EXPERIMENT NO. 9

Quantitative Analysis

Read through the whole method before starting any practical work. Where appropriate, prepare a table for your results in the space provided.

Show your working and appropriate significant figures in the final answer to **each** step of your calculations.

1 The thiosulfate ion, $S_2O_3^{2-}$, reacts in acidic conditions as shown.

$$S_2O_3^{2-}(aq) + 2H^+(aq) \rightarrow S(s) + SO_2(g) + H_2O(l)$$

You will investigate how the concentration of the thiosulfate ions affects the rate of this reaction. The rate can be measured by timing how long it takes for the solid sulfur that is formed to make the solution too cloudy to see through.

Small amounts of SO_2 gas may be produced during this reaction. Care must be taken to avoid inhaling this SO_2 gas.

It is very important that as soon as each experiment is complete the beaker containing the reaction mixture is emptied into the quenching bath.

FA 1 is 0.100 mol dm^{-3} sodium thiosulfate, $Na_2S_2O_3$.
FA 2 is 2.00 mol dm^{-3} hydrochloric acid, HC*l*.
distilled water

(a) Method

Experiment 1

- Fill the burette labelled **FA 1** with **FA 1**.
- Run 45.00 cm^3 of **FA 1** from the burette into the 100 cm^3 beaker.
- Use the measuring cylinder to measure 10.0 cm^3 of **FA 2**.
- Add the **FA 2** to the **FA 1** in the beaker and start timing immediately.
- Stir the mixture once and place the beaker on the printed insert.
- Look down through the solution in the beaker at the print on the insert.
- Stop timing as soon as the precipitate of sulfur makes the print on the insert **just** invisible.
- Record this reaction time to the nearest second in your results table.
- Empty the contents of the beaker into the quenching bath.
- Wash out the beaker thoroughly.
- Shake the beaker to remove any excess water.

Experiment 2

- Fill a second burette with distilled water.
- Refill the burette labelled **FA 1** with **FA 1**.
- Run 20.00 cm^3 of **FA 1** into the 100 cm^3 beaker.
- Run 25.00 cm^3 of distilled water into the same beaker.
- Use the measuring cylinder to measure 10.0 cm^3 of **FA 2**.
- Add the **FA 2** to the **FA 1** in the beaker and start timing immediately.
- Stir the mixture once and place the beaker on the printed insert.
- Look down through the solution in the beaker at the print on the insert.
- Stop timing as soon as the precipitate of sulfur makes the print on the insert **just** invisible.
- Record this reaction time to the nearest second in your results table.
- Empty the contents of the beaker into the quenching bath.
- Wash out the beaker thoroughly.
- Shake the beaker to remove any excess water.

Experiments 3–5

Carry out three further experiments to investigate how the reaction time changes with different volumes of **FA 1**.
Note that the combined volume of **FA 1** and distilled water must always be 45.00 cm^3.
Do not use a volume of **FA 1** that is less than 20.00 cm^3.

Record all your results in a table. You should include the volume of **FA 1**, the volume of distilled water, the reaction time and the reaction rate for each of your five experiments. The rate of reaction can be calculated using the following expression.

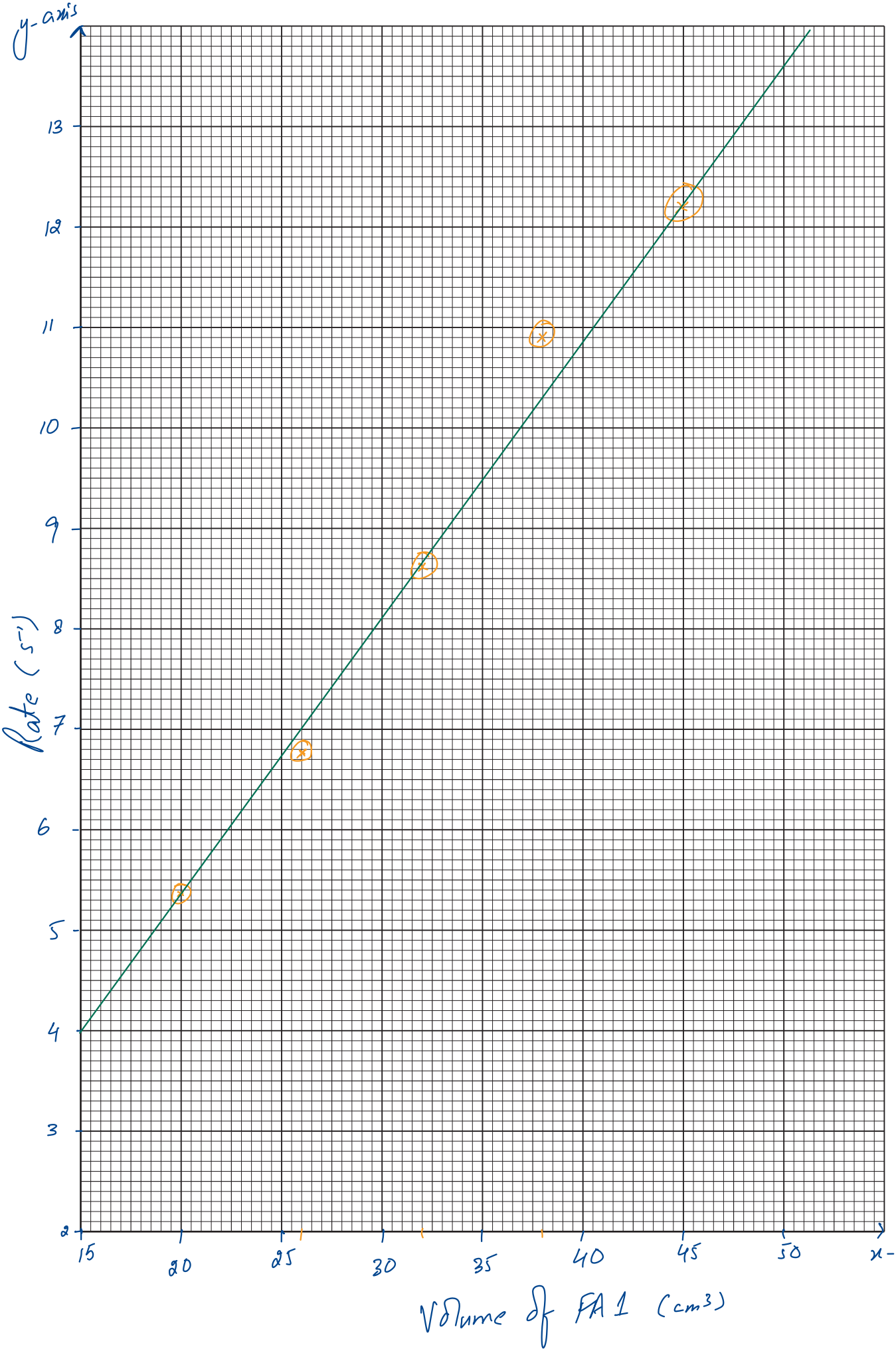
$$\text{rate} = \frac{500}{\text{reaction time}}$$

Experiment No.	Volume of FA1 (cm^3)	Volume of H_2O (cm^3)	Reaction Time (s)	Rate (s^{-1})
01	45.00	0.00	41	12.2
02	20.00	25.00	93	5.38
03	26.00	19.00	75	6.67
04	32.00	13.00	58	8.62
05	38.00	7.00	46	10.9

I	
II	
III	
IV	
V	
VI	
VII	
VIII	
IX	

[9]

(b) On the grid, plot a graph of the rate (*y*-axis) against the volume of **FA 1** (*x*-axis). Label any anomalous points. Draw a line of best fit.


y-axis
13
12
11
10
9
8
7
6
5
4
3
2
Rate (s⁻¹)
15
20
25
30
35
40
45
50
x-axis
Volume of FA 1 (cm³)

I	
II	
III	
IV	

[4]

(c) In these experiments, the volume of **FA 1** is related to the concentration of the thiosulfate ions. From your graph state the relationship between the rate of reaction and the concentration of the thiosulfate ions.

Conc. of thiosulfate ions is proportional to the rate of reaction as conc. increases rate also increases. [1]

(d) Assume that the error in the time measured for each experiment was ± 2 s.

Calculate the minimum value for the reaction rate you observed in **Experiment 2**.
Show your working.

Exp # 2 reaction time = 93 + 2 = 95 s

minimum rate = $\frac{500}{95}$

minimum rate for **Experiment 2** = 5.26 [2]

(e) **(i)** A student suggested that, using a 250 cm^3 beaker, the time recorded for **Experiment 1** would be the same.

Discuss whether the student is correct.

Reaction time would be greater as depth of solution is less. [1]

(ii) A student carried out a further experiment using the same procedure as in **(a)**. The student used 5.00 cm^3 of **FA 1**, 40.00 cm^3 of distilled water and 10.0 cm^3 of **FA 2**.
The print on the insert never became invisible.

Explain why.

Not enough sulfur is produced to obscure the printed insert. [1]

[Total: 18]