## Buffer solutions Virtual Lab

**Goals**

1. **To examine the behavior of buffer solutions.**
2. **Learn to prepare buffers in different ways.**
3. **Test the capacity of the different buffers.**

**Background**

A buffer is a solution that resists changes in pH and contains a conjugate acid-base pair.



In equation 1, the weak acid is HA and the conjugate base is A-. Qualitatively, the action of a buffer can be understood by considering the Law of Mass Action on equation 1. If both HA and A- are present and acid is added to the solution, the added H3O+ is consumed by reaction with A- to produce HA, and the overall [H3O+] does not increase very much. If, on the other hand, some base, OH-, is added, the added OH- is consumed by reaction with HA, and again the overall [H3O+] does not decrease very much. At some point the capacity of the buffer to remove additional acid or base is exceeded, and the [H3O+] does not stay constant. A buffer with a high capacity can maintain its buffering action after the addition of more strong acid or base than one with a small capacity. The buffer becomes exhausted when most of the weak base has been converted to acid or when most of the weak acid has been converted to base.

A buffer solution can be prepared by mixing similar numbers of moles of a weak acid with a salt of its conjugate base. For example, an acetate buffer can be prepared from acetic acid and sodium acetate. In addition, a buffer solution could be prepared by mixing a weak acid with a strong base, for example, acetic acid with sodium hydroxide, or by mixing a weak base with a strong acid, for example, sodium acetate with hydrochloric acid. In all three of these examples, the final buffer solution will contain acetic acid and its conjugate base, the acetate anion.

In order to calculate the theoretical pH of a buffer solution, you must first determine the concentrations of the weak acid and its conjugate base in the buffer solution. Then using these concentrations and the Ka value for the weak acid, you can set up an equilibrium table to calculate the theoretical pH of the buffer solution.

 (2)

As an alternative, the Henderson-Hasselbalch equation can be used to calculate the theoretical pH of buffer solutions.

 (3)

**Pre-lab**

Include a safety assessment of the chemicals used in this experiment and any appropriate safety/ PPE precautions that are appropriate.

Read through the experimental protocol and paraphrase the steps of the procedure in your notebook.

Determine the volume of 1.0 M weak acid needed to prepare 100. mL of 0.10 M weak acid. Also, determine the volume of 1.0 M weak base needed to prepare 100. mL of 0.10 M weak base. Show these calculations in your lab notebook.

**Experimental**

We will use the chemcollective digital workbench to collect this data. <http://chemcollective.org/chem/jsvlab/>

To familiarize yourself with how to work with this simulation, you can watch this

[demonstration video](http://www.chemcollective.org/chem/common/vlab_walkthrouh_html5.php) as well as the video specific to this lab on all labs.

Start by creating 6 workbenches

Workbench 1: Rename as “water”

1. Measure out 30.00mL of water into two separate 250mL Erlenmeyer flasks.
2. Record the pH of the water.
3. Add 2.00 mL of 1M HCl to one flask. Record the pH.
4. Add 2.00 mL of 1M NaOH to the other flask. Record the pH.
5. Rename flasks as appropriate to keep track of the solutions
6. Rename each of the other 5 workbenches with the name of a different buffer (A-E)
7. Follow the instructions in table 1 (below) to prepare the appropriate buffer solutions. Note, if the solution concentration is in blue font, you will need to “prepare” this solution, that concentration is not available in the stockroom. You should use the precise measuring mode for transferring all the solutions.

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| --- | --- | --- | --- | --- | --- | --- | --- |
| Buffer | Vol of  0.10M  acetic  acid | Vol of  0.10M  sodium acetate | Vol of  0.10M  HCl | Vol of  0.10M  NaOH | Vol of  1.0M  acetic  acid | Vol of  1.0M  sodium  acetate | Vol of distilled water |
| A | 15.00 | 15.00 |  |  |  |  |  |
| B | 15.00 |  |  | 7.50 |  |  | 7.50 |
| C |  | 15.00 | 7.50 |  |  |  | 7.50 |
| D | 25.00 | 5.00 |  |  |  |  |  |
| E |  |  |  |  | 15.00 | 15.00 |  |

1. You will have 30.00mL of each buffer. Record the initial pH of these buffers (A-E). Use the table below.
2. Right click on each of these buffers and “duplicate” the solution. Rename these solutions, so if you are working with buffer E, one of these will be E + acid and the other E + base.
3. Add 2.00mL of 1M HCl to each of the buffer flasks that are labelled “+acid”. Record the pH of each buffer after the addition of acid.
4. Add 2.00mL of 1M NaOH to each of the buffer flasks that are labelled “+base”. Record the pH of each buffer after the addition of base.
5. Calculate the theoretical initial pH of solutions A and E. Then, calculate the theoretical pH of solutions A and E after 2 mL of 1.0 M HCl was added to each solution. Don’t forget that when the solutions were mixed together, their concentrations changed. You must account for these changes in your calculations. These calculations will be part of the appendix for your lab report.

**Buffer Solutions**

**Laboratory Report Instructions**

The heading for your report should include your name, your partner’s name, the date and a descriptive title for the experiment.

Include the following sections in your report:

**Introduction**

The introduction section of any report should contain general information pertinent to the topic, one or two specific sentences about the experiment, and should define the question(s) being asked (aim for one paragraph.) For experiments involving reactions, a chemical equation must always be presented in this section. The introduction section should not include a discussion of the experiment, which belongs in the discussion section. It should not be written in the first person, nor should it be a summary or abstract.

**Results and Discussion**

Begin the results section of any report with a sentence about the experiment to put your results in perspective for the reader. Then move onto a summary of the trends in your data and results with a reference to specific tables and figures in your report. Your summary should be a narrative that guides the reader through your tables and figures. For this experiment, you will need to discuss how the addition of a strong acid or base to a buffer solution affects the pH of a buffer solution. How is the effect on pH different when a strong acid or base is added to water? Which buffer had the biggest capacity to withstand the addition of acid and base without changing the pH of the buffer? Explain your answers. You will need to include your specific results in your discussion to strengthen your argument.

Prepare a table showing the pH of each solution. Each column should have a column heading with appropriate units, and the table should have an adequately descriptive figure heading. I suggest that you prepare these tables in Word. Pay attention to significant figures.

**References**

Bibliographic sources referenced in your report (including the lab manual) should be listed here.

**Appendix**

Include clearly labeled, step-by-step calculations for the calculations required in step 12 of the procedure. When completing calculations in lab reports, you must indicate the identity of any variables in an equation and state any assumptions that you make in order to complete the calculation.Also, remember to use the correct number of significant figures and to include your units. Calculations may be hand-written.