Diploma Programme
Programme du diplôme
Programa del Diploma

Chemistry
Higher level
Paper 1B

16 May 2025

Zone A afternoon | **Zone B** afternoon | **Zone C** afternoon

Candidate session number

2 hours [Paper 1A and Paper 1B]

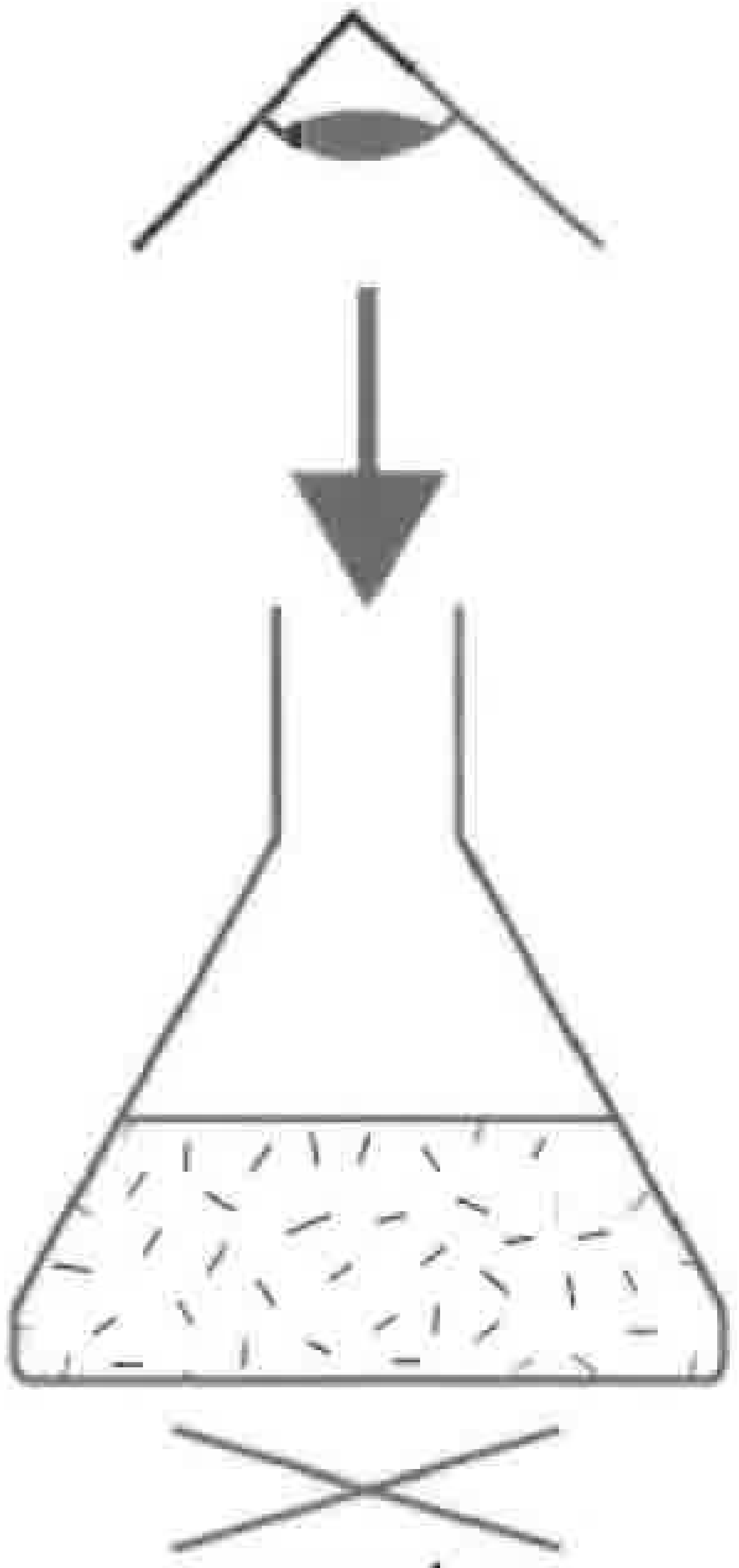
Instructions to candidates

- 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.

1. A student investigated the effect of concentration on the rate of reaction between sodium thiosulfate, $Na_2S_2O_3$, and hydrochloric acid, HCl.

$$Na_2S_2O_3(aq) + 2HCl(aq) \rightarrow S(s) + 2NaCl(aq) + SO_2(g) + H_2O(l)$$

Since the solid sulfur product is insoluble, the rate can be determined by measuring the time it takes for the clear solution to turn off-white or pale yellow until the X mark on a white tile below the flask can no longer be seen.



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(a) Determine the mass of sodium thiosulfate needed to make $500.0\,cm^3$ of a $0.1500\,mol\,dm^{-3}$ solution. [2]

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(b) Explain how to make the $0.1500\,mol\,dm^{-3}$ solution in a volumetric flask. [3]

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(Question 1 continued)

(c) Suggest how to make a 100.0 cm^3 solution of 0.03000 mol dm^{-3} sodium thiosulfate from the original 0.1500 mol dm^{-3} solution. [3]

(d) The student recorded the following data.

$Na_2S_2O_3$ concentration (mol dm^{-3})	Reaction Time s ± 0.1 s					
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Average

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$Na_2S_2O_3$ concentration (mol dm^{-3})	Reaction Time s ± 0.1 s					
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Average
0.1500 ± 0.08 %	21.1	19.7	18.1	17.3	19.4	19.1 ± 1.5
0.120 ± 0.1 %	26.4	24.8	26.9	26.2	25.1	25.9 ± 0.9
0.0900 ± 0.1 %	33.8	32.4	31.5	30.8	32.6	32.2 ± 1.2
0.0600 ± 0.2 %	48.3	49.3	45.9	46.4	44.6	46.9 ± 1.9
0.0300 ± 0.4 %	96.2	95.8	97.9	95.9	93.7	95.9 ± 1.0

The solutions of sodium thiosulfate were in fact, all made as accurately as possible from the solid sodium thiosulfate by weighing the appropriate mass with a balance that can measure to one hundredth of a gram (±0.01 g), rather than by dilution of a stock solution.

(i) Explain why the percent uncertainties of concentrations increase as the

0.0600 ± 0.2 %	48.3	49.3	45.9	46.4	44.6	46.9 ± 1.9
0.0300 ± 0.4 %	96.2	95.8	97.9	95.9	93.7	95.9 ± 1.0

The solutions of sodium thiosulfate were in fact, all made as accurately as possible from the solid sodium thiosulfate by weighing the appropriate mass with a balance that can measure to one hundredth of a gram (±0.01 g), rather than by dilution of a stock solution.

(i) Explain why the percent uncertainties of concentrations increase as the concentrations decrease. [1]

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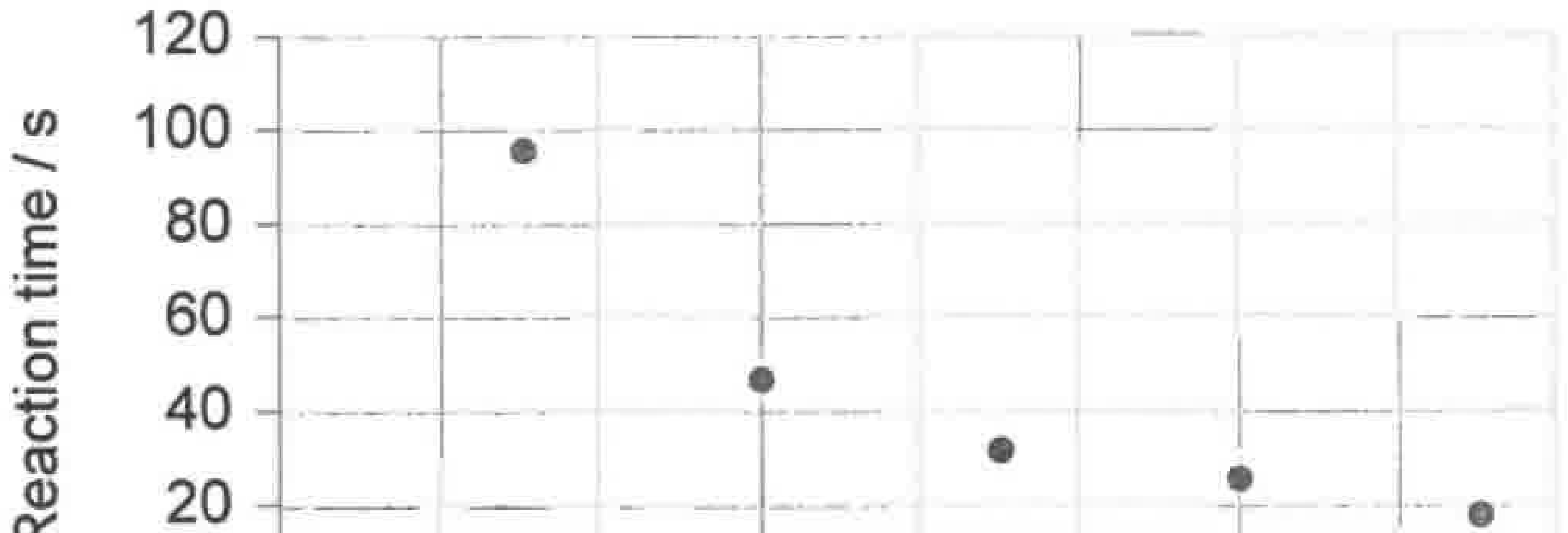
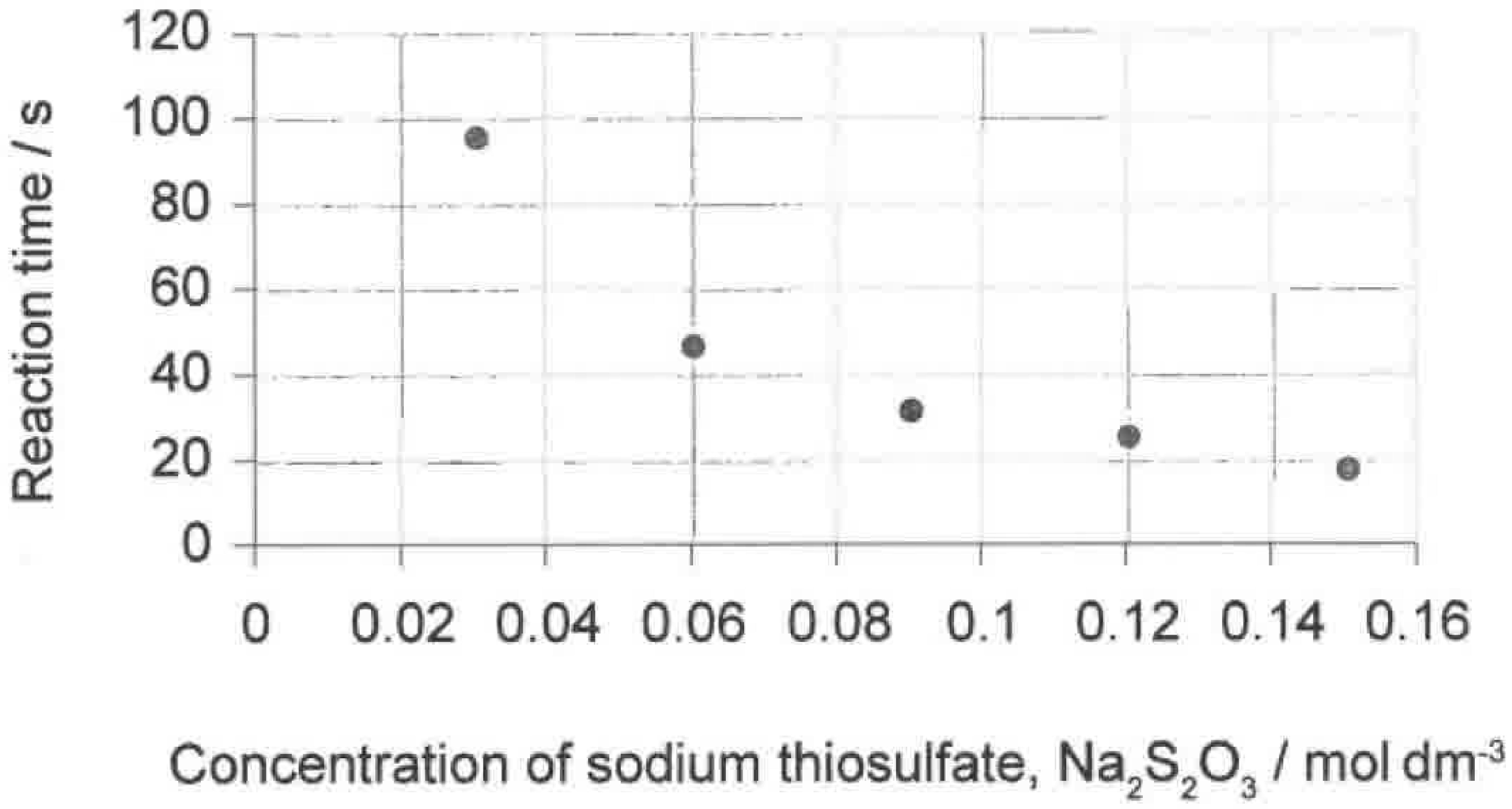
(ii) Estimate the rate of the reaction for 0.1500 mol dm^{-3}, giving the correct units. [2]

(e) A graph of the average values was produced. Draw a curve of best fit through the data in the graph. [1]



(e) A graph of the average values was produced. Draw a curve of best fit through the data in the graph. [1]



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(Question 1 continued)

(f) Additional data were obtained by a different student using the same solutions and identical equipment.

$Na_2S_2O_3$ concentration (mol dm^{-3})	Reaction time / s $\pm$ 0.1 s
	Trial 1
0.1500 $\pm$ 0.08 %	24.2
0.120 $\pm$ 0.1 %	28.6
0.0900 $\pm$ 0.1 %	36.9
0.0600 $\pm$ 0.2 %	50.4
0.0300 $\pm$ 0.4 %	98.2

Suggest **two** reasons why these data differ significantly from those obtained by the first student. [2]

(g) State one safety concern for a product of this experiment and a precaution that should be taken. [2]

Safety Concern: ....

....

Precaution: ....

....

2. A student was given a mixture to separate and collect the individual components. The mixture contained sand, SiO_2(s), sodium chloride, NaCl(s), and iron filings, Fe(s). The student observed the original mixture and made the following hypothesis.

The iron would have the lowest percent by mass because it appeared to be present in the smallest quantity.

(a) Suggest a set of experimental steps required to obtain pure samples of each component of the mixture. [4]

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(b) The following data were collected.

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(b) The following data were collected.

Substance	**Mass in g ± 0.01 g**	**Percent Composition**
Mixture before separation	5.62	N/A
Iron after separation	2.17	
Sand after separation	1.98	
Salt after separation	1.80	32.0 %

Calculate the percent composition of the iron and sand in the mixture [1]

(This question continues on the following page)

(c) The percentages in (b) add up to more than 100. Suggest a reason that would explain these results and how to reduce or eliminate it. [2]

Error: . . . .

. . . .

Reduce or Eliminate: . . . .

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(d) The results did not support the original hypothesis. Suggest why the hypothesis was incorrect. [1]

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(e) In a different experiment, the students needed to separate a mixture of methanol and butan-1-ol. State the best method to separate this mixture and the physical property

(d) The results did not support the original hypothesis. Suggest why the hypothesis was incorrect. [1]

....

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(e) In a different experiment, the students needed to separate a mixture of methanol and butan-1-ol. State the best method to separate this mixture and the physical property used for the separation. [2]

Separation method: ....

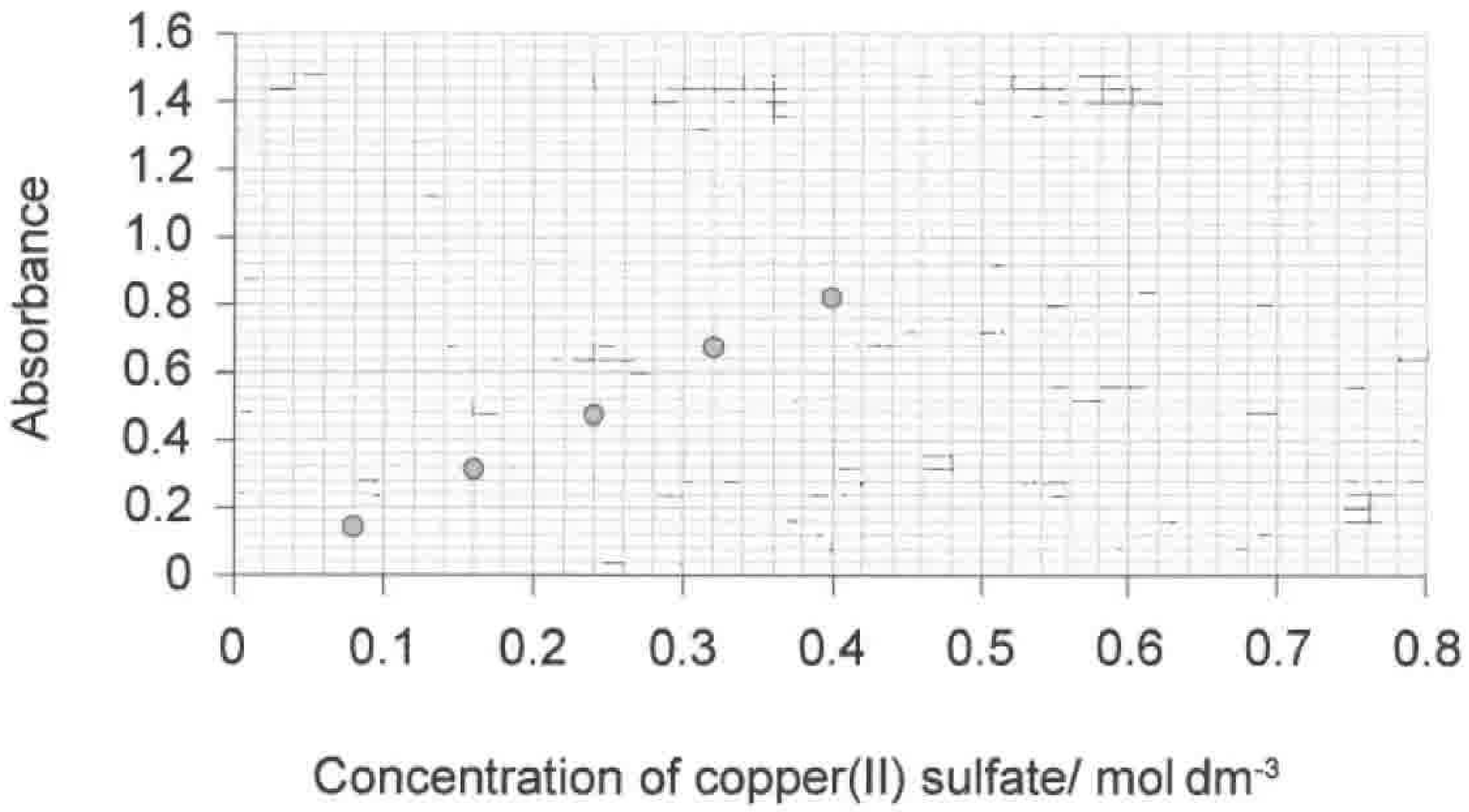
....

Physical property: ....

....

3. A colorimetry experiment was conducted on a series of solutions of copper(II) sulfate, $CuSO_4$. The absorbance versus concentration data were graphed.

(a) Draw a best fit line in the graph below, extrapolating beyond the data given. [2]



(b) State the mathematical relationship between absorbance and concentration. [1]

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(c) The instrument used can collect absorbance or percent transmittance at a specific wavelength. Outline why a specific wavelength must be selected. [1]

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(Question 3 continued)

(d) Deduce the equation that relates the absorbance to concentration including the value of the constant. [2]

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(e) Estimate the absorbance value of a 0.600 mol dm^{-3} $CuSO_4$ solution. [1]

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(f) Predict the difference, if any, between reading the absorbance value for the 0.600 mol dm^{-3} $CuSO_4$ solution from the graph and calculating it using the equation in (d). [1]

(e) Estimate the absorbance value of a 0.600 mol dm^{-3} $CuSO_4$ solution. [1]

....

....

(f) Predict the difference, if any, between reading the absorbance value for the 0.600 mol dm^{-3} $CuSO_4$ solution from the graph and calculating it using the equation in (d). [1]

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(g) The copper(II) sulfate solution is blue. Deduce the optimum wavelength to use for colorimetry, using section 15 of the data booklet. [1]

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