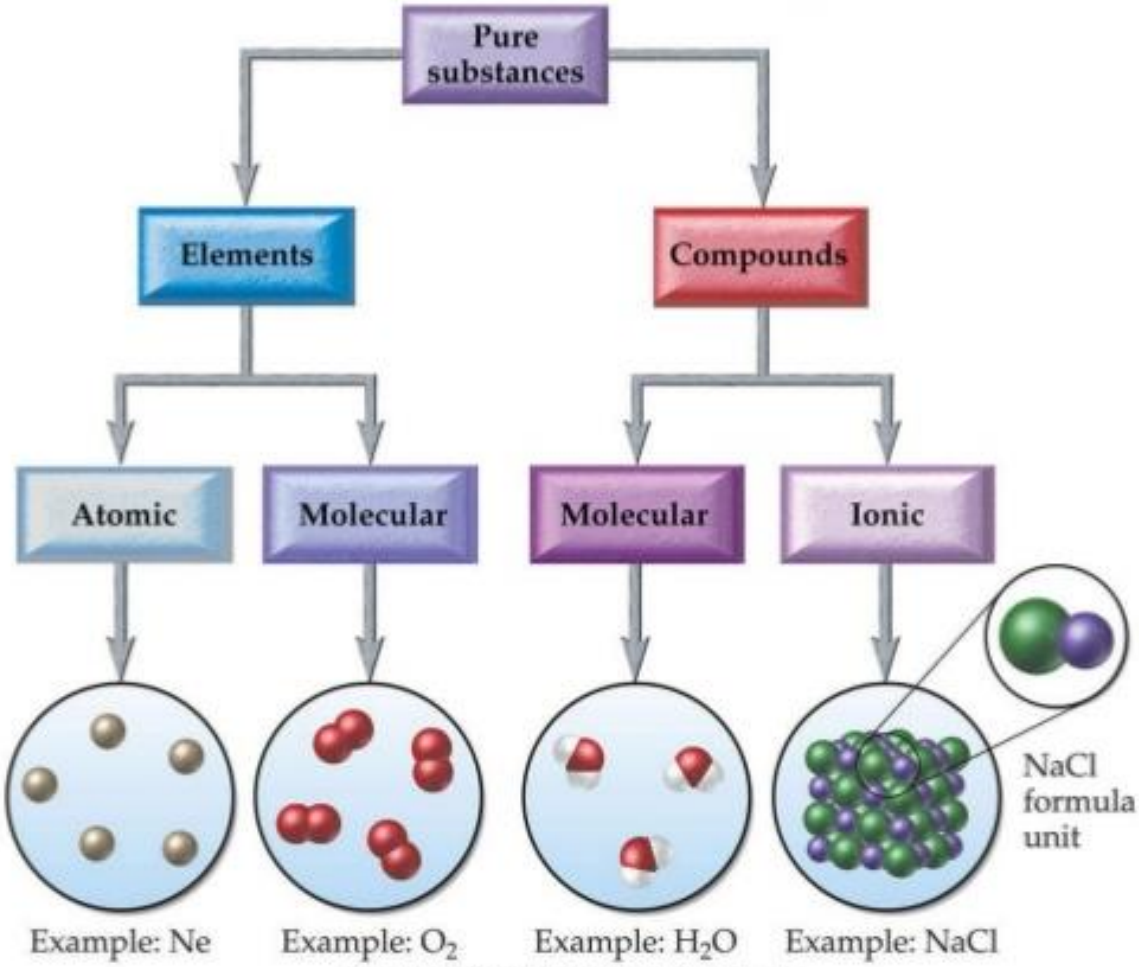
Molecules
&
Compounds

Elements & Compounds



Binary Compounds

1. Ionic compounds (a metal and a nonmetal)

2. Covalent compounds (two nonmetals)
   (Molecular Compounds)

Binary Compounds

1. Ionic compounds (a metal and a nonmetal)

Metals: lose 1, 2 or 3 e^- → Cation (Y^+)

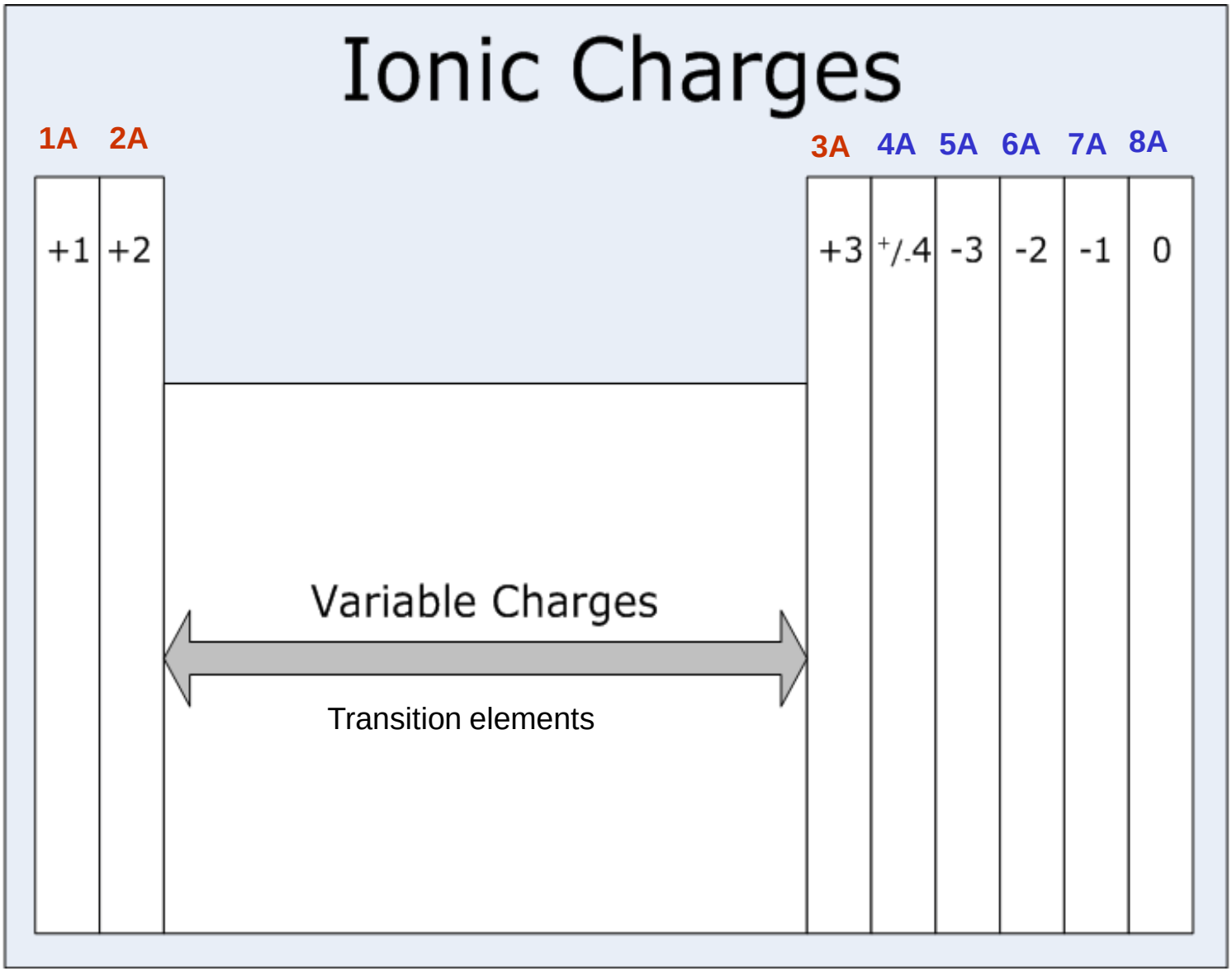
Nonmetals: gain 1, 2 or 3 e^- → Anion (X^-)

} Ions

Number of protons and neutrons in the nucleus remains unchanged.

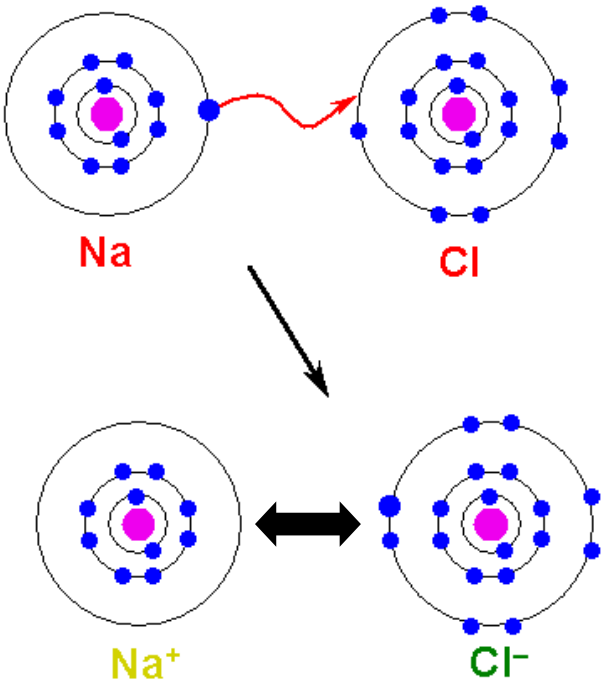
Cation (Y^+): Na^+ Li^+ Ca^{2+} Al^{3+}

Anion (X^-): Cl^- F^- O^{2-}


Ionic Charges
1A
2A
3A
4A
5A
6A
7A
8A
+1
+2
+3
+/-4
-3
-2
-1
0
Variable Charges
Transition elements

Ionic bonds

Metal-Nonmetal



$Na \rightarrow Na^+ + e^-$

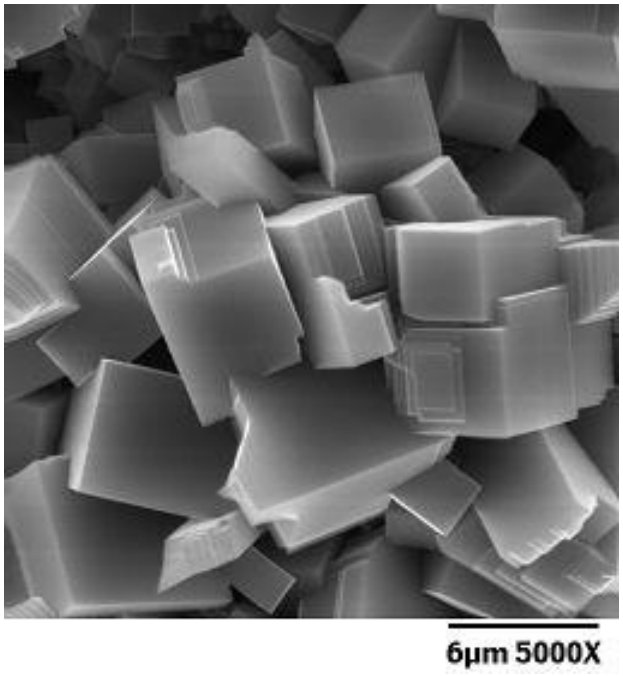
$Cl + e^- \rightarrow Cl^-$

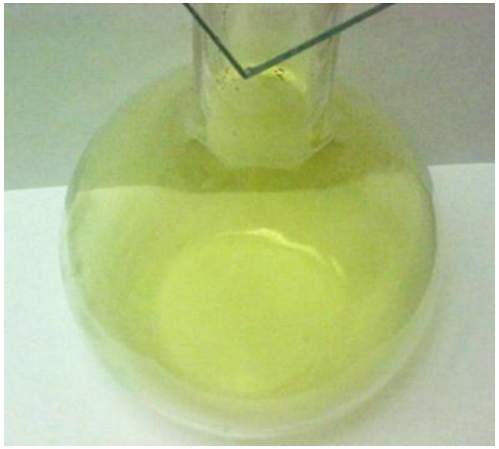
Opposite charges attract each other.

Cation

Anion

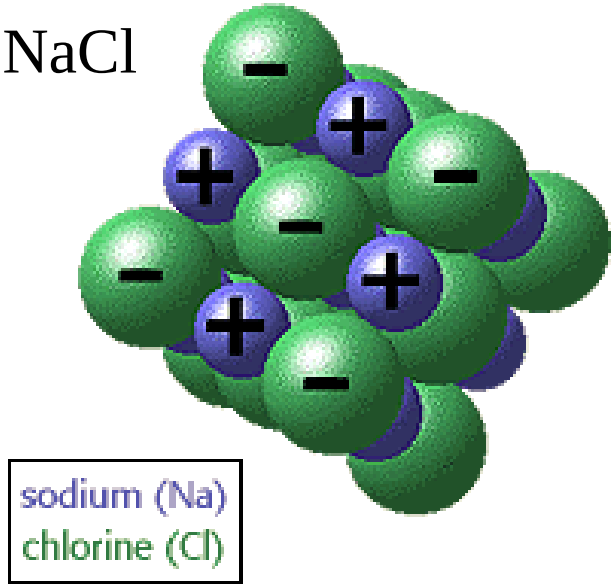
Sodium (Na)





Chlorine (Cl)

NaCl



Type I Monatomic Cations

Metal has only one type of cation (main group elements)

International Union of Pure and Applied Chemistry (IUPAC)
systematic names

Name of the metal + “ion”

H^+	Hydrogen ion
Li^+	Lithium ion
Ca^{2+}	Calcium ion
Al^{3+}	Aluminum ion

Type II Monatomic Cations

Metal has two (or more) type of cations (transition elements)

IUPAC or Systematic names

Memorize!!!

Table 5.2 Common Type II Cations

Ion	Systematic Name	Older Name
Fe^{3+}	iron(III)	ferric
Fe^{2+}	iron(II)	ferrous
Cu^{2+}	copper(II)	cupric
Cu^{+}	copper(I)	cuprous
Co^{3+}	cobalt(III)	cobaltic
Co^{2+}	cobalt(II)	cobaltous
Sn^{4+}	tin(IV)	stannic
Sn^{2+}	tin(II)	stannous
Pb^{4+}	lead(IV)	plumbic
Pb^{2+}	lead(II)	plumbous
Hg^{2+}	mercury(II)	mercuric
Hg_2^{2+}*	mercury(I)	mercurous

*Mercury(I) ions always occur bound together in pairs to form Hg_2^{2+}.

1 = I
2 = II
3 = III
4 = IV
5 = V
6 = VI

Type II Monatomic Cations

Common name (old name)

Name of the metal + “-ous” smaller charge
“-ic” larger charge

Fe^{2+}	Iron(II) ion	Ferrous ion
Fe^{3+}	Iron(III) ion	Ferric ion
Cu^{1+}	Copper(I) ion	Cuprous ion
Cu^{2+}	Copper(II) ion	Cupric ion
Pb^{2+}	Lead(II) ion	Plumbous ion
Pb^{4+}	Lead(IV) ion	Plumbic ion
Sn^{2+}	Tin(II) ion	Stannous ion
Sn^{4+}	Tin(IV) ion	Stannic ion

Memorize!!!

Naming Monatomic Anions

Stem part of name + “-ide ion”

Anion	Stem name	Anion name
F^-	fluor	**Fluoride ion**
Cl^-	chlor	**Chloride ion**
Br^-	brom	**Bromide ion**
I^-	iod	**Iodide ion**
O^{2-}	ox	**Oxide ion**
S^{2-}	sulf	**Sulfide ion**
P^{3-}	phosph	**Phosphide ion**
N^{3-}	nitr	**Nitride ion**

matter are neutral (uncharged):

total number of positive charges = total number of negative charges

Na^+ Cl^- ⟶ NaCl

Ca^{2+} Cl^- ⟶ $CaCl_2$

Al^{3+} S^{2-} ⟶ Al_2S_3

Ba^{2+} O^{2-} ⟶ ~~Ba_2O_2~~ BaO

~~Molecule of NaCl~~ ⟶ Formula of NaCl

Naming Binary Ionic compounds

Name of metal cation	Base name of anion + -ide

NaCl	Sodium chloride	
CaO	Calcium oxide	
Cu_2O	Copper(I) oxide	Cuprous oxide
CuO	Copper(II) oxide	Cupric oxide
CsBr	Cesium bromide	
MgS	Magnesium sulfide	
$FeCl_2$	Iron(II) chloride	Ferrous chloride
$FeCl_3$	Iron(III) chloride	Ferric chloride

Binary Compounds

1. Ionic compounds (a metal and a nonmetal)

2. Covalent compounds (two nonmetals)
   (Molecular Compounds)

Binary Compounds

2. Covalent compounds (two nonmetals)

Naming Binary Covalent compounds (type III)

1	2	3	4	5	6	7	8	9	10
Mono –	Di –	Tri –	Tetra –	Penta –	Hexa –	Hepta –	Octa –	Nona –	Deca

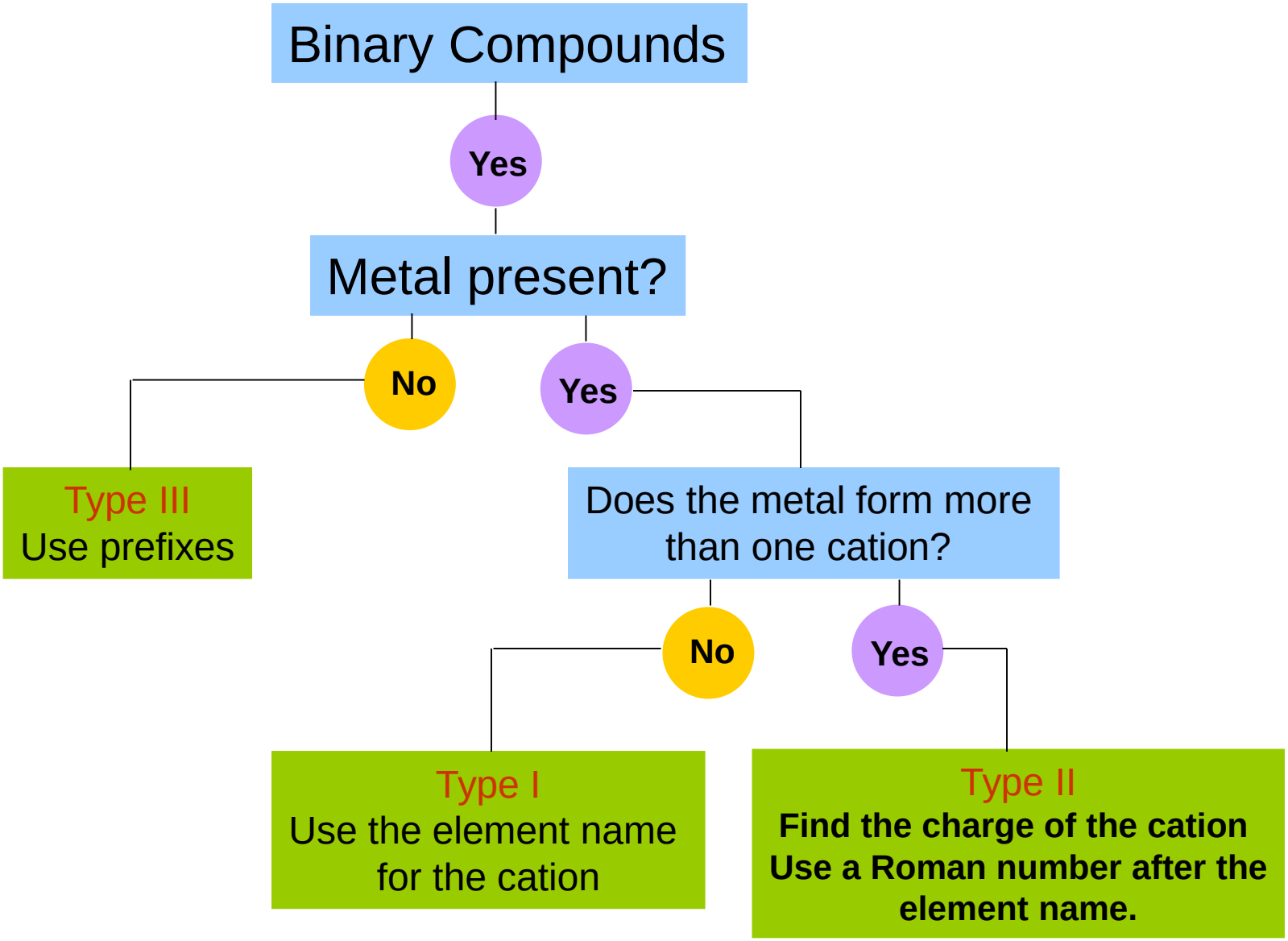
Prefix	**Name of 1st Element**	**Prefix**	**Name of 2nd Element + -ide**

Rules:

1. Don't use "mono" for the 1st element.
2. Drop the "a" when followed by a vowel.

Naming Binary Covalent compounds (type III)

NO_2	Nitrogen dioxide	CCl_4	Carbon tetrachloride
N_2O_4	Dinitrogen tetroxide	S_2O_3	Disulfur trioxide
PCl_5	Phosphorous pentachloride	SF_6	Sulfur hexafluoride


Binary Compounds
Yes
Metal present?
No
Yes
Type III
Use prefixes
Does the metal form more than one cation?
No
Yes
Type I
Use the element name for the cation
Type II
Find the charge of the cation
Use a Roman number after the element name.

Naming Polyatomic Ionic Compounds

They contain more than two elements.

Naming Polyatomic Ions

Memorize!!!

Cation

Table 5.4 Names of Common Polyatomic Ions

Ion	Name	Ion	Name
NH_4^+	ammonium	CO_3^{2-}	carbonate
NO_2^-	nitrite	HCO_3^-	hydrogen carbonate (bicarbonate is a widely used common name)
NO_3^-	nitrate		
SO_3^{2-}	sulfite	ClO^-	hypochlorite
SO_4^{2-}	sulfate	ClO_2^-	chlorite
HSO_4^-	hydrogen sulfate (bisulfate is a widely used common name)	ClO_3^-	chlorate
		ClO_4^-	perchlorate
OH^-	hydroxide		
		MnO_4^-	permanganate
PO_4^{3-}	phosphate	$Cr_2O_7^{2-}$	dichromate
HPO_4^{2-}	hydrogen phosphate	CrO_4^{2-}	chromate
$H_2PO_4^-$	dihydrogen phosphate		

Oxyanions

Polyatomic anions with different numbers of oxygen atoms.

When we have two oxyanions in a series:

Smaller number of oxygen atoms ends with –ite.
Larger number of oxygen atoms ends with –ate.

NO_2^-	**Nitrite**
NO_3^-	**Nitrate**
SO_3^{2-}	**Sulfite**
SO_4^{2-}	**Sulfate**
HSO_3^-	**Hydrogen Sulfite (bisulfite)**
HSO_4^-	**Hydrogen sulfate (bisulfate)**

PO_3^{3-}	**Phosphite**
PO_4^{3-}	**Phosphate**
HPO_4^{2-}	**Hydrogen phosphate**
$H_2PO_4^-$	**Dihydrogen phosphate**

Oxyanions

When we have more than two oxyanions in a series:

(Fewest oxygen atoms) ⟶ Prefix hypo-

(Most oxygen atoms) ⟶ Prefix per-

ClO^-	hypochlorite
ClO_2^-	chlorite
ClO_3^-	chlorate
ClO_4^-	perchlorate

matter are neutral (uncharged):

total number of positive charges = total number of negative charges

Na^{+} NO_3^{-} ⟶ $NaNO_3$

Ca^{2+} CO_3^{2-} ⟶ ~~$Ca_2(CO_3)_2$~~ $CaCO_3$

Al^{3+} SO_4^{2-} ⟶ $Al_2(SO_4)_3$

Mg^{2+} NO_2^{-} ⟶ $Mg(NO_2)_2$

Naming Polyatomic Ionic compounds

Name of metal cation	Name of polyatomic ion
$NaNO_3$	Sodium nitrate
$CaCO_3$	Calcium carbonate
$Al_2(SO_4)_3$	Aluminum sulfate
$Mg(NO_2)_2$	Magnesium nitrite

Naming Polyatomic Ionic compounds

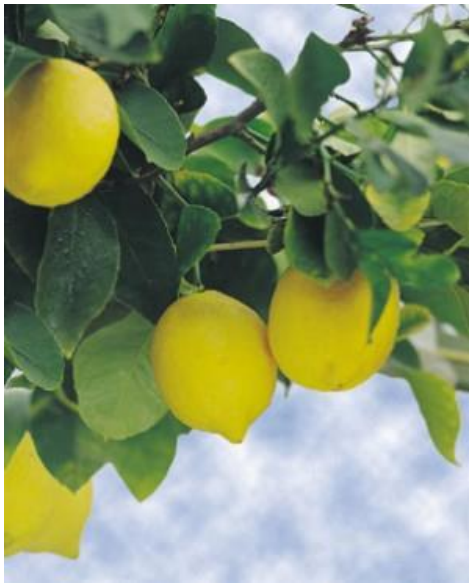
Name of metal cation **(Charge of cation in Roman numerals)** **Name of polyatomic ion**

$FeCO_3$ Iron(II) carbonate

$Fe_2(CO_3)_3$ Iron(III) carbonate

Naming acids

Acids: sour



They produce H^+ (proton) in water.

Naming binary acids

Hydro + Anion : ~~-ide ion~~ → -ic acid

HF	F^- : flouride ion	Hydroflouric acid
HCl	Cl^- : chloride ion	Hydrochloric acid
H_2S	S^{2-} : sulfuride ion	Hydrosulfuric acid

Naming Polyatomic Acids

Anion:

-ite ion → -ous acid

-ate ion → -ic acid

HNO_2	NO_2^- : Nitrite ion	Nitrous acid
HNO_3	NO_3^- : Nitrate ion	Nitric acid
H_2CO_3	CO_3^{2-} : Carbonate ion	Carbonic acid
H_2SO_3	SO_3^{2-} : Sulfurite ion	Sulfurous acid