2.1.5 Redox

oxidation is the process of electron loss:
$Zn \rightarrow Zn^{2+} + 2e^-$
It involves an **increase in oxidation** number

reduction is the process of electron gain:
$Cl_2 + 2e^- \rightarrow 2Cl^-$
It involves a **decrease in oxidation** number

Rules for assigning oxidation numbers

1. All uncombined elements have an oxidation number of zero

eg . Zn, Cl_2, O_2, Ar all have oxidation numbers of zero

2. The oxidation numbers of the elements in a compound add up to zero

In NaCl Na= +1 Cl= -1
Sum = +1 -1 = 0

3. The oxidation number of a monoatomic ion is equal to the ionic charge

e.g. Zn^{2+} = +2 Cl^- = -1

4. In a polyatomic ion (CO_3^{2-}) the sum of the individual oxidation numbers of the elements adds up to the charge on the ion

e.g. in CO_3^{2-} C = +4 and O = -2

sum = +4 + (3 x -2) = -2

5. Several elements have invariable oxidation numbers in their common compounds.

Group 1 metals = +1

Group 2 metals = +2

Al = +3

H = +1 (except in metal hydrides where it is –1 eg NaH)

F = -1

Cl, Br, I = –1 except in compounds with oxygen and fluorine

O = -2 except in peroxides (H_2O_2) where it is –1 and in compounds with fluorine.

We use these rules to identify the oxidation numbers of elements that have variable oxidation numbers.

What is the oxidation number of Fe in $FeCl_3$

Using rule 5, Cl has an O.N. of –1
Using rule 2, the O.N. of the elements must add up to 0

Fe must have an O.N. of +3
in order to cancel out 3 x –1 = -3 of the Cl's

Note the oxidation number of Cl in $CaCl_2$ = -1 and not -2 because there are two Cl's
Always work out the oxidation for one atom of the element

Naming using Roman Numerals

Use a Roman numeral to indicate the magnitude of the oxidation state of an element, when a name may be ambiguous.

$FeCl_2$ Iron(II) Chloride
$FeCl_3$ Iron(III) Chloride

In IUPAC convention the various forms of sulphur, nitrogen and chlorine compounds where oxygen is combined are all called sulfates, nitrates and chlorates with relevant oxidation number given in roman numerals. If asked to name these compounds remember to add the oxidation number.

NaClO: sodium chlorate(I)
$NaClO_3$: sodium chlorate(V)
K_2SO_4 potassium sulfate(VI)
K_2SO_3 potassium sulfate(IV)

$NaNO_2$: Sodium nitrate(III)
$NaNO_3$: Sodium nitrate(V)

Redox Reactions

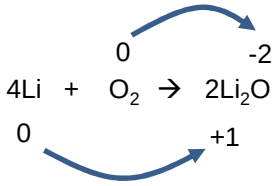
metals generally form ions by losing electrons with an increase in oxidation number to form positive ions:

$Zn \rightarrow Zn^{2+} + 2e^-$

non-metals generally react by gaining electrons with a decrease in oxidation number to form negative ions

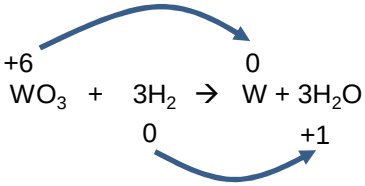
$Cl_2 + 2e^- \rightarrow 2Cl^-$

Oxygen is reducing because its oxidation number is decreasing from 0 to -2



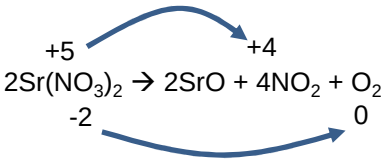
Lithium is oxidising because its oxidation number is increasing from 0 to +1

Tungsten is reducing because its oxidation number is decreasing from +6 to 0



Hydrogen is oxidising because its oxidation number is increasing from 0 to +1

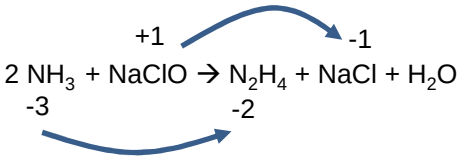
Nitrogen is reducing because its oxidation number is decreasing from +5 to+4



Oxygen is oxidising because its oxidation number is increasing from -2 to 0

Note that not all the oxygen atoms are changing oxidation number in this reaction

Chlorine is reducing because its oxidation number is decreasing from +1 to -1

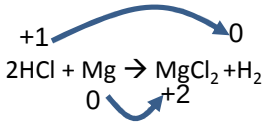


Nitrogen is oxidising because its oxidation number is increasing from -3 to -2

Redox Reactions of Metals and acid

ACID + METAL → SALT + HYDROGEN

Hydrogen is reducing because its oxidation number is decreasing from +1 to 0



Magnesium is oxidising because its oxidation number is increasing from 0 to +2

Be able to write equations for reactions of metals with hydrochloric acid and sulphuric acid

$Fe + H_2SO_4 \rightarrow FeSO_4 + H_2$

Observations: These reaction will effervesce because H_2 gas is evolved and the metal will dissolve