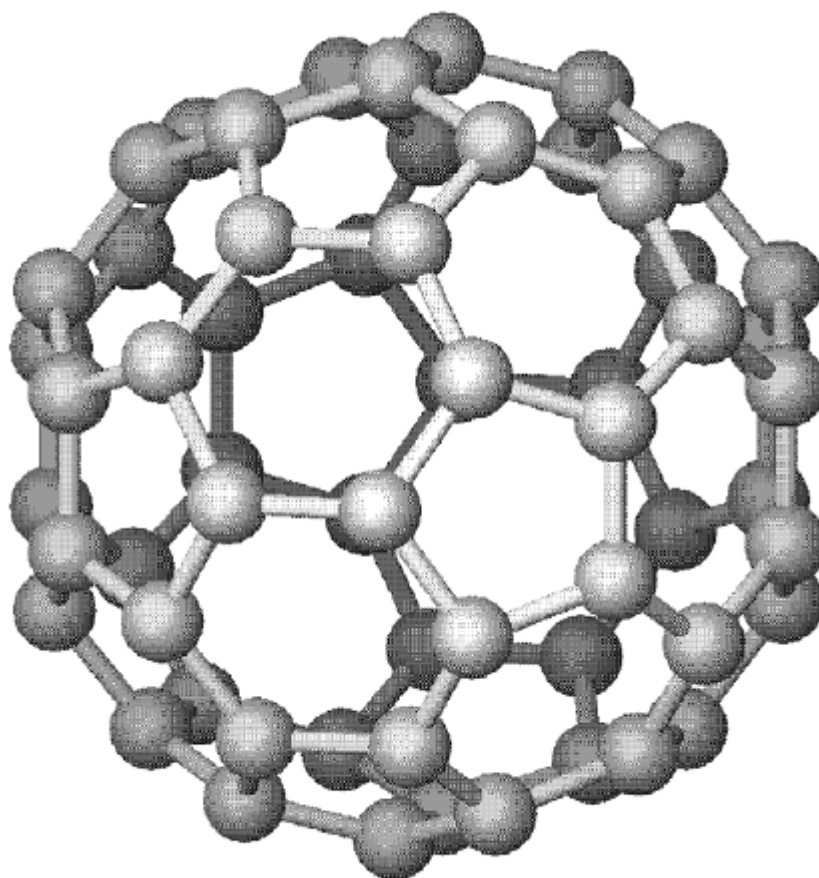


# **NOMENCLATURE PRIMER**

## **INORGANIC CHEMISTRY**



**INSTITUTE OF INORGANIC CHEMISTRY**

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# 1 Basics

## 1.1 International System of Units (SI-Units)

Physical Quantity	Formula symbol	SI-Unit	Symbol
Length	$l$	metre	m
Mass	$m$	kilogram	kg
Time	$t$	second	s
Temperature	$T$	Kelvin	K
Electric current	$I$	Ampere	A
Amount of substance	$n$	mole	mol
Luminous intensity	$I_V$	Candela	cd

## 1.2 Derived SI-Units

Physical Quantity	Formula symbol	SI-Unit	Symbol	Unit
Force	$F$	Newton	N	$\text{m}\cdot\text{kg}\cdot\text{s}^{-2}$
Energy (Work)	$E$	Joule	J	$\text{m}^2\cdot\text{kg}\cdot\text{s}^{-2}$
Pressure	$p$	Pascal	Pa	$\text{m}^{-1}\cdot\text{kg}\cdot\text{s}^{-2}$
Power	$P$	Watt	W	$\text{m}^2\cdot\text{kg}\cdot\text{s}^{-2}$
Electric charge	$q$	Coulomb	C	A·s
Voltage	$U$	Volt	V	$\text{m}^2\cdot\text{kg}\cdot\text{s}^{-3}\cdot\text{A}^{-1}$
Electrical resistance	$R$	Ohm	$\Omega$	$\text{m}^2\cdot\text{kg}\cdot\text{s}^{-3}\cdot\text{A}^{-2}$
Electrical conductance	$\sigma$	Siemens	S	$\text{m}^{-2}\cdot\text{kg}^{-1}\cdot\text{s}^3\cdot\text{A}^2$
Frequency	$\nu$	Hertz	Hz	$\text{s}^{-1}$

### 1.3 Metric prefixes

Factor	Prefix	Symbol	Factor	Prefix	Symbol
$10^{18}$	Exa	E	$10^{-1}$	Dezi	d
$10^{15}$	Peta	P	$10^{-2}$	Centi	c
$10^{12}$	Tera	T	$10^{-3}$	Milli	m
$10^9$	Giga	G	$10^{-6}$	Mikro	$\mu$
$10^6$	Mega	M	$10^{-9}$	Nano	n
$10^3$	Kilo	k	$10^{-12}$	Pico	p
$10^2$	Hekto	h	$10^{-15}$	Femto	f
$10^1$	Deka	da	$10^{-18}$	Ato	a

### 1.4 Physical constants

Avogadro constant*	$N_A$	$6.022 \times 10^{23} \text{ mol}^{-1}$
Boltzmann constant	$k_B$	$1.381 \times 10^{-23} \text{ J}\cdot\text{K}^{-1}$
Gas constant*	$R$	$8.3144 \text{ J}\cdot\text{K}^{-1}\cdot\text{mol}^{-1}$
Elementary charge	$e$	$1.602 \times 10^{-19} \text{ C}$
Faraday constant*	$F$	$96485 \text{ C}\cdot\text{mol}^{-1}$
Planck constant	$h$	$6.626 \times 10^{-34} \text{ J}\cdot\text{s}$
Vacuum permittivity	$\epsilon_0$	$8.855 \times 10^{-12} \text{ F}\cdot\text{m}^{-1}$
Volume of 1 mol of an ideal gas at 0 °C*	$V_0$	$22.414 \text{ l}\cdot\text{mol}^{-1}$
Standard conditions		T = 273.15 K ( <b>0 °C</b> ) p = 100 000 Pa (1 bar)
Atomic mass unit		1 u
speed of light in vacuum	$c$	$3 \times 10^8 \text{ m}\cdot\text{s}^{-1}$
Gravitational acceleration	$g$	$9.81 \text{ m}\cdot\text{s}^{-2}$
Rydberg constant	$R_\infty$	$109\,737 \text{ cm}^{-1}$

\* "molar" constants

## 1.5 The Greek Alphabet

	$\alpha$	alpha	
	$\beta$	beta	
$\Gamma$	$\gamma$	gamma	
$\Delta$	$\delta$	delta	$\delta+$ ; $\delta-$ : Partial charge
	$\epsilon$	epsilon	$\epsilon$ : Vacuum permittivity
	$\zeta$	zeta	
	$\eta$	eta	
$\Theta$	$\theta, \vartheta$	theta	$\theta$ : diffraction angle
	$\iota$	iota	
	$\kappa$	kappa	
$\Lambda$	$\lambda$	lambda	$\lambda$ : wavelength
	$\mu$	my	$\mu$ : mikro (Prefix), Dipole moment
	$\nu$	ny	$\nu$ : frequency
$\Xi$	$\xi$	xi	$\xi$ : mole ratio
	$\omicron$	omikron	
$\Pi$	$\pi$	pi	$\Pi$ : osmotic pressure, $\pi$ -bond
	$\rho$	rho	$\rho$ : density
$\Sigma$	$\sigma$	sigma	$\sigma$ -bond
	$\tau$	tau	$\tau$ : relaxation time
	$\upsilon$	ypsilon	
$\Phi$	$\varphi, \phi$	phi	
	$\chi$	chi	$\chi$ : magnetic susceptibility
$\Psi$	$\psi$	psi	$\psi$ : wave function
$\Omega$	$\omega$	omega	$\Omega$ : Ohm, $\omega$ : angular speed

## 1.6 Number prefixes in chemical formulas

1	(mono)
2	di
3	tri
4	tetra
5	penta
6	hexa
7	hepta
8	octa
9	nona
10	deca
11	undeca
12	dodeca

Examples:	$P_4S_7$	<b>Tetraphosphor</b> <b>hepta</b> sulfide
	$CrO_3$	Chromium <b>trio</b> xide
	$Cr_2O_3$	<b>Dichrom</b> <b>trio</b> xide
	$Na_2HPO_4 \cdot 10 H_2O$	<b>Disodium</b> hydrogenphosphate <b>deca</b> hydrate

For several identical groups alternative prefixes are used:

2	bis
3	tris
4	tetrakis
5	pentakis
	etc.

Example:  $Ca_5F(PO_4)_3$  **Pentacalcium**fluoride **tris**phosphate

Avoids a mix-up with the triphosphate group  $[P_3O_{10}]^{5-}$ .

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## 2 The Elements

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### 2.1 Element symbols

For a particular isotope of an element the numbers of protons and neutrons are summarized and written in superscript in front of the element symbol, e.g.  $^{12}\text{C}$ . Exceptions are the isotopes  $^2\text{H}$  (Deuterium) and  $^3\text{H}$  (Tritium), which are usually symbolized as D and T respectively.

### 2.2 Names of elements

Contrary to element symbols, the names are internationally not the same. Though most elements have their Latin name in all languages, some elements which are known since ancient times have different names in different languages (such as iron, gold, silver, copper, lead, tin, mercury or sulfur).

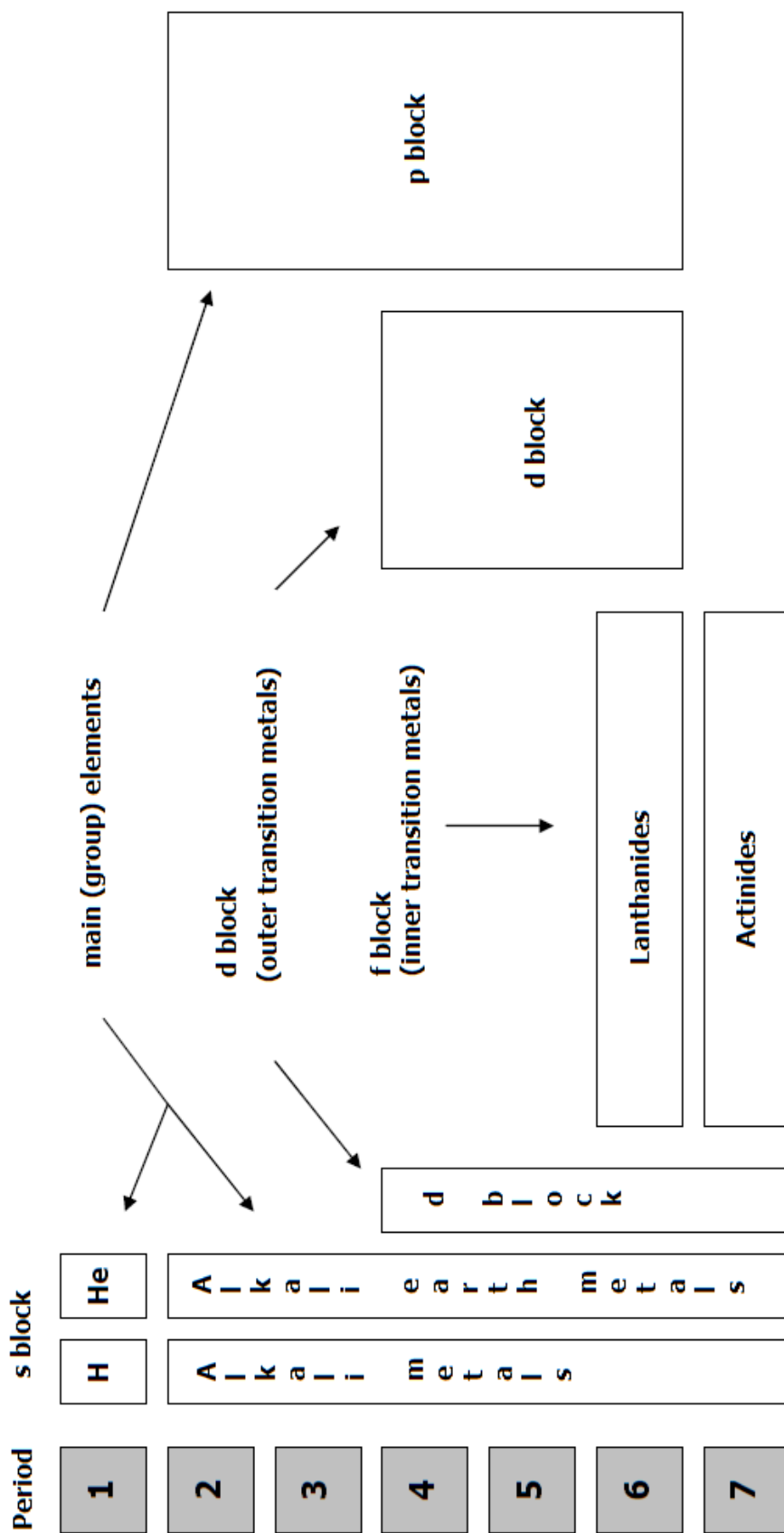
The origin of H, C, N and O is listed in the table below.

	<b>Latin name</b>	<b>meaning</b>	<b>English name</b>
<b>H</b>	Hydro-genium	water forming	hydrogen
<b>C</b>	Carbo	char coal	carbon
<b>N</b>	Nitro-genium	saltpetre forming	nitrogen
<b>O</b>	Oxy-genium	acid forming	oxygen

### 2.3 Element root name

The root name of an element is used for the name of a chemical compound. It is accompanied by the suffixes **-ide**, **-ate** or **-ite**.

### Blocks of the periodic table of elements





## 2.4 Element symbols, element names and element root names of s-, p- and d-blocks of the periodic table of elements

Element	Name	Root name
---------	------	-----------

### Main group elements (s- and p-block)

1<sup>st</sup> Period

<b>H</b>	Hydrogen	<i>hydr</i>
<b>He</b>	Helium	

1<sup>st</sup> Group (I. Main group): Alkali metals

<b>Li</b>	Lithium	
<b>Na</b>	Sodium	
<b>K</b>	Potassium	
<b>Rb</b>	Rubidium	
<b>Cs</b>	Cesium	
<b>Fr</b>	Francium	

2<sup>nd</sup> Group (II. Main group): Alkali earth metals

<b>Be</b>	Beryllium	
<b>Mg</b>	Magnesium	
<b>Ca</b>	Calcium	
<b>Sr</b>	Strontium	
<b>Ba</b>	Barium	
<b>Ra</b>	Radium	

13<sup>th</sup> Group (III. Main group): Boron group

<b>B</b>	Boron	<i>bor</i>
<b>Al</b>	Aluminium [Br.] Aluminum [Am.]	<i>alumin</i>
<b>Ga</b>	Gallium	<i>gall</i>
<b>In</b>	Indium	<i>ind</i>
<b>Tl</b>	Thallium	<i>thall</i>

14<sup>th</sup> Group (IV. Main group): Carbon group

<b>C</b>	Carbon	<i>carb</i> <i>carbon</i> *
<b>Si</b>	Silicon	<i>silic</i>
<b>Ge</b>	Germanium	<i>german</i>
<b>Sn</b>	Tin	<i>stann</i>
<b>Pb</b>	Lead	<i>plumb</i>

\*only for salts of carbon acids (carbonates) and its sulfur analogues (thiocarbonates)

15<sup>th</sup> Group (V. Main group): Nitrogen group (Pnictogenes)

<b>N</b>	Nitrogen	<i>nitr</i>
<b>P</b>	Phosphorus	<i>phosph</i>
<b>As</b>	Arsenic	<i>arsen</i>
<b>Sb</b>	Antimony	<i>antimon</i>
<b>Bi</b>	Bismuth	<i>bismut</i>

16<sup>th</sup> Group (VI. Main group): Oxygen group (Chalcogenes)

<b>O</b>	Oxygen	<i>ox</i>
<b>S</b>	Sulfur	<i>sulf</i>
<b>Se</b>	Selenium	<i>selen</i>
<b>Te</b>	Tellurium	<i>tellur</i>
<b>Po</b>	Polonium	<i>polon</i>

17<sup>th</sup> Group (VII. Main group): Halogenes

<b>F</b>	Fluorine	<i>fluor</i>
<b>Cl</b>	Chlorine	<i>chlor</i>
<b>Br</b>	Bromine	<i>brom</i>
<b>I</b>	Iodine	<i>iod</i>
<b>At</b>	Astatine	<i>astat</i>

18<sup>th</sup> Group (VIII. Main group): Noble gases

<b>He</b>	Helium	
<b>Ne</b>	Neon	
<b>Ar</b>	Argon	
<b>Kr</b>	Krypton	
<b>Xe</b>	Xenon	
<b>Rn</b>	Radon	

**Transition metals (d-Block)**3<sup>rd</sup> Group

<b>Sc</b>	Scandium	
<b>Y</b>	Yttrium	
<b>La</b>	Lanthanum	

4<sup>th</sup> Group

<b>Ti</b>	Titanium	<i>titan</i>
<b>Zr</b>	Zirconium	<i>zircon</i>
<b>Hf</b>	Hafnium	<i>hafn</i>

5<sup>th</sup> Group

<b>V</b>	Vanadium	<i>vanad</i>
<b>Nb</b>	Niobium	<i>niob</i>
<b>Ta</b>	Tantalum	<i>tantal</i>

6<sup>th</sup> Group

<b>Cr</b>	Chromium	<i>chrom</i>
<b>Mo</b>	Molybdenum	<i>molybd</i>
<b>W</b>	Tungsten	<i>wolfram</i> <i>tungs(e)</i>

7<sup>th</sup> Group

<b>Mn</b>	Manganese	<i>mangan</i>
<b>Tc</b>	Technetium	<i>techn</i>
<b>Re</b>	Rhenium	<i>rhen</i>

8<sup>th</sup> Group

<b>Fe</b>	Iron	<i>ferr</i>
<b>Ru</b>	Ruthenium	<i>ruthen</i>
<b>Os</b>	Osmium	<i>osm</i>

9<sup>th</sup> Group

<b>Co</b>	Cobalt	<i>cobalt</i>
<b>Rh</b>	Rhodium	<i>rhod</i>
<b>Ir</b>	Iridium	<i>irid</i>

10<sup>th</sup> Group

<b>Ni</b>	Nickel	<i>niccol</i>
<b>Pd</b>	Palladium	<i>pallad</i>
<b>Pt</b>	Platinum	<i>platin</i>

11<sup>th</sup> Group (coinage metals)

<b>Cu</b>	Copper	<i>cupr</i>
<b>Ag</b>	Silver	<i>argent</i>
<b>Au</b>	Gold	<i>aur</i>

12<sup>th</sup> Group (Zinc group)

<b>Zn</b>	Zinc	<i>zinc</i>
<b>Cd</b>	Cadmium	<i>cadm</i>
<b>Hg</b>	Mercury	<i>mercur</i>

The groups 8-10 are sometimes summarized according to their properties as:

Iron group: Fe, Co, Ni

Platinum group metals: Ru, Rh, Pd, Os, Ir, Pt

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## 3 General Rules for the Nomenclature of Simple Inorganic Compounds

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### 3.1 Formulas

The formulas of simple inorganic compounds follow the electronegativity of the chemical elements present. In the case of binary compounds (two elements are present) the most electropositive element comes first (the element with the positive oxidation state):

BaO, Al<sub>2</sub>S<sub>3</sub>, etc.

### 3.2 Nomenclature of simple (binary) Compounds

The same is true for the nomenclature:

The **more electropositive** partner keeps its **element name**.

The **more electronegative** (anionic) partner is given by its **root name** followed by the suffix **-ide**.

Na <sub>2</sub> S	Sodium- <i>sulf</i> - <b>ide</b>
SF <sub>6</sub>	Sulfur-hexa- <i>fluor</i> - <b>ide</b>
SiC	Silicon- <i>carb</i> - <b>ide</b>

In most cases the more electronegative element is a non-metal. With this nomenclature it is not clear if it is an ionic compound (Na<sub>2</sub>S), a polar covalent molecular compound (SF<sub>6</sub>) or a polar covalent non-molecular compound (SiC)

#### 3.2.1 Number prefixes

Stoichiometric indices of the formula are given by number prefixes:

Al<sub>2</sub>O<sub>3</sub>:        **Di**-aluminium-**tri**-*ox*-**ide**

If the name is unambiguous, the number prefix can be omitted. Aluminium forms only one oxide, therefore aluminium oxide can only be Al<sub>2</sub>O<sub>3</sub>.

### 3.2.2 Different Oxidation States of the more electropositive partner

Most elements occur in different oxidation states. Therefore, a strict linguistic distinction is necessary.

Examples:	CO	Carbon <b>mon</b> oxide
	CO <sub>2</sub>	Carbon <b>di</b> oxide
	CrO <sub>3</sub>	Chromium <b>tri</b> oxide
	CrO <sub>2</sub>	Chromium <b>di</b> oxide
	Cr <sub>2</sub> O <sub>3</sub>	<b>D</b> ichromium <b>tri</b> oxide or rarely: Chromium- <b>sesqui</b> -oxide

(Oxides of the composition A<sub>2</sub>O<sub>3</sub> can be called sesquioxides)

Another very simple method of naming compounds, especially of transition metals, is to give the valence of the more electropositive partner. In that case the number prefix can be omitted.

Example:	CrO <sub>3</sub>	Chromium(VI)oxide
	CrO <sub>2</sub>	Chromium(IV)oxide
	Cr <sub>2</sub> O <sub>3</sub>	Chromium(III)oxide

### 3.2.3 Exceptions

In English literature an old system is still in use. The more electropositive partner is given by its root name and its valence by the suffix **-ous** (for the lower valence) or **-ic** (for the higher valence).

Example: Copper occurs in the valences +1 and +2, thus it can form two chlorides.

The names accordingly are:

$\text{CuCl}$                       *cupr-ous* chloride

$\text{CuCl}_2$                       *cupr-ic* chloride

Iron forms compounds with the valences +2 and +3, its chlorides are called:

$\text{FeCl}_2$                       *ferr-ous* chloride

$\text{FeCl}_3$                       *ferr-ic* chloride

Note: The suffix **-ic** always means the higher oxidation state!



### 3.3 Element Ordering

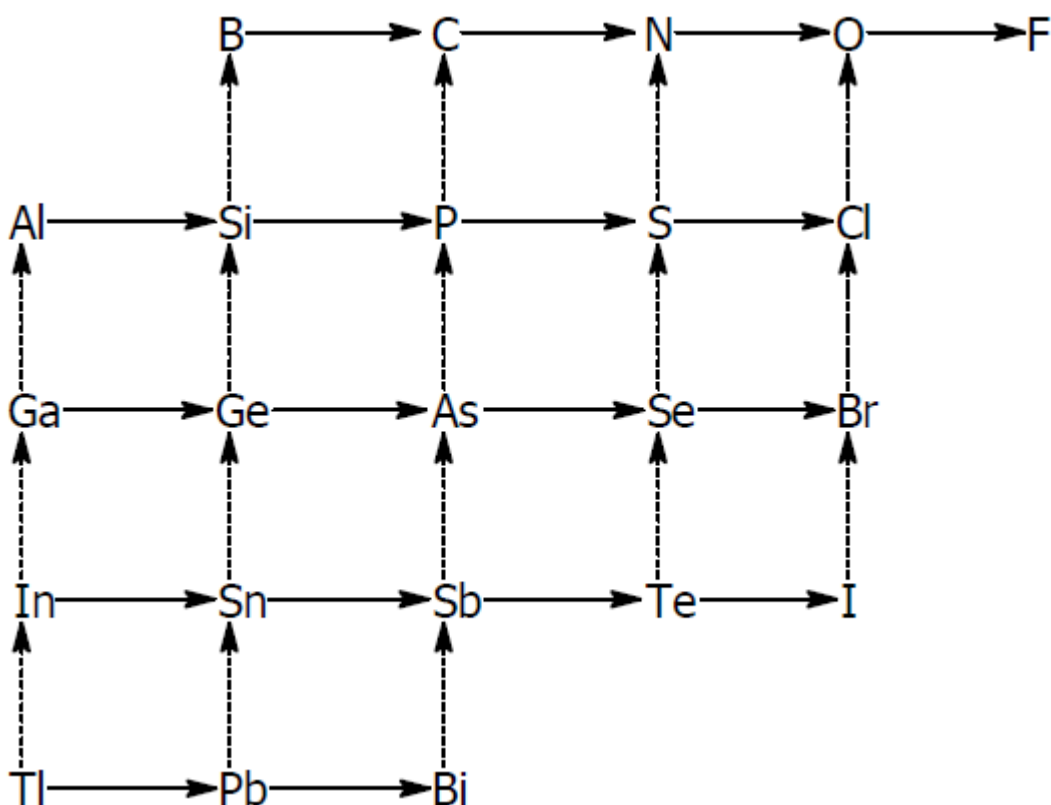
The following table shows how to correctly name a simple compound. The more right or the more at the top of a column the element is located: root name, followed by -**ide** at the end of a formula.

Examples:  $\text{OF}_2$ : oxygen-di-*fluor-ide*,  $\text{ICl}_3$ : iodine-tri-*chlor-ide*,  $\text{AlB}_2$ : aluminium-di-*bor-ide*.

Columns have priority over rows:

Thus:  $\text{BBr}_3$ : boron-tri-*brom-ide*,  $\text{NCl}_3$  nitrogen-tri-*chlor-ide*.

The nomenclature of hydrogen compounds will be explained later.



### 3.3.1 Alloys

All other elements (except for H) in binary compounds with elements of the table above are the more electropositive partner. They are all metals which form alloys. An alloy is a homogeneous hybrid of two or more elements, at least one of which is a metal. They do not have systematic names, but for some there are trivial names, e.g. brass, a Cu/Zn alloy. Alloys with mercury are called amalgams.

### 3.4 Anionic Groups with the Suffix -ide

Besides element ions also other anionic groups (polyanions or heteroaromatic groups) are characterized by the suffix **-ide**.

Formula	Structure	Name	related hydrogen compound
$C_2^{2-}$	$[:C \equiv C:]^{2-}$	Acetylide	Acetylene
$CN^-$	$:N \equiv C:^-$	Cyanide	Hydrogen cyanide (prussic acid)
$CN_2^{2-}$	$\begin{array}{c} :\ddot{N}^-=C=N:\ddot{N}: \\ \updownarrow \\ :N \equiv C - \ddot{N}:^{2-} \end{array}$	Cyanamide	
$SCN^-$	$\begin{array}{c} :\ddot{N}^-=C=S:\ddot{S}: \\ \updownarrow \\ :N \equiv C - \ddot{S}:^- \end{array}$	Thiocyanate (Rhodanide)	Thiocyanate acid
$NH_2^-$		Amide	$NH_3$ , ammonia
$NH^{2-}$		Imide	"-
$N_3^-$	$:\ddot{N}^-=N^+=N:\ddot{N}:^-$	Azide	Hydrazoic acid
$OH^-$		Hydroxide	$H_2O$ , water
$O_2^{2-}$		Peroxide	Hydrogen peroxide
$O_2^-$		Hyperoxide Superoxide	
$O_3^-$		Ozonide	
$HF_2^-$	$:\ddot{F}^- - H - \ddot{F}:^-$	Hydrogendifluoride	

### 3.5 Further usage of the Suffix **-ide**

For some classes of compounds the suffix **-ide** can be used: halogenides (compounds of halogens), chalcogenides (compounds of chalcogens), pnictides (compounds of pnictogens), more rarely also tetrelides (compounds of 14<sup>th</sup> group, especially Si, Ge, Sn) and for all binary compounds, especially hydrides (compound of hydrogen).

### 3.6 Compounds of Hydrogen

The nomenclature of binary hydrogen compounds is often different. Regardless of the electronegativity, hydrogen is at the end of a formula. Exceptions are compounds with acidic hydrogen (compounds which react acidic in aqueous solution) and water.

That means compounds of hydrogen with:

- Halogens: HF, HCl, HBr and HI
- Chalcogens: H<sub>2</sub>O, H<sub>2</sub>O<sub>2</sub>, H<sub>2</sub>S, H<sub>2</sub>Se, H<sub>2</sub>Te
- and HN<sub>3</sub>

Acidic hydrogen in inorganic oxoacids is written at the beginning of a formula, although it is generally bound to an oxygen atom. The commonly used formula fudges the real structure of the molecule.

Examples:	H <sub>2</sub> SO <sub>4</sub>	actually	SO <sub>2</sub> (OH) <sub>2</sub>
	H <sub>5</sub> IO <sub>6</sub>	actually	IO(OH) <sub>5</sub>
	H <sub>3</sub> AsO <sub>3</sub>	actually	As(OH) <sub>3</sub>

Contrary, the acidic hydrogen in organic acids (carbon acids) is at the end of the formula:

Examples:	HCOOH	formic acid
	(COOH) <sub>2</sub>	oxalic acid
	CH <sub>3</sub> COOH	acetic acid

Also in other functional groups the acidic hydrogen appears at the end of the formula.

Example:  $\text{C}_6\text{H}_5\text{SO}_3\text{H}$                   Phenylsulfonic acid

Hydrogen forms compounds with most elements. The properties of binary hydrogen compounds differ significantly with the second element present. Thus, a distinction is made between:

### 3.6.1 Non-molecular Hydrides

#### Ionic Hydrides

With electropositive metals (alkali metals, Ca, Sr, Ba) ionic hydrides are formed where hydrogen has a hydridic (anionic) form ( $\text{Na}^+\text{H}^-$ ,  $\text{Ca}^{2+}\text{H}_2^{2-}$ ). Crystal structures of those compounds are comparable with analogous chlorides. Ionic hydrides form at contact with water (protons) hydrogen spontaneously ( $\text{H}^+ + \text{H}^- \rightarrow \text{H}_2$ ).

#### Metallic Hydrides

With many transition metals metallic hydrides are formed where hydrogen fills up voids between the metal atoms, e.g.  $\text{TiH}_x$  ( $x < 2$ )

#### Covalent Hydrides

Be, Mg and the metals of the 3<sup>rd</sup> main group form non-molecular hydrides with polar-covalent bonds (e.g.  $\text{BeH}_2$ ,  $\text{GaH}_3$ ).

### 3.6.2 Molecular Hydrogen compounds

Elements of 4<sup>th</sup>-7<sup>th</sup> main group and boron form molecular hydrides, in the most simple case with the composition  $\text{AH}_{8-N}$  ( $N = \text{group number}$ ). With the exception of hydrides of carbon, nitrogen, oxygen and the halogens, those compounds have the suffix **-an**, which is attached to the (sometimes shortened) element root. For simple hydrides of the pnictogenes ( $\text{AH}_3$ ) also the Suffix **-in** is frequently used. In the case

of more complicated hydrides the number of the non-hydrogens is given by the Greek number prefix.

Examples:	$\text{SiH}_4$	Silane
	$\text{Si}_2\text{H}_6$	Disilane
	$\text{P}_2\text{H}_4$	Diphosphane

In the case of polyboranes the number of hydrogens has to be specified by Arabic numbers in brackets

Examples:	$\text{B}_{10}\text{H}_{14}$	Decaborane(14)
	$\text{B}_{10}\text{H}_{16}$	Decaborane(16)

The following table shows name roots for binary hydrogen compounds. Shortened roots are in italics. Roots in brackets are for complex hydrido-anions (see below).

Bor	---	---	---
(Al)	<i>Sil</i>	Phosph	Sulf
(Gall)	<i>Germ</i>	<i>Ars</i>	Selen
(Ind)	Stann	<i>Stib</i>	Tellur
(Thall)	Plumb	Bismut	

### Complex Hydrido-anions

Elements of the 3<sup>rd</sup> main group form tetrahedral complex anions of the type  $AH_4^-$ . The most prominent examples are the salts  $NaBH_4$  and  $LiAlH_4$ . For naming these anions the systematic names of the hydrogen compound are extended by the suffix **-ate**.

$NaBH_4$	Sodium-bor-an- <b>ate</b> (Sodiumborohydride) (Sodium-tetra- <i>hydrido</i> -borate)
$LiAlH_4$	Lithium-al-an- <b>ate</b> (Lithiumaluminiumhydride) (Lithium-tetra- <i>hydrido</i> -aluminate)

Alternative names also in use are in brackets.

### Hydrogen compounds of C, N, O and halogens

Nomenclature of carbon compounds will be discussed in Organic Chemistry. Hydrides of nitrogen and oxygen have trivial names (see table below) Compounds of hydrogen with halogens are called hydrogen halogenides (e.g. hydrogen chloride for HCl).

Formula	Name
$B_2H_6$	Diborane
$B_xH_y$	Polyboranes
$C_xH_y$	Hydrocarbons
$SiH_4$	(mono)Silane
$Si_xH_y$	Polysilanes
$GeH_4$	Germane
$SnH_4$	Stannane
$NH_3$	Ammonia
$NH_4^+$	Ammonium ion

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$\text{N}_2\text{H}_4$	Hydrazine
$\text{HN}_3$	Hydrazoic acid
$\text{PH}_3$	Phosphane, trivial: Phosphine
$\text{PH}_4^+$	Phosponium ion
$\text{P}_2\text{H}_4$	Diphosphane
$\text{P}_x\text{H}_y$	Polyphosphanes
$\text{AsH}_3$	Arsane, also: Arsine
$\text{SbH}_3$	Stiban, also: Stibine
$\text{H}_2\text{O}$	Water
$\text{H}_3\text{O}^+$	Oxonium ion, Hydronium ion
$\text{H}_2\text{O}_2$	Hydrogen peroxide
$\text{H}_2\text{S}$	Hydrogen sulfide
$\text{H}_2\text{S}_2$	Disulfane
$\text{H}_2\text{S}_x$	Polysulfanes
$\text{HF}$	hydrogen fluoride, hydrofluoric acid
$\text{HCl}$	hydrogen chloride, hydrochloric acid
$\text{HBr}$	hydrogen bromide, hydrobromic acid
$\text{HI}$	hydrogen iodide, hydroiodic acid

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## 4 Complex Anions

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### 4.1 Definition

Complex anions are anionic groups consisting of different atoms. They are marked by the suffix **-ate** (exceptions see 3.4). Simple complex anions are of the type  $AL_n^{m-}$  with a central atom A in a positive oxidation number surrounded by one or more electronegative atoms or groups as ligands L. In this case we have a mononuclear complex anion. Central atoms are usually main group elements of the p block (except O, F, Ne, Ar, Kr) and transition metals. The most electropositive metals of the s block (except Be) form no anions.

**A group ending with *-ate* is always anionic** (Exception: "hydrate")

Compounds of metals with such groups are usually ionic (salts). The metal centre (cation) is given by its element name. Complex anions with ligands other than oxygen are given by the (Greek) number and name of the ligand before the element root of the central atom and are connected via -o-. In the formula the complex anion should be distinguished by a square bracket.

Examples:     $Na[BF_4]$                       Sodium-tetra-fluoro-o-bor-ate  
                  $K_3[Fe(CN)_6]$                 Potassium-hexa-cyan-o-ferr-ate(III)

## 4.2 Oxoanions und Oxoacids

### 4.2.1 Oxoanions

Nomenclature and formula of anionic groups with oxygen as ligand (oxoanion) deviate from the aforementioned rules. Number and name of the ligand are not part of the formula and the square brackets are omitted.

Examples:  $\text{Na}_2\text{SO}_4$                       Sodiumsulfate instead of  
 $\text{Na}_2[\text{SO}_4]$                       Sodium-tetraoxo-sulfate

If an anionic group contains several central atoms (polynuclear group), their number is given by the element root and a number prefix.

Examples:  $\text{K}_2\text{Cr}_2\text{O}_7$                       Potassium-**di**-chromate  
 $(\text{NH}_4)_6\text{Mo}_7\text{O}_{24}$                       Ammonium-**hepta**-molybdate

It is not possible with this nomenclature to identify if there are discrete anionic groups in the compound.

Examples:  $\text{BaCO}_3$                       Bariumcarbonate (discrete  $\text{CO}_3^{2-}$  anions)  
 $\text{BaTiO}_3$                       Bariumtitanate (infinite three-dimensional sub-lattice of  $\text{TiO}_3$ )

Oxoanions of main group elements usually exist in molecular discrete form. The elements of the 6<sup>th</sup> and 7<sup>th</sup> group (Cr, Mo, W, Mn, Re) form discrete oxoanions in their higher oxidation states.

### 4.2.2 Oxoacids

Oxoanions are the conjugate bases of oxoacids. If the oxoanion is a discrete group, the conjugate oxoacid is a neutral molecule. The acidic hydrogen (proton) in general forms a bond with oxygen.

Not all anions form stable oxoacids. Pure  $\text{H}_2\text{CO}_3$  or  $\text{H}_2\text{SO}_3$  dissociates into  $\text{H}_2\text{O}$  and  $\text{CO}_2$  or  $\text{SO}_2$ , respectively. Therefore they cannot be isolated.

The name is the element name followed by the suffix **-ic** and **acid**.

Example:	$\text{H}_2\text{SO}_4$	sulfur- <b>ic acid</b>
	$\text{H}_3\text{PO}_4$	<i>ortho</i> -phosphoric- <b>ic acid</b>
	$\text{H}_2\text{CO}_3$	carbon- <b>ic acid</b>

Exception:	$\text{HNO}_3$	nitric acid
	$\text{H}_4\text{SiO}_4$	silicic acid

### Polyprotic acids

Depending on the number of protons an acid is classified as mono- or polyprotic (di-, triprotic). Nitric acid is monoprotic, *ortho*-phosphoric acid is triprotic.

Polyprotic acids can form different series of salts, which used to be named as primary, secondary or tertiary salts (if one, two or three protons are replaced) in older literature.

Nowadays the number of protons still present in the anion is specified by a number suffix and the word **hydrogen**.

Examples:	$\text{Ca}(\text{H}_2\text{PO}_4)_2$	prim. calcium phosphate	calcium <b>dihydrogen</b> phosphate
	$\text{CaHPO}_4$	sek. calcium phosphate	calcium <b>hydrogen</b> phosphate
	$\text{Ca}_3(\text{PO}_4)_2$	tert. calcium phosphate	calcium phosphate

Also old names are the following:

Sodium **bi**carbonate

$\text{NaHCO}_3$  (trivial name: washing soda)

Sodium **bi**sulfite

$\text{NaHSO}_3$

The **bi** means that the ratio anion/cation of the primary salt is twice the ratio of the secondary. These names should be avoided.

### 4.3 Hydrates

Many salts crystallize from aqueous solution as solids containing water, which are called hydrates. In inorganic chemistry, hydrates contain water molecules that are either bound to a metal centre or crystallized with the metal complex. Such hydrates are also said to contain "water of crystallization" or "water of hydration".

In nomenclature the water of crystallization is separated by a dot with a number prefix the suffix **-hydrate**. Also fractional values exist, like  $\frac{1}{2}$ . A substance without any water left is called *anhydrous*.

Example:  $\text{CuSO}_4 \cdot 5 \text{H}_2\text{O}$                       Copper(II)sulfate **pentahydrate**  
Copper(II)sulfate-5-hydrate                      (alternative  
IUPAC recommendation)

This notation is unclear with reference to the species present in substance.  $\text{CuSO}_4 \cdot 5 \text{H}_2\text{O}$  contains the cation  $[\text{Cu}(\text{H}_2\text{O})_4]^{2+}$ , the fifth water molecule forms strong H-bonds with the sulfate ion.

In some cases the actual structure is completely concealed:

$\text{Na}_2\text{B}_4\text{O}_7 \cdot 10 \text{H}_2\text{O}$                       Sodium tetraborate decahydrate (Borax)

There are no  $[\text{B}_4\text{O}_7]^{2-}$  anions, but  $[\text{B}_4\text{O}_5(\text{OH})_4]^{2-}$  groups as anionic units.

## 4.4 Classification of Oxoanions and Oxoacids

Since for a given element there is more than one oxoanion or oxoacid, respectively, further linguistic differentiation is necessary. They are specified according to:

- The oxidation state of the element
- The structure of the anion (mononuclear, polynuclear, non-molecular groups)

### 4.4.1 Classification based on the Oxidation State

#### Transition metals as central atom

The (positive) oxidation state of the central atom can be given by Roman numbers in brackets after the metal name.

$\text{MnO}_4^-$	Manganate(VII) or Permanganate
$\text{MnO}_4^{2-}$	Manganate(VI)
$\text{MnO}_4^{3-}$	Manganate(V)
$\text{MnO}_4^{4-}$	Manganate(IV)

Those anions have the same tetrahedral structure, but differ in their d-electron configuration of the Mn central atom ( $d^0$ ,  $d^1$ ,  $d^2$ ,  $d^3$ ) and the charge of the anion.

### Main group elements as central atoms

In principle this nomenclature can also be used for oxoanions of main group elements, but another nomenclature with different prefixes and suffixes has been established.

$\text{ClO}_4^-$	Chlorate(VII)	<b>Perchlorate</b>
$\text{ClO}_3^-$	Chlorate(V)	<b>Chlorate</b>
$\text{ClO}_2^-$	Chlorate(III)	<b>Chlorite</b>
$\text{ClO}^-$	Chlorate(I)	<b>Hypochlorite</b>

The names of their oxacids are accordingly:

$\text{HClO}_4$	Perchloric-acid
$\text{HClO}_3$	Chloric acid
$\text{HClO}_2$	Chlorous acid
$\text{HClO}$	hypochlorous acid

In general **-ate** refers to the highest oxidation state of the central atom (+6 for S in **sulfate**, +5 for P in **phosphate**). Just in case of elements of the 7<sup>th</sup>-8<sup>th</sup> and 17<sup>th</sup>-18<sup>th</sup> group the highest oxidation state +7 (and +8) is indicated by the prefix **-per** (**Perchlorate**, **Perbromate**, **Periodate**, **Permanganate** and **Perrhenate**). The names chlorate, bromate and iodate indicate the oxidation state +5. The next lower oxidation state is given by the suffix **-ite** (sulphite, nitrite, chlorite). The acids have the ending **-ous** (sulfurous acid, nitrous acid, chlorous acid). Is a further anionic group existing with two units lower oxidation states of the central atom, the suffix **-ite** is combined with the prefix **hypo-** (**hypochlorite**, **hypochlorous acid**).

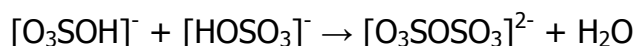
Note: The suffix per is also used in trivial names of acids and anions containing the peroxide group  $\text{O}_2^{2-}$  (persilicate, perborate, persulfate). These names should be avoided and the correct suffix **peroxy-** should be used instead (peroxy-disulfate,  $\text{S}_2\text{O}_8^{2-}$ , oxidation state +6 of S analogous to sulphate,  $[\text{CrO}_8]^{3-}$  tetra(peroxy)chromate(V), an anion with four peroxy groups).

#### 4.4.2 Classification based on the Structure

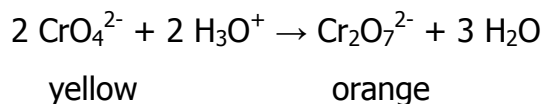
##### Isopolyanions and Isopolyacids

With some exceptions (e.g. the halogenes Cl and Br), there are always polynuclear in addition to the mononuclear oxoanions and oxoacids. They are called Isopolyanions and Isopolyacids.

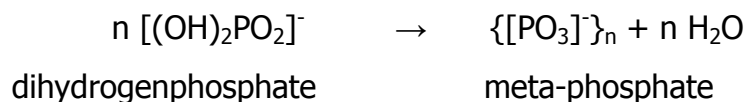
Example: Upon heating of  $\text{KHSO}_4$ , two hydrogen sulfate anions are combined by elimination of water



to a new, dimeric anionic group, the disulfate. Such a reaction is called condensation reaction. For oxoanions of transition metals a condensation can be introduced upon acidification of an aqueous solution. The condensation of a solution of chromate(VI) to dichromate(VI) can be observed by a colour change of the solution from yellow to orange:

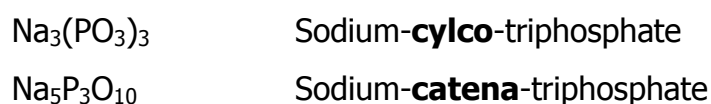


Oxoanions with OH-groups can condensate into infinite one-dimensional chains ( $n = \infty$ ):



or discrete cyclic anions ( $\text{Na}_3(\text{PO}_3)_3$ ) can be formed.

The linguistic differentiation is made by the prefixes **cyclo-** and **catena-**:





**The prefixes ortho- and meta-**

The prefixes **ortho-** and **meta-** define the different water contents of acids. This is an old nomenclature but still in use.

Examples:  $\text{H}_4\text{SiO}_4$                     **orthosilicic acid**  
 $\text{H}_2\text{SiO}_3$                         **metasilicic acid**

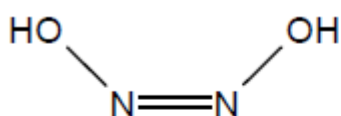
Meta acids are derived from ortho acids by condensation reactions:

$\text{H}_3\text{BO}_3$	orthoboric acid	$(\text{HBO}_2)_n$	metaboric acid
$\text{H}_4\text{SiO}_4$	orthosilicic acid	$(\text{H}_2\text{SiO}_3)_n$	metasilicic acid
$\text{H}_3\text{PO}_4$	orthophosphorous acid	$(\text{HPO}_3)_n$	metaphosphorous acid
$\text{H}_5\text{IO}_6$	orthoperiodic acid	$(\text{HIO}_4)_n$	metaperiodic acid
$\text{H}_6\text{TeO}_6$	orthotelluric acid		

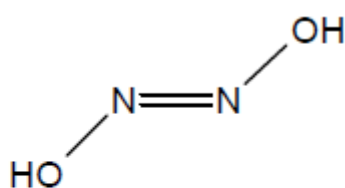
**Isopolyacids and –anions with homonuclear bonds**

These are inorganic compounds mainly containing sulfur or phosphorous with S-S or P-P bonds. They usually have their own names and are summarized in tables below.

An additional aspect has to be taken into account if there is a double bond present in the molecule like there is in hyponitrous acid (also called nitroxyl),  $\text{H}_2\text{N}_2\text{O}_2$ , with its  $\text{N}=\text{N}$  double bond. There are two isomers: cis and trans.



cis



trans

**Acids and Anions with additional non-acidic hydrogens**

Particularly in the case of the oxoacids of phosphorus in low oxidation state one of the hydrogen is directly bonded to the central atom and is not acidic. For example the phosphorous acid  $\text{H}_3\text{PO}_3$  does not have the structure  $\text{P}(\text{OH})_3$  but  $\text{H}-\text{PO}(\text{OH})_2$ , thus it is not triprotic but biprotic.

Another example is the oxoacid  $\text{H}_2\text{CO}_2$ : it is not a "carbonous" acid  $\text{C}(\text{OH})_2$ , but formic acid  $\text{H}-\text{COOH}$ .

More examples can be found in the tables below.

**Oxoacids of Halogenes**

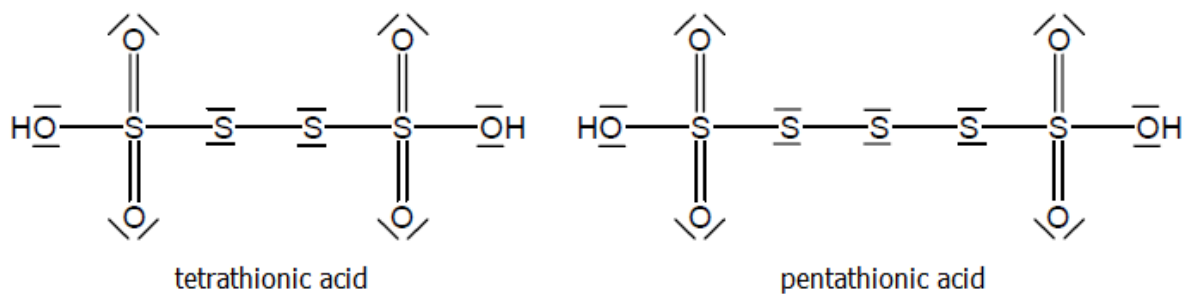
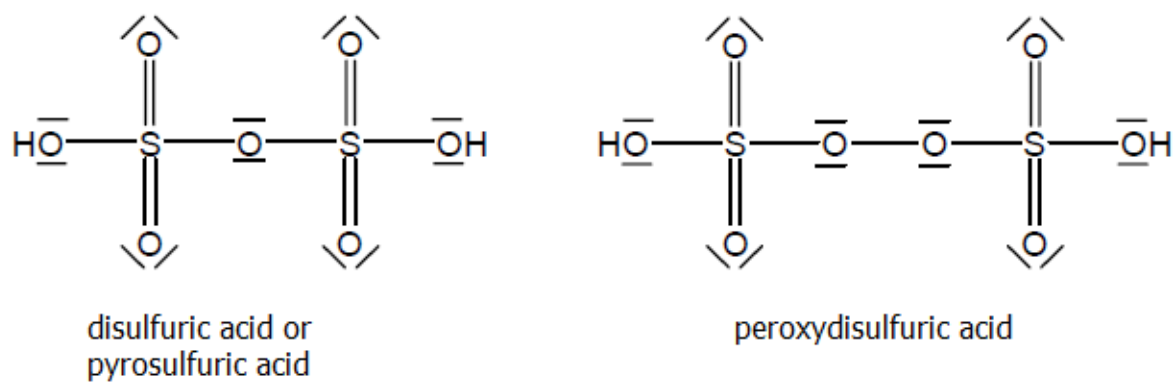
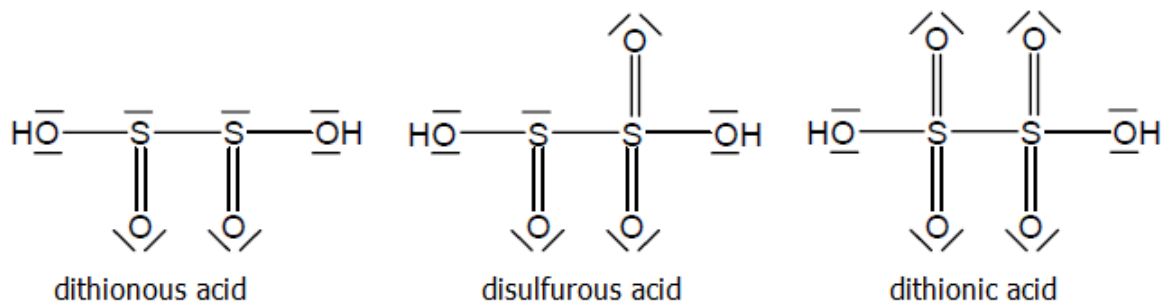
<b>Formula</b>	<b>Oxidation state</b>	<b>Name of the acid</b>	<b>Name of the salt</b>
HClO <sub>4</sub>	+7	perchloric acid	perchlorate
HClO <sub>3</sub>	+5	chloric acid	chlorate
HClO <sub>2</sub>	+3	chlorous acid	chlorite
HClO	+1	hypochlorous acid	hypochlorite
HBrO <sub>4</sub>	+7	perbromic acid	perbromate
HBrO <sub>3</sub>	+5	bromic acid	bromate
HBrO	+1	hypobromous acid	hypobromite
HIO <sub>4</sub>	+7	metaperiodic acid	metaperiodate
H <sub>5</sub> IO <sub>6</sub>	+7	orthoperiodic acid	orthoperiodate
HIO <sub>3</sub>	+5	iodic acid	iodate

Name	octet rule	extended octet	alternative
perchlorate			
chlorate			
chlorite			
hypochlorite			
periodate			
iodate			
orthoperiodic acid			
metaperiodic acid			

## Oxoacids of Chalcogenes

Formula	Oxidation state	Name of the acid	Name of the salt
<b>mononuclear groups</b>			
$\text{H}_2\text{SO}_3$	+4	sulfurous acid	sulfite
$\text{H}_2\text{SO}_4$	+6	sulfuric acid	sulfate
$\text{H}_2\text{SO}_5$	+6	peroxymonosulfuric acid	peroxosulfate
$\text{H}_2\text{S}_2\text{O}_3$	+2	thiosulfuric acid	thiosulfate
$\text{H}_2\text{SeO}_4$	+6	selenic acid	selenate
$\text{H}_6\text{TeO}_6$	+6	orthotelluric acid	tellurate
<b>dinuclear groups</b>			
$\text{H}_2\text{S}_2\text{O}_7$	+6	disulfuric pyrosulfuric acid	disulfate pyrosulfate
$\text{H}_2\text{S}_2\text{O}_8$	+6	peroxydisulfuric acid	peroxydisulfate
<b>dinuclear and polynuclear groups with S-S bonds</b>			
$\text{H}_2\text{S}_2\text{O}_5$	+4	disulfurous acid	disulfite
$\text{H}_2\text{S}_2\text{O}_4$	+3	dithionous acid	dithionite
$\text{H}_2\text{S}_2\text{O}_6$	+5	dithionic acid	dithionate
$\text{H}_2\text{S}_4\text{O}_6$	+2.5	tetrathionic acid	tetrathionate
$\text{H}_2\text{S}_n\text{O}_6$		polythionic acid	polythionate

Name	octet rule	extended octet	alternative
sulfuric acid	$\begin{array}{c} \text{:}\ddot{\text{O}}\text{:}^- \\   \\ \text{H}\ddot{\text{O}}-\text{S}^{2+}-\ddot{\text{O}}\text{H} \\   \\ \text{:}\ddot{\text{O}}\text{:}^- \end{array}$	$\begin{array}{c} \text{:}\ddot{\text{O}}\text{:} \\    \\ \text{H}\ddot{\text{O}}-\text{S}-\ddot{\text{O}}\text{H} \\    \\ \text{:}\ddot{\text{O}}\text{:} \end{array}$	
sulfate	$\begin{array}{c} \text{:}\ddot{\text{O}}\text{:}^- \\   \\ \text{:}\ddot{\text{O}}\text{:}^- - \text{S}^{2+} - \ddot{\text{O}}\text{:}^- \\   \\ \text{:}\ddot{\text{O}}\text{:}^- \end{array}$	$\begin{array}{c} \text{:}\ddot{\text{O}}\text{:}^- \\    \\ \text{:}\ddot{\text{O}}\text{:}^- - \text{S} - \text{O}\text{:} \\    \\ \text{:}\ddot{\text{O}}\text{:} \end{array}$	$\left[ \begin{array}{c} \text{O} \\   \\ \text{O} - \text{S} - \text{O} \\   \\ \text{O} \end{array} \right]^{2-}$
sulfurous acid	$\begin{array}{c} \text{:}\ddot{\text{O}}\text{:}^- \\   \\ \text{H}\ddot{\text{O}}-\text{S}^+-\ddot{\text{O}}\text{H} \\   \\ \text{:}\ddot{\text{O}}\text{:}^- \end{array}$	$\begin{array}{c} \text{:}\text{OH} \\   \\ \text{:}\ddot{\text{O}}=\text{S}-\ddot{\text{O}}\text{H} \\   \\ \text{:}\ddot{\text{O}}\text{:}^- \end{array}$	
sulfite	$\begin{array}{c} \text{:}\ddot{\text{O}}\text{:}^- \\   \\ \text{:}\ddot{\text{O}}\text{:}^- - \text{S}^+ - \ddot{\text{O}}\text{:}^- \\   \\ \text{:}\ddot{\text{O}}\text{:}^- \end{array}$	$\begin{array}{c} \text{:}\ddot{\text{O}}\text{:}^- \\    \\ \text{:}\ddot{\text{O}}\text{:}^- - \text{S} - \ddot{\text{O}}\text{:}^- \\   \\ \text{:}\ddot{\text{O}}\text{:}^- \end{array}$	$\left[ \begin{array}{c} \text{O} \\   \\ \text{O} - \text{S} - \text{O} \\   \\ \text{O} \end{array} \right]^{2-}$
hydrogen sulfite (bisulfite)	$\begin{array}{c} \text{:}\ddot{\text{O}}\text{:}^- \\   \\ \text{:}\ddot{\text{O}}\text{:}^- - \text{S}^+ - \ddot{\text{O}}\text{H} \\   \\ \text{:}\ddot{\text{O}}\text{:}^- \end{array}$	$\begin{array}{c} \text{:}\ddot{\text{O}}\text{:}^- \\    \\ \text{:}\ddot{\text{O}}\text{:}^- - \text{S} - \ddot{\text{O}}\text{H} \\   \\ \text{:}\ddot{\text{O}}\text{:}^- \end{array}$	$\left[ \text{HO} - \text{S}(\ddot{\text{O}}) - \text{O} \right]^- \rightleftharpoons \left[ \begin{array}{c} \text{H} \\   \\ \text{O} - \text{S} - \text{O} \\   \\ \text{O} \end{array} \right]^-$
thiosulfuric acid	$\begin{array}{c} \text{:}\ddot{\text{O}}\text{:}^- \\   \\ \text{H}\ddot{\text{O}}-\text{S}^{2+}-\ddot{\text{O}}\text{H} \\   \\ \text{:}\ddot{\text{S}}\text{:}^- \end{array}$	$\begin{array}{c} \text{:}\ddot{\text{O}}\text{:} \\    \\ \text{H}\ddot{\text{O}}-\text{S}-\ddot{\text{O}}\text{H} \\    \\ \text{:}\ddot{\text{S}}\text{:} \end{array}$	
peroxymonosulfuric acid	$\begin{array}{c} \text{:}\ddot{\text{O}}\text{:}^- \\   \\ \text{H}\ddot{\text{O}}-\text{S}^{2+}-\text{O}-\ddot{\text{O}}\text{H} \\   \\ \text{:}\ddot{\text{O}}\text{:}^- \end{array}$	$\begin{array}{c} \text{:}\ddot{\text{O}}\text{:} \\    \\ \text{H}\ddot{\text{O}}-\text{S}-\text{O}-\ddot{\text{O}}\text{H} \\    \\ \text{:}\ddot{\text{O}}\text{:} \end{array}$	



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**Oxoacids of nitrogen**

<b>Formula</b>	<b>Oxidation state</b>	<b>Name of the acid</b>	<b>Name of the salt</b>
HNO <sub>3</sub>	+5	nitric acid	nitrate
HNO <sub>2</sub>	+3	nitrous acid	nitrite
H <sub>2</sub> N <sub>2</sub> O <sub>2</sub>	+1	hyponitrous acid	hyponitrite

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**Oxoacids of carbon**

H <sub>2</sub> CO <sub>3</sub>	+4	carbonic acid	carbonate
R-COOH	+3	carboxylic acid	organic nomenclature

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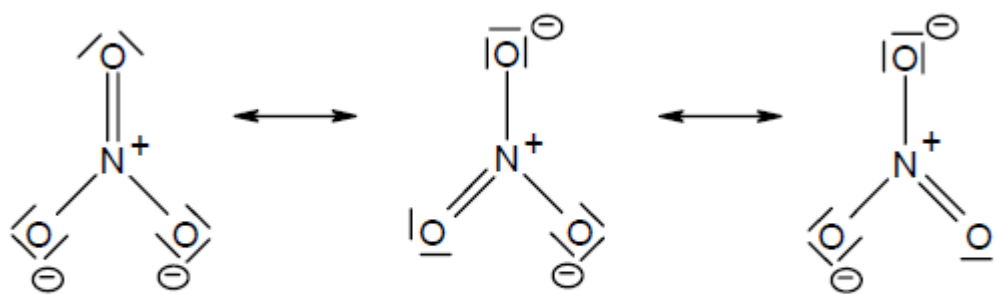
**Oxoacids containing nitrogen and carbon**

HOCN		cyanic acid	cyanate
HNCO		isocyanic acid	isocyanate
HCNO		fulminic acid	fulminate

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Name	octet rule (octet expansion not allowed!)	alternative
nitrate		
nitrite		
carbonate		
cyanate		
isocyanate		
fulminate		

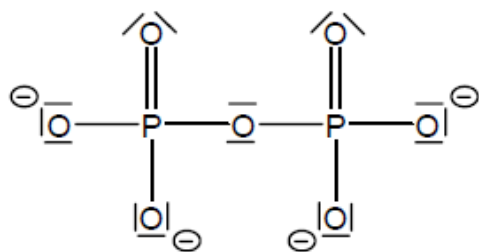


Mesomerism of Nitrate

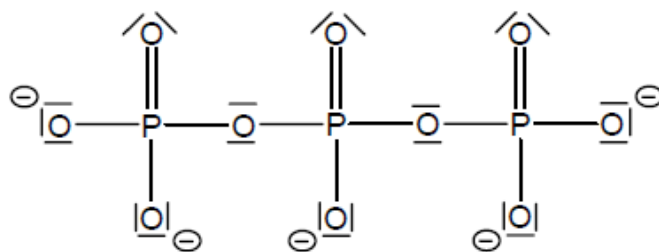
## Oxoacids of Pnictogenes

Formula	Oxidation state	Name of the acid	Name of the salt
<b>mononuclear groups</b>			
H <sub>3</sub> PO <sub>4</sub>	+5	phosphoric acid	phosphate
		orthophosphoric acid	orthophosphate
H <sub>3</sub> PO <sub>3</sub>	+3	phosphonic acid	phosphonate
		phosphorous acid	
H <sub>3</sub> PO <sub>2</sub>	+1	phosphinic acid	Phosphinate
		hypophosphorous acid	
H <sub>3</sub> AsO <sub>4</sub>	+5	arsenic acid	arsenate
H <sub>3</sub> AsO <sub>3</sub>	+3	arsenious acid	arsenite
<b>dinuclear and polynuclear groups</b>			
H <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	+5	diphosphoric acid	diphosphate
		pyrophosphoric acid	pyrophosphate
H <sub>5</sub> P <sub>3</sub> O <sub>10</sub>	+5	triphosphoric acid	triphosphate
H <sub>3</sub> P <sub>3</sub> O <sub>9</sub>	+5	cyclotrisphosphoric acid	cyclotriphosphate
H <sub>4</sub> P <sub>4</sub> O <sub>12</sub>	+5	cyclotetraphosphoric acid	cyclotetraphosphate
<b>non-molecular acids of phosphorous</b>			
HPO <sub>3</sub>	+5	metaphosphoric acid	metaphosphate
<b>Isomeric diphosphoric acid with P in lower oxidations state</b>			
H <sub>4</sub> P <sub>2</sub> O <sub>5</sub>	+3	diphosphoric(III) acid	diphosphate(III)
		diphosphonic acid	diphosphonate
H <sub>4</sub> P <sub>2</sub> O <sub>5</sub>	+3	diphosphoric(II,IV) acid	diphosphate(II,IV)
H <sub>4</sub> P <sub>2</sub> O <sub>6</sub>	+4	diphosphoric(III,V) acid	diphosphate(III,V)
		isohypophosphoric acid	isohypophosphate
H <sub>4</sub> P <sub>2</sub> O <sub>6</sub>	+4	diphosphoric(IV) acid	diphosphate(IV)
		hypophosphoric acid	hypophosphate

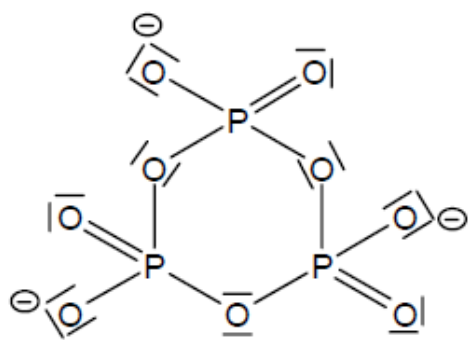
Name	octet rule	extended octet	alternative
phosphoric acid	$\begin{array}{c} \text{:}\ddot{\text{O}}\text{H} \\   \\ \text{H}\ddot{\text{O}}-\text{P}^+-\ddot{\text{O}}\text{H} \\   \\ \text{:}\ddot{\text{O}}\text{:}^- \end{array}$	$\begin{array}{c} \text{:}\ddot{\text{O}}\text{H} \\   \\ \text{H}\ddot{\text{O}}-\text{P}=\ddot{\text{O}} \\   \\ \text{:}\ddot{\text{O}}\text{:}^- \end{array}$	
phosphate	$\begin{array}{c} \text{:}\ddot{\text{O}}\text{:}^- \\   \\ \text{:}\ddot{\text{O}}\text{:}^--\text{P}^+-\ddot{\text{O}}\text{:}^- \\   \\ \text{:}\ddot{\text{O}}\text{:}^- \end{array}$	$\begin{array}{c} \text{:}\ddot{\text{O}}\text{:}^- \\   \\ \text{:}\ddot{\text{O}}\text{:}^--\text{P}=\ddot{\text{O}} \\   \\ \text{:}\ddot{\text{O}}\text{:}^- \end{array}$	$\left[ \begin{array}{c} \text{O} \\ \vdots \\ \text{P} \\ \vdots \\ \text{O} \\ \vdots \\ \text{O} \end{array} \right]^{3-}$
phosphonic acid	$\begin{array}{c} \text{:}\ddot{\text{O}}\text{H} \\   \\ \text{:}\ddot{\text{O}}\text{:}^--\text{P}^+-\ddot{\text{O}}\text{H} \\   \\ \text{H} \end{array}$	$\begin{array}{c} \text{:}\ddot{\text{O}}\text{H} \\   \\ \ddot{\text{O}}=\text{P}-\ddot{\text{O}}\text{H} \\   \\ \text{H} \end{array}$	
phosphonate	$\begin{array}{c} \text{:}\ddot{\text{O}}\text{:}^- \\   \\ \text{:}\ddot{\text{O}}\text{:}^--\text{P}^+-\ddot{\text{O}}\text{:}^- \\   \\ \text{H} \end{array}$	$\begin{array}{c} \text{:}\ddot{\text{O}}\text{:}^- \\   \\ \text{:}\ddot{\text{O}}\text{:}^--\text{P}=\ddot{\text{O}} \\   \\ \text{H} \end{array}$	$\left[ \begin{array}{c} \text{H} \\   \\ \text{P} \\   \\ \text{O} \\ \vdots \\ \text{O} \end{array} \right]^{2-}$
phosphite	$\begin{array}{c} \text{:}\ddot{\text{O}}\text{:}^- \\   \\ \text{:}\ddot{\text{O}}\text{:}^--\text{P} \\   \\ \text{:}\ddot{\text{O}}\text{:}^- \end{array}$		
phosphinic acid	$\begin{array}{c} \text{:}\ddot{\text{O}}\text{:}^- \\   \\ \text{H}\ddot{\text{O}}-\text{P}^+-\text{H} \\   \\ \text{H} \end{array}$	$\begin{array}{c} \text{:}\ddot{\text{O}}\text{:}^- \\    \\ \text{H}\ddot{\text{O}}-\text{P}-\text{H} \\   \\ \text{H} \end{array}$	
phosphinate	$\begin{array}{c} \text{:}\ddot{\text{O}}\text{:}^- \\   \\ \text{:}\ddot{\text{O}}\text{:}^--\text{P}^+-\text{H} \\   \\ \text{H} \end{array}$	$\begin{array}{c} \text{:}\ddot{\text{O}}\text{:}^- \\    \\ \text{:}\ddot{\text{O}}\text{:}^--\text{P}-\text{H} \\   \\ \text{H} \end{array}$	$\left[ \begin{array}{c} \text{H} \\   \\ \text{P} \\   \\ \text{O} \\ \vdots \\ \text{O} \end{array} \right]^{-}$



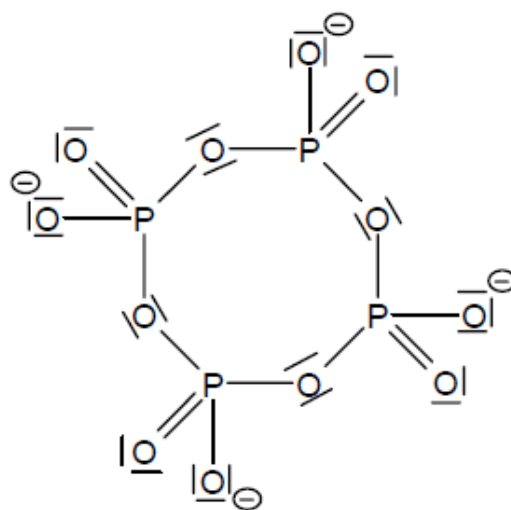
Diphosphate



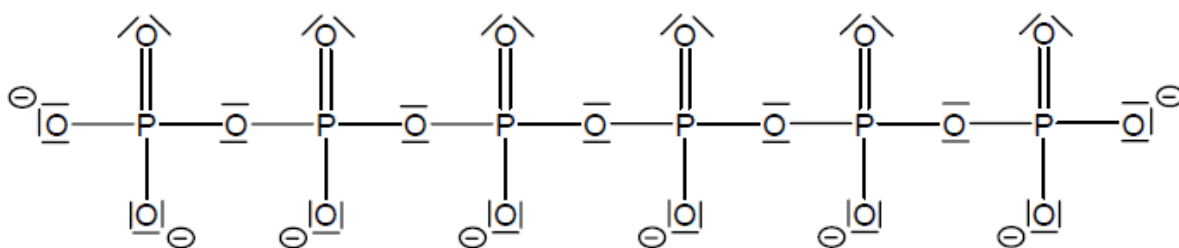
Triphosphate



Cyclotriphosphate



Cyclotetraphosphate



Metaphosphate

**Radicals**

HO	Hydroxyl	ClO	Chlorosyl
CO	Carbonyl	ClO <sub>2</sub>	Chloryl
NO	Nitrosyl	ClO <sub>3</sub>	Perchloryl
NO <sub>2</sub>	Nitryl	TiO	Titanyl
PO	Phosphoryl	CrO <sub>2</sub>	Chromyl
SO	Thionyl, Sulfinyl	UO <sub>2</sub>	Uranyl
SO <sub>2</sub>	Sulfuryl, Sulfonyl	PuO <sub>2</sub>	Plutonyl

## 5 Trivial names

In the following tables frequently used trivial names are listed, which are derived partly from colloquial language, partly from mineralogy or from older chemical nomenclature.

Both tables are sorted alphabetically, the first by the first element, the second by trivial names.

<b>Formula</b>	<b>Trivial name</b>
AgBr	bromargyrite
Al <sub>2</sub> O <sub>3</sub>	alumina, corundum
As <sub>2</sub> O <sub>3</sub>	white arsenic
BaSO <sub>4</sub>	baryte, heavy spar
Ca(OH) <sub>2</sub>	slaked lime
Ca <sub>5</sub> (PO <sub>4</sub> ) <sub>3</sub> F	fluorapatite, fluoroapatite
Ca <sub>5</sub> (PO <sub>4</sub> ) <sub>3</sub> OH	hydroxylapatite
CaCN <sub>2</sub>	lime nitrogen
CaCO <sub>3</sub>	limestone, calcite
CaF <sub>2</sub>	fluorite, flourspar
CaSO <sub>4</sub> · ½ H <sub>2</sub> O	plaster of Paris
CaSO <sub>4</sub> · 2 H <sub>2</sub> O	gypsum
CCl <sub>4</sub>	carbon tetrachloride
CH <sub>3</sub> COOH	glacial acetic acid
ClSO <sub>3</sub> H	chlorosulfuric acid, sulfurochloridic acid
COCl <sub>2</sub>	phosgene
CS <sub>2</sub>	carbon disulfide
CuFeS <sub>2</sub>	copper pyrite
CuSO <sub>4</sub> · 5 H <sub>2</sub> O	copper vitriol, blue vitriol, bluestone
α-Fe <sub>2</sub> O <sub>3</sub>	hematite
Fe <sub>3</sub> O <sub>4</sub>	magnetite
FeS <sub>2</sub>	pyrite

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$\text{FeSO}_4 \cdot 7 \text{H}_2\text{O}$	iron vitriol, green vitriol
$\text{H}_2\text{SO}_4$ conc. with $\text{SO}_3$	oleum
$\text{Hg}_2\text{Cl}_2$	Calomel
$\text{HgCl}_2$	corrosive sublimate
$\text{HgS}$	cinnabar
$\text{K}_2\text{CO}_3$	potash
$\text{K}_3[\text{Fe}(\text{CN})_6]$	red prussiate, prussian red, potassium ferricyanide
$\text{K}_4[\text{Fe}(\text{CN})_6] \cdot 3 \text{H}_2\text{O}$	yellow prussiate, potassium ferrocyanide
$\text{KAl}(\text{SO}_4)_2 \cdot 12 \text{H}_2\text{O}$	potassium alum, potash alum
$\text{KNO}_3$	saltpetre, nitrate of potash
$\text{KOH}$	caustic potash
$\text{KOH}$ (in solution)	potashlye
$\text{MgAl}_2\text{O}_4$	spinel
$\text{MgCO}_3$	magnesite
$\text{MgO}$	magnesia
$\text{MgSO}_4 \cdot 7 \text{H}_2\text{O}$	Epsom salt
$\text{N}_2\text{O}$	laughing gas
$\text{Na}_2\text{B}_4\text{O}_7 \cdot 10 \text{H}_2\text{O}$	borax
$\text{Na}_2\text{CO}_3$	soda ash
$\text{Na}_2\text{CO}_3 \cdot 10 \text{H}_2\text{O}$	washing soda
$\text{Na}_2\text{SO}_4 \cdot 10 \text{H}_2\text{O}$	Glauber salt
$\text{Na}_3\text{AlF}_6$	cryolite
$\text{NaHCO}_3$	baking soda
$\text{NaNO}_3$	Chile saltpetre
$\text{NaOH}$	caustic soda
$\text{NaOH}$ (in solution.)	(caustic) soda lye
$\text{NH}_2\text{Cl}$	chloramine
$\text{NH}_2\text{OH}$	hydroxylamine
$\text{NH}_3$ (in solution)	liquid ammonia
$\text{NH}_4\text{Cl}$	sal ammoniac (dated)
$\text{NHCl}_2$	dichloramine
$\text{NH}_2\text{SO}_3\text{H}$	sulfamic acid, amidosulfonic acid

$(\text{NH}_4)_2\text{Fe}(\text{SO}_4)_2 \cdot 6 \text{H}_2\text{O}$	Mohr's salt
NO	nitric oxide
PbCrO <sub>4</sub>	chrome yellow
PbS	galena
SiC	carborundum
SiO <sub>2</sub>	quartz
SnCl <sub>4</sub> · 5 H <sub>2</sub> O	butter of tin (dated)
TiO <sub>2</sub>	titania, rutile, anatase, brookite (different modifications)
UO <sub>2</sub>	pitchblende
ZnCO <sub>3</sub>	zinc spar
ZnS	sphalerite, wurtzite

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<b>Trivial name</b>	<b>Formula</b>
alumina	$\text{Al}_2\text{O}_3$
amidosulfonic acid	$\text{NH}_2\text{SO}_3\text{H}$
anatase	$\text{TiO}_2$
baking soda	$\text{NaHCO}_3$
baryte	$\text{BaSO}_4$
blue vitriol, bluestone	$\text{CuSO}_4 \cdot 5 \text{H}_2\text{O}$
borax	$\text{Na}_2\text{B}_4\text{O}_7 \cdot 10 \text{H}_2\text{O}$
bromargyrite	$\text{AgBr}$
brookite	$\text{TiO}_2$
butter of tin (dated)	$\text{SnCl}_4 \cdot 5 \text{H}_2\text{O}$
calcite	$\text{CaCO}_3$
calomel	$\text{Hg}_2\text{Cl}_2$
carbon disulfide	$\text{CS}_2$
carbon tetrachloride	$\text{CCl}_4$
carborundum	$\text{SiC}$
caustic potash	$\text{KOH}$
caustic soda	$\text{NaOH}$
Chile saltpetre	$\text{NaNO}_3$
chloramine	$\text{NH}_2\text{Cl}$
chlorosulfuric acid	$\text{ClSO}_3\text{H}$
chrome yellow	$\text{PbCrO}_4$
cinnabar	$\text{HgS}$
copper pyrites	$\text{CuFeS}_2$
copper vitriol	$\text{CuSO}_4 \cdot 5 \text{H}_2\text{O}$
corrosive sublimate	$\text{HgCl}_2$
corundum	$\text{Al}_2\text{O}_3$
cryolite	$\text{Na}_3\text{AlF}_6$
dichloramine	$\text{NHCl}_2$
Epsom salt	$\text{MgSO}_4 \cdot 7 \text{H}_2\text{O}$
fluorite, fluorspar	$\text{CaF}_2$

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fluorapatite, fluoroapatite	$\text{Ca}_5(\text{PO}_4)_3\text{F}$
galena	$\text{PbS}$
glacial acetic acid	$\text{CH}_3\text{COOH}$
Glauber salt	$\text{Na}_2\text{SO}_4 \cdot 10 \text{H}_2\text{O}$
green vitriol	$\text{FeSO}_4 \cdot 7 \text{H}_2\text{O}$
gypsum	$\text{CaSO}_4 \cdot 2 \text{H}_2\text{O}$
heavy spar	$\text{BaSO}_4$
hematite	$\alpha\text{-Fe}_2\text{O}_3$
hydroxylamine	$\text{NH}_2\text{OH}$
hydroxylapatite, hydroxyapatite	$\text{Ca}_5(\text{PO}_4)_3\text{OH}$
iron vitriol	$\text{FeSO}_4 \cdot 7 \text{H}_2\text{O}$
laughing gas	$\text{N}_2\text{O}$
lime nitrogen	$\text{CaCN}_2$
limestone	$\text{CaCO}_3$
liquid ammonia	$\text{NH}_3$ (in solution)
magnesia	$\text{MgO}$
magnesite	$\text{MgCO}_3$
magnetite	$\text{Fe}_3\text{O}_4$
Mohr's salt	$(\text{NH}_4)_2\text{Fe}(\text{SO}_4)_2 \cdot 6 \text{H}_2\text{O}$
nitrate of potash	$\text{KNO}_3$
nitric oxide	$\text{NO}$
oleum	$\text{H}_2\text{SO}_4$ conc. with $\text{SO}_3$
phosgene	$\text{COCl}_2$
pitchblende	$\text{UO}_2$
plaster of Paris	$\text{CaSO}_4 \cdot \frac{1}{2} \text{H}_2\text{O}$
potash	$\text{K}_2\text{CO}_3$
potashlye	$\text{KOH}$ (in solution)
potassium alum, potash alum	$\text{KAl}(\text{SO}_4)_2 \cdot 12 \text{H}_2\text{O}$
potassium ferrocyanide	$\text{K}_4[\text{Fe}(\text{CN})_6] \cdot 3 \text{H}_2\text{O}$
prussian red, potassium ferricyanide	$\text{K}_3[\text{Fe}(\text{CN})_6]$
pyrite	$\text{FeS}_2$
quartz	$\text{SiO}_2$

red prussiate	$K_3[Fe(CN)_6]$
rutile	$TiO_2$
sal ammoniac (dated)	$NH_4Cl$
saltpetre	$KNO_3$
slaked lime	$Ca(OH)_2$
soda ash	$Na_2CO_3$
(caustic) soda lye	NaOH (in solution.)
sphalerite	ZnS
spinel	$MgAl_2O_4$
sulfamic acid	$NH_2SO_3H$
sulfurochloridic acid	$ClSO_3H$
titania	$TiO_2$
washing soda	$Na_2CO_3 \cdot 10 H_2O$
white arsenic	$As_2O_3$
wurtzite	ZnS
yellow prussiate	$K_4[Fe(CN)_6] \cdot 3 H_2O$
zinc spar	$ZnCO_3$

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