Chemistry Lecture #35: Names and Formulas for Ionic Compounds.

Monatomic ion: single atom with a + or - charge. Examples: Na^+, Cl^-.

Positive monatomic ions, like Na^+ or Ca^{2+} are simply called "sodium ion" or "calcium ion." They could also be called "sodium cation" or "calcium cation."

Negative monatomic ions end with "ide." For example, the chlorine anion, Cl^- , is called "chloride," and the S^{-2} ion is called "sulfide."

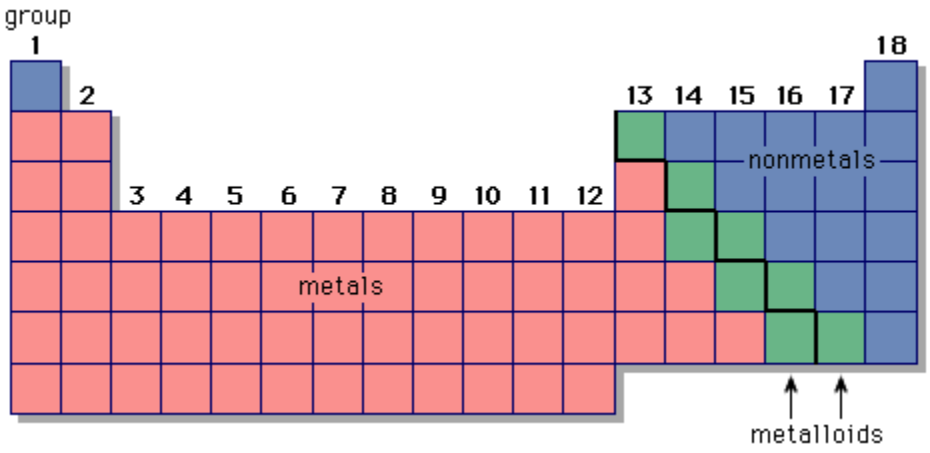
Fe^{2+} and Fe^{3+} could each be called "iron cation" but this name does not distinguish the two. To distinguish them, we use Roman numerals. Fe^{2+} is called "iron (II) ion" and Fe^{3+} is called "iron (III) ion."

An older form of naming would use the Latin name of the element, and the endings "ous" and "ic" to distinguish the oxidation states. The ion with lower oxidation state would end in "ous" and the one with the higher state would end in "ic." Thus, we would call Fe^{2+} "ferrous ion" and Fe^{3+} "ferric ion."

Below are further examples of how the older Latin system would be used to distinguish transition metal ions:

Symbol	name	older Latin name
Sn^{2+}	tin (II) ion	stannous ion
Sn^{4+}	tin (IV) ion	stannic ion
Cu^+	copper (I) ion	cuprous ion
Cu^{2+}	copper (II) ion	cupric ion

Binary ionic compounds are made of 2 types of monatomic ions: one metal ion and one nonmetal ion.



In naming a binary ionic compound, the positive ion (metal) is named first, followed by the negative ion (nonmetal).

Ionic compound	name
NaCl	sodium chloride
Cs_2O	cesium oxide
SrF_2	strontium fluoride

All binary ionic compounds end with "ide."

Binary ionic compounds with transition metals or group 4A elements often require the use of Roman numerals since these metals have variable oxidation states.

For example, CuO and Cu_2O could both be called copper oxide. But the oxidation state of Cu in CuO is +2, and the oxidation state of Cu in Cu_2O is +1. We use the Roman numerals II and I to distinguish CuO and Cu_2O.

Cu^{2+} O^{2-} ⇒ CuO copper (II) oxide
Cu^{+1} O^{2-} ⇒ Cu_2O copper (I) oxide

Sometimes the older Latin names are used to distinguish binary ionic compounds with transition metals.

Sn^{2+} F^{-1} ⇒ SnF_2 tin (II) fluoride or stannous fluoride
Sn^{4+} F^{-1} ⇒ SnF_4 tin (IV) fluoride or stannic fluoride

Fe^{2+} O^{-2} ⇒ FeO iron (II) oxide or ferrous oxide
Fe^{3+} O^{-2} ⇒ Fe_2O_3 iron (III) oxide or ferric oxide

Cr_2O_3 ⇒ chromium (III) oxide
Chromium must have a +3 charge since oxygen has a -2 charge, and 2(+3) + 3(-2) = 0

CrO ⇒ chromium (II) oxide
Chromium must have a +2 charge since oxygen has a -2 charge, and 1(+2) + 1(-2) = 0

The compounds below have transition elements, yet they have no Roman numerals.

$AgCl$ ⟹ silver chloride
$NiBr_2$ ⟹ nickel bromide
ZnS ⟹ zinc sulfide

Silver, nickel and zinc are transition elements which do not have variable oxidation states. You need to memorize that silver ion is Ag^{+}, nickel ion is Ni^{2+}, and zinc ion is Zn^{2+}.

If the compound has more than two types of atoms, it means that the cation is attached to a polyatomic ion. To name the compound, you give the name of the cation and the name of the polyatomic ion. You need to have the formulas for the polyatomic ions memorized so that you can recognize them on sight.

For example, to name KNO_3 , you start with the name of K, which is potassium. If you've done your homework, you'll recognize that NO_3 is nitrate. So the name of the compound is potassium nitrate.

KNO_3 ⟹ potassium nitrate
Na_3PO_4 ⟹ sodium phosphate
$CaSO_4$ ⟹ calcium sulfate

Be sure to include Roman numerals if the cation is a transition element or group 4A element. For example,

$Pb_3(PO_4)_2$ ⟹ lead (II) phosphate
$Fe(OH)_3$ ⟹ iron (III) hydroxide

The formula of a binary ionic compound can be derived from its name. Write the element symbols with their oxidation numbers, then crisscross the numbers to get the number of each type of atom.

Aluminum oxide → Al^{3+} O^{2-} → Al_2O_3

Calcium bromide → Ca^{2+} Br^{-1} → $CaBr_2$ or $CaBr_2$

The same procedure is used if polyatomic ions are used.

Calcium nitrate → Ca^{2+} NO_3^{-1} → $Ca(NO_3)_2$

Strontium sulfate → Sr^{2+} SO_4^{2-} → $SrSO_4$

If a Roman numeral is given in the name, use it to assign an oxidation number to the cation.

Tin (IV) phosphate → Sn^{4+} PO_4^{3-} → $Sn_3(PO_4)_4$

If the cation is a transition element and no oxidation number is given, it is probably a transition element that does not have variable oxidation states. You need to have the oxidation number for this element memorized. For example, silver is a transition element.

Silver nitrate → Ag^{+} NO_3^{-} → $AgNO_3$