Lab 7: Titration of an Unknown Acid

Objectives:

- To determine the molarity of an unknown acid solution using acid/base titration.
- To practice stoichiometry.
- To study acid/base reactions.

Background:

Titration is a volumetric technique used to determine the concentrations of solutions. A titration involves the addition of a titrant (a solution of known concentration) to an analyte (a solution of unknown concentration), or vice versa, using a piece of glassware called a buret. The titration is carried out until it reaches an equivalence point (the exact point at which the reaction between the two solutions is complete). A chemical indicator is often used to aid in the identification of the equivalence point. An indicator changes color upon reaching the equivalence point or endpoint. Since we will be carrying out an acid-base titration, the indicator must change color upon reaching the endpoint at a specific pH. An example of such an indicator is phenolphthalein, which changes from colorless to pink near the equivalence point. It should be noted that the indicator selected is dependent upon a given titration, so that the observed color change is close to the ideal equivalence point. Once the titration is completed, we can use the volumes measured for each solution, as well as the concentration of the titrant, to determine the concentration of the analyte. The equations you will use for this lab are as follows (for a monoprotic acid):

OH^- (aq) + H_3O^+ (aq) → 2 H_2O (l)

$mol_{NaOH} = V_{NaOH} \times M_{NaOH}$ $\qquad$ $mol_{acid} = mol_{NaOH}$

$M_{acid} = mol_{acid}/V_{acid}$

Pre-Lab Questions:

1. Summary of the procedure in your own words.
2. Why is it necessary to get the air bubbles out of the tip of the buret before starting the experiment?
3. What is the visual indication that the titration is complete?

Procedures:

1. Obtain about 40 mL of an unknown acid in a beaker and record the unknown letter.

2. Pipet 10.00 mL of the unknown acid into an Erlenmeyer flask. Add three drops of phenolphthalein. Place a clean magnetic stir bar into the flask.

3. Obtain about 60 mL of an approximately 0.1 M solution of NaOH in a beaker. Record the actual concentration (it's on the container). *Note: label your beakers.

4. Rinse the buret a few times with small portions of the titrant (NaOH solution). Fill the buret with the titrant. **Make sure that the buret tip is filled with the titrant and that there are no air bubbles present. Clamp the buret securely in a vertical position, leaving enough room to place the flask and a stir plate underneath. Record the initial volume.

5. Turn on the stir plate (not the heat!) and slowly increase the spin until the stir bar is spinning rapidly in the center of the flask but not splashing. Slowly add the base into the flask that contains the unknown acid (analyte). Eventually, you will observe a localized flash of color. At this point, add the base dropwise, allowing the pink color to disappear in between each drop. Continue this process until you observe a faint but permanent, pink color in the flask. Record the volume on the buret. (Technically, the permanent faint pink color indicates that the equivalence point has been reached. If unsure, you can always note the volume, and then add another drop of the base.)

6. Repeat the above procedure two more times. Note: The first run should be done quickly to determine the approximate endpoint. The 2nd and 3rd runs should be done as per the above instructions, except initially add NaOH until about 5 mL before endpoint, then add slowly drop by drop as you approach the endpoint.

Lab Report Guide:

- **1. Results (3 pts)**
  - **Data sheets neatly filled out with data**
  - **Proper significant figures**
  - **Legible sample calculations**

- **2. Error Analysis (2 pts)**
  - **Typed discussion of the degree of agreement between your trials. If error appears to be present, explain possible sources. Note that "human error" is not an acceptable answer. Please be specific.**

- **3. Post Lab Questions (5 pts)**
  - **Typed answers to the Post Lab questions. Note that single sentence answers will not suffice. State the answer to the question followed by a brief description of the evidence supporting that answer.**

Post Lab Questions:

1. Why is it important to record the endpoint of the titration at the permanent faint pink color as opposed to the permanent dark pink color?
2. Calculate what the M_{ACID} would be if the acid were diprotic (able to donate two protons).
3. Why is the stir bar used?
4. Would it be possible to do this experiment without using an indicator dye? If so, explain how.
5. Is the titration technique limited to acid/base reactions?

Data Sheets (To be attached to your lab report. Recopy if messy):

Unknown Letter _____ Molarity of NaOH (mol/L) _____

Volume of unknown acid (mL):

Run 1 _____ Run 2 _____ Run 3 _____

Initial Volume of NaOH (mL):

Run 1 _____ Run 2 _____ Run 3 _____

Final Volume of NaOH (mL):

Run 1 _____ Run 2 _____ Run 3 _____

Volume of NaOH added (subract to find):

Run 1 _____ Run 2 _____ Run 3 _____

Analysis:

Molarity of unknown acid (assuming the acid is monoprotic):

Run 2 _____ Run 3 _____ Average _____

Sample Calculation of Molarity of unknown acid: