TITRATION OF WEAK ACIDS

In this experiment you will perform a titration using a standardized solution of the strong base sodium hydroxide (NaOH) and an unknown weak acid. Based on the titration curve, you will calculate the molar mass of the unknown acid as well as its dissociation constant (K_a).

It is virtually impossible to prepare solutions of most solutes in accurately-known concentrations. Sodium hydroxide, for example, tends to absorb water and carbon dioxide from air. The water does not change the chemistry of the solution but does change the mass. The carbon dioxide reacts with NaOH forming bicarbonate and carbonate ions. Therefore, NaOH is prepared in approximately the concentration desired, then **standardized** (titrated) against a primary standard. A **primary standard** is a substance that is obtainable in high purity and whose mass can be measured with precision. In this lab, potassium hydrogen phthalate or simply **KHP** will be used. The molecular formula of this monoprotic weak acid is $KHC_8H_4O_4$.

The equivalence point of a titration of a strong base and a weak acid occurs when the moles of base equal moles of acid. In part A of this lab, you will use a known quantity of a known acid (KHP) to determine the molarity of your NaOH solution to four significant figures. In part B of this lab, you will use this standardized NaOH solution to determine the molar mass and dissociation constant of an unknown acid.

Special note: To complete this lab, you will need the handout "**Using the MicroLab Environmental Interface**". This handout can be found in this lab packet as well as on the Chemistry 223 website under "Labs". Excel gurus can complete the lab analysis using Excel; instructions on how to do this can be found in the "**MicroLab Data to Excel**" handout on the Chemistry 223 website under "Labs".

PROCEDURE:

Calibrate your pH probe using standardized pH solutions in a 30 ml beaker. You can use the same titration program you used in the previous lab or modify it as you see appropriate.

PART A: STANDARDIZATION OF NaOH SOLUTION:

In a 500 mL flask, add 10 mL 6 M NaOH to 300 mL water; stopper the flask and mix thoroughly. This is the NaOH solution you will use for parts A and B. Prepare your buret by cleaning with soap and water and rinsing with deionized water followed by 5 mL of diluted NaOH solution.

Weigh two samples of approximately 0.5 g of KHP ($KC_8H_5O_4$) using an analytical balance. Record the exact mass of the KHP sample. Dilute in about 75 mL of water. (You may need to warm the solution to dissolve solid.) Place a magnetic stir bar in the KHP sample. Place the pH probe into the KHP solution, being careful that it does not interfere with the stir bar or the drops of NaOH that will be added.

Before you begin to add drops of NaOH, remember to start your MicroLab program. Add NaOH dropwise until the equivalence point is passed. Repeat the standardization with the second sample of KHP.

PART B: TITRATION OF THE WEAK ACID

Prepare two samples of your unknown solid by dissolving approximately 0.5 g of unknown solid in about 75 mL deionized water. Use an analytical balance to record the exact mass of the sample. Titrate each sample with the NaOH solution using the buret. Be sure to record the ID of your unknown.

Be sure to analyze your data before leaving the lab.

DATA ANALYSIS:

Part A: Load your standardization data into a spreadsheet. You can use either Excel or the MicroLab spreadsheet program. As in the previous lab, use a derivative to accurately determine your equivalence points. **Print** a graph of both titrations and include it in your final lab report. Record the volume and pH at and around the equivalence point for both trials. Determine the **concentration** of your NaOH solution from the equivalence point volume and the mass of the KHP sample. Find parts per thousand using the concentration values. ***Do not print data tables!***

Part B: Graph the data using the derivative method described in a previous lab. **Print** a graph of both titrations and include it in your final lab report. Record the volume and pH at and around the equivalence point for both trials; also note the volume and pH of the half equivalence point. Calculate the **molar mass** and **dissociation constant (**K_a**)** for the unknown acid; also find parts per thousand for both the molar mass *and* the dissociation constant. ***Do not print data tables!***

POST LAB QUESTIONS:

1. Indicate how each of the following would affect the values of K_a and molar mass for a weak acid. Use **larger**, **smaller** or **no change**. Explain.

    a. The NaOH molarity is calculated lower than actual.
    b. The pH meter was incorrectly calibrated such that it reads 0.60 units high.
    c. The weak acid sample was impure, containing about 5% inert material.

2. In an acid-base titration, 24.88 mL of an NaOH solution are needed to neutralize 0.3045 g of KHP dissolved in 50.00 mL of water. What is the molarity of the NaOH solution?

3. A 0.2349 g sample of an unknown weak acid dissolved in 50.00 mL of water requires 33.66 mL of the above NaOH solution to reach the equivalence point. What is the molar mass of the acid?

4. If the dissociation constant of the acid is 3.0×10^{-6}, calculate the **pH** at a) the **half equivalence point**, and b) the **equivalence point** (Use the data from problems #2 and #3 as appropriate.)