MS20 Laboratory: Buffering Capacity of Sea Water

Objectives

- To clarify the definitions of acid, base, and neutral pH through experimentation.
- To demonstrate the concept of a buffered solution.
- To experimentally evaluate the buffering capacity of seawater.
- To extrapolate information about pH and buffering capacity to current environmental events.

Acids are compounds that have a sour taste, turn litmus red, and react with bases to yield salts. Bases taste bitter and turn litmus blue. Litmus is a natural dye found in seaweeds, but natural dyes from any flower or vegetable respond to changes in acidity by changing color (the particular color depending on the dye).

It appears that the ability to donate a proton or hydrogen ion (H⁺, or H₃O⁺ in water solutions) is the molecular property common to all acids that gives them the observable properties mentioned above. Bases are characterized by their ability to accept hydrogen ions, and some bases contain the free hydroxide ion, OH⁻, which can accept hydrogen ions to form water.

The pH of a solution is a measure of its acidity or basicity. A very strong acidic solution would have a pH of 1, while a strongly basic solution could have a pH of 12 and a neutral solution, like pure water, would have a pH of 7.0. The pH scale is actually a logarithmic (or exponential) measure of the hydrogen ion concentration, in moles of hydrogen ion per liter of solution:

\[ pH = -\log [H^+] \]

Color indicators can be used for rough determinations of pH in solutions that are otherwise colorless. A pH meter must be used for precise pH measurements, or when coloring agents are present that would mask the color changes of an indicator.

Procedure 1. The Effect of Acid Addition on pH of Distilled Water

Place 20mL of distilled water in each of two 50mL beakers. Label them Xc (concentrated acid) andXd (dilute acid). Measure the pH of each beaker and record. To beaker Xc you will successively add 1 to 10 drops of 1.0M HCl acid (concentrated acid), testing the pH following the addition of each drop. Repeat the procedure in beaker Xd with drops of 0.1M HCl (dilute acid). Enter the results in Table One. Flush the contents of both beakers down the sink.

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<th># drops</th>
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Procedure 2. The Effect of Acid Addition on pH of Sodium Acetate Solution

Rinse beakers from previous activity with distilled water at least three times. Place 20 mL of 0.1M sodium acetate (a buffer solution) into each beaker labeled Xc andXd. Repeat the addition of drops of concentrated acid and dilute acid to the appropriate beaker carefully recording the effect of adding one to five drops on the pH. Now you will try to overload the buffer by adding the acid in 5-drop increments to see at what point the buffering is no longer effective. Record the results in Table two.

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Procedure 3. The Effect of Acid Addition on pH of Sea Water

Repeat the preceding exercise using 20 mL of seawater in each beaker. Record the results in Table three.

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Analysis
1. Plot the data for the concentrated acid (beaker Xc) from Tables One-Three on one sheet of graph paper.

REMINDER: The pH scale is logarithmic!

2. Plot the data for beaker Xd (dilute acid) from Tables One-Three on a second sheet of graph paper.

3. Using the concentrated acid data, calculate the percent difference between the pH of the 0.1M sodium acetate and the seawater solutions using the distilled water as a reference. Do this for three different volumes of acid added. Use this information and the graph to evaluate the response of the two "buffered" solutions to the addition of a concentrated acid. Comment also on how this differs from the response of pure distilled water.
4. Calculate the rate of pH change for distilled water with the addition of both the concentrated acid and the dilute acid. You will want to calculate this change over a portion of the graph that is linear (still demonstrating a change in pH). If you have difficulty with this calculation please include an explanation. Comment on the significance of the differences or similarities in the pH change of distilled water in response to the addition of a concentrated versus a dilute acid.

5. Now calculate the rate of pH change for both 0.1M sodium acetate and seawater solutions with the addition of the dilute acid. You will again want to calculate this change over a portion of the graph that is linear. Attempt to propose a practical explanation for why it might be more valuable to focus on the effects of the dilute acid, rather than the concentrated acid. Discuss your results in terms of the buffering capacity of seawater versus the artificial buffer.

6. Use the information you have gathered during this lab to discuss the potential impact of acid rain on the ocean. How might this differ from the impact of acid rain on a freshwater lake?

7. What have you learned about buffering capacity by doing this lab exercise?