



# Supercooling and the energetics of freezing

## Learning objectives

- 1 Make and record observations.
- 2 Interpret a graph.
- 3 Describe the energy changes that take place during a change of state.

## Introduction

Explore what happens when a liquid is supercooled using sodium thiosulfate crystals.

In this experiment, you will melt sodium thiosulfate crystals before cooling them to a state well below the melting point. The sodium thiosulfate will then exist in a metastable supercooled state. The supercooled liquid will freeze rapidly when you add a crystal of sodium thiosulfate or dust particles, or stir it. Add a crystal of the solid to seed the crystallisation process and observe temperature changes throughout.

## Equipment

### Apparatus

- Eye protection
- Boiling tube (this must be very clean)
- Boiling tube holder
- Stirring thermometer,  $-10^{\circ}\text{C}$  to  $110^{\circ}\text{C}$   
(A temperature sensor attached to a computer can be used in place of a thermometer. A continuous plot can then be drawn as the temperature changes occur.)
- Beaker,  $100\text{ cm}^3$
- Bunsen burner (or kettle to boil water)
- Tripod and gauze
- Cotton wool, small tuft to fit boiling tube

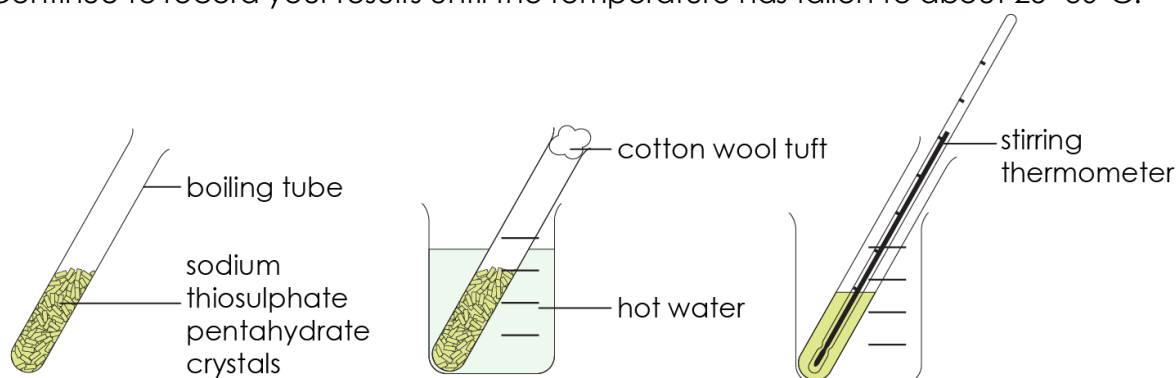
### Chemicals

- sodium thiosulfate pentahydrate, about 20 g



## Method

1. Half-fill a very clean boiling tube with crystals of sodium thiosulfate pentahydrate.
2. Put a tuft of cotton wool in the end of the boiling tube. Then put it in a beaker of hot water (about 50°C) to melt the crystals.
3. When all the crystals have melted, remove the cotton wool, put a thermometer in the melted sodium thiosulfate and record the temperature. If the liquid starts to crystallise on inserting the thermometer, reheat in water to melt all the solid.
4. Stand the boiling tube in an empty beaker and leave to cool where it won't be disturbed.
5. Observe the temperature at various intervals until the value is in the region of 30–40°C. No crystallisation should have occurred.
6. Add a fresh crystal of sodium thiosulfate pentahydrate, observe the rapid crystallisation which occurs, and continue to monitor the temperature at regular intervals. Record your results in the table below.
7. Continue to record your results until the temperature has fallen to about 25–30°C.



## Results table



## Questions

1. State the meaning of the following key words:

(a) Freezing

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(b) Supercooled

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(c) Exothermic

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(d) Crystallisation

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2. Plot a graph of temperature (y-axis) against time (x-axis) using your results.





3. Label the parts of the graph that show:

- (a) the melting point of sodium thiosulfate is  $48^{\circ}\text{C}$
- (b) sodium thiosulfate as a liquid
- (c) sodium thiosulfate as a supercooled liquid
- (d) sodium thiosulfate as a solid

4. Describe what happened to the shape of the graph when a crystal of fresh sodium thiosulfate was added to the liquid. Suggest a reason for your answer.

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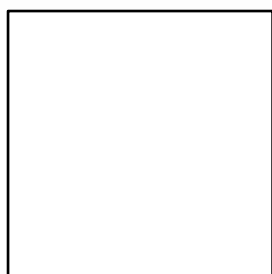
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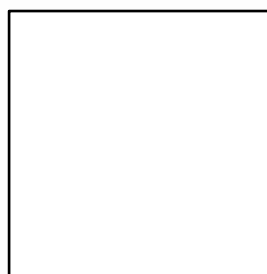
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5. When a substance changes state from a solid to liquid, an exothermic reaction takes place.

Use your experimental results and ideas about particle theory to explain this statement. Include particle diagrams to support your answer.



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