Basic Inorganic Nomenclature

Section (A) : Oxidation number

Th-1 Oxidation Number

- It is an imaginary or apparent charge developed over atom of an element when it goes from its elemental free state to combined state in molecules.
- It is calculated on the basis of an arbitrary set of rules.
- It is a relative charge in a particular bonded state.
- In order to keep track of electron-shifts in chemical reactions involving formation of compounds, a more practical method of using oxidation number has been developed.
- In this method, it is always assumed that there is a complete transfer of electron from a less electronegative atom to a more electronegative atom.

Rules governing oxidation number

The following rules are helpful in calculating oxidation number of the elements in their different compounds. It is to be remembered that the basis of these rule is the electronegativity of the element.

- **Fluorine atom :**
  Fluorine is most electronegative atom (known). It always has oxidation number equal to –1 in all its compounds
- **Oxygen atom :**
  In general and as well as in its oxides, oxygen atom has oxidation number equal to –2.
  In case of
  (i) peroxide (e.g. H_2O_2, Na_2O_2) is –1,
  (ii) super oxide (e.g. KO_2) is –1/2
  (iii) ozonide (e.g. KO_3) is –1/3
  (iv) in OF_2 is + 2 & in O_2F_2 is +1
- **Hydrogen atom :**
  In general, H atom has oxidation number equal to +1. But in metallic hydrides (e.g. NaH, KH), it is –1.
- **HALOGEN ATOM :**
  In general, all halogen atoms (Cl, Br, I) have oxidation number equal to –1.
  But if halogen atom is attached with a more electronegative atom than halogen atom, then it will show positive oxidation numbers.
  e.g. $K\overset{+5}{Cl}O_3$, $H\overset{+5}{I}O_3$, $H\overset{+7}{Cl}O_4$, $K\overset{+5}{Br}O_3$
- **METALS :**
  (a) Alkali metal (Li, Na, K, Rb ....) always have oxidation number +1.
  (b) Alkaline earth metal (Be, Mg, Ca ....) always have oxidation number +2.
  (c) Aluminium always has +3 oxidation number.

Note : Metal may have positive or zero oxidation number

- Oxidation number of an element in free state or in allotropic forms is always zero
  e.g. $\overset{0}{O_2}$, $\overset{0}{S_8}$, $\overset{0}{P_4}$, $\overset{0}{O_3}$
- Sum of the oxidation numbers of atoms of all elements in a molecule is zero.
- Sum of the oxidation numbers of atoms of all elements in an ion is equal to the charge on the ion.
- If the group number of an element in modern periodic table is ***n,*** then its oxidation number may vary from
  (n – 10) to ***(n – 18)***

(but it is mainly applicable for p-block elements)

e.g. N-atom belongs to 15th group in the periodic table, therefore as per rule, its oxidation number may vary from –3 to +5.

$$(\overset{-3}{N}H_3 , \overset{+2}{N}O , \overset{+3}{N_2}O_3 , \overset{+4}{N}O_2 , \overset{+5}{N_2}O_5)$$

- The maximum possible oxidation number of any element in a compound is never more than the number of electrons in valence shell.(but it is mainly applicable for p-block elements)

Table-1
List of common oxidation sate of an element of periodic table, which can be show in compound state

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H **+1** –1																	2 **He**
3 Li +1	3 Be +2											5 **B** **+3** –3	6 **C** **+4** +2 –4 etc.	7 **N** +5 +4 +3 +1 –3 **0** etc.	8 **O** +2 –1/2 –1 **–2**	9 **F** **–1**	10 **Ne**
11 Na +1	12 Mg +2											13 **Al** +3	14 **Si** **+4** –4	15 **P** **+5** +3 +1 –3	16 **S** **+6** +4 +2 –2	17 **Cl** +7 +5 +3 +1 0 **–1**	18 **Ar** **0**
19 **K** +1	20 **Ca** +2	21 **Sc** +2 **+3**	22 **Ti** +2 **+3** **+4**	23 **V** +2 **+3** +4 +5	24 **Cr** +2 **+3** +4 +5 +6	25 **Mn** **+2** +3 **+4** +5 +6 +7	26 **Fe** **+2** +3 +4 +5 +6	27 **Co** **+2** +3 +4 +5	28 **Ni** **+2** +3 +4	29 **Cu** **+1** +2	30 **Zn** **+2**	31 **Ga** +3	32 **Ge** **+4** –4	33 **As** **+5** **+3** –3	34 **Se** **+6** +4 –2	35 **Br** +7 +5 +3 +1 **–1**	36 **Kr** +4 +2 **0**
37 **Rb** +1	38 **Sr** +2											49 **In** **+3** +1	50 **Sn** **+4** +2	51 **Sb** **+5** **+3** –3	52 **Te** **+6** +4 –2	53 **I** +7 +5 +3 +1 **0** **–1**	54 **Xe** +8 +6 +4 +2 **0**
55 **Cs** +1	56 **Ba** +2											81 **Tl** +3 **+1**	82 **Pb** +4 **+2**	83 **Bi** +5 **+3**	84 **Po**	85 **At**	86 **Rn**

* **Bold mark oxidation number are general stable oxidation number of an element in compound state.**

Section (B) : Inorganic nomenclature

Th-1 Elements

General Rule : The names of metals generally end with-ium or-um (examples are sodium, potassium, aluminum, and magnesium).

The exceptions are metals that were used and named in ancient times, such as iron, copper, and gold.

The names of nonmetals frequently end with-ine, -on, or -gen (such as iodine, argon, and oxygen.)

Given the names of the constituent elements and common ions, most of the common inorganic compounds can be named using the rules presented below.

Th-2 Acids :

Acids are normally classified in two groups, hydracids and oxyacids

Hydracids :

Hydracids are acids which contain hydrogen and a non-metal, but no oxygen.

General Rule : The names of hydracids have the prefix hydro-(sometimes shortened to hydr-) and the suffix-ic attached to the stem based on the names of the constituent elements (other than hydrogen.)

For example, HCl (made of hydrogen and chlorine) is hydrochloric acid; HBr (made of hydrogen and bromine) is hydrobromic acid; HI (made of hydrogen and iodine) is hydroiodic acid; HCN (made of hydrogen, carbon and nitrogen) is hydrocyanic acid; and H_2S (made of hydrogen and sulfur) is hydrosulfuric acid.

Th-3 Cations (Positive ions)

Metal atoms with single positive charge

Rule : Names of positive ions end with-ium if the ion has only one oxidation state (Only one level of net charge). For example, the positive ion of sodium is Na^+ (sodium ion), and the positive ion of aluminium is Al^{3+} (aluminium ion).

Metal atoms with more than one possible charges

Rule : If the cation has variable valency (charge), charge is specified in roman numerals in round brackets immediately after the name of metal atom. For example , Sn^{2+} is written as tin (II) ion.

Alternately, the less positive ion ends with -ous, and the more positive ion ends with -ic. For instance, the two positive ions of copper are Cu^+ (cuprous) and Cu^{2+} (cupric). The oxidation state of a positive ion can also be designated by placing a Roman numeral after the name of the elements. These positive ions of copper can also be written as copper(I) and copper(II), respectively.

Ions	Name
Cu^+	cuprous ion
Cu^{2+}	cupric ion
Sn^{2+}	Stannous ion
Sn^{4+}	Stannic ion
Fe^{3+}	Ferric ion
Fe^{2+}	Ferrous ion

General Rule-3

Suffix-nium is often used with cations containing non metals.

For example, the positive ion of ammonia is NH_4^+ (ammonium) and the positive ion of water (H_2O) is H_3O^+ or H^+ (hydronium).

Remember these names !

NO_2^+ : nitronium

NO^+ : nitrosonium

H_3O^+ : hydronium

From NH_3 ammonia is derived NH_4^+ : ammonium.

Similarly.

N_2H_4 : hydrazine $\longrightarrow$ N_2H_5 : hydrazinium

$C_6H_5NH_2$: aniline $\longrightarrow$ $C_6H_5NH_3^+$: anilinium

C_5H_5N : pyridine $\longrightarrow$ $C_5H_5NH^+$: pyridinium

Th-4 Anions (Negative Ions)

Anions can always be looked upon as ions derived from acids by removal of one or more protons. Accordingly, anions can be classified as follows :

Anions derived from hydracids

Rule : Names of negative ions from hydracids end in –ide.

For example, Cl^- (chloride) from HCl, and CN^- (cyanide) from HCN. Following examples will give you a better insight in this nomenclature. It is also useful to remember them.

Remember these names

Anion	**Name**
H^-	Hydride ion
D^-	Deuteride ion
F^-	Fluoride ion
Cl^-	Chloride ion
Br^-	Bromide ion
I^-	Iodide ion
O^{2-}	Oxide ion
S^{2-}	Sulphide ion
Se^{2-}	Selenide ion
Te^{2-}	Telluride ion
N^{3-}	Nitride ion
P^{3-}	Phosphide ion
As^{3-}	Arsenide ion
Sb^{3-}	Antimonide ion
C^{4-}	Carbide ion
Si^{4-}	Silicide ion
B^{3-}	Boride ion

Th-5 Oxoacids or Oxyacids

The acids which contain hydrogen, oxygen and a metal or non-metal.

In this case, more than one possibility aries due to the presence of different number of oxygen atoms. An example of such an oxoacid series is as follows: HClO, $HClO_2$, $HClO_3$, $HClO_4$. All these contains same three elements but differ in the number of oxygen atoms present.

General Rule-1 :

If a class of acids contains only one member, its name is given the suffix-ic.

For example, hydrogen, carbon and oxygen combine to form only one acid i.e. H_2CO_3. It is called carbonic acid (carbonic acid.)

General Rule-2 :

If an acid series contains two acids, such as H_2SO_4 and H_2SO_3, the acid containing more oxygen atoms is given the suffix -ic, while the acid with fewer oxygen atoms is given the suffix-ous.

For example, H_2SO_4 is sulphuric acid, and H_2SO_3 is sulphurous acid.

Similarly, HNO_3 is nitric acid and HNO_2 is nitrous acid.

General Rule-3 :

The prefix ortho and meta have been used to distinguish acids differenting in the 'content of water'

(H_3BO_3)- orthoboric acid $–H_2O$

$(HBO_2)_n$- metaboric acid

General Rule-4 :

The prefix pyro has been used to designate an acid formed from two molecules of an ortho acid minus one molecule of water.

For example, $H_4P_2O_7$ -pyro phosphoric acid

General Rule-5 :

The prefix peroxo indicates the substitution '–O–' by '–O–O–'

HNO_4 - peroxo nitric acid

H_3PO_5 - peroxo mono phosphoric acid

General Rule-6 :

Acid derived by oxoacids by replacement of oxygen by sulphur are called thio acids.

$H_2S_2O_2$ - thio sulphurous acid

$H_2S_2O_3$ - thio sulphuric acid

Note : when more than one oxygen atom can be replaced by sulphur the number of sulphur atom should generally indicated

H_3PO_3S mono thio phosphoric acid

$H_3PO_2S_2$ Dithiophosphoric acid

In the case of an extensive acid series (such as HClO, $HClO_2$, $HClO_3$, $HClO_4$), the acid with the one oxygen atoms lesser than -ous acid is given the prefix hypo- and the suffix -ous, and the acid with the one oxygen atom more than the -ic acid is given the prefix per and a suffix-ic.

In the above example, HClO is hypochlorous acid $HClO_2$ is chlorous acid, $HClO_3$ is chloric acid, and $HClO_4$ is perchloric acid.

Th-6 Anions derived from oxyacids (oxyanions)

(i) Anion derived from an oxyacid by removal of one or more H^+ ions is termed as oxyanion.

Rule : If the oxyacid is – ic acid, suffix - ate is used with oxy-anion.

For example

CO_3^{2-}	carbonate (from H_2CO_3)
ZnO_2^{2-}	zincate
SiO_3^{2-}	silicate

(ii) **Rule : If the oxyacid is - ous acid, suffix -ite is used with oxy-anion.**

For example, NO_2^- (nitrite) is derived from HNO_2 (nitrous acid), and SO_3^{2-} (sulphite) is derived from H_2SO_3 (sulphurous acid)

(iii) **Rule : If the oxyacid has prefixes per-or hypo–, the oxyanion will have same prefixes.**

For example, ClO_4^- perchlorate ion from $HClO_4$, perchloric acid, ClO^- hypochlorite ion from HClO, hypochlorous acid

Remember these names !

SO_4^{2-}	Sulphate
SO_3^{2-}	Sulphite
NO_3^-	Nitrate
NO_2^-	Nitrite
SnO_3^{2-}	Stannate
SnO_2^{2-}	Stannite
PbO_3^{2-}	Plumbate
PbO_2^{2-}	Plumbite

(iv) **Anions containing replacable hydrogen ions**

Polyprotic acid. Any acid containing more than one replacable hydrogens is said to be a polyprotic acid.

(v) **Replacable hydrogens.** H atoms which can be lost as H^+ in reactions with a base.

H atoms connected to O atoms in oxyacids are all replacable. If all the replacable hydrogens are removed, we obtain the anions discussed in the sections above.

However, in all the polyprotic acids it is always possible to remove less than the maximum number of replacable hydrogens. e.g. H_3PO_4 is triprotic. We can remove one, two or three H^+ ions from it to generate $H_2PO_4^-$, HPO_4^{2-} and PO_4^{3-}.

You are already familiar with phosphate ion, PO_4^{3-}. The other two anions, $H_2PO_4^-$ and HPO_4^{2-} still contain H atoms that are replacable. We consider their nomenclature in this section.

(vi) **Rule-1 :** A prefix bi- (old notation) or hydrogen – (IUPAC notation) is attached to the name of anion.

(vii) **Rule-2 :** For triprotic or higher acids, numerical prefixes (e.g. mono, bi, tri) are also used to indicate the number of replacable H atoms left in the sample).

eg. HCO_3^- is bicarbonate or hydrogen carbonate

HSO_3^- bisulphite or hydrogen sulphite

HS^- bisulphide or hydrogen sulphide etc.

when anion has –3 charge,

e.g. PO_4^{3-} then following possibilities arise.

HPO_4^{2-} monohydrogen phosphate,

$H_2PO_4^-$ dihydrogen phosphate.

Th-7 **Miscellaneous Anions (To be comitted to memory)**

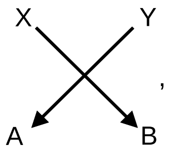
Anion	**Name**
HO^-	Hydroxide ion
O_2^{2-}	Peroxide ion
O_2^-	Superoxide ion
S_2^{2-}	Disulphide ion
I_3^-	Triodide ion
N_3^-	Azide ion
NH^{2-}	Imide ion
NH_2^-	Amide ion
CN^-	Cyanide ion
C_2^{2-}	Acetylide ion
O_3^-	Ozonide ion
MnO_4^{2-}	Manganate ion
MnO_4^-	Permanganate ion
SCN^-	Thiocyanate ion
$S_2O_3^{2-}$	Thiosulphate ion
CH_3COO^-	Acetate ion
$C_2O_4^{2-}$	Oxalate ion

Th-8 Method of writing formula of an ionic compound

In order to write the formula of an ionic compound which is made up of two ions (simple or polyatomic) having net charges x and y respectively, follow the following procedure.

(i) Write the symbols of the ions side by side in such a way that positive ion is at the left and negative ion at the right as AB.

(ii) Write their charges on the top of each symbol as A^xB^y.

(iii) Now apply criss-cross rule as 

,

i.e. formula A_yB_x.

(iv) Cancel out any common factor (or HCF).

Examples :

1.	Calcium chloride	2 1 Ca Cl = $CaCl_2$
2.	Aluminium oxide	3 2 Al O = Al_2O_3
3.	Potassium phosphate	1 3 K PO_4 = K_3PO_4
4.	Magnesium nitride	2 3 Mg N = Mg_3N_2
5.	Calcium oxide	2 2 Ca O = Ca_2O_2
6.	Ammonium sulphate	1 2 NH_4 SO_4 = $(NH_4)_2SO_4$

Cancelling the common factor, answer is CaO

Th.9 : Some important points :

(i) If both element are non-metallic then more electronegative element is anionic part

As_2O_3 – arsenic (III) oxide

OF_2 – oxygen di flouride,

ICl_3 – Iodine trichloride

(ii) pyro name is attached with acid if it is derived by removing one water molecule from two acid molecules.

Two acid molecules $\xrightarrow{-H_2O}$ pyro acid,

N, C, Cl, Br, not forms pyroxy acids

$2HClO_4 \xrightarrow[-H_2O]{} Cl_2O_7$ not oxiacid it is an oxide

(iii) **Meta acid**: If one water molecule is removing from one acid molecule then meta acid is obtained.

One acid molecule $\xrightarrow[-H_2O]{}$ meta acid,

N, C, S, Cl, not forms metaoxy

only Si, P, B forms metaoxy acids,

(iv) **Naming of oxoanions derived from oxyacids**

– ic acid ≡ – ate

– **us** acid ≡ – ite

(v) There are some more anions which are very common like :

CrO_4^{2-} – Chromate (name is derived from SO_4^{2-} sulphate as all features are same)

FeO_4^{2-} – ferrate

MoO_4^{2-} – molybolate

WO_4^{2-} – tungstate

MnO_4^{2-} – manganate

corresponding acids can be

H_2CrO_4 – chromic acid

H_2MnO_4 – manganic acid

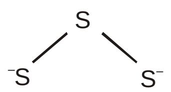
⇒ Higher oxidation state of manganese ≡ $\overset{+7}{Mn}O_4^-$

So called permanganate, $HMnO_4$ permanganic acid

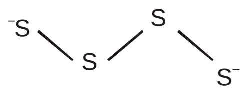
(vi) **Polysulphides**

S_x^{2-} (x = 2, 3, 4, 5..........)

structures S_2^{2-} $^-S – S^-$ disulphide

S_3^{2-} 

trisulphide

S_4^{2-} 

tetra sulphide

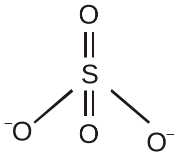
Sodium disulphide ≡ Na_2S_2

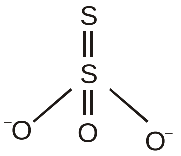
(vii) **Sulphate & thiosulphate (hypo)**

When ever oxygen of normal compound is replaced with sulphur then thio word is used before name of normal compound alcohol –OH   Thioalcohol –SH

ether –O–   Thioether –S–

sulphate SO_4^{2-} Thiosulphate ($S_2O_3^{2-}$)





* Cyanate ion & Thiocyanate ion

Cyanic acid (HOCN)

Cyanate ion ⇒ N≡C–O⁻

⁻N=C=O

Resonating structure

Thio cyanate ion ⇒ N≡C–S⁻

⁻N=C=S

Resonating structure

(viii) Metal cations – Higher oxidation state of Cations ends with ic & lower by – us

Fe^{3+} – ferric Cu^{2+} – cupric

Fe^{2+} – ferrous Cu_2^{2+} – cuprous

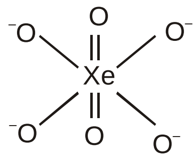
Hg^{2+} – mercuric

Hg_2^{2+} – mercurous

(ix) Xenon :

H_4XeO_6 – perxenic acid

XeO_6^{4-} – perxenate ion



H_2XeO_4 – Xenic acid

XeO_4^{2-} – Xenate ion

Table-2: Difference between Atoms and ions

	Atoms		Ions
1	Atoms are perfectly neutral	1	Ions are charged particles containing one or more atoms.
2	In atoms, the number of protons is equal to the number of electrons. Na (protons 11, electrons 11); Cl (protons 17, electrons 17).	2	In cations (positively charged ions), number of protons is more than the number of electrons. In anions (negatively charged ions) the no. of protons is less than the number of electrons. e.g. Na^+ (protons 11, electrons 10). Cl^- (protons 17, electrons 18)
3	Except noble gases, atoms have less than 8 electrons in the outermost orbit e.g. Na : 2, 8, 1; Ca : 2, 8,8, 2; Cl : 2, 8, 7; S : 2, 8, 6.	3	Ions have generally 8 electrons in the outermost orbit, i.e., ns^2np^6 configuration. Na^+ : 2, 8; Cl^- : 2, 8, 8; Ca^{2+} : 2, 8, 8
4	Chemical activity is due to loss or gain or sharing of electrons as to acquire noble gas configuration.	4	The chemical activity is due to the charge on the ion. Oppositely charged ions are held together by electrostatic forces.

Table - 3 : Naming of Oxyacid

Acid end with IC suffix		Suffix-ous		Prefix -per ; suffix–ic			Prefix -pyro
Formula	**Name**	**Formula**	**Name**	**Formula**	**Name**	**Formula**	**Name**
H_3BO_3	Orthoboric acid	HNO_2	Nitrous Acid	HNO_4	Peroxynitric acid	$H_4P_2O_7$	Pyrophosphoric acid
H_2CO_3	Carbonic acid	H_2SO_3	Sulphurous acid	H_3PO_5	Peroxymonophosphoric acid	$H_4P_2O_5$	Pyrophosphrous acid
HONC	Isocyanic acid	$H_2S_2O_5$	Disulphurous acid	$H_4P_2O_5$	Peroxy diphosphric acid	$H_4B_2O_5$	Pyroboric acid
HOCN	Cyanic acid	$HClO_2$	Chlorous acid	H_2SO_5	Peroxymono sulphuric acid	$H_6Si_2O_7$	Pyro silicilic acid
HNO_3	Nitric Acid	**Prefix - Hypo ; suffix-ic**		$H_2S_2O_8$	Peroxy disulphuric acid	$H_2S_2O_7$	Pyrosulphuric acid
H_2NO_2	Nitroxylic acid	$H_2N_2O_2$	Hyponitrous acid	$HClO_4$	Perchloric acid		
H_3PO_4	Orthophosphoric acid	HClO	Hypochlorous acid	**Prefix-thio**			
H_2SO_4	Sulphuric acid	**Prefix-meta ; suffix-ic**		$H_2S_2O_3$	Thio sulphuric acid		
$HClO_3$	Chloric acid	$(HBO_2)_n$	Metaboric acid	$H_2S_2O_2$	Thio sulphurous acid		
$H_2S_2O_6$	Dithionic acid	$(HPO_3)_n$	Meta phosphoric acid	$H_2S_2O_6$	Dithionic acid		
				$H_2S_2O_4$	Dithionous acid		