The Mole in Unit 3

Redox reactions

Oxidation Is Loss of electrons (OIL)
An oxidising agent therefore removes electrons from the substance it is oxidising.

Reduction Is Gain of electrons (RIG)
An reducing agent donates electrons to the substance it is reducing.

A **REDOX** reaction is a reaction where oxidation and reduction occur together e.g.

$F_2 + H_2O \rightarrow O_2 + H^+F^-$

Problem 1

(a) Write the two ion-electron half-equations for the above reaction.

Answer

$F_2 + 2e \rightarrow 2\ F^-$

$2\ H_2O \rightarrow O_2 + 4\ H^+ + 4e$

(b) Write a full, balanced equation for the reaction.

Answer

Always ensure that an equal number of electrons is transferred. Here, we will ensure that this number is 4 by multiplying the first half-equation by 2 :

$2\ F_2 + 4e \rightarrow 4\ F^-$

Now add the two half equations :

$2\ F_2 + \cancel{4e} \rightarrow 4\ F^-$

$2\ H_2O \rightarrow O_2 + 4\ H^+ + \cancel{4e}$

$2\ F_2 + 2\ H_2O \rightarrow O_2 + 4\ H^+F^-$

(c) Calculate the number of electrons transferred when 5.4g of Water reacts with excess Fluorine.

Answer

No. of moles of $H_2O = \frac{5.4}{18} = 0.3$ moles

When 2 moles of H_2O are used, 4 moles of electrons are transferred

=> When 0.3 moles of H_2O are used, $\frac{4 \times 0.3}{2}$ moles of electrons are transferred

$= 0.6$ moles

$= 0.6 \times 6.023 \times 10^{23}$

$= \underline{3.6 \times 10^{23}}$

Problem 2

When acidified chlorate(V) ClO_3^- is added to Cu^+, Cu^{2+} and $Cl_2(g)$ are some of the products. Write a balanced equation for this redox reaction.

Answer

The oxidation of Cu^+ :

$Cu^+ \rightarrow Cu^{2+} + e$

The reduction of ClO_3^- ?

Use the information given in the question to write as much of the half-equation as possible:

$ClO_3^- \rightarrow Cl_2$

We know this is a reduction reaction so we can add electrons to the left side:

$ClO_3^- + e \rightarrow Cl_2$

Where have the O on the left side gone?

The solution was acidified - it contains H^+.

The H^+ ions have 'mopped up' the O on the left side forming Water!

$ClO_3^- + H^+ + e \rightarrow Cl_2 + H_2O$

Now balance this half-equation:

$2ClO_3^- + 12H^+ + 10e \rightarrow Cl_2 + 6H_2O$

Now add the two half-equations together to get the whole reaction:

$10Cu^+ \rightarrow 10Cu^{2+} + \cancel{10e}$

$2ClO_3^- + 12H^+ + \cancel{10e} \rightarrow Cl_2 + 6H_2O$

$2ClO_3^- + 12H^+ + 10Cu^+ \rightarrow Cl_2 + 6H_2O + 10Cu^{2+}$

Problem 3

21.32 cm^3 Iron(II) sulphate $Fe^{2+}SO_4^{2-}$ solution are required to react with 25 cm^3 0.02M acidified Potassium manganate(VII) $K^+MnO_4^-$. Calculate the molarity of the Iron(II) sulphate solution.

Answer

The two half equations are

$$Fe^{2+} \rightarrow Fe^{3+} + e$$

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

Balance :

$$5Fe^{2+} \rightarrow 5Fe^{3+} + 5e$$

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

Add :

$$5Fe^{2+} \rightarrow 5Fe^{3+} + \cancel{5e}$$

$$MnO_4^- + 8H^+ + \cancel{5e} \rightarrow Mn^{2+} + 4H_2O$$

$$MnO_4^- + 8H^+ + 5Fe^{2+} \rightarrow Mn^{2+} + 4H_2O + 5Fe^{3+}$$

No. of moles $MnO_4^- = \frac{MV}{1000} = \frac{0.02 \times 25}{1000} = 0.0005$ moles

=> No. of moles $Fe^{2+} = 5 \times 0.0005$

$= 0.0025$ moles

=> For Fe^{2+}, $\frac{MV}{1000} = 0.0025$

=> $M = \frac{0.0025 \times 1000}{V}$

$= \frac{0.0025 \times 1000}{21.32}$

$= \underline{0.12\ M}$

Electrolysis Calculations

An electric current is a flow of charge (Q) measured in coulombs.

The rate of flow of charge is called the current (I) measured in amps.

Hence I = Q/t where t = time in seconds

In an electrolysis experiment, therefore, the total charge flowing is given by the equation :

$$\boxed{Q=It}$$

Since it is the electrons which carry this charge, and since the charge on one mole of electrons is 96500 coulombs (Faraday, F),

the number of moles of electrons flowing $= \frac{Q}{F} = \frac{It}{F}$

Problem

Calculate the mass of Copper obtained by passing a current of 2 amps through a solution of Copper(II) nitrate for 30 minutes.

Answer

$Cu^{2+} + 2e \rightarrow Cu$

No.of moles of electrons flowing $= \frac{It}{F}$

Now 2 moles of electrons produce 1 mole of Copper, so

=> No.of moles of Cu produced $= \frac{It}{2F}$

=> Wt.of Cu produced $= \frac{64It}{2F}$

$= \frac{64 \times 2 \times 30 \times 60}{2 \times 96500}$

$= \underline{1.19\ g}$