

Orders, rate constants and activation energy

Chemistry grades 11-12 (A Level · IB · Class 11-12) · Lab

Name: _____ Date: _____ Class: _____

This lab uses the sulfur precipitate clock to find the order of reaction with respect to thiosulfate ions and the activation energy for the reaction with acid. You will turn simple stopwatch times into rates, plot the data and judge how reliable the method is.

Level: Chemistry grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** IB R2.2

Aim

Find the order of reaction with respect to thiosulfate ions and the activation energy for the reaction between sodium thiosulfate and hydrochloric acid, using the time taken for a sulfur precipitate to hide a cross.

Equipment

- 0.150 mol/dm³ sodium thiosulfate solution and 2.0 mol/dm³ hydrochloric acid
- 100 cm³ conical flask, two 50 cm³ measuring cylinders, 10 cm³ measuring cylinder
- paper with a black cross, stopwatch, thermometer
- water bath or kettle, ice, safety goggles

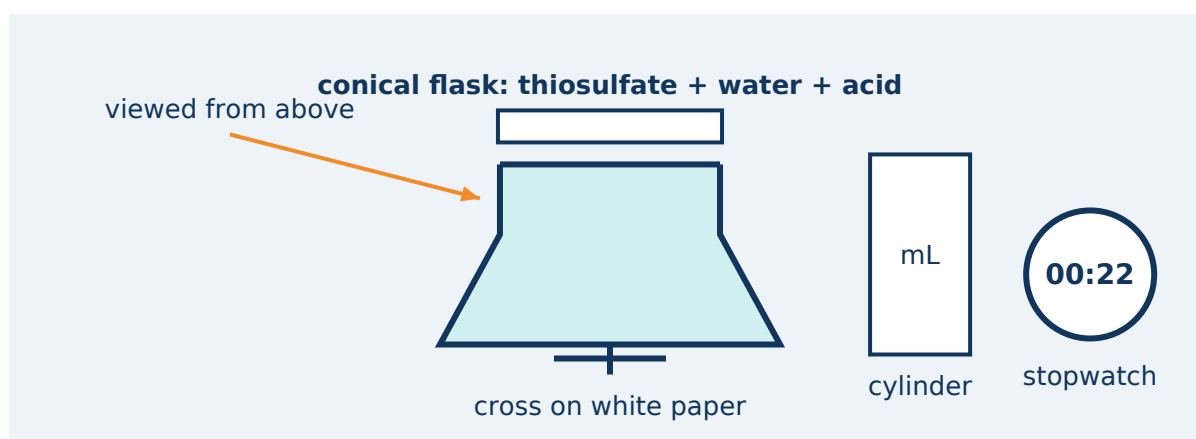
Safety

Safety

Wear safety goggles. The reaction produces sulfur dioxide, a gas that irritates the lungs, so work in a ventilated room and do not use these solutions if you have asthma. Rinse the flask in a sink with plenty of water straight after each run. Take care with hot water.

Method

1. For part A, measure the volume of thiosulfate in the first row of the table into the flask and add water to make 40 cm³.
2. Add 10 cm³ of hydrochloric acid, start the stopwatch, swirl once and place the flask on the cross.
3. Stop the stopwatch when the cross can no longer be seen from above. Record the time.
4. Repeat for each row of part A at room temperature (about 20 °C).
5. For part B, use 24 cm³ of thiosulfate and 16 cm³ of water, bring the mixture and the acid to the temperature in the table before mixing, and time the cross as before.



Set-up: time how long the cross takes to disappear.

Results

Part A (room temperature):

Volume thiosulfate (cm ³)	Volume water (cm ³)	Time t (s)
40	0	22
32	8	28
24	16	37
16	24	55
8	32	110

Part B (24 cm³ thiosulfate):

Temperature (°C)	Time t (s)
20	37
30	19
40	10
50	5.5

Analysis questions

Question 1 Concentrations and rates

The total volume is 50 cm³. Calculate [S₂O₃²⁻] after mixing for each row of part A and the value of 1000 / t, which is proportional to the rate.

Question 2 Order with respect to thiosulfate

Plot or analyse the part A data and deduce the order.

Question 3 Why use $1/t$

Explain why $1/t$ can be used as a measure of the rate.

Question 4 Data for the Arrhenius plot

Convert the part B temperatures to kelvin and calculate $1/T$ and $\ln(1/t)$ for each run.

Question 5 Activation energy

Take the line through the first and last data points of part B. Find its slope and convert it into the activation energy of this reaction in kJ/mol.

Question 6 Sources of error

State two sources of error in this method and say how each affects the result.

Question 7 Improvements

Suggest an improvement that reduces each error in the previous question.

Question 8 Plan to find the order in acid

Describe how you would find the order with respect to hydrochloric acid with the same equipment.