EXPLORATIONS

Activity 10

Warming a Solution

Math Concepts

- Measurement
- Data Analysis
- Algebra

Science Concepts

- Data Collection
- Experimental Design
- Chemistry

Materials

- TI-73 Calculator
- CBL™
- TI temperature probe
- Data cable
- 5 congruent containers
- At least 500 ml of water in a pitcher
- Approximately 100 cubic centimeters (20 teaspoons) of washing soda (Tide, Cheer, Ajax, Fab, Gain, etc.)
- Measuring cup
- Spoon

In this activity, you will:

- Use variables and constants
- Create graphs
- Explore functions
- Measure temperature, volume, and mass
- Make statistical calculations on measured data
- Organize and analyze data
- Explore patterns in data that lead to the statement of a relationship between them
- Test hypotheses
- Discover exothermic chemical reactions

Introduction

Emily noticed as she was hand-washing a sweater in the kitchen sink that when she put a little washing soda (sodium carbonate) in water, the solution seemed to become warmer. To test her hypothesis, she took five glasses (all the same kind) and filled each one with 100 ml of water. She took the temperature of the water in all five glasses to make sure the start temperatures were the same. Then she added different measures of washing soda to each glass and measured the temperature changes again to see if the amount of washing soda affected the water temperature.

The Problem

In this activity, you will measure the temperatures of six water samples with 0, 1, 2, 3, 4, and 25 cubic centimeters (5 teaspoons) of washing soda added to each sample respectively. The container with no washing soda will be used as the control sample.

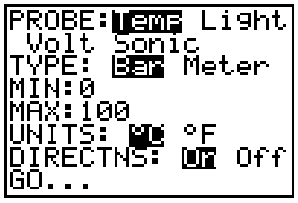
The Set Up

1. Label each of the five sample containers that will hold washing soda with the letters A through E and pour 100 milliliters of water in each. Take the temperature of samples A through E and record in Table 1 on the student data sheet. Before the washing soda is added, you will need to run the experiment on the "control" container with no washing soda so that you will know that the temperature change is due to the washing soda rather than other variables.
2. Add 5 milliliters (1 teaspoon) to container A, 10 milliliters (2 teaspoons) to container B, 15 milliliters (3 teaspoons) to container C and so on. Take the final peak temperature of each container after the washing soda has been added and record in Table 1 on the student data sheet.

Activity

Collecting Data

1. Press [MODE] and highlight **0** to round the temperatures to the nearest whole number.
2. Press [APPS] **2:CBL/CBR**, press any key, select **1:GAUGE**, select the options as shown below. Highlight **GO** and press [ENTER]. Follow the directions on the TI-73 to collect the temperature data.



3. Record the temperature of all five containers before the washing soda is added. You will run this application five different times to collect the temperatures on all five samples. All samples should have the same "before" temperature.

4. Add the washing soda and record the changes in temperature.

a. Add 5 milliliters (1 teaspoon) to container A and use the TI-73 and CBL™ with **GAUGE** (as done earlier) to take the temperature of the solution.

✎ Record temperature on Table 1 on the student data sheet.

b. Add 10 milliliters (2 teaspoons) to container B, note the temperature, and record.

c. Continue adding one more, taking temperature and recording for containers C, D, and E. Watch for a maximum temperature. This will be the value you will record. Once this temperature is achieved, the temperature will start to fall and the data collection on that sample should be finished.

d. Press [CLEAR] to stop the data collection and prepare for the next container. Make sure that you let the probe return to the starting temperature between data collections.

5. After all the data has been collected and recorded, dispose of the solutions, put away the CBL and equipment, and wash your hands.

✎ Answer questions 1 - 3 on the student data sheet.

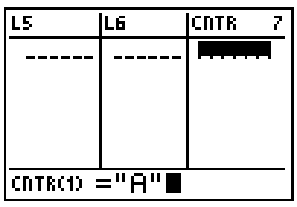
Analyzing the Data

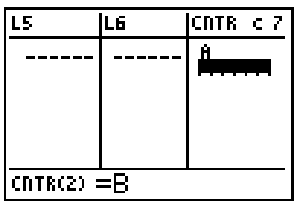
You will analyze the data using the TI-73 lists and statistical plots.

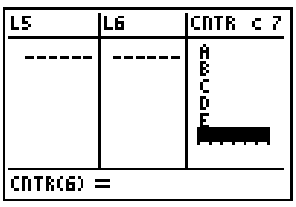
1. Organize your data in a list similar to Table 1.

a. Press [LIST] and press [▸] to move past **L6**. Name this list **CNTR** for container. (See the TI-73 manual for information on naming a list.)

b. The first element in this list will be **A**, the second **B**, the third **C**, and so on. **A** must be enclosed in quotes or the number stored for variable **A** will be displayed. However **B**, **C**, **D**, and **E** will not need to be enclosed in quotes since the list is now formatted as a categorical list.

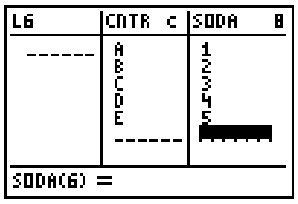






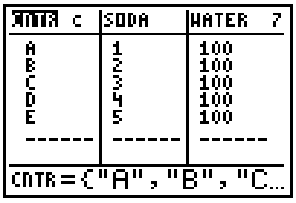
2. Create lists for the remaining data.

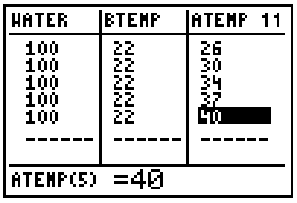
a. Name the list to the right of the container list **SODA** for the number of teaspoons, cubic centimeters, or grams of washing soda added. Then enter the data from Table 1.



b. Name the list to the right of **SODA**, **WATER** for the number of milliliters of water in each container, followed by **BTEMP** for "before" temperature and finally **ATEMP** for "after" temperature.

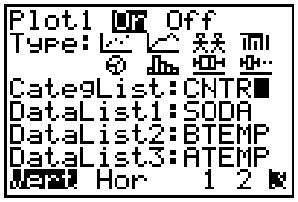
c. Enter the data from Table 1 in all lists.



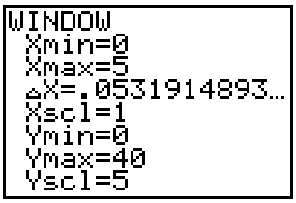


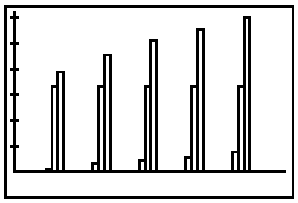
3. Create a triple bar graph to analyze the data.

a. Press [2nd] [PLOT] and select **1:Plot1**. Use the setup shown below. Make sure that all the other plots are **Off**.

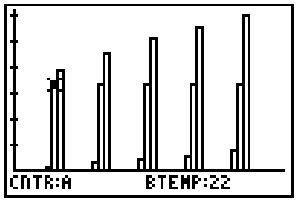


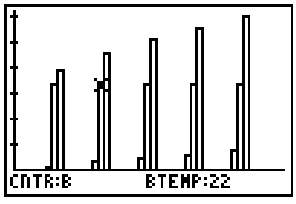
b. Set an appropriate window and graph.

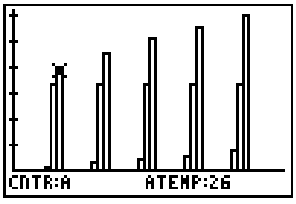




c. [TRACE] the graph and discuss what each bar represents.



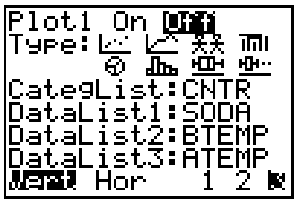




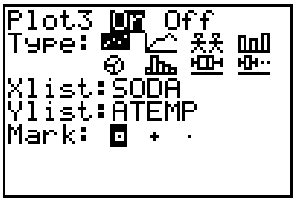
✎ Answer questions 1 - 4 on the student data sheet.

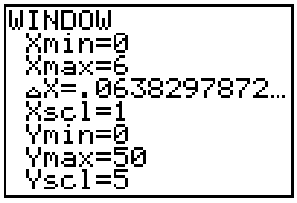
4. Next, create a scatterplot to compare the changes in temperature after the soda is added.

a. Press 2nd [PLOT], select **1:Plot1** and turn Plot 1 **Off**.

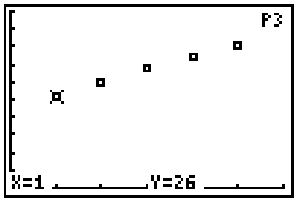


b. Turn Plot 2 off and use Plot 3 and appropriate window values as shown below.





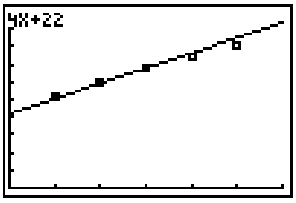
c. Press GRAPH TRACE and determine what units are changing as you trace.

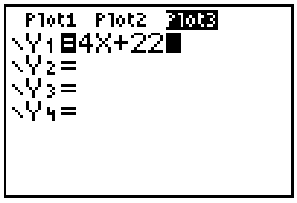


d. Estimate the rate of change.

✎ Answer questions 5 and 6 on the student data sheet.

5. Use the manual-fit option as done earlier to place a line of best fit on these data points. (See the TI-73 manual for instructions on manual-fit.)





✎ Answer questions 7 - 10 on the student data sheet.

Going Further

1. The presence of a solute in a solvent can lower its freezing point and raise its boiling point. When could this property be useful to a substance?
2. Using the data from the above experiment, predict the resulting temperature of the solution if you added:

   10 teaspoons of washing soda: _____

   100 teaspoons of washing soda: _____
3. Using the same data, how much washing soda would one need to add to make the water boil?
4. Given the following data, explain how you would determine the effect of the chemical on the liquid.

Amount of M&Ns	Amount of Dr. Pepper	Before Temperature	After Temperature
1	100	20	28
2	100	20	35
3	100	20	43
4	100	20	51
5	100	20	58
6	100	20	66

5. How would the experiment change if the amount of washing soda was kept constant and the volume of the starting liquid was varied?
6. Why did you need to start the experiment at the same temperature?
7. Do a **Manual-Fit** on the data in **4**.
8. What can you say about a kind of washing soda that caused a greater change in temperature that the one tested, under the same conditions?

Student Data Collection and Analysis Sheet

Name _____

Date _____

Activity 10

Warming a Solution

Table 1

Container	Volume of soda added	Volume of water in mL	Before temperature °C	After Temperature °C
A				
B				
C				
D				
E				

1. What variables in the experiment remained constant?

_____

_____

2. What variable(s) changed? _____

_____

3. When one variable changes in response to another variable, the first variable is called the *independent* and the second variable is called the *dependent.* In this experiment the _____ is the independent variable and the _____ is the dependent variable because it changed in response to _____

4. If X represents the number of teaspoons of soda added and Y represents the temperature of the water after soda added, write an equation to show this relation._____

5. What is the rate of change of amount of soda and temperature, (include units)?

_____

6. What is the percent of difference between the highest and lowest final temperature?

_____

7. In **Y=mx + b**, how does the value of **m** compare to the estimated rate of change in temperatures after consecutive amounts of soda were added?

_____

_____

8. What is the significance of **b** in **Y=mx + b**?

_____

9. What happened when you evaluated the control container?

_____

10. What did Emily find out?_____

_____

Teacher Notes

Math Strands: Algebra, Measurement, and Data Analysis

Use of variables, graphs, functions, measurement of temperature, volume and mass, and statistical calculations on measured data. Measurements of volume and temperature will be taken and recorded in a table to organize and analyze the data. Examples of constants and variables will be discussed and explored for patterns that may lead to a relationship between them.

Science Strands: Experimental Design, Data Collection, and Chemistry

Exothermic chemical reactions: A solution of water and varying amounts of sodium carbonate will be investigated to explore the hypothesis that the amount of sodium carbonate (washing soda) added to water of a constant temperature will produce a corresponding increase in the temperature of the solution.

Classroom Management and Safety

The experiment can be done in groups of 2, 3, or 4, or could be done as a whole class activity. If several groups within the class are conducting the experiment, you can have them use different types of washing detergent. Tell the students to avoid eye and mouth contact after touching the washing soda. Have them wash their hands after they have collected the data. The sodium carbonate should not damage the temperature probe. However, rinse it off with water after completing the experiment. The best way to allow for an equal starting temperature for the five glasses of water is to draw the water into a large container the night before and let it come to room temperature before the experiment begins.

The Set Up

- The Mode was originally set to round to nearest whole number. When tracing and discussing the linear regression equations the mode may need to be changed to not misinform students. Students who are familiar with functions may mistakenly conclude that the 2 linear relations are not functions because of the mode setting.
- Students may need to dissolve the washing soda in the solution to speed the reaction. If they do this they should be consistent in their methodology. The time need to reach a maximum temperature will be a variable depending on the type of washing soda used and the kind of water used with it.

Activity

- The amount of soda in the solution should be changing as the amount of water in the solution remains constant.

Student Data Collection and Analysis Sheet – Key

1. The size and shape of the containers used, the amount of water in the solution, and the starting temperature were variables that were held constant.
2. The amount of soda added and the temperature after the varying amounts of soda added were variables that changed.
3. Soda added, temperature after.
4. Y=4X + 22 (based on the sample data).
5. 4° C/teaspoon.
6. (max Temp - min Temp) / (min Temp) * 100.
7. m is close to the value from question 6.
8. The constant before temperature.
9. No change in temperature.
10. Emily found out that the addition of washing soda raised the temperature of the solution.

Going Further – Key

1. When trying to avoid ice forming on steps.
2. Use the equation developed (Y= 4x+22) and insert values for X.
3. Same as above, inserting values for Y.
4. Set up a graph and do a fit.
5. Same results, but the X variable would be the amount of H_2O.
6. To limit the number of variables.
7. Y = 7.7 X + 20.
8. More energy released in the reaction. Probably stronger cleaner!