

5.1.2 Use redox titration ratios and uncertainty

Name: _____ Class: _____ Date: _____ **Total: 18 marks**

KEY WORDS evidence • conditions

Objective

Use redox titration ratios and uncertainty. All questions and marking guidance are original.

1 Key knowledge and worked examples

In acid, MnO_4^- gains five electrons, while Fe^{2+} loses one: one manganate(VII) ion reacts with five Fe^{2+} ions. Sulfuric acid supplies H^+ without the chloride oxidation problem. The endpoint is the first persistent faint pink excess of manganate(VII).

■ Worked method

20.00 cm^3 of $0.0200 \text{ mol dm}^{-3}$ manganate(VII) contains $0.0200 \times 0.02000 = 0.000400 \text{ mol}$. It reacts with $0.00200 \text{ mol Fe}^{2+}$. In a 25.00 cm^3 sample, $c = 0.00200/0.02500 = 0.0800 \text{ mol dm}^{-3}$. In iodine titration, $\text{I}_2 + 2\text{S}_2\text{O}_3^{2-} \rightarrow 2\text{I}^- + \text{S}_4\text{O}_6^{2-}$. Add starch near the pale-yellow stage, then titrate until blue-black disappears.

2 Practice

2.1 Balance MnO_4^- reduction to Mn^{2+} in acid, including electrons. [3]

2.2 Explain the choice of sulfuric acid rather than hydrochloric acid, and state the manganate(VII) endpoint. [2]

2.3 A titre has two readings, each $\pm 0.05 \text{ cm}^3$. Find worst-case percentage uncertainty for 16.00 cm^3 . [2]

3 Exam-style questions

3.1 $25.00 \text{ cm}^3 \text{ Fe}^{2+}$ requires 22.40 cm^3 of $0.0200 \text{ mol dm}^{-3} \text{ MnO}_4^-$. Calculate Fe^{2+} concentration. [4]

3.2 Excess iodide reacts with 25.00 cm^3 of an oxidant sample: $\text{X} + 2\text{I}^- \rightarrow \text{Y} + \text{I}_2$. The iodine needs 18.60 cm^3 of $0.100 \text{ mol dm}^{-3}$ thiosulfate. Find X concentration. [4]

3.3 Explain when to add starch, why water in the conical flask does not change the titre, and why concordant titres do not remove every error. [3]

Solutions

Original marking guidance: M1 method, A1 accuracy, B1 explanation.

2.1 $\text{MnO}_4^- + 8\text{H}^+ + 5\text{e}^- \rightarrow \text{Mn}^{2+} + 4\text{H}_2\text{O}$. Correct O/H balance, electron count, charge/overall equation.

2.2 Chloride can be oxidised, consuming extra titrant; first persistent faint pink is slight manganate(VII) excess.

2.3 Absolute uncertainty = 0.10 cm^3 ; $100(0.10/16.00) = 0.625\%$.

3.1 $n(\text{MnO}_4^-) = 0.0200 \text{ times } 0.02240 = 4.48 \text{ times } 10^{-4} \text{ mol}$. Fe^{2+} amount is five times this, 0.00224 mol . Concentration = $0.00224/0.02500 = 0.0896 \text{ mol dm}^{-3}$.

3.2 Thiosulfate = 0.001860 mol ; iodine = half, 0.000930 mol . X:iodine is 1:1, so $c(X) = 0.000930/0.02500 = 0.0372 \text{ mol dm}^{-3}$.

3.3 Add near pale yellow to avoid strong iodine/starch binding at high iodine concentration. Water changes volume but not moles of transferred analyte. A systematic error such as incorrect titrant concentration remains.