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 of 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

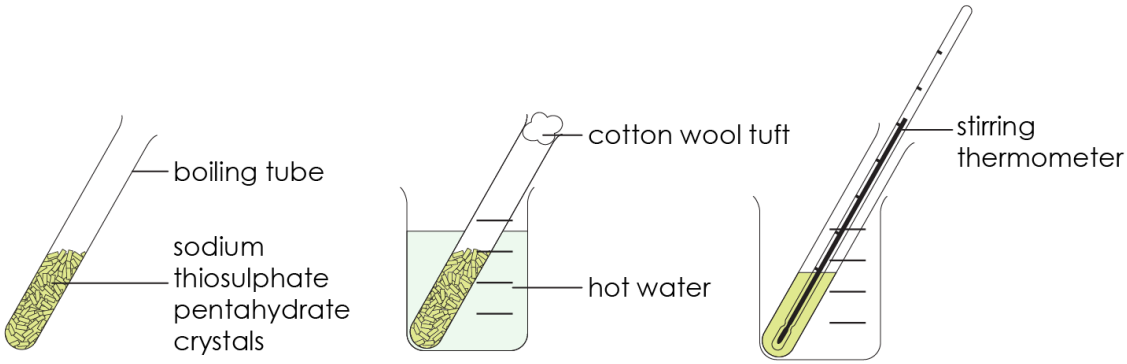
- Eye protection
- Boiling tube (this must be very clean)
- Boiling tube holder
- Stirring thermometer, −10°C to 110°C
  (A temperature sensor attached to a computer can be used in place of a thermometer. A continuous plot can then be drawn as the temperature changes occur.)
- Beaker, 100 cm^3
- Bunsen 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 and place the boiling tube 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 result in the table below.
7. Continue to record your results until the temperature has fallen to about 25–30°C.



Results table

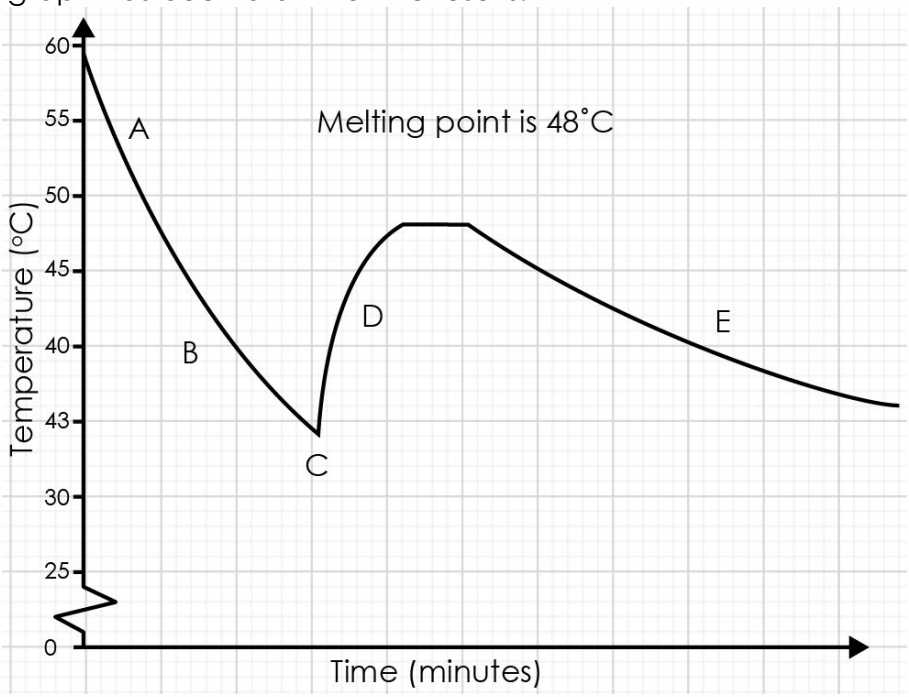
Time (minutes)	Temperature (°C)	Observations

Questions

1. Match the keywords to their meanings.

Freezing	When a substance is in the liquid state below its freezing point.
Crystallisation	The process used to produce solid crystals from a concentrated solution.
Supercooled liquid	When energy is transferred from a substance to the surroundings, usually in the form of heat.
Exothermic	When a substance changes from a liquid to a solid.

2. A sketch graph has been drawn of the results.



Match the statements to the points, A–E on the graph.

(a) Crystallisation taking place _____

(b) Liquid sodium thiosulfate _____

(c) Supercooled liquid sodium thiosulfate _____

(d) Solid sodium thiosulfate _____

(e) Sodium thiosulfate crystal added _____

3. Describe what happened to the shape of the graph when a crystal of fresh sodium thiosulfate was added to the liquid.

_____

_____

4. How does your graph prove that crystallisation is exothermic (releases energy)?

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