Acids and Bases

Introduction

According to the Bronsted-Lowry theory of acids and bases, an acid is defined as a proton donor and bases are proton acceptors. Strong acids give up their protons readily where as weak acids give up their protons with difficulty. Likewise, strong bases accept protons easily and weak bases do not.

An acid may contain one or more protons or ionizable hydrogen atoms (H^+) per molecule. The equivalent mass or normality of an acid is the mass that provides one mole of hydrogen ions. The equivalent mass can be calculated by dividing the molecular mass of an acid by the number of hydrogens. Some examples are listed below:

Acid	Formula	Molar mass	Equivalent mass	Molarity/Normality
Hydrochloric	HCl	36	36	1:1
Nitric	HNO_3	63	63	1:1
Sulfuric	H_2SO_4	98	49	1:2
Phosphoric	H_3PO_4	98	32.6	1:3

The equivalent mass or moles of hydrogen present in an unknown acid can be determined by titration with a standardized solution of sodium hydroxide. Since one mole of sodium hydroxide (NaOH) will react completely with one mole of H^+, a volumetric analysis, using either a pH indicator such as phenolphthalein or a pH meter, can be employed to determine the moles of H^+ present.

Objective

A solution of sodium hydroxide which is approximately 0.01M will be standardized with a solid acid, potassium hydrogen phthalate, to determine the exact molarity of the base. The standardized base will then be titrated against a monoprotic unknown acid to determine the molarity of the acid. A pH indicator and/or a pH meter will be used to determine the equivalence point.

Chemicals and Equipment

Materials included in this kit:

2 X 100mL	Hydrochloric acid, 0.1M
2 X 25mL	Sodium hydroxide, 6M
2 X 5g	Potassium hydrogen phthalate
2 X 25mL	Phenolphthalein, 0.1%

1 Set of Student study and analysis masters
1 Teacher Guide

Materials needed but not supplied:

1	Analytical balance
1	Drying oven or desiccator
30	50mL burets
1	150mL beaker
18	250mL Erlenmeyer flasks
5	1 liter volumetric flasks

Optional:

5	pH meters
15	250mL beakers

Safety equipment required:

Rubber gloves
Aprons
Safety goggles

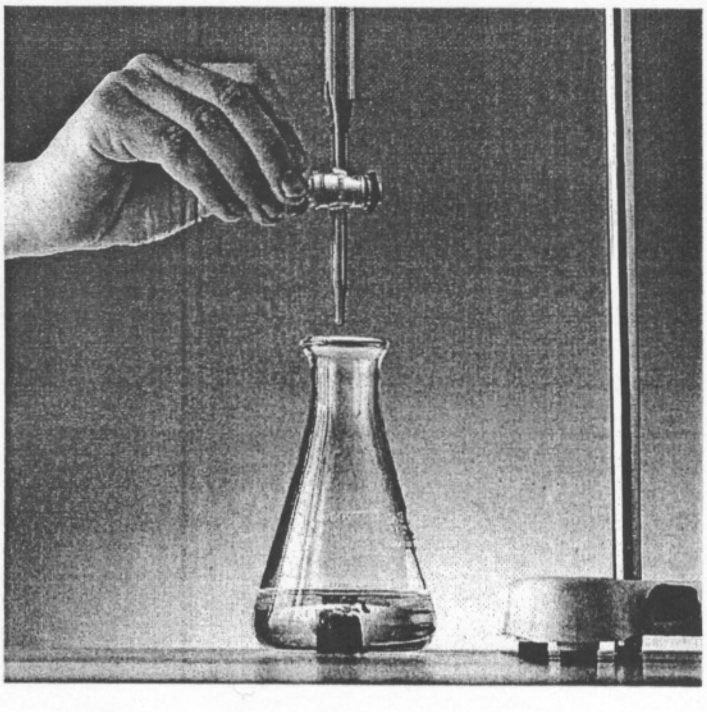
Safety note: Acids and bases are hazardous to skin and eyes. Wash contaminated area immediately with water. Phenolphthalein solution contains alcohol and is flammable. Keep away from flames and other ignition sources.

Procedure

Standardization of 0.01M NaOH with potassium hydrogen phthalate ($KHC_8H_4O_4$):

1.) Place 5 grams of potassium hydrogen phthalate in a 150 ml beaker and place it in a drying oven for about 20 minutes to remove all moisture. The sample can also be placed in a desiccator for 48 hours to dry.

2.) Weigh 3 X 0.05g samples of the potassium hydrogen phthalate on



an analytical balance and place each into a 250mL Erlenmeyer flask. Add 50mL of boiled and cooled de-ionized water into each flask and swirl to mix. Place 1-2 drops of the phenolphthalein solution in each flask and mix.

3.) Place about 1.7mL of the 6M NaOH in a volumetric 1 liter flask and QS to one liter with boiled and cooled de-ionized water. Use this 0.01M NaOH to fill a buret. Carefully titrate each sample of potassium hydrogen phthalate with the 0.01M NaOH until the solution turns pink. Record your beginning and ending buret readings for each titration.

4.) If pH meters are available repeat the standardization using the pH meter.

Determine the H^+ concentration of an unknown acid:

1.) Refill the 0.01M NaOH buret and set up a second buret containing the unknown acid.

2.) From the second buret dispense 5.0mL of the unknown acid in a 250mL Erlenmeyer flask. Add 25mL boiled and cooled de-ionized water and 1-2 drops of phenolphthalein indicator solution.

3.) Titrate the unknown acid with the standardized 0.01M NaOH. If the end point is missed, back titrate with the unknown acid. Record initial and final readings of both burets.

4.) Clean and dry the Erlenmeyer flask and repeat the titration two additional times.

5.) If pH meters are available, repeat the experiment using the pH meter.

Chemical disposal: Since the product of these titrations are dilute salt solutions, it is safe to flush these solutions down the drain with copious amounts of water.

Discussion and Laboratory Report

1.) Calculate the molarity of the standardized NaOH:

Moles of $KHC_8H_4O_4$ tritrated = Moles of NaOH in volume used

$$\frac{\text{Grams } (KHC_8H_4O_4)}{\text{M.W. } (KHC_8H_4O_4)} = \text{Moles of NaOH}$$

$$\frac{\text{Moles of NaOH}}{\text{Liters (volume titrated)}} = \text{Molarity of NaOH solution}$$

2.) Calculate the H^+ concentration on the unknown acid:

Molarity of acid X mL of acid used = Molarity of base X mL of base used

$$\text{Moles } H^+ = \text{Moles NaOH}$$

3.) Calculate the percent error in the titration of the unknown and suggest possible sources of error. If measurements were made with a pH meter, compare the data between the two methods of titration and explain the differences in end point using phenolphthalein versus the pH meter.

4.) Explain why the experiment called for the use of boiled de-ionized water.

5.) In this experiment the molarity of a monoprotic acid was determined. How would the experiment change if a polyprotic acid were used as the unknown?