Titrations part 3

Over the years OCR A have given many difficult titration questions. The example below is quite different from those in parts 1 and 2.

Oxidation State

Calculating the oxidation state of an ion is a slight twist on the usual titration questions. The problem is that there will only be one half-equation given where you usually have two.

Normally you would have two half-equations and cancel the electrons → ratio. In this type of question we don't have both of the half-equations so we can't cancel electrons. So we need to do the question the "other way round".

If we get the ratio, we can then get the electrons, from which we can deduce the oxidation state.

the aim of this type of question is to get the **ratio** using **moles**

Example

$$\mathbf{Na_2O_2 + 2H_2O \rightarrow 2NaOH + H_2O_2}$$

0.403 g of sodium peroxide was reacted with water. The hydrogen peroxide produced was determined by titration with cerium(IV) ions, Ce^{4+}. In this reaction hydrogen peroxide was converted into oxygen:

$$\mathbf{H_2O_2 \rightarrow 2H^+ + O_2 + 2e^-}$$

The hydrogen peroxide solution reacted exactly with 24.85 cm^3 of 0.420 mol dm^{-3} of Ce^{4+}. Deduce the formula of the cerium ion in the final solution.

Looks complicated! The first thing to remember is that there is an equation "missing". The titration is between Ce^{4+} and H_2O_2. We don't have the Ce^{4+} half-equation as we don't know what ion it produces. That's the point of the question!

So imagine that we have: $\mathbf{Ce^{4+} + xe^- \rightarrow Ce^{x+}}$

We know that Ce^{4+} is reduced as H_2O_2 is being oxidised. Our aim is to get x. If we have the number of electrons we can work out the final oxidation state.

As was mentioned above, we do this by **mole ratios**.

we need the ratio of H_2O_2 to Ce^{4+} using moles

Step 1: calculate the moles of H_2O_2

Moles Na_2O_2 = 0.403/78

= 5.17 x 10^{-3}

From the first equation the ratio of Na_2O_2: H_2O_2 is 1:1 therefore H_2O_2 moles = **5.17 x 10^{-3}**

Step 2: moles of Ce^{4+}

Moles = 24.85 x 0.420/1000

= 1.04 x 10^{-2}

Step 3: work out the ratio between Ce^{4+}: H_2O_2

Just divide the moles: **1.04 x 10^{-2}/5.17 x 10^{-3}**

= 2

therefore ratio = 2:1

Step 4: what does this ratio tell us?

Imagine we had the two half-equations as normal:

this ratio means we would multiply the Ce^{4+} half-equation **x 2** to balance the electrons

We know the H_2O_2 half-equation involves $2e^-$:

H_2O_2 → $2H^+$ + O_2 + $2e^-$

Therefore the Ce^{4+} half-equation **must** involve $1e^-$. This gives us:

H_2O_2 → $2H^+$ + O_2 + $2e^-$

Ce^{4+} + e^- → Ce^{3+} (x 2 to cancel electrons)

Therefore the final answer is **Ce^{3+}**.

The full equation would look like:

H_2O_2 + $2Ce^{4+}$ → $2H^+$ + O_2 + $2Ce^{3+}$

This is the point you are trying to get to. Imagine the full equation after the electrons have been cancelled.

- ✓ this question is not that difficult, just very different to what you are used to. Now you know what to do. Get the moles and divide.

If you want a rock hard example of one of these questions, try the old spec January 2013 paper F325 Q8…seriously, it's hard!!

- ✓ Watch out for "strange" ratios…if you get 1:1.5 or 1:667 or 1:1.333, those are all ok. You just need to multiply them x2, x3 and x3 respectively to get whole numbers.