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Experiment
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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 use an EasyTemp temperature probe to determine temperature changes as several different solid substances dissolve in water. You will then develop and test a plan for making the best cold pack using 3.0 grams of one of the substances and the best amount of water.

OBJECTIVES

In this experiment, you will

- Use an EasyTemp 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-84 Plus or TI-84 Plus Silver Edition graphing calculator
Vernier EasyTemp
Vernier EasyData application
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

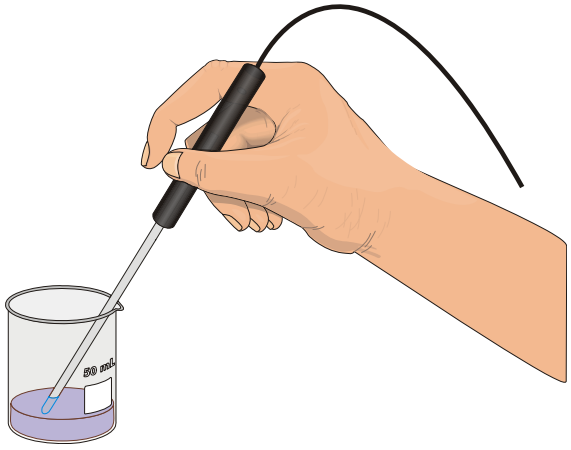

Figure 1

PROCEDURE

Part I Finding Temperature Changes

1. Obtain and wear goggles.

2. Turn on your TI-84 Plus (or TI-84 Plus Silver Edition) graphing calculator and make sure that it is on the home screen. Plug the EasyTemp probe into the USB port of the graphing calculator. The EasyData application will automatically start and the Main screen will be displayed.

3. Set up the data collection.
   a. Select **File** from the Main screen, and then select **New**.
   b. Select Setup from the Main screen.
   c. Select **Time Graph…**.
   d. Select Edit.
   e. Press CLEAR on the calculator and type **5** as the time between samples in seconds. Select Next.
   f. Press CLEAR on the calculator and type **60** as the number of samples. Select Next. The length of the data collection will be 300 seconds (5 minutes).
   g. Confirm that time graph settings are correct. Select OK.

4. Measure out 3.0 g of each of the test substances. Use and label a new piece of weighing paper for each substance.

5. Use a 10 mL graduated cylinder to measure out 10 mL of room temperature water into a clean 50 mL beaker.

6. Collect temperature data.
   a. Place the EasyTemp probe into the 50 mL beaker containing the 10 mL of water.
   b. Gently move the probe and note the temperature displayed at the top of the Main screen.
   c. When the temperature stops changing, select Start to begin data collection.
   d. Monitor the temperature for 15 seconds to establish the initial temperature of the water.
   e. Carefully add the solid ammonium chloride, NH_4Cl, to the water. Stir gently with the EasyTemp probe.
   f. When the temperature stops changing, select Stop to end the data collection.

7. Determine the minimum and maximum temperatures.
   a. When data collection stops, a graph of temperature *vs*. time will be displayed. Use ▷ to examine the data points along the curve. As you move the cursor, the time (X) and temperature (Y) values of each data point are displayed above the graph.
   b. Record the minimum and maximum temperatures in your data table.
   c. Select Main to return to the Main screen.

8. Repeat Steps 5-7 for each of the remaining substances. Clean the probe after each trial and place it into a 250 mL beaker containing room temperature water to bring the probe back to room temperature.

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Part II Finding the Best Cold-Pack Mixture

9. 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. Prepare a report that includes your procedure and results.

10. When you have completed Part II, select Main to return to the Main screen. Select Quit from the Main screen. Select OK to exit the EasyData application.

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.