Unit 5: Electrochemistry

9.1 Oxidation and Reduction

- In a historical context, metallurgy gives us the terms reduction and oxidation.
- Historically, ores were reduced to an elemental metal by a reducing agent. E.g. Iron oxide was reduced by carbon monoxide to produce iron and carbon dioxide.
- Oxidation was typically used to explain corrosion, explosions, and the burning of wood (usually in the presence of oxygen). Oxidation has been modified to mean the creation of a metal compounds. The compound used to oxidize the metal was called an oxidizing agent. E.g. Magnesium and oxygen produce magnesium oxide.

Electron Transfer Theory

- Help understanding → think of single displacement reactions as 2 half reactions.
- E.g. $Zn_{(s)} + 2HCl \rightarrow ZnCl_{(aq)} + H_{2(g)}$
  - $Zn_{(s)} \rightarrow Zn^{2+}_{(aq)} + 2e^-$ oxidation
  - $2H^+ + 2e^- \rightarrow H_{2(g)}$ reduction
- Use a mnemonic: "LEO says GER" – Loss of electrons is oxidation, gain of electrons is reduction.
- In the Electron Transfer Theory, the total number of electrons gained in a reaction must equal the total number of electrons lost. Also, oxidation and reduction are separate processes that occur simultaneously.

Oxidation States

- Oxidation state is an arbitrary number used to keep track of electric charges ("electron bookkeeping"). It is the apparent net electric charge that an atom would have if electrons pairs in covalent bonds belonged entirely to the more electronegative atom. We assign an oxidation number.
- Oxidation Number: a positive or negative number corresponding to the apparent change that an atom in a molecule or ion would have if the electron pair in covalent bonds belonged entirely to the more electronegative atom.
- An oxidation number is written X^{+2} to denote a positive 2 oxidation number. Do not get confused by X^{2-} which is an ion of X which has gained 2 electrons.
- Table 1 on page 658 is essential.
- E.g. What is the oxidation number in manganese in a permanganate ion, MnO_4^-?
  All atoms must equal the charge. From the table we know that O has an oxidation number of –2 and the atom has a charge of 1-.

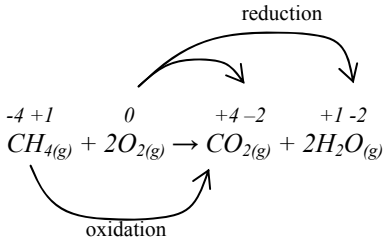
  MnO_4^- Mn = ? O = 4(-2) x + 4(-2) = -1 x = +7
  Therefore the oxidation numbers are +7 for Mn and –2 for O.

Oxidation Numbers and Redox Reactions

- Oxidation is an increase in oxidation number
- Reduction is a decrease in oxidation number
- In a redox reaction the oxidation numbers change.
- E.g. When natural gas burns in a furnace, carbon dioxide and water form. Identify oxidation and reduction in this reaction.

  $CH_{4(g)} + 2O_{2(g)} \rightarrow CO_{2(g)} + 2H_2O_{(g)}$

  First figure out the oxidation numbers: *$CH_{4(g)} \rightarrow x + 4(+1) = 0$ therefore $x = -4$*
  O_2 is an element therefore given an oxidation number of 0
  $CO_{2(g)} \rightarrow x + 2(-2) = 0$ therefore $x = +4$
  $H_2O_{(g)} \rightarrow 2x + (-2) = 0$ therefore $x = +1$



Carbon's oxidation number increases = oxidation
Oxygen's oxidation number decreases in both instances = reduction