

## CHEM 113L#6-Titration of Three Acids

### Introduction

This experiment will introduce you to using a pH meter to make careful measurements. It will also show you another method of titration called a potentiometric titration, where potential differences (also called voltages) are measured using ion selective electrodes. In this case, the electrode measures responses to changes in the  $H^+$  ion concentration in solution. It is called a pH electrode.

Like any other measuring tool pH electrode and meter must be calibrated together. Calibration is performed by measuring standard buffers of known pH with a pH meter. Effectively, you are placing the pH electrode in a buffer and “telling it” what the “pH” looks like. Details for calibration are attached and will be demonstrated by your instructor.

### I. Titration of HCl with NaOH

A. Calibrate your pH meter with pH 7 buffer. Measure the initial pH of your diluted HCl solution prior to the addition of the NaOH solution, **Calculate  $[H_3O^+]$** .

B. Using the result from above, calculate the  $[H_3O^+]$  for the original HCl solution (before dilution with 140 mL  $H_2O$ ).

C. Plot your data using EXCEL. At end point of this titration (pH=7.00), graphically determine the number of mL of base required for the titration. Use this to calculate the concentration of the HCl solution. How does this compare with your value from the initial pH? How does this

endpoint compare with the phenolphthalein endpoint?

### II. Titration of $HC_2H_3O_2$ with NaOH

A. Calibrate your pH meter with pH 7 buffer. Measure the initial pH of your diluted  $HC_2H_3O_2$  solution and, calculate  $[H_3O^+]$  of your diluted  $HC_2H_3O_2$  solution prior to the addition of the NaOH solution.

B. Plot your data using EXCEL. Determine the pKa for the  $HC_2H_3O_2$  from the graph. By find the pH halfway to the equivalence point!

C. Calculate the endpoint for this titration based on your initial pH, your graphic Ka, and your NaOH concentration from Part I. How does it compare with your graphic endpoint? With the phenolphthalein endpoint?

### III. Titration of a weak diprotic acid with NaOH.

A. Calibrate your pH meter with pH 7 buffer. Measure the initial pH of your diluted  $H_2X$  (aq) and, calculate  $[H_3O^+]$ , prior to the addition of the NaOH solution.

B. Plot your data using EXCEL. Determine the pKa for the  $H_2X$  (aq) from the graph. Show how!

## Experimental

**I. Titration of HCl with NaOH.** Fill the 50-mL burette with 0.1xxxM NaOH and record the molarity of the solution. Pipette 10.00 mL of the 0.1 M HCl solution into a clean 250-mL beaker. Dilute the HCl with 140 mL of distilled water measured with a graduated cylinder. Add a magnetic stirring bar and 3 drops of phenolphthalein to the beaker.

Check and calibrate the pH meter using the standard buffer solution (the instructor will give details for your particular pH-meter). Rinse off the pH electrode with distilled water, blot it with a tissue and immerse it in the beaker containing the diluted HCl sample. Measure the initial pH of the solution (0.00 mL NaOH solution added).

Be sure to mark the points at which all pertinent observations were made, or operations performed (e.g., color changes, reagents added, precipitates, etc.).

Start the stirrer and add from the burette 2.00, 4.00, 6.00, 7.00, 8.00 mL of 0.1xxx M NaOH, stopping the stirrer and reading and recording the pH after each addition. Continue the titration but add fractional-ml increments, decreasing the size of the increment as the pH begins to change more rapidly. Note the point at which the indicator changes color. When the pH change is again small, begin to increase the volume of the added increment until at the end of the titration, 1-2 ml of the NaOH solution is being added at a time. At this point you will have added about twice the volume of titrant which was required to cause the indicator to change color. Plot the data (pH vs. ml of titrant added).

**II. Titration of HC<sub>2</sub>H<sub>3</sub>O<sub>2</sub> with NaOH.** Repeat the procedure above for a 10.00 mL aliquot of 0.1 M HC<sub>2</sub>H<sub>3</sub>O<sub>2</sub>. Draw the titration curve, and carry out the calculations indicated on the Report Sheet.

**III. Titration of a weak diprotic acid with NaOH.** Pipette 10.00mL of 0.1M H<sub>2</sub>X (aq) and prepare the sample solution as in Part I. Set up the electrode and carry out the titration as in Part I except that the titration should be continued until 30 mL of 0.1xxxM NaOH have been added. Draw the titration curve, and carry out the calculations indicated on the Report Sheet.

## Calculations

Important formulas to remember:

1. Equations for pH:

$$\text{pH} = -\log[\text{H}_3\text{O}^+]$$

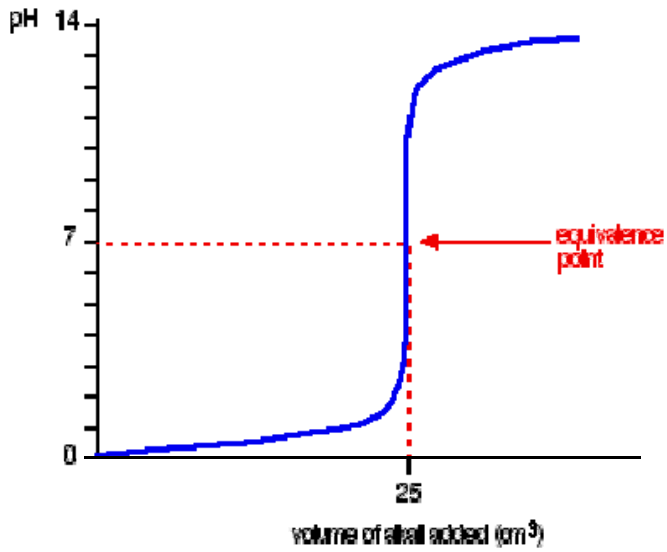
$$\text{pOH} = -\log[\text{OH}^-]$$

$$\text{pH} + \text{pOH} = 14$$

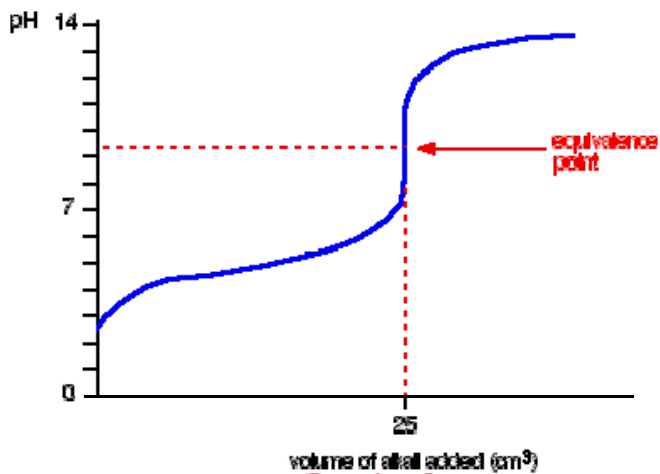
2. Henderson Hasselbalch Equation for Buffers

$$\text{pH} = \text{pK}_a + \log \frac{[\text{A}^-]}{[\text{HA}]}$$

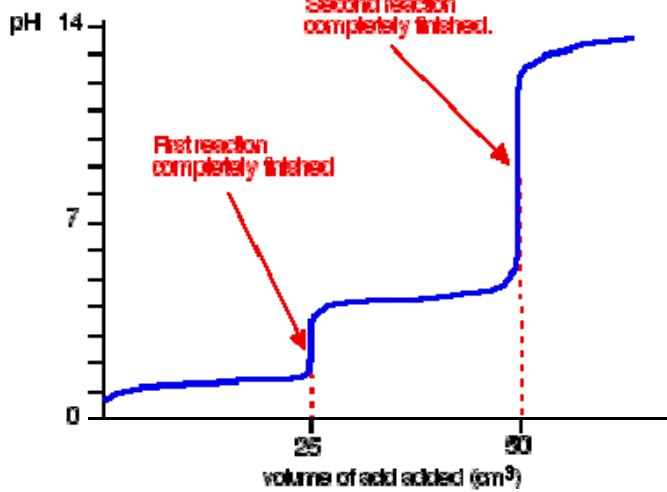
Half-way to the equivalence point in an acid base titration  $[\text{A}^-] = [\text{HA}]$ , so  $\text{pH} = \text{pK}_a$ .



Titration Curve for Strong Acid with Strong Base



Titration Curve for Weak Acid with Strong Base



Titration Curve for Weak Diprotic Acid with Strong Base