**Acid Rain**

**LAB 22**

From *Chemistry with Vernier*

1. The water in Part I should be boiled, cooled, and stored in a bottle filled to capacity. This will prevent the CO2 from the atmosphere from affecting its pH. Alternatively, you can adjust the pH with 0.050 M NaOH to about 7. The latter option is much easier to accomplish.
2. To prepare the dilute (0.02 M) H2SO4 solution, dilute 1.1 mL of concentrated sulfuric acid into distilled water to make a total volume of 1 L.
3. If ocean water is not available, synthetic ocean water can easily be prepared:

? Dissolve the following ingredients, one at a time in the order given, in 800 mL of distilled water: 23.2 g NaCl, 1.11 g CaCl2, 6.46 g MgCl2.

? Add 0.84 g of NaHCO3 slowly with rapid stirring.

? Add 5.40 g Na2SO4.

? Bring the volume up to 1 L with distilled water.

? Bring the pH of the solution to 7.8, using 0.01 M NaOH.

? Fill the bottle completely and stopper it tightly. This will prevent the pH from lowering due to the absorption of CO2.

1. If lake water is not available, hard or soft water might be used, depending upon the local water characteristics:

A recipe for hard water follows:

? To 800 mL of distilled water, add 0.12 g CaCO3; 0.10 g CaSO4; 0.038 g MgCl2.

? With rapid stirring, slowly add 0.10 g NaHCO3.

? Bring the volume up to 1 L with distilled water. A recipe for *softened* hard water follows:

? To 800 mL of distilled water, add 0.191 g NaCl; 0.107 g Na2SO4.

? With rapid stirring, slowly add 0.109 g NaHCO3.

? Bring the volume up to 1 L with distilled water.

1. To prepare a buffer solution, add up to four times the recommended amount of water to a commercially available pH 7 buffer tablet. Since the amount of acid added is very small, the buffer tablet need not be made to full strength.

Vernier Software sells a pH buffer package for preparing buffer solutions with pH values of 4, 7, and 10 (order code PHB, $10). To prepare a standard solution, simply add the capsule contents to 100 mL of distilled water. This solution can be diluted to 500 mL for this experiment.

You can also prepare a pH 7 buffer using the following recipe: Add 582 mL of 0.1 M NaOH to 1000 mL of 0.1 M potassium dihydrogen phosphate.

1. The pH calibration that is stored in the DataMate program works well for this experiment. For more accurate pH readings, you (or your students) can do a 2-point calibration for each pH system using pH-4 and pH-10 buffers.

# SAMPLE RESULTS

The following data will be different from students’ results.

**Part I**

|  |
| --- |
| Table 1: Adding CO2 from the breath to water. |
| Time (s) | 0 | 10 | 20 | 30 | 40 | 50 | 60 | pH |
| pH | 6.1 | 5.1 | 4.8 | 4.6 | 4.6 | 4.6 | 4.6 | 1.5 |

**Part II**

The following data were taken from the Puget Sound area.

|  |
| --- |
| Table 2 |
| Drops | pH of this water type |
|  | distilled | ocean | lake | buffer |
| 0 | 6.5 | 6.4 | 7.2 | 7.1 |
| 1 | 4.3 | 6.3 | 6.4 | 7.0 |
| 2 | 3.9 | 6.2 | 6.1 | 6.6 |
| 3 | 3.7 | 6.2 | 5.8 | 6.4 |
| 4 | 3.5 | 6.1 | 5.6 | 6.3 |
| 5 | 3.4 | 6.1 | 5.4 | 6.2 |
| 6 | 3.4 | 6.0 | 5.3 | 6.1 |
| 7 | 3.3 | 6.0 | 5.2 | 6.0 |
| 8 | 3.2 | 5.9 | 5.1 | 5.9 |
| 9 | 3.2 | 5.9 | 5.0 | 5.8 |
| 10 | 3.1 | 5.8 | 5.0 | 5.7 |
| pH | 3.4 | 0.6 | 2.2 | 1.4 |


# ANSWERS TO QUESTIONS

1. Exhaled breath contains carbon dioxide that causes the water to become acidic—CO2 reacts with the water to make carbonic acid, H2CO3.
2. As the water becomes saturated with CO2, no more CO2 can dissolve in the water. When this happens, no more H2CO3 is formed, so the pH remains stable.
3. Answers may vary.
4. The distilled water should yield the largest change, followed by lake water, ocean water, and the buffer. The buffer should resist pH changes more than the others.
5. Buffers resist pH changes. As acid is added to the ocean water, the pH changes less than with other natural water sources.
6. The ocean water is buffered due to a mixture of salts. Some of these salts are capable of resisting changes in pH.
7. Living things would be more threatened by acid rain in lake water, as it is not as well buffered as ocean water.
8. Winds may blow polluted air vast distances. Acid rain may affect bodies of water far from the polluted air’s origin, especially if the acid rain falls in unbuffered waters.
9. Student answers may vary.

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