PREPARING BUFFERS AND BUFFER CAPACITY

LAB

From Juniata College, Science in Motion

INTRODUCTION

A buffer solution is one that is resistant to change in pH when small amounts of strong acid or base are added. For example, when 0.01 mole of strong acid or base are added to distilled water, the pH drops to 2 with the acid and rises to 12 with the base. If the same amount of acid or base is added to an acetic acid – sodium acetate buffer, the pH may only change a fraction of a unit.

Buffers are important in many areas of chemistry. When the pH must be controlled during the course of a reaction, the solutions are often buffered. This is often the case in biochemistry when enzymes or proteins are being studied. Our blood is buffered to a pH of 7.4. Variations of a few tenths of a pH unit can cause illness or death. Acidosis is the condition when pH drops too low. Alkalosis results when the pH is higher than normal.

Two species are required in a buffer solution. One is capable of reacting with ^-OH and the other will react with H_3O^+. The two species must not react with each other. Many buffers are prepared by combining a weak acid and its conjugate (acetic acid and sodium acetate) or a weak base and its conjugate (ammonia and ammonium chloride). In general, the pH range in which a buffer solution is effective is +/- one pH unit on either side of the pKa. The Henderson–Hasselbalch provides the information needed to prepare a buffer.

$$Ph = PkA + \log \frac{[conjugate base]}{[weak acid]}$$

There is a limit to the amount of acid or base that can be added to a buffer solution before one of the components is used up. This limit is called the buffer capacity and is defined as the moles of acid or base necessary to change the pH of one liter of solution by one unit.

$$\text{Buffer Capacity} = \frac{\text{(number of moles of } ^-OH \text{ or } H_3O^+ \text{ added)}}{\text{(pH change)(volume of buffer in L)}}$$

In this experiment, the Henderson-Hasselbalch equation will be used to determine the amount of acetic acid and sodium acetate required to prepare a series of buffer solutions. Once the buffer solutions have been prepared, their buffer capacity will be determined.

PURPOSE

The purpose of this experiment is to prepare buffer solutions and to determine their buffer capacity.

EQUIPMENT/MATERIALS

acetic acid (0.10, 0.30, 0.50M)   NaOH
sodium acetate   2 burets
buret clamp   pH probe, LabQuest
standard buffer solution (pH 4 & 7)   magnetic stirrer (if available)
100 mL graduated cylinder   250 mL beaker

SAFETY

- Always wear an apron and goggles in the lab.

- Report any spills so they may be cleaned up.

PROCEDURE

1. Before preparing the buffer solutions, you must determine the amount of acetic acid and sodium acetate required. The K_a of acetic acid is 1.8×10^{-5}. You will be using one of the provided acetic acid solutions (0.1M, 0.30 M, or 0.50M). Your instructor will assign one of these solutions for your group.

    a. Calculate the number of moles of acetic acid present in 100 Ml of your assigned acetic acid solution.

    b. If equal moles of sodium acetate and acetic acid are required to make an effective buffer, how many moles of sodium acetate need to be added to your acetic acid solutions?

    c. Calculate the number of grams of sodium acetate needed using its molar mass.

2. Check your calculations with your instructor before proceeding.

    a. In a graduated cylinder measure 100 mL of your assigned acetic acid solution and transfer it to a 250 mL beaker.

    b. Weigh out the correct mass of sodium acetate and dissolve it in the acetic acid solution to make your buffer.

3. Attach pH probe to LabQuest.

4. Measure the pH of the buffer solution that your group prepared. Record the value in your data table.

5. Set up two burets, buret clamp, and ring stand (see Figure 1). Rinse and fill one buret with 0.100 M NaOH solution. Rinse and fill the second buret with the buffer solution that you prepared. Make sure that the tips of the burets are filled and that the level of the liquids is at or below the 0.00 mL line.

6. Connect the pH Sensor to LabQuest. Suspend the pH Sensor in the buffer solution, as shown in Figure 1. Make sure that the sensor is not struck by the stirring bar.

7. Transfer 10.00 mL of the buffer solution to a 250 mL beaker and add some distilled water. If a magnetic stirrer is to be used, keep the tip of the electrode above the stir bar.

8. Begin adding the NaOH to the buffer solution in small increments, i.e. 0.05-0.1 mL. After each addition, record the total volume of NaOH added and the pH of the solution in the data table.

9. Continue adding the NaOH solution until the pH has risen at least one pH unit.
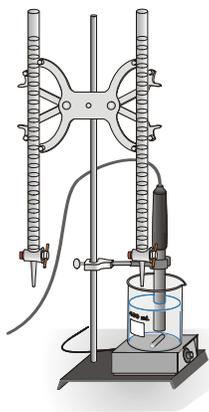
10. Repeat as time allows.

Figure 1

DATA

Buffer Prepared: _____

Concentration: _____

pH of buffer solution _____

	Trial 1	Trial 2	Trial 3
Initial pH of Buffer			
mL of Buffer			
mL of NaOH			
Final pH			

CALCULATIONS

1. Summarize the data for your titrations in the table below.

	Trial 1	Trial 2	Trial 3
Vol of buffer, mL			
Vol of buffer, L			
Change of pH			
Vol 0.100 M NaOH			
Moles of NaOH			
Buffer Capacity			

2. Show the calculations for one of the trials above.

3. What was the average buffer capacity for the buffer that your group prepared?

QUESTIONS

1. How does the concentration of the buffer affect the buffer capacity?

2. What differences would be observed if HCl were used in place of NaOH?

3. Write equations to show how a buffer works.