Cooling curve of stearic acid

Chemistry / Science · Lesson 1 States of Matter · Specification 1.1, 1.2 and 1.9

Name _____ Class _____ Date _____

Aim

Let a molten sample of stearic acid cool while you record its temperature and appearance every minute. Plot a cooling curve, read the freezing (melting) point from the plateau, and explain the shape in terms of particles and energy.

Equipment (per group)

- Test tube containing about 5 g of stearic acid, already molten (teacher-prepared)
- Thermometer, −10 to 110 °C, spirit-filled or digital, reading to 0.5 °C or better (not mercury)
- 250 cm^3 beaker, if a remelt or a water jacket is needed
- This results table and graph, or graph paper
- Test-tube rack
- Stop clock
- Beaker tongs or a heat-resistant glove
- Eye protection

Safety, before you begin

Wear eye protection throughout. The water bath is at about 80 °C, and the beaker, water and hotplate stay hot after they are switched off: move the beaker only with tongs and let everything cool before clearing away. Molten stearic acid is above about 70 °C and sticks to skin, so keep the tube upright in the rack, do not tip it, and if any splashes on skin, cool the area under running water and tell your teacher.

Stearic acid itself is low hazard, but it is a fatty acid: never heat the tube in a naked flame, because it can ignite. Leave the thermometer in place once the sample has solidified; pulling it out of the solid will break it. Use a spirit-filled or digital thermometer, never mercury. Handle glassware carefully and report any breakages immediately. Never wash stearic acid down the sink; it solidifies and blocks drains.

Follow your teacher's instructions and your school's risk assessment.

Method

1. Put on eye protection. Read the method, then complete the results table as you work. The table already has columns for time (min), temperature (°C) and appearance (liquid, cloudy or solid forming, or solid).
2. Collect a test tube of molten stearic acid from your teacher and stand it in the test-tube rack, away from the hot-water bath and draughts. The thermometer should already be in the liquid, with its bulb in the centre and not touching the glass. If it is not, your teacher will place it while the sample is still fully liquid.
3. Immediately record the temperature and appearance, and start the stop clock. This is time 0.
4. Every 1 minute, stir gently with the thermometer only while the sample is still fully liquid, then record the temperature to the nearest 0.5 °C and the appearance.
5. As soon as solid starts to form, stop stirring. Leave the thermometer in place and continue recording every minute.
6. Continue for 20 minutes, or until the sample has been completely solid for at least 3 minutes and the temperature has fallen well below the plateau (typically to about 45–50 °C).
7. Do not pull the thermometer out. Return the tube, with the thermometer still in it, as your teacher directs.
8. Plot a graph of temperature (°C) against time (min) on the grid provided. Identify the liquid-cooling region, the freezing plateau, and the solid-cooling region. Read the freezing point from the plateau and compare it with a data-book value. Pure stearic acid melts at about 69 °C; laboratory grades are often mixtures and may melt over a range around 55–70 °C.

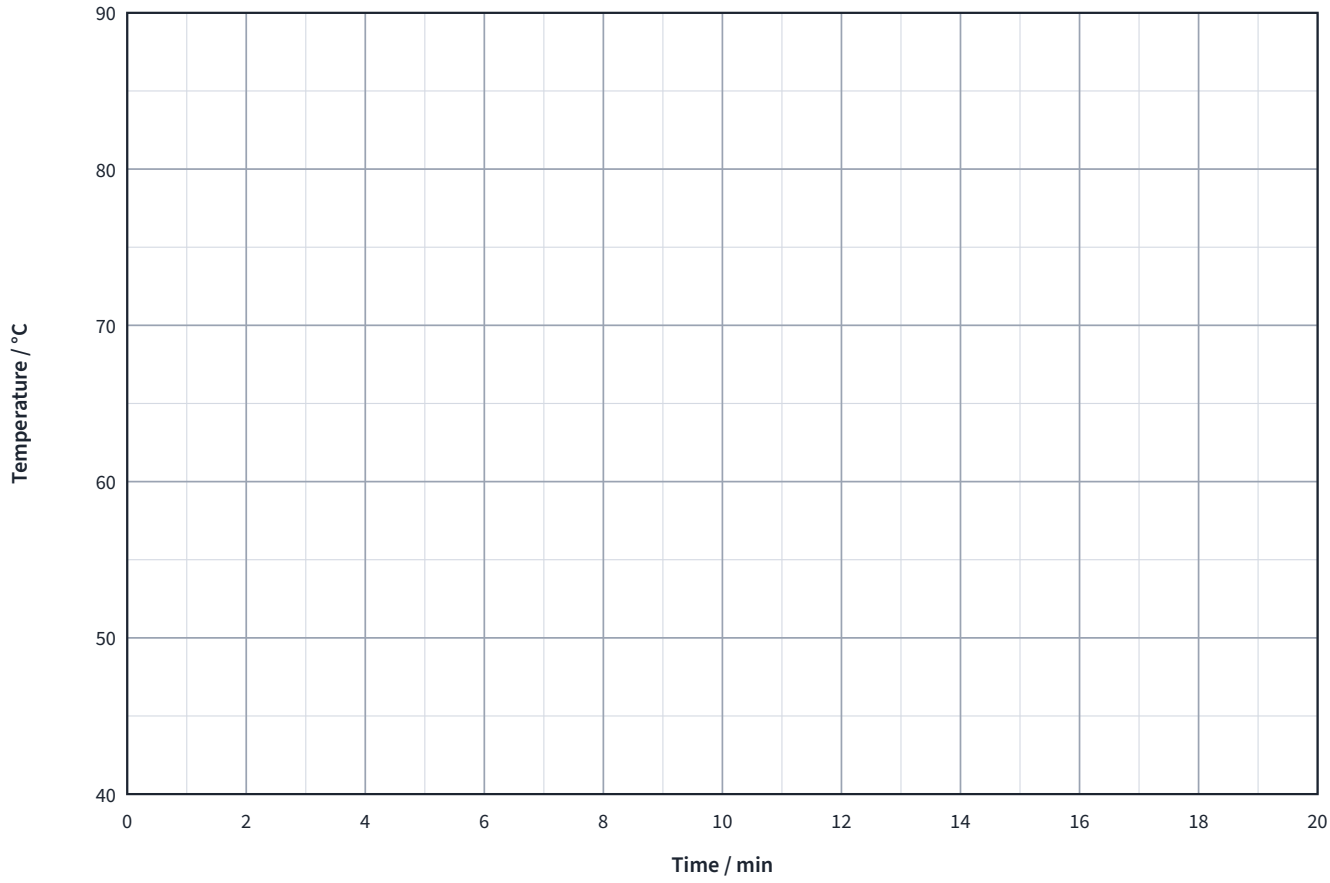
Results

Record temperature to the nearest 0.5 °C. For appearance use: liquid / cloudy or solid forming / solid.

Time / min	Temperature / °C	Appearance
0		
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Time / min	Temperature / °C	Appearance
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		

Graph of temperature (°C) against time (min)



Label the liquid-cooling region, the freezing plateau and the solid-cooling region. Mark the freezing point you read from the plateau. If the temperature falls then rises before the plateau, that is supercooling: read the freezing point from the plateau, not from the lowest temperature.

Questions

1. Identify the three regions of your cooling curve. Explain, in terms of particle arrangement and the energy released as particles form a solid, why the temperature stays almost constant while the liquid is freezing, even though the tube is still losing heat to the room.

2. Read the freezing point from your plateau. Why, for a pure substance, is this the same as the melting point? Compare your value with a data-book value for stearic acid.

3. Was your plateau flat or sloping? What does the shape suggest about whether the sample is a pure substance or a mixture?

4. Calculate the cooling rate in °C per minute for a section of the curve before the plateau and for a section after it. Why is the rate usually higher at the start of the run?

Freezing point from my plateau: _____ °C **Data-book value:** _____ °C

Disposal and tidy-up

Leave the test tube standing in the rack with the thermometer inside until your teacher says it can be remelted or stored. Return the tube of stearic acid for reuse. Leave any water bath or jacket as your teacher directs; pour one away only if you are told to, and only when it is cool enough to handle with tongs. Wipe the bench and wash your hands.

FOR TECHNICIANS AND TEACHERS — NOT FOR STUDENT ISSUE

Technician requisition and preparation notes

Pearson Edexcel International GCSE (9–1) · Lesson 1 States of Matter

Issue pages 1–3 only to students.

Class estimate: 10 groups of up to 3, for a class of 30 (12 tubes including 2 spares). Review for your own class size and risk assessment.

Equipment: 1 pre-filled test tube of stearic acid per group, plus 2 spares; 1 test-tube rack per group; 1 spirit or digital thermometer (−10 to 110 °C) per group; 1 stop clock per group; 1 × 250 cm^3 beaker per group; tongs or a heat-resistant glove per group; eye protection for every student; access to a shared hot-water bath or hotplates for pre-melting (hotplates are preferred, so there is no flame near a fatty acid). A set of 12 tubes will need several large beakers or a large tray/bath, not one 250 cm^3 beaker. If hotplates are not available, use a Bunsen, tripod, gauze and heat-resistant mat for the water bath only, never to heat the tube directly.

Chemicals: about 5 g of laboratory-grade stearic acid (octadecanoic acid) per group, so about 60 g for 10 groups plus spares. This is not consumed; the tubes are reused. Tap water for the baths. Labels for the tubes. Graph paper if students are not plotting on this sheet.

Advance preparation

1. Weigh about 5 g of stearic acid flakes into each test tube (enough to cover the thermometer bulb once molten). Stand the tubes in a beaker of hot water until melted, then allow them to cool with nothing inside, or leave the thermometers in only if you are sure they can be remelted safely. Label each tube “Stearic acid — do not heat in a flame”.
2. Before the lesson, stand the filled tubes in a large water bath or several beakers of water at 75–85 °C until every sample is fully molten and at about 80 °C. One 250 cm^3 beaker is not large enough for the whole set of 12 tubes. Start this 30–60 minutes before the class so the whole set is ready. Place a thermometer in each molten tube, bulb central and not touching the glass, just before students collect them.
3. Pilot one run: in a test tube, cooling in a rack in air, a plateau should appear within a few minutes and the run should finish in about 15–20 minutes. If the room is very warm or the plateau is very short, use a beaker of room-temperature water as a jacket.
4. Check thermometers (no cracked bulbs; spirit column continuous) and hotplate leads. Students can use the results table on this sheet (time 0, 1, 2 … min, temperature and appearance).

Timing and storage

Students can start recording as soon as they collect a tube. One 20-minute run plus a start on the graph fits a single lesson; finishing the graph and questions may need a second lesson or homework. Store the filled tubes upright in a rack; they keep indefinitely. If a thermometer is frozen into a tube, remelt it in hot water; do not pull it out.

Staff hazards

Hot water and hotplates; molten stearic acid (tubes upright, never tipped, never heated in a flame); thermometers left in the solid until remelted; eye protection for all. Brief students not to wash stearic acid down the sink.

Cleanup

Let tubes cool and store them with the solid inside for reuse. Scrape any spill into solid waste when cold, then wipe with hot soapy water. Empty and dry the water-bath beakers, unplug hotplates and coil the leads once cool.

Troubleshooting

No clear plateau usually means the sample cooled too fast, or readings were missed — move the tube away from windows and the hot bath, and keep the 1-minute interval. A sloping plateau or two plateaux usually means the stearic acid is a mixture, which is a useful discussion point; compare with the supplier’s melting range. If the water bath will not reach 80 °C, use less water or turn the hotplate up. A temperature dip then a rise before the plateau is supercooling; students should read the freezing point from the plateau, not from the lowest temperature.

Matching online student sheet (for signed-in users): https://practical-science.com/practicals/cooling-curve-of-stearic-acid/