TOPIC 12 Oxidation And Reduction

Objectives

Candidates should be able to:

(a) define *oxidation* and *reduction* (redox) in terms of oxygen/hydrogen gain/loss
(b) define redox in terms of electron transfer and changes in oxidation state
(c) identify redox reactions in terms of oxygen/hydrogen gain/loss, electron gain/loss and changes in oxidation state
(d) describe the use of aqueous potassium iodide and acidified potassium manganate(VII) in testing for oxidising and reducing agents from the resulting colour changes

1. Oxidation and Reduction

Oxidation can be seen as the gain of oxygen, the loss of hydrogen, the loss of electrons or the increase in oxidation number of a substance.

The reverse occurs in reduction. It can be seen as the loss of oxygen, the gain of hydrogen, the gain of electrons or the decrease in oxidation number of a substance.

2. Calculating Oxidation Numbers

An element has an oxidation state of 0, regardless of whether it is found as individual atoms or in molecules. For example, neon (Ne) and chlorine (Cl_2) have oxidation states of 0.

The sum of oxidation numbers of all atoms in an uncharged compound is 0. For a polyatomic ion, the sum of oxidation numbers of all atoms is equal to its charge.

The oxidation state of an ion is given by its charge. For example, a magnesium ion Mg^{2+} and an oxide ion O^{2-} have oxidation states of +2 and –2 respectively.

Some elements have fixed oxidation numbers in compounds. Oxygen usually has the oxidation state of –2 in its compounds. Hydrogen usually has the oxidation state of +1 in its compounds.

3. Oxidising and Reducing Agents

An oxidising agent is a substance that causes another substance to be oxidised.

The presence of an oxidising agent can be tested using potassium iodide (KI) solution. Iodide ions (I^-) are oxidised to form iodine (I_2) when an oxidising agent is present. The solution turns from colourless to brown.

$$2I^-(aq) \rightarrow I_2(aq) + 2e^-$$

colourless brown

A reducing agent is a substance that causes another substance to be reduced.

The presence of a reducing agent can be tested using acidified potassium manganate(VII) ($KMnO_4$) solution. Manganate(VII) ions are reduced to manganese(II) ions in the presence of a reducing agent. The solution turns from purple to colourless.

$$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightarrow Mn^{2+}(aq) + 4H_2O(l)$$

purple colourless

Acidified potassium dichromate(VI) solution can also be used to test for the presence of reducing agents. Dichromate(VI) ions ($Cr_2O_7^{2-}$) are reduced to form chromium(III) (Cr^{3+}) ions. The solution turns from orange to green.

$$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e^- \rightarrow 2Cr^{3+}(aq) + 7H_2O(l)$$

orange green