Virtual Laboratory – Titration Curves

Description

As an acid reacts with a base, the solution experiences an increase in pH. At the stoichiometric equivalence point in a titration, the acid has been completely neutralized by the base, resulting in the formation of a soluble salt and water:

$$HCl + NaOH \rightarrow NaCl + H_2O$$

In the case of a strong acid/strong base titration, the pH at the equivalence point is expected to be 7. Since the anion of the acid and the cation of the base are both neutral, the pH is determined only by the value of K_w, which is 1.0×10^{-14} at 25 °C. Such is not the case in weak acid/strong base or strong acid/weak base titration. Weak acid/weak base titration does not have a reliable equivalence point; it is dependent on the relative strengths of the acids and bases involved.

You will be using the virtual laboratory to perform four titrations:

Strong acid vs. Strong base
Strong acid vs. Weak base
Weak acid vs. Strong base
Weak acid vs. Weak base

Materials

Carnegie Mellon University's "Virtual Laboratory" Software
Lab book
Graph paper

Procedure

Be sure to wear your virtual goggles when working with in the virtual lab!

1. Access the Virtual Lab Applet at:
   http://www.sciencegeek.net/VirtualLabs/VLab.html
1. Unlike previous virtual labs, there is no pre-designed assignment to load. In this activity, you will have access to the entire stockroom of the Virtual Lab!
2. For each titration, show in your data section the math behind any dilution that you needed to perform. Note that your ONLY choice for a strong base is sodium hydroxide, NaOH, which is already available in a 0.1 M concentration.
3. Set up your virtual lab for a titration between a 0.1 M solution of ANY strong acid and a 0.1 M solution of NaOH. The volumes used are your choice, but the titration must include at least 6 data points both before and after the equivalence point. Perform the titration by adding the base (in the buret) to the acid. In your lab book, record the volume of base added (independent variable) and the resulting pH (dependent variable).
4. Repeat the process for the remaining three combinations, using 0.1 M concentrations of acid and base in each titration. CAUTION: Since you are going to be doing calculations involving K_a and K_b values, you will want to select weak acids and weak bases for which your text provides those values. Otherwise, you will have to look those values up elsewhere.

Data

Include at the beginning of this section, the math associated with any dilutions that you performed in order to produce your 0.1 M solutions.

This section should include appropriate tables in which you have recorded "Volume of base added" and "Solution pH" for EACH titration that you performed. Be certain to indicate your choices, as appropriate, for strong acids, weak acids, and weak bases (again, NaOH is the **only** choice for a strong base). Include both a formula and a name for each acid and base used.

Last, record the the K_a for your weak acid and the K_b for your weak base, providing a source for each (Zumdahl is a good place to start).

Calculations and Graphs

1. Graph each of the titrations on GRAPH paper. You are welcome (encouraged) to place all of the curves on the same graph to make comparisons easier. Be certain to label each curve to distinguish it from the other titrations. Make the graph as large as possible in order to make reading the graph easier on the aging eyes of your instructor.
2. On your graph, estimate the equivalence point of each titration, labeling it with your estimate of the pH.
3. **Calculate** the pH at the equivalence point for each of the titrations that you performed. Your book explains how to do this. Your instructor will not explain how to do this.

Conclusions

1. In what ways are the titration curves different? In what ways are the equivalence points different?

Discussion of Theory

1. For the two questions in the Conclusions section, answer the question: **WHY?**

Error Analysis

NONE.

Analysis Questions

1. For each of the titrations that you performed, select an appropriate indicator for the titration. Explain your reasoning. You are not limited to the indicators available in the Virtual Lab.