Chemistry | Analytical Chemistry

Determination of Concentration of Acetic Acid in Commercial Vinegar

General Aim

To determine concentration of acetic acid in a commercial vinegar sample of vinegar by titrating it with a standard solution of NaOH.

Method

Determination of acetic acid by acid- base titration.

Learning Objectives (ILOs)

- Identify the difference between acid and base.
- Define the meaning of a standard solution.
- Predict how a certain sample could be analyzed.
- Determine accurately the concentration of acetic acid in vinegar via volumetric analysis, making use of the reaction of acetic acid with a strong base, sodium hydroxide.
- Acquire the correct techniques of titration.

Theoretical Background/Context

- Quantitative analysis deals with the determination of the quantity of the substance to be analyzed. Methods of quantitative analysis may be classified into:
  1. **Gravimetric analysis:** It depends on isolating and weighing of the final product with known pure, stable and definite form.
  2. **Instrumental analysis:** It depends on measuring some physical properties which change quantitatively with changing concentration of sample.
  3. **Volumetric analysis (Titration):** It depends on measuring volume of standard solution (titrant) used for complete reaction with the sample.

- Titration is the capacity of the sample to combine with the suitable standard quantitatively through quantitative reaction. A quantitative reaction is the reaction that proceeds forward to produce stable product(s) such as weakly ionizable compounds, e.g. H2O, weak acids & base, sparingly soluble salts (precipitate), complex ion, etc. The types of quantitative Reactions can be:

  1. Neutralization Reactions
     a. H2O formation
     b. Displacement: Formation of weak acid or weak base
  2. Complexometric reactions
  3. Redox reactions (Electron transfer)
  4. Preciptimetric reactions

Theoretical Background/Context

- Any sample is a solution of unknown concentration and a Standard is a solution of exactly known concentration. The requirements of titrimetric reactions are:
  - The reaction must be simple and expressed by a chemical equation
  - A single reaction must occur between the sample and titrant
  - The reaction must be instantaneous (rapid).
  - Suitable standard solutions must be available.
  - The end point should be easily detected.

Oxidation is loss of electrons and increase in valency number, gain of oxygen or loss of hydrogen

$Fe^{2+} \rightarrow Fe^{3+} + e^{-1}$

Reduction is gain of electrons and reduction in valency number, loss of oxygen or gain of hydrogen

$Fe^{3+} + e^{-1} \rightarrow Fe^{2+}$, $Fe^{2+} + 2e^{-1} \rightarrow Fe^{0}$

Oxidizing agent or oxidant is the substance that gain electrons

Ex: $KMnO_4$, $K_2Cr_2O_7$, $Ce(SO_4)_2$

Reducing agent or reductant is the substance that donate (lose) electrons

$FeSO_4$, $Na_2S_2O_3$, $H_2C_2O_4$

Principle of Work

- Vinegar is a common household item containing acetic acid as well as some other chemicals. This experiment is designed to determine the molar concentration of acetic acid in a sample of vinegar by titrating it with a standard solution of NaOH.

$CH_3COOH(aq) + NaOH(aq) \rightarrow CH_3COONa(aq) + H_2O$

- By adding the sodium hydroxide, which is a basic solution, to the acetic acid, which is an acidic solution, a neutralization reaction occurs. An indicator known as phenolphthalein, is also added to the vinegar. This indicator turns the solution to a dark pink when excess NaOH is added to make the solution more basic.