Chapter One

Introduction to Analytical chemistry

1 Introduction to Analytical Chemistry

1.1 Analytical Chemistry and its Importance

The analytical chemistry has played an important role in the progress and advance of chemistry sciences which is considered the basic stone of the other branches of chemistry.

Thus, the analytical chemistry has enabled the chemists to determine the matter composition and the atomic weights of the elements.

These concepts have encouraged the chemists to find out the essential chemical laws such as the law of constant proportion by Broansted and the multiple proportion law for Dalton according to the conclusions resulted from the study of the ratios on which the elements are united. Therefore, the Faraday's law are the quantitative relation between the electrical energy and the corresponding chemical variation .The same scheme is followed for the other chemical laws.

This important situation which was occupied by analytical chemistry in the past is not altered today . Each experimental research depends almost to some extent on the results of the analytical data. Therefore , the study of analytical chemistry is very necessary for the students whom their ambitions to become chemists or pharmaceutists whatever their specialization will be thereafter.

Although the establishment of analytical chemistry was not so near, but the rapid progress in the analytical methods had been occurred during the third decade of the last century. The progress was very necessary to accompany the rapid advance in Industrial, Economics and the large growth in research progress in different aspects of life.

At present , the raw materials are sold in trade on the basis of their required containers of components which is determined by chemical analysis .The product values in the industrial progress are estimated and evaluated by chemical analysis.

The human beings health is protected by the chemical analysis of foods, waters and drugs . The production of fertilizers and insecticides and the clinical and bioclinical research programs are subject largely to the chemical analysis .

In brief , we can say that there is no product we use in our daily life , the analytical chemistry has no significant role on it.

. The analytical chemistry involves the investigations of the components of the matter or the sample , i.e., the identification of the components of that matter or that sample which is called the Qualitative analysis ,and the determination of their amounts which is called the Quantitative analysis. Qualitative analysis always precedes the quantitative analysis. Quantitative analysis depends particularly on the measurement of a property which is related directly or indirectly to the quantity of the required component.

The method used for this measurement is limited by the required components without interference from other components . It is very rare to find this selectivity in the analytical process unless the interferents are separated or isolated from the required component. Therefore , the quantitative analysis involves two main processes ;the separation (or isolation) & determination of sample components.

If we want to compare between quantitative & qualitative analysis we find that both of them depend on physical & chemical properties which can be confidently followed to get the required purpose of the analysis whether by detecting or standardization . In many cases, the same properties are

employed for the detection of one of the components and determination of its quantity.

Both analysis also require several steps for isolation of the wanted components from other interferents. But the loss in the amount or shortages in its quantity is accepted in qualitative analysis but is not recommended in quantitative analysis where the weight is very important and should be kept as constant as possible .

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.

Thus, in quantitative analysis one property is measured and found its relation with the concentration. These conditions render the suitable reactions limited in the quantitative analysis measurements.

1.2 Types of scales in chemical analysis :

The types of analysis are sometimes classified according to the quantity of the sample or specimen into:

1.2.1 **Macro scale:** Where the quantity of the sample is ranged between 0.1–2.0 g or more while the volume ranges between 10 – 20 ml.

1.2.2 **Semi micro scale:** Where the sample quantity is ranged between 10-100 mg and the volumes of solution do not exceed 1 ml.

1.2.3 **Micro scale:** Where the weight of sample or matter is ranged from 1 mg to several milligrams and the volume of solutions is decimals of millilitre.

1.2.4 **Ultra micro scale:** Where the weight of the sample does not exceed several micrograms and several microlitres are used for liquids or solutions. After the manufacture of microbalances and their use in

laboratories and factories , it becomes possible to analyse samples of weight ranged from microgram to one milligram.

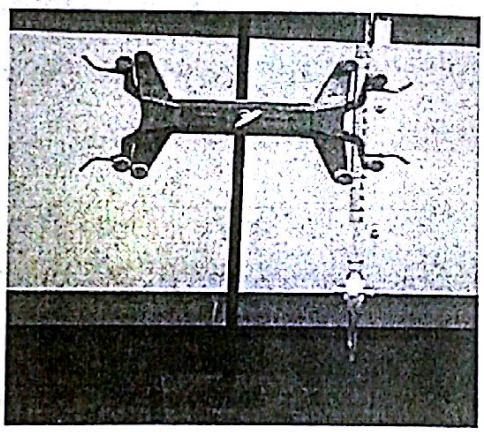
Actually , there is no separating boundaries between these scales of analysis and the same method can be used for example with semi-micro and micro scales but the difference is in the amount of the sample and the volume of the liquid or solution.

1.3 Methods of quantitative analysis :

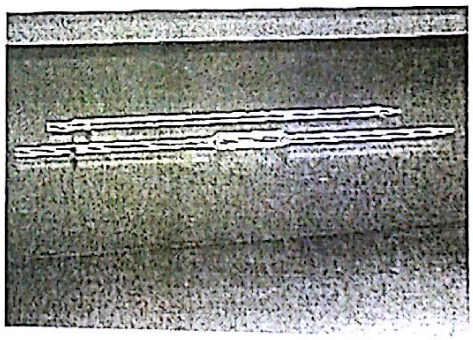
Quantitative analysis is classified into two main methods :

1.3.1 Classical methods of analysis :

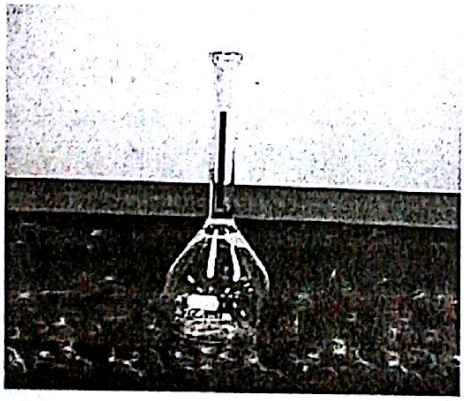
Manual simple methods and simple items are used in these methods like burettes(fig 1.1a), pipettes(fig 1.1b), measuring flasks(fig 1.1c), different crucibles, desiccators, conical flasks(fig 1.1d), beakers, ...etc.



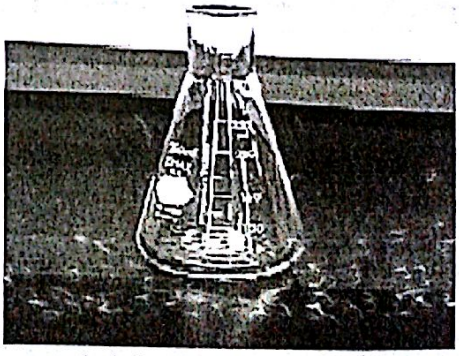
1.1a: Burette and it's stand



1.1b: Pipettes



1.1c: Measuring flask



1.1d: Conical flask

Figure (1.1): Some items used in Volumetric analysis.

Although these methods are very ancient , they are still used, exploited and improved in the laboratories. These methods are subclassified into two types of analysis:

A- Volumetric analysis (Volumetry):

These methods are concentrated on the exact volume measurement of the solutions during the titration process. The volumes are precisely measured by the burettes, pipettes and measuring flasks. The volumetric methods of analysis include acid-base reactions or titrations which are called also neutralization reactions, the precipitation titrations or reactions, oxidation-reduction reactions or titrations and complex formation reactions or titrations.

B- Gravimetric methods (Gravimetry):

These methods involve the alteration of the wanted component into a slightly soluble material called Precipitate. The precipitate is easily separated, dried and weighed. These methods are also called precipitation methods which are either chemical precipitation, when a chemical precipitating agent is used, or electrical precipitation when the precipitation is performed by electrical cell.

These methods involve also volatilization methods in which the component is separated by heating or adding special reagent. The method may be physical like the determination of moisture by drying or chemical like the liberation of carbon dioxide by heating $CaCO_3$ or adding hydrochloric acid .

1.3.2 Instrumental methods of 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 are subclassified into three methods:

A- Optical or Spectrophotometric methods.

They are the methods which depend on the characteristics of electromagnetic radiation and its interaction with component under test. These methods involve molecular and atomic absorption and emission, spectrophotometry, different X-Ray methods of analysis ...etc.

B- Electroanalytical methods.

They are the methods in which the electrical property is related to the components ~~that~~ ~~wanted~~ to be determined, such as pH measurements, electrodeposition, voltametry, ~~and thermal analysis~~.

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 equipments are used in separation processes. These methods involve precipitation, volatilization, ion-exchange, extraction with solvent and various chromatographic methods.

Our study in this book is concentrated on the quantitative volumetric methods of analysis which explain the different types of reactions in different titration processes.

The Authors