Experiment
29

Acid Rain

Acid rain is a topic of much concern in today's world. As carbon dioxide gas, CO_2, dissolves in water droplets of unpolluted air, the following reaction happens

$$CO_2 + H_2O \longrightarrow H_2CO_3$$

H_2CO_3 is a weak acid that causes the rain from unpolluted air to be slightly acidic.

Oxides of sulfur dissolve in water droplets to cause more serious problems. Sulfur trioxide dissolves to produce sulfuric acid, H_2SO_4, by the equation

$$SO_3 + H_2O \longrightarrow H_2SO_4$$

The acidity of a solution can be expressed using the pH scale, which ranges from 0 to 14. Solutions with pH above 7 are basic, solutions with pH below 7 are acidic, and a neutral solution has a pH of 7. In Part I of this experiment, you will study the effect of dissolving CO_2 in distilled water, which is similar to rain water, on the pH of the water. Then in Part II, you will study the effects of dissolving sulfuric acid on the pH of different water types.

OBJECTIVES

In this experiment, you will

- Use a computer to measure pH.
- Study the effect of dissolved CO_2 on the pH of distilled water.
- Study the effect on pH of dissolving H_2SO_4 in various waters.
- Learn why some bodies of water are more vulnerable to acid rain than others.

MATERIALS

computer
Vernier computer interface
Logger*Pro*
Vernier pH Sensor
ring stand and utility clamp
250 mL and 100 mL beaker
rinse bottle with distilled water
drinking straw
dilute H_2SO_4
hard water (well water)
soft water (tap water)
buffer solution

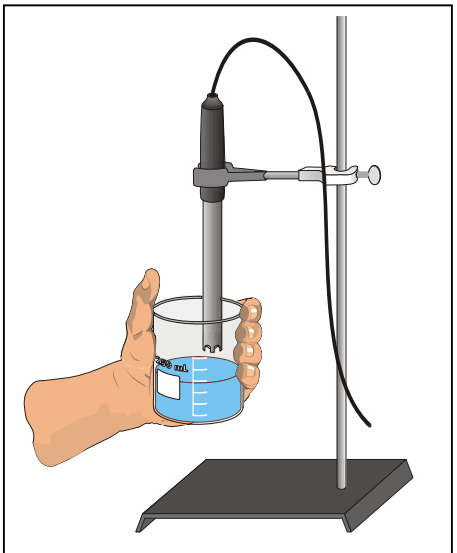

Figure 1

PROCEDURE

Part I CO_2 and Distilled Water

1. Obtain and wear goggles!
2. Connect the pH Sensor to the computer interface. Prepare the computer for data collection by opening the file "29a Acid Rain" from the *Physical Science w Computers* folder.
3. Raise the pH Sensor from the "Temporary Storage Solution" and set the solution aside. Use a rinse bottle filled with distilled water to thoroughly rinse the pH Sensor as shown by your teacher. Catch the rinse water in a 250 mL beaker.
4. Wash a 100 mL beaker with tap water and dry it with a paper towel. Note: All glassware must be clean in this experiment! Get a 50 mL portion of distilled water in this clean beaker. Lower the pH Sensor into the distilled water and swirl the water around the sensor briefly. Be careful not to damage the sensor!
5. Click Collect to begin data collection. After the computer registers the initial pH, use a straw to blow your breath, containing CO_2, into the distilled water for 100 seconds.
6. Click the Statistics button, . Record the minimum and maximum pH values.
7. Print copies of the graph as directed by your teacher.

Part II H_2SO_4 and Distilled Water

8. Open the file "29b Acid Rain."
9. Prepare the pH Sensor for reuse.
   a. Rinse it with distilled water from a rinse bottle.
   b. Place the Sensor into the "Temporary Storage Solution" and swirl the solution about the Sensor briefly.
   c. Rinse with distilled water again.
10. Wash and dry the 100 mL beaker. Get a new 50 mL portion of distilled water. Place the pH Sensor into the distilled water.
11. Before adding any H_2SO_4 solution
    a. Click Collect.
    b. When the pH stabilizes, click Keep, and then type "0" in the edit box (for 0 drops

added). This gives the pH of the water before any H_2SO_4 solution is added.

c. Click OK. The pH and Acid Drop values are now saved.

12. You are now ready to begin adding H_2SO_4 solution. **CAUTION:** Sulfuric acid can cause burns. Avoid inhaling its vapors. Avoid contacting it with your skin and clothing.

    a. Add 1 drop of H_2SO_4 solution to the distilled water.

    b. Swirl to ensure thorough mixing.

    c. When the pH stabilizes, click Keep, and then enter "1" (the total drops added).

    d. Press ENTER.

13. Repeat the Step 12 procedure, entering "2" this time.

14. Repeat the Step 12 procedure, entering "3" this time.

15. Click Stop to end data collection. Record the pH values displayed in the table in your data table.

16. H_2SO_4 AND HARD WATER

    a. Clean the sensor using the Step 9 sequence of washes.

    b. Wash and dry the 100 mL beaker.

    c. Get a 50 mL portion of "Hard Water" in the 100 mL beaker, lower the pH Sensor into this water, and then briefly swirl the water about the Sensor.

    d. Repeat Steps 11-15 for this sample.

17. H_2SO_4 AND SOFT WATER

    Repeat the Step 16 procedure using "Soft Water."

18. H_2SO_4 AND BUFFER SOLUTION

    Repeat the Step 16 procedure using "Buffer Solution" from your teacher.

REPORT SHEET

NAME_____DATE_____

DATA

Part I

Maximum pH _____ Minimum pH _____

Part II

pH Readings

Drops	Distilled Water	Well Water	Tap Water	Buffer Solution
0	_____	_____	_____	_____
1	_____	_____	_____	_____
2	_____	_____	_____	_____
3	_____	_____	_____	_____

PROCESSING THE DATA

1. Calculate the change in pH (ΔpH) for Part I (CO_2). Subtract the minimum pH from the maximum pH.

2. Calculate the change in pH (ΔpH) for each of the Part II trials. Subtract the final pH from the initial pH.

3. Compare the Part II ΔpH values. Which test gave the largest pH change? Which test gave the smallest pH change?

4. Why is H_2SO_4 in acid rain more damaging than H_2CO_3?

5. Hard water from much of the Midwestern United States is said to be "naturally buffered." From the results of this experiment, what does this mean?

6. How does hard water from the Midwest become "buffered"?

7. Many aquatic life forms can only survive in water with a narrow range of pH values. In which water, Midwestern or New England, would living things be more threatened by acid rain? **Explain**.

8. There are numerous coal-burning electric power plants along the Ohio River in the Midwest. However, air pollution produced there is more harmful to water life in New England than in the Midwest. A similar situation exists in Europe where air pollutants from highly industrialized Germany are more harmful to Scandinavian water life than to water life in Germany. Use the results of this experiment to explain these situations.