CHARACTERIZATION OF WEAK ACIDS (#11.4)

The CCLI Initiative
Computers in Chemistry Laboratory Instruction

Learning Objectives

The objectives of this experiment are to ...

- understand the titration curve for a weak acid.
- calculate the molar mass of the weak acid.
- calculate the Ka value for the weak acid.
- use the molar mass and Ka values to identify the acid.

Background

In this experiment you will determine two important properties of an unknown weak acid: its dissociation constant (Ka) and its molar mass. Both of these quantities can be determined by titrating a known mass of the acid with a standard solution of sodium hydroxide while electronically monitoring the pH. The unknown acid might be monoprotic or diprotic. If the acid is monoprotic, the pH curve for the titration will resemble Figure 1. In this case the titration reaction is

$$HA + OH^- \implies H_2O + A^-$$

and the Ka value for the acid can be determined by using the Ka expression for the acid HA:

$$Ka = \frac{[H+][A^-]}{[HA]}$$

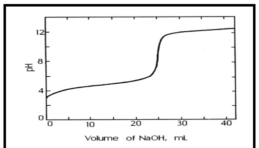

Figure 1. pH versus volume curve for the titration of a monoprotic acid.

If the weak acid being titrated is diprotic, a pH curve resembling that shown in Figure 2 will be obtained. In this case the titration reaction to reach the first equivalence point is:

$$H_2A + OH^- \Rightarrow HA^- + H_2O$$

Between the first and second equivalence points the titration reaction is

$$HA^- + OH- \Rightarrow A^{2-} + H_2O$$

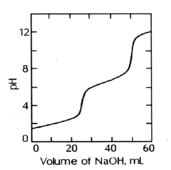

Figure 2. pH versus volume curve for the titration of a diprotic acid.

The stoichiometry of the reactions, requires that for a pure acid, the volume to the second equivalence point be exactly twice that to the first equivalence point. to reach the first equivalence point. A diprotic acid has two dissociation constants, K_{a1} and K_{a2} The value of K_{a1} can be calculated from any point on the titration curve before the first equivalence point and that of K_{a2} between the first and second equivalence points. However, the best place to determine either Ka is exactly half-way to either equivalence point, as that is where [HA] = $[A^-]$, and therefor Ka = $[H^+]$

Experimental Procedure

- KHP is dried for one hour at 110°C.
- Boil one liter of de-ionized water and store in a capped Nalgene bottle.
- Solutions are prepared and stored in capped Nalgene bottle for use.
- The sodium hydroxide solution is standardized.
- Calibration of the drop counter to determine the volume per drop for conversion of drops to volume.
- Calibration of the pH electrode with buffers at 4, 7 and 10 pH.
- Titration of an unknown acid.
- Guidance is provided for the data analysis, calculations and interpretation of titration curves.
- A table of some 25 weak acids with their structures is provided to assist in determining their unknown.

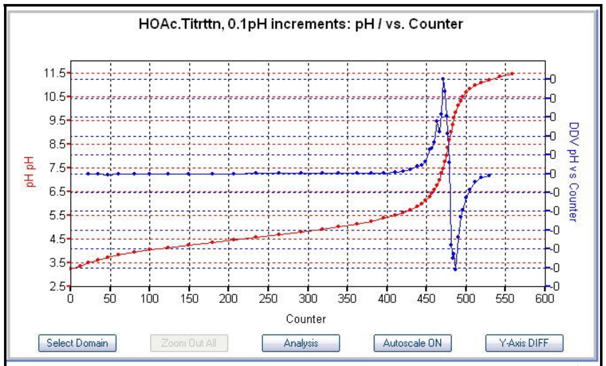

Figure 3. Classic titration curve for a weak acid with the 2nd derivative.

Resources Provided

- Sample Report Sheets providing the format to organize the data collection with sample data.
- Questions to consider, answer and turn-in with suggested answers.
- Tips and Traps section to assist the instructor with potential problems and solutions.
- Sample ***MicroLAB*** screen shots and graphs.
- Laboratory preparation per student station.