Unit IV: Writing Formulas & Naming Compounds Guide

I) Metal + Non-metal:

*Ions are **atoms** or **groups of atoms** that have a **charge**. An **ionic** compound is a compound consisting of **positive** and **negative** ions held together in an **ionic bond**.

Example: What is the formula for the ionic compound formed by sodium (Na) and chlorine (Cl)?

1. Symbols: Na Cl
2. Combining capacities: Na (+1) Cl (–1)
3. Balanced charges: (+1) balances out (–1) so this ion pair is neutral.

There will be **one** sodium ion for each chlorine ion. The formula is **NaCl**.

Writing Formulas with Monatomic ions

- Write the symbol for metal first, non-metal second
- Add subscripts (small numbers below & to the right) according to their ionic charges

E.g 1. Magnesium Chloride:

Magnesium (Mg^{2+}) Chloride (Cl^-) → $MgCl_2$

E.g. 2. Copper (II) Sulphate:

Copper (Cu^{2+}) Sulphate (SO_4^{2-}) → $CuSO_4$ **Note: Reduce subscripts to the lowest ratio.**

Rules for Writing Chemical Formulas

1. Write the symbol for the more metallic element **before** the non – metallic element. (Metallics are on the **left side** of the periodic table!)
   Example: Ca Cl

2. Write the **combining capacities** for the elements, using the periodic table.
   Example: Ca^{2+} Cl^{-1}

3. The combining capacities (c.c.) should "**balance**" to make a **neutral** compound. To balance the c.c. of 1 calcium ion (+2), you need 2 chloride ions (– 1 plus – 1).
   Example: c.c. → (+2) (–2)

4. **Subscripts** indicate the **number** of atoms each element has in the compound. If the element has only 1 atom, no subscript is needed. The subscripts should be the smallest possible whole numbers.
   Example: 1 ion of calcium and 2 ions of chlorine is $CaCl_2$

Using the Cross – over method

Cross over the combining capacities from each of the ions so that they become the subscripts of the opposite ions. Reduce the subscripts to **lowest terms** if possible.

Example: Ca^{+2} Cl^{-1}

Ca_1 Cl_2 Ca_1Cl_2 → **$CaCl_2$**

Naming Compounds

Metal + Monatomic Ions

- Write the name of the metal first, then the non-metal
- Drop ending of non-metal (usually "ine" and add "ide") *See table below for examples.

E.g. 1. MgO → magnesium oxide
CaF_2 → calcium fluoride

Naming Monatomic Non-metal Ions:

Element name	Symbol	Ion name	Ion symbol
Fluor**ine**	F	Fluor**ide**	F^-
Chlor**ine**	Cl	Chlor**ide**	Cl^-
Brom**ine**	Br	Brom**ide**	Br^-
Iod**ine**	I	Iod**ide**	I^-
Ox**ygen**	O	Ox**ide**	O^{2-} ***
Sulph**ur**	S	Sulph**ide**	S^{2-} ***
Selen**ium**	Se	Selen**ide**	Se^{2-} ***
Nitr**ogen**	N	Nitr**ide**	N^{3-} ***
Phosph**orus**	P	Phosph**ide**	P^{3-} ***
Carb**on**	C	Carb**ide**	C^{4-} ***

Note: *** Students' common mistake!!!

Q: If a metal has more than one combining capacity, how do you know which one is it?

- Use the Roman numeral to indicate the charge/combining capacity.
- Place the Roman numeral charge value in brackets between the metal name and the word ion.
  Fe^{3+} = iron (III) ion, Fe^{2+} = iron (II) ion, Cu^{1+} = copper (I) ion, Cu^{2+} = copper (II) ion

E.g. $Cu(SO_4)_2$ → copper (I) sulfate
$Cu(SO_4)$ → copper (II) sulfate

II) Metal + Non-metal (Polyatomic ions):

- Polyatomic ions act as a group (as if they were one element) that carry an **overall charge** as a group
- They are usually negative, non-metals, ending in **"ate"** or sometimes **"ide"** or **"ite"**
- Except for **ammonium** ion which is a positive, polyatomic metallic ion.

Writing Formulas

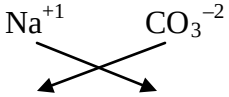
- Same as before,
  - Write the symbol for metal first, non-metal second
  - Add subscripts (small numbers below & to the right) according to their ionic charges
- But you need to use a bracket to for the group of polyatomic atoms if you have >1 group

Example potassium sulfate → K_2SO_4
nickel (III) dichromate → $Ni_2(Cr_2O_7)_3$

Treat a polyatomic ion as a **single** ion.

Example: Hydroxide = $(OH)^{-1}$
Carbonate = $(CO_3)^{-2}$

Example: We used a chemical in the lab called sodium carbonate (Na_2CO_3). The compound contains 2 sodium ions and 1 polyatomic carbonate ion.



Na_2 $(CO_3)_1$ Answer is **Na_2CO_3**

To name formulas that contain polyatomic ions, **do not** change the **endings** of the polyatomic ion.

Example: $FeCO_3$ → Iron (II) carbon**ate**
NH_4Cl → Ammon**ium** chloride

Naming Compounds

a) Metal + Polyatomic Ions

- Write the name of the metal first, then the non-metal
- Don't need to change the ending "ate"

E.g. $KMnO_4$→ potassium permanganate
$Mn_2(CO_2)_3$→ manganese (III) carbonate

*Exception: **Ammonium** (**positive metallic)** Don't change its ending & write it 1st as a metal!

E.g. NH_4OH→ ammonium hydroxide
$(NH_4)_2SO_4$ → ammonium sulphate (or sulfate)

Some Common Polyatomic Ions (See Hebden, p. 341)

Carbonate = CO_2^{2-}	Nitrate = NO_3^-	Phosphate = PO_4^{3-}	Hydroxide = OH^-
Dichromate = $Cr_2O_7^{2-}$	Ammonium = NH_4^+	Chromate = CrO_4^{2-}	Acetate = CH_3COO^-
Sulfate (Sulphate) = SO_4^{2-}		Permanganate = MnO_4^-	

III) Non-metal + Non-Metal

- Non-metals form **COVALENT** COMPOUNDS. They **don't follow the regular rules**, so prefixes are required to show the number of atoms present in each compound.

Learn these prefixes!!!

Prefix	# of atoms/ # of water molecules
mono	1
di	2
tri	3
tetra	4
penta	5
Hexa	6
hepta	7
octa	8
nona	9
deca	10

Writing Formulas

- Write the symbol for the more metallic, positive element first
- Add subscripts (small numbers below & to the right) and the prefixes tell you how many of each atom there is in the compound.

E.g 1. Trinitrogen tetroxide → N_3O_4
Carbon momoxide → CO
Carbon dioxide → CO_2

Naming Compounds

- Place the prefixes before the name of each element according to the number of atoms present in the formula
- Leave out MONO if it comes before the first element

E.g. P_2O_5 = diphosphorus pentoxide
CCl_4 = carbon tetrachloride not ~~mono~~carbon tetrachloride

Contraction:
The last vowel of these 3 prefixes (MONO, TETRA & PENTA) are dropped when combined with a compound beginning with a vowel.

- **Mono** + oxide --> monoxide but Di + iodine --> diiodine
- **Tetra** + oxide --> tetroxide Tri + iodine --> triiodine
- **Penta** + oxide --> pentoxide Hexa + oxide --> hexaoxide etc.

IV) Naming Hydrates

- Hydrates are solid compounds that contain water molecules.
- E.g. Crystallized ionic solids --- When solids crystallize from aqueous solutions, they frequently include have water molecules surrounding them.
- E.g. $Al_2O_3 \cdot 3H_2O$, means 3 water molecules surround every one Al_2O_3 group.

Naming Hydrates & Writing Formulas

- Just like before. Next, include the "hydrate" part.
- The prefixes tell you the number of water molecules

E.g. $CuSO_4 \cdot 5H_2O$ = copper (II) sulphate pentahydrate
$Zn(CH_3COO)_2$ = zinc acetate dihydrate
$Na_2CO_3.H_2O$ = sodium carbonate monhydrate

V) Common acids

- An acid is a compound starting with an **H** for hydrogen and has a **pH level less than 7**.
- Most acids are oxoacids. That is they contain oxygen in addition to hydrogen and another element.
- When dissolved in water, an oxoacid yields one ore more H^+ ions and a polyatomic oxianion.

Naming Oxoacids:

- Name the oxoanion + acid
- Change "ite" → "ous" or "ate" → "ic"

E.g.

Oxoacid	**Oxoanion**
HNO_2 Nitrous acid	NO_2^- Nitrite ion
HNO_3 Nitric acid	NO_3^- Nitrate ion

Some other acids that are not oxacids are:

- HF = **hydro**fluor**ic acid**
- HCl = **hydro**chlor**ic acid**

Q: How would you name HBr? Hydrobromic acid
Q: How would you name HI? Hydroiodic acid

Examples:

Oxoacid	**Oxoanion**
HNO_2 Nitrous acid	NO_2^- Nitrite ion
HNO_3 Nitric acid	NO_3^- Nitrate ion
H_3PO_4 Phosphoric acid	PO_4^{3-} Phosphate ion
H_2SO_3 Sulphrous acid	SO_3^{2-} Sulphite ion
H_2SO_4 Sulphuric acid	SO_4^{2-} Sulphate ion
$HClO$ Hypochlorous acid	ClO^- Hypochlorite ion
$HClO_2$ Chlorous acid	ClO_2^- Chlorite ion
$HClO_3$ Chloric acid	ClO_3^- Chlorate ion
$HClO_4$ Perchloric acid	ClO_4^- Perchlorate ion