Quantitative Analysis

- Quantitative analysis seeks to quantify the chemical species in a sample.
- Broadly speaking, an analysis can also aim to quantify thermodynamic and kinetic properties of a chemical system.

Generally, the Analytical Process has three distinct steps:

- Sample preparation
- Separation
- Measurement

Basic Steps of Analysis

1. Sample preparation
   - Sampling: Getting a representative sample to measure
   - Substances being measured are called ‘Analytes’
2. Separation
   - Separation of the species of interest from the sample matrix for better quantitation and identification
3. Measurements
   - The chemical analysis
   - Identifying how much (i.e. measurement of quantities)
   - Calibration curves
   - A curve of the detector response as a function of analyte concentration
   - Interpretation of the results
Wet Chemical Analysis: Volumetric

Volumetric analysis
a. Two ways to measure quantities (i.e. moles) of chemical species
   1. Measure weight (primary standard)
      Primary standard is defined as a reagent that is pure enough to be weighed and used directly
   2. Measure volume of a standard solution
      Standard solution is the solution created with a primary standard reagent

Chapter 7

Standard Solution Preparation. Calculate the amount of the required solid

The course of a volumetric analysis
1) Standardization of titrant
   Determination of the concentration of a titrant by titrating with a primary standard
2) Titrate samples
3) Endpoint determination
   a) Indicators
   b) Titration curve
4) Titration calculations
Titrations

**Titration**: Titrant added to analyte until the reaction is completed

**Equivalence point**: Ideal result when exactly stoichiometric amount of titrant is added to the analyte

**End point**: Actual result obtained by observation of a sudden change of physical properties

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**End point**: By observing change in color

\[ \text{H}_2\text{O} \rightarrow \text{C} \rightarrow \text{OH} + 2\text{MnO}_4^- + 6\text{H}^+ \rightarrow 10\text{CO}_2 + 2\text{Mn}^{2+} + 8\text{H}_2\text{O} \]

- **Analyte**: Oxalic acid (colorless)
- **Titrant**: Permanaguanate (purple)
- **Observable color change monitored by eye**

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**Acid-base Titrations**

- Titrations involving acid-base neutralization reactions
- **Equivalence point**: The point in the reaction at which both acid and base have been consumed, i.e. neither acid nor base is present in excess.
- **End point**: The point at which the indicator changes color.
- **Titrant**: The known solution added to the solution of unknown concentration.
- **Titration Curve**: The plot of pH vs. volume.
Acid-base Indicators

These are chemical species that are weak acids and bases and whose color varies in protonated and deprotonated form

$$\text{HIn} + \text{H}_2\text{O} \rightleftharpoons \text{In}^- + \text{H}_3\text{O}^+$$

In the acid form the color appears to be the acid color.
In the base form the color appears to be the base color.
Intermediate color is seen in between these two states.
The complete color change can occur over about 2 pH units.

Indicator Colors and Ranges

Acid-base Neutralization Reactions

Strong acid-strong base
Acid-base Neutralization Reactions

Weak acid-strong base

Redox Titrations

A redox titration is similar to an acid-base titration except it involves a redox reaction and generally does not require an indicator.

Vitamin C Oxidation Half-Reaction

Oxidation: Loss of $e^-$

Reduced: L-Ascorbic Acid (vitamin)

Oxidized: L-Dehydroascorbic Acid (excreted)

DCP Reduction Half-Reaction

Reduction: Gain of $e^-$

Reduced DCP: Colorless

Oxidized DCP: Dark blue in base

Red-pink in acid

Direct and Back Titrations

Direct titration: We titrate the analyte by adding titrant until the reaction is complete

Back titration: We add a known excess of a standard reagent to the analyte. Then we titrate the excess reagent with a second standard solution.