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| **Titrations, Indicators and Buffers** | Name: |  |
| Hand-In, Chem 210L | Partner: |  |

See the attached rubric for more detailed information about grading.

1. (2 points) Write a correctly balanced series of chemical net-ionic equations to describe the stepwise protonation of the carbonate ion.

{Type answer here.}

2. (4 points) Include the plot you generated using the pH meter (Part II). Using the substances in the chemical equations in question 1, label each of the regions or important points in the plot with the major substances present in the solution at that point in the titration. Figure needs to be fully labeled and should take up at least a half page. Show that first and second derivatives were determined from the plot.

{Insert labeled plot here.}

3. (3 points) Based on the results from Part I and II, comment on each of the following questions.

a. Did all 3 visual indicators reach their endpoints at the same volume of acid added? If not, why not?

b. Are all three visual indicators equally “good” for this titration?

c. Which visual pH indicator(s) would you use if a pH meter weren’t available? (Explain your choice or choices.)

{Type answers to part a. here.}

{Type answers to part b. here.}

{Type answers to part c. here.}

4. (5 points) Calculate the concentration of the unknown Na2CO3(aq) stock solution based on each of the end points or equivalence points that provide reliable information about the system. Show **EACH** calculation you do and make sure it is clear where the data for each calculation came from. Report the average Na2CO3 concentration with the numeric error (avg. M Na2CO3 ± some number).

{Insert calculations of Na2CO3 concentration, average and error here.}

{Report properly rounded average Na2CO3 concentration and error here.}

5. (3 points) Describe in a table what you observed in the buffer portion of this experiment. Explain why the pH changed by different amounts when you tested the 3 samples (concentrated buffer, dilute buffer, water)?

{Include table here.}  
{Type explanation here}

6. (3 points) Describe the changes that occur in the Absorbance vs. Wavelength spectra in Part IV as the pH changes. What do the spectra imply about the number of distinct chemical forms of the indicator during a titration? How are the different chemical forms of the indicator related to each other?

{Insert spectrum here.}

{Type answer here.}

See the attached rubric on the next page for more detailed information about grading.

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|  | **Unsatisfactory** | **Borderline** | **Satisfactory** | **Excellent** | **Score** |
| **Q #1**  **Eqns.** | Incorrect formulas in equation.  **0 points** | Incorrect charges or state labels.  **1 point** |  | Correct equations with proper charges and state labels.  **2 points** | 2 pts. |
| **Q #2**  **pH plot** | Plot of pH vs. volume is not present.  **0 points** | **1-2 points** | -0.5 pt for each region or point not correctly identified.  **3 points** | Each section or important point in the pH vs. volume plot is properly labeled with the substance present at that point as directed in prelab.  **4 points** | 4 pts. |
| **Q #3**  **Indica-tors** | **0 points** | **1 point** | Explanation not clear or missing an answer to one of the three questions.  **2 points** | Clear, correct understanding of which indicators are useful and which are not useful for determining each equivalence point in this reaction and why.  **3 points** | 3 pts. |
| **Q #4**  **M** **Calc.** | No calculations or Microsoft Equation not used.  **0 points** | **1-2 points** | No determination of error or unclear calculations.  **3-4 points** | Clear, correct calculations of Molarity (4 of them) and determination of average + error.  -1 pt. for each missed molarity calculation and -1 for incorrect average and error calculation. Eq pts determined using first and second derivatives of pH.  **5 points** | 5 pts. |
| **Q #5**  **Buffers** | No table or explanation given  **0 points** | Table included but no explanation.  **1 point** | Table and trend given but explanation of behavior of buffers not well explained.  **2 points** | Clear description and valid explanation of behavior of buffers.  **3 points** | 3 pts. |
| **Q #6**  **Indica-tor spectra** | No spectra or explanation given  **0 points** | Spectra included but little to no description or explanation.  **1 point** | Spectra and explanation attempted but changes with additional acid not well explained.  **2 points** | Clear, correct description of spectra and valid explanation of behavior of indicators with addition of acid.  **3 points** | 3 pts. |
| **Total** |  |  |  |  | 20 pts |