Pharmaceutical analysis is analytical chemistry that deals with which process or series of process or series to identify and quantify the drug or formulation and purification of substances, separation of the components from mixture or solutions and determination of structure of chemical compound.

Techniques of Analysis

There are mainly two types of chemical analysis:

(i) Qualitative analysis (identification)

ⓘ Quantitative analysis (estimation).

(i) Qualitative Analysis

Qualitative analysis gives an indication of the identity of the chemical species of the sample.

This method is perform to establish composition of natural or synthetic substances. It gives the information whether the substance or compound is present in the sample or not.

Qualitative analysis includes detection of evolved gas, formation of precipitate, limit test, colour change reaction, melting point and boiling point, taste etc.

1. Melting point.

The temperature at which a solid melts is known as the melting point.

It is a physical property of solid substances. This method is used to identify substances.

Melting point determination is a simple, fast and economic method used to obtain a first impression of the purity of a substance.

Pure crystalline substance gives a clear sharp melting point.

This method can identify purity of compound as small amount of impurities present in sample can change the melting or enlarge its melting range.

2. Boiling point

Boiling point is the temperature at which the vapour pressure of a liquid equal to the atmospheric pressure ~~of~~ or some other applied pressure.

Boiling point is physical property of liquids for indicating the purity of solvent or liquids.

The boiling point of a liquid varies depending upon the surrounding, environmental pressure. A liquid in a partial vaccum has a lower boiling point than when that liquid is at atmospheric pressure.

Refractive Index.

Refractive index also called index of refraction is specific property of light. It gives information regarding behaviour of light.

The refractive index is measure of the bending of a ray of light when passing from one medium into another.

When light passes through any substance its velocity decreases and refractive index increases due to the effect of interaction between molecules of substance on light.

Refractometer is a device which is use to measure the refractive index of substance.

8/12/21

Optical Rotation

Optical rotation or optical activity is the rotation of the plane of polarisation of linearly polarised light as it travels through certain materials. Optical activity occurs only in chiral materials, those lacking microscopic mirror symmetry. Optical activity can be observed in fluids. This can include gases or solutions of chiral molecule such as sugars, some proteins and also chiral liquid crystals.

The substance which rotates plane of polarisation of light towards right or in clockwise direction are called **dextrorotatory**.

The substance which rotates plane of polarisation of light towards left or in anti-clockwise direction are called **leavorotatory**.

Polarimeter is used to measure the optical activity.

Quantitative Analysis.

These techniques are mainly used to quantify any compound or substance in the sample or to determine the amount of each compound present in the sample.

Types of Quantitative analysis:

1. Chemical Methods
    a). Volumetric or titrimetric methods.
    b). Gravimetric methods.
    c). Gasometric analysis.

2. Electrical methods.
3. Instrumental methods.
4. Biological and Microbiological methods.

1. Chemical Method.

a). Volumetric or titrametric methods:-

This methods involves the measurement of volume of a solution of known concentration which is used to determine the concentration of the analyte.

Volumetric method is a simple method and requires less apparatus and they are susceptible of high accuracy.

Basic terms involves in Titrimetric or volumetric method.

1. Titrate :- A substance is to be titrated is called titrate.

2. Titrant :- A solution of known concentration is called titrant.

3. Indicator :-

Indicator is a substance that show colour change after completion of chemical reaction between titrate and titrant.

It depends upon pH of solution.

• End point or Equivalence point.

The equivalence point is the point in a titration at which the amount of titrant added is completely neutralises analyte in the solution.

• Standard solution.

A solution of known concentration is called standard solution.

Pharmaceutical Analysis - I

Qualitative   Quantitative

It refers to the chemical analysis of drug molecules or medicinal agents and their metabolites. It consist of quality and quantity of drug and fine chemical which are used in pharmaceutical preparations.

★ Pharmaceutical Analysis is generally involved in two steps.

① Separation of compound of interest.

② Quantification of compound.

Scope :-

The scope of pharmaceutical Analysis can be extended by incorporating during disease states which serves as diagnostic aid in medicine.

The main object and aim of quantitative analysis is to carry out the determination of the quantitative contents of the individual compound or element. +nt in a drug solution.

Importance of Quantitative analysis in quality control.

The various silent features with respect to the quantitative analysis in quality control are as experimented under:-

① Chemical formula of an unknown substances:

Formula of an 'unknown' substances, either synthesized in a laboratory or isolated from natural occuring plant sources is in variable determined and established from the percentage contents of its constituents found by actual analysis.

② Infact the chemical analysis represent the backbone of a Pletbora of most impt. method of investigation and therefore, imployed extensively and profusely impractical all branches of science that use intimatly associated to chemistry.

eg:- It finds it ~~adb~~ ~~ad~~ abdunt utility in pharmaceutical analysis of inorganic and organic chemical substances, microbiology, bio-chemistry, bio-technology, pharmaceutical technology, besides certain highly specific discipline → physiology, Geology , Minerology , Medical and Agricultural sciences.

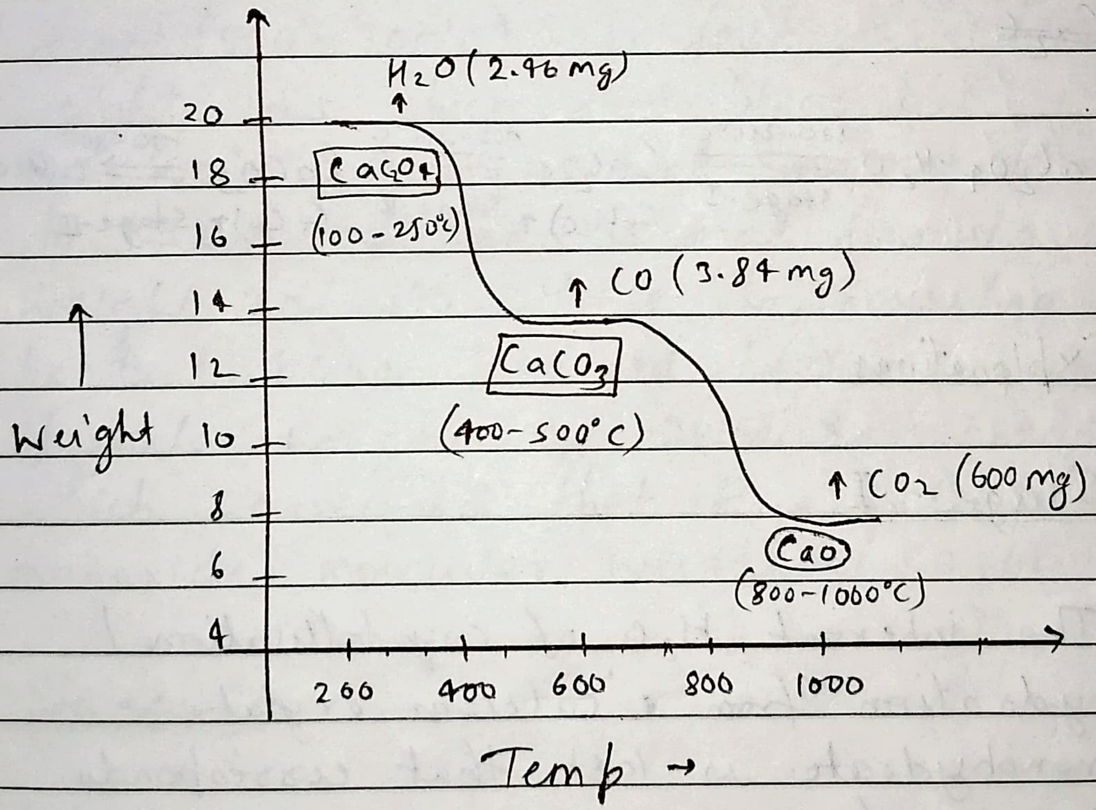
③ The chemical analysis of posses an enormous potential in pharmaceutical industry in particular and others allied industries in general. On a rather more specific note a 'Pharmacist', should be fully aware at each and every steps of adopted production process the qualititative as well as quantitative chemical composition of the materials (substances) that have undergone expected and desired conversion (modification).

eg:-) Thermogravimetric Analysis (TGA) of calcium ~~oxe~~ oxcelate Monohydrate.

It has been duly observed that a large no. of chemical substances usually get decomposed upon heating. Infact this very idea and concept of heating a particular given sample to observe carefully that ensuring weight variations in the underlaying principle of thermogravimetric analysis (TGA). Interestingly , the TGA of ~~Ca~~ Calcium oxalate monohydrate reprents the dynamic TGA. Whereas in the solid sample is specifically subjected to conditions of predetemined and controlled continuous increases in temperature which is mostly observed to be linear with time.

Method:-

The 'thermogram' for calcium oxalate monohydrate ($CaC_2O_4 \cdot H_2O$) is dully represended in fig. one may however distinctly observe the successive plateous namely.



(i) Correspond to anhydrous oxalate (100- 250°C).
(ii) Correspond to calcium carbonate.
(iii) Correpond to Calcium oxide.

In other words, the three observed plateous clearly designate the following vital aspect of the decomposition curve namely.

ⓐ Clear indication of constant weight.

ⓑ Stable phase encounted within a specific temperature interval.

The various distinct chemical reaction that are actually may be summarized as follows :-

~~Ca_2C~~

$$CaC_2O_4 \cdot H_2O \underset{\text{Stage-I}}{\overset{100-250^\circ C}{\rightleftharpoons}} \underset{(+H_2O)\uparrow}{CaC_2O_4} \underset{\text{Stage-II}}{\overset{400-500^\circ C}{\rightleftharpoons}} \underset{(+CO)\uparrow}{CaCO_3} \underset{\text{Stage-III}}{\overset{700-800^\circ}{\rightleftharpoons}} Ca(+CO_2)\uparrow$$

<u>Explanations</u> :-

<u>Stage - I</u>

① The inherent H_2O of crystallisation / hydration from calcium oxylate monohydrate is last that corresponds to 2.46 (12.3%) equivalent to 1 mole of H_2O b/w the tempt. range 100°c -250°c. In actual practice the (12.3%) weight has normally occur between 100°-250°c must correspond to 12.3% of the original formula weight for $CaC_2O_4 \cdot H_2O$ (146) Therefore the product which get lost eventually has a formula weight of $0.123 \times 146 = 17.958 \ (\simeq 18)$ and it definitely correspond to H_2O (water) (Molecular weight of $H_2O = 18$)

Stage -2

One mole carbon monoxide (CO) gets evolved from calcium oxalate (CaC_2O_4) corresponding to 3.84 mg (19.2%) between the temperature varying from (400° - 500°c). In fact the 19.2% weight loss which took place b/w 400 - 500°c must actual correspond to 19.2% of the original formula weight of 146. Hence the resulting product being produced bears a formula weight of $0.192 \times 146 = 28.0$ which correspond that it is CO (carbon monoxide) molecular weight of CO = (12+16=28)

Stage -3:

At the final stage one mole of CO_2 (carbon dioxide get evolved from one mole of $CaCO_3$ which eventually correspond to 6.02 mg (3.01%) in the tempt range varying b/w 700°- 800°c . Interestingly the weight loss corresponding to 3.01% which occurs in tempt. range b/w 700°-800° should be equivalent to 3.01% of the original formula weight of 146. Hence the generated product bears a formula weight of 0.301 × 146 = 43.946 (≃ 44) and its correspond to CO_2 (carbon dioxide) (12 + 32 = 44)

Imp

* ④ As to date this is widely accepted practice that no 'drug substances' is either taken into production for actual consumption without proper quality control screening that essentially characterised its overall quality, stability and suitability for various purpose. Importantly those ultimate result serve two major objective namely.

ⓐ To form the fundamental basis of all the processing calculation and.

ⓑ To determine exactly the 'naked cost' of various materials inputs that predominally serve as core basis of all financial estimates.

⑤ In a broader perspective, the ulmost impt. of adequate and proper control of production is quit evident. Hence it is absolutely necessary each and every pharmaceutical industry should essentially have an well equiped analytical laboratory under the command of a qualified experienced and highly motivated pharmaceutical analysis personally. Now a days these laboratories are called 'Quality Assurance' and 'Quality control' laboratory for the chemical control physical parameters and microbiological screening of a raw material. Intermediates and finite product.

⑥ In actual practice, however pharmaceutical analysis major problem is most commonly implified to a greater extent significantly by vertuie of the fact that the qualititative composition of majority of the investigated product pure drug → substance chemically additives, pharmaceutical intermediate and finished dosage form is well known as

described in official compedia
eg :- (IP, BP, USP, EP, International P.)
Furthermore, the approximately contents of the individual elements are obviously known quite frequently.

Evidently in such particular instances the usual preliminary qualititative analysis become more or less unnecessary absolutely, thereby rendering the proper solution of the most appropriate technique of the qualitative analysis become much more easier and meaningful

Types of Quantitative Analysis :-

① Titrimetry :
Volumetric :- of quantitave method of analysis dealing with volume of solution and their measurement is termed as titrimetric analysis or tritometry. The substance is allow to react with an appropriate reagent added as a standard sol^n and the vol. of sol^n needed for complexo rxn is determined.

The common type of rxn that are used in titrimetry are..

1) Neutrilization rxn (acid, base)

Acid base titration is based on the neutralization rxn b/w the analyte and acidic or basic titrant. Those rxn used at pH indicator, pH meter, as a conductant meter to determine a end point.

2) Precipitate rxn.

A precipitation titration comprises a class of rxn that required a formulation of insoluble precipitate. Provided that the end point at which the precipitation is complete can be determined.

3) Oxidation Reduction rxn :-

ⓐ Redox :-

A redox titration is based on an oxidation - reduction rxn b/w the analyte an oxidant or reductant.

A potentiometer or redox indicator is used to determined the end point. Frequently either the reactants or the titrant have a colour intense enough that an additional indicator is not needed.

(b) Complex forming rxn :-

A complexometric titration is based on the formation of a complex b/w the analyte and the titrant the chelating agent EDTA is very commonly used to tritrid metal ions in the soln. This titration generally requires specialised indicators that forms weaker complexes with the analyte. A common examples is Eriochrome. T for the titration of Ca and Mg ions.

★ Non - aquous titration

Non - aquous titration is the titration of substance discolve in a non - aquous solvent. It is the most common titrimetry procedure used in pharmacopoel assay and serve a double purpose.

① It is suitable for the titration of very weak acid and bases.

② And it provides a solvent in which organic compound are soluble.

Gravimetry :

It involves the separation of the constituents to be estimated in the form of and insoluble precipitate. The insoluble precipitate is vast to free it from all impurities, dried and weighted either as such as ignited to give a residue of some other compound which is the weight. Now from its weighed and no one composition the amount of the constituents in the given sample is calculated.

Determination of chlorine content in common salt (NaCl) the various forms of gravimetry are :-

(i) Electrogravimetry :

It involves at electrolysis and the materials deposited on one of the electrodes is weighed.

(ii) Thermogravity :-

It estimates the change in ~~wood~~ weight as a function of temp.

(iii) Differential Thermalanalysis :-

Determine the difference in tempt. b/w a test substance and an inert reference material.

(iv) Differential Scanning colorimetry :-

Records the energy needed to establish at a zero tempt. difference b/w a test substance and a reference materials.

Volumetry.

It is concerned with measuring the vol. of gas evolved and absorb in a chemical method.

★ (II) Physical Method of Analysis :-

It involves the determination of physical properties of liquid like specific gravity, viscosity as surface tension. The common types of measurement that are used in physical method of analysis are.

1) Refractometry :-

It involve the measurement of refractive index of liquids using a refractometer.

eg. → Refractive index of arachis against water.

2) Polarimetry :-

It is used to measure optical relation of an optically active compound using a polarimeter.
eg.. Optical rotation sucrose.

3) Viscometry :

It involves the measurement of viscocity of a liquid using viscometer.

eg. Viscosity of solvent.

III Electrical method of Analysis.

It ~~ino~~ involves the measurement of current voltage as resistance in relation to the concentration of a certain species in solution. The common types of measurements that are used in ~~elem~~ electrical method of analysis includes :-

1. Voltametry :-

It involves the measurement of current at a micro electrode at specified voltage.

2. Carlometry :-

It measures current and time needed to compete an ~~electrode~~ electrochemical rxn. or to generate sufficient materials to react completely with a specified reagent.

③ Potentiometry :-

It is used to measure the potential of an electrode in equilibrium with an ions to be determind.

④ Spectroscopic method of Analysis.

Spectromethod measure the electromagnetic radiation i.e absorbed scattered or emitted by the analyte the methods of measurement of radiation vary from one method to another. The imp. ~~section~~ . spectro methods are :-

ⓐ Absorption spectroscopic :-

It depends on measuring the amount of a particular wavelength absorbed by the sample. Absorption method are usually classified according to wavelength involved as visible, ultraviolet or infra-red spectroscopy. The visible spectroscopy or spectroscopy photo-metry is some time called as calorimetry.

ⓑ Turbidimetry and Nephalometric method :-

This process are used to measure the amount of light stolped or scattered by a suspension..

© Emission Spectroscopy :-

It determines the amount of radient energy of a particular wavelength emitted by the sample.

ⓓ Flame photometry :-

It uses a solution of this sample injected into a flame.

⑤ Fluorimetry :-

It takes a suitable substance in solⁿ (commonly a metal fluorescent reagent complex) and excites it using visible or uv radiation.

⑥ Chromatographic methods :-

This methods are used to separate mixture of substances and to identify components of a mixture.
For eg :- Paper chromatography, thin layer chromatography and gas-liquid chromatography.

IV Special technique:

1. X-ray methods:

X-rays are produced when speed $e^{\ominus}$ collide with a solid target (which can be the material under investigation) it is possible to identity certain emission pears that are characteristic of element contain in the target.

2. Radio-activity:-

This procedure measures intensity of the ~~solution~~ radiation from a naturally occuring radioactive material. Measuring radioactivity induced by exposing the sample to a neutron source (activation analysis) or isotope dilution and radioimmunoassay.

③ Kinetic methods:-

This methods are based on increasing the speed of a rxn by adding a small amount of a catalyst, within limits, and the rate of catalyst rxn will be governed by the amount of catalyst Ant.

Volumetory method of Analysis :-

Volumetric analysis is depends on the measurement of the vol. of the solution of the interactive substances. In this analysis a measured vol. of solution of a substance is allowed to react completely with the solⁿ of a given strength of another substance. The end point of the rxn is indicated by sum marked changes such as appear as disappearance of colour or formation of precipitate and the process is termed as titration. The stage during titration at which the rxn is just complete is known as equivalence or end point. Generally end point in a volumetric analysis is detected by the addition of a suitable substance called indicator that changes its colour when the rxn is just completed.

Fundamental of volumetory analysis:-

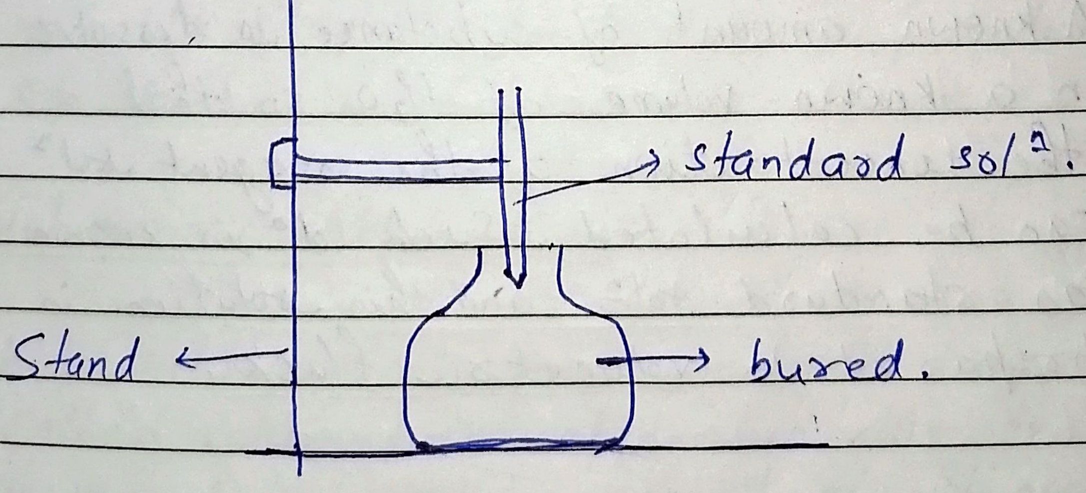
The fundamental requirements to carry out titrimetric or volumetric process are :-

① The rx^n b/w titrate and titrand must be well defined i.e. definite amount of reactants must react to produce definite amount of products.

② The rxn must be rapid so that little time is needed to complete the titration. A catalyst may also be used to increase the rate of rx^n.

③ Titrimetric cal. are based on 100% rx^n b/w the reactants, thus mixing of equivalent amounts of the rx^n must gives a complete rx^n.

④ A standard sol^n of reagent i.e titrand should be taken in a bured and titrate is kept in a conical flask as shown in fig.



⑤ An indicator kept in a conical flask must be available to show the conclusion of the rxn.

⑥ The end point should be well defined

⑦ The vol. of titrand used for completion of a rxn is known as titre volume.

⑧ As the concentration of the reagent sol^n is known the quantity of reagent ⊕nt in the sol^n can be calculated.

Step involved in Volumetric Analysis.

→ Volumetric determination of a sol^n of a given substance (Analyte) with the reagents involves the following steps.

① A known amount of substance is dissolve in a known volume of H_2O so that the concentration of the reagent sol^n can be calculated. Such sol^n is known as standard sol^n. and this solution is prepared in volumetric flask.

② A known vol. of analyte sol^n is taken in a conical flask with the help of a pipette. The analyte sol^n is also called as sample sol^n, test sol^n or titrate sol^n.

③ Few drops of an indicator are added to the titrand sol^n taken in the conical flask. The use of the indicators is to show the colour change when the ~~a~~ rxn b/w the analyte and the reagent sol^n is just complete.

④ The objective of titrating and alkaline sol^n with a standard sol^n of an acid is to determine the amount of acid which is exactly equivalent chemically to the amount of the base Ⓟnt. This point of neutrilization is termed as equivalence point or theoritical end point due to formation of salt.

Volumetric Apparatus:-

Apparatus used for titrations are called volumetric apparatus due to involvent of measurement of volumes. Acid base titration form part of a group of laboratory procedures known as volumetric analysis.

Some of the characters are given as:

① **Pipette :-**

Bulb pipette is designed to deliver an accurately known vol. of solution, after it has been filled exactly to the ~~tank~~ . mark. They are available in volumes of 1, 2, 5, 10 and 20 ml. Also volumetric pipettes are calibrated in units of milimeter (mm). The pipette is held vertically to fix the mark at the same level as the eye.

~~Pipt~~ Pipettes are of two types:-

ⓐ **Transfer pipette :-**

It has one mark and withdraw a small and constant vol. of sol^{n}.

ⓑ **Measuring / Graduated pipette:**

These are graduated used to deliver various small volume. During withdrawal the adhering drops addition are removed by stroking against an inside walls of glass surface as touching to the surface of sol^n.

② Beaker :-

It is a container having beak like structure. Borosil beaker is used as it with stand with frequent heating and cooling. Beaker's are different capacities.

eg :- 50 ml, 100ml, 500ml and ~~50~~ 1000ml are available in market.

The following process are carried out in such containers.

(i) Preparation of solution
(ii) Heating
(iii) Precipitation.

③ Burette :-

A burette consists of a graduated tube fitted with stop cock and used to deliver variable vol. Burettes are normally available in max^m capacities of 2,5,10,25,50 and 100 ml. Before using, the burette is thoroughly cleaned with a cleaning agent, rinsed well with a distilled H_2O the stop cock is lubricated and fixed in burette holder. The solⁿ is filled the help of a small funnel upto zero mark. The liquid is discharged. from a burette into a conical flask. The flask is gently rotated with the right hand. for mixing of content well. Meniscus is a curve in the surface of a liquid and is produced in response to the Surface of the container or another object. It can be either concave or convex.

④. Conical flask:

A conical flask is flat bottom pear shaped apparatus with short ~~neck~~ narrow neck of thin line marked around the neck indicates the volume that it holds at a certain definite tempt. solution to be titrated are usually pipette into a conical flask, also known as an Erlenmayer flask.

⑤ Volumetric flask :-

This flask are used to prepare standard solⁿ of solutes. In known mass of solute is placed in a flask, dissolved in pure water and then made up a mark etched in the neck of flask. Volumetric flask are normally supplied in volumes of 100ml to 1000ml.

⑥ Measuring Cylinder:-

These are used to measure standard solⁿ of solutes with permanent graduations they are made up of borosilicate glass. The commonly used sized of measuring cylinder are 10 ml, 50 ml, 100ml, 250 ml, 500 ml and 1000 ml. Before use the burette is thoroughly cleaned with a cleaning agent and rinsed well with distilled H_2O. While reading the measuring cylinder you should read the no. i.e. at the bottom of the miniscus.

Some Important terms in volumetric analysis:-

① Titrand or Titrate:-

It is prepared by dissolving a known amount of substance into a known amount of H_2O as solvent. It is prepared in volumetric flask, it has ~~exactly~~ exact purity non-hydroscopic in nature. It is also known primary standard solution, test solution or analyte solution.

Titrant:-

The secondary standard sol^n is known as Titrant. It is used in process of standardization and whose content or concentration of active compound is formed by compassion against primary standard. It is prepared in volumetric flask and taken in burette.

Indicator:-

Indicator is an organic dye which signal the completion of a rxn or titration by the visual change in the colour eg:- methyl orange, phenol red, starch and phenolphthalein etc.

Equivalence point:-

It is a point of a rxn or titration when the no. of titrand molecule reacting with titrate molecule will be equal.

Standardization:- It is the process where the concentration of one solution is determined by the known concentration of the other solution.

End point:

It is exact stage at which an indicator gives its visual colour change and the rxn is just completed.

Standard solution:

A solution whose concentration is accurately known is called standard solution.

Preparation:-

An exactly weight amount of the substance of definite and known volume in composition is dissolve in distilled water and made up to the known vol. in graduated volumetric flask. From the known weight and volume, the concentration of the solution is calculated. These are of the following type of standard solⁿ.

① Primary Standard solⁿ:-

A primary standard is a compound of efficient purity from which a standard solution can be prepared by direct weighing of a quantity of it and followed by detection to give a definite vol. of solⁿ, the solⁿ then produced is primary standard solⁿ.

A primary standard solⁿ should satisfy the following requirements:-

ⓐ It must be easy to purify, to dry (preferably at 110°- 180°C) and to preserve in pure ~~water~~ state.

ⓑ The substance should not be altered in air during weighing.

(c) The substance should be capable of being tested for impurities by qualities and other test of known sensitivity.

(d) The substance should be readily soluble under each condition in which it is employed.

(e) The rxn with standard relationship b/w reactant and products in chemical rxn.

Some ex. of primary standard sol^{n} :-

(i) Arsenic trioxide for standardization of iodine and calcium (IV) sulphate solution.

(ii) Benzoic acid for standardization of TBAH (Tetry- butyl ammonium hydrate) in methanol sol.

(iii) Potassium bromate ($KBrO_3$) for standardization of sodium thiosulphate sol^{n}.

Secondary Standard solⁿ :-

A secondary standard solⁿ is a substance which may be useful for standardization and whose content of the ~~above~~ active substance have been found by comparison against a primary std. solⁿ. They are prepared in a laboratory for specific analysis and are usually standardized against primary standard as follows that a secondary standard solⁿ is a solution in which the concⁿ of dissolve solute has not been determined from the weight of the compound dissolved but by rxⁿ (titration) of measured vol. of a primary standard solⁿ.

eg:-

① Alkali hydroxide → potassium hydroxide (KOH), (NaOH).

② Mineral acids :- HCl, H_2SO_4 (sulphuric acid) and nitric acid (NHO_3).

③ Oxidizing agent :- Potassium permanganate ($KMnO_4$), and potassium dichromate ($K_2Cr_2O_7$).

The secondary standard component which is not obtain in pure state eg:- Caustic soda (NaOH) and Minerals acids (HCl, H_2SO_4) and (HNO_3) are prepared little more concentrated than required and to dilute it with distilled water until the desired normality is obtained. This sample must be standardized and for standardization they have to be titrated against the solution of pure substances of known concentration (primary standard).

Accuracy :-

The accuracy of determination may be defined as the closeness of a measured value of the true or most probable value for analytical methods there are 2 possible ways of determining the accuracy absolute method and comparative method.

① Absolute method. :

These test ~~fo~~ of accuracy of the method under consideration is carried out taking varying amounts of the constituents and proceeding according to specified institution. The amount of the constituents must be varied ~~be~~ the determinate errors in the procedure may a function of the amount used. The difference between the mean of an adequate no. of results and the amount of constituents actually Int is a measure of accuracy of the method in the substance. Here primary std. are used.

Comparative method:-

In this method of accuracy the solid synthetic secondary standard sample of desired composition are prepared. The samples are resorted further as to determine the content of the constituents by one or more accurate method of analysis. This method indicates the absence of appreciable systematic error in the procedure of analysis.

Precision :-

Precision is defined at the agreement of a series of measurement of the same quantity when an analyst is able to reproduce two or more measurement with only slight difference in the result, this work may be reproduced as to be precision.

There are 2 forms of precision :-

① Run Precision Repeatibility :-

If a analyst has marked the determination on the same day in rapid succession, the set of result would be defined as repeatable.

② Run Precision reproductibility :-

If an analyst has made the determination on the separate days when laboratory condition may be vary the set of results would be defined as reproductiable.

(i) Mean or Average :-

Mean or average is obtained by dividing the sum of a set of measurement by the no. of individual measurement in the set.

$$\boxed{\text{Mean} = \frac{Mn}{n}}$$

M = Individual measurement
n = total no. of measurement

(ii) Mean deviation of a single measurements :-

It is the mean of the derivations of all the individuals measurements. It can be calculated as.

ⓐ Determining the arithmetic mean of results.

ⓑ Calculating the deviation of each individuals measurements from the mean.

ⓒ Calculating the deviation by the no. of measurements and.

ⓓ Coefficient of variable.

$$\boxed{(CV) = \frac{S \times 100}{x}}$$

S = Standard deviation, x = mean.

Precipitation ~~method~~ :- Titration :-

Q. Discuss principle of precipitation titration. Discuss Fajan method in detal? [14 marks]

Principle of ppt. titration :-

The main principle of precipitation titration is that the quality of adding precipitating reagent or precipitant is equivalent to the substance been precipitated.

PDF - start

Significant figures :-

The number of digits necessary to express the result of a measurement consistent with measured precision or in other words a significant figure is digit having some practical meaning i.e, it is a figure or digits which denotes the amount of quantity in the place in which it stands or the digit of a number which are needed to express the precision of the measurements from which the number derived are known as significant figures.

The following guidelines indicate whether or not a digit is significant:

(1) All non-zero digits are significant digits

eg. 1, 2, 3, 4, 5, 6, 7, 8, and 9

eg. 345.76 has five significant digit.

(2) Zeros are significant if they :

ⓐ are the last digit of a measurement as long as they are to the right of the decimal point.

Example:- 3.70 has three significant digit. The zero is significant because it is the last digit.

ⓑ Come between two other significant digits.

Example:- 340.61 has five significant digits. The first zero is significant because it falls between 4 and the 6 which are both significant.

③ Zeroes are not significant if they act as placeholder.

eg.. 0.035 has two significant digits. The zeroes are place holder and are not significant.

④ When the zeroes are on the left of the decimal point then they are not necessarily significant.

Ex→ 2100 may have 2, 3 or 4 significant figure.

Ex→ 350 may have 2 or 3 significant no.

This ambiguity can be avoided by writing the number in scientific notion.

⑤. In Scientific notation, all digits in the coefficient are significant. The exponent is not considered in terms of significant figure.

eg. → 2.100×10^3 will have with certainty 4 significant figure.

→ 3.50×10^2 will have with certainty 3 significant figure.

→ 3.54×10^5 will have with certainty 4 significant figure.

⑥ Numbers that are known with complete certainty are said to be exact conversion factor, constraints, values that are part of a formula are said to be exact. This exact numbers are considered to have an unlimited number of significant figures and are never used as a limited factor in determining the number of significant figures in the result of an operation.

eg:- 1cm = 10millimeter. The number 10 Will have an infinity number of significant figure.

Rules for Retaining Significant figures

There are several rules to remember regarding significant figures when manipulating numbers.

(1) When measurements are multiplied or derived, the answer can contain no more significant figures than the ~~last~~ least accurate measurement.

(2) When measurement are added or substracted, the answer can contain no more decimal places than the least accurate measurement.

$$\begin{array}{r} 150.0\ g \\ +\ 0.507\ g \\ \hline 150.5 \end{array}$$

(using significant figures)

(3) In a quotient of experimental members, the final rebuilt has only as many significant figures as the factor with the smallest number of significant no.

eg. In the calculation =

$$= \frac{(0.0181057)(0197.15)(0.218)}{0.4970} = 1.568$$

$$= 1.57$$

least no. of significant figures is in number 0.218 . Thus the answer should also be ~~experiment~~ expressed in three significant figures.

④ Two rules are given for rejecting superflouous digits :

i) When the last digit dropped is greater than 5, the last digit retained is increased by one. It is called rounding

8.492 → New value will be 8.49 as 2 is smaller than 5.

4.863 g → New value will be 4.9 as 8 is greater than 5.

ii) When the last digit disconded is less than 5, the last digit retained is decreased by one. It is called rounding about.

Errors :

It is observed that the numerical data obtained in quantitative analysis or determination differ to greater or lesser extent. Sometimes. It is difficult to obtain the same measurement when performed under identical conditions. So, the reliability of the results depends upon the magnite of the difference between the average value and the true value or more probable value. Under such conditions the determination is subjected to errors. Error ~~then~~ often denote the estimated uncertaintly in a measurement or experiment.

Classification of errors :-

1. Systematic / determination or constant error.

   ⓐ Person error.
   ⓑ Operational error.
   ⓒ Instrument of reagent error.
   ⓓ Methodic error.

2. Random or Indeterminate error.

③ Errors in measurement

④ Gross error.

Systematic / determinate or constant error:-

The determinate errors are the errors that remain in a constant way and to a fixed degree in each of the determinations or affect the series of determination to the same degree. These errors can be avoided or their magnitude can be determined, thereby correct.

ⓐ Personal error :-

These errors depend on the personal characteristics of an analyst himself. They may occur due to constitutional inability of the individual to certain observations accurately.

eg:-

① Inability in judging color change sharply in a visual titration.

(ii) The estimation of value between two scales devision of the burette.

(iii) Inability to detect end point in the titration.

(iv) Error in calculation i.e. induplicate weighing and titration.

(v) Mechanical loss of material in various steps of analysis during bumping.

ⓑ Operational error:-

These errors are physical in nature and occur when sound analytical technique is not followed. They are easy to detect and eliminate.

eg.

(i) Incomplete drying of analytical samples before weighing.

(ii) Under washing of the precipitate which gives consistent excessive results.

(iii) Over-washing of the precipitate resulting in systematic losses.

(iv) Incorrect draining of the solution from the precipitate.

(c) Instrument and reagent error :-

These errors arise from the comperfections in the measuring device and quality of reagent used. eg :-

(i) Inequality of the length of the balance arm.

(ii) Incorrectly graduated burette.

(iii) Using impure reagent.

(iv) Incorrect technique involving in the transfer of solution.