

Appendix 2

## 15. The effect of temperature on reaction rate – Student Sheet

This experiment investigates the effect of temperature on the rate of reaction between sodium thiosulphate and dilute hydrochloric acid.

### Intended lesson outcomes

By the end of this practical you should be able to:

- measure the effect of temperature on a reaction rate;
- represent your results graphically and draw conclusions;
- explain, in terms of the collision theory, why temperature change affects the reaction rate.

### Background information




When sodium thiosulphate reacts with hydrochloric acid, a precipitate of sulphur forms. The time taken for a certain amount of sulphur to form is used to measure the reaction rate. The sodium thiosulphate solution can be heated to different temperatures before hydrochloric acid is added, so the effect of increasing temperature can be measured.

The effect of temperature increase on this reaction can be predicted using the collision theory. This theory says that for a reaction to occur, particles must collide with a certain minimum energy called the **activation energy,  $E_A$** . When temperature is increased, particles have increased kinetic energy and move around faster. There is therefore an increase in the frequency of collisions.

### Question

- 1 If sodium thiosulphate solution is heated, predict the effect of increasing the temperature on the rate of this reaction.

### Safety

	You must wear eye protection throughout this experiment.
	Hydrochloric acid is <b>corrosive</b> .
	This reaction produces sulphur dioxide, which is <b>toxic</b> , so ensure good ventilation or use a fume cupboard. Take care not to inhale the fumes. Asthmatics need to be particularly careful.

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### Procedure

1. Measure  $10\text{ cm}^3$  of sodium thiosulphate solution and  $40\text{ cm}^3$  of water into a conical flask.
2. Measure  $5\text{ cm}^3$  of dilute hydrochloric acid in a  $10\text{ cm}^3$  measuring cylinder.
3. Warm the thiosulphate solution in the flask to the required temperature, as in Fig. 15.1.

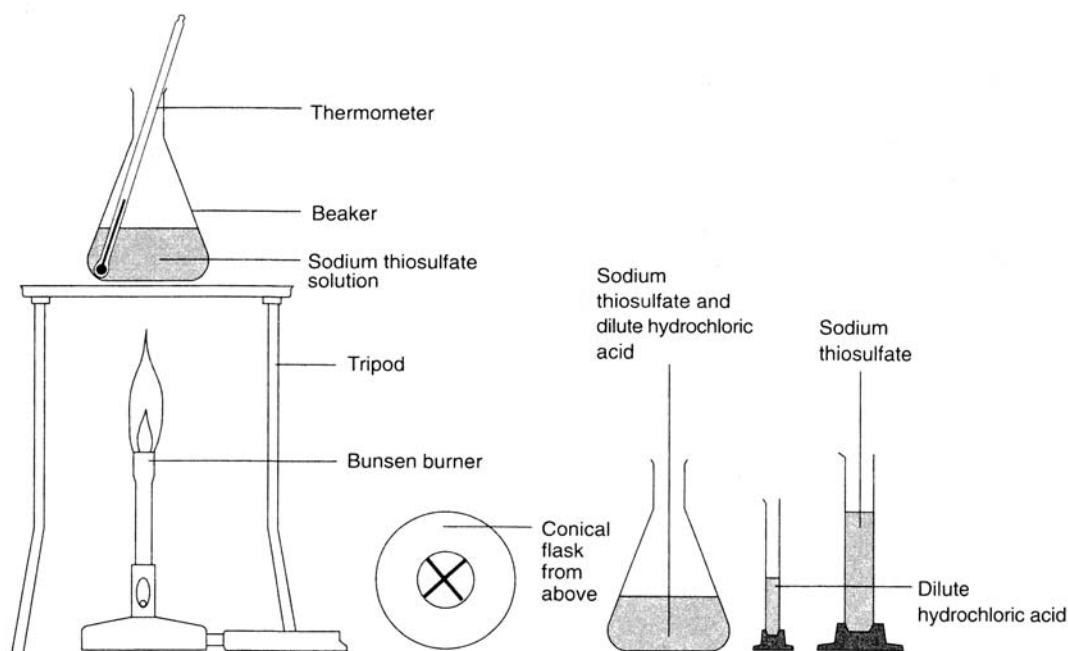


Figure 15.1

4. Put the conical flask over a piece of paper with a cross drawn on it.
5. Add the acid and start timing. Swirl the flask to mix the contents. Take the initial temperature of the mixture and record it in a table like the one below.
6. Repeat the experiment using different temperatures in the range  $15^\circ\text{C}$  to  $65^\circ\text{C}$ . Remember that one of your experiments can be carried out at room temperature and so will not require heating.

<i>initial temperature of the mixture in the flask/<math>^\circ\text{C}</math></i>	<i>final temperature of the mixture in the flask/<math>^\circ\text{C}</math></i>	<i>average temperature of the mixture in the flask/<math>^\circ\text{C}</math></i>	<i>time taken for the cross to disappear</i>	<i><math>1/\text{time taken}/\text{s}^{-1}</math></i>

7. Look down on the cross from above. When the cross disappears, stop timing and note the time taken. Record the final temperature of the mixture in the flask.
8. Immediately wash the solution down a sink with plenty of water.

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### Processing your results

For each set of results, calculate the average temperature and the value  $1/\text{time}$ .  $1/\text{time}$  can be taken as a measure of the rate for this reaction.

Plot a graph of  $1/\text{time}$  on the vertical ( $y$ ) axis and average temperature on the horizontal ( $x$ ) axis.

### Question

- 2 What does the graph indicate about the effect of temperature on this chemical reaction?

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### 15. The effect of temperature on reaction rate – Teachers' Notes

This experiment investigates the effect of temperature on the rate of the reaction between sodium thiosulphate and sulphur by using the time taken for the precipitate of sulphur that forms to blot out a cross drawn on a piece of paper.

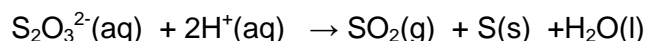
#### Learning outcomes

These are printed on the Student Sheet.

#### A suggested approach

The effect of change of temperature on reaction rate is an everyday experience. Ask students to consider cooking ingredients to make a cake or the way that milk rapidly goes sour if it is not kept cold. When introducing this experiment, students will better understand the procedure if you demonstrate. The experiment can be used as an introduction to collision theory and there is a little about this in the 'Background information' on the Student Sheet. It can also lead to a discussion of the Boltzmann distribution.

The equation for the reaction is:



This is also a useful practical for emphasising graph-drawing skills such as choice of scale and line of best fit.

#### Technical information

Requirements per student/group:

Thermometer,  $-10^\circ\text{C}$  to  $110^\circ\text{C}$

250 cm<sup>3</sup> conical flask

2 x 10 cm<sup>3</sup> measuring cylinders

25 cm<sup>3</sup> or 50 cm<sup>3</sup> measuring cylinder

2 mol dm<sup>-3</sup> hydrochloric acid, approximately 25 cm<sup>3</sup> (**irritant**)

40 g dm<sup>-3</sup> sodium thiosulphate, approximately 50 cm<sup>3</sup>

Bunsen burner, tripod, gauze and heatproof mat

#### Safety

The main points are included on the Student Sheet but it is the teacher's responsibility to ensure that a full risk assessment is carried out prior to the practical session. Sulphur dioxide, which is toxic, is produced in this reaction. A well-ventilated laboratory is essential. You should also warn asthmatics, as it is preferable for them to use a fume cupboard. If there is access to a fume cupboard with a sink, use this to wash away the reaction mixture with plenty of water as soon as the reaction is finished. This is particularly important with solutions at higher temperatures.

#### Processing the results

A curve showing that increase in temperature increases reaction rate, as measured by 1/time, should be obtained.

#### Answers to questions on the Student Sheet

- 1 Expect a prediction that increasing the temperature should increase the rate of reaction, since energy is increased so more particles would have the activation energy and there would be an increase in frequency of collision. A discussion of the Boltzmann distribution curve may be appropriate here.

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- 2 Temperature increases the rate of reaction. It is not a directly proportional relationship. You may wish to inform students that, as a guide, for every 10°C rise in temperature, the rate doubles for reactions that work readily at room temperature.