Buffer Lab

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Period 4

**Purpose**

The purpose of this lab was to determine the whether or not two household substances (Sprite and tonic water) have buffering activity and determine the buffer system within the substance through titrations to find pKa and evidence of buffering activity.

**Procedure**

1. Prepare a solution of 10 mL of Sprite and 90 mL of distilled water in a 250-mL beaker.

2. Place a magnetic stirrer in the beaker and place the beaker on the stirrer. Set the stirrer to spin gently.

3. Rinse a buret three times with about 7 mL of 0.1 M NaOH each time.

4. Put the buret on a ring stand and fill the buret with around 45 mL of .1 M NaOH. Record the initial volume.

5. Calibrate a pH probe in a 7.0 pH buffer solution.

6. Set up the pH probe on the ring stand and record the initial pH of the solution in the beaker.

7. Carefully titrate the Sprite solution with 1 mL of .1 M NaOH at a time, recording the volume and pH for each mL added.

8. When pH change is greater than 0.30 per mL of .1 M NaOH added, switch to 0.2 mL of increments of .1 M NaOH, still recording pH and volume for every 0.2 mL added.

9. When pH change is again greater than 0.30 per 0.20 mL of Sprite solution added, switch back to adding 1 mL at a time until pH is 11.50 or greater.

10. Rinse out the beaker with distilled water, and dry it.

11. Prepare a 100 mL solution containing 90 mL of de-ionized water and 10 mL of tonic water.

12. Repeat steps 3,5,7, 8 and 9 with the tonic water solution.

13. Continue titrating until pH is above 10.00 and the change is less than 0.30. Switch back to titrating 1.00 mL at a time, recording the pH and volume after each addition.

**Data**

Table 1: Sprite Titration

|  |  |  |
| --- | --- | --- |
| Buret reading (mL) | Volume NaOH added (mL) | pH |
| 9.40 (initial) | 0 | 2.99 (initial) |
| 10.40 | 1.00 | 4.57 |
| 10.60 | 1.20 | 4.99 |
| 10.80 | 1.40 | 5.20 |
| 11.00 | 1.60 | 5.58 |
| 11.20 | 1.80 | 5.76 |
| 11.40 | 2.00 | 6.17 |
| 11.60 | 2.20 | 6.92 |
| 11.80 | 2.40 | 7.80 |
| 12.00 | 2.60 | 8.39 |
| 12.20 | 2.80 | 8.78 |
| 12.40 | 3.00 | 8.92 |
| 12.60 | 3.20 | 9.09 |
| 13.60 | 4.20 | 9.59 |
| 14.60 | 5.20 | 9.92 |
| 15.60 | 6.20 | 10.16 |
| 16.60 | 7.20 | 10.32 |
| 17.60 | 8.20 | 10.47 |

Table 2: Tonic Water Titration

|  |  |  |
| --- | --- | --- |
| Buret Reading (mL) | Volume NaOH added (mL) | pH |
| 17.50 (initial) | 0 | 2.75 (initial) |
| 18.50 | 1.00 | 2.90 |
| 19.50 | 2.00 | 3.31 |
| 20.50 | 3.00 | 3.89 |
| 21.50 | 4.00 | 4.42 |
| 21.70 | 4.20 | 4.50 |
| 21.90 | 4.40 | 4.69 |
| 22.10 | 4.60 | 4.82 |
| 22.30 | 4.80 | 5.01 |
| 22.50 | 5.00 | 5.15 |
| 22.70 | 5.20 | 5.21 |
| 22.90 | 5.40 | 5.32 |
| 23.20 | 5.70 | 5.53 |
| 23.50 | 6.00 | 5.79 |
| 23.70 | 6.20 | 5.87 |
| 23.90 | 6.40 | 5.93 |
| 24.10 | 6.60 | 6.11 |
| 24.30 | 6.80 | 6.35 |
| 24.50 | 7.00 | 6.67 |
| 24.70 | 7.20 | 7.10 |
| 24.90 | 7.40 | 8.32 |
| 25.10 | 7.60 | 8.84 |
| 25.30 | 7.80 | 9.24 |
| 25.50 | 8.00 | 9.36 |
| 26.50 | 9.00 | 9.85 |
| 27.50 | 10.00 | 10.20 |
| 28.50 | 11.00 | 10.45 |
| 29.50 | 12.00 | 10.56 |

**Graphs and Calculations**

The Sprite titration rose in pH fairly quickly and did not show much buffering activity although the pH rise did slow down a bit indicating some form of buffering activity. Only one equivalence point was clearly visible and it appeared to be at a pH of 8.4 with 2.6 mL of NaOH added. The half equivalence point then would have occurred with 1.3 mL of NaOH added with a pH of 5.2. The pH equaled pKa at this point since this was a weak acid, so pKa was 5.2 and according to Table 1 from the lab handout, citric acid/citrate ion appeared to be the buffering system responsible for the buffering effect in sprite. The neutralization reaction for citric acid was C6H8O7 +3 NaOH → 3 H2O + Na3C6H5O7.

The titration curve for tonic water was a lot more gradual in the rise in pH than the titration curve for Sprite. Once can see buffering activity in this lab as it slows down and then rises a little more quickly at about 6 mL of NaOH added and slows down again indicating more buffering activity. There were two equivalence points present in this curve one at a pH of 5.5 with 5.7 mL of NaOH added and one at a pH of 7.7 with 7.3 mL of NaOH added. This meant that there were two half equivalence points with 2.4 mL and 6.7 mL of NaOH added with pH values of 3.5 and 6.1, respectively. According to table 1, this was substance had a quinine (C20H24N2O2)/ C20H23N2O2-1 buffer system. The neutralization reaction for quinine was: C20H24N2O2 + NaOH → H2O + C20H23N2O2Na.

**Conclusion**

Sprite was found to have a citric acid/citrate ion buffer system with at least one calculated pKa value of 5.2 and tonic water had a quinine (C20H24N2O2)/ C20H23N2O2-1 buffer system with pKa values of 3.5 and 6.1. The neutralization reaction for citric acid was C6H8O7 +3 NaOH → 3 H2O + Na3C6H5O7 and the neutralization reaction for quinine was: C20H24N2O2 + NaOH → H2O + C20H23N2O2Na. Both of these substances showed buffering activity as they both showed decreases in slope after an initial sharper rise in pH.

**Questions**

Pre-Lab Questions

1. A buffer was a mixture of a weak acid and its conjugate base or a weak base and its conjugate acid.

2. The buffer effect would eventually disappear since eventually NaOH would neutralize all of the acetic acid, so the pH would rise significantly once this happened as there would only be hydroxide ion being added to the solution since there would not be any acetic acid to neutralize the sodium hydroxide after a certain point.

3. Titration curve B represented the strong acid-strong base titration since it started at a very low pH, stayed pretty constant down there and then dramatically rose to a high pH. Titration curve A represented the weak acid-strong base titration since it started at a higher pH, but still ended at the same pH as titration curve B. Titration curve A displayed a buffer effect as it rose steadily, but at a certain point both the weak acid and its conjugate base were present resulting in a buffer solution.

4. The equivalence point was where the moles of titrant added was equal to the number of moles of the titrate in the solution. The equivalence point for curve A was approximately at a pH of 9 while the equivalence point for curve B was at a pH of 7.

5. pKa equaled pH at the half equivalence point (where half of the volume of the equivalence point had been added).

6.



The best estimate for pKa would be at a pH of 4.5.

7. For a basic buffer, the buffering region would be at a pH above the point where all the buffer was neutralized and the equivalence point would be at a pH below 7. For an acidic buffer, the buffering region would be at a pH below the point where all the buffer was neutralized and the equivalence point would be at a pH above 7.

8. The neutralization reaction would be: CH3COOH (aq) + Na+ (aq) + OH- (aq) → H2O (l) + CH3COONa (aq). 0.5 moles of NaOH would be necessary to neutralize the buffer.

9. The titration curve for a polyprotic acid would look different from one for a monoprotic acid in that there would be multiple equivalence points with multiple increases and decreases in slope of the titration curve.

10. All polyprotic acids except sulfuric acid form buffers in aqueous solution since a buffer solution was created from weak acids and their conjugate base pairs. Sulfuric acid was a strong acid, so it could not form a buffer solution. The buffer activity of a polyproptic acid was determined by its pKa since it was a way to determine how strong or weak the acid was.

11. They flatten out around pH 1 and 13 because strong acids had a pH at 1 and strong bases had a pH at 13, so at the beginning of the curve only the strong acid was present, so the pH was at 1, while at the end of the curve only the strong base was present, so the pH was around 13.

12. Salt could act as a buffer if an acid and its salt or a base and its salt were used in the proper proportions. An example of this would citric acid and sodium citrate.

Post Lab Questions

1.a. H3C6H5O7 + 3 H2O ↔ C6H5O7-3 + 3 H3O+

b. Citric acid and sodium citrate act to moderate the pH in the soda when an acid or base was added to the soda.

2. This difference was observed since citric acid had three similar dissociation constants, so there were not any sudden rises in pH as the buffering effect of the first and second dissociation had not been neutralized yet which differs from phosphoric acid, which had three very different dissociation constants, so it had multiple sharp rises in pH. The neutralization reaction for phosphate buffer and sodium hydroxide would be: H2PO4- (aq) + 3 Na+ (aq) + 2 OH- (aq) ↔ Na3PO4 (aq) + 2 H2O (aq).

3. Buffers in an aquarium were necessary since fish only develop properly in a certain range of pH values; going outside of this range could be lethal. Thus a buffer would be needed to keep the pH from changing too much.

**References**

Hill, John William, and Ralph H. Petrucci. *General chemistry: An Integrated Approach*. 2nd ed. Upper Saddle River, N.J.: Prentice Hall, 1999. Print.

Reed, Nicole. " To What Extent do Common Household Products Have Buffering Activity Lab." *Blackboard*. np. n.d. Web. 1. January 2014.