Effect of buffers on ph levels

Abstract

A buffer is a solution that helps keep the pH of other solutions at a steady level with the addition of limited acids or bases. The purpose if this experiment was to figure out how to create an optimal buffer and to determine how effective buffers are at stabilizing the pH of different solutions. An optimal buffer was made after calculating the [H+] levels and determining how much weak acid and conjugate base was needed to test when added to beakers containing either acidic or basic solutions. The results found that the buffers helped get the solutions closer to a neutral pH and were found to be effective pH stabilizers.

Introduction

In the real world, pH levels are important in the function of many life processes. For instance, the average human body's average pH level is approximately 7. 4, and if there are any changes to that pH at all, no matter how small it may be, one would eventually get sick and die, since the human body is not meant to handle such a large fluctuation of pH levels. These pH levels are the measurement of Hydronium ions (H_3O^+) in a solution and are measured on a pH scale going from 0 to 14, with 7 being neutral, anything less than 7 would be considered acidic, and anything greater than 7 would be considered basic. One might wonder how a person's pH levels do not change so easily, and the answer is because of a solution is known as a buffer. The main function of buffers is to help keep pH levels steady when a certain amount of acids or bases are introduced in a solution. Once a buffer has reached its limit, the solution will exponentially increase or decrease, depending on if a base or an acid were used, respectively. In the graph shown, it depicts how the buffer helps to keep the pH levels steady for as long as it can, but when too much base is added, the buffer will reach its capacity and the excess base will cause the pH to rise quickly, while an addition of excess base will cause the pH to drop quickly. Buffers are made from weak acids or bases paired with their conjugate bases or acids, and weak acids and bases are used because they do not disassociate fully in a solution and the hydrogen or hydroxide (OH^-) ions will mostly stay connected to the other molecules, unlike strong acids or bases that will completely dissociate into either the hydrogen or hydroxide ions. A good weak acid to use is acetic acid (CH_3COOH), which is commonly found in vinegar. Another thing to keep in mind is how this relates to Le Chatelier’s Principle, which means for acetic acid that if a base were added, the equilibrium would shift to the right to want to produce more hydrogen ions, and if an acid were added, the equilibrium would shift left to want to produce more conjugate base. Lastly, a good buffer should have equal amounts of a weak acid and a conjugate base, which is done experimentally.

Materials and Methods

Materials used:

- Three 250 mL beakers
- One 50 mL graduated cylinder
- One 10 mL graduated cylinder
- An unknown weak acid
- $K_a=[CH_3COO^-]/[CH_3COOH]$
- $pH=-log[H^+]$

- $[H^+] = 10^{-pH}$
- $K_a = ([H^+]*[WA^-])/[HWA]$

Procedures:

1. Obtain three 250 mL beakers, and a 10 mL and a 50 mL graduated cylinder.
2. To the first beaker, add a pipette bulb of the unknown weak acid and 110 mL of distilled water.
3. Measure 50 mL of the acid solution and add it to each of the remaining two beakers, and then wash it out and keep the beaker.
4. Label one beaker [HWA], or acid, and the other $[WA^-]$, or conjugate base.
5. Fill burette with an NaOH solution and add two to three drops of phenolphthalein indicator to $[WA^-]$ beaker and titrate solution using base in burette to indicator end point, which will be signaled through a pink color change, so HWA will be converted to WA^-.
6. Determine the volume of base added to $[WA^-]$ beaker during titration and add that same volume of water to the [HWA] beaker so that the $[HWA]=[WA^-]$.
7. Make an optimal buffer by mixing 20 mL of [HWA] and 20 mL $[WA^-]$ in the third beaker.
8. Prepare pH meter by standardizing it with standard solutions of pH 4 and 7.
9. Take pH of optimal buffer and calculate $[H^+]$ from pH reading.

10. Determine K_a value and show calculations to TA, and a new buffer will be assigned to be made.
11. Using assigned buffer, determine $[H^+]$.
12. Use K_a equation to determine volume of conjugate base needed when 10 mL of acid is used, and use Ka value from step 10, $[H^+]$ value from pH, and 10 mL to replace [CH3COOH] to find volume of $[CH3COO^-]$ needed.
13. Make a new buffer using these volumes in a clean beaker, then take the pH of the new buffer to see how close the found pH is to the assigned value.
14. Get two 50 mL beakers and add 5 mL of new buffer to one beaker and 5 mL of distilled water to the other.
15. Add five drops of NaOH to each beaker and read pH for each one and record both.
16. Thoroughly wash out small beakers and repeat step 13.
17. Add five drops of HCl to each beaker and read pH for each one and record both.
18. Clean up and turn in data sheet.

Results: Data and Calculations

0. 10 M NaOH added to 50 mL of acid mixture:

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Final Burette Reading	34. 7 mL
Volume of NaOH Added	16. 3 mL
pH of Optimal Buffer	4. 7
K_a of Unknown Weak Acid	$2*10^{-5}$

$10^{-4.7} = 2*10^{-5} = K_a$

Assigned pH of new buffer to make: 4. 85

New Buffer Data:

$[H^+]$ needed	$1.41*10^{-5}$
$K_a : [H^+] = (K_a / [H^+])$	1. 42
$[A^-] : [HWA] = (K_a / [H^+])$	1. 42
Volume of A^-	14. 2 mL
Volume of HWA	10 mL
pH of New Buffer	4. 84

$(2*10^{-5})/(1.41*10^{-5}) = 1.42$

Test of New Buffer:

pH of Distilled Water with Acid	2.88
pH of New Buffer with Acid	4.5
pH of Distilled Water with Base	10.9
pH of New Buffer with Base	5.18

Discussion/Conclusion

In conclusion, the results determined that the buffer was effective at stabilizing the pH of both solutions containing distilled water and either an acid or a base added. The results also showed that the new buffer pH was very similar to the assigned pH, indicating that the overall reactions in this experiment were precise and accurate. A buffer is a solution that controls the pH of other solutions it is added in from fluctuating, and it is made by mixing equal amounts of a weak acid with its conjugate base. The reason it needs to be a weak acid because it will not dissociate fully when added in a solution, so the hydrogen ions will mostly be intact and not free floating. This would be able to help the pH of the solution in which it is added stable when combined with the conjugate base that is formed when the hydrogen ion dissociates from its original molecule from which it was connected.

The K_a of the weak acid used in this experiment was determined after titrating NaOH to the acid mixture until the indicator turned light pink and then taking the pH reading of the titrated solution and using the 10^{-pH} formula to find $[H^+]$ which equaled the K_a of the weak acid. The new buffer was then made when the newly assigned pH was taken, the $[H^+]$ needed to achieve that new pH was determined, the K_a value by the needed $[H^+]$ value was divided, and the decimal for the product was moved one decimal place to the right, since the amount of HWA needed was 10 mL, and the pH was then determined from that solution, and it matched very closely to the assigned pH. Lastly, although not major, there was one experimental error that occurred when the solutions prepared in the first part of the lab were accidentally disposed of early, but a new solution was made again which was the same pH of the previous solution, so that error did not affect the overall results of this experiment.