Nomenclature of Oxyacids and Oxyanions

There exists a class of ternary compounds (compounds which contain three elements) called oxyacids. These compounds contain hydrogen, oxygen and a third element which is a nonmetal. In these materials the oxygens are bonded directly to the nonmetal atom with hydrogens attached to the oxygens. For any given nonmetal atom there may be up to four oxyacids that exist. For example, there are four different oxyacids for the element chlorine; $HClO$, $HClO_2$, $HClO_3$, and $HClO_4$. If these acids are stripped of their protons by reaction with base four oxyanions are produced; ClO^{-1}, ClO_2^{-1}, ClO_3^{-1}, and ClO_4^{-1}. Each **nonmetal element** is assigned a reference oxidation state. The systematic names given to oxyacids and oxyanions are based on the oxidation state of the **nonmetal atom** in each species relative to the reference oxidation state. For all nonmetal elements this reference oxidation state is equal to the group number except those nonmetal elements in group VIIA where the reference is (+5). That is, the reference oxidation states are:

GRP III A	GRP IV A	GRP V A	GRP VI A	GRP VII A
B	C	N	O	F
	Si	P	S	Cl
		As	Se	Br
			Te	I
Ref Ox St = +3	Ref Ox St = +4	Ref Ox St = +5	Ref Ox St = +6	**Ref Ox St = +5**

NAMES OF OXYACIDS

The names of the various oxyacids are derived from the oxidation state of the nonmetal atom in the acid and the reference oxidation state from that nonmetal atom. The following table illustrates the connection between these two factors.

Oxidation State of Non-Metal Atom	**Name of Acid**	**Example***
= to Ref # - 4 (or 2 less oxygen than Ref)	"**hypo**" + root of element name + "**ous**" acid	$HClO$ hypochlorous acid
= to Ref # - 2 (or 1 less oxygen than Ref)	root of element name + "**ous**" acid	$HClO_2$ chlorous acid
= to Ref #	root of element name + "**ic**" acid	$HClO_3$ chloric acid
= to Ref # + 2 (or 1 more oxygen than Ref)	"**per**" + root of element name + "**ic**" acid	$HClO_4$ perchloric acid

* Chlorine is in group VII A where the reference oxidation state is +5. In the oxyacids $HClO$, $HClO_2$, $HClO_3$, $HClO_4$, the oxidation states of Cl are +1, +3, +5, and +7 respectively. Thus $HClO_3$, is the reference acid and therefore has the name "chloric acid". The oxidation states of Cl in $HClO_2$ and $HClO$ are two and four lower respectively than in "chloric acid" and are therefore called "chlorous acid" and "hypochlorous acid". In $HClO_4$, the oxidation state of Cl is two higher than in "chloric acid" and is called "perchloric acid".

NAMES OF OXYANIONS

Oxyanions are named in a manner analogous to the oxyacids. The names of the various oxyanions are derived from the oxidation state of the nonmetal atom in the anion and the reference oxidation state from that nonmetal atom. The following table illustrates the connection between these two factors.

Oxidation State of Non-Metal Atom	**Name of Anion**	**Example***
= to Ref # - 4 (or 2 less oxygen than Ref)	"**hypo**" + root of element name + "**ite**" ion	ClO^{-1} hypochlorite ion
= to Ref # - 2 (or 1 less oxygen than Ref)	root of element name + "**ite**" ion	ClO_2^{-1} chlorite ion
= to Ref #	root of element name + "**ate**" ion	ClO_3^{-1} chlorate ion
= to Ref # + 2 (or 1 more oxygen than Ref)	"**per**" + root of element name + "**ate**" ion	ClO_4^{-1} perchlorate ion

* Chlorine is in group VII A where the reference oxidation state is +5. In the oxyanions ClO^{-1}, ClO_2^{-1}, ClO_3^{-1}, ClO_4^{-1}, the oxidation states of Cl are +1, +3, +5, and +7 respectively. Thus ClO_3^{-1}, is the reference anion and therefore has the name "chlorate ion". The oxidation states of Cl in ClO_2^{-1} and ClO^{-1} are two and four lower respectively than in "chlorate ion" and are therefore called "chlorite ion" and "hypochlorite ion". In ClO_4^{-1}, the oxidation state of Cl is two higher than in "chlorate ion" and is called "perchlorate ion".

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EXAMPLES

Name the following species:

a) H_2SO_3 b) CO_3^{-2} c) PO_2^{-3} d) H_3BO_3 e) NO_2^{-1} f) HIO_4

ANSWERS

a) Since sulfur is in group VI A the reference oxidation state is +6. In H_2SO_3 the sulfur has an oxidation state of +4 or **two lower** than the reference oxidation state. Thus H_2SO_3 is sulfurous acid.

b) Since carbon is in group IV A the reference oxidation state is +4. In CO_3^{-2} the carbon has an oxidation state of +4 which equals the reference oxidaion state. Thus CO_3^{-2} is the carbonate ion.

c) Since phosphorus is in group V A the reference oxidation state is +5. In PO_2^{-3} the phosphorus has an oxidation state of +1 or **four lower** than the reference oxidaion state. Thus PO_2^{-3} is the hypophosphite ion.

d) Since boron is in group III A the reference oxidation state is +3. In H_3BO_3 the boron has an oxidation state of +3 which equals the reference oxidation state. Thus H_3BO_3 is boric acid.

e) Since nitrogen is in group V A the reference oxidation state is +5. In NO_2^{-1} the nitrogen has an oxidation state of +3 or **two lower** than the reference oxidaion state. Thus NO_2^{-1} is the nitrite ion.

f) Since iodine is in group VII A the reference oxidation state is **+5**. In HIO_4 the iodine has an oxidation state of +7 or **two higher** than the reference oxidation state. Thus HIO_4 is periodic acid.