LAB 13 Teacher Preparation

Endothermic and Exothermic Processes

Purpose

Students will measure temperature changes that occur as chemical compounds dissolve in water. They will collect temperature data for three minutes using the CBL 2 unit and a temperature probe. Students will use graphing calculators to observe exothermic and endothermic processes in progress and analyze data.

Time Requirements

one 45-minute class period

Advance Preparation

- Install the DataMate program on the graphing calculators.
- Prepare sets of materials or lab stations in advance to help insure that students easily complete the lab.
- Allow about 2 L of distilled water to sit overnight at room temperature.

Safety Information

Review all safety precautions. Remind students to observe all laboratory rules.

Teaching Tips

- Potassium chloride absorbs heat from its surroundings when it dissolves in water. Therefore, dissolution of potassium chloride is an endothermic process. The dissolution of calcium chloride is an exothermic process.
- Review with students the difference between chemical processes and physical processes. In this lab, they will be investigating the dissolving of a solid in water. This is a physical process.
- To help them understand why dissolution is a physical process, remind them that when they dissolve salt in water, they can still taste the salt. If the water were to evaporate, the salt would remain. It is not changed chemically.
- Lumps or chunks work better than fine-granulated material because they take longer to dissolve. Granulated material works, but it dissolves in approximately 15–25 seconds when the water in the beaker is stirred.
- Ammonium nitrate (NH_4NO_3) may be used instead of potassium chloride to demonstrate an endothermic process. It will release a larger amount of energy per gram than KCl will. If ammonium nitrate is used instead of potassium chloride, a mild ammonia odor may occur when it is mixed with water. Caution students not to intentionally inhale the fumes near the beaker. Small first aid cold packs often use ammonium nitrate and water.
- Sodium chloride also can be substituted for potassium chloride, however it produces a smaller temperature change.
- The solution may become saturated and additional material will not dissolve. If students see undissolved solids in the bottom of the beaker, the solution is probably saturated.

Extensions

- Have students hypothesize what will happen if they try increasing the amount of solid or decreasing the amount of water. Allow students to perform the experiment to test their hypotheses.
- Have students research to find out how calcium chloride is used when outdoor temperatures drop below freezing.
- Have students make a list of everyday activities that use endothermic and exothermic processes. The class can compile all of their items and make a master list.
- Have students research to find out about cold packs. Students can find the different types of chemicals used, methods of packaging, and shelf life of these products.

Teacher Preparation (continued)

- Exothermic processes are common and the class can generate a long list of activities that use them. Students can pick a process to research and present their report to the class. Some students may be interested in researching how pyrotechnics are used for stunts in the movies.

Pre-Lab Answers

1. A physical change is one in which the form or appearance of a substance changes but its composition stays the same.

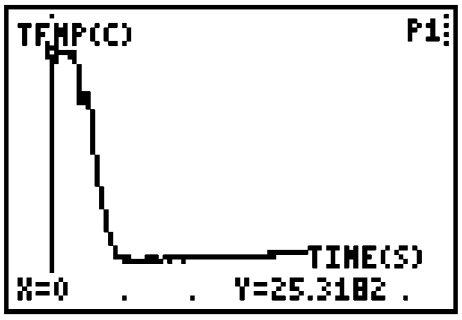
2. Possible examples of physical change are changing shape, changing state, and dissolving.

3. An exothermic process is one that releases heat.

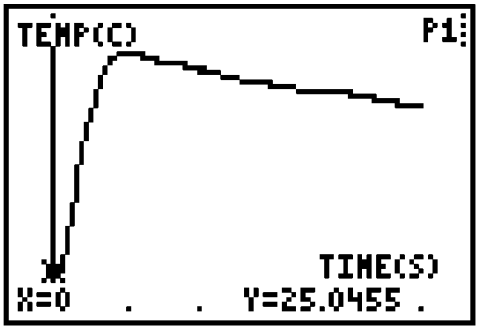
4. An endothermic process is one that absorbs heat.

Sample graphs of both endothermic and exothermic processes are shown below.

Dissolving of KCL in water



Dissolving of $CaCl_2$ in water



Name Date Class

LAB 13 Probeware Activity

Endothermic and Exothermic Processes

When a substance dissolves in water, a change in energy usually occurs. Although a change in energy can be a sign of a chemical change, the dissolving of a substance is a physical change. The water molecules break apart into positive and negative parts and surround the particles of the substance that is dissolving. In some cases, dissolving releases heat energy into the surroundings. Processes that release heat energy are called *exothermic*. In other cases, dissolving absorbs heat energy from the surroundings. Processes that absorb heat are called *endothermic*. How can you tell if heat energy is released or absorbed? In this activity you will collect data and search for clues to determine which type of heat energy transfer is taking place.

What You'll Investigate

- What happens when $CaCl_2$ and KCl are added to water?
- Will these processes produce temperature changes?

Goals

Measure the change in temperature when substances are added to water.
Calculate any change in water temperature that occurs during the process.
Graph temperature changes over time.

Materials

CBL 2 or LabPro unit
TI graphing calculator
link cable
DataMate program
temperature probe
400-mL beaker
100-mL beaker
plastic spoon
glass stirring rod
distilled water (room temperature)
5.0g calcium chloride ($CaCl_2$)
5.0g potassium chloride (KCl)

Safety Precautions

- Always wear safety goggles and a lab apron.
- Report any spills to your teacher.
- Do not taste, eat, or drink any materials used in the lab.
- Wash your hands before leaving the laboratory.

Pre-Lab

1. What is a physical change?

2. What are examples of physical change?

3. What is an exothermic process?

4. What is an endothermic process?

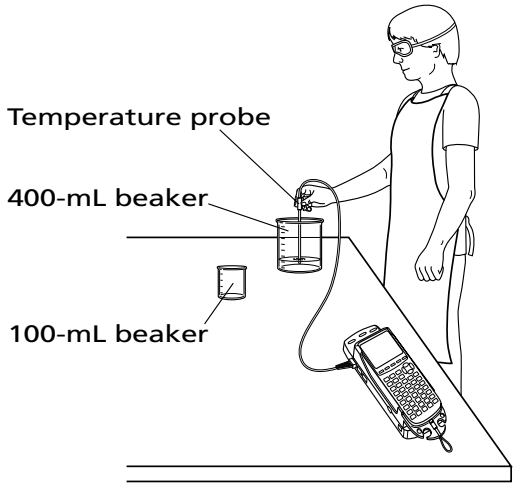
Probeware Activity 13 (continued)

Procedure

Part A: Preparing the CBL System

1. Set up the calculator and CBL 2 unit, as shown in **Figure 1.** Plug the temperature probe into channel 1 of the CBL 2 unit.
2. Turn on the calculator and start DataMate. Press CLEAR to reset the program. The temperature probe should be recognized automatically. If not, turn to page *vi* for instructions on how to set up the probe manually.

Figure 1



Part B: Collecting Data

1. Add 100 mL of room-temperature water to the 400-mL beaker.
2. Place the temperature probe in the water.
3. Use a balance to measure 5.0 g of potassium chloride on a piece of weighing paper or in a weighing dish.
4. On the graphing calculator, select **START** to begin the data collection. About five seconds after data collection has begun, carefully add the potassium chloride to the water. Make sure all of the potassium chloride is emptied into the water. Data will be collected for 180 seconds.
5. Using a glass stirring rod, gently stir the water in the beaker for about 20 seconds to help the potassium chloride dissolve.
6. After 180 seconds have lapsed, the calculator will display a graph of temperature versus time with temperature on the *y*-axis and time on the *x*-axis. Sketch and label this graph in your **Science Journal.**

Part C: Examining the Data

1. Return to the main screen by pressing ENTER.
2. Select **ANALYZE.**
3. Select **STATISTICS.**
4. Press ENTER to select the beginning of the temperature graph. Use the right arrow key to select the last temperature data point reached. Press ENTER to select this point.
5. Your calculator will display the minimum and maximum temperatures reached. Determine which of these is the starting temperature and which is the ending temperature—the temperature after all of the solid dissolved. Record these temperatures in the **Data Table.** When you are finished, press ENTER. Select **RETURN TO MAIN SCREEN.**
6. Rinse your beaker thoroughly and repeat parts **B** and **C** using 5 g of calcium chloride.
7. When you are finished, press ENTER. Select **RETURN TO MAIN SCREEN.** Select **QUIT.** Follow the directions on the screen.

Cleanup and Disposal

1. Turn off the graphing calculator and disconnect the temperature probe and CBL 2 unit.
2. Clean and return all equipment as directed by your teacher and answer the questions on the following page.

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Name Date Class

Probeware Activity 13 (continued)

Data Table: Dissolving of KCl and $CaCl_2$

Substance	Starting Temperature (°C)	Ending Temperature (°C)	Temperature Change (°C)	Type of Process
Potassium chloride (KCl)	*25.31*	*19.61*	*–5.70*	*Endothermic*
Calcium chloride ($CaCl_2$)	*25.04*	*30.16*	*+5.12*	*Exothermic*

Conclude and Apply

1. Calculate the temperature change for each substance by subtracting the starting temperature from the ending temperature. Record your results in the **Data Table.** How are these temperature changes different?

Student results may vary. The potassium chloride solution should be cooler (negative change) and the calcium chloride solution should be warmer (positive change) than the starting temperature of the water.

2. Which process is endothermic and which is exothermic?

Potassium chloride dissolving in water is an endothermic process while calcium chloride dissolving in water is an exothermic process.

3. Look at your graphs. Suggest a possible explanation for why the temperature of the water changed rapidly at first and then leveled off.

Student answers will vary. The temperature of the water changed rapidly when the solid was dissolving. The temperature of the water leveled off when the solid was completely dissolved.

4. From your results, infer what the result might be if twice as much potassium chloride was added to the same amount of water.

The water will cool more, possibly cooling twice as much. Students could test this as an extension. Teacher Note: When the water becomes saturated with the substance being dissolved no additional cooling will be observed.