Analytical Chemistry is the branch of chemistry principally concerned with determining the chemical composition of materials, which may be solids, liquids, gases, pure elements, compounds, or complex mixtures. In addition, chemical analysis can characterize materials but determining their molecular structures and measuring such physical properties as pH, color, and solubility. Wet analysis involves the studying of substances that have been submerged in a solution and microanalysis uses substances in very small amounts.

Qualitative chemical analysis is used to detect and identify one or more constituents of a sample. This process involves a wide variety of tests. Ideally, the tests should be simple, direct, and easily performed with available instruments and chemicals. Test results may be an instrument reading, and observation of a physical property, or a chemical reaction. Reactions used in qualitative analysis may attempt to cause a characteristic color, odor, precipitate, or gas appear. Identification of an unknown substance is accomplished when a known one is found with identical properties. If none is found, the uknown substance must be a newly identified chemical. Tests should not use up excessive amounts of a material to be identified. Most chemical methods of qualitative analysis require a very small amount of the sample. Advance instrumental techniques often use less than one millionth of a gram. An example of this is mass spectrometry.

Quantitative chemical analysis is used to determine the amounts of constituents. Most work in analytical chemistry is quantitative. It is also the most difficult. In principle the analysis is simple. One measures the amount of sample. In practice, however, the analysis is often complicated by interferences among sample constituents and chemical separations are necessary to isolate tthe analyte or remove interfering constituents.

The choice of method depends on a number of factors: Speed, Cost, Accuracy, Convenience, Available equipment, Number of samples, Size of sample, Nature of sample, and Expected concentration. Because these factors are interrelated any final choice of analytical method involves compromises and it is impossible to specify a single best method to carry out a given analysis in all laboratories under all conditions. Since analyses are carried out under small amounts one must be careful when dealing with heterogeneous materials. Carefullly designed sampling techniques must be used to obtan representative samples.

Preparing solid samples for analysis usually involves grinding to reduce particle size and ensure homogeneity and drying. Solid samples are weighed using an accurate analytical balance. Liquid or gaseous samples are measureed by volume using accurately calibrated glassware or flowmeters. Many, but not all, analyses are carried out on solutions of the sample. Solid samples that are insoluble in water must be treated chemically to dissolve them without any loss of analyte. Dissolving intractable substances such as ores, plastics, or animal tisure is sometimes extremely difficult and time consuming.

A most demanding step in many analytical procedures is isolating the analyte or separating from it those sample constituents that otherwise would interfere with its measurement. Most of the chemical and physical properties on which the final measurement rests are not specific. Consequently, a variety of separation methods have been developed to cope with the interference problem. Some common separation methods are precipitation, distillation, extraction into an immiscible solvent, and various chromatography procedures. Loss of analyte during separation procedures must be guarded against. The purpose of all earlier steps in an analysis is to make the final measurement a true indication of the quantity of analyte in the sample. Many types of final measurement are possible, including gravimetric and volumetric analysis. Modern analysis uses sophisticated instruments to measure a wide variety of optical, electrochemical, and other physical properties of the analyte.

Methods of chemical analysis are frequently classified as classical and instrumental, depending on the techniques and equipment used. Many of the methods currently used are of relatively recent origin and employ sophisticated instruments to measure physical properties of molecules, atoms, and ions. Such instruments have been made possible by spectacular advances in electronics, including computer and microprocessor development. Instrumental measurements can sometimes be carried out without separating the constituents of interest from the rest of the sample, but often the instrumental measurement is the final step following separation of the samples's components, frequently by means of one or another type of chromatography.

One of the best instrumental method is various types of spectroscopy. All materials absorb or emit electromagnetic radiation to varying extents, depending of their electronic structure. Therefore, studies of the electromagnetic spectrum of a material yield scientific information. Many spectroscopic methods are based upon the exposure of a sample substance to electromagnetic radiation. Measurements are then made of how the intensity of radiation absorbed, emitted, or scattered by the sample changes as a function of the energy, wave length, or frequency of the radiation. Other important methods are based upon using beams of electrons or other particles to excite a sample to emit radiation, or using radiation to induce a sample to emit electrons. In conjunction with the related techniques of mass spectrometry and X-ray or neutron diffraction, spectroscopy has almost completely replaced classical chemical analysis in studies of the structure of materials.

Classical chemical procedures such as determination by volume as in titrations is also used. A titration is a procedure for analyzing a sample solution by gradually adding another solution and measuring the minimum volume required to react with all of the analyte in the sample. The titrant contains a reagent whose concentration is accurately known; it is added to the sample solution using a calibrated volumetric burette to measure accurately the volume delivered.

When a precisely sufficient volume of titrant has been added, the equivalence point, or endpoint, is reached. An endpoint can be located either visually, using a suitable chemical indicator, or instrumentally, using an instrument to monitor some appropriate physical property of the solution, such as pH or optical absorbance, that changes during the titration. Ideally, the experimental endpoint coincides with the true equivalence point, where an exactly equivalent amount of the titrant has been added, but in practice some discrepancy exists. Proper choice of endpoint location system minimizes this error.

Analytical chemistry has widespred useful applications. For example, the problems of ascertaining the extent of pollution in the air or water involves qualitative and quantitative chemical analysis to identify contaminants and to determine their concentrations. Diagnosing human health problems in a clinical chemistry laboratory is facilitated by quantitative analyses carried out on samples of the patient's blood and other fluids. Modern industrial chemical plants rely heavily on quantitative analyses of raw materials, intermediates, and final products to ensure product quality and provide information for process control. In addition, chemical analyses are essential to research in all areas of chemistry as well as such related sciences as biology and geology.