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, $MnSO_4(aq)$.

Solution **Y** is alkaline aqueous potassium iodide, KI(aq).

(a) Calculate the mass of solid hydrated manganese(II) sulfate, $MnSO_4 \cdot H_2O(s)$, needed to make 100.0 cm^3 of solution **X**.

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

mass of $MnSO_4 \cdot H_2O(s)$ = ... g [1]

(b) The student is given a small beaker containing the mass of $MnSO_4 \cdot H_2O(s)$ 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.

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..... [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, NaOH(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 NaOH(s) has been dissolved.

step 5 Dissolve about 14 g of potassium iodide, KI(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.

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..... [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, $Mn(OH)_3(s)$, 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 1.00×10^{-3} mol dm^{-3} aqueous sodium thiosulfate, $Na_2S_2O_3(aq)$. 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**

$$4Mn^{2+}(aq) + 8OH^-(aq) + O_2(aq) + 2H_2O(l) \rightarrow 4Mn(OH)_3(s)$$

step 5

$$2Mn(OH)_3(s) + 2I^-(aq) + 6H^+(aq) \rightarrow I_2(aq) + 6H_2O(l) + 2Mn^{2+}(aq)$$

step 7

$$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$

(i) Calculate the amount, in mol, of iodine, $I_2(aq)$, in 25.0 cm^3 of solution **Z**.

amount of $I_2(aq)$ = ... mol [1]

(ii) Use your answer to **(f)(i)** and the equations given to calculate the amount, in mol, of dissolved oxygen, $O_2(aq)$, in 500.0 cm^3 of solution **Z**.

amount of $O_2(aq)$ 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 $O_2(aq)$ in 500.0 cm^3 of solution **Z** = 7.12×10^{-5} mol. This is **not** the correct answer.]

dissolved oxygen content = ... mg dm^{-3} [1]

[Total: 16]