11–14 years

Supercooling and the energetics of freezing

ROYAL SOCIETY OF CHEMISTRY

Education
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Learning objectives

During this lesson, you will:

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

Supercooling

You are going to explore what happens when a liquid is supercooled, by melting sodium thiosulfate crystals.

Supercooling is the process of lowering the temperature of a liquid (or gas) to below its freezing point, without it solidifying.

The melted crystals exist in a metastable supercooled state.

How low the temperature will go depends on:

- the purity of the sample.
- how clean the boiling tube is.
- whether the sample is disturbed.

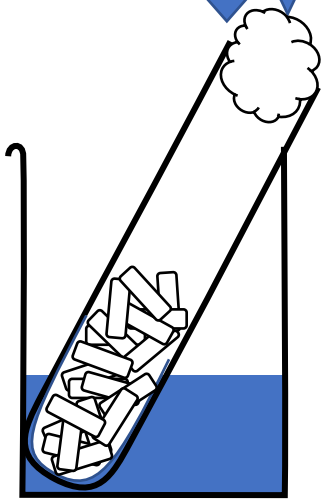
Method

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 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 boiling tube and record the temperature of the liquid. 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, observe the rapid crystallisation which occurs, and continue to monitor the temperature at regular intervals. Record your results in a table
7. Continue to record your results until the temperature has fallen to about 25−30°C.

1. Add sodium thiosulfate pentahydrate crystals to boiling tube ❑

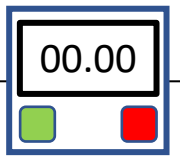
2. Put cotton wool in end of tube ❑

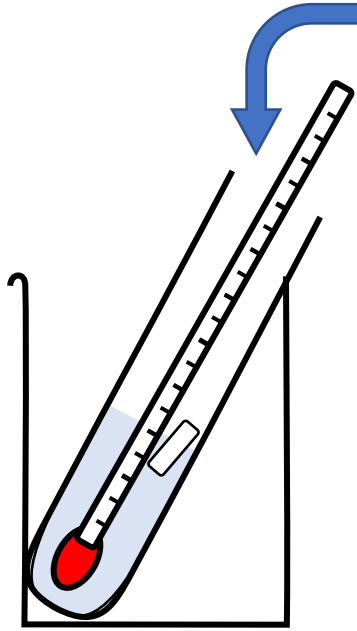
3. Melt crystals in beaker of hot water ❑



4. Remove boiling tube from hot water and stand in an empty beaker ❑

5. Place thermometer in boiling tube. Leave to cool. Start timer ❑





6. Record the temperature, until it reaches 30–40°C ❑

7. Add a fresh crystal of sodium thiosulfate pentahydrate ❑

8. Continue to record the temperature until it reaches 25–30°C ❑

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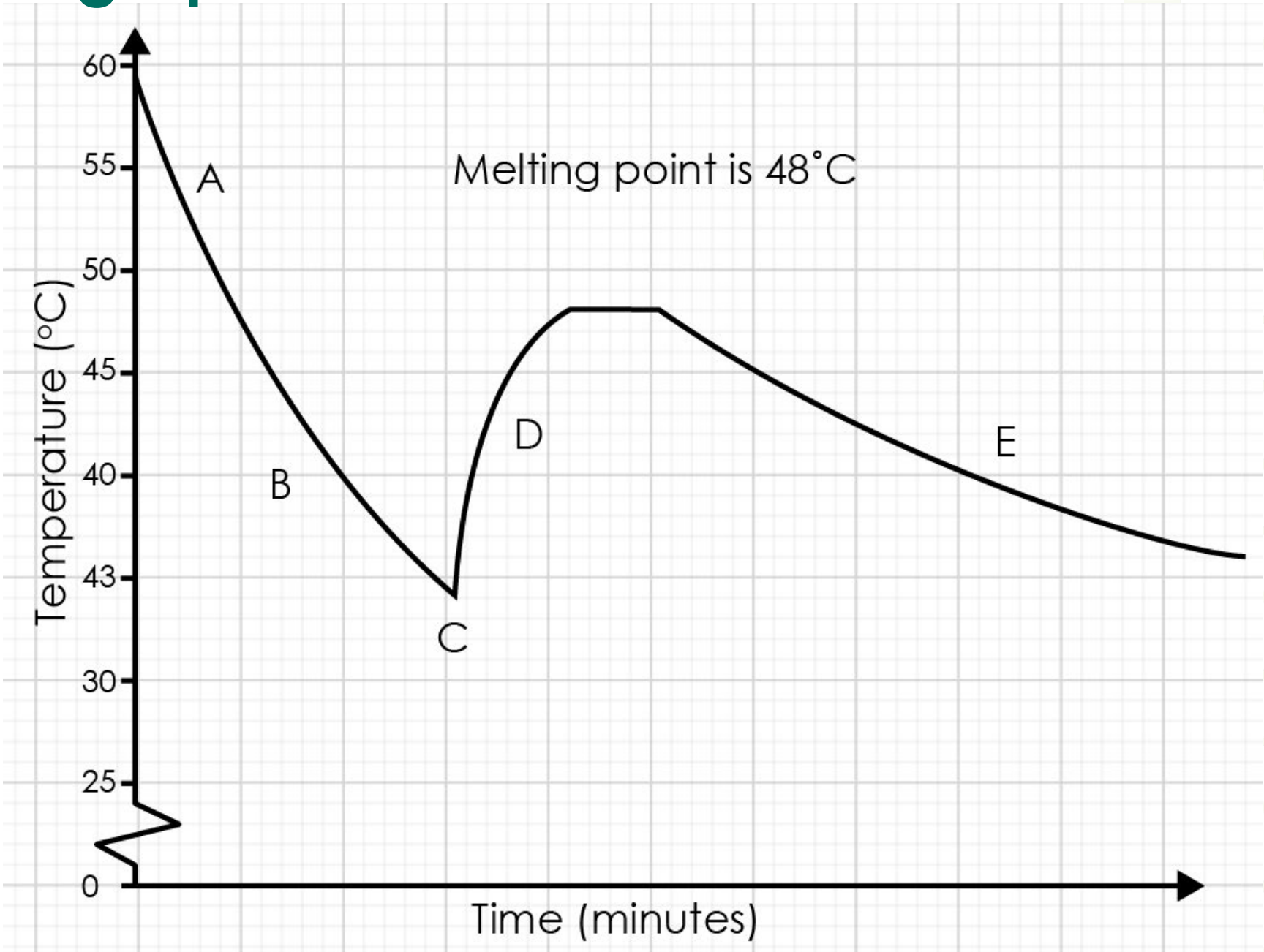
Results table

Time (minutes)	Temperature (°C)	Observations

Sketch graph of the results



Questions

1. State the meaning of the following key words:

a) freezing

b) supercooled

c) exothermic

d) crystallisation

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

3. Label the parts of the graph that show:

a) the melting point of sodium thiosulfate is 48°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.

Challenge question

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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Have you met all of the learning objectives?