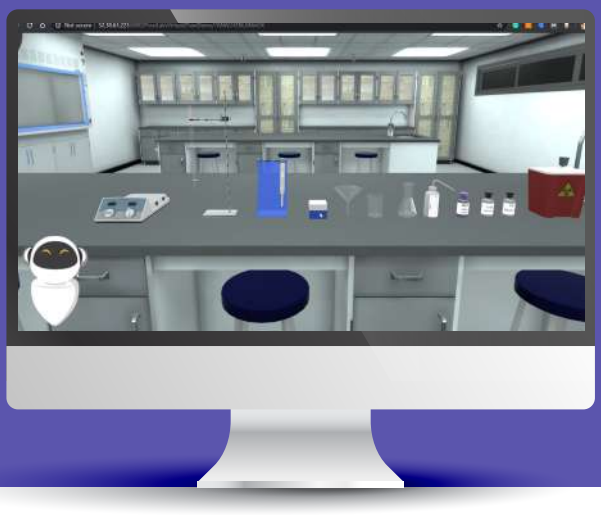
Chemistry | Analytical Chemistry

Standardization of Potassium Permanganate



General Aim

To determine the strength of potassium permanganate with a standard oxalic acid solution.

Method

Determination of potassium permanganate by redox titration.

Learning Objectives (ILOs)

- Define direct titration.
- Define the meaning of a standard solution.
- Differentiate between primary and secondary standards.
- Predict how a certain sample could be analyzed.
- Determine the strength of potassium permanganate with a standard oxalic acid solution.
- Perform titration with the control of the temperature.
- Calculate the molarity and the strength of a given standard based on a similar procedure.

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 (Cont')

- 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

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

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

- This experiment is a redox titration where potassium permanganate (KMnO4) is the titrant and oxalic acid is the analyte. Also, KMnO4 is the oxidizing agent and oxalic acid is the reducing agent. The reaction between KMnO4 and oxalic acid is carried out in an acidic medium because permanganate ion in the acidic medium is a very strong oxidizing agent. Acidity is introduced by adding dil. H2SO4.
- No indicators are used to determine the endpoint, because KMnO4 is a self-indicator. Permanganate (MnO4-) ion has a dark purple colour. In an acidic medium, MnO4- is reduced to colorless manganous (Mn2+) ions. On reaching the end point, the addition of the last single drop of permanganate imparts a light purple colour to the solution.

$$2MnO_4^- + 5\,C_2O_4^{--} + 16H^+ = 10CO_2 + 2Mn^{++} + 8H_2O$$