Laboratory Session: Wednesday October 4 in Urbauer Room 1 (Jens Lab)
Laboratory report due Thursday October 12

Laboratory Objectives: The objectives of this laboratory are to experimentally investigate the acid-base balance in several aqueous solutions and to compare experimentally determined alkalinities and buffer intensities for each test solution with values calculated from theory. Experimental determinations will be made via acidimetric titrations of the test solutions which will be provided to the lab groups. Students will be divided into groups, and each group will have responsibility for titration of one solution of known composition and one of unknown composition. Laboratory data collected by each group will be distributed to all students for independent interpretation.

Procedures for this laboratory were adapted from those used by David A. Dzombak of Carnegie Mellon University in his course Water Resources Chemistry.

Equipment Needed
- pH meter
- combination pH electrode
- magnetic stirrer with magnetic stir bar
- burette
- glass beakers

Reagents
The following reagents will have been prepared or acquired before the laboratory session by the instructor.

Standard nitric acid, approximately 0.01 N: to 1000 mL deionized water, carefully add 10.0 mL 1.0 N HNO₃ standard.

Standard buffer solutions: pH = 4, 7, and 10

Test solutions:
(a) Dilute 3 mL 1 M NaOH to 1.000 L with deionized water.
(b) Dilute 3 mL 1 M NaOH and 3 mL 1 M NaHCO₃ to 1.000 L with deionized water.
(c) Dilute 3 mL 1 M NaHCO₃ to 1.000 L with deionized water.
(d) Dilute 5 mL 1 M NaOH and 3 mL 1 M NaHCO₃ to 1.000 L with deionized water.
(e) Unknown solution #1
(f) Unknown solution #2

Procedures: The samples will be distributed among the laboratory groups such that each group has two samples to analyze. At least 250 mL of each solution will be provided to the laboratory groups.

With the standardized nitric acid, titrate 50 mL volumes of each solution as follows:
1. Measure the initial pH of the sample with a calibrated pH meter.
2. Titrate the sample by adding acid in appropriate incremental volumes. After an addition of acid, allow time for equilibration and then record the pH and the volume added.
3. Continue the titration to about pH 3-3.5.
4. If time permits, perform replicate titrations for each sample.
Data Preparation

The raw titration data for each sample (acid added and pH) should be recorded neatly so that the data record can be copied directly and distributed to the other students. Make sure that there is sufficient sample identification information on the data record.

Each student should prepare a plot of pH versus acid added for each sample. All data collected for each solution should be presented on the plot for the sample, with different symbols used for different data sets.

Data Analysis: The following analyses should be performed and incorporated in the Results and/or Discussion sections of the laboratory report in an organized and appropriate manner.

(i) For each test solution of known composition, calculate the equilibrium composition based on the specified reagent quantities. How does the calculated pH compare with the initial pH measured for each solution? If there is a deviation, how might it be explained?

(ii) For each test solution, calculate the caustic alkalinity, the HCO₃⁻-alkalinity, and the total alkalinity based on the specified reagent quantities. How do the calculated alkalinites compare with those observed experimentally?

(iii) Determine the inflection points of the titration curves and compare these with the relevant acidity constants and indicator endpoints.

(iv) With the data from the titration curves, determine and plot buffer intensity versus pH for each sample. Identify the pH values associated with maxima and minima on the buffer intensity versus pH plots. Discuss the significance of the maxima and minima.

(v) For the solutions of unknown composition, estimate their initial compositions (potential components include the acids and bases given in Table 3.2 of Water Chemistry by Benjamin). Explain the basis for your estimates.


Reports will be evaluated based on:

1. Abstract (5 points)
2. Introduction (10 points)
3. Background/Theory (10 points)
4. Experimental Methods ( 10 points)
5. Results (15 points: prose (5 points) and graphical/tabular (10 points))
6. Discussion of Results (15 points)
7. Summary and Conclusions (10 points)
8. Table of Contents; References (5 points)
9. Appendices (presentation of raw data, data reduction, other supporting material) (10 points)
10. Overall organization and clarity of report (10 points)