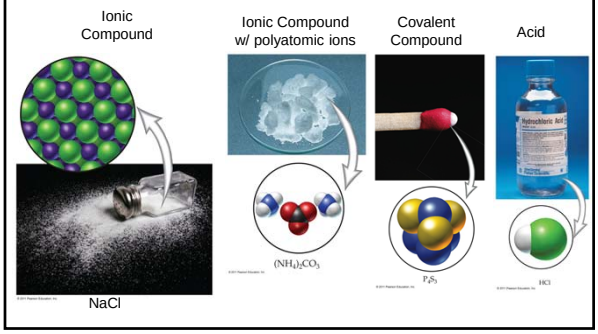
Chapter 7: The Language of Chemistry

Nomenclature Rules

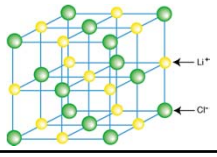


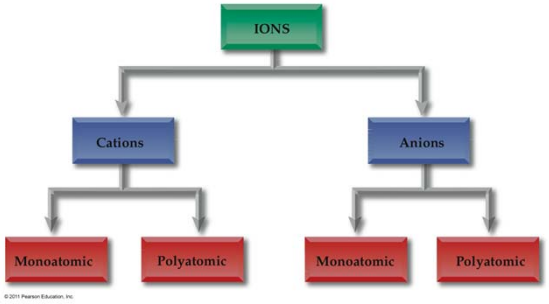
Chemical Compounds: ***The drive to achieve noble gas electron configuration.***

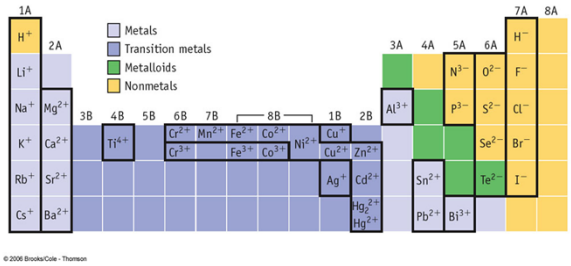
Ionic Compounds: Those in which electrons are transferred

-Generally form between metals and nonmetals
-The bond between atoms forms from a transfer of electrons from one atom to another.

-Metals tend to lose electrons and nonmetals tend to gain electrons.
-There is no such thing as an ionic "molecule" because the compound exists as a repeating pattern of positive and negative ions (i.e. an ionic crystal).







See page 22 in your laboratory manual

Formation of ionic compounds

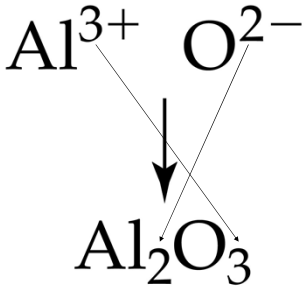
Charges MUST be balanced

The criss-cross method can be used but be sure to reduce to lowest terms (empirical formula).

The number of electrons lost = number of electrons gained.

Metal is listed before the nonmetal in the formula

To name this compound: Write the name of the cation (metal) then the name of the anion with its ending changed to "ide". Example aluminum oxide.



Notice that once the charges are known to be balanced, the charges on the individual ions are *not* written into the formula. The subscripts must also be reduced to lowest terms whenever possible.

On Your Own:
a) Write as many binary ionic compound formulas as you can from the following ions; K^+, O^{2-}, Ga^{3+}, N^{3-}, I^-, Ba^{2+}

b) Name all of the compounds you formed.

Did you remember to:
- Charge Balance (Give every electron a home)?
- Place the cation (metal) before the anion (nonmetal)?
- Change the ending to "ide" on the anion name?

Answers:
K_2O, K_3N, KI, Ga_2O_3, GaN, GaI_3, BaO, Ba_3N_2, BaI_2

Potassium oxide
Potassium nitride
Potassium iodide
Gallium oxide
Gallium nitride
Gallium iodide
Barium oxide
Barium nitride
Barium iodide

On Your Own

Write the formula for the compound formed between the following pairs of elements. Then, name the compound.

1. Strontium and sulfur
2. Selenium and potassium
3. Aluminum and chlorine
4. Nitrogen and lithium

Answers

1. SrS strontium sulfide
2. K_2Se potassium selenide
3. $AlCl_3$ aluminum chloride
4. Li_3N lithium nitride

Cations With More Than One Possible Charge

(See pages 22, 26-29 in your lab manual for a summary of rules)

•Many of the transition and post-transition metals have more than one possible charge

•There is no easy way to determine their charges from the periodic table and therefore must be memorized.

•The same rules for writing empirical formulas by charge balancing apply to these compounds as well

•Naming this type of compound however, requires an extra step in order to differentiate between the different possible compounds that can be formed

•For example, iron (Fe) has the ability to form 2+ or 3+ cations. When iron combines with chlorine, two possible compounds may be formed:

$FeCl_2$	Iron in its 2+ state
$FeCl_3$	Iron in its 3+ state

•Using conventional rules of naming won't work here because both of these compounds would be called iron chloride. Two different compounds can't have the same name.

•In order to distinguish between the two, one of two methods may be used…

The IUPAC (aka systematic, standardized or stock) method requires you to place a Roman numeral in parenthesis after the cation name that is equal to the charge on the ion. Therefore:

$FeCl_2$	becomes	iron(II) chloride
$FeCl_3$	becomes	iron(III) chloride

*It is extremely important to understand that the Roman numeral designates the charge on the ion, **NOT** the quantity of atoms.*

•Another, older method is called the "Latin or trivial system" of naming compounds.

•In this system, the suffix of the **cation** name is altered depending upon its charge.

•The greater of two possible charges changes the suffix of the cation to *–ic*. The lesser charge is changed to *–ous*.

•Furthermore, whenever possible, the Latin derivative of the element name is used with this method. If the element doesn't have a Latin name, the common name is used.

Example: Rewrite the names of the two possible compounds containing iron and chlorine using the trivial system of naming.

Answer:

$FeCl_3$	becomes	ferric chloride
$FeCl_2$	becomes	ferrous chloride

Ex. Write the names (trivial and standardized (stock)) and formulas of the two oxides of lead.

Answer: Lead comes as Pb^{2+} and Pb^{4+}

The formulas are PbO and PbO_2

The first is written as
lead(II)oxide (or plumbous oxide)
and the second is written as
lead(IV)oxide (or plumbic oxide)

On Your Own

Write the standardized and trivial system names for the following compounds:

CuO **Sn_3N_4** **Fe_2S_3** **BaI_2**

Write the formulas for the following compounds:

plumbic fluoride **tin(II)phosphide** **cuprous iodide**

Answers

Copper(II) oxide or cupric oxide
Stannic nitride or tin(IV) nitride
Ferric sulfide or iron(III)sulfide
Barium iodide (barium doesn't have more than one charge)

PbF_4
Sn_3P_2
CuI

Compounds Containing Polyatomic Ions "Ternary Ionic Compounds"

•Groups of elements bonded together with an overall charge are known as polyatomic ions.
•Examples of polyatomic ions are nitrate (NO_3^-), sulfite (SO_3^{2-}), and carbonate (CO_3^{2-})
•Most polyatomic ions have an overall negative charge (notable exceptions are ammonium (NH_4^+ and the mercurous ion Hg_2^{2+})
•The polyatomic ion must be treated as a single unit. Therefore, if more than one ion is needed in a compound the polyatomic ion should be placed in parenthesis with a subscript outside denoting the quantity required.

Ionic Compounds Containing Polyatomic Ions

When writing names with polyatomic ions, do not change the ending.

The whole polyatomic ion carries the charge, so it must be treated as a group

Ex. PO_4^{3-}
phosphate

Example:

Write the formula and name for the compound made from the phosphate ion and magnesium.

Answer: $Mg_3(PO_4)_2$ **Magnesium phosphate**

- **A polyatomic ion's name should never be altered. When naming a compound containing a polyatomic ion, simply write the name of the ion in its original form**
- **NOTE: Be very careful about names. Subtle differences in names refer to very different ions. For instance sulfide, sulfate and sulfite refer to the following ions:**
  - S^{2-} SO_4^{2-} SO_3^{2-}
- **The charge on a polyatomic ion is an overall charge on all of the elements it contains.**
- **Some of the more common polyatomic ions and their charges should be memorized.**

Examples

Write the name or formula for each of the following compounds.

$Ca(NO_3)_2$

$MgSO_4$

$Ba(OH)_2$

Cupric phosphate

Cobalt(II) carbonate

Answers

Calcium nitrate

Magnesium sulfate

Barium hydroxide

$Cu_3(PO_4)_2$

$CoCO_3$

On Your Own

Write the name or formula for the following compounds

$Ga(C_2H_3O_2)_3$ **$CuNO_2$** **$(NH_4)_3PO_4$**

Zinc cyanide

Ammonium nitrate

Stannous bicarbonate

Answers

Write the name or formula for the following compounds

Gallium acetate
Cuprous nitrite [or copper(I) nitrite]
Ammonium phosphate

$Zn(CN)_2$

NH_4NO_3

$Sn(HCO_3)_2$

Final notes on polyatomic ions

•You will notice that many polyatomic ions contain oxygen.

•Some polyatomic ions differ by the number of oxygen atoms that are paired with a particular element. In this case, the polyatomic ion with the greater number of oxygens has an *–ate* ending and the lesser number is given an *–ite* ending (for instance, nitrate (NO_3^-) and nitrite (NO_2^-)).

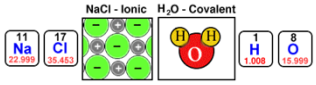
•Some elements (such as the halogens chlorine, bromine and iodine) form four possible combinations with oxygen. In these cases the prefixes *per-* and *hypo-* are also added.

For instance:

ClO^-	**hypochlorite**	BrO^-	**hypobromite**
ClO_2^-	**chlorite**	BrO_2^-	**bromite**
ClO_3^-	**chlorate**	BrO_3^-	**bromate**
ClO_4^-	**perchlorate**	BrO_4^-	**perbromate**

Covalent Compounds (molecules)

- Formed between two or more nonmetals
- Electrons are shared, not transferred, therefore no ions are formed.
- Formula may exist as **molecular** (where subscripts show actual number of each type of element in the compound) or **empirical** (subscripts in their lowest terms).
- Naming the compound requires the use of prefixes to denote the quantity of each type of atom (mono, di, tri, tetra, pent, hex, hept, oct, non, dec).
- The prefix mono- is never used for the first occurring element in the name.



Examples

Write the name or formula for each of the following:

N_2O_6

SF_6

NO_2

diboron trioxide

tetraphosphorus octaoxide

Prefixes
1 – mono
2 – di
3 – tri
4 – tetra
5 – pent
6 – hex
7 – hept
8 – oct
9 – non
10 - dec

Answers

dinitrogen hexaoxide

sulfur hexafluoride

nitrogen dioxide

B_2O_3

P_4O_8

On your Own

Write the name or formula for each of the following:

P_4S_3

IF_7

N_2O

tetraarsenic decaoxide

dichlorine heptaoxide

Answers

tetraphosphorus trisulfide

iodine heptafluoride

dinitrogen monoxide

As_4O_{10}

Cl_2O_7

Nomenclature of Acids

See pages 26 - 29 in your lab manual for a summary of rules

By the Arrhenius definition of acids, an acid is a substance that produces H^+ ions in solution (usually water as the solvent).

Therefore, by this definition acids will have one or more hydrogen atoms in their formulas. (Usually leading hydrogens like HCl and H_2SO_4)

Although acids are not technically ionic compounds, the hydrogen is so strongly attracted to the water molecules in solution that it ionizes the compound.

Acids should not be named by rules of acid nomenclature unless they are dissolved in solution*. However acids are usually considered in their dissociated state (i.e. dissolved in water).

Solutions in which water is the solvent are called aqueous solutions. An "aq" subscript in parenthesis following the compound formula is used to denote this condition.

$HCl_{(aq)}$

*Assume all identifiable acids are in their dissolved (aqueous) states unless otherwise stated.

There are essentially two types of acid categories:

•Acids that contain oxygen in them, known as oxoacids or oxyacids. (e.g. HNO_3)

•Acids that don't contain oxygen (usually a binary acid with a hydrogen paired with another nonmetal) (e.g. HCl).

To name an oxoacid do the following:

•Identify the portion of the acid containing the oxygen (usually a polyatomic ion).
•If the polyatomic ion normally has an *–ate* ending, change it to *–ic*, then add the word acid after the name.
•If the polyatomic ion normally has an *–ite* ending, change it to *–ous*, then add the word acid after the name.

Example: HNO_3
In this example, the oxygen containing polyatomic ion is nitrate. The name becomes nitric acid.

To name an acid that does not contain oxygen:

•Identify the non-hydrogen part of the acid.
•Give it a prefix of *hydro-* and change its ending to *–ic*. Then write acid.

Example: HCl
Chlorine is paired with the hydrogen, so the name is hydrochloric acid

Example: HCN
This is the polyatomic ion cyanide CN^-, therefore the name is hydrocyanic acid

Writing formulas for acids from their names

- **How do you know how many hydrogens to use in the formula?**
  - **As stated before, although acids are not strictly ionic compounds, it is useful to think of hydrogen as having a 1^+ charge. Add as many hydrogens as would be needed to balance out the charge on the other half of the acid.**

Example: Write the formula for phosphoric acid.
Answer: Since phosphate has a 3- charge (PO_4^{3-}) three hydrogens are required to balance the charge, therefore the formula becomes H_3PO_4

On your Own

Write the name or formula for each of the following acids:

$HC_2H_3O_2$

H_2SO_3

HI

hydrosulfuric acid

carbonic acid

Answers

Acetic acid (also CH_3COOH and HCH_3COO)

Sulfurous acid

Hydroiodic acid

H_2S

H_2CO_3