LAB 6 Teacher Preparation

The Effect of Acid Rain on Limestone

Purpose

Students will collect rainwater and measure its acidity. They will use the rainwater to determine the effect that acid rain has on limestone.

Time Requirements

one 45-minute class period

Advance Preparation

- Crush limestone into small, pea-sized pieces. Each student will need about five pieces.
- Install the DataMate program on the graphing calculators.

Materials

The rainwater in this activity should have a pH of about 3.5 or lower. If necessary, students can prepare simulated acid rain with a pH of about 3.5 by adding 1.5 mL of vinegar to 100 mL of distilled water.

Safety Information

Remind students to review all safety precautions and to observe laboratory rules.

Teaching Tips

- Before the lab, review the meaning of pH with students. Be sure they understand that pH is logarithmic. A solution with a pH of 3, for example, is ten times more acidic than a solution with a pH of 4.
- Discuss acid rain and how it affects limestone. Show students limestone rocks.
- Explain that limestone is composed mainly of calcite (calcium carbonate), a crystal that is dissolved easily by acid rain.
- Bring in an antacid package. Tell students that calcium carbonate is a primary ingredient in many antacids because of its ability to neutralize acids.

Extensions

Students can investigate how the level of acidity of acid rain affects limestone by repeating the experiment using simulated rainwater with different pH values. Add enough vinegar to distilled water to prepare solutions with pH values of 2.5, 3.5, 4.5, and 5.5. Have them repeat the experiment for each of these solutions and compare the results. Students also can collect rainwater over an extended period and determine if the acidity changes over time.

Pre-Lab Answers

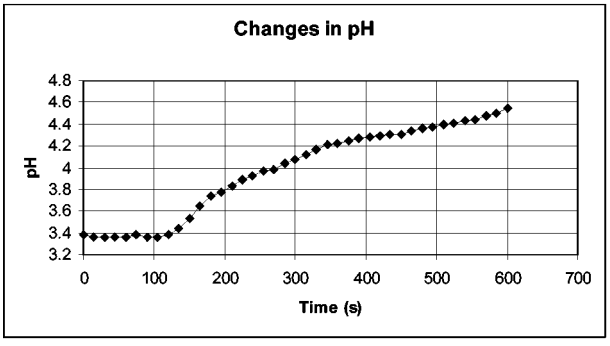
1. The pH scale is a measure of acidity. A substance with a pH of 7 is neutral. A substance with pH less than 7 is acidic, and a substance with pH greater than 7 is basic.

2. less acidic

3. The solution would become less acidic and the pH would rise.

4. A solution with a pH of 3 is ten times more acidic than a solution with a pH of 4.

A sample graph is shown below.



Name Date Class

LAB 6 Probeware Activity

The Effect of Acid Rain on Limestone

Acid rain is harming some of the world's most beautiful structures. Ancient Mayan pyramids in Mexico are crumbling because the acidic rainwater slowly dissolves minerals in the rocks. The Taj Mahal in India has undergone extensive and costly reconstruction to repair damage from acid rain. Buildings and monuments in Washington, D.C. are slowly weathering because precipitation in the area is ten times more acidic than unpolluted rainwater. In this activity, you will observe the effect that acid rain has on limestone. Limestone is the type of rock that was used in the construction of many of the damaged structures. It is composed primarily of calcite (calcium carbonate), a mineral that is dissolved easily by weak acids.

What You'll Investigate

- What is the pH of rain in your area?
- How does the pH of acid rain change when limestone is added to it?
- What effect does acid rain have on limestone?

Goals

Measure the pH of rainwater.
Observe the effect that limestone has on the pH of acid rain.
Infer the effect that acid rain has on limestone buildings and monuments.

Materials

CBL 2 or LabPro unit
TI graphing calculator
link cable
DataMate program
pH probe
150-mL beaker
400-mL beaker
distilled water
1-L glass jar
pea-sized limestone pebbles (5)

Safety Precautions

- Always wear safety goggles and a lab apron.

Pre-Lab

1. Explain the pH scale.

2. If the pH of an acidic solution rises, does this indicate that the solution is becoming more acidic or less acidic?

3. What effect would adding a basic substance have on the pH of an acidic solution?

4. The pH scale is logarithmic. How does a pH of 3 compare to a pH of 4?

Name Date Class

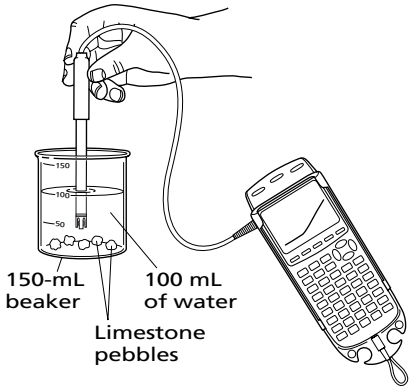
Probeware Activity 6 (continued)

Procedure

Part A: Preparing the CBL System

1. Place a glass jar outside, away from trees and buildings, during a rain shower. Collect at least 100 mL of rainwater. Cover the jar until you are ready to use it.
2. Connect the pH probe into channel 1 of the CBL 2 unit, as shown in **Figure 1.** Connect the CBL 2 unit to the graphing calculator.

Figure 1



3. Turn on the graphing calculator and start the DataMate program. Press CLEAR to reset the program. The pH probe should be recognized automatically. If not, turn to page *vi* for instructions on how to set up the probe manually.
4. Select **SETUP.** Press the up arrow once to select **MODE: TIMEGRAPH.** Press ENTER.
5. Select **TIME GRAPH.** Select **CHANGE TIME SETTINGS.** The screen will display "Enter the time interval between samples in seconds."
6. Press 1 5 ENTER.
7. The screen will display "Enter number of samples." Press 4 0 ENTER. The CBL 2 unit will collect data every 15 seconds for 10 minutes. Select **OK** twice.

Part B: Collecting Data

1. Partially fill a 400-mL beaker with distilled water. This will be the soaking solution.
2. Carefully unscrew the pH sensor from the storage-solution bottle sliding the cap and o-ring up the barrel of the sensor. Set the storage bottle aside. Over a sink, rinse the sensor with distilled water and place it in the soaking solution.
3. Pour 100 mL of rainwater into a 150-mL beaker. Insert the pH probe and watch the pH reading at the top right of the calculator screen. When the reading has stabilized, select **START.**
4. Gently swirl the pH probe in the rainwater. After about 2 minutes, add the limestone pebbles to the rainwater.
5. Gently swirl the pH probe until the recording period ends. Remember that the probe is fragile. Be sure the recording tip remains submerged but do not allow it to hit the pebbles or the side of the beaker.
6. At the end of 10 minutes, the CBL 2 unit will make a tone. Remove the pH probe from the rainwater, rinse it over a sink, and place it in the soaking solution.
7. Sketch and label your graph in the space below.

Probeware Activity 6 (continued)

Part C: Examining the Data

1. Observe the graph, noting what happened to the graph when the limestone was added.
2. Determine the initial pH of the rainwater before the limestone was added.
   - **a.** Return to the main screen by pressing ENTER. Select **ANALYZE.** Select **STATISTICS.**
   - **b.** Press ENTER to select the beginning of the graph.
   - **c.** Use the right arrow key to select a point just before the limestone was added. Press ENTER.
   - **d.** Record the mean, which is the initial pH, in the **Data Table**. Press ENTER.
3. Determine the pH after adding the limestone pebbles.
   - **a.** Select **RETURN TO THE MAIN SCREEN.** Select **GRAPH.**
   - **b.** Use the right arrow to select the last point on the graph. In the table below, record the *y*-value shown in the lower right corner of the screen. This is the final pH.
4. When you are finished with the graph, press ENTER. Select **QUIT.**

Data Table: pH Change

Initial pH	*3.3*
Final pH	*4.6*
pH Change	*1.3*

Cleanup and Disposal

1. Remove the pH probe from the soaking beaker. Carefully place it in the storage-solution bottle.
2. Turn off the calculator and disconnect the pH probe and CBL 2 unit.
3. Follow your teacher's instructions for disposing of the contents of the beakers and returning all equipment to its proper location.

Conclude and Apply

1. Look at the graph of your data. What was the approximate time (*x*) when you added the limestone? How can you tell?

   Answers will vary. In the sample data, the limestone was added at about x = 120 s. A short time later, the pH of the solution began to rise.

2. Why did the graph change after you added the limestone? Calculate the change in pH.

   The acid began to dissolve the calcium carbonate in the limestone. The acidity of the rainwater decreased. Students should subtract the initial pH from the final pH.

3. What would you expect your graph to look like if you continued taking data for 10 additional minutes? How would this affect your final pH and the change in pH? How could you test this?

   Students might expect the pH to continue rising and eventually level off. The final pH would be higher than the value they recorded, and the pH change would be greater. They could test this by repeating the experiment using the same amount of limestone and water but allowing it to continue for 20 minutes.

4. Infer from your experiment how acid rain would affect a monument made of limestone.

   Students should infer that acid rain would gradually dissolve the calcite in the monument, eventually damaging it.

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