Experiment 8: How to measure buffer capacity

Procedure

In this lab you will

- measure the pH of salt solutions
- investigate buffer capacity when a strong acid or a strong base is added to buffer solutions.
- design and prepare a buffer of specific pH.

Part 1. Measuring pH of salt solutions

1. Collect three dry and clean 50 mL beakers and label them A, B, and C.
2. Add a small amount (approximately 30 mL) of 0.10 M NaCl into beaker A, 0.10 M Na_2CO_3 into beaker B, and 0.10 M $NaHSO_4$ into beaker C.
3. Measure the pH of each solution and record each result in your lab notebook. Make sure you rinse the pH probe between pH measurements.
4. Write an equation that represents the equilibrium reaction to explain the pH readings.

Part 2. Measuring buffer capacity when a strong acid or a strong base is added to buffer solutions.

1. Obtain six 50 mL beakers. **Label** them 1-6.
2. Obtain about 100 mL of 0.50 M acetic acid (CH_3COOH) and 0.50 M of sodium acetate (CH_3COONa).
3. Using a 50 mL graduated cylinder, add the volumes of 0.50 M CH_3COOH indicated in the table below to each of the beakers.

Beaker #	Volume of 0.50 M CH_3COOH (mL)	Volume of 0.50 M CH_3COONa (mL)
1	30.0	0.0
2	24.0	6.0
3	18.0	12.0
4	12.0	18.0
5	6.0	24.0
6	0.0	30.0

4. Rinse out the graduated cylinder and measure out the volumes of 0.50 M CH_3COONa shown in the table above and add to the beakers 1-6.
5. Swirl the solutions in each beaker or use a stirring rod (rinsed between solutions) to mix them.
6. Measure the pH of a solution.
7. Record the pH of the solutions in each of the beakers. Don't forget to rinse the pH electrode using the wash bottle between the measurements.

Addition of a strong acid

1. Obtain about 20.0 mL of 3.0 M HCl and a digital pipet with a tip.
2. Using a digital pipette, add 1.0 mL of HCl solution to each beaker and stir the solutions.
3. Measure and record the pH of each solution. Don't forget to rinse the pH electrode using the wash bottle between the measurements.
4. If the pH of a solution changes by **more than 1.0 pH unit** from the initial measurement, then the acid buffer capacity has been exceeded, and the solution can be discarded. You can say that the solution has no buffer capacity.

5. Add another 1.0 mL of 3.0 M HCl to the remaining buffer solutions, stir and record the pH of each of the solution. If any of the pH measurements differs by more than 1.0 pH unit from the initial measurement, discard the solution as the buffer capacity has been exceeded.
6. Repeat the previous step until the acid buffer capacities of all the solutions have been exceeded. If the pH has not changed by 1.0 pH unit from the initial pH after the addition of 3 mL of the acid, then the buffer capacity of this solution was never reached.

Addition of a strong base

1. Rinse out all the small beakers and make the buffer solutions again as described in the table above. Measure each solution's pH and record the values.
2. Obtain about 30.0 mL of 3.0 M NaOH.
3. Rinse the tip for the digital pipet.
4. Add 1.0 mL of NaOH solution to each beaker and stir the solutions.
5. Measure and record the pH of each solution. Discard any solutions with pH change of more than 1.0 pH units.
6. Repeat steps 4 and 5 until the buffer capacities of all the solutions have been exceeded. If the pH has not changed by 1.0 pH unit from the initial pH after the addition of 3 mL of the base, then the buffer capacity of this solution was never reached.
7. When you are finished making measurements, rinse the electrode with DI water.

Part 3. Designing and preparing a buffer of a specific pH.

1. You will be assigned a specific pH by your TA. Record the value in your lab notebook and determine which buffer system available would be appropriate to design a buffer of this assigned pH. You should use the table below.
2. Check with your TA to make sure you've selected the correct buffer system.
3. Calculate the volume of each solution you need to prepare buffer solution of your target pH. You should choose either acid or base to begin with 20 mL and determine the volume you need of the other solution to have the correct base/acid ratio for your target pH.
4. **Record** all your calculations in your notebook.
5. Measure the determined volumes of each solution into a clean and dry beaker.
6. Measure the pH value of the solution. Record it.
7. Clean up your bench. The materials you used in the lab are safe to dispose down the drain.

Weak acid (or base)	**Conjugate base (or acid)**	**pK_a value**
0.5 M Acetic acid (CH_3COOH)	0.5 M Sodium Acetate (CH_3COONa)	4.76
0.1 M Sodium bicarbonate ($NaHCO_3$)	0.1 M Sodium carbonate (Na_2CO_3)	10.3
0.1 M Sodium phosphate monobasic (NaH_2PO_4)	0.1 M Sodium phosphate dibasic (Na_2HPO_4)	7.21
0.1 M Ammonia (NH_3)	0.1 M Ammonium Chloride (NH_4Cl)	9.25

Data Analysis (done in the lab!)

	1. Open the lab report on Labflow. 2. Enter all the data. 3. Calculate the concentrations of CH_3COOH and CH_3COO^- in each beaker. 4. Calculate the theoretical pH for each solution. 5. Show the results of your calculations to your TA **BEFORE** leaving the lab!