

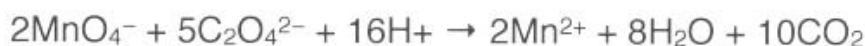
[AQA A2 Paper 1 2017]

This question is about compounds containing ethanedioate ions.

A white solid is a mixture of sodium ethanedioate ( $\text{Na}_2\text{C}_2\text{O}_4$ ), ethanedioic acid dihydrate ( $\text{H}_2\text{C}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$ ) and an inert solid. A volumetric flask contained 1.90 g of this solid mixture in 250  $\text{cm}^3$  of aqueous solution.

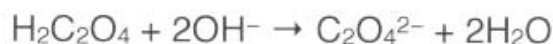
Redox

Two different titrations were carried out using this solution. In the first titration 25.0  $\text{cm}^3$  of the solution were added to an excess of sulfuric acid in a conical flask. The flask and contents were heated to 60  $^\circ\text{C}$  and then titrated with a 0.0200  $\text{mol dm}^{-3}$  solution of potassium manganate(VII). When 26.50  $\text{cm}^3$  of potassium manganate(VII) had been added the solution changed colour. The equation for this reaction is:



Acid-Base

In the second titration 25.0  $\text{cm}^3$  of the solution were titrated with a 0.100  $\text{mol dm}^{-3}$  solution of sodium hydroxide using phenolphthalein as an indicator. The indicator changed colour after the addition of 10.45  $\text{cm}^3$  of sodium hydroxide solution. The equation for this reaction is:



a question like this is worth up to 8 marks.

- a) Calculate the percentage by mass of sodium ethanedioate in the white solid. Give your answer to the appropriate number of significant figures. Show your working.

↑ in this question there are two different reactions:

① Acid-Base

② Redox Titration

⇒ Only the acid reacts with the base but they both react in the redox reaction. This means the moles of sodium ethanedioate can be found:

$$\left[ \begin{array}{l} \text{moles from} \\ \text{redox reaction} \end{array} - \begin{array}{l} \text{moles from} \\ \text{acid-base reaction} \end{array} = \text{moles of} \right. \left. \text{Na}_2\text{C}_2\text{O}_4 \right]$$



① Use the Acid-base reaction to find the moles of ethanedioic acid in the mixture:

$$\text{moles of NaOH} = \frac{10.45 \times 0.100}{1000}$$

$$\text{moles} = \frac{\text{conc.} \times \text{vol.}}{1000}$$

$$= 1.045 \times 10^{-3} \text{ moles of base}$$

use molar ratio.

$$\Rightarrow \text{moles of } \text{C}_2\text{O}_4^{2-} \text{ in acid} = \frac{1}{2} \times 1.045 \times 10^{-3}$$

$$= 5.224 \times 10^{-4} \text{ moles (in } 25\text{cm}^3)$$

② Use the Redox reaction to find the total moles of oxalate ions ( $\text{C}_2\text{O}_4^{2-}$ ) in the mixture:

$$\text{moles of } \text{MnO}_4^- \text{ ions} = \frac{26.50 \times 0.0200}{1000}$$

$$= 5.30 \times 10^{-4} \text{ moles}$$

use molar ratio.

$$\Rightarrow \text{moles of } \text{C}_2\text{O}_4^{2-} \text{ in mixture} = \frac{5}{2} \times 5.30 \times 10^{-4}$$

$$= 1.325 \times 10^{-3} \text{ moles (in } 25\text{cm}^3)$$

③ Find the moles of  $\text{Na}_2\text{C}_2\text{O}_4$  in  $25\text{cm}^3$ :

$$\Rightarrow 1.325 \times 10^{-3} - 5.224 \times 10^{-4} = 8.025 \times 10^{-4} \text{ moles}$$

④ Scale up to find the moles of  $\text{Na}_2\text{C}_2\text{O}_4$  in the  $250\text{cm}^3$  sample:

$$\Rightarrow 8.025 \times 10^{-4} \times 10 = 8.025 \times 10^{-3} \text{ moles}$$



⑤ Calculate the Mr of  $\text{Na}_2\text{C}_2\text{O}_4$  :

$$\begin{aligned}\text{Mr} &= (2 \times 23.0) + (2 \times 12.0) + (4 \times 16.0) \\ &= 134.0\end{aligned}$$

⑥ Use this to find the mass of  $\text{Na}_2\text{C}_2\text{O}_4$  present :

$$\begin{aligned}\text{mass} &= 8.025 \times 10^{-3} \times 134.0 \\ &= 1.0753 \dots \text{g}\end{aligned}$$

⑦ Express this mass as a percentage of the original sample :

$$\begin{aligned}\% &= \frac{1.0753 \dots}{1.90} \times 100 \\ &= 56.594 \dots\end{aligned}$$

$$\Rightarrow \underline{56.6\%} \quad (3\text{sf})$$

↖ 3sf is appropriate to the question.

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⇒ A question like this is often used towards the end of a paper as an A/A\* differentiator.

