

Rate laws, orders and half-lives

AP Chemistry · Lab

Name: _____ Date: _____ Class: _____

How does the concentration of sodium thiosulfate change the rate of its reaction with acid? In this lab you time the formation of a fixed amount of sulfur at five concentrations, turn the times into relative rates and use a graph to find the order in thiosulfate. The method suits a school lab at AP level.

Level: AP Chemistry · **Curriculum:** AP Chem Unit 5

Aim

Determine the order of reaction with respect to thiosulfate ions in the reaction $\text{S}_2\text{O}_3^{2-}(\text{aq}) + 2\text{H}^+(\text{aq}) \rightarrow \text{S}(\text{s}) + \text{SO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$, using $1/t$ as a measure of initial rate.

Equipment

- 0.100 M sodium thiosulfate solution, 1.0 M hydrochloric acid, distilled water
- Two 50 cm³ measuring cylinders, one 10 cm³ cylinder, 100 cm³ conical flask
- Stopwatch, white paper with a black cross, stirring rod

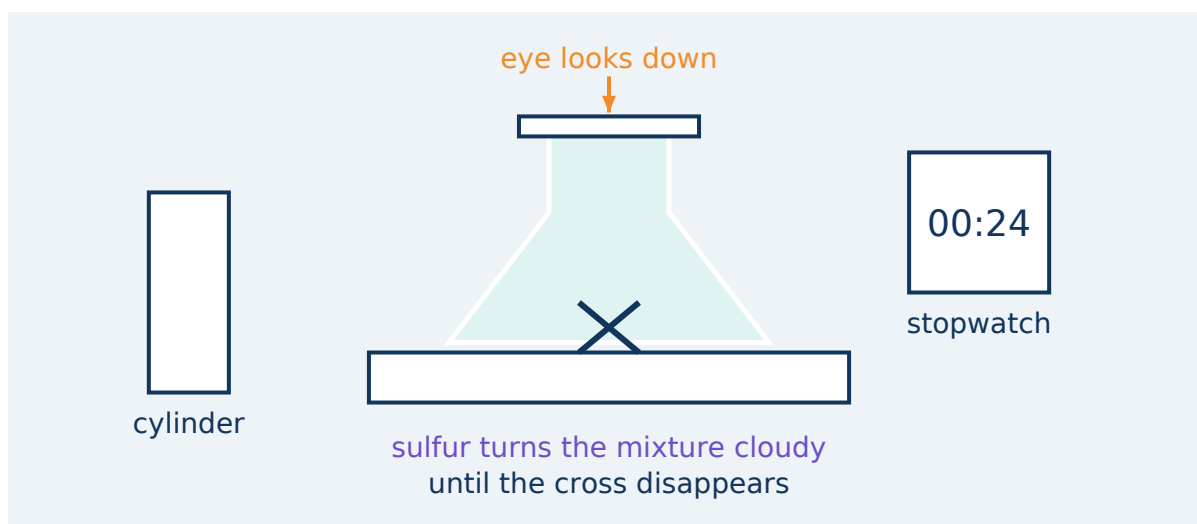
Safety

Safety

Wear eye protection. The reaction releases sulfur dioxide, which irritates the lungs: use small volumes, work in a ventilated room and rinse the flask in a fume cupboard or open area. Asthmatic students should not handle the mixtures.

Method

1. Place the flask on the paper cross.
2. Measure 50 cm³ of thiosulfate solution (no water) into the flask.
3. Add 5.0 cm³ of 1.0 M acid, start the stopwatch and swirl once.
4. Look down from above and stop the stopwatch when the cross disappears. Record t .
5. Repeat with 40, 30, 20 and 10 cm³ of thiosulfate, adding water to make 50 cm³ each time, so the acid volume and total volume stay fixed.
6. Rinse and dry the flask between runs and use the same observer each time.



Set-up: the cross under the flask fades as sulfur forms; the timer stops when it can no longer be seen.

Results

Volume of thiosulfate (cm ³)	Volume of water (cm ³)	Time <i>t</i> (s)
50	0	24
40	10	30
30	20	41
20	30	62
10	40	125

Analysis questions

Question 1 Fair test

Explain why the total volume and the acid volume are kept constant in all runs.

Question 2 Mixed concentration

Calculate $[S_2O_3^{2-}]$ in the 55 cm³ final mixture for each run (0.100 M stock).

Question 3 Relative rate

Calculate $1/t$ for each run and explain why it can stand in for the initial rate.

Question 4 Graph

Describe a graph of $1/t$ against $[S_2O_3^{2-}]$ and state what its shape would show for first order.

Question 5 Order from two points

Use the 20 cm³ and 40 cm³ runs to find the order in thiosulfate.

Question 6 Uncertainty

The timing error is about ± 1 s. Calculate the percentage uncertainty in t for the 24 s and 125 s runs.

Question 7 Improvement

Suggest two improvements to the method and predict the effect of doing the same experiment at 10 °C higher.