Analytical chemistry

is a branch of chemistry that deals with the quantitative and qualitative estimation of the elements or compounds that make up the substance to be analyzed. This branch is divided into several methods and techniques that can be used**,**

each of which has its uses and importance, including:

1. Volumetric analysis and gravimetric analysis
2. Thermal analysis
3. Qualitative analysis
4. Spectrometric analysis
5. Instrumental analysis
6. Electrolysis.

Some of these methods can detect the presence of a compound or elements with high sensitivity that may reach a concentration of one part per million billion grams/liter.

The subject of analytical chemistry and its tasks

The methods of qualitative and quantitative analysis are very diverse. Therefore, a substance can be studied in different ways. The name analytical chemistry is given to the science that specializes in methods of analysis. In a broader sense, analytical chemistry is a science that is not limited to methods of analyzing the composition of an analyte to be analyzed, but also includes methods of studying the multifaceted chemical aspects of the materials around us on Earth and the planets that we can observe.

Analytical chemistry helps solve many problems, including:

Clarifying the nature of the studied sample (analyte), proving whether the substance in question is of organic or inorganic origin.

Determining the forms of existence of independent components in the sample (for example, the presence of) S^{-2}, SO^{-23}, or SO^{-24}) and the degree of oxidation of elements (Fe^{+2}, Fe^{+3}, CR^{+3}, etc.).

Determining the composition and quantity of each of the main component (gold in the form of an innate metal, for example) and foreign impurities in it (copper and silver in a gold sample, for example), as well as the quantity of fine impurities (those present in very small quantities) and their local distribution in highly pure technical samples (such as boron in graphite, iron, semiconductors, etc.).

Determining the formula of an unknown compound (such as a metal, a newly synthetic substance, a pharmaceutical preparation extracted from a plant, etc.). Detecting certain structural elements in the compound in question and then determining the structure of this compound (such as detecting certain hydroxyl or carboxyl groups, double bonds, hydrocarbon moieties, or the like in the compound under study).

Basic concept of qualitative and quantitative analysis

The major types of analytical procedures used in chemistry to determine the chemical composition of a material qualitatively and quantitatively include qualitative and quantitative analysis**.**

Qualitative Analysis

Qualitative analysis in chemistry, is a branch of the subject that examines the chemical makeup of a material. It denotes the presence of several elements or groupings of elements in the sample, such as functional groups. As a result, a qualitative analysis of a sample can be utilized to establish whether or not a

specific component is present. However, no information regarding the quantity of that chemical component is provided by this examination. Color, aroma, melting point, boiling point, reactivity, precipitation, and other characteristics of the sample are frequently evaluated in the analysis.

There are two forms of qualitative analysis:

1. **organic qualitative analysis**

and

2. **inorganic qualitative analysis**.

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Examples:

Let's look at a few examples to see how a sample's qualitative analysis works:

1. Test for Iodine (An Organic Qualitative Analysis Technique) – The iodine test is used to determine whether or not starch is present. Sugar is a type of organic substance. The indication is liquid iodine in this case. To test, utilize a spot test (take a white tile and drop some drops of the samples to be examined on it.) Then, for each drop of sample, add a drop iodine solution. The presence of starch is indicated by a change in the color of the sample to a brown color.

2. Test with a flame (An Inorganic Qualitative Analysis Technique) – The existence of a certain metal or its ions can be determined via a flame test. The flame takes on varied hues depending on which metal atoms are present. The presence of some metal ions can be determined based on the flame color produced when a part of the sample is burned in the Bunsen burner. Zinc, for example, produces a green flame.

The following chemical procedures can be employed in the qualitative examination of a sample:

- Variation in color
- Extraction
- Precipitation
- Chromatography
- Spectroscopy

- **Variation in color**

In a chemical reaction, bonds of the reactant molecules will break and new bonds are made within the molecules of the product.

These chemical changes are not always visible to the naked eye, but some chemical reactions are characterized by a change in the color of reactants. In a chemical reaction, two or more elements combine to interact and a different structure is formed, with a different composition and color in total. For example, on heating, the green color of Ferrous Sulphate (FeSO4).

changes to the reddish-brown color of Ferric Oxide (Fe2O3)

$$2FeSo_4\,(s) \rightarrow Fe_2O_3\,(s) + So_2\,(g) + So_3\,(g)$$

• Extraction

it is the process of transferring a substance or compound from one place to another. This extraction method can be liquid-liquid extraction or a liquid-solid extraction. In a liquid-liquid extraction separation is based on the solubility of compounds in solvents. One common extraction chemistry technique is an **acid-base extraction**, which is a liquid-liquid extraction. This acid-base extraction separates compounds based on the direction of equilibrium in an acid-base reaction. The extraction method can also be used to isolate a desired substance from a mixture or remove impurities. Extraction is important in chemistry because a scientist can use this method to separate a desired substance to use in other applications.

The act of making tea or coffee is an everyday example of extraction. This extraction is a liquid-solid extraction, where the tea leaves or ground coffee are solid.

The tea or coffee is transferred to the liquid, which is water. In this liquid-solid extraction, the end product is a hot tea or coffee drink.

Uses of Extraction

There are several reasons to use extraction in the chemistry lab. It is a principal method for isolating compounds from plant materials.
Extraction moves compounds

from one liquid to another, so that they can be more easily manipulated or concentrated. It also enables the selective removal of components in a mixture.

Types of Extractions

In the two main types of extraction, which are liquid-liquid extraction and liquid solid extraction, the separation is based on solubility. The acid-base extraction is a liquid-liquid extraction that is based on acid-base reactions and a substance will be extracted when reacting with an acid or a base.

If an organic solvent contains a polar compound and a non-polar compound, a liquid-liquid extraction can be performed to extract the polar compound out of the organic solvent. This extraction process will take place because the polar compound will be more soluble in a polar solvent, like water. This extraction will have a general procedure similar to the following procedure.

Organic solvents containing both polar and non-polar compounds are added to a **separatory funnel**. This separatory funnel is a piece of lab equipment that has two openings, one on top with a cap and the other at the bottom with a stopcock.

Before adding anything to a separatory funnel, always make sure the stopcock is closed. A ring stands with an iron ring to hold the separatory funnel upright.

- **Precipitation**

is the process of forming a solid in a solution during a chemical reaction. When a reaction occurs in a liquid solution, the solid formed is known as a precipitate, and the reaction that causes the precipitate to form is called a precipitation reaction. Certain types of precipitates do not settle (settle) to the bottom of the reaction vessel due to gravity, but remain suspended in the solution, which can be converted to a precipitate by centrifugation. An example of inorganic precipitation reactions is the reaction between silver nitrate and sodium chloride, where silver precipitates as a white precipitate, as in the following reaction:

$$NaCl(aq) + AgNo3(aq) \rightarrow Na+ + No3- + AgCl\ Cl(s) \downarrow$$

An example of organic precipitation reactions is the reaction between porphyrin in reflux distillation with pyrolytic acid, then cooling the element to room temperature, then completing filtration.

- **Chromatography**

  is one of the analytical techniques used to separate and estimate a mixture of different chemical compounds based on physical changes and effects. This technique consists of two phases: a mobile phase and a stationary phase.

  The process is carried out by dissolving the mixture whose components are to be separated in the mobile phase, then passing the mobile phase with its components from the top of the column filled with the stationary phase and receiving the separated compounds at the bottom of the column at different times.

  The material to be separated is distributed between the mobile and stationary phases, either by different solubility, polarity, degree of ionization, or size differences.

  The mobile phase can be either an inert gas, as in gas chromatography (GC), or a liquid substance consisting of one or more solvents in specific proportions, provided that the mixture (model) compounds are completely dissolved in it, as in liquid chromatography (LC).

Types of Chromatography

There are several classifications of chromatography technology

1-Based on the principles on which it works.

a. Adsorption Chromatography

b. Partition Chromatography- Distribution Chromatography

c. Ion exchange chromatography

d. Size exclusion chromatography

2-Based on the geometric shape of the technique.

a. Column Chromatography

b. Thin layer Chromatography

c. paper Chromatography

The stationary phase

(Which is either a solid or a liquid fixed to a fixed support and is usually placed in the column or painted on a plastic or glass plate or a piece of paper.

The mobile phase

(Is either a liquid or a gas that passes through the stationary phase and does not transport the components of the mixture) of the substance to be analyzed

The importance of studying chromatography is primarily in using analytical methods to determine the internal compounds in a mixture from a quantitative and quantitative point of view.

• Spectroscopy

It is the science of the interaction of radiation (whether electromagnetic or particle radiation) with matter, which includes atoms and molecules.

Spectroscopy is used in various fields of science and technology, including chemical analysis, environmental monitoring, material characterization, forensic analysis, medical diagnosis, and astronomical studies.

The **goal of any optical spectrometer** is to measure the interaction (absorption, reflection, scattering) of electromagnetic radiation with a sample or the emission (fluorescence, phosphorescence, electroluminescence) of electromagnetic radiation from a sample.