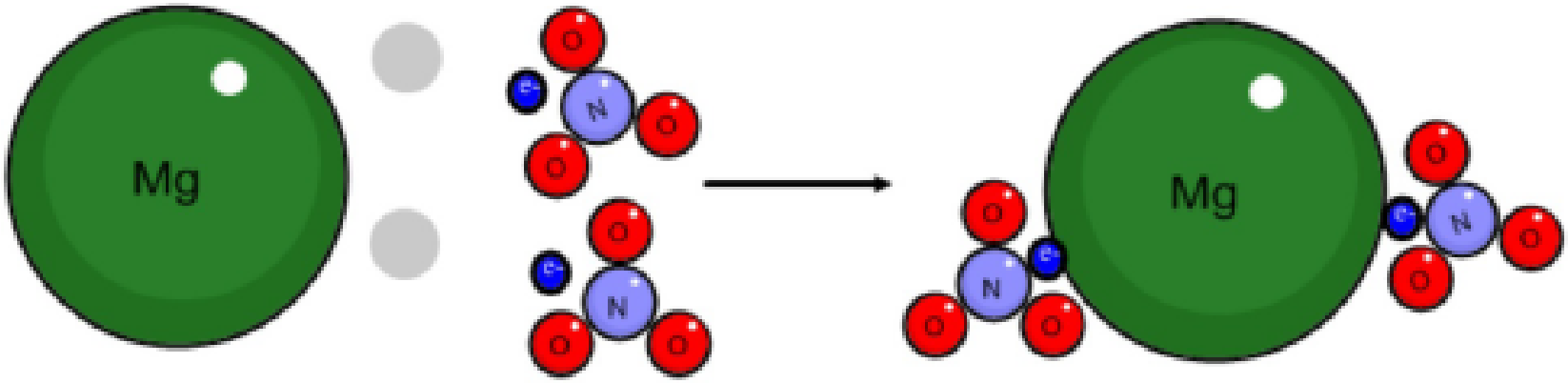
The subscript 3 only applies to the OH. There is not three Al.

ex. What is the formula for magnesium nitrate?

The magnesium ion is Mg^{2+} and nitrate ion is NO_3^-.
Remember to cross the charges.

$$Mg^{2+} + NO_3^- \longrightarrow Mg(NO_3)_2$$

We have one Mg ion and two NO_3 ions.

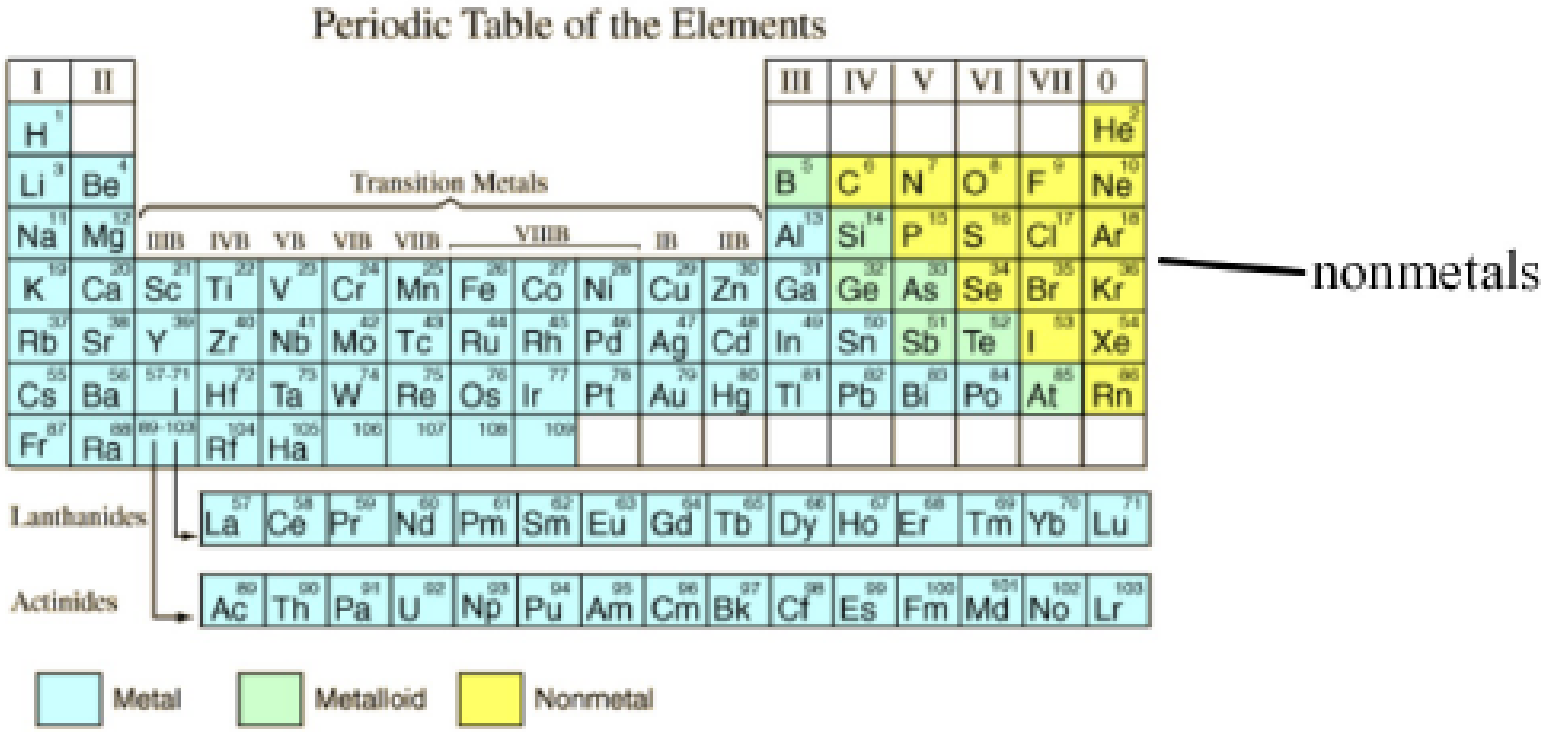


Practice: try these questions

Name	Metal Ion Charge	Non-Metal Ion Charge	Formula
sodium chlorate			
aluminium sulfate			
copper (II) nitrate			
lithium hydroxide			
magnesium nitrate			

Naming and Writing Formulas for Molecular Compounds

A molecular compound is made up of two or more nonmetals bonded together. In this type of bond, electrons are not exchanged, but shared between atoms.



Latin and Greek prefixes are used to indicate the number of molecules of each element present.

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

***Weird: we don't use prefixes for binary hydrogen compounds (ex. H_2S is not dihydrogen sulfide, just hydrogen sulfide.)**

***Tip: try recording these in the notes section of your data booklet.**

For example:

CO_2 - carbon dioxide.

P_2O_5 - diphosphorous pentaoxide

nitrogen dioxide - NO_2

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

***note: the mono is only used for the second element, not for the first**

***bonus note: note the suffix on the last element changes to "ide"**

Practice: try these questions

Name	Formula
sulphur dioxide	
carbon monoxide	
dihydrogen monosulphide	
sulfur dichloride	
tetraphosphorus decaoxide	

Molecular Compounds to be Memorized

These compounds have traditional names that are often used. It is helpful to memorize the names and formulas of these compounds.

$NH_3(g)$	ammonia
$C_6H_{12}O_6(s)$	glucose (simple sugar)
$C_{12}H_{22}O_{11}(s)$	sucrose (table sugar)
$CH_4(g)$	methane
$C_3H_8(g)$	propane
$CH_3COOH(l)$	acetic acid (vinegar)
$O_3(g)$	ozone
$CH_3OH(l)$	methanol
$C_2H_5OH(l)$	ethanol (grain alcohol)
$H_2O_2(l)$	hydrogen peroxide

The following elements only exist in molecular form and their formulas also need to be memorized (although most appear in the data table of the periodic table).

$P_4(s)$	phosphorous
$S_8(s)$	sulfur
$H_2(g)$	hydrogen gas
$O_2(g)$	oxygen gas
$N_2(g)$	nitrogen gas
$F_2(g)$	fluorine gas
$Cl_2(g)$	chlorine gas
$Br_2(l)$	bromine
$I_2(l)$	iodine

***Note that all the halogens (group 17) form diatomic molecules.**

Naming and writing formulas for Acids

For now, we will consider an acid to be any compound which can dissolve in water and contains hydrogen.

There are two types of acids we are concerned with now:

Binary Acids: consist of two elements: the first always hydrogen and the second a nonmetal ion. Binary acids always end in "ide".

Oxy acids: consist of two ions, the first always hydrogen, the second a complex ion containing oxygen, which will end in "ate" or "ite" (eg. sulfate, sulfite, phosphate, phosphite)

Note: we add an (aq)behind the acid to indicate it is aqueous, or soluble in water.

To name an acid, first name the compound like any other ionic hydrogen compound, then follow one of these three rules.

COMPOUND NAME	ACID NAME	ACID TYPE
hydrogen _____ide	hydro_____ic acid	binary acid
hydrogen _____ate	_____ ic acid	oxy acid
hydrogen _____ite	_____ous acid	oxy acid

ex. What is the name of $HClO_{3(aq)}$?

ex. What is the formula for hydrosulfuric acid?

Practice

Ex. Write the names of the following acids.

a) $HCl_{(aq)}$

b) $H_2SO_{4(aq)}$

c) $H_3BO_{3(aq)}$

d) $HNO_{3(aq)}$