1 The thiosulfate ion, $S_2O_3^{2-}$, decomposes when an acid is added.

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

The rate of this reaction can be investigated by measuring how long it takes for the solid sulfur forming to obscure the print on the insert.
You will investigate how the concentration of the thiosulfate ion affects the rate of the reaction.

Note: A small amount of sulfur dioxide gas may be formed in the experiment. It is very important that you avoid inhaling any fumes. As soon as each experiment is complete, add the reaction mixture to the quenching bath and rinse the beaker thoroughly.

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*.

(a) Method

Experiment 1

- Fill a burette with **FA 1**.
- Run 40.00 cm^3 of **FA 1** into the 100 cm^3 beaker.
- Use the 25 cm^3 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.
- View the printing on the insert from above through the solution.
- Stop timing when the print on the insert becomes obscured.
- Record this reaction time to the nearest second in the space for results.
- Empty the contents of the beaker into the quenching bath.
- Rinse and dry the beaker so it is ready to use in **Experiment 2**.

Experiment 2

- Refill the burette with **FA 1**.
- Fill the second burette with distilled water.
- Run 20.00 cm^3 of **FA 1** into the 100 cm^3 beaker.
- Run 20.00 cm^3 of distilled water into the same beaker.
- Use the 25 cm^3 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.
- View the printing on the insert from above through the solution.
- Stop timing when the print on the insert becomes obscured.
- Record this reaction time to the nearest second in the space for results.
- Empty the contents of the beaker into the quenching bath.
- Rinse and dry the beaker so it is ready to use in the next experiment.

Experiments 3–5

- Carry out three further experiments to investigate how using different volumes of **FA 1** affects the reaction time.

Note: the combined volumes of **FA 1** and distilled water must always be 40.00 cm^3.
Do not use a volume of **FA 1** that is less than 15.00 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 formula.

$$\text{rate} = \frac{1000}{\text{reaction time}}$$

Results

I	
II	
III	
IV	
V	
VI	
VII	
VIII	

[8]

(b) (i) On the grid in Fig. 1.1, plot the rate (*y*-axis) against the volume of **FA 1** (*x*-axis).
Start each axis at the origin (0, 0).

Ring any anomalous points. Draw a line of best fit.

Fig. 1.1

I	
II	
III	

[3]

(ii) Use your graph in Fig. 1.1 to determine the time it would take for the print to be obscured if 7.50 cm^3 of **FA 1**, 32.50 cm^3 of water and 10.0 cm^3 of **FA 2** had been used.
Show clearly on the graph how you worked out your answer.

time for printing to be obscured = ... s [2]

(c) A student carries out the same method as given in **(a)** but using a different concentration of acid. The student's calculated values for the rate are plotted on the grid in Fig. 1.2.

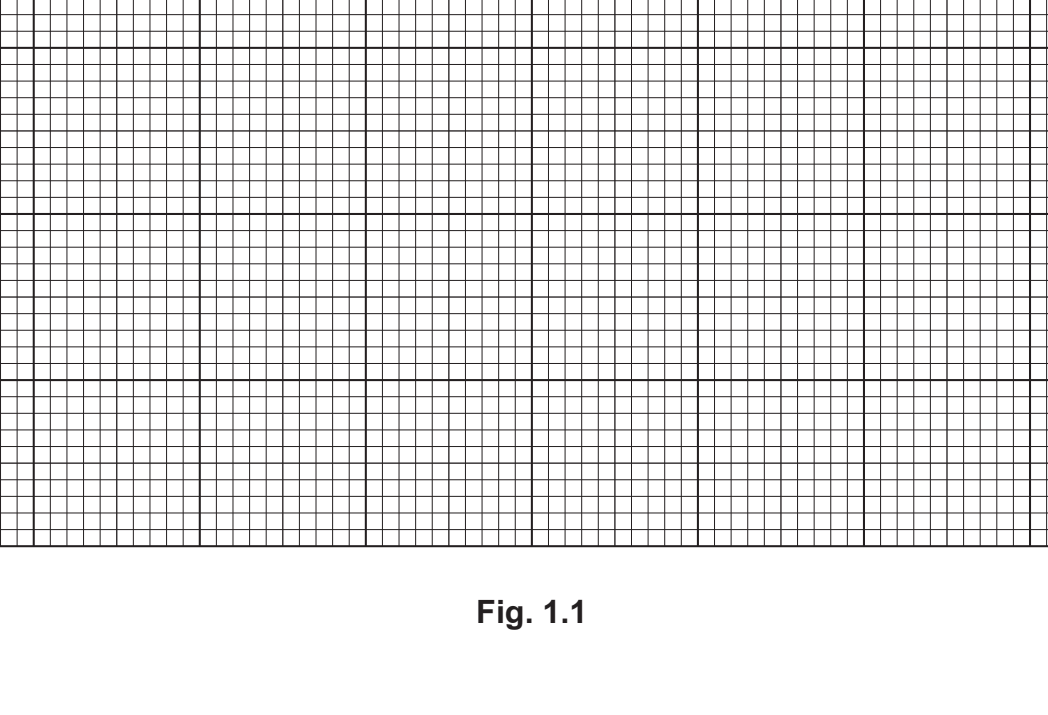

Fig. 1.2

State whether the student's results show that the rate is directly proportional to the volume of **FA 1** used.
Explain your answer.

.....

..... [2]

[Total: 15]