Chemistry 101 Laboratory
Fall 2005 - 2006

Lecture 5

Acid - Base Titration

purpose

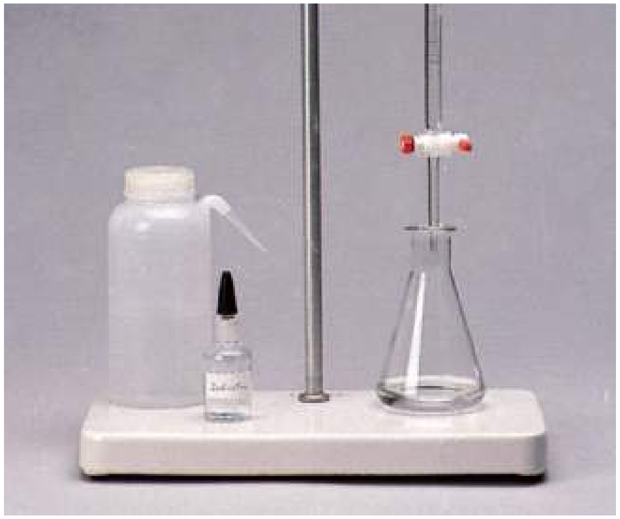
- To learn the concept and technique of titration.
- To standardize a sodium hydroxide (NaOH) solution against a primary standard acid.
- To determine the concentration of an unknown acid by titration with the standardized base solution.

Titration

In **titration** a solution of accurately known concentration, ***called a standard solution***, is added gradually to another solution of unknown concentration (or vice versa) until the chemical reaction between the two solutions is **complete.**

Equivalence point – the point at which the reaction is **complete.**

Indicator – substance that changes color at (or near) the equivalence point



Slowly add base to unknown acid
UNTIL

the indicator changes color

Titration (Cont'd)

- ***End Point:*** the point in the titration at which the indicator changes color (visually determined).

- ***Conditions for a good titration***
  - Rapid and complete reaction.
  - Reaction of known stoichiometry (no side products).
  - End point easily detected (use proper indicator).

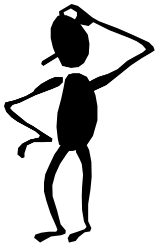
Acid – Base Titration

Involves a **neutralization reaction** which is the complete reaction between an acid and a base.

Acid + base $\rightarrow$ Salt + water

$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$

$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$ **Net ionic equation**



What volume of a 1.420 *M* NaOH solution is Required to titrate 25.00 mL of a 4.50 *M* H_2SO_4 solution?

WRITE THE CHEMICAL EQUATION!

$$H_2SO_4 + 2NaOH \longrightarrow 2H_2O + Na_2SO_4$$

$$n_{NaOH} = 2\, n_{H2SO4}$$

$$(M \times V)_{NaOH} = 2\, (M \times V)_{H2SO4}$$

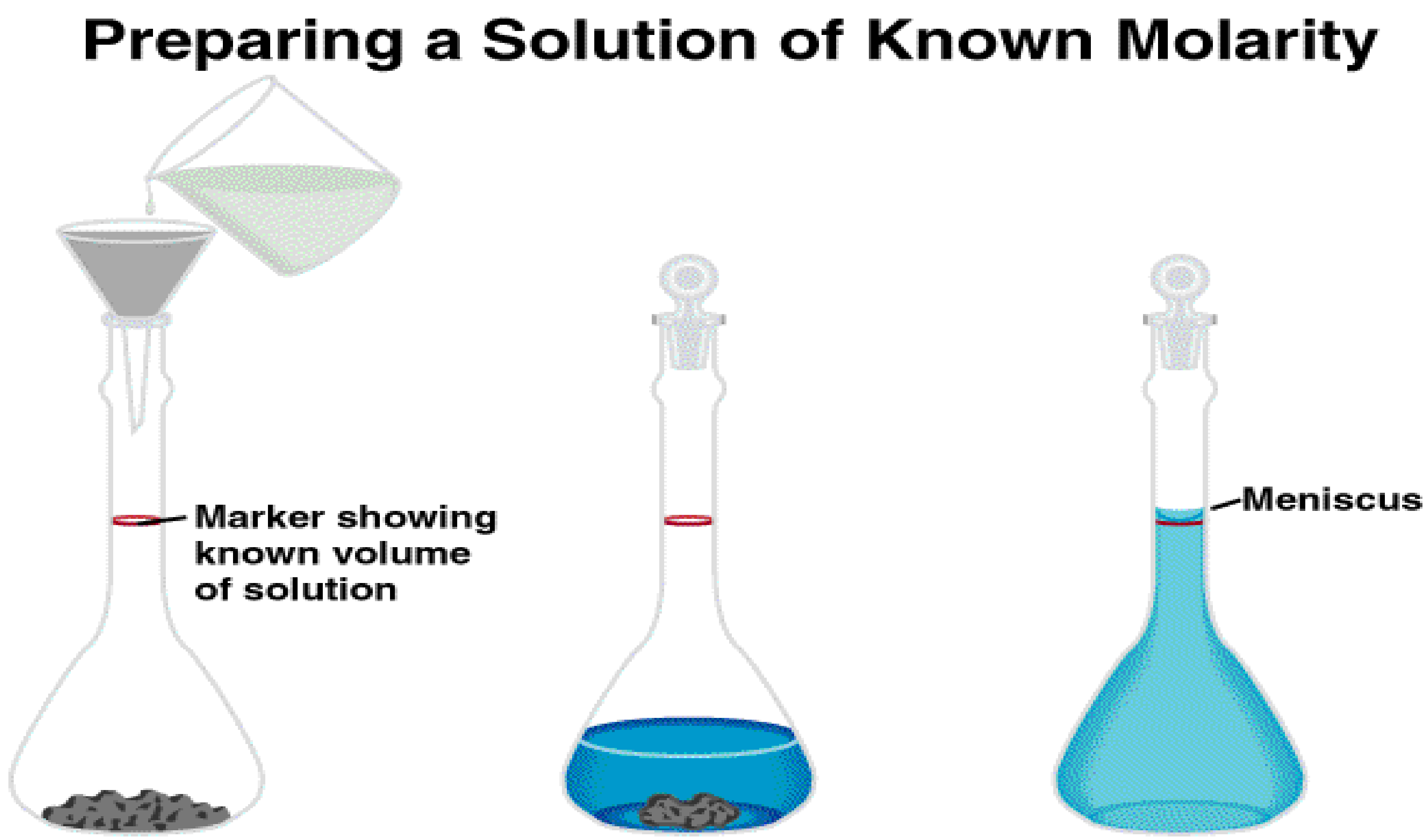
$$1.420 \text{ mol/L} \times V_{NaOH} = 2\, (4.50 \text{ mol/L} \times 25.00 \times 10^{-3} \text{L})$$

$$V_{NaOH} = 0.158 \text{ L} = 158 \text{ mL}$$

Standard Solution

• Is a solution of ***accurately known concentration.***

• prepared by dissolving an exact amount of the solute, followed by dilution, to form a definite volume of solution.



Standard solution (cont'd)

- ***Properties of a good primary standard***
  - High molar mass
  - Stable
  - Not hygroscopic
  - Highly pure, cheap and available

- ***Example:*** potassium hydrogen phthalate, $KHC_8H_4O_4$, abbreviated as KHP, molar mass = 204.23 g / mol.

Standard solution (cont'd)

- Sodium hydroxide is not a good primary standard solution. Solid NaOH absorbs water from air (hygroscopic), and its solution reacts with carbon dioxide.

- In this experiment a sodium hydroxide (NaOH) solution will be ***standardized*** by titration with a ***primary standard acid (KHP)*** as follows:

$$KHC_8H_4O_4(aq) + NaOH(aq) \rightarrow KNaC_8H_4O_4(aq) + H_2O(l)$$

or

$$KHP(aq) + NaOH(aq) \rightarrow KNaP(aq) + H_2O(l)$$

or

$$HP^-(aq) + OH^-(aq) \rightarrow P^{2-}(aq) + H_2O(l)$$

net ionic equation

Experimental

Three steps are involved:

1- Preparation of a primary standard potassium hydrogen phthalate (KHP) solution.

2- Standardization of 0.1 M sodium hydroxide solution with KHP.

3- Titration of an unknown monoprotic acid with the standardized sodium hydroxide solution.

1- Preparation of KHP Primary Standard

- Weigh KHP bottle using the analytical balance.
- Transfer the KHP to a 250 mL volumetric flask using a funnel.
- Add some water, dissolve ,dilute and shake, make up to the mark and homogenize.
- Weigh the empty bottle
- Calculate molarity of KHP

$$M = n / V = m / (\text{molar mass}) \times V$$

$$M = m\,(g)/204.22\ g/mol \times (250.0 \times 10^{-3}\ L)$$

2- Standardization of 0.1M NaOH

- Rinse the buret with NaOH.
- Fill it to the mark, make sure that there are no air bubbles in the tip.
- Pipet 10 mL of KHP into an Erlenmeyer flask and add two drops of phenolphthalein indicator.
- Add 10mL of water.
- Titrate against KHP to the end point (light pink color).
- Repeat the titration 3 times.
- Calculate M of NaOH.

(MxV) of NaOH = (MxV) of KHP

3- Titration of an Unknown Acid

- Proceed as in part 2.
- Use the unknown instead of KHP
- Titrate against the standardized NaOH solution using phenolphthalein as an indicator.
- Repeat three times.
- Calculate the molarity of the unknown.