

# How Low Can You Go? The Effect of Salt on Ice

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This is a guided inquiry lab used in Science 100, an interdisciplinary lab-based science course for non-science majors at the University of Maryland, Baltimore County. Water provides the central theme of the course. Labs emphasize group collaboration, and the process of actually *doing* science. This particular exercise allows groups of students the opportunity to design and revise an experiment multiple times within a 90-minute block of time.

In lecture prior to this lab, students have read about and discussed the thermodynamics of phase changes in water. These concepts are then linked to precipitation and weather patterns, ocean currents and global heat transfer. We also discuss freezing point depression and the different adaptations that organisms have to surviving in sub freezing temperatures.

In lab we present the following challenge: *Which group of students can generate the lowest temperature using whatever water and ice they choose, and a maximum of 5 grams of salt?* Students are allowed to use whatever other basic lab supplies that are available, including an array of glass and plastic ware, Styrofoam cups, aluminum foil, hot plates, small fans, etc. For data collection students use TI-83+ calculators connected to a CBL or LabPro interface with a temperature probe (both by Vernier Software and Technology). Students are already familiar with the use of this

equipment from a previous lab exercise. Lab groups are allowed almost complete free reign in their experimental design and revision, with very little input from either the instructor or teaching assistants. They are asked to document what seems to work and what doesn't, providing some rationale for their experimental setup. After approximately 60 minutes, we ask students to prepare their equipment for one final 10-minute competition. Only the results obtained during that "round" are used to determine which group wins. The winning group has to present their methods to the rest of the class, after which they are awarded their prize (usually a bag of candy). All students turn in a simple worksheet before they leave.

We find that this lab reinforces the bonds among group members, and also allows for more creativity vs. many of the other labs. Additionally the friendly competition between groups leads to a lively, animated experience, increasing the involvement of those students who are typically content to sit back and let someone else run the show. This lab also allows students to become more comfortable with the CBL or LabPro system. This benefits them later on in the semester, when they use these interfaces in the field with a variety of other probes (dissolved oxygen, stream flow, conductivity, pH, etc).

### Equipment and Supplies:

*Each group of 4-5 students has the following equipment on their lab bench:*

- 1 CBL or Lab Pro interface
- 1 TI 83+ calculator
- 2 temperature probes
- appropriate linking and adapter cables

*Additional supplies available in the lab (for 4 groups of students):*

- |   |  |
|---|--|
| • 2 small balances                          | • Styrofoam cups   |
| • spatulas                                  | • Aluminum foil  |
| • weigh boats                               | • Bubble wrap or Styrofoam peanuts (if available)                              |
| • salt                                      | • Small fans   |
| • beakers (8-10 each of a variety of sizes) | • Hot plate/ stirrers  |
| • graduated cylinders (10 ml and 50 ml)     | • Ice (bags of ice cubes; typically 1 16 lb bag is sufficient per lab section) |
| • paper cups                                | • Hammer and plastic bags, to crush ice  |

### Directions for setting up the LabPro units for initial experimentation:

1. The TI-83 + calculator is mounted in a cradle on top of the Lab Pro interface. Make sure that the Lab Pro is plugged in and turn the calculator on. Check to make sure that the link cable is fully inserted into both the Lab Pro and the calculator.
2. Plug the temperature probe into channel 1 on the left side of the Lab Pro
3. Select the *Apps* button on the calculator and then enter "4" to start the *DataMate* program. Alternatively you could use the arrow keys to move the cursor to line 4 and then push the *Enter* key.

4. The LabPro should perceive the temperature probe. The current temperature will appear in the upper right corner of the screen. Using this setting you can monitor the temperature “on the fly”, as you revise your experimental setup.

**Directions for setting up the LabPro units for final competition:**

*Set up the calculator and Lab Pro for data collection during the final round of competition.*

- Press “1” to enter the *SetUp Menu*.
- Use the down arrow key to scroll down to *Mode* and the press *Enter*.
- Press “2” to select *Time Graph* from the *Select Mode* menu.
- The Time Graph Settings are displayed on the screen and should be as follows:
  - Time Interval: 10
  - Number of Samples: 60
  - Experiment Length: 600
- If the settings are correct Press “1.” If not, Press “2” to change them. Once they are correct press “1.”
- Press “1” again to return to the main screen.
- When everyone is ready, I’ll say “Start” to begin the final competition. Press “2” to begin data collection. Your data will be displayed as a graph on the calculator screen, with the current temperature value in the upper right corner. Individual data points will also be stored in the memory of the calculator.

**Typical Results:**

Typically most groups in a lab will design an experiment that results in temperature readings below 0° C, with the winning group usually recording a value near -17.0° C. However, each semester there are 3 or 4 groups (out of 40-48) who never get below zero. Through their experimentation, most students realize that in order to achieve the greatest drop in temperature, they need to maximize the salt to ice ratio. They also realize the benefits of insulation, and use the Styrofoam cups, foam, and peanuts in creative ways.

One common mistake that students make is the use of large volumes of water/ice. Since ice is somewhat limited (there is no ice machine in the building), the teaching assistants remind students to “think small.” We have also had students who have heard that warm water will freeze faster than cold water, so they request a hot plate to heat their water up. Despite the fact that this is a different question than the one posed, the teaching assistants have been instructed to hand over any equipment (within reason) available so that each group may try out their design. In all such cases the students quickly realized that they were asking the wrong question and needed to revise their design to get back on track. We have also learned that it is best to have the teaching assistants weigh out the 5 grams of salt for the final competition vs. letting groups weigh it out themselves.

**Vendor Information for LabPro interfaces and probes:**

