Nomenclature

(Compounds: Formulas & Names)

Rules & Tutorial

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Chemical Formulas and Unambiguous Names

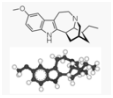
- Molecular Formula:
- **Elements' Symbols** = atoms
- **Subscripts** = relative numbers of atoms
- How are compounds named?

$CaCl_2$ **CCl_4** **NaOH** **$(NH_4)_2CO_3$**

$C_{20}H_{26}N_2O$

(Ibogaine)

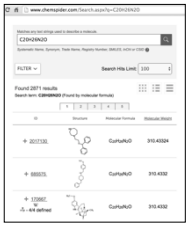
Tabernanthe iboga



Chemical Formulas and Unambiguous Names

- Molecular Formula:

$C_{20}H_{26}N_2O$



Search term: $C_{20}H_{26}N_2O$ produced 2871 results, ***where the names were different for the respective 2871 organic compounds.***

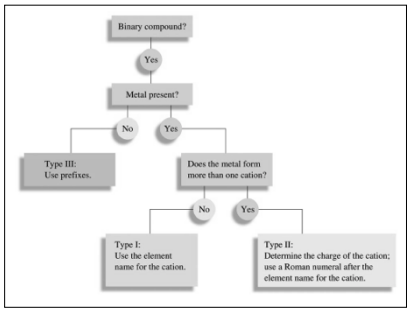
Nomenclature

- Nomenclature: the unambiguous naming of compounds/ molecules
- Governed by IUPAC: *International Union of Pure and Applied Chemistry*
- International rules are updated periodically

https://www.iupac.org/fileadmin/user_upload/databases/Red_Book_2005.pdf

Organic and Inorganic compounds/ molecules have separate naming rules. Only Inorganic rules will be considered.

Naming Inorganic Compounds

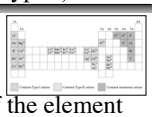


https://chem.libretexts.org/Core/Inorganic_Chemistry/Chemical_Compounds/Nomenclature_of_Inorganic_Compounds

Naming Compounds

Binary Ionic Compounds (Type I)

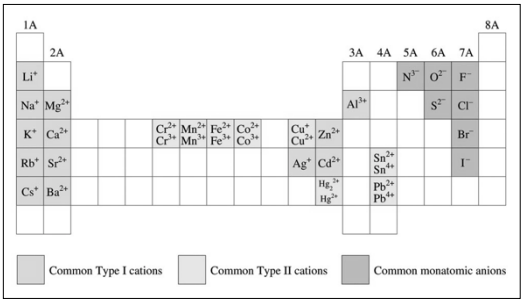
For example; $CaCl_2$



- Name cation first, then anion
- Monatomic cation = name of the element
  - Ca^{2+} = calcium ion
- Anion = root + -ide
  - Cl^- = chlor**ide**

$CaCl_2$ = calcium chloride

Common Cations and Anions



Common Monatomic Cations and Anions

Common Monatomic Cations and Anions

Cation	Name	Anion	Name
H^+	Hydrogen	H^-	Hydride
Li^+	Lithium	F^-	Fluoride
Na^+	Sodium	Cl^-	Chloride
K^+	Potassium	Br^-	Bromide
Cs^+	Cesium	I^-	Iodide
Be^{2+}	Beryllium	O^{2-}	Oxide
Mg^{2+}	Magnesium	S^{2-}	Sulfide
Ca^{2+}	Calcium	N^{3-}	Nitride
Ba^{2+}	Barium	P^{3-}	Phosphide
Al^{3+}	Aluminum		
Ag^+	Silver		

QUESTION

The correct name for LiCl is:

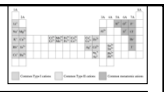
A) lithium monochloride.
B) lithium (I) chloride.
C) monolithium chloride.
D) lithium chloride.
E) monolithium monochloride.

ANSWER

D) lithium chloride.

Lithium is a Group IA metal, so it always forms a +1 ion. Therefore, no roman numeral is necessary.

Naming Compounds

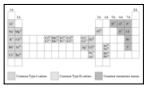


Ionic Compounds (Type II):

- metal forms more than one cation: Pb^{2+} or possibly Pb^{4+} ? *Ambiguous?*
- option 1) use Roman numeral in name
  - If Pb^{2+} is the cation; eg. $PbCl_2$:
    - $PbCl_2$ = lead (II) chloride
- or 2) use name (latinized) + suffix: -ous (lower) or -ic (higher)

Plumbum Plumbous

Common Type II Cations



Common Type II

Ion	Systematic Name
Fe^{3+}	Iron(III)
Fe^{2+}	Iron(II)
Cu^{2+}	Copper(II)
Cu^+	Copper(I)
Co^{3+}	Cobalt(III)
Co^{2+}	Cobalt(II)
Sn^{4+}	Tin(IV)
Sn^{2+}	Tin(II)
Pb^{4+}	Lead(IV)
Pb^{2+}	Lead(II)
Hg^{2+}	Mercury(II)
Hg_2^{2+*}	Mercury(I)
Ag^+	Silver†
Zn^{2+}	Zinc†
Cd^{2+}	Cadmium†

*Note that mercury(I) ions always occur bound together to form Hg_2^{2+} ions.
†Although these are transition metals, they form only one type of ion, and a Roman numeral is not used.

Naming Compounds

Ionic Compounds (Type III):

- Compounds formed between ***two nonmetals***
- First element in the formula is named first. It is the more electropositive.
- Second element is named as if it were an anion.
- Use prefixes to count the # of atoms.
- Do not normally use mono as a prefix.-
  - P_2O_5 = diphosphorus pentoxide

QUESTION

The correct name for FeO is:

A) iron oxide.
B) iron (II) oxide.
C) iron (III) oxide.
D) iron monoxide.
E) iron (I) oxide.

ANSWER

B) iron (II) oxide.

Iron is a transition metal that forms more than one type of ion. A roman numeral is needed to indicate which ion is present in the compound.

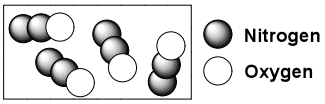
Prefixes & The Number of Atoms

Prefixes Used to Indicate Number in Chemical Names

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

QUESTION

Predict the correct name of the compound represented in the box.

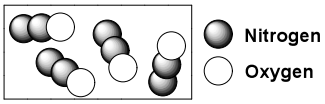


A) Nitrogen oxide **B) Oxygen nitride**

C) Dinitrogen monoxide **D) Nitrogen dioxide**

ANSWER

Predict the correct name of the compound represented in the box.



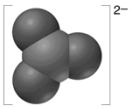
A) Nitrogen oxide **B) Oxygen nitride**

C) Dinitrogen monoxide **D) Nitrogen dioxide**

Compounds with more than two different elements

- Polyatomic ions: [oxygen as the third atom]

http://chemconnections.org/general/chem120/polyatomics.html



Carbonate ion CO_3^{2-}

Common Polyatomic Ions

Ion	Name	Ion	Name
Hg_2^{2+}	Mercury(I)	NCS^-	Thiocyanate
NH_4^+	Ammonium	CO_3^{2-}	Carbonate
NO_2^-	Nitrite	HCO_3^-	Hydrogen carbonate (bicarbonate is a widely used common name)
NO_3^-	Nitrate		
SO_3^{2-}	Sulfite		
SO_4^{2-}	Sulfate	ClO^-	Hypochlorite
HSO_4^-	Hydrogen sulfate (bisulfate is a widely used common name)	ClO_2^-	Chlorite
		ClO_3^-	Chlorate
		ClO_4^-	Perchlorate
OH^-	Hydroxide	$C_2H_3O_2^-$	Acetate
CN^-	Cyanide	MnO_4^-	Permanganate
PO_4^{3-}	Phosphate	$Cr_2O_7^{2-}$	Dichromate
HPO_4^{2-}	Hydrogen phosphate	CrO_4^{2-}	Chromate
$H_2PO_4^-$	Dihydrogen phosphate	O_2^{2-}	Peroxide
		$C_2O_4^{2-}$	Oxalate

QUESTION

Which of the following provides the correct name for $Ca(H_2PO_4)_2$?

A. Calcium dihydrogen phosphate
B. Calcium (II) hydrogen phosphate
C. Calcium di-dihydrogen phosphate
D. Calcium (II) dihydrogen phosphate

ANSWER

Which of the following provides the correct name for $Ca(H_2PO_4)_2$?

A. Calcium dihydrogen phosphate
B. Calcium (II) hydrogen phosphate
C. Calcium di-dihydrogen phosphate
D. Calcium (II) dihydrogen phosphate

QUESTION

Of the following, which provides the most acceptable name for $Fe_2(C_2O_4)_3$?

A. Iron (II) oxalate
B. Iron (II) oxalate (III)
C. Iron (III) trioxalate
D. Iron (III) oxalate

ANSWER

Of the following, which provides the most acceptable name for $Fe_2(C_2O_4)_3$?

A. Iron (II) oxalate
B. Iron (II) oxalate (III)
C. Iron (III) trioxalate
D. Iron (III) oxalate

Naming Acids

[Compounds with electropositive Hydrogen atom(s)]

hydro-
+ anion root
+ *-ic*
hydro(anion root)*ic* acid

Names of Acids* That Do Not Contain Oxygen

Acid	Name
HF	Hydrofluoric acid
HCl	Hydrochloric acid
HBr	Hydrobromic acid
HI	Hydroiodic acid
HCN	Hydrocyanic acid
H_2S	Hydrosulfuric acid

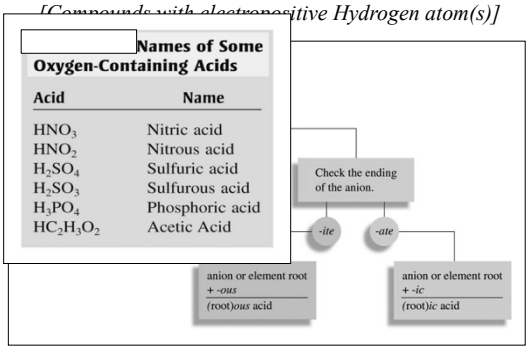
*Note that these acids are aqueous solutions containing these substances.

Naming Acids

[Compounds with electronegative Hydrogen atom(s)]

Names of Some Oxygen-Containing Acids

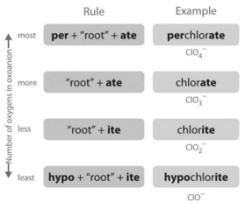
Acid	Name
HNO_3	Nitric acid
HNO_2	Nitrous acid
H_2SO_4	Sulfuric acid
H_2SO_3	Sulfurous acid
H_3PO_4	Phosphoric acid
$HC_2H_3O_2$	Acetic Acid



QUESTION

Hypochlorous acid is related to the anion found in common household bleach. Identify the formula of the polyatomic anion.

A. ClO_4^-
B. ClO_3^-
C. ClO_2^-
D. ClO^-



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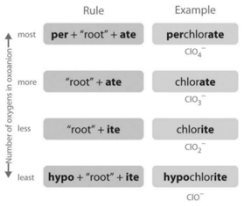

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Names from Formulas

Name the following

- SO_2 $CaBr_2$ $Zn(NO_3)_2$
- PCl_5 $(NH_4)_2SO_4$ FeO
- $HI_{(aq)}$ $HBrO_3$ $NaClO_4$
- SO_3 PCl_3 $HClO$
- Na_3PO_4 $NaOH$ KH_2PO_4

Names from Formulas

- *Solutions:*
- Sulfur dioxide Calcium bromide Zinc nitrate
- Phosphorus pentachloride Ammonium sulfate Iron(II) oxide
- Hydroiodic acid Bromic acid Sodium perchlorate
- Sulfur trioxide Phosphorus trichloride Hypochlorous acid
- Sodium phosphate Sodium hydroxide Potassium dihydrogen phosphate

Formulas from Names

Provide formulas for the following

- Sulfur trioxide
- Magnesium chloride
- Lead (IV) sulfate
- Diphosphorus pentasulfide
- Ammonium phosphate
- Iron (III) oxide
- Hydrobromic acid
- Chloric acid
- Sodium chlorite

Formulas from Names

- Solutions:

• SO_3	$MgCl_2$	$Pb(SO_4)_2$
• P_2S_5	$(NH_4)_3PO_4$	Fe_2O_3
• $HBr_{(aq)}$	$HClO_3$	$NaClO_2$