1.1 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 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.

1.2 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 in Periodic Table

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** +5 +7 +3 +1 **–1** etc.	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** **+2** +3	30 **Zn** **+2**	31 **Ga** +3	32 **Ge** +4 **–4**	33 **As** **+5** **+3** –3	34 **Se** **+6** +4 –2	35 **Br** +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 +1 **0** **–1**	54 **Xe** +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**

2.1 Elements

General Rule : The names of metals generally end in-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 in-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.

2.2. Acids

Acids are normally classified in two groups, hydracids and oxyacids

2.2.1 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.

2.2.2 Oxoacids or Oxyacids

The acids which contain hydrogen , oxygen and a metal or non-metal.
In this case , more than one possibilities arise because of 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 sulfuric acid , and H_2SO_3 is sulfurous acid
Similarly, HNO_3 is nitric acid and HNO_2 is nitrous 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.

A very valid doubt may arise, "How to decide which one is -ic acid to begin with ? This is somewhat arbitrary and has no unique answer. It depends upon the name given to it by old chemists, when no systematic nomenclature existed. Now these names have becomes so popular that it is difficult to change them. Do not worry, as you go through these notes, you will get a sufficient idea regarding these names.

2.3 Cations (Positive ions)

2.3.1 Metal atoms with single positive charge

Rule : Names of positive ions end in-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).

2.3.2 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 in -ous, and the more positive ion ends in-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
Sn^{2+}	Stannous ion
Sn^{4+}	Stannic ion
Fe^{3+}	Ferric ion
Fe^{2+}	Ferrous ion

2.3.3. 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

2.4 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.

2.4.1 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

F^{-}	fluoride	from HF	
Cl^{-}	chloride	from HCl	
Br^{-}	bromide from HBr		
I^{-}	iodide	from HI	
O^{2-}	oxide	S^{2-}	sulphide
N^{3-}	nitride	P^{3-}	phosphide
As^{3-}	arsenide	Cu^{-}	cupride
H^{-}	hydride	Au^{-}	auride

2.4.2 Anions derived from oxyacids

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

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-} (sulfite) is derived from H_2SO_3 (sulfurous acid)

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

For example,

ClO_4^- percholrate 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

2.4.3 Anions containing replacable hydrogen ions

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

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_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.

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

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

- Miscellaneous Anions (To be comitted to memory)

NH_2^- amide, NH^{2-} imide, N^{3-} nitride, N_3^- azide, O_2^{2-} peroxide, O_2^- superoxide, O_3^- ozonide
CrO_4^{2-} chromate, $Cr_2O_7^{2-}$ dichromate, MnO_4^{2-} manganate, MnO_4^- permanganate , CN^- cyanide
OCN^- cyanate, SCN^- thiocyanate, $S_2O_3^{2-}$ thiosulphate, CH_3COO^- acetate, $C_2O_4^{2-}$ oxalate
$[Fe(CN)_6]^{3-}$ ferricyanide ,$[Fe(CN)_6]^{4-}$ ferrocyanide

2.5 Difference between Atoms and ions

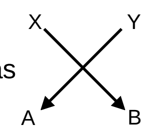
We have been talking for quite sometime. The distinction between atoms and ions, though simple, must be very clear in your mind. The following are the points summarise this difference.

2.6 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 — Ca (2), Cl (1) $= CaCl_2$

2. Aluminium oxide — Al (3), O (2) $= Al_2O_3$

3. Potassium phosphate — K (1), PO_4 (3) $= K_3PO_4$

4. Magnesium nitride — Mg (2), N (3) $= Mg_3N_2$

5. Calcium oxide — Ca (2), O (2) $= Ca_2O_2$

6. Ammonium sulphate — NH_4 (1), SO_4 (2) $= (NH_4)_2SO_4$

Cancelling the common factor, answer is CaO

Table-2

	Atoms		Ions
1.	Atoms are perfectly neutral	1.	Ions are charged particles containing one or more atoms.
2.	In atoms, the number of portons 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^3np^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.

Nomenclature of the elements with atomic number > 100 (IUPAC) :

According to IUPAC, elements with atomic number greater than 100 are represented by three letter symbols.

- These symbols are based on first letter of numbers from 0 to 9. The names of these number are derived from Greek and Latin languages.
- The Latin words for various digits of the atomic number are written together in the order of which makes the atomic number and suffix 'ium' is added at the end. In case of bi and tri one 'i' is omitted.

NOTATION FOR IUPAC NOMENCLATURE OF ELEMENTS

Table-3

Digit	Name	Abbreviation
0	nil	n
1	un	u
2	bi	b
3	tri	t
4	quad	q
5	pent	p
6	hex	h
7	sept	s
8	oct	o
9	enn	e

NOMENCLATURE OF ELEMENTS

Table-4

Atomic Number	Name	Symbol	IUPAC Official Name	IUPAC symbol
104	Unnilquadium	Unq	Rutherfordium	Rf
105	Unnilpentium	Unp	Dubnium	Db
106	Unnilhexium	Unh	Seaborgium	Sg
107	Unnilseptium	Uns	Bohrium	Bh
108	Unniloctium	Uno	Hassnium	Hs
109	Unnilennium	Une	Meitnerium	Mt
110	Ununnilium	Uun	Darmstadtium	Ds
111	Unununium	Uuu	*	*
112	Ununbium	Uub	*	*
113	Ununtrium	Uut	+	
114	Ununquadium	Uuq	*	*
115	Ununpentium	Uup	+	
116	Ununhexium	Uuh	+	
117	Ununseptium	Uus	+	
118	Ununoctium	Uuo	+	

* Official IUPAC name yet to be announced   + Elements yet to be discovered

❍ IUPAC recommended this nomenclature to be followed until their names are officially recognised.