Mini-projects: Finding out about freezing — Teacher notes

Introduction
This mini-project allows wide-ranging practical investigations and research on the effect of different solids on the melting point of ice. The study can lead in many directions, allowing individuals to explore different questions either independently or as part of a whole-class co-operative study.

Running the activity
The initial stimulus
Students may be familiar with the use of salt to clear ice from footpaths in the school or from the roads. If they stir salt into crushed ice, they can see that the ice begins to melt. If a thermometer is placed in the ice, students are amazed to see that the temperature is getting lower!

Possible lines of study
- How cold can you get? Amounts of salt and ice can be varied, looking for the lowest temperature which can be reached.
- Does it matter how much salt? Measure the freezing point of solutions containing different concentrations of dissolved salt.
- Can other substances be used? Establish criteria for a suitable de-icer: cost, safety, availability, etc.; research substances found in the stores for suitable properties; preliminary tests to see which do produce an effect such as sugar, flour etc. as well as laboratory chemicals; more detailed studies of particular substances e.g. which can produce the greatest cooling.
- A comparison of commercially used de-icers: salt, urea, CMA (calcium magnesium acetate). York Science Curriculum Centre can supply CMA on request. Which melts ice fastest? Which can melt ice down to the lowest temperature? What are the cost comparisons? Are there any environmental differences in large scale use?
- Are the freezing points of other substances lowered by impurities? e.g. stearic acid.
- The freezing point can be measured for equi-molar solutions of different solutes. Sugar and urea both give the same depression, binary salts like sodium chloride all give a depression about double that from urea, and 3-ion salts such as sodium sulphate give three times the depression. Very able students may be challenged to explain this phenomenon.

Practical techniques
For many of these experiments, crushed ice will be needed in fairly large amounts. Studies of the cooling effect of solids can be done by placing crushed ice in a beaker or boiling tube that is thickly wrapped with cotton wool and stood inside a large beaker or small trough. The solid under test (in powder form) is stirred in, and the temperature recorded at intervals.

Laboratory suppliers offer thermometers which will read down to –35°C. Thermistor probes can be linked to data-logging devices. Direct reading thermistor probes are also available, though very expensive.

Depression of freezing point can be measured using solutions of known concentration in boiling tubes immersed in an ice-salt freezing mixture. Students can learn about the characteristic shape of cooling curves, and about supercooling. An important aspect of de-icing is rate of melting. Known masses of crushed ice and powdered de-icer can be stirred in beakers for a set time, then poured into a filter funnel with a small loose cotton wool plug. The volume of melt-water that drains through is compared.

Learning outcomes
- assessment of chemical hazards
- greater understanding of changes of state
- development of investigative skills
- awareness of environmental consequences of large-scale de-icing

Prior learning
- arrangement of particles in solids, liquids and gases
- changes of state
- methods of measuring temperatures

Where the activity fits in
- Sc1 skills development
- KS3
  Sc3.1a, b, g
  Sc3.2a, b, c
  Sc4.5d, g
- KS4
  Sc3.3t, u, v

Skills
Pupils general manipulative skills will be developed by these exercises with basic laboratory apparatus.
Where investigations extend over more than one session, skills in planning and monitoring progress will be enhanced.
Where a class or group collaborate to share out tasks in order to give wider coverage of the chosen topic, skills of working with others will be demonstrated.
ICT skills may be developed by using thermistor-based sensors to monitor temperatures, and/or spread-sheets to record and analyse data.
Communication skills are involved in locating information about the substances tested and in writing reports.

Safety

Eye protection should be worn at all times when any of this practical work is in progress.

Water from the atmosphere condenses onto beakers containing freezing mixtures and can cause the beaker to freeze to the bench, causing difficulty if pupils try to move it. Beakers, flasks, etc should be stood on small mats. The mat may temporarily freeze to the beaker, but can be moved with it.

Freezing mixtures can reach very low temperatures. Pupils must not touch the mixtures, and should not touch parts of vessels which contain freezing mixtures (the skin can freeze to the glass). Containers should either be left in position until all ice has melted, for clearing away later, or wrapped in folded cloths for moving.

It should not be necessary to clamp thermometers, or push them into tight-fitting corks or bungs, all of which can cause accidents. Warn pupils not to lay thermometers where they may roll off the edge of the bench.

In measuring freezing points, it is helpful if the contents of the test tube are **gently** mixed to ensure even temperature distribution. Pupils should be given guidance on the technique of stirring round and round, rather than up and down.

As part of the trials of this project, we should be very grateful to receive information about any arrangements of apparatus that work particularly well, and also any which should be avoided.

Finding out about freezing — Technician notes

Introduction

This mini-project allows wide-ranging practical investigations and research on the effect of different solids on the melting point of ice. The study can lead in many directions, allowing individuals to explore different questions either independently or as part of a whole-class co-operative study.

Requirements (per group)

Schools who are interested in using these activities should, in the first instance, contact the Science Education Group, FREEPOST (Y0264), YORK YO10 5BR for further information about materials and equipment. (Tel: 01904 432524 email: pen1@york.ac.uk)

Students will be finding out about de-icers and anti-freezes. Large quantities of ice, crushed into small (and preferably even) sized pieces will be needed for most of the experiments.

Temperature sensing:

Thermometers for reading the low temperatures will also be needed. Philip Harris have relatively low-priced thermometers which will read down to –35°C (and also some to –20°C, which will be enough for most purposes). Thermometers with thickened glass bulbs are preferable, to reduce breakages when stirring. Temperature sensors based on thermistors are available with data-logging and computer sensing kits from several manufacturers. The SEP temperature logger also offers the opportunity to monitor temperature changes continuously during cooling and freezing. A limited number of these will be available from the address above for evaluation by schools.

Materials to test:

- Materials used commercially for de-icing: common salt (sodium chloride); urea; CMA (calcium magnesium acetate, available from the address above); ethylene glycol; glycerine (**irritant**)
- Other materials which can be dissolved in water for lowering of freezing point experiments: sodium nitrate (**oxidising, irritant**); sodium sulphate, potassium chloride; potassium nitrate (**oxidising**); potassium sulphate; magnesium sulphate, iron(**III**) chloride (**corrosive**); sucrose; glucose.

General apparatus:

Beakers of various sizes (or small troughs); wide test tubes; glass rods; stands and clamps; measuring cylinders; plastic funnels; cotton wool; pieces of expanded plastic ceiling tile to use as lids for beakers; access to balances.

For studies of effects of de-icers on plants:

Petri dishes containing cress or barley seeds or mung beans spread on damp cotton wool; droppers; bottles to store solutions.

Safety

Eye protection should be worn at all times when any of this practical work is in progress.

Water from the atmosphere condenses onto beakers containing freezing mixtures and can cause the beaker to freeze to the bench, causing difficulty if pupils try to move it. Beakers, flasks, etc should be stood on small mats. The mat may temporarily freeze to the beaker, but can be moved with it.

Freezing mixtures can reach very low temperatures. Pupils must not touch the mixtures, and should not touch parts of vessels which contain freezing mixtures (the skin can freeze to the glass). Containers should either be left in position until all ice has melted, for clearing away later, or wrapped in folded cloths for moving.

It should not be necessary to clamp thermometers, or push them into tight-fitting corks or bungs, all of which can cause accidents. Warn students not to lay thermometers where they may roll off the edge of the bench.