Introduction: The Analytical Process

Chemical Analysis

- Chemical analysis includes any aspect of the chemical characterization of a sample material.

- Analytical Chemistry?
  - "Science of Chemical Measurements"

Qualitative and Quantitative Analysis

- Qualitative analysis: What is it?
- Quantitative analysis: How much?
Too much consumption of these molecules are harmful

We need to measure the content of these molecules

Overdose potentially dangerous

Lisinopril: Antihypertensive

What are the steps of an analytical process?
Steps 1: Sample preparation

**Analyte:** The chemical substance being measured

Suppose, we want to measure calcium in calcium supplement tablets.

We precipitate all calcium using oxalate.

Steps 2: Separation

Filtration and drying the precipitate.

Steps 3: Measurement

Measuring the weight of the precipitate.
The Analytical Process

- Sample preparation
- Separation
- Measurement

Steps 1: Sample preparation

Or, measure caffeine in a chocolate bar

Steps 2: Separation

Chromatographic separation
How Do We Measure?

- Analytes: The chemical species being measured
- Sampling: To obtain a representative sample of the analyte
- Qualitative analysis: Identifying the analyte
- Quantitative analysis: Quantifying the analyte
- Standard Curve (or Calibration Curve): Plot of the detector response vs. the variable quantities of the standard solutions

How Do We Measure?

- Compare sample (of the analyte) with standard (or reference)
- Examples: What do we measure?
  - Liquid with graduated glasswares
  - Mass of a solid with analytical balance
  - Concentration of base with an acid of known strength
  - Peak area of the signal with the standard value
How Do We Measure?

- **Chemical Standards**: Certain chemicals that we use to determine the quantity of other chemicals.

- **Standard Solutions**: Known concentrations of chemical standards.
  - **Primary standard solution**: Pure and stable enough (during handling) to be used directly.
  - **Secondary standard solution**: Can not be used directly because they can not be measured correctly or are not stable enough over longer period of time.

- **Calibrations**: *Calibration is the process of comparing the measurement of an unknown standard against an equal or better standard.*

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Analytical Process: Summary

- **Caffeine in your favorite brand of coffee by HPLC**
  - **Sample preparation**: Dilution
  - **Separation**: Chromatography
  - **Measurement**: Measuring peak of the caffeine and referencing with calibration curve

- **Calcium in an impure sample of calcium carbonate by gravimetry**
  - **Sample preparation**: Dissolving a CaCO₃ in dil. HCl and precipitating by calcium oxalate
  - **Separation**: Filtering the precipitate, washing
  - **Measurement**: Measuring the weight of the precipitate

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Analytical Process: Our Advancements

- **Biosensor for glucose in the blood**
  - Ferrocyanide modulates the electronic structure and optical characteristics of the nanotube.
  - The more glucose that is present, the brighter the nanotube will fluoresce.
Units of Measurements

**Fundamental SI Units**

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Unit (symbol)</th>
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<tbody>
<tr>
<td>Length</td>
<td>meter (m)</td>
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<tr>
<td>Mass</td>
<td>kilogram (kg)</td>
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<tr>
<td>Time</td>
<td>second (s)</td>
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<tr>
<td>Electric current</td>
<td>ampere (A)</td>
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<tr>
<td>Temperature</td>
<td>kelvin (K)</td>
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<tr>
<td>Luminous intensity</td>
<td>candela (cd)</td>
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<tr>
<td>Amount of substance</td>
<td>mole (mol)</td>
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<tr>
<td>Plane Angle</td>
<td>radian (rad)</td>
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<tr>
<td>Solid angle</td>
<td>steradian (sr)</td>
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**Derived SI Units**

<table>
<thead>
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<th>Unit (symbol)</th>
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<tr>
<td>Frequency</td>
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<td>Force</td>
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<tr>
<td>Pressure</td>
<td>pascal (Pa)</td>
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<tr>
<td>Energy, work, quantity of heat</td>
<td>joule (J)</td>
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<tr>
<td>Power, radiant flux</td>
<td>watt (W)</td>
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<tr>
<td>Quantity of electricity, electrical charge</td>
<td>coulomb (C)</td>
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<tr>
<td>Electric potential, potential difference, electromotive force</td>
<td>volt (V)</td>
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<tr>
<td>Electric resistance</td>
<td>ohm (Ω)</td>
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<tr>
<td>Electric capacitance</td>
<td>farad (F)</td>
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Prefixes of Measurements

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Revisiting the Units of Quantities

In a mixture
- %: The amount of a substance (in g) in 100 g of sample
- % (wt/wt): Amount of solute (in g) in 100 g of a sample
- % (wt/vol): Amount of a substance (in g) in 100 mL of a sample liquid

In a solution
- %: The amount of a solute (in g) in 100 g of solution
- ppm: The amount of a substance (in g) in 10^6 g of a solution (for aqueous solution it is equal to amount of solute in mg in 1 L of the solution)
- ppb: The amount of a solute (in g) in 10^9 g of a solution
- Molar: Number of moles of a solute in 1 L solution
A Revisit to Stoichiometry

Recall the example of turkey sandwiches:

2 slices bread + 1 slice cheese + 1 slice turkey → 1 sandwich

How many breads are there in 5 sandwiches?

For 25 people how many cheese slices will be required? How many bread packets (containing 12 slices each) will be required?

In chemical analysis, we refer units of a chemical species as ‘moles’ (symbol ‘mol’) or millimoles (symbol ‘mmol’).

Reading Assignments: Chapter 1 and 2