SCOPE, SEQUENCE, and COORDINATION

A National Curriculum Project for High School Science Education

This project was funded in part by the National Science Foundation. Opinions expressed are those of the authors and not necessarily those of the Foundation. The SS&C Project encourages reproduction of these materials for distribution in the classroom. For permission for any other use, please contact SS&C, National Science Teachers Association, 1840 Wilson Blvd., Arlington, VA 22201-3000.

SS&C · National Science Foundation · NSTA National Science Teachers Association

SCOPE, SEQUENCE, and COORDINATION

SS&C Research and Development Center
Gerry Wheeler, *Principal Investigator*
Erma M. Anderson, *Project Director*
Nancy Erwin, *Project Editor*
Rick McGolerick, *Project Coordinator*
Arlington, Va., 703.312.9256

Evaluation Center
Frances Lawrenz, *Center Director*
Doug Huffman, *Associate Director*
Wayne Welch, *Consultant*
University of Minnesota, 612.625.2046

Houston SS&C Materials Development and Coordination Center
Linda W. Crow, *Center Director*
Godrej H. Sethna, *School Coordinator*
University of Houston-Downtown, 713.221.8583

Houston School Sites and Lead Teachers
Jefferson Davis H.S., Lois Range
Lee H.S., Thomas Ivy
Jack Yates H.S., Diane Schranck

California Coordination Center
Tom Hinojosa, *Center Coordinator*
Santa Clara, Calif., 408.244.3080

California School Sites and Lead Teachers
Sherman Indian H.S., Mary Yarger
Sacramento H.S., Brian Jacobs

Iowa Coordination Center
Robert Yager, *Center Director*
University of Iowa, 319.335.1189

Iowa School Sites and Lead Teachers
Pleasant Valley H.S., William Roberts
North Scott H.S., Mike Brown

North Carolina Coordination Center
Charles Coble, *Center Co-Director*
Jessie Jones, *School Coordinator*
East Carolina University, 919.328.6172

North Carolina School Sites and Lead Teachers
Tarboro H.S., Ernestine Smith
Northside H.S., Glenda Burrus

Puerto Rico Coordination Center*
Manuel Gomez, *Center Co-Director*
Acenet Bernacet, *Center Co-Director*
University of Puerto Rico, 809.765.5170

Puerto Rico School Site
UPR Lab H.S.

* * * * * * * * * * * *

Pilot Sites
Site Coordinator and Lead Teacher
Fox Lane H.S., New York, Arthur Eisenkraft
Georgetown Day School, Washington, D.C., William George
Flathead H.S., Montana, Gary Freebury
Clinton H.S., New York, John Laffan*

*not part of the NSF-funded SS&C Project.

Project Associates
Bill G. Aldridge
SciEdSol, Henderson, Nev.

Dorothy L. Gabel
Indiana University

Stephen D. Druger
Northwestern University

George Miller
University of California-Irvine

Student Materials

Learning Sequence Item:

1024

Properties of Aqueous Solutions

May 1996
Adapted by: George Miller

Contents

This micro-unit was adapted by **George Miller** (University of California, Irvine)

Science as Inquiry

Is It Hot Enough to Melt?

What is the melting point of different substances?

Overview:

This activity introduces you to the technique of measuring the melting (freezing) temperature of micro-scale amounts of substances. This is a method used in many chemistry laboratories, and has become very important as substances have become expensive and disposing of toxic chemicals has become difficult and expensive. When chemists make new substances they often are only able to prepare small amounts, perhaps less than one gram. So being able to make measurements of properties of very small amounts is useful.

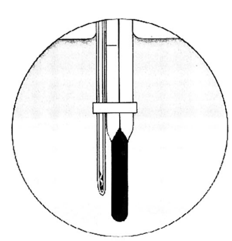
When one or more substances are mixed together, the properties change, sometimes in unexpected ways. You will investigate this in this activity.

Procedure:

You will be using heaters, and a variety chemicals in this experiment. Be careful of heat sources, and do not ingest any chemicals.

Work in groups as assigned by the teacher. Your group will be given specific assignments of pure substances and relative amounts to be mixed for mixed substances. Be sure to observe what is happening and make notes about what you observe.

When your measurements are complete, the full class will compare results and answer the questions that follow.



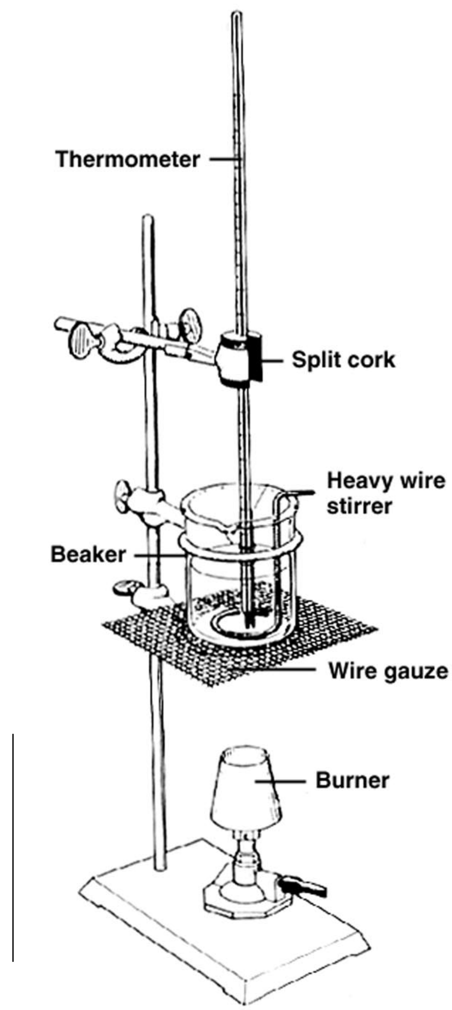


Fig. 1. Melting Point Setup

Questions:

1. First compare your observations among your own experiments, and then with other students in your class. Did some samples seem to melt very quickly, and others over a broad range of temperatures? Was there any pattern to these observations?

2. When you measured the melting point for same substance, did you all get the same answer? How

different were the results? What are some reasons why the results differed? How can these results be treated if only one result can be reported for the class?

3. Plot a graph of all the data for the class of melting results vs. composition. When a range of melting temperature was observed, discuss how you will represent this information on the graph.

4. What can you state about mixtures of these substances? Is this behavior expected? What model involving sub-microscopic particles can explain what you observed?

Science as Inquiry/Science and Technology
Science in Personal and Social Perspectives

Melting Ice is a Good Idea!

What influences the freezing point of ice?

Overview:

No one likes to slip on an icy road or sidewalk. Highway Departments in places where temperatures fall below freezing for any part of the year try to keep roads and sidewalks clear of ice. The reading should convince you that people are always searching for new methods to help accomplish this. You and your class are to investigate how this search is conducted and try out some of the substances that have been used or suggested for use. Before starting this experiment, read "Winter Roads" (Reading 1).

Procedure:

You and your fellow students will be assigned one or more of these compounds to investigate. The substances will all dissolve in water. You will measure the freezing point of pure water, and of water with one or more of the above chemicals dissolved in it. You need to establish the effect of adding different amounts of your assigned compound to a fixed amount of water. It is suggested that you use 10 mL as your standard amount of water (or solution), but you will only need a few drops of this to measure the freezing point by the micro-method, or a few mL for the small samples method. When you have completed your measurements, exchange information with other groups in the class so as to collect the information needed to answer the following questions. You may need to do a little additional reading, or ask other students or adults for information to answer some of the questions that follow.

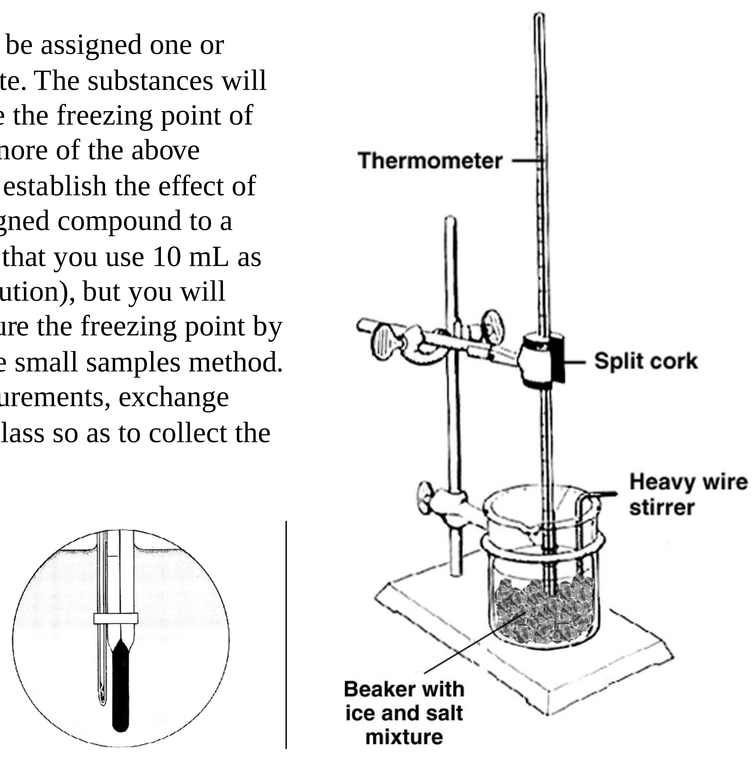


Fig. 1. Freezing Point Setup (similar to melting setup).

Questions:

1. Do substances like these change the freezing point of water?

2. How much is the freezing point changed? Plot a graph to show the change as a function of concentration. Calculate the slope of the graph so that you can state

how many degrees Celsius the freezing point is changed for every 1% more of your substance added to the solution.

3. Which compounds have the greatest effect on freezing of water?

4. Why are such effects observed?

5. Why is common salt (NaCl) the most commonly used chemical for de-icing roads?

6. Why are people trying to find an alternative to common salt?

7. What is the difference between de-icing and anti-icing? Why does the Highway Department care?

8. Why are highway personnel concerned about bridges. Why do motorists see road signs saying "Caution: Bridge May Be Icy"?

9. What factors will decide which is the best compound to use for anti-icing an important bridge?

Science as Inquiry/Science and Technology/
Science in Personal and Social Perspectives

Boil This!

How do boiling points for solutions differ?

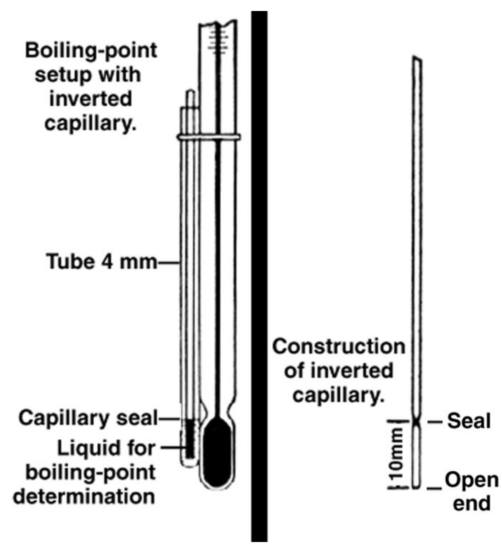
Overview:

In a previous activity you have learned that solid salts dissolved in water can lower the freezing point. Automobile engines operate at high temperature and are generally cooled by water to prevent some parts from getting too hot. But water may freeze if the vehicle is left for any length of time with the engine not operating in winter temperatures. Solid salts, such as those investigated for de-icing roads, are not suitable for adding to automobile engine coolant water. Why not?

Chemists developed liquid substances that can be mixed with water to lower the freezing point substantially so that the coolant does not freeze even in very cold climates. These chemicals are sold under the general name “antifreeze.” Similar chemicals are now known to be involved in helping biological organisms to survive very cold weather. However, a problem with water as an automobile coolant, is that it tends to boil easily—releasing steam. More water has to be added frequently to make up for that which has “boiled over” from the car cooling system. In this activity you and your fellow students will investigate what happens to the boiling of water when antifreeze compounds are added. You will also be able to compare two different compounds being sold as antifreeze compounds. Before starting this experiment, read “Salamanders in the Deep Freeze” and “Organ Transplants and the Big Chill, (Readings 2 and 3).

Procedure:

Your group will be assigned a compound or compounds, and a concentration@Íange in water solution to investigate. You will employ a standard method for determining boiling points that will enable you to compare the boiling point of pure water with that of antifreeze solutions. You will then exchange results with other students in your class in order to answer the following questions. You may need to do further reading to fully answer some of the questions.



Questions:

1. Does the adding of antifreeze compound to water change the boiling point of the solution?

2. Does the concentration of added substance make a difference? Plot class results to see how the boiling point varies as concentration changes.

3. Does the type of substance matter?

4. Why is the change in boiling point useful, so that antifreeze compounds are also marketed as "summer coolants"?

5. What do automobile and insect antifreeze compounds have in common? Why is this important?

6. Generally, conventional antifreeze is ethylene glycol-water system. Why is there interest in finding new glycol type alternatives, and which countries have adopted them?

7. Why is pure glycol not used as coolant, rather than a glycol-water mixture?

8. Why does the boiling point change as substances are mixed?

Science as Inquiry

Diffusion in Every Phase

What are the properties of diffusion?

Overview:

Solutions are made by placing two or more chemical substances in contact with each other. Normally when preparing a solution, rapid stirring is used to facilitate the process—as when sugar is stirred into tea using a spoon. In Britain, milk and sugar are often placed in a tea cup before adding the tea, so that the act of adding the tea accomplishes the stirring, and there is no need for a spoon!

Mixing of substances into one another to form a homogenous solution in the absence of stirring is called diffusion. In this activity you will be investigating what happens if no stirring is done. How fast do substances mix? What factors may influence the rate of mixing?

Procedure:

You and your group are to design a presentation to the rest of the class which illustrates the formation of a solution. Each group will be assigned just one type (gas-gas, liquid-liquid, solid-liquid, or solid-solid) and will compete to make the most effective presentation.

The presentation should illustrate the kinetics of solution formation (i.e., that mixing takes time, and different amounts of time—depending on the distances and the phases involved). The presentation should also discuss the model for the structure of matter that supports the ideas illustrated in the presentation.

Questions:

1. How does motion of particles differ in a gas, a liquid, and a solid?

2. Which makes the most difference to the rate of mixing in forming a solution, and why?
   A. Changing the type of solute, but same solvent and phases.
   B. Changing the type of solvent, but same solute and phases.
   C. Changing the type of phases of solute and solvent, changing the temperature, but keeping the same substances.

Science and Technology

Winter Roads

Winter storms can create slippery pavements and make driving hazardous. Each year, state highway agencies spend about $1.5 billion plowing, salting, and sanding their roadways to keep them safe for motorists. But what if we could prevent snow, ice, and frost from sticking to the pavement in the first place? We would not only have safer roadways, but we would also save money and use less salt, sand, and other materials.

A Revolutionary Concept

Anti-icing is a revolutionary new strategy for preventing a strong bond from forming between snow or frost and the pavement surface. It involves applying a chemical that will lower the temperature at which water freezes. If the snow can be prevented from bonding to the pavement, the roadway will remain wet or slushy, rather than icy. Motorists will be better able to control their vehicles—thus making traveling safer.

Most highway agencies in the United States today rely on a deicing strategy—as opposed to an anti-icing strategy—on roads that receive chemical treatments. Deicing operations involve breaking the bond between the pavement and the snow and frost on its surface.

Although effective, deicing operations are not always efficient. A lack of site-specific, detailed weather information results in many highway agencies waiting until a storm hits to send out their work crews to salt, sand, and plow. But by then, the storm already has the advantage, and crews struggle to keep up and to clear pavements that are already covered with snow or frost.

In contrast, anti-icing operations usually begin before or just as a storm hits. Using new, sophisticated weather information technologies that include road weather information systems, highway agencies can pinpoint when and where to begin anti-icing operations. For example, a chemical that lowers the freezing point of water is uniformly spread across the pavement just before, or just as, the first snowflakes begin to fall. Depending on the strength and duration of the storm, the chemical might need to be periodically reapplied. Such anti-icing strategies help keep roads safe for travel, reduce the environmental impact of winter operations, and make post-storm clean-up easier.

European countries have been successfully conducting anti-icing operations for several years now. Through a cooperative technical exchange program, they have shared their knowledge with highway agencies in the United States. Their experiences were used in the development of an anti-icing test and evaluation project sponsored by the Federal Highway Administration (FHWA).

Field Testing

Since, the winter of 1993–94, 15 states—representing about half of those states with significant winter maintenance programs—have been participating in FHWA's test and evaluation project to determine the effectiveness of anti-icing operations. The study is a continuation, with some

Reprint from Mergenmeier, Andrew, "New Strategies Can Improve Winter Road Maintenance Operations," *Public Roads*, Washington, D. C.: U. S. Dept. of Transportation, Federal Highway Admin., TD 2.19: 58/4, Spring 1995, pp. 16–17.Permission pending.

modifications, of an anti-icing study initiated under the now-completed Strategic Highway Research Program. Technical support for the test and evaluation project is being provided by the U. S. Army Corps of Engineers Cold Regions Research and Engineering Laboratory (CRREL), located in Hanover, N. H. CRREL is responsible for analyzing the data collected by the states.

The states' experiences will help determine the conditions under which anti-icing is most effective, as well as the strategies or techniques that hold the greatest potential for success in a broad range of topographic, climatic, and traffic conditions. The evaluations will continue through the 1934–35 winter, a final report on the project is due next fall.

The key to a successful anti-icing strategy is knowing which chemical to use, in what amount, and when. Answering these questions is not simple. A highway agency needs real-time, localized weather information, as well as accurate forecasts for specific corridors.

There is no one solution for all conditions. The optimum strategy will vary depending on a site's conditions, such as weather, geography, and traffic. Candidate chemicals for anti-icing operations include liquid calcium magnesium acetate (CMA), liquid calcium chloride, liquid magnesium chloride, liquid sodium chloride (salt brine), liquid potassium acetate, and pre-wetted solid sodium chloride (NaCI, commonly known as rock salt).

The technology for applying the chemicals is also being examined. For example, several sites are using innovative material spreaders to apply liquid and pre-wetted materials. This equipment is capable of varying the spreading rate, spreading width, and pre-wetting rate upon demand, while correlating the application rate with the vehicle speed.

Results to Date

At an FHWA-sponsored conference in Minneapolis in August 1994, the 15 states participating in the test and evaluation recounted their first-year experiences. In general, they were enthusiastic about anti-icing operations, having found that these operations can:

- Reduce the amounts of chemicals needed.
- Prevent black ice or frost on bridge decks when liquid chemicals are periodically applied.
- Require less effort to return the pavement to a bare condition at the end of a storm.
- Reduce the amount of abrasives (sand) used.

In short, safe driving conditions can be maintained with less materials; this translates directly into reduced environmental and operational costs. Also, with the development of anti-icing technologies, additional options will be available to highway agencies to help them match their unique winter maintenance needs with specific conditions.

The states cautioned, however, that effective anti-icing operations require better weather information systems, improved materials and material spreaders, and more crew training. The potential savings in time and materials are great, but they won't and can't be realized overnight.