REDOX – THE BASICS (REVISION)

Adding Half Equations

- Redox equations are achieved by adding an oxidation half-equation to a reduction half equation making sure that the number of electrons in each half-equation is the same. This can be achieved by multiplying one or both of the equations by a factor so as to achieve a lowest common multiple.

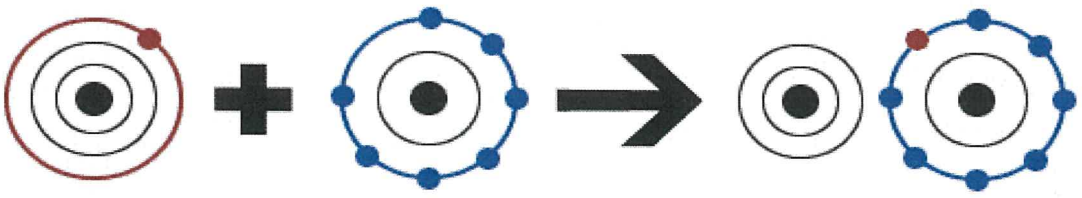
$$3(Cu^{2+} + 2e^- \rightarrow Cu)$$
$$2(Al \rightarrow Al^{3+} + 3e^-)$$
$$2Al_{(s)} + 3Cu^{2+}_{(aq)} \rightarrow 2Al^{3+}_{(aq)} + 3Cu_{(s)}$$

*(Metal Displacement)

Oxidising and Reducing Agents

- The substance that is **oxidised** is by definition **losing electrons**. This can only occur if there is another substance that will accept them- and in turn be **reduced**. The chemical that is oxidised could be seen to be **causing the reduction** of another chemical or at least bringing it about. It is for this reason that the chemical undergoing oxidation is referred to as the ***REDUCING AGENT (REDUCER or REDUCTANT)***.
eg: In the reaction above, the Aluminium metal is being oxidised and thus brings about the reduction of copper (II) ions to copper metal. Aluminiim metal is the REDUCING AGENT.

- The opposite of the above logic can be applied to the substance that is reduced. The substance that is **reduced** is by definition **gaining electrons**. This can only occur if there is another substance that has lost them- and in turn been **oxidised**. The chemical that is reduced could be seen to be **causing the oxidation** of another chemical or at least bringing it about. It is for this reason that the chemical undergoing reduction is referred to as the ***OXIDISING AGENT (OXIDISER or OXIDANT)***.
eg: In the reaction above, the Copper (II) ions are being reduced and thus bringing about the oxidation of Aluminium metal to Aluminium ions. Copper (II) ions are the OXIDISING AGENT.



Relative Oxidising and Reducing Ability

- Substances that are the most easily ***reduced*** are the best ***oxidisers***. They are found at the TOP LEFT of the reduction potential table.

e.g. $F_2 + 2e^- \rightarrow 2F^-$
$H_2O_2 + 2H^+ + 2e^- \rightarrow 2H_2O$
$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$

- These substances are the best at taking in electrons or ***competing*** for electrons.

- The Standard Reduction Potential table really tells us what are the ***best competitors*** for electrons.

- Substances that are the most easily ***oxidised*** are the best ***reducers***. They are found at the BOTTOM RIGHT of the reduction potential table, as we read these equations in reverse when we are looking for oxidation processes.

e.g. $K \rightarrow K^+ + e^-$
$Ca \rightarrow Ca^{2+} + 2e^-$
$Na \rightarrow Na^+ + e^-$

Balancing Half-Equations from 1st Principles (Acidic Solution)

- Most reactions can be generated by the addition of half-equations that appear in the standard reduction potential table. When a half-equation is not in this list it is necessary to know the formula of the reactant and its eventual product so as to balance it by a technique known as **1st Principles balancing**.

- There is a standard set of steps to follow each and every time, starting from what is referred to as the "Skeleton" equation (the raw basic starting and finishing chemicals).

⊠ Balance atoms **other** than HYDROGEN or OXYGEN.
⊠ Balance **OXYGEN** atoms by adding **WATER (H_2O)** molecule/s to the appropriate side of the equation.
⊠ Balance **HYDROGEN** atoms by adding **H^+** ion/s to the appropriate side of the equation.
⊠ Balance the **CHARGE** on both sides of the equation by adding **ELECTRONS** (e^-) so as to ensure that the total charge on both sides of the equation is the same.
NB: The charge does not have to be zero on both sides!

⌘ It may be that in some cases there is no need for all steps as there may not be an involvement of oxygen.

TYPE EXAMPLE:

Nitrate ions can be converted in reaction to nitrogen dioxide gas.
The "Skeleton" equation for this transformation would be:

$$NO_3^- \rightarrow NO_2$$

⌦ Balance atoms **other** than HYDROGEN or OXYGEN.
*The only other atom here is nitrogen (N), which is already balanced
➲ NO CHANGE:

$$NO_3^- \rightarrow NO_2$$

⌦ Balance **OXYGEN** atoms by adding **WATER (H_2O)** molecule/s to the appropriate side of the equation.

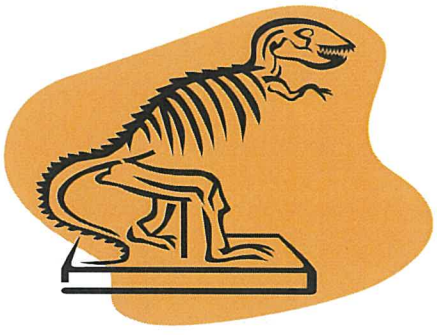
$$NO_3^- \rightarrow NO_2 + H_2O$$

⌦ Balance **HYDROGEN** atoms by adding H^+ ion/s to the appropriate side of the equation.

$$NO_3^- + 2H^+ \rightarrow NO_2 + H_2O$$

⌦ Balance the **CHARGE** on both sides of the equation by adding **ELECTRONS** (e^-) so as to ensure that the total charge on both sides of the equation is the same.

$$\underline{\underline{NO_3^- + 2H^+ + e^- \rightarrow NO_2 + H_2O}}$$



Balancing Overall Equations from 1st Principles by Dissection

- A full equation may be presented in an **unbalanced form**. It can be broken down or **dissected** into **two skeleton equations** which can each be balanced by1st principles and then added together.

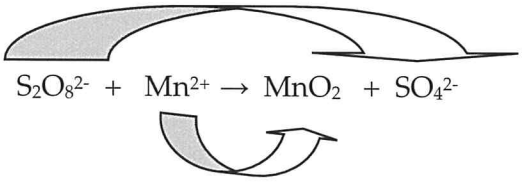
  - If hydrogen ions and/or water appear in the equation they may generally be ignored as they will be corrected for during the 1st principles balancing of the skeleton half equations

⌦ *EXAMPLE:*

Balance the following by establishing half equations and then balancing them by 1st principles. Show the addition of these half equations to give a fully balanced equation:

$$S_2O_8^{2-} + Mn^{2+} \rightarrow MnO_2 + SO_4^{2-}$$

STEP 1 : Establish the two skeleton equations by asking what becomes what?



STEP 2 : Balance half equations by 1st Principles

1. $S_2O_8^{2-} \rightarrow SO_4^{2-}$

$S_2O_8^{2-} \rightarrow 2SO_4^{2-}$

$S_2O_8^{2-} + 2e^- \rightarrow 2SO_4^{2-}$

2. $Mn^{2+} \rightarrow MnO_2$

$Mn^{2+} + 2H_2O \rightarrow MnO_2$

$Mn^{2+} + 2H_2O \rightarrow MnO_2 + 4H^+$

$Mn^{2+} + 2H_2O \rightarrow MnO_2 + 4H^+ + 2e^-$

STEP 3 : Addd half equations to get a balanced overall equation

$S_2O_8^{2-} + 2e^- \rightarrow 2SO_4^{2-}$

$Mn^{2+} + 2H_2O \rightarrow MnO_2 + 4H^+ + 2e^-$

$S_2O_8^{2-} + Mn^{2+} + 2H_2O \rightarrow 2SO_4^{2-} + MnO_2 + 4H^+$