1. Formulation and nomenclature of inorganic compounds

(nomenclature is de systematic approach to naming chemical compounds)

There are two different ways to name inorganic compounds: systematic or stoichiometric, and common nomenclature.

- The systematic nomenclature indicates the number of atoms of each element in the formula by using Greek prefixes.(1-mono, 2-di, 3-tri, 4-tetra, 5-penta, 6-hexa, 7-hepta, 8-octa, 9-nona, 10-deca). The systematic nomenclature is often used to name binary compounds, but hardly used in any other cases.
  In some cases, the oxidation number of the cation can be indicated in roman between brackets when it has more than one oxidation number.

- The common nomenclature is only used for oxyacids and oxysalts. It uses accepted names. It is very simple and frequently used.

To work out the formula, simply identify the cation and anion and calculate the adequate sub index to get an overall zero charge for the compound.

1.1. Ions

Cations are named with the name of the element followed by the charge in parentheses:

Fe^{2+}: iron (2+)
Na^{+}: sodium (1+)

Anions are named with the –ide ending followed by the charge in parentheses, although this one can be omitted if there is no ambiguity:

Cl^{-}: chloride
S^{2-}: sulfide

1.2. Metallic hydrides

These are combinations of a metallic cation with the hydride anion (H^{-}).

Two ways for the stoichiometric nomenclature:

- *metal name*(oxidation state in romans) hydride; if the metal has only one oxidation state, it is omitted.
- *metal name* prefix-hydride; if the metal has only one oxidation state prefixes can be avoided, and often mono- prefix too.

Examples:

LiH	lithium hydride	lithium hydride
PdH_2	palladium(II) hydride	palladium dihydride
FeH_3	iron(III) hydride	iron trihydride
AlH_3	aluminium hydride	aluminium trihydride

1.3. Non-metallic hydrides

These are combinations of non-metal simple anions with the H^{+} ion.

There are two kind of non-metallic hydrides. The ones of the groups 13, 14, 15 and O have their own names that you have to know:

B_2H_6	borane
CH_4	methane
NH_3	ammonia

Hydrides of the other non-metals are gases that, when dissolved in water, have acid character and can be named with the prefix hydro- connected to the stem of the non-metal with an –ic suffix and ending with the word acid. When referring to the gases, then they are named with the word hydrogen followed by the name of the non-metal ended with the prefix –ide:

H_2S	hydrosulfuric acid	hydrogen sulfide
H_2Se	hydroselenic acid	hydrogen selenide
HF	hydrofluoric acid	hydrogen fluoride
HCl	hydrochloric acid	hydrogen chloride
HBr	hydrobromic acid	hydrogen bromide
HI	hydriodic acid	hydrogen iodide
	(note the –o- of prefix dropped)	

1.4. Metallic oxides

These are combinations of the oxide anion (O^{2-}) with metallic cations. They have basic character, and, when reacted with water, produce hydroxides.

Their nomenclature is the same that for metallic hydrides, changing the word hydride for oxide:

FeO	iron(II) oxide	iron monoxide
Fe_2O_3	iron(III) oxide	diiron trioxide
Al_2O_3	aluminium oxide	aluminium oxide
Cu_2O	copper(I) oxide	dicopper monoxide

1.5. Non-metallic oxides

These are combinations of the oxide anion (O^{2-}) with non-metals, acting with some of their positive oxidation states. They have acid character, and, when reacted with water, produce oxyacids. They are formulated in the same way as the metallic oxides, and their nomenclature is also the same:

Cl_2O	chlorine(I) oxide	dichlorine monoxide
Cl_2O_3	chlorine(III) oxide	dichlorine trioxide
Cl_2O_5	chlorine(V) oxide	dichlorine pentoxide
Cl_2O_7	chlorine(VII) oxide	dichlorine heptoxide
SO_3	sulfur(VI) oxide	sulfur trioxide
SO_2	sulfur(IV) oxide	sulfur dioxide

There are two metals that present a dual behavior, being able to act both as metals and non-metals; these are chromium and manganese. When chromium acts with the oxidations state +6 and manganese with +6 and +7, their oxides have acid character and produce oxyacids and anions like chromate or permanganate.

1.6. Binary salts

Binary salts have a metallic cation and a simple non-metallic anion. They are named writing the name of the cation followed by the one of the anion.

NaCl	sodium chloride	sodium chloride
FeS	iron(II) sulfide	iron monosulfide
CoI_3	cobalt(III) iodide	cobalt triiodide
NiN	nickel(III) nitride	nickel mononitride
Li_2Se	lithium selenide	lithium selenide

1.7. Hydroxides

In the hydroxides, a metallic cation is combined with the hydroxide group, OH^-, which formally acts on the whole with the oxidation state –1. They are named like the metallic oxides, changing oxide for hydroxide:

NaOH	sodium hydroxide	sodium hydroxide
$Sn(OH)_2$	tin(II) hydroxide	tin dihydroxide
$Mn(OH)_3$	manganese(III) hydroxide	manganese trihydroxide
$Al(OH)_3$	aluminium hydroxide	aluminium trihydroxide

1.8. Oxyacids

Oxyacids are formed by the reaction of water with non-metallic oxides. They are formulated adding to the corresponding anion the ions H^+ needed to get a zero charge. **They are only named using a common nomenclature** by changing the anion endings –ite and –ate by –ous and –ic respectively and adding the word acid:

HClO	hypochlorous acid
$HClO_2$	chlorous acid
$HClO_3$	chloric acid
$HClO_4$	perchloric acid
H_2CO_3	carbonic acid
H_2SO_3	sulfurous acid
H_2SO_4	sulfuric acid
HIO_4	periodic acid
H_3PO_4	phosphoric acid
H_2CrO_4	chromic acid
$H_2Cr_2O_7$	dichromic acid

1.9. Salts

Salts are formulated combining the ions that form them correctly. **They are only named using a common nomenclature:**

$BrO_3^- + Au^+ = AuBrO_3$	gold(I) bromate
$MnO_4^- + K^+ = KMnO_4$	potassium permanganate
$CO_3^- + K^+ = K_2CO_3$	potassium carbonate
$ClO_2^- + Ca^{2+} = Ca(ClO_2)_2$	calcium chlorite
$CrO_4^{2-} + Cu^{2+} = CuCrO_4$	copper(II) chromate
$PO_4^{3-} + Al^{3+} = AlPO_4$	aluminium phosphate
$SO_3^{2-} + Fe^{2+} = FeSO_3$	iron(II) sulphite
$NO_2^- + Na^+ = NaNO_2$	sodium nitrite

2. Exercises

1. $ZnSO_3$
2. SrO
3. Hg_2CO_3
4. NO_2
5. KBr
6. $CuOH$
7. PdH_2
8. HIO
9. K_2MnO_4
10. $Au_2(CrO_4)_3$
11. KIO_4
12. $HBrO_3$
13. Co_2O_3
14. Ag_2O
15. $Pb(OH)_2$
16. H_2Se
17. H_2S
18. $Ni(OH)_2$
19. $BaSO_3$
20. mercury(II) sulfide
21. zinc dichromate
22. ammonia
23. nitrous acid
24. phosphorus(III) iodide
25. copper(I) hydroxide
26. lead(II) iodate
27. iron(III) fluoride
28. gold(III) hydroxide
29. sodium hypochlorite
30. zinc chromate
31. nickel(II) nitrate
32. rubidium hydride
33. sulfurous acid
34. borane
35. methane
36. tin(II) chlorate
37. aluminium trichloride
38. nickel(III) iodide
39. nitrogen(III) oxide
40. cobalt(II) oxide
41. lead(IV) sulfide
42. sodium manganate

SYMBOL AND OXIDATION NUMBER OF THE MAIN CHEMICAL ELEMENTS

Symbol: how we represent the elements of the periodic table. Generally we represent the elements with one capital letter. If we use two letters, then the 2nd letter is always written in lower case. Ex: Hydrogen → H ; Nickel → Ni
Valency (Oxidation number): the number of electrons lost (positive on.), gained (negative on.), or shared (we assigned the negative on. to the most electronegative element), by an element when it combines with another.

Hydrogen H (on.=+/-1)

Alkali metals (on.= +1)

Lithium	Li
Sodium	Na
Potassium	K
Rubidium	Rb
Caesium	Cs
Francium	Fr

Alkaline-earth metals (on.= +2)

Beryllium	Be
Magnesium	Mg
Calcium	Ca
Strontium	Sr
Barium	Ba
Radium	Ra

Earth metals (on.=+3)

Boron	B
Aluminium	Al
Gallium	Ga
Indium	In
Thallium	Tl

Group IV (on.=+2,+4)

Carbon	C
Silicon	Si
Germanium	Ge
Tin	Sn
Lead	Pb

Group V (on.=+/-3,+5)

Nitrogen	N
Phosphorus	P
Arsenic	As
Antimony	Sb
Bismuth	Bi

Group VI (on.=+/-2,+4,+6)

Oxygen	O (on.= -2)
Sulfur	S
Selenium	Se
Tellurium	Te
Polonium	Po

Halogens (on.=+/-1,+3,+5,+7)

Fluorine	F (on.= -1)
Chlorine	Cl
Bromine	Br
Iodine	I
Astatine	At

Noble Gases

Helium	He
Neon	Ne
Argon	Ar
Krypton	Kr
Xenon	Xe
Radon	Rn

<u>Transition Metals</u>

(on.=+1)	Silver	Ag
(on.=+2)	Zinc	Zn
	Cadmium	Cd
(on.=+1,+2)	Copper	Cu
	Mercury	Hg
(on.=+1,+3)	Gold	Au
(on.=+2,+3)	Iron	Fe
	Cobalt	Co
	Nickel	Ni

(on.=+2,+3,+6)	Chromium	Cr
(on.=+2,+3,+4,+6,+7)	Manganese	Mn
(on.=+2,+4)	Palladium	Pd
	Platinum	Pt
	Scandium	Sc
	Titanium	Ti
	Vanadium	V

Main Ions Year 9

Group 6

CrO_4^{2-}: chromate
$Cr_2O_7^{2-}$: dichromate

Group 7

MnO_4^{2-}: manganate
MnO_4^-: permanganate

Group 13

Group 14

CO_3^{2-}: carbonate
^-CN: cyanide

Group 15

NO_2^-: nitrite
NO_3^-: nitrate

PO_4^{3-}: (ortho) phosphate

AsO_4^{3-}: (ortho) arsenate

Group 1

H^-: hydride

NH_3 ammonia
CH_4 methane
B_2H_6 borane

Group 16

O^{2-}: oxide
OH^-: hydroxide
S^{2-}: sulfide
SO_3^{2-}: sulfite
SO_4^{2-}: sulfate

Group 17

F^-: fluoride
Cl^-: chloride
ClO^-: hypochlorite
ClO_2^-: chlorite
ClO_3^-: chlorate
ClO_4^-: perchlorate
Br^-: bromide
BrO^-: hypobromite
BrO_2^-: bromite
BrO_3^-: bromate
BrO_4^-: perbromate
I^-: iodide
IO^-: hypoiodite
IO_3^-: iodate
IO_4^-: periodate

The more common oxidation states

H: ±1	Group 1:	Group 2:	Group 13	Group 14	Group 15	Group 16	Group 17
NH_4^+: ammonium	+1	+2	B, Al: +3 Ga, In, Tl: +1, +3	C, Si: +2, ±4 Ge, Sn, Pb: +2, +4	N: -3 to +5 P, As, Sb, Bi: ±3, +5	O: -2 S, Se, Te, Po: -2, +4, +6	F: -1 Cl, Br, I, At: ±1, +3, +5, +7

Group 3	Group 4	Group 5	Group 6	Group 7	Group 8-10	Group 11	Group 12
Sc, Y, La: +3	Ti, Zr, Hf: +2 to +4	V, Nb, Ta: +2 to +5	Cr, Mo, W: +2 to+6	Mn, Tc, Re: +2 to +7	Fe, Co, Ni: +2, +3 Pd, Pt: +2, +4	Cu: +1, +2 Ag: +1 Au: +1, +3	Zn, Cd: +2 (Hg)