

### Moles question worked example

The following is a method by which the reaction between iron(III) ions and hydroxylammonium chloride,  $\text{NH}_3\text{OH}^+\text{Cl}^-$ , may be investigated:

25.0cm<sup>3</sup> of a solution of 0.0518 moldm<sup>-3</sup> hydroxylammonium chloride is added to a solution containing an excess of Fe<sup>3+</sup> ions and about 25cm<sup>3</sup> of 1 moldm<sup>-3</sup> sulphuric acid, and the mixture boiled. It is then diluted with water, allowed to cool, and the Fe<sup>2+</sup> ions titrated with 0.02moldm<sup>-3</sup> potassium manganate(VII) (potassium permanganate) of which 25.9cm<sup>3</sup> were required.

- Calculate the molar ratio Fe<sup>3+</sup> / NH<sub>3</sub>OH<sup>+</sup> in the reaction, and hence determine the oxidation number of nitrogen in the product.
- Using the oxidation number concept, or otherwise, deduce the equation for the reaction.

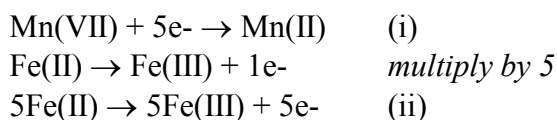
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This is a redox reaction. The Fe<sup>3+</sup> ions each gain an electron to form Fe<sup>2+</sup> ions. Each NH<sub>3</sub>OH<sup>+</sup> ion loses electrons, but you don't know how many yet. The way to find out, is to compare the amount of NH<sub>3</sub>OH<sup>+</sup> used and the amount of Fe<sup>2+</sup>.

$$\begin{aligned}\text{amount of NH}_3\text{OH}^+ &= (\text{conc.} \times \text{vol.})/1000 \\ &= (0.0518 \times 25)/1000 \\ &= \underline{1.295 \times 10^{-3} \text{ moles}}\end{aligned}$$

amount of Fe<sup>2+</sup>...

This has to be worked out from the potassium manganate(VII) data. It is essential to *learn* that the Mn(VII) gains 5 electrons to form Mn(II), and recognise that the Fe(II) loses 1 electron to form Fe(III).



combing (i) and (ii) and cancelling the electrons gives;

Equation	Mn(VII) + 5Fe(II) → Mn(II) + 5Fe(III)
Ratio	1 : 5
Moles	(0.02 x 25.9)/1000 = 5.9 x 10 <sup>-4</sup> 5 x 5.9 x 10 <sup>-4</sup> = <u>2.95 x 10<sup>-3</sup> moles</u>

Moles	(Fe <sup>3+</sup> )                      (NH <sub>3</sub> OH <sup>+</sup> )	
Ratio	2.95 x 10 <sup>-3</sup> : 1.295 x 10 <sup>-3</sup>	<i>divide by smallest</i>
Ratio	2 : 1	
Equation	2Fe <sup>3+</sup> NH <sub>3</sub> OH <sup>+</sup> → products	

This 2 : 1 ratio is the answer to the first part of the question.

To determine the oxidation number of nitrogen in the product;

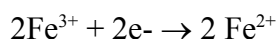
The oxidation number of nitrogen in  $\text{NH}_3\text{OH}^+$  can be worked out:

Each H is +1, so +4 for all the hydrogens.

The O is -2, so +2 for the hydrogens and oxygen.

The ion has charge +1 overall, so the nitrogen must be -1.

The half equation for the iron ions is



so  $\text{N}(-1) \rightarrow \underline{\text{N}(+1)} + 2\text{e}^-$  must be the half equation for nitrogen, such that the electrons balance.

You wouldn't really be expected to know, but hopefully you can recognise that a species with nitrogen in this oxidation state is  $\text{N}_2\text{O}$ . Therefore a plausible balanced equation would be;



Always check that charge balances;

$$\text{LHS } 4 \times 3^+ + 2 \times 1^+ = 14^+$$

$$\text{RHS } 4 \times 2^+ + 6 \times 1^+ = 14^+ \quad \text{OK charge same on both sides}$$