Thiosulphate and Acid Reaction Using a Colorimeter

Teacher and Technician Sheet

Apparatus

Colorimeter set to Transmission and blue

Hydrochloric acid 1 mol dm^{-3}

Sodium thiosulphate solution of 4g per litre (0.15 mol dm^{-3})

1 and 2 ml syringes

Distilled water

EasySense software App

Data Recording Setup

Default settings (Graph/Continuous)

Continuous Run for 7 minutes (Interval 5s)

Introduction

This investigation is concerned with rate of reaction; it can easily be extended into a set of investigations that study the factors affecting rates.

The understanding of reaction rates enables scientists to make predictions and understand reaction mechanisms. The thiosulphate reaction detailed here, is popular for rate investigations, because it produces a coloured opaque product. The quantifiable appearance of the reaction product (sulphur) over time yields the reaction rate.

Rate estimates can be produced by timing how long it takes for a cross drawn on paper at the opposing end of a reaction cell, to become obscured by the yellow opaque reaction product. Although this works well, it is limited for several reasons, e.g.

- The rate is simply the perceived “end point” divided by the time taken.
- The interpretation of the end point is subjective.
- There is no allowance for the latency of the reaction.

Using a colorimeter allows the end point to become defined, e.g., the time taken to reach a 90% transmission fall. This makes the rate data objective and improves the quality of the trends derived from that data. Using a colorimeter to record reaction changes, allows the entire experiment to be recorded.

This version of the practical uses a change in transmission to follow the reaction’s development.

Reaction

In the first reaction (1), thiosulphuric acid is formed. The unstable thiosulphuric acid decomposes producing sulphur dioxide and solid sulphur that is forms the cloudy precipitate (2).

$$Na_2S_2O_{3\,(aq)} + 2HCl_{\,(aq)} \rightarrow 2NaCl_{\,(aq)} + S_{\,(s)} + SO_{2\,(g)} + H_2O_{\,(l)}$$

1. $Na_2S_2O_{3\,(aq)} + 2HCl_{\,(aq)} \rightarrow 2NaCl_{\,(aq)} + H_2S_2O_{3(aq)}$
2. $H_2S_2O_{3(aq)} \rightarrow S_{\,(s)} + SO_{2\,(g)} + H_2O_{\,(l)}$

Practical Notes

Care needs to be taken that the acid and thiosulphate do not become cross contaminated during experimentation. Ideally the stock solutions of each should be on different sides of the room.

The volumes indicated are for the reaction to take place in a 4 ml capacity square cuvette (12 mm). The volumes are small and take care and patience to prepare.

The colorimeter does take a larger test tube so scaling the volumes up will make it easier; care needs to be taken to use the same tube for the reaction series and to set the orientation consistently. A mark on the tube being used will give consistent orientation. Test tubes (and boiling tubes) do not always have good optical characteristics, so consistency in use and placement and orientation for the colorimeter is desired.

Encourage a routine that adds the largest volume last, this helps homogenise the reaction mixture.

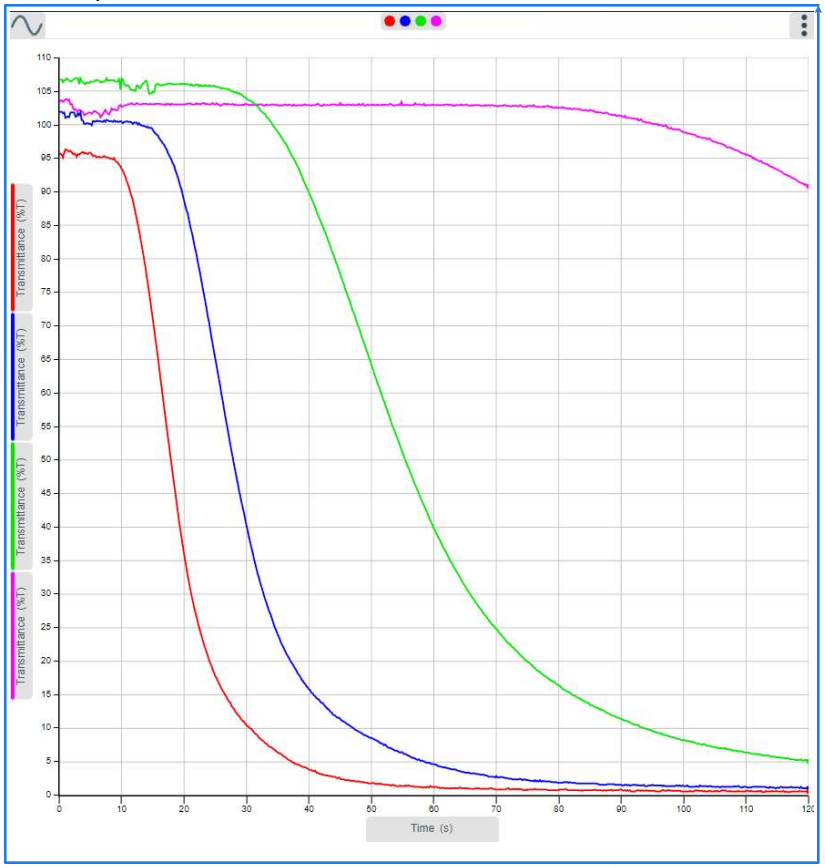
Tubes need to be cleaned promptly after the run has finished; the colloidal sulphur produced is very “sticky” and will slowly contaminate the surfaces of the reaction vessels.

The reaction does produce sulphur dioxide, albeit in small quantities. Adequate ventilation of the room should be considered. Hydrochloric acid is an irritant. Eye protection should be used.

Should you have multiple colorimeters available, consider allocating one or more “trials” to the groups and pooling data at the end of the lesson. The reaction has the reputation of being very reliable.

If you use 0.1 mol dm^{-3} HCl, the reaction will progress less rapidly, this may give students some advantage in transferring solutions etc.

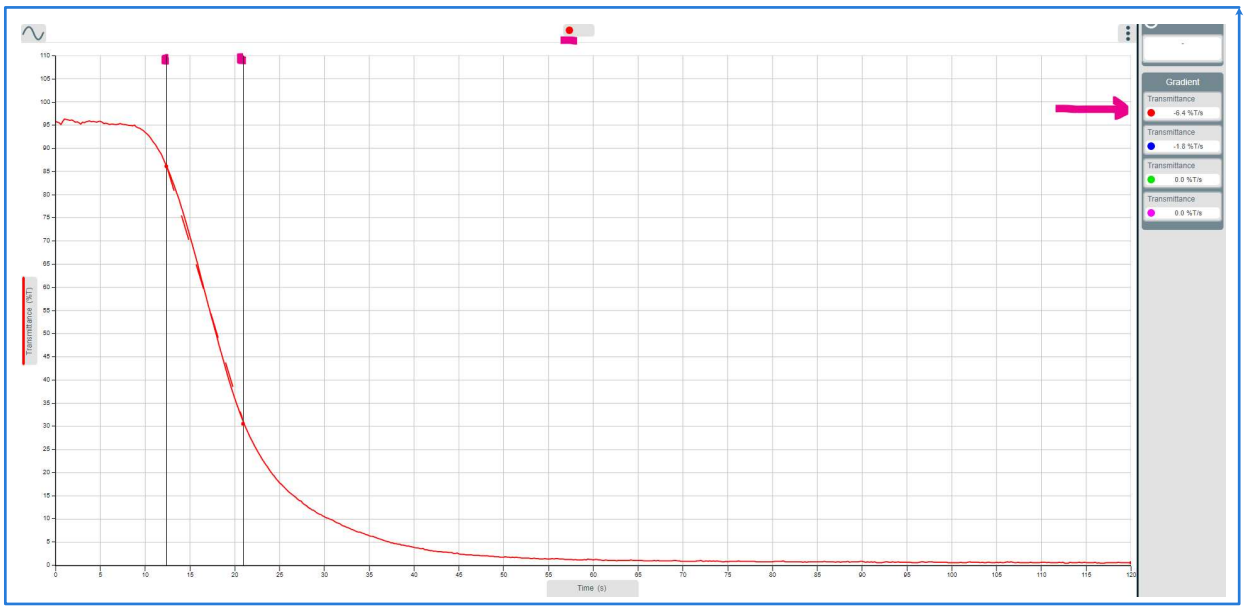
Quickly check how the cuvette should be oriented in the colorimeter.



Example of multiple runs of this practical, using different ratios of thiosulphate and water (concentrations). The volume of acid catalyst remained constant throughout.

To find a rate value, use Tools Crosshair to find the time taken for transmission to fall by a fixed percent. You could use the Gradient tool and bracket a good section of linear changes.

Try to make the Transmission (%) change start and end points as close as possible.



Practical Tips and Notes

Using the Tools, Gradient to read off a fixed time, directly.

Select a good linear selection of the data.

It's better that all runs try to use the same start and finish transmission % if linearity in the transmission change allows.

The rate is shown to the right of the graphing area as "units" per second (in the example -6.4%T/s)

Use Runs manager to only show the data under study on the screen.

Note the Gradient data also shows the values for the other lines, in the same bracketed section.

Lambert Beer Law

The amount of light that penetrates a solution, relative to an incident reference, is known as the transmittance.

The transmittance of a solution varies the following factors:

- The molar absorptivity of the solution, E
- The molar concentration, C
- The cell or cuvette dimension (path length), l

E and l are constants in this practical.

If we take the incident intensity to be I_0, the intensity after the beam has passed through material as I_l, the Transmittance (%), T, is defined as:

$$T = I_l / I_0$$

Absorbance, A, is defined as

$$A = \text{Log}(I_0 / I_l)$$

Therefore

$$A = \log(T^{-1})$$

Absorbance is also equal to

$$A = ECl$$

And so

$$\log(T^{-1}) = ECl$$

Software Knowledge Required

1. Connecting the sensor to the software
2. Configure the correct colour wavelength to use
3. Understanding Calibration
4. Use the Runs manager to show individual or multiple runs on the same chart
5. Using the Tools to display and analyse the rate of reaction