AQA Chemistry A-level

Required Practical 3

Investigation of how the rate of a reaction changes with temperature

Disappearing cross:Change in rate of the reaction of sodium thiosulphate with hydrochloric acid as temperature is changed: [$Na_2S_2O_3 + 2HCl \rightarrow 2NaCl + SO_2 + S + H_2O$]

Method	Accuracy	Explanation
1. Add about 10 cm of 1 moldm^{-3} hydrochloric acid to the 'acid' tube. Place this tube into a plastic container (without the cross under it).	• Hold the glass tubes and vertically in the plastic container.	
2. Use a measuring cylinder to add 10.0 cm of 0.05 moldm^{-3} sodium thiosulfate solution to the second tube. Place this tube into the plastic container with the cross under it and carefully place a thermometer in this tube.		
3. Record the start temperature and then add 1 cm of the acid to the thiosulfate solution and start timing.		
4. Look down through the tube from above and record the time for the cross to disappear from view.		
5. Record the final temperature of the reaction mixture, then pour the cloudy contents of the tube into the sodium carbonate solution.	• The temperature at which each experiment is carried out must be known as accurately as possible. This is done by measuring the initial and the final temperature to find a mean temperature.	This acts as the 'stop bath'.

6. Now add water from a very hot water tap (or kettle) to the plastic container. The water should be no hotter than 55 °C. Add cold water if necessary.		
7. Measure another 10.0 cm of 0.05 mol dm sodium thiosulfate solution into a clean tube. Insert this tube into the correct hole in the plastic container (ie the one with the cross under it).		
8. Leave the tube to warm up for about 3 minutes.		
9. Repeat steps (3) to (6) in order to obtain results for at least 5 different temperatures in total.		

Safety:

- To minimise the escape of toxic sulfur dioxide during the experiment a lid is advised. Two holes should be made in the lid using a hot wide cork borer. These holes should securely hold the glass tubes and vertically in the plastic container. Could also perform the experiment in a fume cupboard.
- Wear eye protection, a lab coat and gloves as HCl is an irritant.
- Ensure that the investigation is carried out in a well-ventilated room and that appropriate measures are taken to dispose of waste solutions.

Stop baths:

- Containers of sodium carbonate solution and phenolphthalein (stop baths) should be available to students so that the acid and sulfur dioxide can be neutralised at any point during the experiment.
- Once the colour of the solution in the stop bath changes, the sodium carbonate has been used up and the stop bath will need to be replenished.
- The stop bath should be placed in a fume cupboard, if available.

Analysing the data:

- In these experiments at different temperatures, the concentrations of all the reactants are the same.
- The time taken to produce the same amount of sulfur at different temperatures is an indication of rate of the reaction.
- A graph of the amount of sulfur produced against time can be plotted.
- The initial rate of reaction = (amount of sulfur)/time so the initial rate of reaction is proportional to 1/time.
- This is an approximation for rate of reaction as it does not include concentration. This can be used because it is assumed that the amount of sulphur produced is fixed and constant.

A2-level analysis:

The rate constant for a reaction varies with temperature according to the following equation, where T is the temperature in **kelvins**:

$$k = Ae^{-Ea/RT}$$

taking natural logarithms

$$\ln k = -\frac{E_a}{R}\left(\frac{1}{T}\right) + \ln A$$

In this experiment, the rate constant is directly proportional to $\frac{1}{t}$. Therefore

$$\ln \frac{1}{t} = -\frac{E_a}{R}\left(\frac{1}{T}\right) + \text{constant}$$

- plot a graph of $\ln\frac{1}{t}$ on the *y*-axis against $\frac{1}{T}$
- the graph should be a straight line with gradient $-\frac{E_a}{R}$ so measure the gradient
- calculate a value for the activation energy and express your answer in $kJ\ mol^{-1}$
- $R = 8.31\ J\ K^{-1}\ mol^{-1}$