Topic 9 Redox processes (SL)

Syllabus:

9.1 Oxidation and reduction

Oxidation and reduction can be considered in terms of oxygen gain/ hydrogen loss, electron transfer or change in oxidation number.

An oxidizing agent is reduced and an reducing agent is oxidized.

Transition metals and most main-group non-metals have variable oxidation numbers.

The Winkler Method can be used to measure biochemical oxygen demand (BOD), used as a measure of the degree of pollution in a water sample.

9.2 Electrometrical cells

Voltaic (Galvanic) cells:

It converts chemical energy to electrical energy, through spontaneous, exothermic chemical processes.

Oxidation at Anode (– ve electrode), Reduction at Cathode (+ electrode) in voltaic cell

Electrolytic cells:

It converts electrical energy to chemical energy through non-spontaneous processes.

Oxidation at Anode (+ ve electrode), Reduction at Cathode (– electrode) in electrolytic cell

9.1 Oxidation and reduction

(A) Introduction to oxidation and reduction

1. In terms of oxygen and hydrogen atoms

Oxidation	Reduction
Gain of oxygen	Loss of oxygen
Loss hydrogen	Gain of hydrogen

For example,

$2Mg + O_2 \rightarrow 2MgO$

$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

2. In terms of electrons

Oxidation is the loss of electrons, reduction is the gain of electrons. **(OIL RIG)**

Chemical equation: $3Mg + N_2 \rightarrow Mg_3N_2$

Half equations: $3Mg \rightarrow 3Mg^{2+} + 6e^-$

$N_2 + 6e^- \rightarrow 2N^{3-}$

Mg is losing electrons so it is oxidized.

N_2 is gaining electrons so it is reduced.

3. Oxidation number

- Oxidation is the increases in oxidation number.
- Reduction is the decrease in oxidation number.
- Oxidation states should be represented with the sign given before the number.

  e.g. +2, –2

1. Atoms in free element have an oxidation state of 0. e.g. Na, Mg, N_2, O_2, Ar
2. In simple ions, the oxidation number is the same as the charge of ion. e.g. N^{3-} is –3 Mg^{2+} is +2 O^{2-} is –2 H^{+} is +1
3. In the compound containing H or O, H is usually +1 and O is usually –2. e.g. In HCl, H is +1 In CO_2, O is –2 **Exception:** The oxidation number of H in metal hydride is –1. In NaH, H is –1. The oxidation number of O in peroxide is –1. In H_2O_2, O is –1. The oxidation number of O in OF_2 is +2.
4. In the neutral compound, the total oxidation number of all the atoms are 0. e.g. H_2SO_4 is 0 H_2O is 0
5. In the polyatomic ions, the total oxidation number of all the atoms equals to the charge of the ion. e.g. SO_4^{2-} is –2 NH_4^{+} is +1

Work example

1. Find the oxidation number of all the elements in H_2SO_4.

It is known that H is +1 and O is –2 in the compound, and the total oxidation number of all the atoms equals to 0.

$0 = 2(+1) + S + 4(-2)$

$S = +6$

2. Find the oxidation number of all the elements in PO_4^{3-}.

It is known that O is –2 in the compound, and the total oxidation number of all the atoms equals to –3.

$-3 = P + 4(-2)$

$P = +5$

- Work out the oxidation number of the transition metal in a complex ion.

  e.g. $[Co(NH_3)_6]^{3+}$

  NH_3 is neutral ligand, the charge of the complex ion equals to the charge of the metal ion.

  So the oxidation number of Co in the complex ion is +3.

  e.g. $[CuCl_4]^{2-}$

  The charge of Cl^- is –1.

  $-2 = Cu + 4(-1)$

  $Cu = +2$

Practice

Find the oxidation number of all the elements of the following species.

1. H_2O
2. CO_2
3. K
4. MnO_4^-
5. $K_2Cr_2O_7$
6. NH_4^+
7. H_2O_2
8. O_3
9. V_2O_5
10. S_8
11. $[Fe(H_2O)_6]^{3+}$
12. $TiCl_4$