Introduction to Analytical Chemistry ,Definition, Scope and Classification

Analytical chemistry is the branch of chemistry that deals with the analysis of different substances, and it involves the separation, identification, and the quantification of matter. by using of classical methods along with modern scientific instruments to achieve all these purposes. Analytical chemistry is often described as the area of chemistry responsible for:

1. Characterizing the composition of matter, both qualitatively and quantitatively.

2. Improving established analytical methods.

3. Extending existing analytical methods to new types of samples.

4. Developing new analytical methods for measuring chemical phenomena...

υ The scope of analytical chemistry:

The science seeks ever-improved means of measuring the chemical composition of natural and artificial materials by using techniques to identify the substances that may be present in a material and to determine the exact amounts of the identified substance. Analytical chemistry involves the analysis of matter to determine its composition and the quantity of each kind of matter that is present. Analytical chemists detect traces of toxic chemicals in water and air. A detection of the component in qualitative analysis can be the basis of the method or the procedure of its quantitative analysis. The reaction may be incomplete in qualitative analysis, while in quantitative analysis the reaction should be complete and give clear and known products.

υ Analytical chemistry consists of:

(A) Qualitative analysis: which deals with the identification of elements, ions, or compounds present in a sample (tells us what chemicals are present in a sample).

(B) **Quantitative analysis:** which is dealing with the determination of how much of one or more constituents is present (tells how much amounts of chemicals are present in a sample). This analysis can be divided into three types:

(1) **Volumetric analysis (Titrimetric analysis):** is measured the volume of a solution containing sufficient reagent to react completely with the analyte.

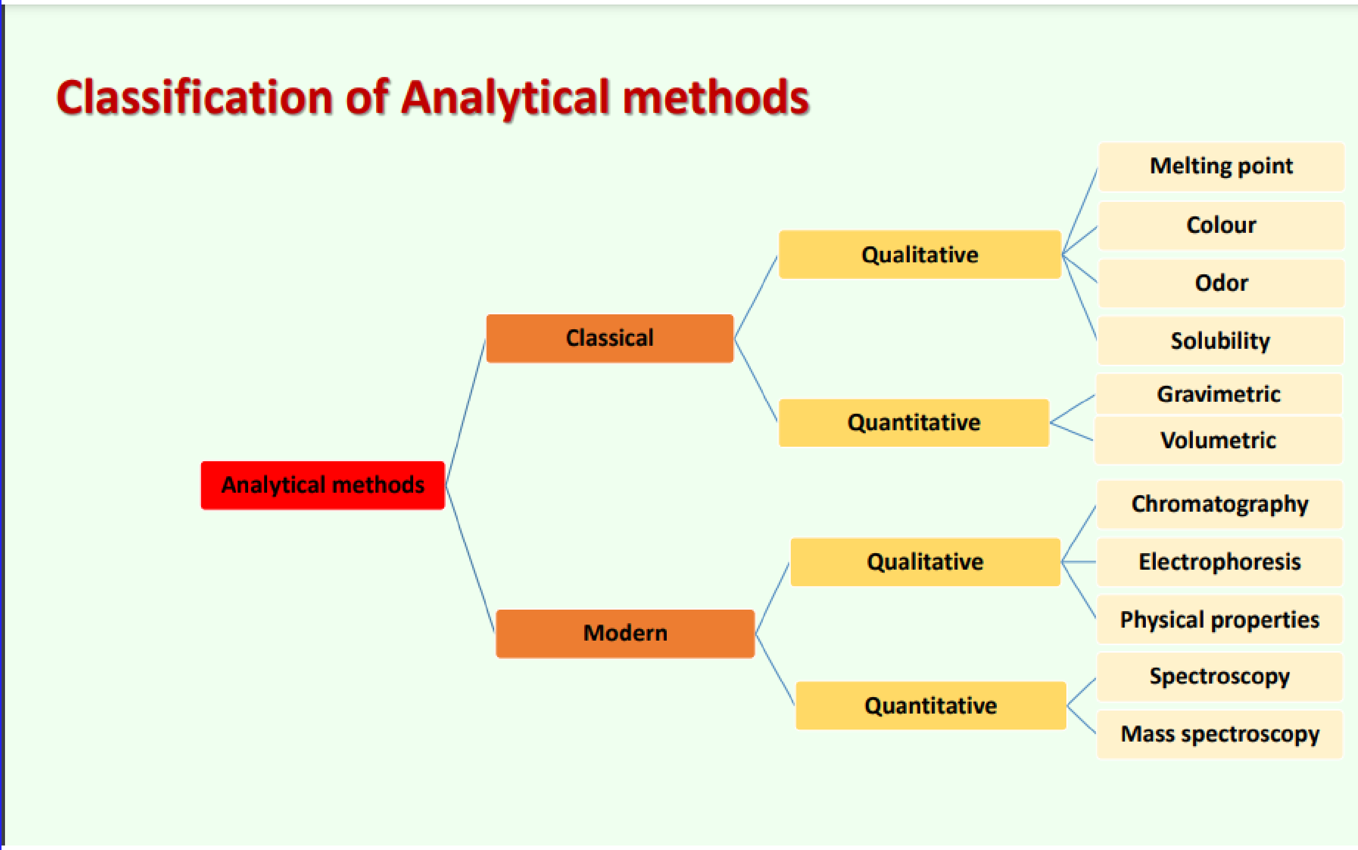
(2) **Gravimetric analysis**: Gravimetric methods, determine the mass of the analyte or some compound chemically related to it.

(3) **Instrumental analysis:** These methods are based on the measurement of physical or chemical properties using special instruments. These properties are related to the concentrations or amounts of the components in the sample. These methods are compared directly or indirectly with typical standard methods. These methods consist of:

a) **Spectroscopic methods:** are based on measurement of the interaction between electromagnetic radiation and analyte atoms or molecules or on the production of such radiation by analytes (ultraviolet, visible, or infrared), fluorimetry, atomic spectroscopy (absorption, emission), mass spectrometry, nuclear magnetic resonance spectrometry (NMR), X-ray spectroscopy (absorption, fluorescence).

b**) Electroanalytical methods:** involve the measurement of such electrical properties that wanted to be determined, such as pH measurements, electrodeposition, voltametry, thermal analysis, potential, current, resistance, and quantity of electrical charge.

c) **Separation methods:** They mean the isolation of one component or more from a mixture of components in solid, liquid and gas cases. These methods are included with instrumental methods since the instruments and equipment's are used in separation processes. These methods involve precipitation, volatilization, ion



exchange, extraction with solvent and various chromatographic methods.

Modern analytical chemistry

Modern analytical chemistry is dominated by instrumental analysis. There are so many different types of instruments today that it can seem like a confusing array of acronyms rather than a unified field of study. Many analytical chemists focus on a single type of instrument. Academics tend to either focus on new applications and discoveries or on new methods of analysis. The discovery of a chemical present in blood that increases the risk of cancer would be a discovery that an analytical chemist might be involved in. An effort to develop a new method might involve the use of a tunable laser to increase the specificity and sensitivity of a spectrometric method. Many methods, once developed, are kept purposely static so that data can be compared over long periods of time. This is particularly true in industrial quality assurance (QA), forensic and environmental applications. Analytical chemistry plays an increasingly important role in the pharmaceutical industry where, aside from QA, it is used in discovery of new drug candidates and in clinical applications where understanding the interactions between the drug and the patient are critical.

Types

Traditionally, analytical chemistry has been split into two main types, qualitative and quantitative:

Qualitative

- Qualitative inorganic analysis seeks to establish the presence of a given element or inorganic compound in a sample.
- Qualitative organic analysis seeks to establish the presence of a given functional group or organic compound in a sample.

Quantitative

- Quantitative analysis seeks to establish the amount of a given element or compound in a sample.

Traditional analytical techniques

Although modern analytical chemistry is dominated by sophisticated instrumentation, the roots of analytical chemistry and some of the principles used in modern instruments are from traditional techniques many of which are still used today. These techniques also tend to form the backbone of most undergraduate analytical chemistry educational labs. Examples include:

Titration

Titration involves the addition of a reactant to a solution being analyzed until some equivalence point is reached. Often the amount of material in the solution being analyzed may be determined. like the acid-base titration involving a color changing indicator. There are many other types of titrations, for example potentiometric titrations.

Gravimetry

Gravimetric analysis involves determining the amount of material present by weighing the sample before and/or after some transformation. A common example used in undergraduate education is the determination of the amount of water in a hydrate by heating the sample to remove the water such that the difference in weight is due to the water lost.

Instrumental Analysis

Spectroscopy

Spectroscopy measures the interaction of the molecules with electromagnetic radiation. Spectroscopy consists of many different applications such as atomic absorption spectroscopy, atomic emission spectroscopy, ultraviolet-visible spectroscopy, infrared spectroscopy, Raman spectroscopy, nuclear magnetic resonance spectroscopy, photoemission spectroscopy.

Mass Spectrometry

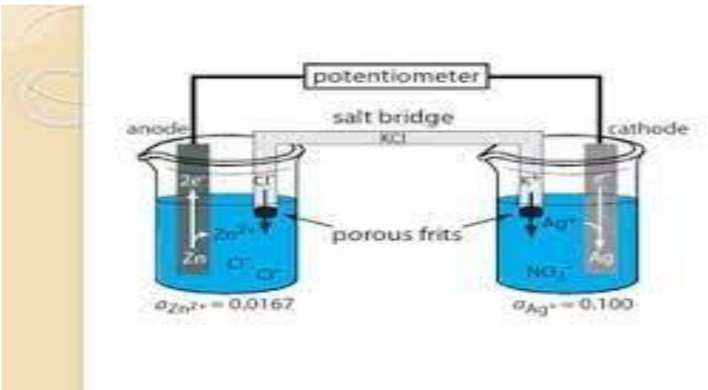
Mass spectrometry measures mass-to-charge ratio of molecules using electric and magnetic fields. There are several ionization methods: electron impact, chemical ionization, electrospray, matrix assisted laser desorption ionization, and others. Also, mass spectrometry is categorized by approaches of mass analyzers: magnetic-sector, quadrupole mass analyzer, quadrupole ion trap, Time-of-flight, Fourier transform ion cyclotron resonance.

Crystallography

Crystallography is a technique that characterizes the chemical structure of materials at the atomic level by analyzing the diffraction patterns of usually x-rays that have been deflected by atoms in the material. From the raw data the relative placement of atoms in space may be determined.

Electrochemical Analysis

Electrochemistry measures the interaction of the material with an electric field.

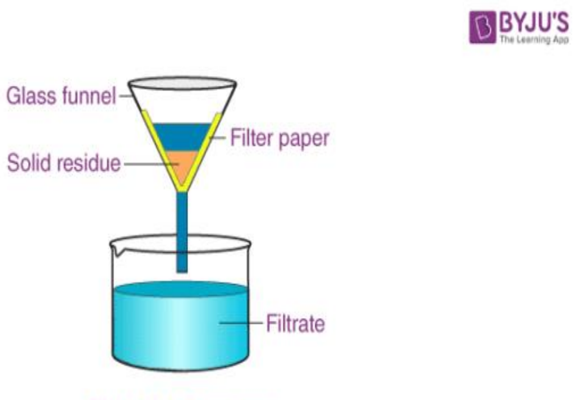


Thermal Analysis

Calorimetry and thermogravimetric analysis measure the interaction of a material and heat.

Separation

Separation processes are used to decrease the complexity of material mixtures. Chromatography and electrophoresis are representative of this field.



Filtration process

Hybrid Techniques

Combinations of the above techniques produce "hybrid" or "hyphenated" techniques. Several examples are in popular use today and new hybrid techniques are under development. For example, Gas chromatography-mass spectrometry .

Microscopy

The visualization of single molecules, single cells, biological tissues and nano-micro materials is very important and attractive approach in analytical science. Also, hybridization with other traditional analytical tools is revolutionizing analytical science. Microscopy can be categorized into three different fields: optical microscopy, electron microscopy, and scanning probe microscopy. Recently, this field is rapidly progressing because of the rapid development of computer and camera industries.

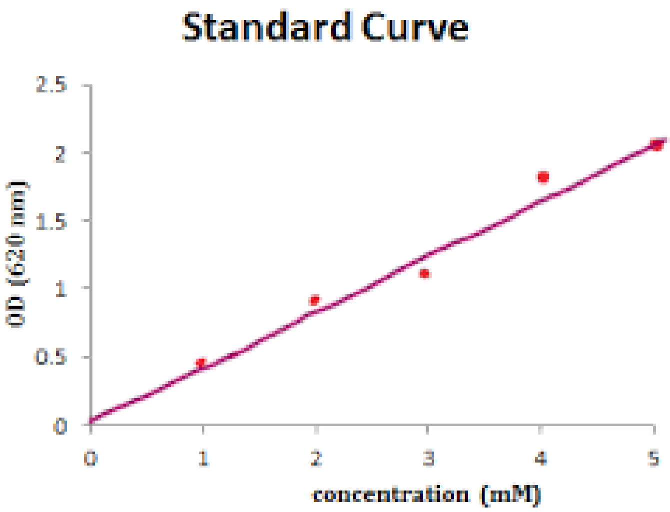
Lab-on-a-chip

Miniaturized analytical instrumentation, which is also called as microfluidics or micro total analysis system (μTAS). The beauty of lab-on-a-chip system is that a whole device can be visualized under a microscope.

Methods and data analysis

Standard Curve

A standard method for analysis of concentration involves the creation of a calibration curve. This allows for determination of the amount of a chemical in a material by comparing the results of unknown sample to those of a series known standards.If the concentration of element or compound in a sample is too high for the detection range of the technique, it can simply be diluted in a pure solvent. If the amount in the sample is below an instrument's range of measurement, the method of addition can be used. In this method a known quantity of the element or compound under study is added, and the difference between the concentration added, and the concentration observed is the amount actually in the sample.



Internal Standards

Sometimes an internal standard is added at a known concentration directly to an analytical sample to aid in quantitation. The amount of analyte present is then determined relative to the internal standard as a calibrant.