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Chemistry Higher level Paper 1B

16 May 2025

Zone A afternoon | Zone B afternoon | Zone C afternoon

Candidate session number

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2 hours [Paper 1A and Paper 1B]

Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answer all questions.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- A clean copy of the **chemistry data booklet** is required for this paper.
- The maximum mark for paper 1B is **[35 marks]**.
- The maximum mark for paper 1A and paper 1B is **[75 marks]**.



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Answers written on this page
will not be marked.



Section B

Answer **all** questions. Answers must be written within the answer boxes provided.

1. The concentration of calcium ions, Ca^{2+} , in aqueous solution can be determined by titration with ethylenediaminetetraacetic acid (EDTA), or by atomic absorption spectrophotometry.

(a) EDTA solution must be standardized before use, by titrating it with a standard solution of calcium chloride.

An accurately weighed mass of powdered calcium carbonate was dissolved in concentrated hydrochloric acid and heated to remove all of the carbon dioxide. After cooling, the calcium chloride solution was made up to exactly 250.0 cm^3 .

(i) State the most appropriate glassware to make 250.0 cm^3 of a Ca^{2+} solution. [1]

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(ii) Describe the steps involved in preparing the standard solution by dilution of the initial calcium chloride solution. [2]

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(b) Calcium chloride is not used to make the standard solution because it readily absorbs water.

Suggest how solid calcium chloride, CaCl_2 , could be treated in the laboratory to remove all of the absorbed water. [2]

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Turn over

(Question 1 continued)

- (c) A sample of tap water was titrated against the standardized EDTA solution, using Eriochrome Black T as an indicator.

The following titration data were obtained.

	Trial 1	Trial 2	Trial 3	Trial 4
Final burette reading / cm³ ± 0.05 cm³	26.15	34.25	29.30	32.20
Initial burette reading / cm³ ± 0.05 cm³	0.00	10.00	5.00	8.00
Volume added / cm³	26.15	24.25	24.30	24.20

- (i) Suggest **two** reasons why the volume added in trial 1 is much larger than the other values.

[2]

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- (ii) State the name given to a value that differs significantly from others.

[1]

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- (iii) Suggest a reason why trial 1 should not be included when finding the mean volume of EDTA used.

[1]

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(This question continues on the following page)



(Question 1 continued)

- (iv) Calculate the percentage uncertainty in the volume of EDTA used in trial 2. [1]

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- (v) The end point of the titration is determined when a red complex, **X**, changes to a blue ion, **Y**. Explain how this shows that **X** absorbs radiation with higher energy than **Y**. [2]

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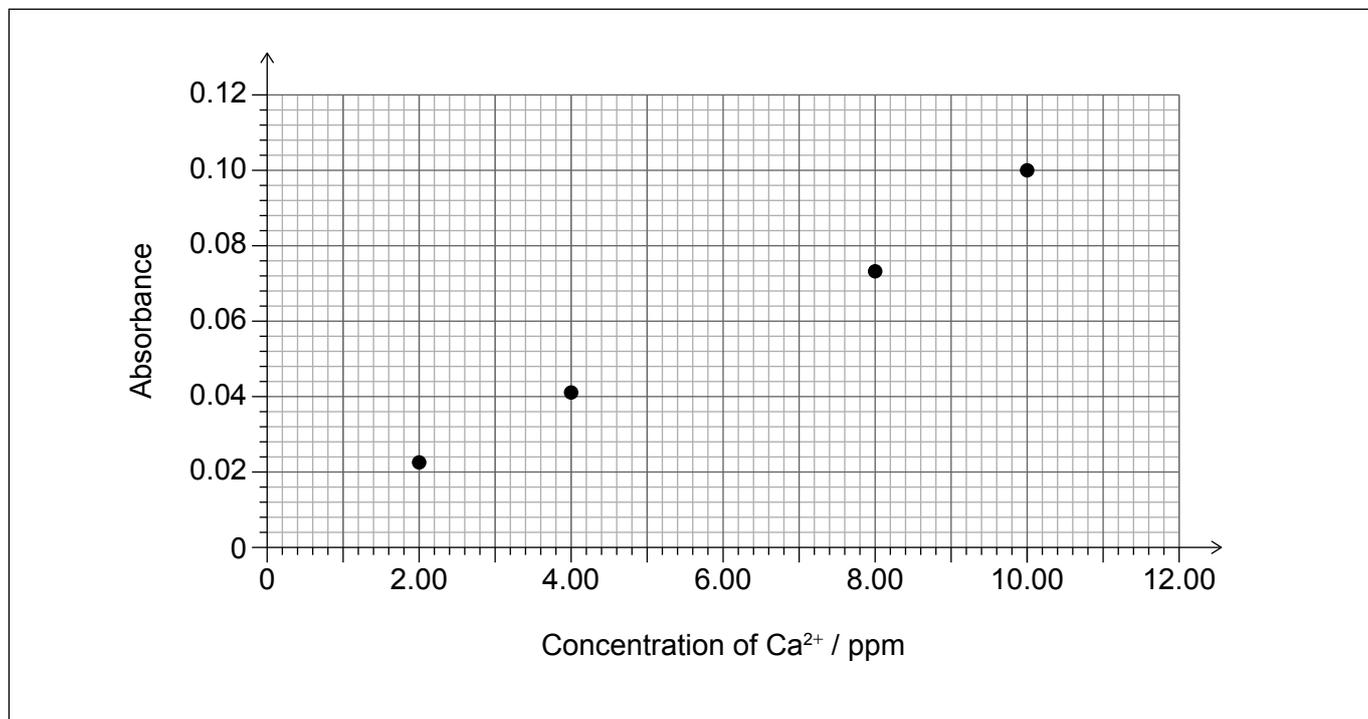


(Question 1 continued)

(d) A standard stock solution of calcium chloride was diluted to produce several solutions with accurately known concentrations. The absorbance of these solutions was measured in a spectrophotometer that was calibrated with distilled water.

(i) Draw a line of best fit on the graph.

[1]



(ii) Determine the concentration, in ppm, of Ca²⁺ ions in a sample of tap water with an absorbance of 0.090.

[1]

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(This question continues on the following page)



(Question 1 continued)

(iii) $A = \log_{10} \frac{I_0}{I}$

where A is absorbance, I_0 is intensity of incident radiation and I is intensity of radiation that has passed through the sample.

Determine the percentage of incident radiation that is absorbed by a sample of tap water with an absorbance of 0.090.

[2]

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(iv) The 4.00 ppm solution was made by diluting 2.00 cm³ of the stock solution to 25.00 cm³. Calculate the concentration, in ppm, of the stock solution.

[1]

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(v) Calculate the concentration, in mol dm⁻³, of Ca²⁺ in the 4.00 ppm solution.
1 ppm = 1 mg dm⁻³.

[1]

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2. Spinach leaves were boiled in water for varying times. The water was cooled and tested for the presence of Fe^{2+} ions by titration with standardized potassium manganate (VII) solution, $\text{KMnO}_4(\text{aq})$.

(a) Three trials were performed for each boiling time. In each trial, 10.0 g of spinach was boiled in a beaker containing 250 cm^3 of tap water for 5, 10, 15, and 20 minutes. The spinach was removed by filtration and the solution was bottled and stored in a refrigerator until titration was performed.

(i) State the independent and dependent variables. [1]

Independent variable:
Dependent variable:

(ii) Suggest **two** additional experimental conditions that should be controlled to ensure that the methodology of this investigation is valid. [2]

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(iii) Suggest an additional trial that should be performed so that it can be determined how much Fe^{2+} was extracted only from the spinach leaves. [1]

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(iv) Discuss **two** difficulties that a student might experience when determining the end point of this titration. [2]

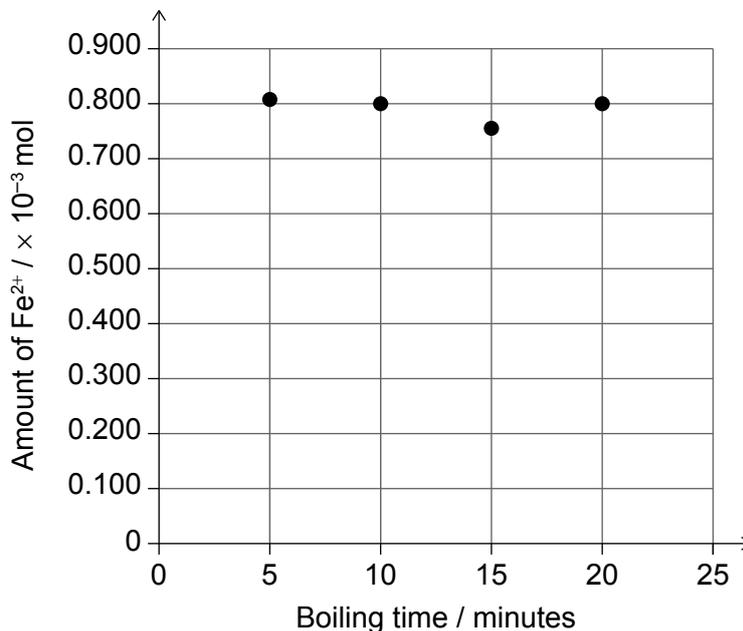
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(Question 2 continued)

(b) The average results from (a) were graphed.



(i) State the relationship shown in the graph between the amount of Fe²⁺ released from the spinach and the boiling time. [1]

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(ii) Comment on the range and quantity of measurements used in the investigation. [2]

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(Question 2 continued)

(c) The initial hypothesis was that more Fe^{2+} would be extracted from the spinach leaves as the boiling time increased.

(i) Evaluate, giving a reason, whether the results support the hypothesis. [1]

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(ii) Suggest **one** modification to the investigation that would make it more suitable for testing the hypothesis. [1]

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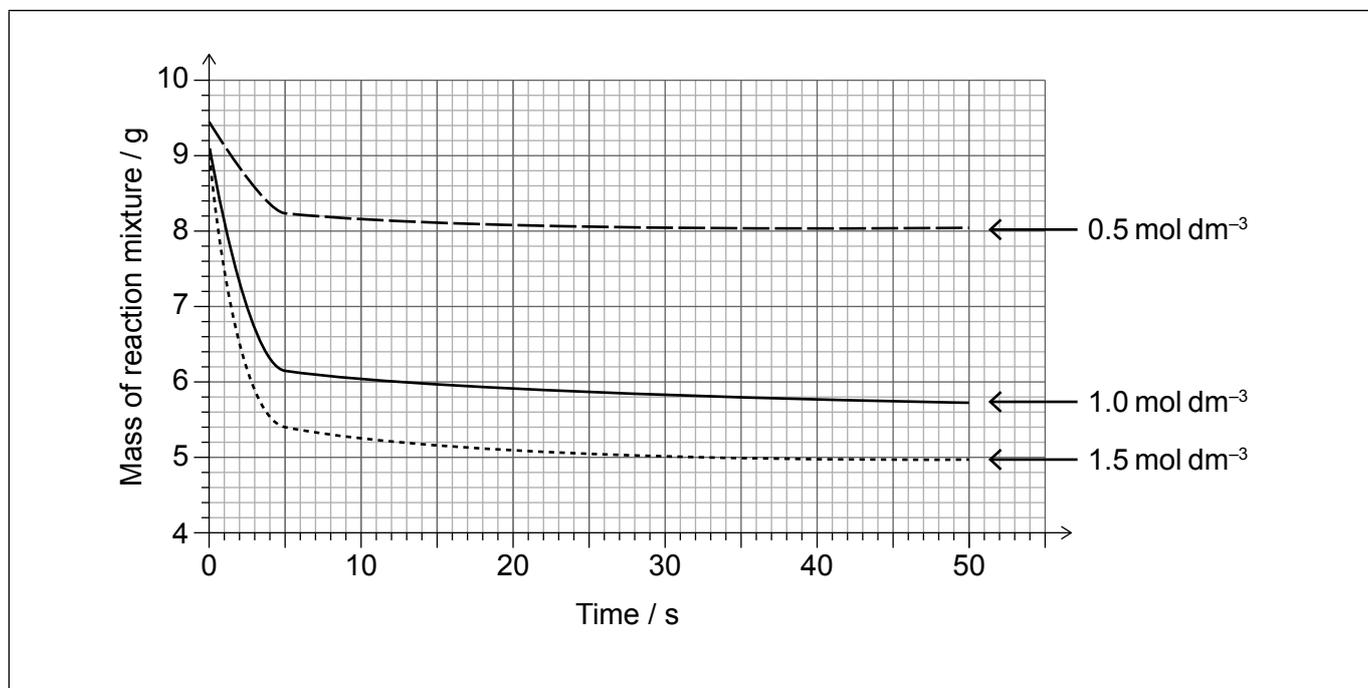
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3. The reaction of solid sodium hydrogencarbonate, $\text{NaHCO}_3(\text{s})$, with hydrochloric acid, $\text{HCl}(\text{aq})$, was investigated using the same mass of solid and a constant volume of different concentrations of acid. A data logger was used to measure the mass of the reaction mixture every five seconds.

The results were graphed.



- (a) Determine, by annotating the graph, the initial rate of release of $\text{CO}_2(\text{g})$, in g s^{-1} , with the $1.5 \text{ mol dm}^{-3} \text{ HCl}(\text{aq})$. [2]

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- (b) Suggest, with a reason, whether $\text{NaHCO}_3(\text{s})$ or $\text{HCl}(\text{aq})$ was the limiting reagent in the reactions using 0.5 and $1.0 \text{ mol dm}^{-3} \text{ HCl}(\text{aq})$. [1]

Limiting reagent:

Reason:

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.....

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(Question 3 continued)

(c) The expected (theoretical) mass of $\text{CO}_2(\text{g})$ produced in a complete reaction with $1.0 \text{ mol dm}^{-3} \text{ HCl}(\text{aq})$ is 4.40 g.

(i) Determine from the graph the actual mass, in g, of $\text{CO}_2(\text{g})$ produced. [1]

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(ii) Calculate the percentage difference between the theoretical and actual mass of $\text{CO}_2(\text{g})$ produced. [1]

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(iii) Although the same mass of $\text{NaHCO}_3(\text{s})$ and volume of $\text{HCl}(\text{aq})$ were used each time, the graphs begin from different points.

Suggest an error in the method that may have caused this. [1]

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16EP16