Names and Formulas of Inorganic Compounds – IUPAC Rules

as taught in "Introductory Chemistry: Concepts and Critical Thinking" Seventh Edition by Charles H. Corwin

For this course, here are the classes and subclasses of inorganic compounds to know about:

1. ionic – compound composed of ions, but overall neutral charge (compound typically contains a metal)
   A. binary ionic compound – two elements: metal cation and nonmetal anion
   B. ternary ionic compound – three elements: metal cation and polyatomic anion
2. molecular – compound composed only of nonmetals (NOT in ionic form)
   C. binary molecular compound – two elements: both nonmetals
3. aqueous acid – solution of acidic compound in water (compound typically contains hydrogen)
   D. binary acid – aqueous solution of acid with two elements: hydrogen and nonmetal
   E. ternary oxyacid – aqueous solution of acid with three elements: hydrogen, nonmetal, and oxygen

Before naming ionic compounds (A. and B. above), it is necessary to know how to name ions:

- monoatomic ions
  - monoatomic cations – typically metals
    - for H, for main-group metals (except Sn and Pb), and for the transition metals Ag, Zn, and Cd
      (H^+, Li^+, Na^+, K^+, Mg^{2+}, Ca^{2+}, Sr^{2+}, Ba^{2+}, Ag^+, Zn^{2+}, Cd^{2+}, Al^{3+})
      name as *"element name" ion*, Na^+ is sodium ion, Zn^{2+} is zinc ion
    - for transition metals (except Ag, Zn, and Cd) and for Sn and Pb
      (Cr^{3+}, Mn^{2+}, Fe^{2+}, Fe^{3+}, Co^{2+}, Co^{3+}, Ni^{2+}, Cu^+, Cu^{2+}, Hg_2^{2+}, Hg^{2+}, Sn^{2+}, Sn^{4+}, Pb^{2+}, Pb^{4+})*
      *note that Hg^+ exists in its diatomic form, Hg_2^{2+}
      name as *"element name"(charge in roman numerals) ion*, Co^{3+} is cobalt(III) ion
  - monoatomic anions – typically nonmetals
    for nonmetals
    name as *"element stem"ide ion*, see table for all examples

anion	name	anion	name
Br^-	bromide ion	N^{3-}	nitride ion
Cl^-	chloride ion	O^{2-}	oxide ion
F^-	fluoride ion	P^{3-}	phosphide ion
I^-	iodide ion	S^{2-}	sulfide ion

- polyatomic ions – typically oxyanions, one or more elements combined with oxygen
  - polyatomic cation – only one is needed to be known for this course
    NH_4^+, ammonium ion
  - polyatomic anions – see table, some naming trends exist, best to use flash cards to memorize names

anion	name	anion	name
OH^-	hydroxide ion	ClO^-	hypochlorite ion
CN^-	cyanide ion	ClO_2^-	chlorite ion
MnO_4^-	permanganate ion	ClO_3^-	chlorate ion
CrO_4^{2-}	chromate ion	ClO_4^-	perchlorate ion
$Cr_2O_7^{2-}$	dichromate ion	NO_2^-	nitrite ion
$C_2H_3O_2^-$	acetate ion	NO_3^-	nitrate ion
PO_4^{3-}	phosphate ion	SO_3^{2-}	sulfite ion
CO_3^{2-}	carbonate ion	SO_4^{2-}	sulfate ion
HCO_3^-	hydrogen carbonate ion	HSO_4^-	hydrogen sulfate ion

note – numerous other ions exist besides what is taught in the textbook

A. **binary ionic compound**

from formula to name – cation named first, followed by anion (drop the words "ion" in compound name)

NaCl is sodium chloride, ZnO is zinc oxide

for metals where more than one type of cation is possible, the charge must first be determined

Fe_2O_3, iron is Fe^{3+}, therefore name is iron(III) oxide

from name to formula – determine charge on each ion from name, write formula with neutral charge

cobalt(III) oxide; cation is Co^{3+}, anion is O^{2-}, formula must be Co_2O_3 to have neutral (zero) charge

B. **ternary ionic compound** – same general rules as for binary ionic compound, but with polyatomic anion

from formula to name

$KMnO_4$ is potassium permanganate, $BaCO_3$ is barium carbonate, $Cu(NO_2)_2$ is copper(II) nitrite

from name to formula – be careful to put parentheses around entire anion if more than one is needed

nickel(II) acetate; cation is Ni^{2+}, anion is $C_2H_3O_2^-$, formula must be $Ni(C_2H_3O_2)_2$

C. **binary molecular compound** – only nonmetals (no ions)

from formula to name – name first element followed by second element with *-ide* suffix, also number of atoms of each element are indicated by using Greek prefixes (*mono-*, *di-*, *tri-*, *tetra-*, *penta-*, *hexa-*, *hepta-*, *octa-*, *nona-*, *deca-*) for 1-10 atoms, respectively (*mono-* prefix is only used when necessary)

IF_6 is iodine hexafluoride, Br_3O_8 is tribromine octaoxide

from name to formula – based on above rule, also note the IUPAC order for writing elements in molecular compounds: C, P, N, H, S, I, Br, Cl, O, F

dichlorine pentaoxide is Cl_2O_5, tetraphosphorus decasulfide is P_4S_{10}

D. **binary acid**

from formula to name – name as *hydro-"element stem"-ic acid*

HBr (*aq*) is hydrobromic acid

from name to formula – based on above rule, the symbol (*aq*) must be included to indicate aqueous solution

hydrofluoric acid is HF (*aq*)

E. **ternary oxyacid** – also requires memorization of polyatomic anions!

from formula to name – name as either *"polyatomic anion stem"-ic acid* for polyatomic anions which end in *-ate* or *"polyatomic anion stem"-ous acid* for polyatomic anions which end in *-ite*

in some cases, the polyatomic stem slightly varies – see table for all names used for this class

acid	name	acid	name
$HMnO_4$ (*aq*)	permanganic acid	H_3PO_4 (*aq*)	phosphoric acid
H_2CrO_4 (*aq*)	chromic acid	HClO (*aq*)	hypochlorous acid
$H_2Cr_2O_7$ (*aq*)	dichromic acid	$HClO_2$ (*aq*)	chlorous acid
$HC_2H_3O_2$ (*aq*)	acetic acid	$HClO_3$ (*aq*)	chloric acid
H_2CO_3 (*aq*)	carbonic acid	$HClO_4$ (*aq*)	perchloric acid
H_2SO_3 (*aq*)	sulfurous acid	HNO_2 (*aq*)	nitrous acid
H_2SO_4 (*aq*)	sulfuric acid	HNO_3 (*aq*)	nitric acid

from name to formula – based on above rule, see table for all examples, the symbol (*aq*) must be used again