**Acid – Base Titrations**

**Goals:**

1) To learn the popular technique of titration.
2) To practice calculations involving concentration and stoichiometry.
3) To determine the concentration of acetic acid in vinegar.

**Experiment:**

Titration is an experimental analysis technique that allows determination of the concentration of an unknown solution (i.e.: an acid in this lab). Since Molarity is the number of moles of solute per Liter of solution, then measuring the volume of acid solution directly, and then calculating the number of moles present via titration, the concentration in Molarity (and Normality if necessary) can be determined.

\[
\text{Molarity of acid} = \frac{\text{moles of acid}}{\text{volume of acid}} = \frac{\text{mol}}{L}
\]

During a titration, a measured volume of acid is reacted with a base (commonly NaOH) of a precisely determined concentration (called a standard solution). The concentration of the base times its volume gives moles of base, which can be related stoichiometrically to moles of acid via the balanced neutralization equation.

\[
\text{moles base} = \text{Molarity base} \times \text{Volume base} = M \times V
\]

A buret is used to precisely measure the volume of base reacted with the acid. A buret is essentially an inverted graduated cylinder with a controllable dispensing device on the bottom. Burets are precise to 0.01 mL. By recording the initial volume of base in the buret, and the final volume after reaction with the acid is complete, the volume dispensed can be calculated:

\[
\text{Volume base dispensed} = \text{Final volume} - \text{Initial volume}
\]

Most acid and base solutions are clear and colorless. A macroscopic property is needed to visually be able to tell when the base has completely reacted with all of the acid. An indicator (i.e.: phenolphthalein) will be used that changes color depending on the pH of the solution. Phenolphthalein happens to be clear in acidic solution and pink in basic solutions. When all of the acid has been reacted with added base (the equivalence point), the indicator is still clear. Upon addition of a partial drop of base, the solution becomes basic and turns light pink. This point of color change of the indicator is the endpoint, and signifies the reaction is complete. Since the endpoint and equivalence point are not at the exact same point, a small error occurs. This is very minor.

To convert from moles of base to moles of acid, the balanced reaction must be known. In this lab, acetic acid in vinegar is the acid and NaOH the base. Acetic acid is a weak organic acid with one carboxylic acid group

The reaction is given on the next page.

Besides the concentration of the acid being calculated, the mass percent of acetic acid in the vinegar can be determined. As long as the molecular formula for acetic acid is known, its molar mass can be used to convert moles of acid to grams of acid. Dividing the mass of acetic acid by the mass of vinegar used and converting to a percent gives the mass %.

\[
\text{mass % acetic acid in vinegar} = \frac{\text{mass acetic acid}}{\text{mass vinegar}} \times 100\%
\]

The reaction between acetic acid and sodium hydroxide:

\[
\text{HC}_2\text{H}_3\text{O}_2 (aq) + \text{NaOH (aq)} \rightarrow \text{H}_2\text{O (l)} + \text{NaC}_2\text{H}_3\text{O}_2 (aq)
\]

After doing 3 to 4 trials for vinegar and determining your average value of mass % acetic acid, you will write your value on the board. A value averaged over all the class results will be calculated and used as the “true” value in order to perform an error analysis.
Acid – Base Titrations Prelab

These prelab questions must be answered prior to coming to lab:

1) What is the difference between the endpoint and the equivalence point?

For questions 2) through 11), use the following data:

A titration of 25.00 mL of an unknown HCl solution with 0.1550 M NaOH starts at a buret reading for NaOH of 0.33 mL. The phenolphthalein indicator turns light pink in the acid solution for over 30 seconds at a buret reading of 24.19 mL.

2) What was the volume of NaOH dispensed?

3) How many moles of NaOH were dispensed?

4) Write the balanced molecular equation for the neutralization reaction:

5) Write the net ionic equation (Note: STRONG acid and base!!):

6) How many moles of HCl are present in the acid solution?

7) What is the Molarity of the unknown HCl solution?

8) If the density of the HCl solution is 1.097 g/mL, what is the mass of the HCl solution?

9) What is the mass of HCl present in the acid solution (see # moles HCl calculated in problem #6)?

10) What is the % mass of HCl in the acid solution?