

1 A student uses a technique called the Winkler method to determine the mass of oxygen dissolved in a sample of water from a lake.

Two solutions, **X** and **Y**, are prepared.

Solution **X** is 2.30 mol dm^{-3} aqueous manganese(II) sulfate, $\text{MnSO}_4(\text{aq})$.

Solution **Y** is alkaline aqueous potassium iodide, $\text{KI}(\text{aq})$.

(a) Calculate the mass of solid hydrated manganese(II) sulfate, $\text{MnSO}_4 \cdot \text{H}_2\text{O}(\text{s})$, needed to make 100.0 cm^3 of solution **X**.

Give your answer to **two** decimal places.

mass of $\text{MnSO}_4 \cdot \text{H}_2\text{O}(\text{s}) = \dots\dots\dots \text{ g}$ [1]

(b) The student is given a small beaker containing the mass of $\text{MnSO}_4 \cdot \text{H}_2\text{O}(\text{s})$ calculated in (a). Describe how the student should prepare exactly 100.0 cm^3 of solution **X**.

Include the names and capacities of each piece of key apparatus used.

Write your answer using a series of numbered steps.

.....

 [3]

(c) Solution **Y** is prepared as follows.

- step 1** Place 100 cm^3 of distilled water in a 250 cm^3 beaker.
- step 2** Add about 8 g of solid sodium hydroxide, $\text{NaOH}(\text{s})$, and stir to dissolve.
- step 3** Cool the solution to room temperature using an ice-bath.
- step 4** Repeat steps 2 and 3 until a total of 32 g of $\text{NaOH}(\text{s})$ has been dissolved.
- step 5** Dissolve about 14 g of potassium iodide, $\text{KI}(\text{s})$, into the solution formed in step 4.

(i) Solution **Y** is corrosive.
 Other than wearing safety goggles, state **one** safety precaution that the student should take when preparing solution **Y**.
 [1]

(ii) Suggest why the solution is cooled in step 3.

 [1]

(d) The student uses the following procedure to determine the mass of oxygen dissolved in a sample of water from the lake.

- step 1** Collect a 250 cm^3 sample of lake water in a bottle.
- step 2** Add 1 cm^3 of solution **X** and 1 cm^3 of solution **Y** to the bottle.
- step 3** Immediately stopper the bottle, ensuring as little air as possible is trapped.
- step 4** Shake the bottle to mix its contents.
A brown precipitate, manganese(III) hydroxide, $\text{Mn}(\text{OH})_3(\text{s})$, is formed.
- step 5** Add 1.5 cm^3 of concentrated sulfuric acid to the contents of the bottle.
The precipitate dissolves, and iodine is formed.
- step 6** Dilute this solution to exactly 500.0 cm^3 using distilled water to form solution **Z**.
- step 7** Transfer 25.0 cm^3 of solution **Z** into a conical flask, and titrate with $1.00 \times 10^{-3} \text{ mol dm}^{-3}$ aqueous sodium thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3(\text{aq})$. Add 1 cm^3 of starch solution near to the end-point.
- step 8** Repeat step 7 as many times as necessary.

(i) Suggest why it is important to avoid trapping air inside the bottle in step 3.
 [1]

(ii) Identify the piece of apparatus that the student should use to transfer the 25.0 cm^3 of solution **Z** in step 7.
 [1]

(iii) Suggest why starch solution is added in step 7.
 [1]

(e) The student records the results shown in Table 1.1.

Table 1.1

	rough titration	titration 1	titration 2	titration 3
final burette reading / cm^3	13.60	12.75	26.20	14.50
initial burette reading / cm^3	0.00	0.05	13.15	1.35
titre / cm^3	13.60			

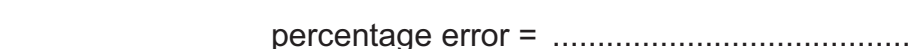
(i) Complete Table 1.1 and calculate the mean titre.
 mean titre = cm^3 [2]

(ii) Explain why the student does **not** need to carry out any further titrations.
 [1]

(iii) Calculate the percentage error in the measurement of the titre for titration 3. Show your working.
 percentage error = % [1]

(f) The following equations show the reactions that take place during the procedure in (d).

steps 2, 3 and 4



step 5



step 7



(i) Calculate the amount, in mol, of iodine, $\text{I}_2(\text{aq})$, in 25.0 cm^3 of solution **Z**.
 amount of $\text{I}_2(\text{aq}) = \dots\dots\dots \text{ mol}$ [1]

(ii) Use your answer to (f)(i) and the equations given to calculate the amount, in mol, of dissolved oxygen, $\text{O}_2(\text{aq})$, in 500.0 cm^3 of solution **Z**.
 amount of $\text{O}_2(\text{aq})$ in 500.0 cm^3 of solution **Z** = mol [1]

(iii) Dissolved oxygen content, mg dm^{-3} , is the mass of oxygen dissolved in water.
 Use your answer to (f)(ii) to calculate the dissolved oxygen content in the lake water collected in step 1.
 [If you were unable to obtain an answer to (f)(ii), then use amount of $\text{O}_2(\text{aq})$ in 500.0 cm^3 of solution **Z** = $7.12 \times 10^{-5} \text{ mol}$. This is **not** the correct answer.]
 dissolved oxygen content = mg dm^{-3} [1]