

OCR Manganate(VII) redox titrations

(OCR student book ISBN 978-0-19-835197-0, p380)

Manganate(VII) titrations can be used to analyse many different reducing agents, for example Fe(II) ions / $\text{Fe}^{2+}(\text{aq})$.

A student tried to answer the following question recently. The answer the student got was out by a factor of 10, and the student could not work out why this was. Here's the solution:

Q5

A metal ore contains Fe(II). 6.46g of the ore is dissolved in sulfuric acid and the resulting solution is made up to 250.0cm^3 . 25.0cm^3 of this solution is titrated against 21.40cm^3 of 0.0200mol dm^{-3} potassium manganate(VII) solution. Calculate the percentage by mass of iron(II) in the sample of ore. (1 mark)

Answer:

$$m(\text{ore}) = 6.46\text{g}$$

$$V_{\text{total}}(\text{ore}) = 250.0\text{cm}^3 = 0.250\text{dm}^3$$

$$V_{\text{used}}(\text{ore}) = 25.0\text{cm}^3 = 0.0250\text{dm}^3$$

$$V_{\text{used}}(\text{MnO}_4^-) = 21.40\text{cm}^3 = 0.02140\text{dm}^3$$

$$c(\text{MnO}_4^-) = 0.0200\text{mol dm}^{-3}$$

$$m(\text{Fe}^{2+}) = ?$$

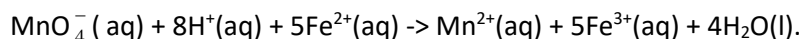
Start off by listing everything you know from the question in a neat list with everything labelled.

Don't forget to convert cm^3 to dm^3 !

1. From what we know we can calculate the moles of MnO_4^- :

$$n_{\text{used}}(\text{MnO}_4^-) = c V = 0.02140\text{dm}^3 \times 0.0200\text{mol dm}^{-3} = 4.28 \times 10^{-4}\text{mol}$$

2. You should know from the course and your redox titrations that the reaction is based on the reaction:



Therefore the molar ratio between MnO_4^- and Fe^{2+} is 1 : 5.

Use this to calculate the moles of Fe^{2+} used in the titration:

$$n_{\text{used}}(\text{Fe}^{2+}) = 5 \times 4.28 \times 10^{-4}\text{mol} = 2.14 \times 10^{-3}\text{mol}$$

3. These are the moles used in the experiment. We know that we used only $\frac{1}{10}$ of the original solution of MnO_4^- (25cm^3 instead of 250cm^3).

The total number of moles in the total solution is therefore 10x the amount just calculated in step 2:

$$n_{\text{total}}(\text{MnO}_4^-) = 10 \times 2.14 \times 10^{-3} \text{ mol} = 2.14 \times 10^{-2} \text{ mol}$$

This is where the factor of 10 was dropped by the student.

4. Now we can calculate the mass of Fe^{2+} in the ore:

$$m_{\text{in ore}}(\text{Fe}^{2+}) = n M = 2.14 \times 10^{-2} \text{ mol} \times 55.85 \text{ g mol}^{-1} = 1.19519 \text{ g}$$

5. Now we're nearly there as all that's left now it to calculate the percentage by mass of Fe(II) in the ore:

$$\% = \frac{1.19519}{6.46} \times 100 = 18.5\%$$