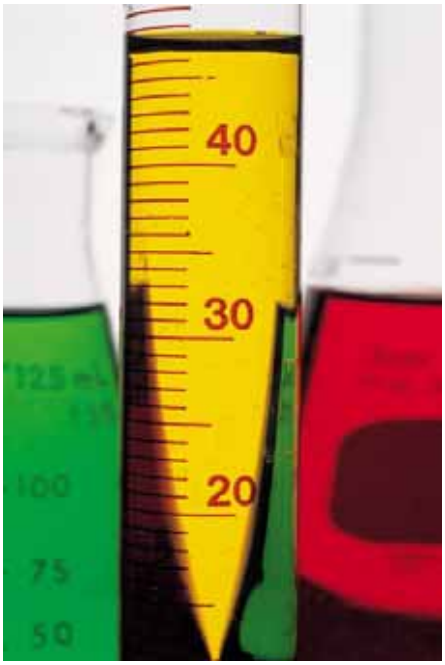
Acid-Base Titrations

June 27, 2006

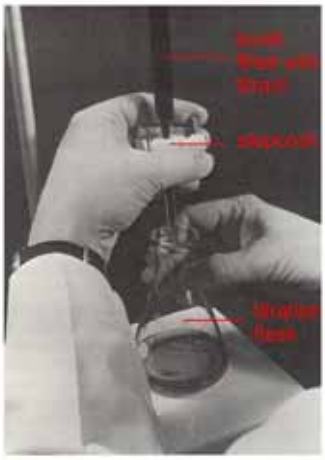


Purpose

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

Theoretical background

- **Titration is defined as the gradual addition of a measurable volume of a solution (the titrant), to exactly react a certain amount of another substance (in solution).**
- **The titration reaction must be *instantaneous* and *stoichiometric* (complete).**
- **We can titrate an acid with a base (or vice-versa).**



Theory (cont'd)

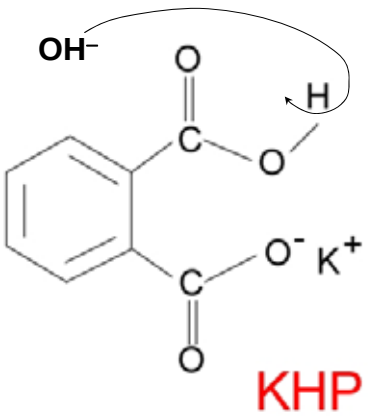
- **The point at which all the substance (acid or base) is exactly reacted (and thus the titration subsequently stopped), is called the equivalence point of the titration.**
- **In *potentiometric* titrations (based on pH measurement), the equivalence point is indicated by a sudden, sharp rise in the pH.**

Visual end point

- **In a simple acid-base titration, the equivalence point is detected visually by using an acid-base indicator.**
- **An *indicator* is a substance (added in small amount to the titration flask) which has the virtue of changing its color just at the point when the reactant in the flask is completely consumed. Such a visually determined time to stop the titration is called the end-point.**

Primary standard

- **In this experiment, you will standardize a sodium hydroxide (NaOH) solution by titration with a** primary **acid** standard **(potassium hydrogen phthalate, abbreviated as KHP,** M = **204.23 g/mol).**



KHP

Properties of a primary standard

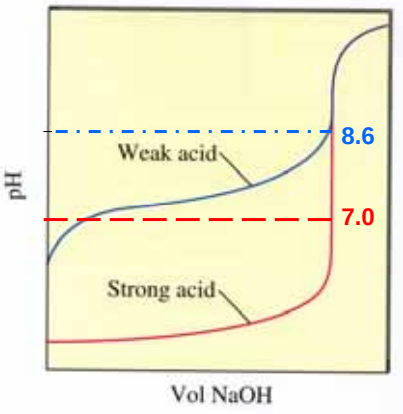
- **Requirements for a good primary standard:**
  - **High molar mass**
  - **Stable**
  - ***Not* hygroscopic**
- **Reaction of KHP with NaOH:**

$$HP^- + OH^- \longrightarrow H_2O + P^{2-}$$

Neutralization

Titration curve

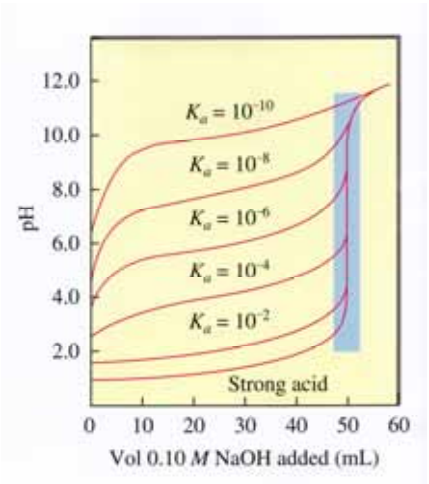
- **Titration curve ≡ a plot of pH with volume of titrant added.**
  - **Equivalence pH for titration of strong acid ≡ 7.0**
  - **Equivalence pH for titration of KHP ≅ 8.5 - 9.5**



Zumdahl, Chemistry, 6th Edition, Fig. 15.3

Titration curves of various acids

- **The weaker the acid (smaller K_a):**
  - **the *higher the value of the equivalence pH*,**
  - **and the *narrower the equivalence point range*.**



Zumdahl, Chemistry, 6th Edition, Fig. 15.4

Indicator

- **An acid-base indicator is a weak acid (say, HIn) whose acid and base forms have different colors.**
- **Ionization in water:**

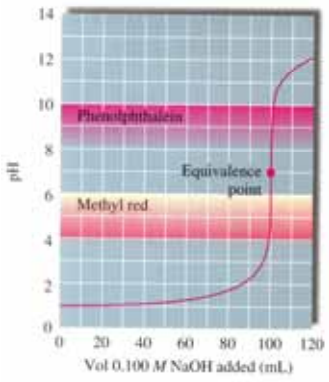
$$HIn + H_2O \rightleftharpoons H_3O^+ + In^-$$

pH range of indicator color change

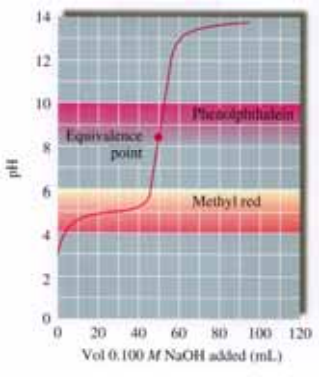
- **pH range of indicator = $pK_{In} \pm 1$.**
- **For example if $pK_{In} = 5.5$, then the indicator pH range is 4.5 – 6.5.**

Selection of a suitable indicator

- **The best indicator is the one whose color range includes the equivalence pH, *at best*, in its mid-range.**

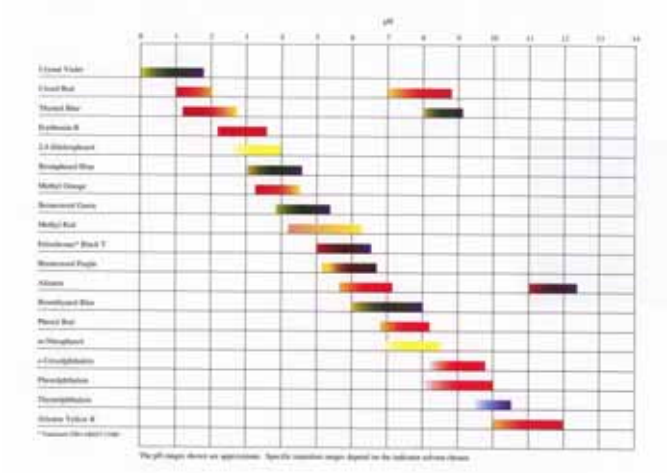


Zumdahl, Chemistry, 6th Edition, Fig. 15.9



Zumdahl, Fig. 15.10

Variety of indicators



Zumdahl, Chemistry, 6th Edition, Fig. 15.8

Procedure and Report

- Procedure
- Report
- Assigned questions: *All*