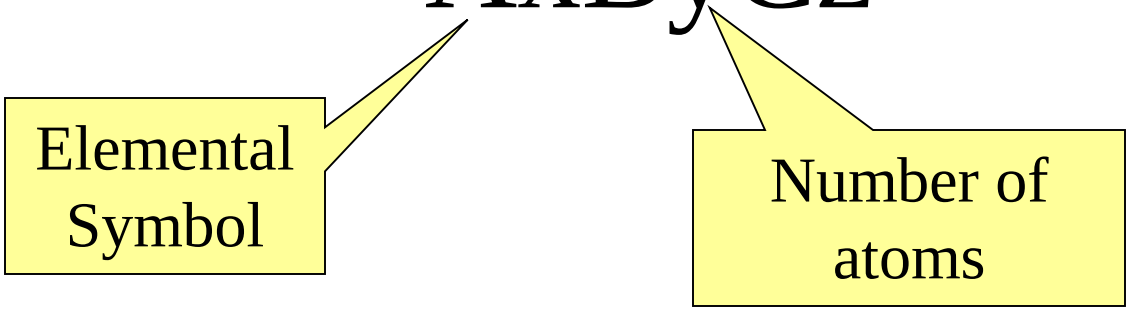
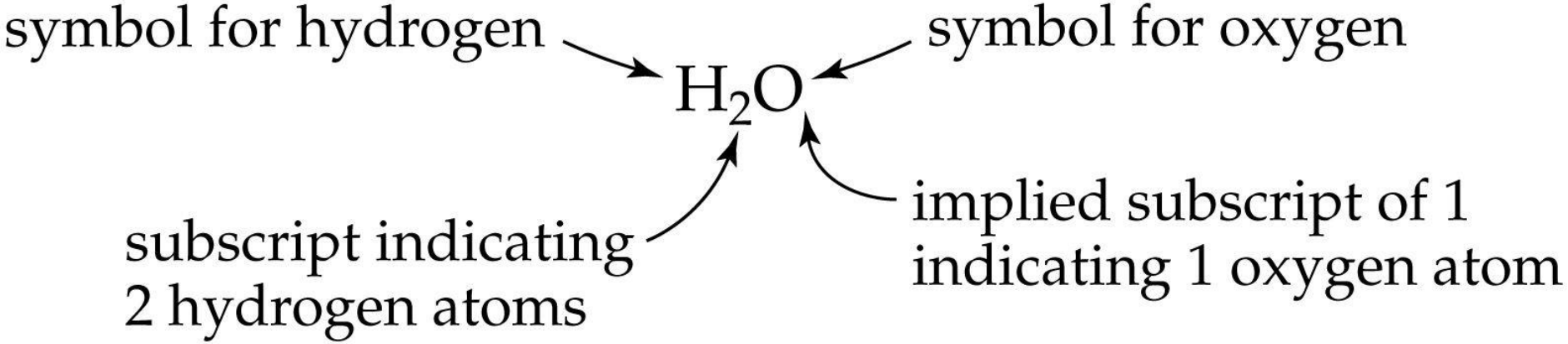
Nomenclature of Inorganic Compounds

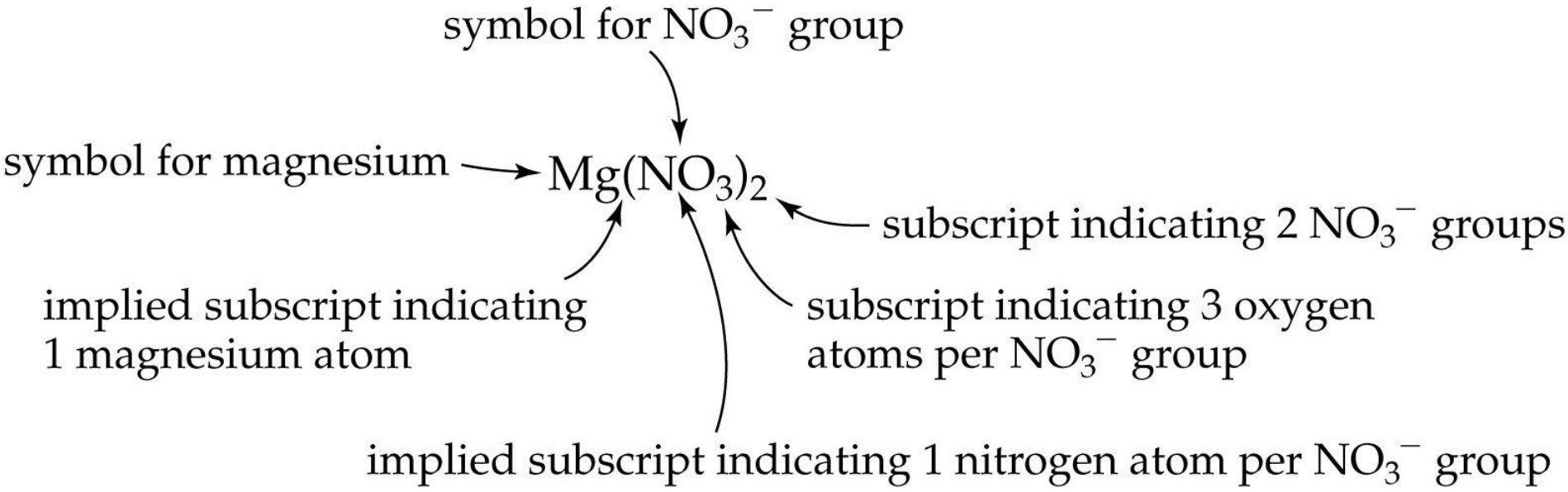
Chapter 6

Chemical Formulas

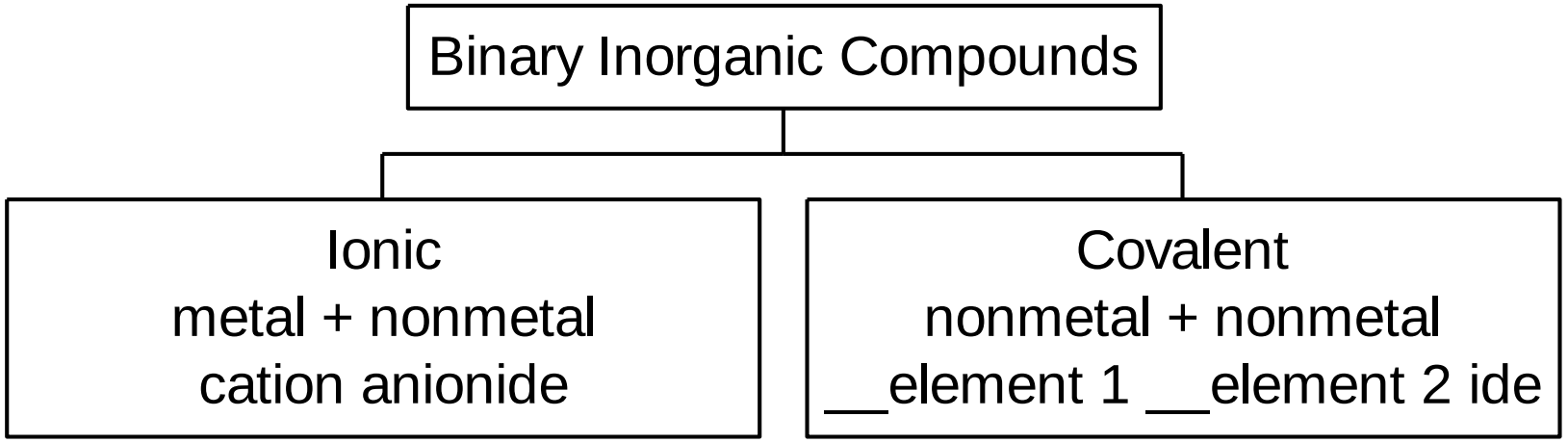
- AxByCz




symbol for hydrogen
symbol for oxygen
H_2O
subscript indicating
2 hydrogen atoms
implied subscript of 1
indicating 1 oxygen atom


symbol for NO_3^- group
symbol for magnesium
$Mg(NO_3)_2$
subscript indicating 2 NO_3^- groups
implied subscript indicating 1 magnesium atom
subscript indicating 3 oxygen atoms per NO_3^- group
implied subscript indicating 1 nitrogen atom per NO_3^- group

Inorganic Nomenclature



Nomenclature I

Binary ionic nomenclature

Ions

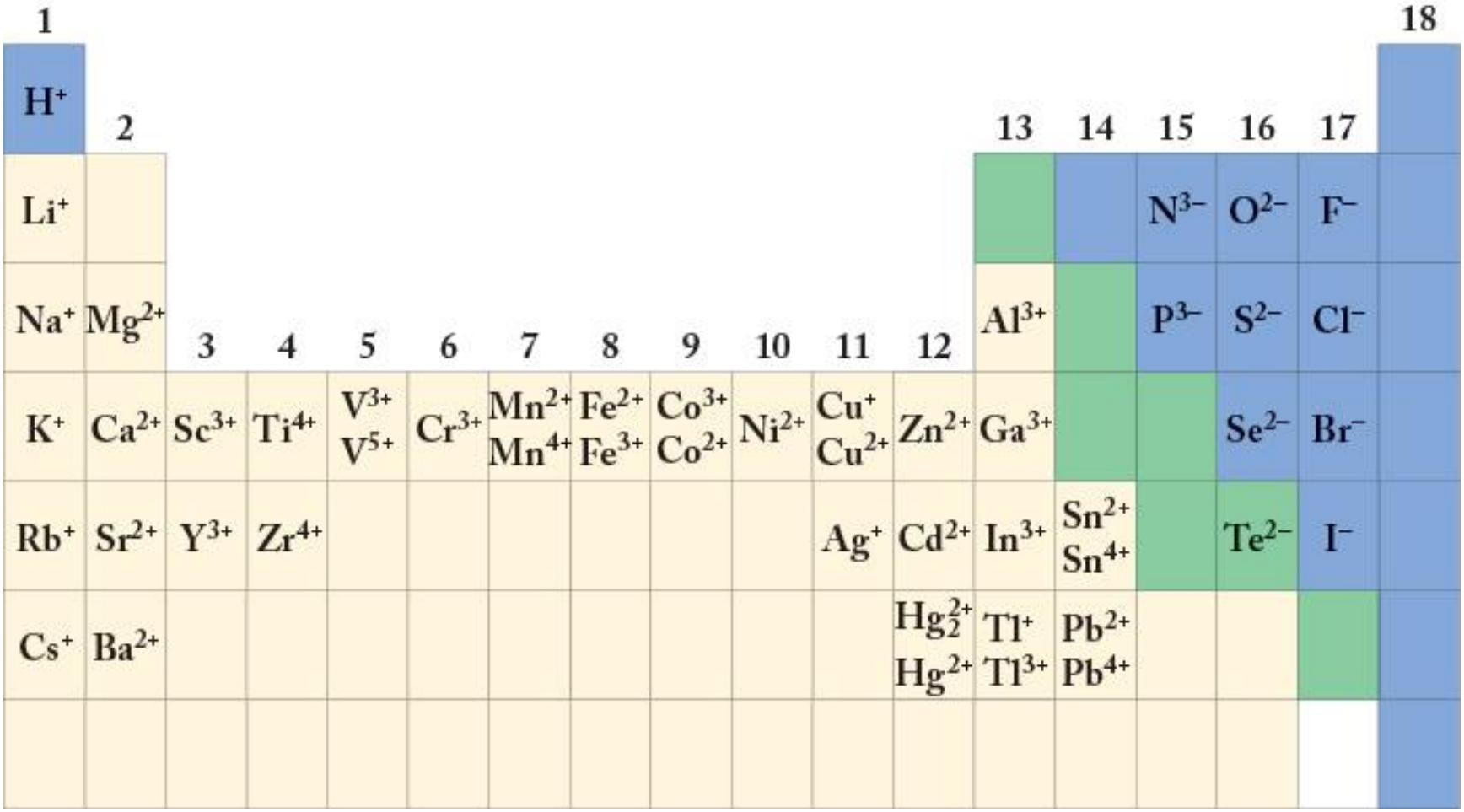
- atoms or groups of atoms that have gained or lost electrons.
- cation -- positive ion
- anion -- negative ion

Ionic Compounds

- Neutral compounds which are formed when anions and cations come together in ratios that balance the positive and negative charges. (Form formula units)

Common monatomic ions

- H^{+}
- Li^{+} Be^{+2} N^{-3} O^{-2} F^{-}
- Na^{+} Mg^{+2} Al^{+3} P^{-3} S^{-2} Cl^{-}
- K^{+} Ca^{+2} Zn^{+2} As^{-3} Se^{-2} Br^{-}
- Rb^{+} Sr^{+2} Ag^{+} Cd^{+2} Te^{-2} I^{-}
- Cs^{+} Ra^{+2}


1
18
H+
2
13
14
15
16
17
Li+
N3−
O2−
F−
Na+
Mg2+
3
4
5
6
7
8
9
10
11
12
Al3+
P3−
S2−
Cl−
K+
Ca2+
Sc3+
Ti4+
V3+
V5+
Cr3+
Mn2+
Mn4+
Fe2+
Fe3+
Co3+
Co2+
Ni2+
Cu+
Cu2+
Zn2+
Ga3+
Se2−
Br−
Rb+
Sr2+
Y3+
Zr4+
Ag+
Cd2+
In3+
Sn2+
Sn4+
Te2−
I−
Cs+
Ba2+
Hg22+
Hg2+
Tl+
Tl3+
Pb2+
Pb4+

Cation names = element name

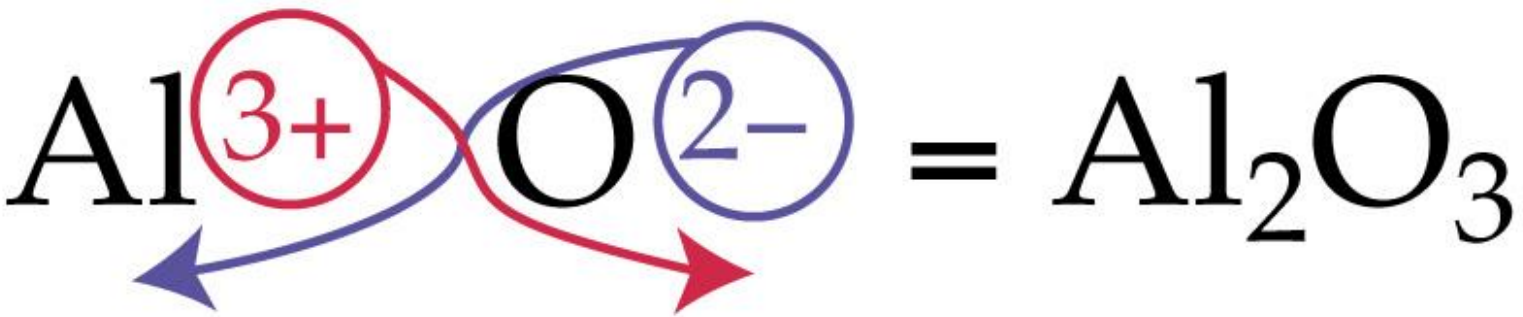
- Na^{+} sodium ion
- Ca^{2+} calcium ion
- Co^{3+} cobalt(III) ion
- Co^{2+} cobalt(II) ion
  - » for transition metals or other metals with variable oxidation states use roman numerals to designate charge.

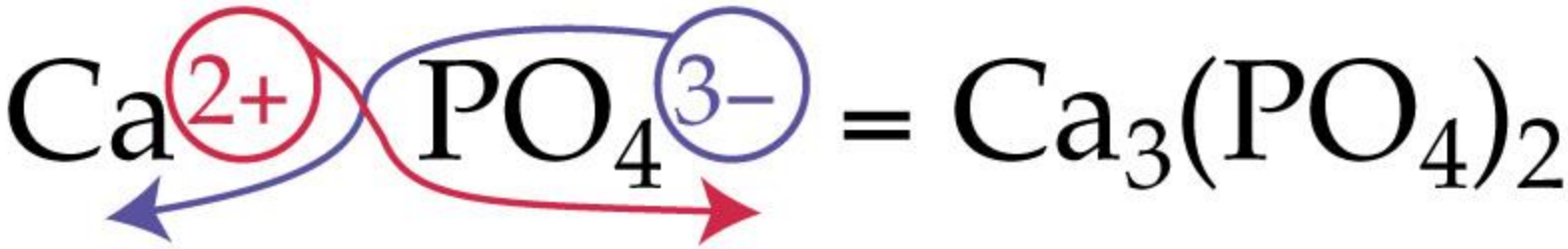
Anion names = elementide ion

- N^{3-} nitrogen $\Rightarrow$ nitride ion
- O^{2-} oxygen $\Rightarrow$ oxide ion
- S^{2-} sulfur $\Rightarrow$ sulfide ion
- Cl^{-} chlorine $\Rightarrow$ chloride ion

Compound formation

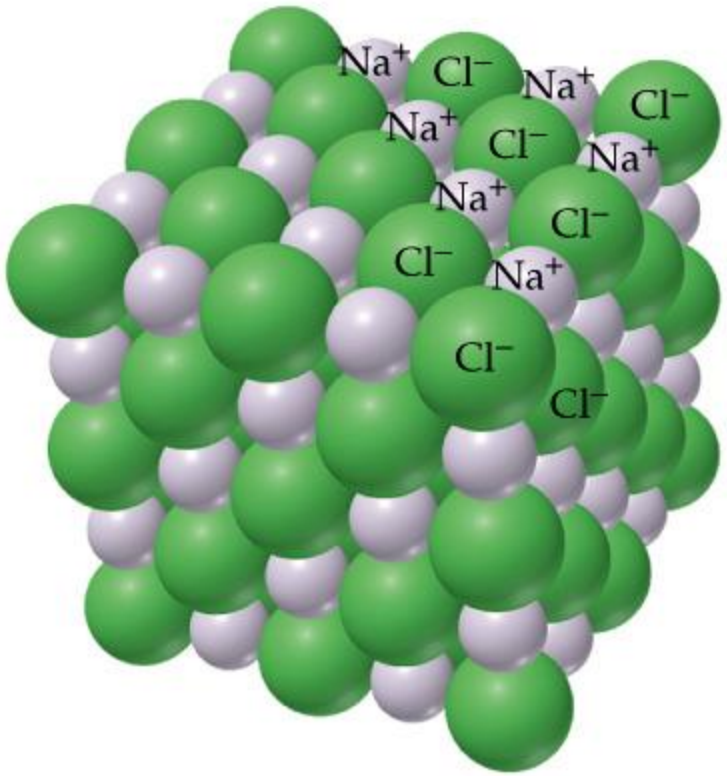
- Ions will combine in such a way as to neutralize charges


Al
3+
O
2–
= Al2O3


Ca2+
PO43–
= Ca3(PO4)2

Formula Unit

- The smallest representative unit of an ionic compound.



(e)

(d)

Cations with one oxidation state

Name of cation (metal)

Base name of anion (nonmetal) + *-ide*

Cations with multiple oxidation states

Name of cation (metal)

((Charge of cation (metal) in roman numerals in parenthesis))

Base name of anion (nonmetal) + -ide

- calcium + bromine
- $Ca^{+2} + Br^{-1}$
- $CaBr_2$
- calcium bromide

- silver + oxygen

- $\Rightarrow Ag^{+} + O^{-2}$
- $\Rightarrow Ag_2O$
- silver oxide

- potassium + chlorine

- $\Rightarrow K^{+} + Cl^{-}$
- $\Rightarrow$ KCl
- potassium chloride

- aluminum + oxygen

- $\Rightarrow Al^{+3} + O^{-2}$
- $\Rightarrow Al_2O_3$
- aluminum oxide

Name to Formula

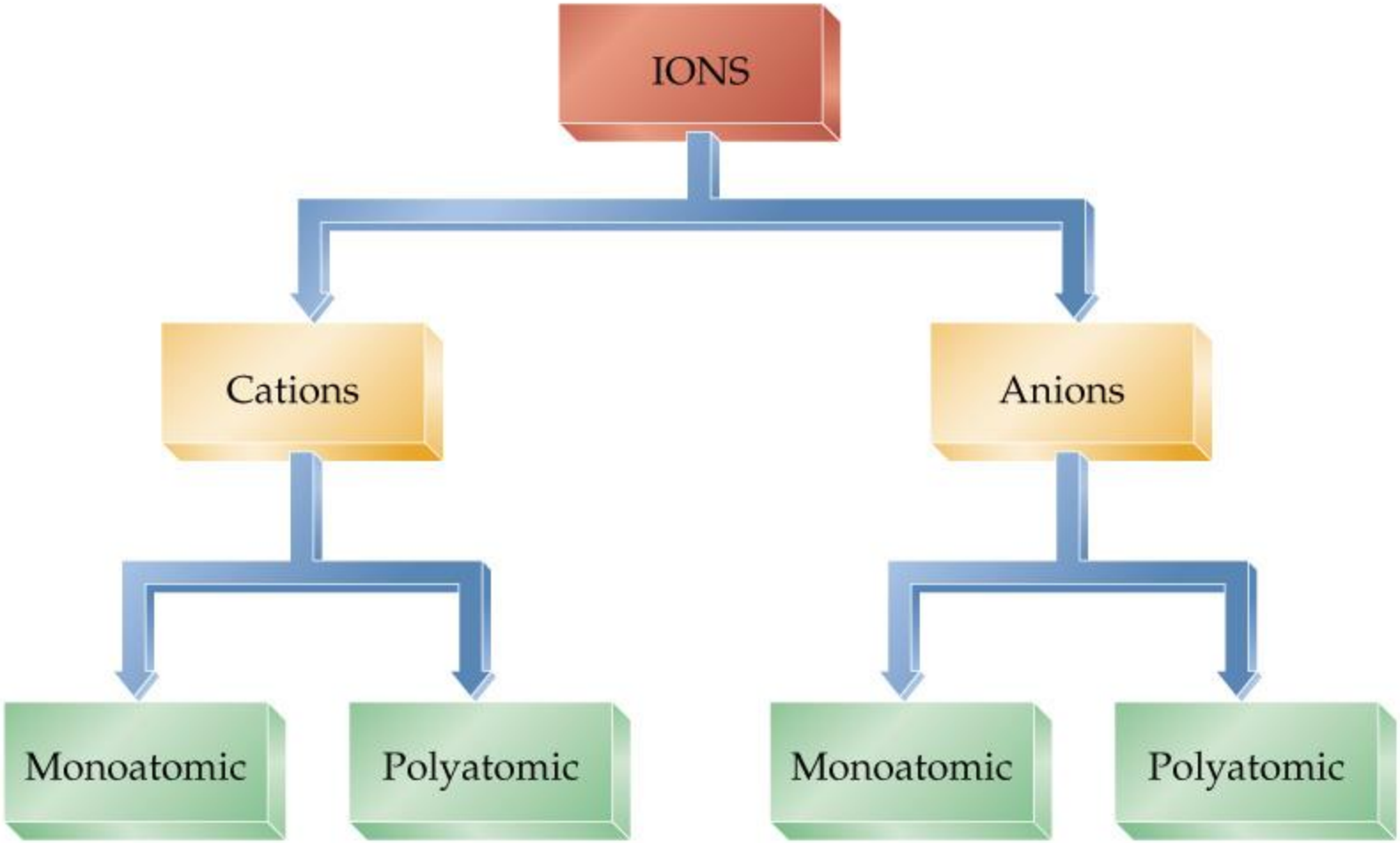
- Magnesium chloride
- Cadmium nitride
- Potassium bromide
- Rubidium oxide
- Silver sulfide

- $MgCl_2$
- Cd_3N_2
- KBr
- Rb_2O
- Ag_2S

Formula to Name

- Na_3N
- $FeCl_3$
- Ca_3P_2
- CdO
- LiI

- sodium nitride
- iron(III) chloride
- calcium phosphide
- cadmium oxide
- lithium iodide


IONS
Cations
Anions
Monoatomic
Polyatomic
Monoatomic
Polyatomic

Latin names for cations

- Copper(I) = cuprous = Cu^{+}
- Copper(II) = cupric = Cu^{+2}
- Iron(II) = ferrous = Fe^{+2}
- Iron(III) = ferric Fe^{+3}
- Tin(II) = stannous = Sn^{+2}
- Tin(IV) = stannic = Sn^{+4}

Mercury

- Remember—
- Mercury (I) exists only as Hg_2^{+2}
- Mercury (II) is Hg^{+2}

Acid Nomenclature

- Binary Acids

- HX hydrogen _____ide
  - becomes
- Hydro_____ ic acid

- HCl(g) hydrogen chloride
- HCl (aq) hydrochloric acid

- H_2S(g) hydrogen sulfide
- H_2S(aq) hydrosulfuric acid

- HCN(g) hydrogen cyanide
- HCN(aq) hydrocyanic acid

Binary Covalent Nomenclature

- Name as

- prefix telling number of each type of atom at arrows
    - Generally more metallic atom listed first

- CO_2 carbon dioxide
- Br_3O_8 tribromine octaoxide

Prefixes

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

- mono prefix used only for second element.
- For example
- NO nitrogen monoxide
  CO carbon monoxide

Formula to name

- NI_3
- $BrCl_5$
- N_2F_4
- SO_3
- I_2O_5
- XeF_4

- Nitrogen triiodide
- Bromine pentachloride
- Dinitrogen tetrafluoride
- Sulfur trioxide
- Diiodine pentoxide
- Xenon tetrafluoride

Name to formula

- Chlorine monoxide
- Carbon tetrabromide
- Xenon hexafluoride
- Diboron tetrachloride
- Diphosphorous pentasulfide
- Tetraphosphorous triselenide

- ClO
- CBr_4
- XeF_6
- B_2Cl_4
- P_2S_5
- P_4Se_3

Nomenclature 2

Ternary “ate” ions

Ternary “ate” anions

- Ions inside Mississippi
  - contain 4 oxygen atoms.
- Ions outside Mississippi
  - contain 3 oxygen atoms
- look at charge trends

Formula to name

- $Ca(ClO_3)_2$
- Na_2SO_4
- $Mg_{3(}PO_4)_2$
- $Al(BrO_3)_3$

- calcium chlorate
- sodium sulfate
- magnesium phosphate
- aluminum bromate

Name to formula

- lithium selenate -
- potassium iodate
- aluminum carbonate
- calcium borate
- cuprous sulfate

- Li_2SeO_4
- KIO_3
- $Al_2(CO_3)_3$
- $Ca_3(BO_3)_2$
- Cu_2SO_4

Nomenclature 3 +

Ternary ions – ite, per-ate, hypo-ite

Ite anions

- Subtract one oxygen from ate anion and leave charge the same

Group III (-3)	Group IV (-2)	Group V (-3 except N)	Group VI (-2)	Group VII (-1)
Borate BO_3^{-3}	Carbonate CO_3^{-2}	Nitrate NO_3^{-1} Nitrite NO_2^{-1}		
		Phosphate PO_4^{-3} Phosphite PO_3^{-3}	Sulfate SO_4^{-2} Sulfite SO_3^{-2}	Chlorate ClO_3^{-1} Chlorite ClO_2^{-1}
		Arsenate AsO_4^{-3} Arsenite AsO_3^{-3}	Selenate SeO_4^{-2} Selenite SeO_3^{-2}	Bromate BrO_3^{-1} Bromite BrO_2^{-1}
			Tellurate TeO_4^{-2} Tellurite TeO_3^{-2}	Iodate IO_3^{-1} Iodite IO_2^{-1}

Name to Formula

- Strontium sulfite
- Beryllium carbonate
- Aluminum oxide
- Lithium nitrite
- Barium sulfate

- $SrSO_3$
- $BeCO_3$
- Al_2O_3
- $LiNO_2$
- $BaSO_4$

Formula to name

- K_3PO_3
- $Mg_3(BO_3)_2$
- $Al(ClO_2)_3$
- $Al(IO_3)_3$

- potassium phosphite
- magnesium borate
- aluminum chlorite
- aluminum iodate

Hypo -- ites and per -- ates

- Hypo -- ite = ite - 1 oxygen
- Per -- ate = ate + 1 oxygen

- These exist only for the halogens.
- perchlorate ClO_4^{-1}
- chlorate ClO_3^{-1}
- chlorite ClO_2^{-1}
- hypochlorite ClO^{-1}

- Same pattern for bromine and iodine.

- $NaBrO$
- $Mg(NO_3)_2$
- Na_2SO_3
- $LiIO_4$
- $Mg(ClO_3)_2$

- sodium hypobromite
- Magnesium nitrate
- sodium sulfite
- lithium periodate
- magnesium chlorate

Formula to name

- aluminum perbromate
- calcium hypoiodite
- potassium nitrite
- strontium hypochlorite

- $Al(BrO_4)_3$
- $Ca(IO)_2$
- KNO_2
- $Sr(ClO)_2$

Formula to Name

- $Mn(NO_2)_3$
- Cu_2O
- $AlPO_4$
- $V(BrO)_5$
- $Fe_2(CO_3)_3$

- Manganese(III) nitrite
- Copper(I) oxide
  or cuprous oxide
- Aluminum phosphate
- Vanadium(V) hypobromite
- Iron(III) carbonate
  or ferric carbonate

Name to Formula

- Stannic sulfate
- Titanium(II) arsenate
- Mercury(I) chloride
- Copper(II) phosphate
- Ferrous sulfide

- $Sn(SO_4)_2$
- $Ti_3(AsO_4)_2$
- Hg_2Cl_2
- $Cu_3(PO_4)_2$
- FeS

Ions to Memorize

- NH_4^{+1} ammonium ion
- OCN^{-1} cyanate ion
- CrO_4^{-2} chromate ion
- $Cr_2O_7^{-2}$ dichromate ion
- MnO_4^{-1} permanganate ion
- CN^{-1} cyanide ion
- $C_2H_3O_2^{-1}$ acetate ion
  $C_2O_4^{-2}$ oxalate ion
- OH^{-1} hydroxide ion
- O_2^{-2} peroxide ion

Sulfur compounds

- When an oxygen atom in an ion is replaced by a sulfur atom the prefix thio is added to the name.

- OCN^{-1} cyanate SCN^{-1} thiocyanate
- SO_4^{-2} sulfate $S_2O_3^{-2}$ thiosulfate

Name to formula

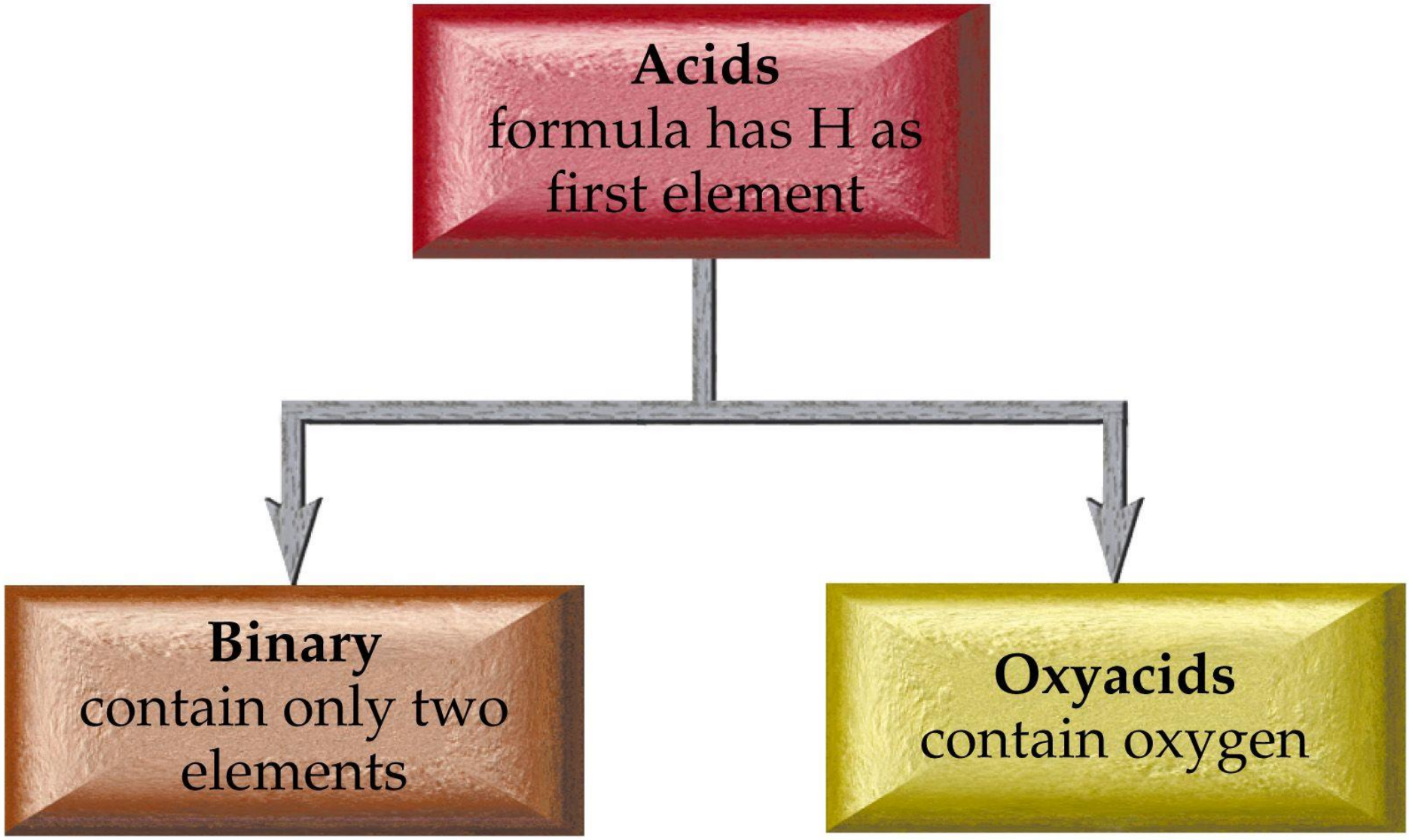
- Rubidium thiosulfate
- Calcium peroxide
- Sodium dichromate
- Ammonium perchlorate
- Potassium permanganate
- Aluminum cyanide

- $Rb_2S_2O_3$
- CaO_2
- $Na_2Cr_2O_7$
- NH_4ClO_4
- $KMnO_4$
- $Al(CN)_3$

Formula to name

- Na_2CrO_4
- $(NH_4)_2SO_4$
- MnC_2O_4
- $Al(C_2H_3O_2)_3$
- $Ba(OH)_2$
- KSCN

- Sodium chromate
- Ammonium sulfate
- Manganese(II) oxalate
- Aluminum acetate
- Barium hydroxide
- Potassium thiocyanate


Acids
formula has H as first element
Binary
contain only two elements
Oxyacids
contain oxygen

Base name of oxyanion + “-ous”

Acid

Base name of oxyanion + “-ic”

Acid

Oxyacid Nomenclature

- Hydrogen ___ate → ___ic acid
- Hydrogen ___ite → ___ous acid
- Hydrogen per __ate → per__ic acid
- Hydrogen hypo__ite →hypo__ous acid

- H_2SO_4
- H_2SO_3
- H_2CO_3
- $HClO$
- H_2TeO_3
- $HBrO_4$

- sulfuric acid
- sulfurous acid
- carbonic acid
- hypochlorous acid
- tellurous acid
- perbromic acid

Acid salt nomenclature

- HX-? Hydrogen anion name
- H_2X-? Dihydrogen anion name

- Sometimes use the prefix bi to indicate the presence of one H attached to an anion

- HCO_3^{-1} hydrogen carbonate or bicarbonate
- HS^{-1} hydrogen sulfide or bisulfide
- HSO_4^{-1} hydrogen sulfate or bisulfate

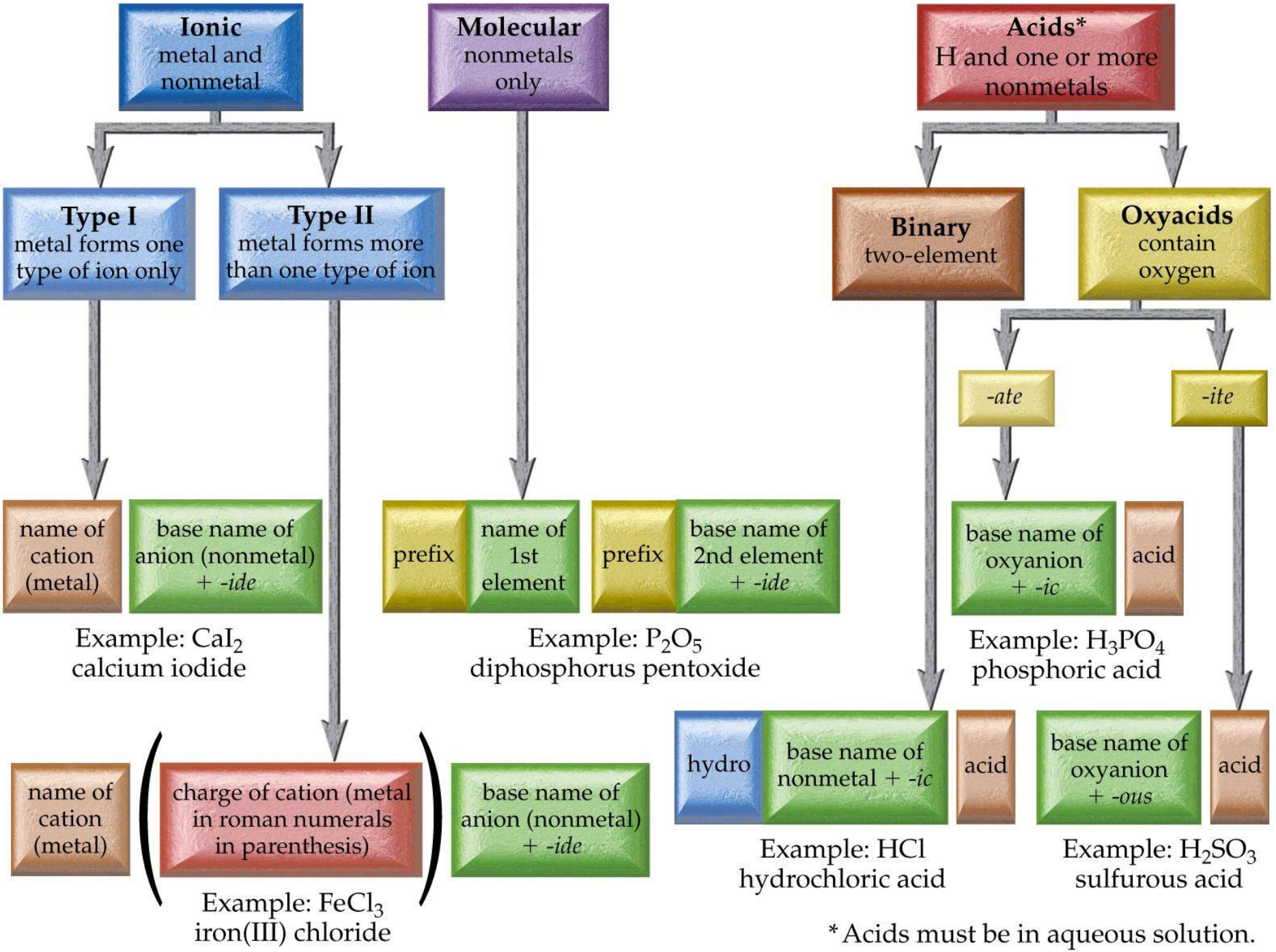
- HPO_4^{-2} hydrogen phosphate
- $H_2PO_3^{-1}$ dihydrogen phosphite

Hydrates

- Some salts precipitate with water molecules in the crystal lattice. These are called hydrates.

- Name as compound name ___hydrate
  - Where the prefix tells the number of water molecules in the crystal

- $NaNO_3 \cdot 4H_2O$ sodium nitrate tetrahydrate
- $K_3PO_4 \cdot 7H_2O$ potassium phosphate heptahydrate
- $MgO \cdot 5H_2O$ magnesium oxide pentahydrate


Ionic
metal and nonmetal
Molecular
nonmetals only
Acids*
H and one or more nonmetals
Type I
metal forms one type of ion only
Type II
metal forms more than one type of ion
Binary
two-element
Oxyacids
contain oxygen
-ate
-ite
name of cation (metal)
base name of anion (nonmetal) + -ide
prefix
name of 1st element
prefix
base name of 2nd element + -ide
base name of oxyanion + -ic
acid
Example: CaI2
calcium iodide
Example: P2O5
diphosphorus pentoxide
Example: H3PO4
phosphoric acid
name of cation (metal)
charge of cation (metal in roman numerals in parenthesis)
base name of anion (nonmetal) + -ide
hydro
base name of nonmetal + -ic
acid
base name of oxyanion + -ous
acid
Example: FeCl3
iron(III) chloride
Example: HCl
hydrochloric acid
Example: H2SO3
sulfurous acid
*Acids must be in aqueous solution.