

An icebreaker for thermodynamics

Education in Chemistry

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Technician notes

Kit

- Data logger with temperature probe, capable of live graphing, resolution $\pm 0.1^\circ\text{C}$, and sample frequency at least once per second
- Test tube
- 500 cm³ beaker
- Ice (about 200 g)
- Salt (about 25 g)
- Tap water (about 200 cm³)
- Deionised water (about 5 cm³)
- Retort stand and clamp
- Stirring rod or magnetic stirrer

Preparation

Make a water bath by placing the tap water in the 500 cm³ beaker – if a stirrer is available then you can place the beaker on it and add a magnetic follower. Use the clamp and retort stand to hold a test tube containing 5 cm³ of deionised water above the the water bath. Set up the data logger to record at for at least 1200 s (20 mins) (eg 2 samples per second recording 2400 samples). Connect and place the temperature probe in the test tube.

Measure out about 5 teaspoons of salt (20–25 g) and 200 g of ice.

In front of the class

Project the temperature–time graph from the data logger and add the salt and half the ice to the water bath.

Stir the water bath throughout the experiment and start data collection. Lower the test tube and probe into the bath so that the water within is submerged. The temperature on the screen will begin to drop. You can draw students' attention to the fact that the water is still liquid by gently moving the probe.

The water may continue to supercool for up to three more minutes. Then, a shocking temperature spike appears as an ice crystal nucleates and rapid freezing occurs exothermically. The temperature then locks onto 0°C until the freezing has completed, and only then resumes decreasing towards the temperature of the water bath, which may by now require more ice.

After about ten minutes, lift the tube out and replace the contents of the bath with lukewarm tap water. Lower the test tube back in, but do not disturb the probe, which should remain frozen within the ice. The temperature will rise, lock onto 0°C until the thaw is complete and then continue towards the ambient temperature.

By zooming in on the graph, the random error in the probe's readings will be evident – these can be reduced by taking an average of the readings in the straight-line section. The average values for freezing and melting will agree within the uncertainty of the probe.