5.3 Chemical Nomenclature

Naming compounds and writing chemical formulas.

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Chemistry 100

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Objective

Charge of elemental ions.

Getting to know your polyatomic ions: Top - 12

Expanding your knowledge-base on polyatomic ions.
The oxy ions (…ates)

Behavior of atoms to form compounds.

Criss-Cross trick

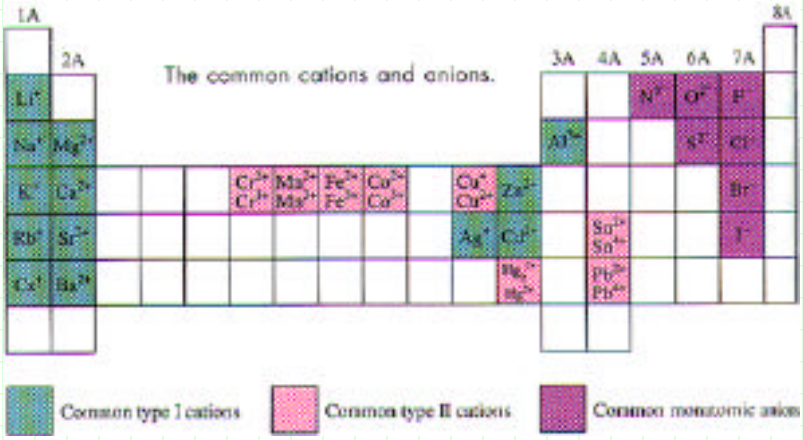
Knowing the different type of compounds Ionic vs Covalent, Type I, Type II, Type III

Naming ionic compounds based on chemical formulas.

Writing chemical formula based on chemical names.

Charge of Elemental Ions

The common charge (oxidation state) of many representative and some transition metals elements can be determine by the periodic table.



Polyatomic Ions

Cations : ammonia, NH_4^+ ; Mercury (I), Hg_2^{2+}

Anions

-1: hydroxide, OH- ; cyanide, CN- ; nitrate, NO_3^-

-2 : carbonate, CO_3^{2-} ; chromate CrO_4^{2-}, Dichromate $Cr_2O_7^{2-}$, sulfate SO_4^{2-}

-3 : phosphate, PO_4^{3-}

Polyatomic oxy-ions: Chlorate, bromate, iodinate, sulfate, nitrate, phosphate, chromate

Some form four anions

chlorate: perchlorate → chlorate → chlorite → hypochlorite

Some form only two oxy anions

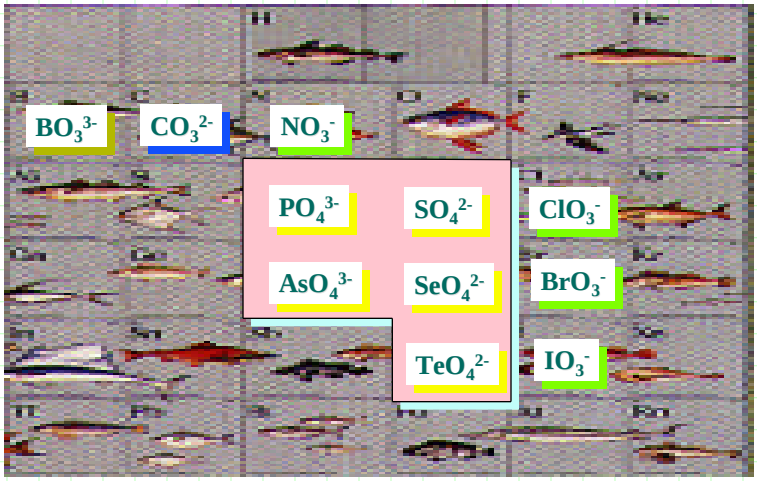
sulfate: sulfate → sulfite

Some form only on oxy anion

carbonate: carbonate

... the `ate

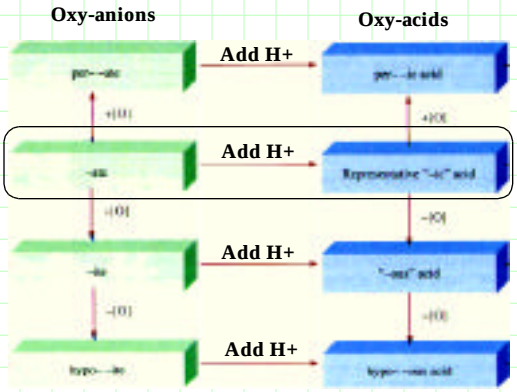
XO_3 chg XO_4 chg



-3 -2 -1

Polyatomic oxyions naming scheme

Remember the -ate ion and start nomenclature from there.



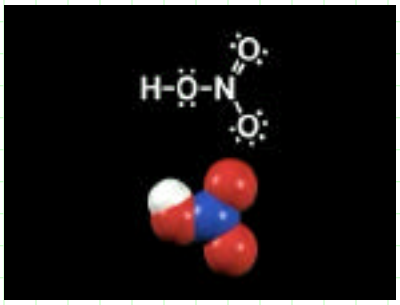
Not all -ate follow this pattern
carbonate: CO_3^{2-}
No carbonite

Metals which form oxyanions
permanganate, MnO_4^-
chromate, CrO_4^{2-}
dichromate, $Cr_2O_7^{2-}$
...still many others

Example of polyatomic ions

Most common polyatomic ions

Cation-	
Ammonium	NH_4^+



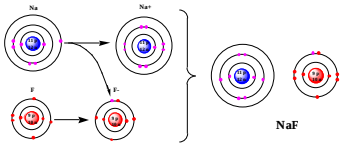
Anion-	
12. Chromate	CrO_4^{2-}
11. Permanganate	MnO_4^-
10. Perchlorate	ClO_4^-
9. Dichromate	$Cr_2O_7^{2-}$
8. Acetate	$CH_3CO_2^-$
7. Carbonate	CO_3^{2-}
6. Phosphate	PO_4^{3-}
5. Sulfate	SO_4^{-2}
4. Nitrate	NO_3^-
3. Cyanide	CN^-
2. Peroxide	O_2^{2-}
1. Hydroxide.	OH^-

Behavior of atoms to form Compounds

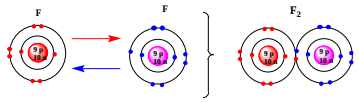
Two main type of compounds

Ionic	Covalent
electrons are transferred	**electrons are shared**

Sodium and chlorine cooperate symbiotically in electron transfer in order to have eight electrons in its valence shell.



Fluorine prefers to share its electrons to obtain 8 total in its valence shell



Atoms will transfer or share electrons in order to have the same number of electrons as its closest noble gas

Ways Compounds Ionic and Covalent Forms

Ionic Compounds: Type I

Binary Form - Composed from two different elements bonding

Polyatomic Form - Compounds with some part of substituents clustered together covalently with some charge.

Covalent Compounds: Type II

Combination of nonmetal atoms sharing electrons.

Principle of Electrical Neutrality

When elements combine to form compounds, the principle of electrical neutrality allows prediction of formulas of the ionic compound.

Basic idea:

Sum of the charges must add to zero.

That is the sum of the cation charge and the sum of the anion charge must cancel each other so that the compound form is neutral.

$$M^{+} \; X^{-} \rightarrow M_n X_m$$

$$\Sigma \text{ cation (charges)} = \Sigma \text{ anion (charges)}$$

Type I, II and III

Ionic : Type I & II

Type I : Metal - nonmetal

metal has a definite oxidation state.

$Ca \rightarrow Ca^{+2}$, $K \rightarrow K^{+}$, $Al \rightarrow Al^{+3}$, $Zn \rightarrow Zn^{+2}$

Type II : Metal(Ox#) - nonmetal

metal has a variable oxidation state.

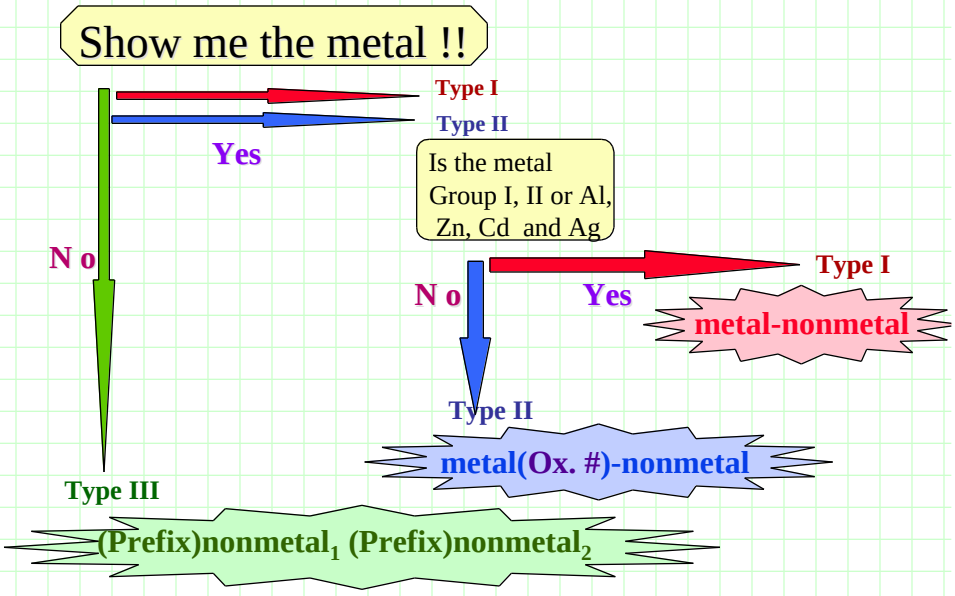
$Cu \rightarrow Cu^{+2}$ or Cu^{+}, $Cr \rightarrow Cr^{+4}$ or Cr^{+4}

Molecular: Type III

Type III : $(prefix_1)nonMetal_1 - (prefix_2)nonMetal_2$

covalent type of compounds

Determining Type of Compound



Type I, II and III

Type	Anion: Elemental	Anion: Polyatomic
I (Metal - nonMetal) Cation; Rep Metal Cation - Anion	Cation - Anion(ide) MgO; Magnesium oxide Na_2S; Sodium sulfide	Cation - Anion $Mg(NO_3)_2$; magnesium nitrate K_2SO_4; potassium sulfate
II (Metal - nonMetal) (Transition) metal Cation (O St #) - Anion Cat ; 3rd row and lower old method lower ox. st. -ous higher ox.st. -ic	Cat (oxidation state) Anion(ide) $FeCl_3$; Iron(III) chloride CuS; Copper(II) sulfide Cation(ous) Anion(ide) Cation(ic) - Anion(ide) $FeBr_3$; Iron(III) bromide or Ferrric bromide	Cat (oxidation state) Anion $Pb(C_2H_3O_2)_2$; Lead(II) acetate Ag_3PO_4; Silver(I) phosphate Cation(ous) Anion Cation(ic) - Anion $Fe(NO_3)_2$; Iron(II) nitrate or Ferrrous nitrate
III Molc' compounds - Compounds which contains nonmetal (Prefix) $nonmetal_1$ - (Prefix) $nonmetal_2$	(Prefix) $nonmetal_1$ - (Prefix) $nonmetal_2$ (ide) • Prefixes are indication of the number of atoms: mono-, di-, tri-, tetra-, penta • order of naming $nonmetal_1$ & $nonmetal_2$ $nonmetal_1$ is to the left and bottom of $nonmetal_2$ it is named first in the nomenclature scheme. Si - C - As - P - N - H - Se - S - I - Br - Cl - O - F • S & 3O forms SO_3 ; Sulfur trioxide • 2I & 2Se forms Se_2I_2; diselinium diiodide	

Example: Type-I

Given the Chem Formula provide the name

Name Type I: Binary **Metal - nonmetal(ide)**

SrSe	Strontium selenide
Mg_3N_2	Magnesium nitride
Li_2O	Lithium oxide

Chem Formula Type I: Polyatomic **Metal - polyatomic**

$SrSO_4$	Strontium sulfate
$Mg_3(PO_4)_2$	Magnesium phosphate
$LiClO_4$	Lithium perchlorate

Example: Type-I

Given the name provide the chemical formula

Name Type I: Binary **Metal - nonmetal(ide)**

potassium sulfide

Elemental symbol	K & S	
Charge of ions	K (+1)	S(-2)
Criss-Cross	K(2)	S(1) → K_2S

Chem Formula Type I: Polyatomic **Metal - polyatomic**

Cadmium bisulfite

Elemental symbol	Cd & HSO_3	
Charge of ions	Cd (+2)	HSO_3(-1)
Criss-Cross	Cd(1)	HSO_3(2) → $Cd(HSO_3)_2$

Example: Type-II

Given the Chem Formula provide the name

Name Type II: Binary **Metal(Ox.#) - nonmetal(ide)**

Mn_3N_2

Elemental symbol	Mn (3) & N (2)
Reverse Criss-Cross	Mn (2) & N (3)
Ox. State of metal	Ox St = 2; Mn(II)
Name of Chemical	Manganese(II) nitride

Chem Formula Type II: Polyatomic **Metal(Ox#) - polyatomic**

$Mn(NO_2)_2$

Elemental symbol	Mn (1) & NO_2 (2)
Reverse Criss-Cross	Mn (2) & NO_2 (1)
Ox. State of metal	Ox St= 2; Mn(II)
Name of Chemical	Manganese(II) nitrite

Example: Type-II

Given the name provide the chemical formula

Name Type II: Binary **Metal - nonmetal(ide)**

Iron(II) sulfide

Elemental symbol	Fe & S
Charge of ions	Fe(+2) S(-2)
Criss-Cross	Fe(2) S(2) → Fe_2S_2
Reduce ratio	FeS

Name Type II: Polyatomic **Metal - polyatomic**

Tin(IV) sulfite

Elemental symbol	Sn & SO_3
Charge of ions	Sn(+4) SO_3(-2)
Criss-Cross	Sn(2) SO_3(4) → $Sn_2(SO_3)_4$
Reduce ratio	$Sn(SO_3)_2$

Example: Type-III

Given the Chem Formula determine the name

Name Type III: **(prefix$_1$)nonMetal$_1$ - (prefix$_2$)nonMetal$_2$(ide)**

N_2O_2

Elemental symbol	N (2) & O (2)
Prefix	dinitrogen & dioxide
Name of Chemical	dinitrogen dioxide

XeF_2

Elemental symbol	Xe (1) & F(2)
Prefix	monoxenon & difluoride
Name of Chemical	xenon difluoride

P_4Se_{10}

Elemental symbol	P (4) & Se(10)
Prefix	tetraphosphorus & decaselenide
Name of Chemical	tetraphosphorus decaselenide

Example: Type-III

Given the name determine the chemical formula

Name Type III: **(prefix$_1$)nonMetal$_1$ - (prefix$_2$)nonMetal$_2$(ide)**

Diboron trisulfide	Elemental symbol	B & S
	Prefix for atoms	B(2) & S(3)
	Chemical formula	B_2S_3
Silicon tricarbide	Elemental symbol	Si & C
	Prefix for atoms	Si(1) & C(3)
	Chemical formula	SiC_3
Iodine monochloride	Elemental symbol	I & Cl
	Prefix for atoms	I(1) & Cl(1)
	Chemical formula	ICl

Summary

An ionic compound is named with cation first and anion last. For metals that can form more than one ion, the charge is shown with a Roman numerical. For example, copper forms the mono-cation Cu^{+} and the di-cation, Cu^{2+}, these are distinguished from each other in their chemical name as copper(I) and copper (II). Oxyanions (or anions with two kinds of element one of which is oxygen) have suffixes, and some sometimes prefixes, attached to their element root name to indicate the number of oxygen atoms. For example the oxy anion containing sulfur and oxygen may form the following anions, hyposulfite SO_2^{2-}, sulfite SO_3^{2-}, sulfate SO_4^{2-}, and persulfate SO_5^{2-}. Binary covalent compounds nomenclature consist of writing the most electropositive elements first proceeded by a prefix which indicates the number of atoms , I.e., di-2, tri-3, tetra-4 and so on. The second more electronegative element is written next which also is proceeded by the prefix which indicates the number of atoms. For the second element, a “mono” prefix must always be written if there is only one atom in the chemical formula. i.e., carbon monoxide for CO.