Chemistry: Buffers

Buffers are compounds that bind or release hydrogen ions to maintain a solution's pH within a given range. Through their activity buffers prevent wide swings in the pH of any solution. pH is one of most closely controlled characteristics of all living things, whether it is the cytoplasm of a single-celled organism or the blood plasma of a complex multi-cellular organism. Maintaining the correct pH range is essential for life. Buffers maintain the pH of the blood with the range of pH 7.35-7.45. Blood plasma contains 3 separate buffering systems. Proteins in the plasma provide some buffering in the blood by binding and releasing hydrogen ions. The blood is also buffered by a potassium buffering system, but the most important buffering system in the blood is the carbonate-bicarbonate buffering system. Carbon dioxide released as a waste product from cells dissolves in the plasma and combines with water to form carbonic acid. Carbonic acid in turn dissociates to release hydrogen ions and bicarbonate. Depending on the pH of the solution, the reaction shifts either forward or backward to maintain pH within the acceptable range.

water carbon dioxide carbonic acid bicarbonate hydrogen ion

$$H_2O + CO_2 \leftrightarrows H_2CO_3 \leftrightarrows HCO_3^- + H^+$$

This activity is intended to exemplify the action of buffers. The student will add acid slowly to distilled water and milk until the initial pH has changed 1 unit.

Write a hypothesis for your experiment. What are you trying to determine? What result do you expect?

Materials

Milk (1%)
Distilled water
Pipette
pH indicator paper
Graduated cylinder (50 mL)
Medium beaker (100 mL) – 2
Small beaker (50 mL) – 1

Procedure

1. Pick up a graduated cylinder, 1 small and 2 medium beakers from the supply table.

2. Use the graduated cylinder to obtain 25 mL of distilled water. Pour the water into one of the medium beakers.

3. Use the graduated cylinder to obtain 25 mL of milk from the supply table. Pour the milk into the second empty medium beaker. Wash the graduated cylinder.

4. Use the graduated cylinder to obtain 20 mL of HCl from the supply table. Pour the HCl into the small beaker.

5. Measure the pH of the milk and distilled water in the beakers using a 1 inch strip of pH indicator paper. Record the pH here: Initial pH of water _____ Initial pH of milk _____

Why do you think the pH of water is not 7?

6. Fill the pipette with HCl. Add 3 drops of acid into the beaker of water. Swirl the beaker. Measure the pH. Record the pH value here _____.

7. Continue adding drops of HCl until the pH value of the water has decreased one full pH unit. Count your drops! How many drops were needed to change the pH of distilled water by one pH unit? _____

8. Refill the pipette with HCL. Add 3 drops to the beaker of milk. Swirl the beaker. Measure the pH with the indicator paper. Record the pH value here. _____

9. Continue adding drops of HCl until the pH value of the milk has decreased one full pH unit. Count your drops! How many drops were needed to change the pH of milk by one pH unit? _____

	Initial pH	Acid or Base?	Final pH	Total number of drops
water				
milk				

From your experiment, which solution water or milk had the higher buffering capacity?

How did you know?

Speculate on what provided the buffering capacity in the solution you identified as having the greatest buffering capacity?

Was your hypothesis supported? Why or why not?

What was the independent variable? _____

What was the dependent variable? _____