PHARMACEUTICAL CHEMISTRY

INTRODUCTION:- Pharmaceutical chemistry is a branch of chemistry ~~is a~~ that deals with the chemical biochemical and pharmacological aspects of drugs It include synthesis/isolation identification, structural elucidation structural modification. Structural activity Relationship(SAR) studies. study of chemical characteristics, biochemical changes after drug administration and their Pharmacological effects.

Pharmaceutical Chemistry is the large part of field of medicinal chemistry, Pharmaceutical chemist develop and evaluate new and better drug for healthcare industry.

This medicinal chemist focus on drug development and discovery by concentrating on creating new synthetic drug compound.

OBJECTIVE

The pharmacist chemistry will discuss the following aspects of the chemical substances used as drug and pharmaceuticals for various disease conditions.

⇒ Chemical classification, chemical name, chemical
⇒ Pharmacological uses, doses, stability & storage
⇒ Different types of formulations/doses form available and their brand names
⇒ Impurity testing and basic quality control tests
⇒ To enhance the knowledge for synthesis, isolation, purification and characterisation of various pharmaceutical
⇒ To enhance the skill for effective handling of chemical, glassware and analytical instrument
⇒ To encourage students & faculty for research activity.
⇒ To provide proper qualities and skill to the students required to fulfill their job responsibilities as chemist in pharmaceutical, chemical and biotechemical industries

* SCOPE

The pharmaceutical chemistry is designed to impart basic knowledge on the chemical structure, storage conditions and medicinal uses of organic and inorganic chemical substances used as drugs and pharmaceuticals.

Also, the pharmaceutical chemistry is ~~designed to~~ discusses the impurities, quality control aspects of chemical substances used in pharmaceuticals.

⇒ In development and formulation of drugs
⇒ Treating patient with disease
⇒ To analyse the effects of different chemicals
⇒ To drugs application by form pharmaceutical companies are reviewed by the chemist of FDA.
⇒ Synthetic pharmaceutical and analytical pharmaceutical are the two distinct field of pharmaceutical chemistry
⇒ Synthetic pharmaceutical - In this the drug is refined by using various analytical method
⇒ Synthetic pharmaceutical - In this new drugs and products are created in the most effective way that generates leastside effects.

* CONCENTRATION TERMS

It is the amount of solute present in one litre of solution. It is denoted by 'C' or

$$\text{Concentration} = \frac{\text{Weight of Solute in grams}}{\text{volume in litre}}$$

1. Concentration in parts per million (ppm) -

The parts of a component per million parts (10^6) of the solution.

$$\text{ppm (A)} = \frac{\text{Mass of A}}{\text{Total mass of the solution}} \times 10^6$$

Eg - What is the ppm of NaCl in the solution with 117g of NaCl dissolved in 500 ml of water?

Sol

$$\text{ppm} = \frac{\text{Mass of solute}}{\text{Total mass of the solution}} \times 10^6$$

$$ppm = \frac{117}{117 + 500} \times 10^6$$

$$ppm = \frac{117}{617} \times 1000000$$

$$ppm = 190000 \text{ ppm.}$$

2. Mass percentage (w/w)

When the concentration is expressed as the present of one component in the solution by mass it is called mass percentage (w/w). Suppose we have a solution containing component A as the solution and B as the solvents, then its mass percentage is expressed as:

$$\text{Mass/of A} = \frac{\text{Mass of component A in the solution}}{\text{Total volume of the solution}} \times 100$$

Eg - Ordinary bleach is 5.25% NaOCl by mass, which means each 100 g of bleach contains 5.25g NaOCl.

3. Volume percentage (V/w)

Sometimes we express the concentration as a percent of one component in the solution by volume. it is then called as volume percentage and is given as:

$$\text{Volume \% of A} = \frac{\text{Volume of Component A in the solution}}{\text{Total volume of the solution}} \times 100$$

Eg - If solution of NaCl in water is said to be 10% by volume that means a 100ml solution will contain 10ml NaCl.

4. Mass by volume percentage (w/v)

This unit is majorly used in the pharmaceutical industry. It is defined as the mass of a solute dissolve per 100 ml of the solution.

$$\% \text{ w/v} = \frac{\text{Mass of component A in the solution}}{\text{Total volume of the solution}} \times 100$$

Eg - 0.9 % (w/v) NaCl sol^n containing 0.9 g of NaCl per 100 ml of solution in medical saline solution.

5.) Molarity (M)

One of the most commonly used methods for expressing the concentrations is molarity. It is the number of moles of ~~ethanol~~ solute dissolved in one litre of a solution. suppose a solution of ethanol is marked 0.25 M, this means that is one litre of the given solution 0.25 moles of ethanol is dissolved.

$$\text{Molarity} = \frac{\text{Moles of Solute}}{\text{Volume of solution in litres.}}$$

6.) Molality :-

Molality represent the concentration regarding moles of solute and the mass of solvent. It is given by ~~moles~~ moles of solute dissolved per kg of the solvent. The molality formula is as given

$$\text{Molality (m)} = \frac{\text{moles of solute}}{\text{mass of solvent (kg)}}$$

7.) Normality

It is the number of gram equivalents of solute present in one litre of the solution and it is denoted by N.

$$N = \frac{\text{Weight of Solute in grams}}{\text{Equivalent mass}} \times \text{Volume in L}$$

The Relation b/w ~~n~~ normality & Molarity

$N \times \text{Eq. wt} = \text{molarity} \times \text{Molar mass.}$

$N = \text{Molarity} \times \text{Valency}$

$N = \text{Molarity} \times \text{Number of } H^+ \text{ or } OH^- \text{ ion.}$

8. Formality -

It is the number of gram formula units presents in one litre of solution. It is denoted by F.

$$f = \frac{\text{Weight of solution in gram}}{\text{formula wt.}} \times \text{Volume in litre.}$$

It is applicable in the case of ionic solids like NaCl.

9. Mole fraction -

If the solution has a solvent and the solute, a mole fraction gives a concentration as the ratio of moles of one component to the total mole present in the solution. It is denoted by X. Suppose we have a solution containing A as a solute and B as the solvent. Let nA and nB be the number of moles of A and B present in the solution respectively. So, mole fraction of A & B are given as:

$$X_A = \frac{N_A}{N_A + N_B}$$

$$X_B = \frac{N_B}{N_A + N_B}$$

* IMPURITIES OF PHARMACEUTICAL CHEMISTRY-

QUALITY CONTROL:- It is the day to day process of controlling quality of every incoming material till the finished product quality.

FUNCTIONS OF QUALITY CONTROL -

⇒ Analysis of raw material.
⇒ Analysis of Packaging materials.
⇒ Analysis of in process product.
⇒ Analysis of final doses form.
⇒ Analysis of batch product.

⇒ Recording the result of analysis in a standard format.

IMPORTANCE OF QUALITY CONTROL:-

⇒ To avoid toxic & unwanted effect of impurity.
⇒ To avoid techniqual difficulties during manufacturing.
⇒ To maintain safety & effectiveness of product.
⇒ To maintain product with adequate physical & chemal stability.
⇒ To ensure ~~chemical and~~ quality drug for consumption to the patient.
⇒ To maintain purity of product & thus protect public health.
⇒ To ~~maint~~ help in maintainance of quality of product with better utilisation of labours & machines.
⇒ To help in adjustment and setting of machinery.
⇒ It helps in product development and in research with control over wastage & scraps.
⇒ It helps in decreasing the cost of manufacturing so that the cost of final product maybe decrease.

QUALITY ASSURANCE - It is the department which includes a total quality control, ~~gover~~ government regulation, company standards & development of SOP (Standard operating procedure) of Analysis.

FUNCTIONS OF QUALITY ASSURANCE:-

⇒ Development of SOP (Standard operating procedure) & supply to every department of company.
⇒ It has a responsibility of "total quality of products."
⇒ It gives guidelines during adjustment & setting of machineries.
⇒ It helps to maintain quality of product with better utilisation of labour & machine.
⇒ It helps in product development & research.

Qualitative Analysis	Quantative Analysis
→ Color, odour, solubility	Chemical Assay method
→ Identification test	a) Volumetric analysis
→ Boiling point & Melting point	1) Acid-base titration
	2) Redox titration
	3) Precipitate titration
	4) Complexometric titration
	b) Gravimetric analysis
	1) Estimation of weight
	→ Photometric method
	→ Electrochemical method
	→ Biological assay method

IMPURITY- It is an undesireable matter which may or may not be toxic but present in the pharmaceutical substances.

** SOURCES OF IMPURITIES-

1) RAW MATERIAL USED IN MANUFACTURING- If raw material contents impurity, then this impurity get incorporated into the final products. Impurities like lead, Arsenic etc. are present in the raw materials & hence found in substances as impurities.

Eg- If copper foils are contaminated with as, the final product Copper Sulphate may contain as impurity.

2) REAGENT USED IN MANUFACTURING PROCESS- If reagent contain impurity, it is transfered to the final product.

Eg- $CaCO_3$ (Calcium carbonate) is prepared by using calcium chloride & Sodium carbonate ($NaCO_3$) thus it may contain impurity of $NaCO_3$ (Sodium Carbonate) or $CaCl_2$ (Calcium chloride).

3.) The PROCESS USED IN MANUFACTURING:- There are a no. of chemicals which are manufactured from different raw material by different method or process. Due to this some impurities get incorporated into the materials during manufacturing process. Tap is generally used in various manufacturing process. Tap water contains chlorides Calcium, Magnesium thus get incorporated in the product.

4.) MATERIAL OF PLANT- Equipment & vessels used in manufacturing process are made up of metals like Copper, Iron, Aluminium, Zinc but these metals are introduced as impurities by the solvent action of raw materials. Now a days, these metals are replaced by stainless steel.

5.) Intermediate Products- Incomplete reaction produce unwanted intermediate product which may be the impurity in the final product.

6.) Adulteration / Accidental substitution- The cheap substances are added in pure substances as a substitute and therefore, added substances act as an impurity in the pure substance.

Eg- Sodium bromide is an impurity in Potassium bromide as the Sodium salt is cheaper.

7.) INADEQUATE STORAGE / DEFECTIVE STORAGE-

(i) Many chemical substances undergo changes due to careless storage. thus, may develop impurity in it.

(ii) Stored product may become contaminated with dust, the bodies of insects and even animals.

(iii) Many substances which exposed to light, air & moisture, may change the color, properties & shelf-life of products.

Eg- Due to careless storage, $FeSO_4$ is slowly converted

into insoluble ferrous oxide by air & moisture.

Eg- Surgical sol. of chlorinated soda deteriorates upon exposure to light & Heat. Hence it should be stored in well closed -Amber color bottles in cool place.

Eg- Chloroform decomposes in presence of light & air & form a phosgene gas which is toxic. So it should stored in well closed amber color bottles.

Eg- Bismuth CO_3 is blackened on long exposure in sunlight.

8) MANUFACTURING HAZARDS- Impurity may get incorporated at various stages of manufacturing

① Particulate contamination- It involve the piece of plastic, threads, in the products & also come from improperly cleaned equipment and also due to wear & tear of equipments.

② Process error - It involves incomplete reaction during processing

③ Cross - contamination - Handling of powder, granules & tablets may produce considerable airborne dust

④ Microbial contamination - Liquid or creams may be contaminated due to bacteria & fungi from atmosphere.

⑤ Packeging error - The product of similar appearance such as tablet of same size, color & shape may be packed in the similar container & can causes danger due to mislabelling.

9) TYPES OF IMPURITIES COMMONLY OCCURING IN PHARMACEUTICALS-

TOXIC IMPURITY- If impurity is present above the prescribed limit and produced toxic effect on the body, it is called toxic impurity.

Eg - Pb, As impurities.

Harmless Impurity - Some impurities are harmless but if present above the prescribe limit, they lower Active strength of substance.

Eg - Impurity of NaCl salt in K salt.

IMPURITY AFFECTING STORAGE PROPERTY - for eg. presence of small amount of moisture in ~~the~~ the drug may reduce flow propedy of drug / talcum powder.

IMPURITY CAUSING TECHNIQUAL DIFFUCULTIES - Impurity cosues many technical problems during manufacturing.
Eg - Peeking and sticking defect may occur in tablet manufacturing.

→ Impurity affecting taste, odour and apperance of product.
→ Impurities even when present in trace may show collective toxic effect after cortain periods.
→ Impurity which lower the shelf-life of substances.

** LIMIT TEST - It is quantative or semi-quantative test designed to identify and control small quantities of impurity, which are like to be present in the substances.

LIMITS - a value or amount that is likely to be present in a substances

TEST - to examine or to investigate.

IMPORTANCE OF LIMIT TEST -
→ To find out the harmful amount of impurities
→ To find out avoidable and unavoidable amount of impurity.
→ ~~Test~~ In

TYPES -
→ Test in which their is no visible reaction.
→ Comparison metaod
→ Quantative determination

GENERAL PRINCIPLE – If the sample is lighter (color/turbidity/opalescence) than the standard solution then it is within the pharmacopoeial limit.

→ If sample is darker/heavier than standard solution then it is above

→ If the pharmacopoeial limit (rejected) @Specificity of limit test, a given limit test for a trace impurity should involve some selective reaction of the reagent with the trace impurity under consideration/detection specifically characteristic only to it.

Sensitivity of limit test – As most of the limit test involved dil. solution and results are based on concentration of trace impurity, the result may take longer duration to become observable. Thus, consideration of duration of test need to be prime consideration in designing the limit test.

Precautions of limit test –

→ The liquid used must be cleaned & filtered if necessary.

→ The nessler cylinder must be made up of colorless glass & of some inner diameter.

→ Detecting opalescence or color development must be performed in day light.

→ Comparison of turbidity, it should be done against a black background

→ Comparison of color, it should be done against white background.

LIMIT TEST OF CHLORIDE –

Limit test are quantative or semi-quantative test designed to identify and control small quantities of impurity, which are likely to be present in the substance.

Principal of limit test of chloride –

It is based upon chemical reaction between $AgNO_3$ and soluble chloride opalescence of $AgCl$. The opalescence produce is compared with standard solution if the opalescence in the sample is less than standard, it passes the test. If it is more than standard, it fails the test. Chemical reac- $NaCl + AgNO_3 \xrightarrow{dil.\ HNO_3} AgCl\downarrow + NaNO_3$ (s)

Procedure –

Take two 50 ml of nessler cylinder lable one as a test and other as standard.

Standard Nessler cylinder	Test Nessler cylinder
(i) Place 5ml of 0.05845 % w/v solution of NaCl in a nessler cylinder.	Dissolve the specified quantity of the substance in distilled water and transfer to nessler cylinder
(ii) Add 10ml of dilute HNO_3 in it.	Add 10ml of dilute HNO_3 to it.
(iii) Dilute upto 50ml with H_2O and 1ml of $AgNO_3$ solution.	Dilute upto 50ml with H_2O & 1ml of $AgNO_3$ solution
(iv) Stir immediately with a glass rod and allow to stand for 5 minutes.	Stir immediately with a glass rod and allow for 5 minutes.
(v) Observe the opalescence developed & compare with that of sample solution.	Observe the opaleseence developed & compare with that of standard solution.

OBSERVATION –

The opalescence produce in sample solution should not be greater than standard solution. If opalescence produces in sample solution is less than the standard solution, the sample will pass the limit test of chloride and vice-versa.

LIMIT TEST OF SULPHATE

Principle – Limit test of sulphate is based on the reaction of soluble sulphate with barium chloride in presence of dilute hydrochloric acid to form barium sulphate which appears as solid particles (turbidity) in the solution.

Procedure –

Test sample	Standard Compound
→ Specific weight of compound is dissolved in water or sol^{n} is prepared as directed in the pharmacopoeia and transferred in Nessler Cylinder	Take 1ml of 0.1089% w/v solution of potassium sulphate in Nessler Cylinder.
→ Add 2ml of dilute hydrochloric acid	Add 2ml of dilute hydrochloric acid
→ Dilute to 45ml in Nessler Cylinder	Dilute to 45 ml in Nessler cylinder
→ Add 5 ml of barium sulphate reagent	Add 5ml of barium sulphate reagent
→ Keep aside for 5min	Keep aside for 5 min
→ Observe the turbidity	Observe the turbidity.

CHEMICAL FORMULAE –

$$SO_4^{-2} + BaCl_2 \xrightarrow{dil.\ HCl} BaSO_4\downarrow + Cl^-_2$$

OBSERVATION – The turbidity produce in sample solution should not be greater than standard solution. If turbidity produces in sample solution is less than the standard solution, the sample will pass the limit test of sulphate and vice versa.

LIMIT TEST FOR IRON -

Principal - The reaction based on the interaction of iron impurity react with thioglycollic acid in the presence of ammonical alkaline medium to form purple color ferric thioglycolate

Chemical reaction -

$$Fe^{3+} \xrightarrow[HS+CH_2-COOH]{} Fe^{2+} + HS-CH_2-COOH \xrightarrow{Citric\ acid/NH_3} (HS-CH_2-COOH)_2^{Fe}$$

ferric ion — ferrous ion — Ferric thioglycolate (Purple color)

Note - Ammonia solution provide alkaline medium which is necessary for reaction of thioglycollic acid with iron impurity.

- Citric acids prevents prepitation of iron with ammonia
- Thioglycollic acid is used because it react with ferrous ion and convert into ferric ion, thus it form purple color.

Procedure

Standard solution	Test solution
→ 2 ml of standard iron solution 0.17$\frac{26}{g}$ of ferric ammonium sulphate	Weight of substance as per monograph
→ Add 20ml of water in it	Add 20ml of water in it
→ Add 2ml of citric acid of 20% of W/V	Add 2 ml of citric acid 20% W/V
→ Add 1 ml of ammonia solution in it	Add 1 ml of ammonia solution in it.
→ Add 1 ml of thioglycollic acid.	Add 1 ml of thioglycollic acid.
→ Adjust volume upto 50 ml with water	Adjust volume upto 50 ml with water.
→ Stir well & keep aside for 5 minutes	Stir well & keep aside for 5 minute.

OBSERVATION -

If purple color obtained in test solution is less than standard solution sample passes limit test for iron and vice-versa.

LIMIT TEST FOR HEAVY METAL -

Principal - Heavy metals impurity react with Hydrogen sulphide / Sodium sulphide in the presence of acidic/alkaline medium respectively to form brown ppt. of metal sulphide. Eg- Pb, Cd, Hg.

Chemical reaction -

$$M + H_2S \xrightarrow{\text{Alkaline/acid}} MS + H_2(\uparrow)$$

$$M + Na_2S \longrightarrow MS + 2Na^{++}(\uparrow)$$

Note - Hydrogen sulphide & Na_2S solution are the reactant and require acidic/alkaline media for their reaction respectively. Acidic medium is adjusted by NH_3 or acetic acid while alkaline medium is adjusted by NaOH.

Procedure - According to I.P.1985

Standard	Test
→ Take 2 ml of standard Pb solution & dilute upto 25 ml	As per monograph in 25 ml solution Prepared.
→ Add dilute acetic acid / ammonia to adjust the pH between 3-4	Add dilute acetic acid / ammonia to adjust the pH between 3-4
→ Add water upto 35 ml	Add water upto 35 ml.
→ Add 10 ml of H_2S solution.	Add 10 ml of H_2S solution.
→ Dilute it upto 50 ml with H_2O	Dilute it upto 50 ml with H_2O.
→ Stir well and keep aside for 5 min. observe and compare the brown color produced	Stir well and keep aside for 5 min, Observe and compare the brown color produced.

OBSERVATION -

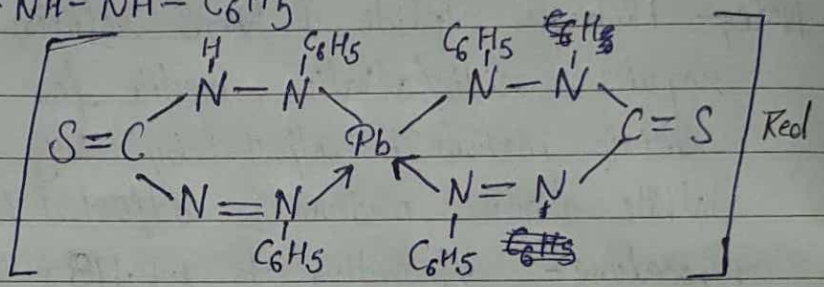
If brown color obtained in test solution is less than the standard solution sample passes the limit test of Heavy metals according to I.P 1985. & vice- versa.

LIMIT TEST OF LEAD

Principle- based on the reaction of lead with di-phenyl-thiocarbazone (di-thizole) in alkaline solution to form lead di-thiosone complex which is red in color.

Chemical reaction-

$$Pb + S=C(NH-NH-C_6H_5)_2 \xrightarrow{\text{alkaline}} \text{(green color)}$$



Apparatus - Nessler/Seperating funnel.

Procedure

Standard	Test
→ Transfer required amount of lead standard solution in (1 Ppm) lead equivalent to the amount of lead permetale in the substance being examined in to a seperating funnel.	The required quantity of sample is dissolved in water & transfer into an seperating funnel.
→ Add 6ml of ammonia citrate sol:	Add 6ml of ammonia citrate sol.
→ Add 2ml of hydroxylamine hydrochloride sol., add 2 drop of phenol red solution.	→ Add 2ml of hydroxylamine hydrochloride. sol. add 2 drop of phenol red solution
→ Add 2ml of KCN sol.	Add 2ml of KCN sol.
→ Extract immediately with several quantities each of 5ml of dithizone extraction sol. until it become green.	Extract immediately with several quantities each of 5ml of dithizone extraction sol until it become green
→ Combine dithizone extract & shake for 30 sec with 30ml of 1% v/v sol. of nitric acid. and	Combine for 3 dithizone extract & shake for 30 sec with 30ml of 1% v/v sol. of nitric acid and discard

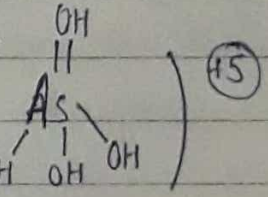
discard the chloroform layer (dithizone remain some) chloroform layer, lead nitrate in Aqueous solution.	the chloroform layer (dithizone remain same) chloroform layer, lead nitrate in Aqueous solution.
→ To this acidic solution add 5 ml of standard dithizone solution	To this acidic solution add 5 ml of standard dithizone solution.
→ Shake well for 30 min and observe the color of chloroform layer after seperation.	Shake well for 30 min and observe the color chloroform layer after seperation.

OBSERVATION – The test color of chloroform layer is not more intense than standard color of chloroform layer & vice-versa.

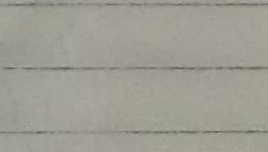
LIMIT TEST OF ARSENIC –

Principle – Arsenic impurity is converted into arsene gas which further react with mercuric chloride paper to form yellow stain of mercuric arsenide. A specially designed apparatus use for (arsenic) As limit test called as Gutzeit apparatus.

CHEMICAL ~~TEST~~ REACTION :-

→ $SnCl_2 + H_2SO_3 \longrightarrow H_2SO_4 + As \longrightarrow H_3AsO_4$ (arsenic acid)  (15)

(Sulphurus acid)

→ $H_3AsO_4 \longrightarrow H_3AsO_3$  (13)

(arsenic acid) (arseneous acid)

→ $H_3AsO_3 + 3H_2 \longrightarrow H_3As + 3H_2O$

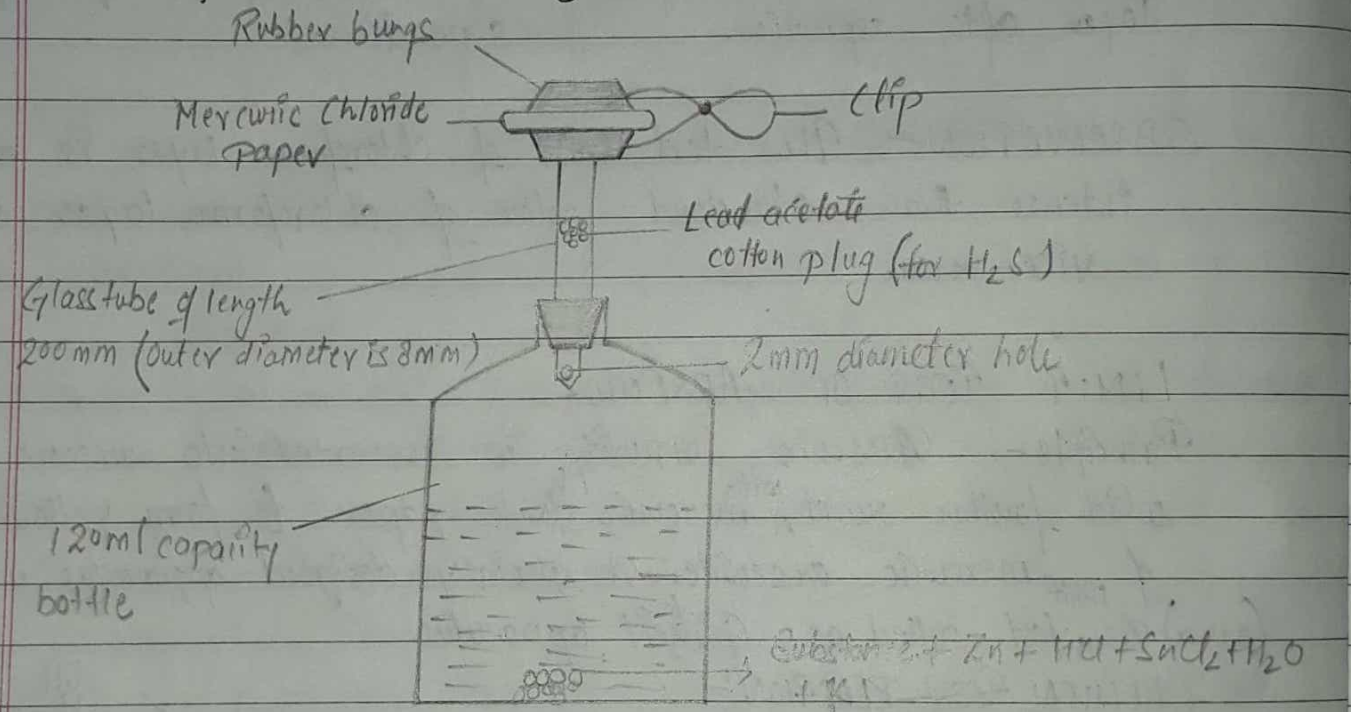
(arseneous acid) (nascent) (Arsene gas) (water)

→ $2H_3As + HgCl_2 \longrightarrow Hg(AsH_2)_2 + 2HCl_2 (\uparrow)$

(Arsene gas) mercuric chloride (mercuric arsenide)

Arsenic present in solution is converted into arsenic acid in the presence of acid, the arsenic acid reduced to arsenious acid and this arsenious acid react with necent H_2 atom produced by reaction of Zn & HCl reduce arsenious acid to arsene gas, After this reaction arsene gas react with mercuric chloride paper and form mercuric ~~arsed~~ arsenide in the form yellow stain.

— Apparatus — Gutzeit



Gutzeit Apparatus.

Construction – It consist of wide mouthed glass bottle of capacity 120ml.

→ glass tube of 200mm length is passed in it through the rubber bungs.

→ Glass tube is constricted at lower end and it has 2mm hole.

→ The end of tube should be above the liquid.

→ Mercuric chloride paper is sandwitched between two rubber bungs. and fixed by clip.

→ lead acetate cotton plug is inserted into the glass tube before operation.

Note- lead acetate cotton plug is used to avoid the interaction of H_2S gas with mercuric chloride paper.

- Stanned zinc is used for slow & steady evolution of nescent H_2.
- Time required for the preparation is more i.e, this test should be observed after 40 min.
- All reagent should having free from arsenic.

Procedure

Standard solution	Test solution
→ 0.2 ml standard arsenic solution	Substance as per monograph
→ Add 1gm of KI	→ Add 1gm of KI.
→ Add 10gm of stanned zinc ($SnCl_2 + Zn + HCl$)	→ Add 10gm of stanned zinc ($SnCl_2+Zn+HCl$)
→ Shake the bottle and keep aside for 40 minutes.	→ Shake the bottle and keep aside for 40 minutes.

OBSERVATION- If yellow stain observed in test mercuric chloride paper is less than standard yellow stain, sample passes limit test for arsenic according to IPC 1985 and vice-versa.

SIGNIFICANT FIGURE:- It can be defined as the number of digits necessary to express the result of measurement consent with the measured precision.

Eg- 900.001
(Accurate, Precision (doubtful value))

Rules for Significant numbers -
Add all accurate digits with precision digit.

- All Non-zero digit are Significant digit.
  Eg ① 3.144 S.F = 4
  2.123 S.F = 4
- All zero between two significant digit are significant number
  Eg 0.0402 SF = 4
- Ending zero decimal after Significant number
  Eg. 2.40 (S.F=3), 3.000 - S.F. = 4
- Initial zero are insignificant
  Eg - 0.0042 0.0123
- Power of 10 are insignificant number
  Eg. 3.6×10^6 SF = 2
  3.0×10^4 S.F = 1

Note - All pure no. and constant value have Infinite significant figure.

- It should be clear that zeros are used to denote the significant part of measurements.

ERRORS -

Errors refer to the difference between the measured value and the true/known value. Eg - A P.C.M tab of 500 mg (true value) is observed to have 495 mg (observed value).

for % = $\boxed{\frac{T-O}{T} \times 100}$ or $\boxed{T-O}$ - Normal.

Errors often denotes the estimate uncertainity in a measurement or experiment.

Absolute Error - the difference between experimental mean and true value is termed as absolute error.

Sources of Errors-

- Improper sampling - Error may occur due to improper sampling.
- Errors during sample prep. - Error may occur during sample prep.
- Error by Analyst - Analyst can do error during analysis, it also known as manual errors.
- Error by Equipment - Error causes due to improper function of Equipments.
- Calibration error - Error may occur if proper calibration is not done.
- Reporting error - Error occur due to wrong improper data or observation.
- Calculation error - Error due to wrong calculation.
- Error in method selection - Error may occur due to wrong method selection.
- Error during transport & storage - Errors may occur due to improper handeling of materials during transport & storage.
- Error due to laboratory environment - Errors occur due to unsuitable environment conditions.

TYPES OF ERRORS (i) Determinant / Systematic / known errors
(ii) Indeterminant / unknown / random / accidental errors.

⇒ Determinant - These type of errors are determinable and can be either avoided or corrected.

Eg - (i) Instrumental - Caused by use of faulty equipments.
(ii) Personal error - Caused during analysis by a person
(iii) Chemical error - Due to impurities in chemical
(iv) Methodical error - arises due to faulty method used for analysis.
Eg - Incomplete heating, Incomplete reaction.

⇒ In Determinant Errors - also called accidental errors. these errors are fluctuating & do not have a definite value & are difficult to locate. They arises due to unknown & uncertain measurement or may be due to difference in judgement and skill of analyst.

hence, elimination ~~is~~ of these error is impossible to analyst.

Accuracy – The term accuracy refers to the agreement of experimental result with the true value & it is usually expressed in term of error. In scientific experiment it is known that true value is not known.

- It is simply that value that has been accepted & is usually a mean calculated from the result of several determination from many laboratories ~~emple~~ implying different techniques.

Precision – It may be defined as the degree of agreement between various result of same quality. i.e, it refers to the reproducibility of result, good precisions are not necessarily accurate.

→ A constant error may always yield reproducible result at debating accuracy.

→ An analytical chemist always attempts for reproducible result to assure the highest possible accuracy