1 The concentration of aqueous chloride ions can be found by titration with aqueous silver nitrate, $AgNO_3(aq)$.

$$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$$

The indicator used is aqueous potassium chromate(VI), $K_2CrO_4(aq)$.

As $AgNO_3(aq)$ is added to aqueous chloride ions, a white precipitate of $AgCl(s)$ is formed.

When all the chloride ions have reacted, further addition of $AgNO_3(aq)$ leads to the formation of a red precipitate of silver chromate(VI), $Ag_2CrO_4(s)$. The first appearance of the red precipitate shows the end-point of the titration.

A student carries out an experiment to determine the number of molecules of water of crystallisation, x, in hydrated barium chloride, $BaCl_2 \cdot xH_2O(s)$.

(a) The student makes 250.0 cm^3 of 0.0500 mol dm^{-3} $AgNO_3(aq)$ to use for the titration.

(i) Calculate the mass of solid silver nitrate, $AgNO_3(s)$, needed to make 250.0 cm^3 of 0.0500 mol dm^{-3} $AgNO_3(aq)$.

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

mass of $AgNO_3(s)$ = ... g [1]

(ii) Describe how the student should make 250.0 cm^3 of 0.0500 mol dm^{-3} $AgNO_3(aq)$ starting from the mass of $AgNO_3(s)$ calculated in **(a)(i)** in a 50 cm^3 beaker.

Give the name and size of any key apparatus used.

Write your answer using a series of numbered steps.

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..... [3]

(b) The student uses the following method.

step 1 Dissolve 1.58 g of $BaCl_2 \cdot xH_2O(s)$ to form 250 cm^3 of aqueous solution. Label this solution **A**.

step 2 Transfer 20.0 cm^3 of solution **A** into a conical flask.

step 3 Add aqueous sodium sulfate, $Na_2SO_4(aq)$, to the flask and swirl the mixture to remove barium ions from the solution.

step 4 Add 2–3 drops of $K_2CrO_4(aq)$ indicator to the flask.

step 5 Titrate the contents of the flask against 0.0500 mol dm^{-3} $AgNO_3(aq)$.

step 6 Repeat steps 2 to 5 to collect sufficient data for analysis.

(i) Suggest a suitable piece of apparatus for transferring 20.0 cm^3 of solution **A** in step 2.

..... [1]

(ii) Suggest why barium ions are removed in step 3 before performing the titration.

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..... [1]

(iii) Suggest why chemically resistant gloves should be worn to carry out step 4.

..... [1]

(c) The student's results are shown in Table 1.1.

Table 1.1

	rough titration	titration 1	titration 2	titration 3
burette reading (final) / cm^3	20.10	40.55	20.75	20.90
burette reading (initial) / cm^3	0.00	20.25	0.05	0.30
titre / cm^3	20.10	20.30	20.70	20.60

The student uses the titres from titrations 2 and 3 shown in Table 1.1 to calculate a mean titre value of 20.65 cm^3.

(i) Explain why only these two values are used.

..... [1]

(ii) Calculate the percentage error in the titre volume for titration 3.
Show your working.

percentage error = ... [1]

(d) The equation for the reaction of silver nitrate with barium chloride is shown.

$$2AgNO_3(aq) + BaCl_2(aq) \rightarrow Ba(NO_3)_2(aq) + 2AgCl(s)$$

(i) Calculate the amount, in mol, of $AgNO_3(aq)$ in the mean titre of 20.65 cm^3.

amount of $AgNO_3$ = ... mol [1]

(ii) Calculate the amount, in mol, of $BaCl_2(aq)$ in 250 cm^3 of solution **A**.

amount of $BaCl_2$ = ... mol [1]

(iii) Calculate the value of x in the formula $BaCl_2 \cdot xH_2O$.

x = ... [2]

(e) Another student uses a different experimental method to check the value of x obtained by the method described in **(b)**.

Give a **brief** description of another method, not involving titration, that could be used to determine the value of x in the formula $BaCl_2 \cdot xH_2O(s)$. Write your answer using a series of numbered steps.

Your plan should include details of the following:
- the apparatus and method you would use
- the measurements you would make.

You are provided with standard laboratory apparatus.

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..... [3]

[Total: 16]