Name: _____ Date: _____

Rates of Reaction

Unit 6 - Kinetics

Please Note: A full risk assessment should be carried out prior to commencing this experiment. Personal safety equipment should be worn (splash goggles). Chemicals should be disposed of safely and with due regard to any environmental considerations.

Aim: To compare the rate of the reaction between sodium thiosulfate ($Na_2S_2O_3$) and hydrochloric acid (HCl) at different concentrations of sodium thiosulfate.

Introduction

When we want to investigate the effect of a specific factor on the rate of a reaction, it is sometimes convenient to choose a certain detectable 'end point'. By timing how long it takes the reaction to reach this point under different conditions, we can compare the rate of reaction as the specific variable is changed. In this reaction we will compare the time it takes for a solution to reach a certain level of cloudiness or turbidity as the concentration of one of the reactants is changed.

Sodium thiosulfate, $Na_2S_2O_3$, and hydrochloric acid, HCl, react together to form sodium chloride, sulfur dioxide and sulfur.

$$Na_2S_2O_3(aq) + 2HCl(aq) \rightarrow 2NaCl(aq) + SO_2(g) + H_2O(l) + S(s)$$

The sulfur formed in the reaction precipitates and causes the solution to increase in turbidity (cloudy or opaque). The end point is chosen to be when a dark cross drawn on a piece of paper that is placed under the reaction mature is no longer visible (Figure 1).

In the experiment, we will vary the concentration of $Na_2S_2O_3$. By measuring the time it takes for the reaction to reach the end point in each case, we can calculate the rate of reaction from the following relationship:

$$\text{rate } (s^{-1}) = \frac{1}{\text{time (s)}}$$

In order to compare the results of different $Na_2S_2O_3$ concentrations, we must keep all other variables that could influence the rate of reaction as constant as possible.

Figure 1. Sample experimental outcome.

Itemize those variables in the table below and suggest how they could be controlled.

Variable to be controlled	How it will be controlled

Pre-lab Questions

1. Identify the dependent and the independent variable in this experiment.
2. What would you expect the effect of changing the concentration of $Na_2S_2O_3$ to have on the rate of the reaction? Explain this in terms of the collision theory.
3. Other than changes in turbidity, what other ways could be used to measure the rate of this reaction? (pp. 274-278)
4. Create your data tables by reading the method and understanding what data needs to be collected.

Method

1. Label five 100 mL beakers 1-5 and clean the bottom of each beaker (if necessary).
2. Draw a large 'X' on the bottom of a note card and set it under one of your beakers.
3. Using separate graduated cylinders for the solution and water, measure and add the required amounts of 0.15 M sodium thiosulfate and distilled water to each beaker. Be as precise as possible.

0.15 M $Na_2S_2O_3$ (mL)	Distilled Water (mL)	[$Na_2S_2O_3$] (mol•dm^{-3})
10	40	
20	30	
30	20	
40	10	
50	0	

4. Calculate the final concentration of sodium thiosulfate in each beaker 1-5.
5. Measure 5.0 mL of 2 M HCl into a 10 mL graduated cylinder.

6. Carefully add the HCl all in one pour to the sodium thiosulfate solution. Stir the solution once with a stirring rod and immediately start timing.
7. Stop timing when your 'X' is no longer visible. Record the reaction time in seconds in the data table.
8. Repeat with the other four solutions of sodium thiosulfate.

Results and Analysis

- Set your results out clearly, showing qualitative data and a table of quantitative data.
- Remember to include uncertainties and units with ***all*** of your measurements.
- Using a computer application (Google Sheets), construct graphs of time versus concentration and rate versus concentration. Refer back to the first pre-lab question to make sure you have correctly identified the dependent and independent variable to determine what to plot on which axis.

Conclusion and Evaluation

- What can you conclude about the influence of the concentration of $Na_2S_2O_3$ on the rate of the reaction?
- Does this fit with your expectations based on collision theory?
- Calculate the % error arising from random errors in the experiment. Also, discuss the random errors in the experiment.
- Itemize systematic errors and suggest ***realistic*** modifications to the experiment.

For Consideration

1. What can you conclude about the order of the reaction with respect to $Na_2S_2O_3$ from the experimental results? Can you write a rate equation for the reaction?
2. Consider which other factors affect the rate of this reaction and could be investigated using this 'clock' method.
3. The time taken to reach the end point of the reaction is measured by making a subjective judgement based on the apparent 'disappearance' of the black cross. Suggest a suitable control to test the repeatability of this method.