



Driving Question:

What is the rate and order of reaction of a solution of sodium thiosulphate with hydrochloric acid?

Applied Technology: Data-logging

Student Level: High School Level (14-18)

Duration: 1 lesson period

Recommended Settings: Student Investigations

Learning Objectives

- To introduce the concept of the reaction rate.
- To study the reaction rate during the reaction between sodium thiosulphate and hydrochloric acid.
- Optional: To determine the order of a reaction.

Didactical Approach

When a sodium thiosulphate solution reacts with hydrochloric acid, a precipitate of sulphur is formed:



sodium thiosulphate + hydrochloric acid \rightarrow sodium chloride + sulphur dioxide + water + sulphur

In this activity students measure the rate of this reaction by using a turbidity sensor to detect the precipitate formation. Within the sensor, the reaction vessel (cuvette) is placed between a light emitter and sensor. Less light can pass through the mixture as the sulphur precipitate forms and the time taken to form a certain amount of sulphur is measured.

Common student difficulties:

- Associate a high reaction rate constant with a very fast reaction.
- Assuming that all rate laws are expressed using stoichiometric coefficients.

Concepts learnt in this activity:

- Reaction rate, reaction order.

Materials

- Data-logger e.g. CMA €Lab,
- Turbidity sensor
- Measuring cylinder (10 mL)
- Beaker (100 mL)
- 10 ml of hydrochloric acid HCl (0.1 M),
- 10 ml of sodium thiosulphate Na₂S₂O₃ (0.1 M).

Procedure

- Connect the turbidity sensor to the input 1 of your interface.
- Open Coach 6 Activity 'Rate and order of reaction'.
- Let the students setup the experiment.
- Let the students perform the measurements.

Questions and Assignments

- How does the appearance of the solution change during the reaction?
- What does the graph tell you about the progress of reaction?
- Determine the reaction rate in which certain amount of sulphur has been formed, in other words a certain level of turbidity is reached. (Use '1/time' as a measure for the reaction rate, do you know why?)
- For each reaction determine the reaction rate.
- Calculate the concentration of hydrochloric acid in each experiment.
- How does the reaction rate depend on the hydrochloric acid concentration?
- Optional: Determine the order of the reaction with respect to hydrochloric acid.
- Optional: How would you find the order of reaction for sodium thiosulphate?

Data Analysis

To determine the reaction rate the formation of sulphur during the reaction is used. Some examples of results can be found in the figure below.

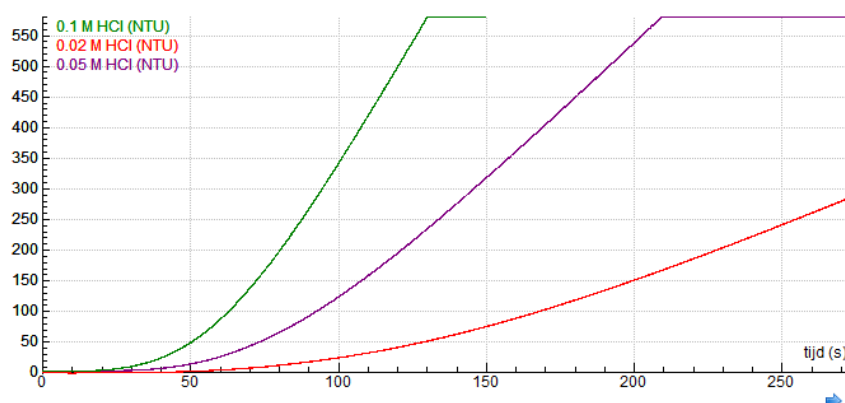


Figure 1: Example of turbidity measurements at different concentrations for hydrochloric acid

The reaction time is equal to the time it takes to reach a certain level of turbidity (a certain amount of sulphur is formed). So therefore

$$\text{reaction rate} = \text{amount of sulphur formed}/\text{time}$$

Since the amount of formed sulphur is constant for each run of the experiment then

$$\text{reaction rate} = \text{constant}/\text{time}$$

which means that the reciprocal of time (1/time) may be used as a comparative measure of the rate. For determining the order of reaction 'n' with respect to sodium thiosulphate, reaction rates for different thiosulphate concentrations are determined.

The rate equation is expressed as:

$$r = k[\text{HCl}]^m[\text{thiosulphate}]^n$$

Assuming that concentration of thiosulphate does not change:

$$r = \text{const} \cdot [\text{HCl}]^n$$

Taking logarithms of both sides of the rate equation gives:

$$\ln(r) = \ln(\text{const}) + n \cdot \ln([\text{HCl}])$$

Plotting $\ln(r)$ against $\ln([\text{HCl}])$ results in a straight line which gradient is the order of the reaction in respect to hydrochloric acid.

If temperature isn't a variable, it must be kept constant. The simplest solution here is to make sure all the chemicals have been standing in the laboratory prior to the lesson.

Resources

Coach 6 Activity: Rate and order of reaction.cma

Coach 6 Result: Rate and order of reaction.cmr

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