Chapter 6 (AS-Level)

Electrochemistry

Elements have different combining power, which is different ratios of atoms that combine with each other is called valency (Strength).

Example:

- MgO which has a ratio of 1:1
- Al_2O_3 which has a ratio of 2:3

At present a more useful measure is used, Oxidation state or Oxidation number.

"The charge an atom would have in a molecule or ion, if electrons were completely transferred (to the more electronegative atoms) in covalent molecules or ions."

Rules for assigning oxidation numbers:

1. Oxidation numbers are calculated as the number of electrons that an atom loses, gains or shares in forming ionic or covalent bonds.
2. The oxidation state of free element is zero. E.g. H_2, Br_2, O_2, etc.
3. The oxidation number of a simple ion (monatomic) is its charge. E.g. Na+ (+1)
4. The oxidation number of hydrogen in compounds is (+1), except in metal hydrides, where it is (-1)
5. The oxidation number of oxidation in compounds is (-2), except in peroxides and in OF_2 where it is (-1) and (+2) respectively.
6. In the molecules and ions, the more electronegative atom in given the negative oxidation numbers.
7. The sum of oxidation numbers of all atoms in a neutral molecule is zero.
8. The sum of oxidation numbers of all atom in a complex ion is equal to the charge of the ion.

Oxidation Numbers Calculation Examples:

- The oxidation number of Carbon in CO_2 is:
  (-2) x 2 = (+4)
- The oxidation number of Carbon in CH_4 is:
  X + 4 x(+1) = 0, therefore X = (-4)
- … of Mn in $KMnO_4$ is:
  1 + X + 4(-2) = 0
  X = +7
- … of Cl in $KClO_3$ is:
  1+ X + 3(-2) = 0
  X = +5

Redox Reactions:

Reduction – Oxidation Reactions:

The term *redox* is used for the simultaneous processes of reduction and oxidation, in which one element is reduced and another oxidized.

Examples:

$$4\,Fe + 3\,O_2 \rightarrow 2\,Fe_2O_3$$

$$2\,Fe\ +\ 3\,Cl_2 \rightarrow\ 2\,FeCl_3$$

Both are redox reactions.

Fe is oxidized, it is the reducing agent.

O is reduced it is the oxidizing agent.

From the example:

Fe had an oxidation number of 0. After the reaction, the Fe lost 3 electrons, so its oxidation number increased. Similarly, the oxygen had an oxidation number of 0 before the reaction and gained 4 electrons, so its oxidation number decreased from 0 to -2.

Oxidation is:

- ***The loss of electrons.***
- ***Increase in oxidation number.***

Reduction is:

- ***The gain of electrons.***
- ***The decrease in oxidation number.***

Electrolysis

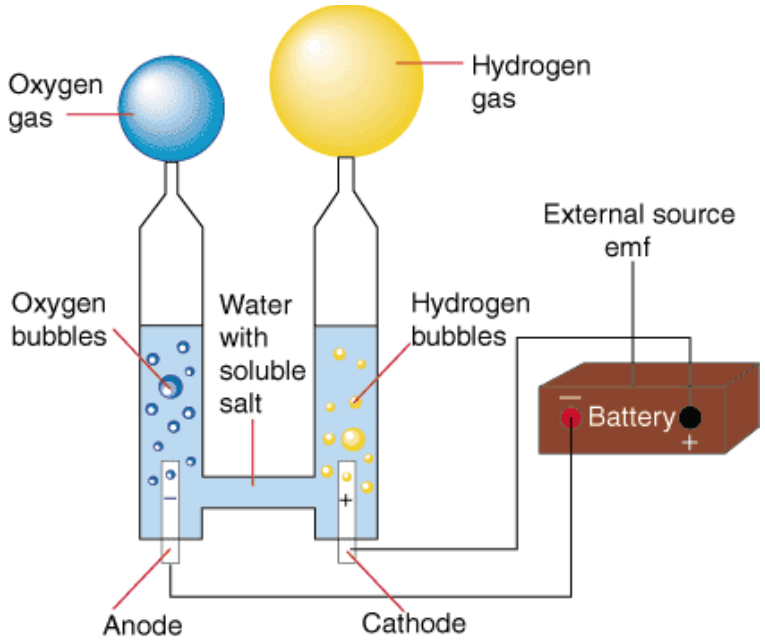
It is a redox Chemical reaction that takes place when a direct current is passed in an aqueous solution or molten ionic compound.

Oxidation takes place at the anode.

Reduction takes place at the cathode.

Example:

Electrolysis of H_2O



$$4\ OH^- \rightarrow O_2 + 2\ H_2O + 4\ e^-$$

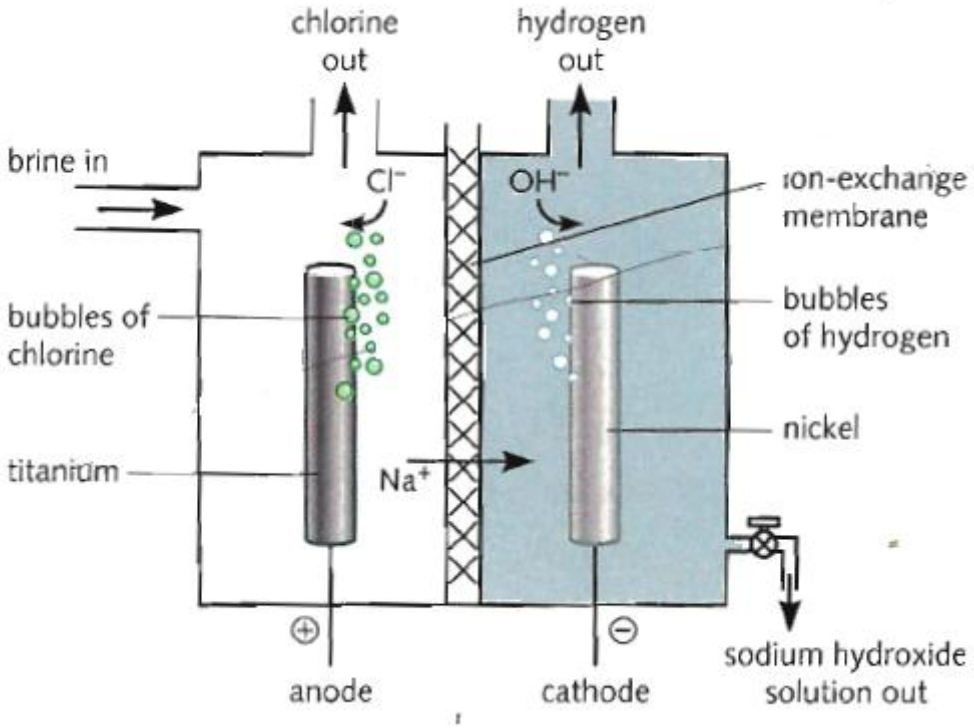
$$4\ H^+ + 4\ e^- \rightarrow 2\ H_2$$

Net reaction:

$$4\ OH^- + 4\ e^- \rightarrow 2\ H_2O + 2\ H_2 + O_2$$

More information available in the book.

Electrolysis of Brine using Diaphragm cell



At the anode (oxidation):

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

At the cathode (reduction):

$$2\ H^+ + 2\ e^- \rightarrow H_2$$

Net reaction:

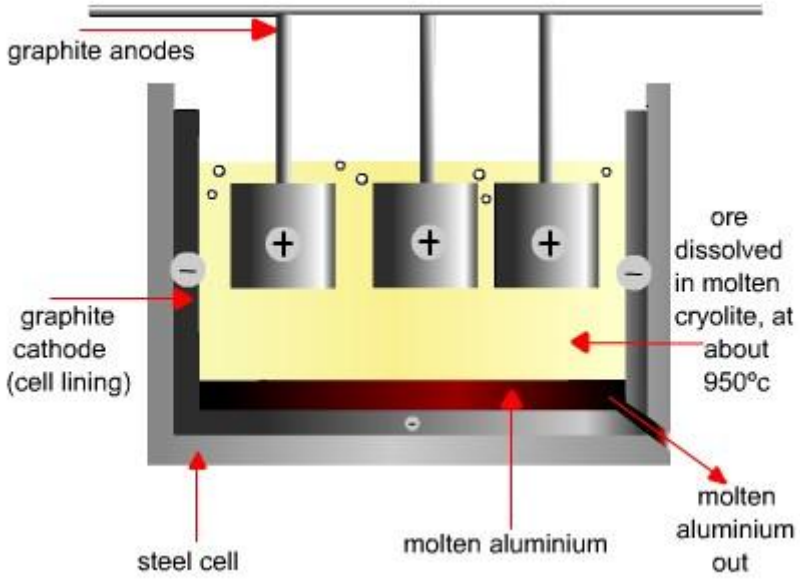
$$H_2O \rightarrow \leftarrow H^+ + OH^-$$

$$OH^- + Na+ \rightarrow NaOH$$

Extraction of Aluminium from Alumina

The method used to extract the metal form its ore depends on the position of the metal in the reactivity series. If the metal is high up in the series, its ores are stable and can be only be obtained by electrolysis.

Aluminium is extracted from bauxite (Al_2O_3) by electrolysis. However, bauxite has a very high melting point but can be dissolved in molten cryolite at 900 degrees Celsius. In other words, the cryolite is used to lower the melting point of bauxite.



Cathode reaction:

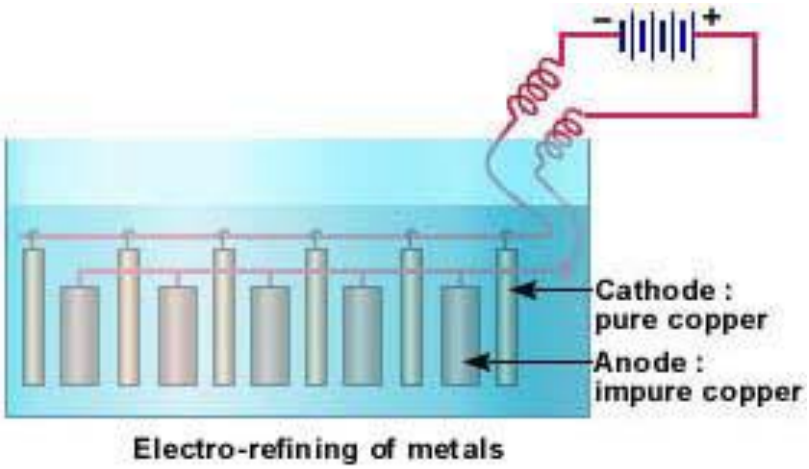
$4\ Al^{3+} + 12\ e^- = 4\ Al$

Anode reaction:

$6\ O_2^- = 3O_2 + 12\ e^-$

Carbon dioxide is also produced from this reaction. It is produced from the carbon electrodes burning in the heat and oxygen produced.

Electrolytic purification of copper



Electro-refining of metals

Metals can be refined or purified by electrolysis. The impure metal forms the anode and the pure metal forms the cathode. The electrolyte is an aqueous metal salt.

In the purification of copper, impure copper is used as the anode and a thin sheet of pure copper is used as the cathode.

The following reaction occurs:

At anode, the copper is ionized (becomes an ion):

$Cu - 2e^- = Cu^{2+}$

At the cathode, the copper ion is unionized, which produces solid copper on the cathode:

$Cu^{2+} + 2e^- = Cu$

As electrolysis takes place the pure copper sheet gains mass and the anode (impure copper) loses mass and the impurities are deposited under the anode in the container.

This means that the copper ions had left the impure copper side and joined the pure copper side.

The colour of the copper (II) sulphate solution does not change as the concentration of copper ions in the solution does not change.

END OF LESSON