A Good Cold Pack

Cold packs are used to treat sprained ankles and similar injuries. A cold pack is typically made of a thin plastic inner bag containing water. That bag, in turn, is surrounded by a heavier plastic bag containing a solid substance. When the pack is twisted, the inner bag breaks and releases the water. As the solid substance dissolves in the water, energy is absorbed and the resulting mixture gets colder.

In this experiment, you will dissolve solid substances in water and observe how the temperature changes. Then, you will then develop and test a plan for making the best cold pack.

OBJECTIVES

In this experiment, you will

- Use a Temperature Probe to measure temperature.
- Determine temperature changes as solid substances dissolve in water.
- Design and test a plan for making the best cold pack.
- Report your results.

MATERIALS

TI-Nspire handheld **or**
computer and TI-Nspire software
data-collection interface
Temperature Probe
balance
weighing paper
50 mL beaker
250 mL beaker
10 mL graduated cylinder
water
ammonium chloride, NH_4Cl
citric acid, $H_3C_6H_5O_7$
potassium chloride, KCl
sodium bicarbonate, $NaHCO_3$
sodium carbonate, Na_2CO_3

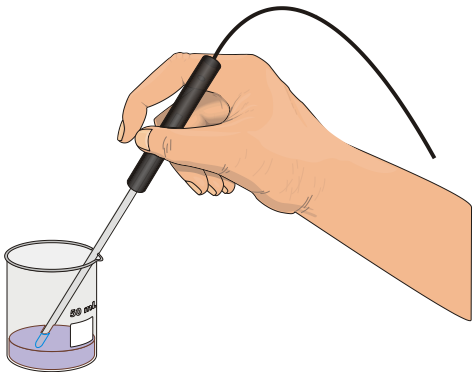

Figure 1

PROCEDURE

Part I Finding Temperature Changes

1. Obtain and wear goggles.
2. Connect the Temperature Probe to the data-collection interface. Connect the interface to the TI-Nspire handheld or computer.
3. Measure out 3.0 g of each of the test substances. Use and label a new piece of weighing paper for each substance.
4. Use a 10 mL graduated cylinder to measure out 10 mL of room-temperature water into a clean 50 mL beaker.
5. Collect temperature data.
   a. Place the Temperature Probe into the 50 mL beaker containing the 10 mL of water.
   b. Gently move the probe and note the temperature displayed in the meter.
   c. When the temperature stops changing, start data collection ( ).
   d. Monitor the temperature for 5 seconds to establish the initial temperature of the water.
   e. Carefully add the solid ammonium chloride to the water. Stir gently with the Temperature Probe.
   f. When the temperature stops changing, end data collection ( ).
   g. Choose Analyze ► Statistics from the Experiment menu. Record the minimum and maximum temperatures. Close the Statistics box.
6. Repeat Steps 4 - 5 for each of the remaining substances. Clean the probe after each run and place it into a 250 mL beaker containing room-temperature water to bring the probe back to room temperature.

Part II Finding the Best Cold-Pack Mixture

7. Make and test a plan for making the coldest temperature using 3.0 g of one of the solid substances and the best amount of water. Turn in a report that includes your procedure and results.

DATA

Substance	Maximum temperature (°C)	Minimum temperature (°C)	Temperature change (°C)
Ammonium chloride (NH_4Cl)			
Citric acid ($H_3C_6H_5O_7$)			
Potassium chloride (KCl)			
Sodium bicarbonate ($NaHCO_3$)			
Sodium carbonate (Na_2CO_3)			

PROCESSING THE DATA

1. In the space provided in the data table above, subtract to calculate the temperature changes. If the temperature went down, mark the answer with a down arrow (↓). If the temperature went up, mark the answer with an up arrow (↑).

2. Which substance caused the greatest temperature decrease?

3. Which substance is the most unsuitable for a cold pack? Explain.

4. How did your Part II results compare with those of other student groups?

5. Which factors other than cooling ability might be considered when choosing a substance for use in a cold pack?

EXTENSIONS

1. Research the types of injuries that are treated with the use of a cold pack.
2. Make a cold pack using your suggested substance, water, and Ziplock© or other bags.