Chemistry Laboratory Work

The Department of Chemistry (College Section)

Forman Christian College (A Chartered University), Lahore, Pakistan

Dear Students,

According to Gregory Benford, “When the chemistry is right, all the experiments work”, and this applies well to the Lab demonstrators of the Department of Chemistry (College Section), Forman Christian College (A Chartered University), Lahore, Pakistan. They impart a lot of energy and enthusiasm in giving visual ideas of the practical concepts given in notebook.

A small glimpse of their devotion, dedication and commitment to the cause can be clearly seen in the compilation of their notes which they have keenly made for the student benefit.

You are instructed to go through all the material given in the booklet carefully so you may easily score high in your practical exam.

All the very best for your endeavors to achieve high.

Bless you

Table of Contents

BIRD'S EYE VIEW
CHEMISTRY PRACTICAL SYLLABUS.
1st Year Session 2023—2024

Chemistry practical syllabus consists of two categories:

(1) General Experiments
(2) Volumetric Analysis

(General Experiments) - (Minor)

Following General Experiments are included in syllabus of XI Chemistry:

(i) Determination of Heat of Neutralization of Acid with Base.
(ii) Crystallization of Benzoic Acid from Water.
(iii) Purification of NaCl by Passing HCl gas (Common Ion Effect)
(iv) Separation of Mixture of Ink by Paper Chromatography.
(v) Separation of Cd^{2+} and Pb^{2+} Cations by Paper Chromatography.

(Volumetric Analysis) - (Titrations)

There are two types of Titrations:

(1) Acid Base Titrations
(2) Redox (Oxidation-Reduction Titration)

Redox Titrations are of Two Types:

(i) $KMnO_4$ Titrations (Oxidizing agent is $KMnO_4$)

$KMnO_4$ Titrations have three categories on the basis of Reducing Agents:

(a) Ferrous Sulphate ($FeSO_4.7H_2O$)
(b) Mohr's Salt [$(NH_4)_2SO_4.FeSO_4.6H_2O$]
(c) Oxalic Acid ($H_2C_2O_4.2H_2O$)

(ii) Iodine Titration (Oxidizing Agent is Iodine)

TO THE POINT

There are almost 25^+ Volumetric Titrations excluding General Experiments. But dear students, for your Convenience here are mentioned only 07 types of Calculations which cover up all these 25^+calculative protocol material mentioned above.

(1) Standardization / Concentration of the solutions.
(2) Percentage purity / impurity of a substance.
(3) Percentage Composition of a mixture.
(4) Percentage Oxidation of partially oxidized sample.
(5) Atomic or Molecular Weight of Metal "M"
(6) No. of water molecules in a crystalline hydrated solids.
(7) Solubility of different substances at room temperature.

*The below list of experiments is followed by 'Modern Chemistry Practical Notebook'.

Sr.	Types of calculations	Categories		
		Acid-Base Titration	**Redox ($KMnO_4$) Titration**	**Iodimetric Titration.**
1	Standardization	Exp.# 01,02,03	Exp.# 01	Exp.# 01
2	Amount of Comp.(volume)	Exp.# 04,05,06	Exp.# 02,06	-----
3	% composition	Exp.# 10,11,12	Exp.# 05	Exp.# 04
4	% Purity & Impurity	Exp.# 07,08,09	Exp. # 03, 04	Exp.# 02,03
5	Atomic weight of metal 'M'	Exp.# 15,16,17	-----	Exp.# 06
6	Water of crystallization	Exp.# 13	Exp.# 10,11	Exp.# 05
7	Solubility of Compound	Exp.# 14	Exp.# 12,13,14	-----
8	% Oxidation of $FeSO_4$	-----	Exp.# 08, 09	-----
9	% of Mn^{+2} in $KMnO_4$	-----	Exp.# 07	-----

Dear students, for your convenience here are mentioned few key tips to learn Volumetric Analysis (Titrations) in short and better way.

(1) Acid Base Titrations:

(A) Chemical Equations:

- $(COOH)_2 + 2NaOH \longrightarrow (COONa)_2 + 2H_2O$
- $NaOH + HCl \longrightarrow NaCl + H_2O$
- $CH_3COOH + NaOH \longrightarrow CH_3COONa + H_2O$
- $Na_2CO_3 + 2HCl \longrightarrow 2NaCl + CO_2 + H_2O$
- $NaHCO_3 + HCl \longrightarrow NaCl + CO_2 + H_2O$

(B) Indicators:

Two types of indicators are being used in acid-base titrations.

(a) *Phenolphthalein:* In case of strong base.
(In Acid medium gives No Colour, but in Base gives dark Pink)

(b) *Methyl Orange:* In case of weak base.
(In Acid medium gives Red Colour, and in Base gives Yellow)

(C) End Point:

In case of Phenolphthalein, Light Pink to Just Colorless.
In case of Methyl Orange, Pale Yellow to Light Pink colour.

(2) Redox Titrations ($KMnO_4$)

(A) Chemical Equations:

- $2KMnO_4 + 8H_2SO_4 + 10FeSO_4 \longrightarrow 5Fe_2(SO_4)_3 + K_2SO_4 + 2MnSO_4 + {}_8\, H_2O$
- $2KMnO_4 + 8H_2SO_4 + 10(NH_4)_2SO_4.FeSO_4 \longrightarrow 10(NH_4)_2SO_4 + 5Fe_2(SO_4)_3 + K_2SO_4 + K_2SO_4 + 2MnSO_4 + 8\, H_2O$
- $2KMnO_4 + 8H_2SO_4 + 5(NH_4)_2C_2O_4 \longrightarrow 5(NH_4)_2SO_4 + K_2SO_4 + 2MnSO_4 + 8\, H_2O + 10CO_2$

(B) Indicators:
In Redox titrations with $KMnO_4$, Potassium permanganate 'itself' acts as an indicator. So no need to add an external indicator.

(C) End Point:
Appearance of Light Pink Colour

(3) Redox Titrations (Iodine)

(A) Chemical Equations:

- $2Na_2S_2O_3 + I_2 \longrightarrow Na_2S_4O_6 + {}_2NaI$

(B) Indicators:
In case of Iodine titrations, 'Starch solution' will be an indicator.

(C) End Point:
Blue to Colorless

First Year Chemistry Lab.

1. An Introduction to Volumetric Analysis
2. Some Important Terms
3. Experiment No. 5

   (1st Experiment from Volumetric Analysis. Page No. 26)

The syllabus consist of two parts

1. General (Minor) Experiments
2. Volumetric Analysis

We have completed Minor portion of practical , now from today we will study Volumetric Analysis.

So, let’s see what is meant by Volumetric Analysis

Volumetric Analysis

It is a quantitative chemical analysis in which the amount of a substance is determined by measuring the volume that it occupies. The volume of a second substance that combines with the first in known proportions.

Titration/Trimetery

A **titration** is a technique where a solution of known concentration is used to determine the concentration of an unknown solution.

There are four types of Titrations

1. Acid Base Titrations

2. Redox (Oxidation-Reduction Titration)

3. Precipitation Titrations

4. Complexometric Titrations

Redox Titrations are further split into types

$KMnO_4$ Titrations (Oxidizing agent is $KMnO_4$**)**

$KMnO_4$ Titrations have three categories on the basis of **Reducing Agents:**

Ferrous Sulphate ($FeSO_4$)

Mohr's Salt [$(NH_4)_2SO_4.FeSO_4$]

Oxalic Acid ($H_2C_2O_4$)

Iodine Titration (Oxidizing Agent is Iodine**)**

An **Acid–Base Titration**

It is a method of quantitative analysis for determining the concentration of

an **acid** or **base** by exactly neutralizing it with a standard solution of **base** or **acid** having known concentration.

Redox Titration It is used in determine the concentration of a given solution by that contains an oxidizing or reducing agent. It involves the transfer of electrons during the reaction.

Titrant

It is a solution that is added (titrated) from burette e,g Acid solution or $KMNO_4$ solution.

The **titrant** may also be called the titrator.

An Analyte

In a titration, whose quantity or concentration is to be determined.

Standard solution

It is a solution containing a precisely known concentration (Molarity) of an element or a substance.

Standard solutions are used to determine the concentrations of other substances.

Standardization

It is the process of determining the exact unknown concentration (molarity) of a solution with the help of standard solution.

Indcator

A chemical compound that changes **color** in response to a chemical change.

A drop of indicator solution is added to the titration at the beginning.

End Point

The end point has been reached when the **color changes**.

Molarity

The number of gram moles of substance dissolved in one liter of solution

Molality

The number of gram moles of substance dissolved in one kg of solvent.

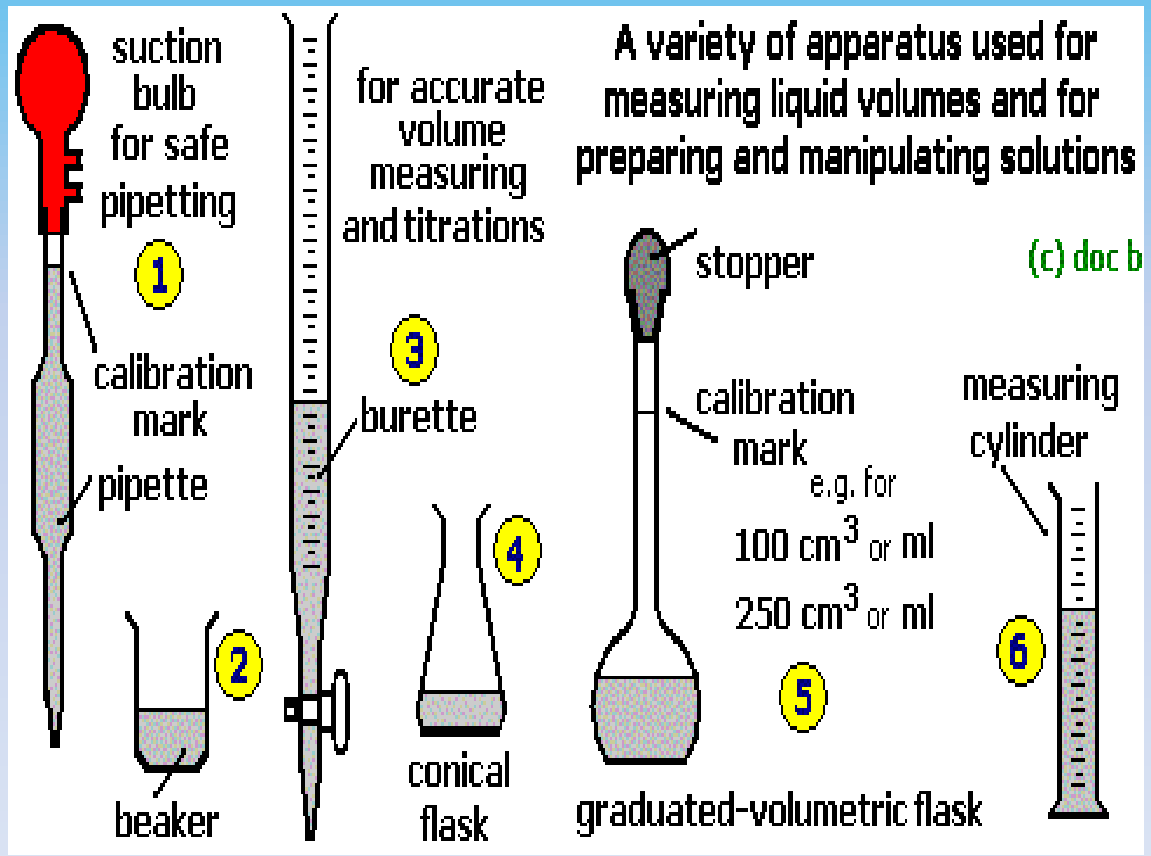
Indicators in Acid–base titration

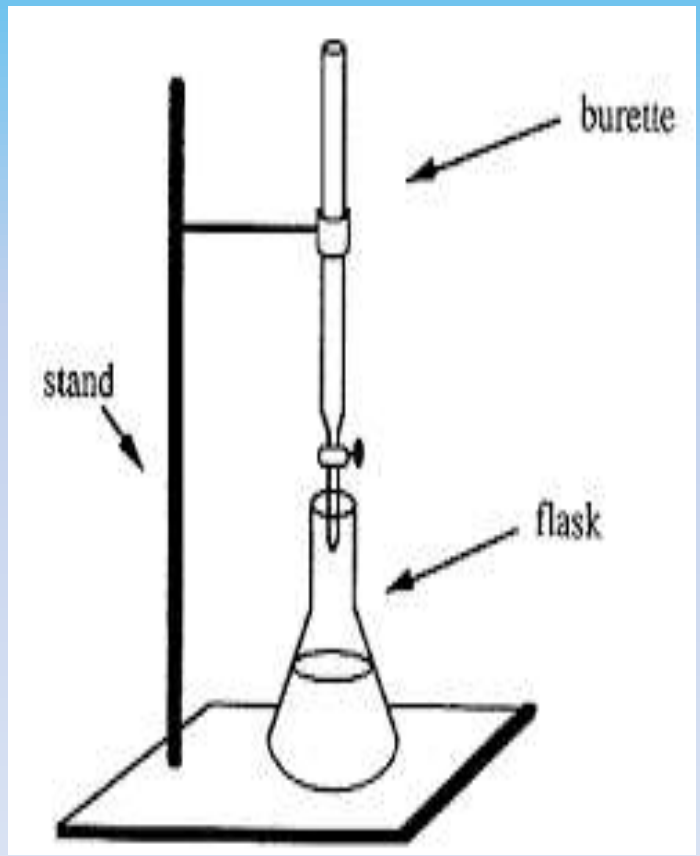
Indicator	Color on acidic side	Color on basic side
Methyl Orange	Orange Red/Light Pink	Pale Yellow
Phenolphthalein	Colorless	Pink

Indicators in Redox Titrations

Redox Titration Using $KMnO_4$ as Oxidizing Agent	Iodimetric Titration Using Iodine as Oxidizing Agent
$KMnO_4$ itself act as indicator as well	Starch solution is used as indicator Its end point is blue to colorless

Apparatus


A variety of apparatus used for measuring liquid volumes and for preparing and manipulating solutions
suction bulb for safe pipetting
1
calibration mark
pipette
2
beaker
for accurate volume measuring and titrations
3
burette
4
conical flask
stopper
(c) doc b
calibration mark
e.g. for
100 cm3 or ml
250 cm3 or ml
5
graduated-volumetric flask
measuring cylinder
6


burette
stand
flask

Experiment No. 5

0.1M NaOH solution is provided. Standardize the given solution of HCl and also calculate volume of this solution required to prepare 500cm^3 of 0.025M HCl.

Principle: It is an Acid-Base Titration

Standard Solution: 0.1M NaOH

Indicator: Phenolphthalein

End Point: Very light pink to just colorless

Chemical Equation:

$$HCl + NaOH \rightarrow NaCl + H2O$$

Mole Ratio: Acid :Base

1 : 1

Procedure

1. Fill the burette with acid up to the zero mark and note the initial reading.
2. Pipette out 10.0cm^3 of base solution into a conical flask.
3. Add 1 to 2 drops of Phenolphthalein as indicator which will turn the solution pink.
4. Add acid solution drop wise from burette into conical flask with constant stirring.
5. Keep on titrating till light pink to colorless and note the end point.
6. Note the final reading from burette and the difference between two reading gives the the volume of acid used.
7. Repeat the experiment three times to get concordant readings.

Observations

Sr. No.	Initial Reading (cm^3)	Final Reading (cm^3)	Volume of Acid Used (cm^3)
1.	0.0	10.0	10.0 cm^3
2.	10.0	20.0	10.0 cm^3
3.	20.0	30.0	10.0 cm^3

Concordant Volume = 10.0 cm^3

Calculations

HCl	**:**	**NaOH**
1	:	1
M_1V_1 **/** n_1	=	M_2V_2 **/** n_2
M_1X10 **/** 1	=	0.1X10 **/** 1
M_1	=	0.1 X 10/1 X 1/10
M_1	=	**0.1M**

Given	**:**	**Required**
HCl	:	HCl

By Using Dilution Equation,

M_1V_1	=	M_2V_2
0.1 x V_1	=	0.025 x 500
V_1	=	0.025 x 500 / 0.1
	=	**125cm^3**

Result: The Molarity of HCl is 0.1M and to prepare 500cm^3 of 0.025M HCl, 125cm^3 of given HCl is required.

Note: Take 125cm^3 of given HCl in 500cm^3 measuring flask and make up volume with distilled water up to the etched mark.

ACID BASE TITRATION

Experiment No. 8

The given solution contains 30 g of washing soda (Na_2CO_3) dissolved per dm^3. Find impurity present in 50 g of sample and also % impurity of the sample.

Principle : It is an Acid-Base Titration
Standard Solution : 0.1 M HCl
Indicator : **Methyl Orange**
End Point : **Pale yellow to light pink**

Chemical Eq. $Na_2CO_3 + 2HCl \rightarrow 2\,NaCl + CO_2 + H_2O$

Mole Ratio: Acid : Base
2 : 1

PROCEDURE

1. Fill the burette with acid up to zero mark and note the initial reading.
2. Pipette out 10.0 cm^3 of base solution (Na_2CO_3) into a conical flask.
3. Add 2 to 3 drops of Methyl Orange as indicator which will turn the solution pale yellow.
4. Add acid solution drop wise from burette into conical flask with constant shaking .

5. Keep on titrating till pale yellow to pink and note the end point.
6. Note the final reading from burette and the difference between two reading gives the volume of acid used.
7. Repeat the experiment two times to get three concordant readings.

OBSERVATIONS

Sr. No.	Initial Reading (cm^3)	Final Reading (cm^3)	Volume of Acid Used (cm^3)
1.	0.0	10.0	10.0 cm^3
2.	10.0	20.0	10.0 cm^3
3.	20.0	30.0	10.0 cm^3

Concordant Volume = 10.0 cm^3

CALCULATIONS

Na_2CO_3 **HCl**

$M_1V_1 / n_1 = M_2V_2 / n_2$

$M_1 \times 10.0 / 1 = 0.1 \times 10 / 1$

$M_1 = 0.1 \times 10/1 \times 1 / 10$

$M_1 =$ **0.1 M**

CALCULATIONS

- Amount per dm^3 = Molarity x Molecular weight.

$0.1 \times 106 = 10.6\ g / dm^3$

30 g washing soda contains pure Na_2CO_3 = 10.6g

1 g washing soda contains pure Na_2CO_3 = 10.6 / 30

50 g washing soda contains pure Na_2CO_3 =

$10.6 / 30 \times 50 = 18\ g$

% purity in 50 g = $18 / 50 \times 100 = 36\ \%$

Result: The purity present in 30 g sample is 10.6 g , and in 50 g sample is 18g.

Assignment

- Dear students please write another Practical of the same kind in your practical note books

- Experiment # 9 At Page # 42

PAPER CHROMATOGRAPHY

SEPARATION OF MIXTURE OF INKS BY PAPER CHROMATOGRAPHY

INTRODUCTION

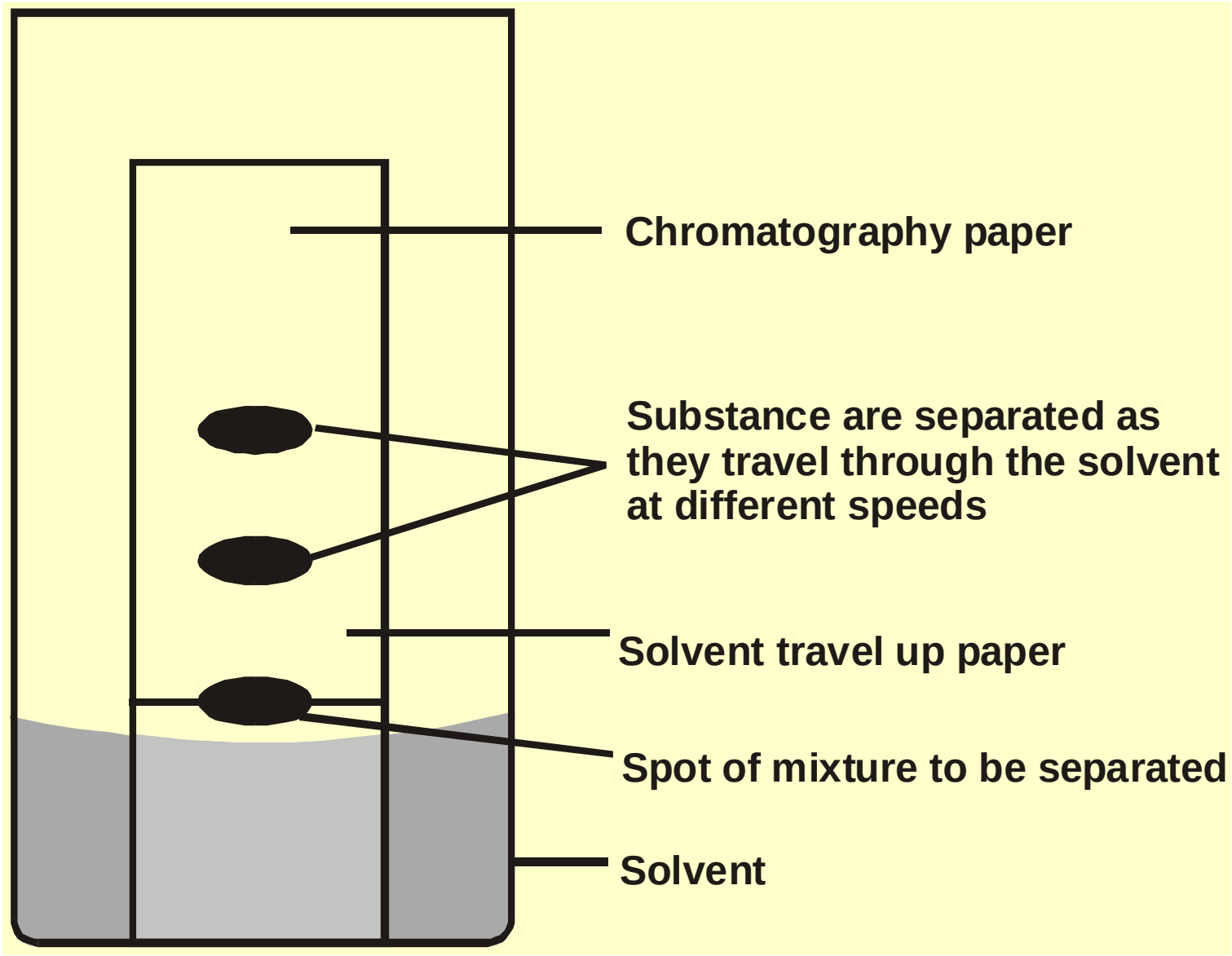
- *Paper chromatography is one of the methods for testing the purity of compounds and identifying substances. Paper chromatography is a useful technique because it is relatively quick and requires small quantities of material.*
- *Separations in paper chromatography involve the same principles as those in thin layer chromatography. In paper chromatography, like thin layer chromatography, substances are distributed between a stationary phase and a mobile phase. The stationary phase is usually a piece of high quality filter paper. The mobile phase is a developing solution that travels up the stationary phase, carrying the samples with it. Components of the sample will separate readily according to how strongly they adsorb on the stationary phase versus how readily they dissolve in the mobile phase*

Paper Chromatography

Thin Layer Chromatography

MATERIALS/APPARATUS REQUIRED

- Chromatographic cylinder or jar fitted with lid
- Lead pencil
- Whatman filter paper
- Mixture of inks
- Solvent as Mobile phase


Chromatography paper
Substance are separated as they travel through the solvent at different speeds
Solvent travel up paper
Spot of mixture to be separated
Solvent

PROCEDURE

- Take a 20 cm long filter paper strip.
- Mark a line with lead pencil at 2 cm from one end.
- Put ink spot at the centre of base line with the help of capillary tube.
- Into a chromatographic cylinder, take some volume of solvent or mobile phase (mixture of Ethyl alcohol, water and Acetic acid)

PROCEDURE

- Insert the strip into chromatographic cylinder such that base line does not dip into solvent.
- Cover the cylinder and keep it as such for 15-20 min. Inks are separated in the form of colored bands.
- Take the strip out of cylinder and dry it in air.
- Mark again the line at the level of maximum solvent rise. This line is called as solvent front. The strip with separated colors is called as Chromatogram.
- Calculate the R_f value of every colored band using formula mentioned below

Calculation of R_f value

R_f is abbreviation of retardation factor or retention factor. It is calculated for each ink. It has no units.

$$R_f = \frac{\text{Distance moved by ink from base line}}{\text{Maximum distance moved by solvent from base line}}$$

CALCULATIONS

S.NO.	COLOUR BAND (INK)	DISTANCE OF BAND (INK) FROM BASE LINE (CM)	MAXIMUM DISTANCE MOVED BY SOLVENT FROM BASE LINE (CM)	R_F
1	Blue	2.0	10	2.0/10=0.2
2	Red	4.0	10	4.0/10=0.4
3	**Green**	**6.0**	**10**	**6.0/10=0.6**

THANKS FOR TAKING KEEN INTEREST.

Composed by:

Zahid Isaac Sindhu
Demonstrator
Chemistry Department

HEAT OF NEUTRALIZATION

DETERMINATION OF HEAT OF NEUTRALIZATION OF STRONG ACID (HCL) AND STRONG BASE (NAOH) BY COPPER CALORIMETER

INTRODUCTION

- Calorimeter is a device to determine the heat released or absorbed during a chemical reaction.
- Definition: Quantity of Heat energy released when one mole of acid and one mole of base neutralizes each other to produce salt and water.

INTRODUCTION

- In this experiment, an aqueous solution of HCl will be added to an aqueous solution of NaOH within Calorimeter. The neutralization reaction will occur until either H^+ or OH^- ion is entirely consumed.

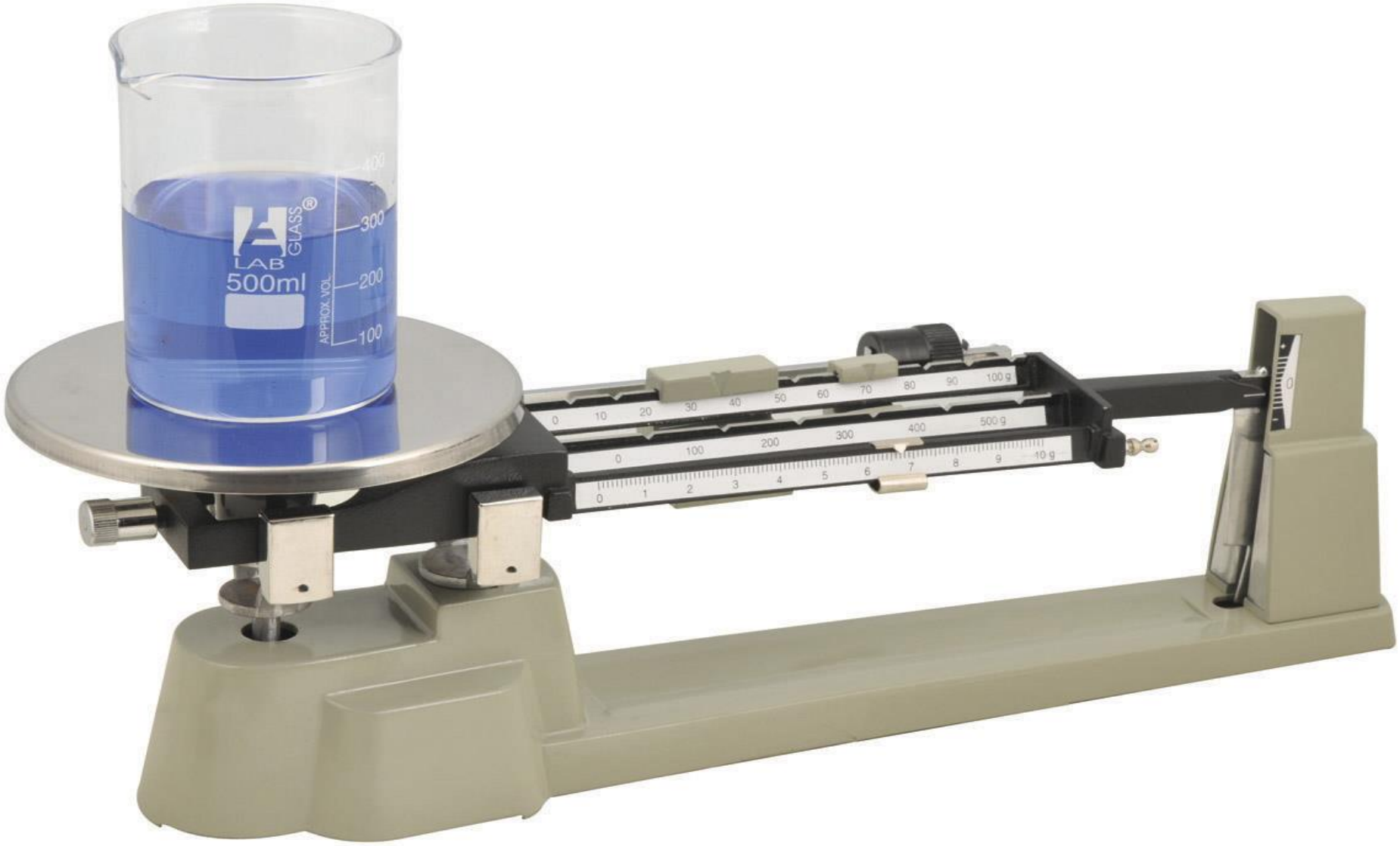
MATERIALS REQUIRED

- Thermometer,
- Calorimeter with all Accessories
- Triple beam balance
- 50 cm^3 of 1 M NaOH solution
- 50 cm^3 of 1 M HCl solution

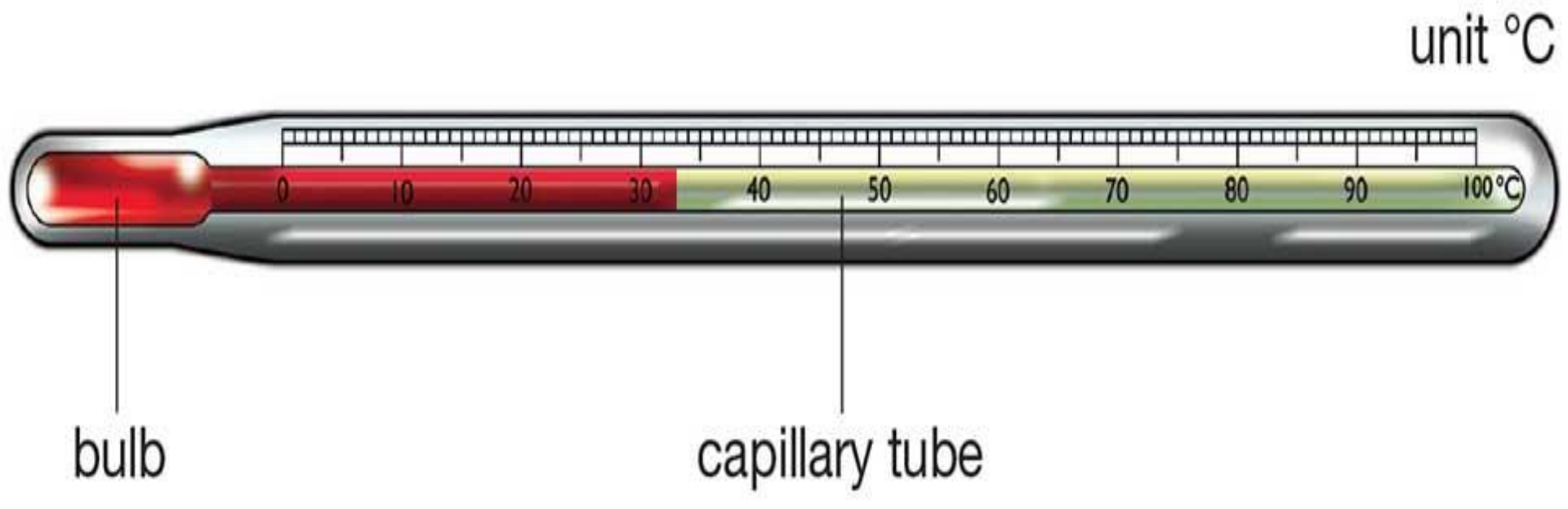
DIAGRAM

DIAGRAM

DIAGRAM


LAB GLASS®
500ml
APPROX. VOL.
400
300
200
100
0 10 20 30 40 50 60 70 80 90 100 g
0 100 200 300 400 500 g
0 1 2 3 4 5 6 7 8 9 10 g

DIAGRAM



PROCEDURE

- Take a copper calorimeter along with stirrer and lid, and weigh it as 'm_1'
- Add 50 cm^3 of NaOH (1M) solution into it and note its temp. as 'T_1'
- Add 50 cm^3 of HCl (1M) solution into base with continuous stirring. Temp. on thermometer would rise due to heat released during this neutralization reaction.

PROCEDURE

- Note the constant final temp. as 'T_2'
- Weigh calorimeter again along with lid, stirrer and mixture solution as 'W'.
- Now calculate 'm_2' by subtracting W-m_1.
- Perform the following calculations to calculate the Heat of Neutralization.

SUPPOSED CALCULATIONS

- Weigh of calorimeter(along with stirrer and lid) = m_1 = 45g
- Initial temp. of solution = T_1 = 21 ^{o} C .
- Final temp. of the solution = T_2 = 27 ^{o} C
- Increase in temp. due to Neutralization reaction =
  - $\Delta T = T_2 - T_1$ (27 - 21) = 6 ^{o} C .

SUPPOSED CALCULATIONS

- Weight of Calorimeter along with stirrer, lid and solution = W = 155 g.
- Weight of solution (m_2) = W–m1= 110 g.
- Specific heat of Copper calorimeter (S_1) = 0.091 Cal. g^{-1}. $^oC^{-1}$

SUPPOSED CALCULATIONS

- Specific heat of solution (S_2) =
  1 Cal. g^{-1}. $^oC^{-1}$
- Volume of Acid or Base taken (V) =
  50 cm^3 .
- Molarity of Acid or Base taken = M = 1

FORMULA TO FIND Hn

$$Hn = \frac{(m_1 \cdot S_1 + m_2 \cdot S_2)\, T \times 1000}{1000 \times V \times M}$$

RESULT

- Enthalpy or heat of neutralization = $\triangle$ Hn
- $\triangle$ Hn = -13.3 x 4.18 = -55.6 KJ / mol.
  - (As 1 Cal = 4.18J)
  - Standard Value = -13.7 K. Cal / mol. = -57.3v KJ / mol

Prepared BY:

Nadeem Masih

Senior Demonstrator

Chemistry Department

Forman Christian College

(A Chartered University)

Lahore

Key Notes

2nd Year Chemistry Practical 2023-2024

Key Notes Of Acid Radicals

Dilute Acid Group:

CO_3^{-2} **(Carbonate)**, HCO_3^{-} **(Bicarbonate)**, S^{-2}**(Sulphide)**, SO_3^{-2}**(Sulphite)**, $S_2O_3^{-2}$**(Thiosulphate)**, NO_2^{-}**(Nitrite)**

==========

Gases which evolve from Dilute Acid Group :

1- Colorless & odorless gas (CO_2) *turns lime water milky* from -- CO_3^{-2}, HCO_3^{-}

2- Colorless & rotten egg smell (H_2S) *turns Lead Acetate Paper/soln. black* from -- S^{-2}

3- Colorless & Sulphur burning smell (SO_2) *turns $K_2Cr_2O_7$ Paper/soln. black* from - SO_3^{-2} $S_2O_3^{-2}$

4- Reddish brown & pungent smell (NO_2) *turns $FeSO_4$ Paper/ soln. brownish black* from NO_3^{-}

==========

Confirmatory Test of dilute Acid Group :-

CO_3^{-2} **(i)** O.S + **$CaCl_2$** = white ppt on cold state **(ii)** O.S + **$MgSO_4$** = white ppt on cold state.

HCO_3^{-} **(i)** O.S + **$CaCl_2$** = white ppt on cold state **(ii)** O.S + **$MgSO_4$** = white ppt on cold state.

S^{-2} **(i)** O.S + **$AgNO_3$** = black ppt **(ii)** O.S + **$CdCl_2$** = yellow ppt

SO_3^{-2} **(i)** O.S + **$AgNO_3$** = white ppt **(ii)** O.S.+ **acidified $KMnO_4$** = $KMnO_4$ color discharged

$S_2O_3^{-2}$ **(i)** O.S + **$AgNO_3$** = yellow, brown & finally black ppt **(ii)** O.S + **I_2 solution** = I_2 color discharged.

NO_2^{-} (i) O.S. + **Diphenylamine** ($(C_6H_5)_2NH$) = deep blue coloration **(ii)** O.S.+ **acidified $KMnO_4$** = $KMnO_4$ color discharged

==========

Confirmatory Test of Special Group:-

SO_4^{-2} **(i)** O.S. + **$AgNO_3$** = white ppt **(ii)** O.S. + **Lead Acetate** = white ppt

PO_4^{-3} **(i)** O.S. + **$AgNO_3$** = yellow ppt **(ii)** O.S. + **$FeCl_3$** = yellow ppt

Conc. Acid Group :

Cl^{-} **(Chloride)**, Br^{-}**(Bromide)**, I^{-} **(Iodide)** , CH_3COOH^{-} **(Acetate)**, . $C_2O_4^{-2}$ **(Oxalate)**, NO_3^{-} **(Nitrate)**

==========

Gases which evolve from Conc. Acid Group :

1- Colorless & pungent gas (HCl) *white dense fumes with NH_4OH dipped rod* from -- Cl^{-}

2- Reddish & pungent gas (Br_2) *no effect on $FeSO_4$ solution* from ------ -- Br^{-}

3- Violet gas along the walls of test tube (I_2) *turns starch paper blue* from -- -- I^{-}

4- Colorless gas having vinegar smell (CH_3COOH^{-}) *turns litmus paper blue to red* from - CH_3COO^{-}

5- Colorless & odorless gas (CO_2 & CO) *turns lime water milky* from - $C_2O_4^{-2}$

6- Reddish brown & pungent gas evolves (NO_2) *turns lime water milky* from -- NO_3^{-} **Only** with strong heating with paper pallet.

==========

Confirmatory Test of Conc. Acid Group :-

Cl^{-} **(i)** O.S + **$AgNO_3$** = white ppt **(ii) Chromyl Chloride Test** –Salt + **$K_2Cr_2O_7$**(s) + few drops of Conc H_2SO_4 + Heat = reddish brown fumes of chromyl chloride(**CrO_2Cl_2**)

Br^{-} **(i)** O.S.+ **$AgNO_3$** = Pale yellow ppt

(ii) Layer Test --- O.S.+ **acidified $KMnO_4$ + CS_2** + Shake =orange layer at the bottom of test tube

I^{-} **(i)** O.S.+ **$AgNO_3$** = yellow ppt

(ii) Layer Test --- O.S.+ **acidified $KMnO_4$ + CS_2** + Shake =violet layer at the bottom of test tube

$C_2O_4^{-2}$ **(i)** O.S. + **$AgNO_3$** = white ppt **(ii)** O.S+**acidified $KMnO_4$** + Heat = $KMnO_4$ color discharged

CH_3COOH^{-} **CH** (i) O.S. + **C_2H_5OH** +few drops of Conc. **H_2SO_4** + Heat = fruity smell evolved

(ii) PalmTest --- Salt +**Oxalic acid** few crystals a drop of water on palm + rub with finger = strong vinegar smell evolve.

NO_3^{-} **(i)** O.S. + **Diphenylamine ($(C_6H_5)_2NH$)** = deep blue coloration.**(ii) *Ring test* :** O.S + $FeSO_4$ solution + Conc. **H_2SO_4** along the walls of test tube liquids = A dark brown ring at the junction of two liquids.

KEY NOTES OF BASIC RADICALS

Basic Radicals Groups — **Group Reagents**

Group I - Ag^{+} , Hg_2^{+2} , Pb^{+2} ---------- (Dilute HCl)

Group IIA – Cu^{+2} , Cd^{+2} , Bi^{+3} , Hg^{+2} , Pb^{+2} ---------- (Dilute HCl $+H_2S$ gas)

Group IIB – Sn^{+2} , Sn^{+4} , Sb^{+3} , As^{+3}

Group III – Fe^{+2} , Fe^{+3} , Al^{+3} , Cr^{+3} ..... ($NH_4Cl_{(solid)}$ + Boil , cool + NH_4OH)

Group IV – Ni^{+2} , Co^{+2}, Zn^{+2} , Mn^{+2} ---------- ($NH_4Cl_{(solid)}$ + Boil , cool + NH_4OH + H_2S_{gas})

Group V – Ba^{+2} , Sr^{+2} , Ca^{+2}---------- ----------$NH_4Cl_{(solid)}$ + Boil , cool + NH_4OH + $(NH_4)_2CO_3$

Group VI – Na^{+} , K^{+} , NH_4^{+} , Mg^{+2} .----------(No common group reagent)

==========

Dry Test

1-Color of Salt :- (i) Cu^{+2} ---- Blue (ii) Fe^{+2} --- Light Green , (iii) Fe^{+3} ---- Rust brown ,

(iv) Cr^{+3} --- Dark Green (v) Ni^{+2}--- Rich green, (vi) Co^{+2} -- Pink to violet (vii) Mn^{+2} ---Light Pink

2- Flame Test :- Made the paste of salt+ Conc. HCl , take some paste to the flame with Pt wire & note the color of flame.

(i) Cu^{+2} --- Bluish green, (ii) Ba^{+2} --- Apple green ,(iii) Sr^{+2} -- Crimson red ,

(iv) Ca^{+2} --- Brick red (v) Na^{+} -- Golden yellow ,(vi) K^{+} -- violet

3- Filter Ash Test :- Dip a filter paper strip in the mixture of Salt + $Co(NO_3)_2$[Cobalt nitrate] Dry, ignite and note the color of ash.

(i) Sn^{+2} – Dirty blue (ii) Al^{+3} – Blue (iii) Zn^{+2} – Green (iv) Mg^{+2} – Pink

==========

Confirmatory Test Of Group I :

Ag^{+} (i) O.S + $K_2Cr_2O_7$ = brick red ppt (ii) O.S. + **KI** = yellow ppt

Hg_2^{+2} (i) O.S + $K_2Cr_2O_7$ = Red brown ppt (ii) O.S. + **KI** = Dirty green ppt

Pb^{+2} (i) O.S + $K_2Cr_2O_7$ = bright yellow ppt (ii) O.S. + **KI** = Bright yellow ppt

• Confirmatory Test of Group IIA –

Cu^{+2} (i) O.S.+ **NaOH** = blue ppt (ii) O.S.+ NH_4OH in excess = deep blue coloration

Cd^{+2} (i) O.S + **NaOH** = white ppt (ii) O.S + NH_4OH = White ppt

Bi^{+3} (i) O.S + **NaOH** = White ppt (ii) O.S + **dil.HCl** + excess of water = Milk like white ppt – $BiOCl_3$

Confirmatory Test of Group IIB –

Hg^{+2} (i) O.S + **NaOH** = yellow ppt – HgO (ii) O.S + **KI** = Red ppt

Sn^{+} (i) O.S + **NaOH/ NH_4OH** = white ppt (ii) O.S + **Hg_2Cl** white ppt turns grey in excess of reagent

Sb^{+3} (i) O.S + **NaOH** = white ppt (ii) O.S + **dil.HCl** + excess of water = Milk like white PPt -- SbOCl

Confirmatory Test of Group III –

Fe^{+2} (i) O.S + **NaOH** = Green ppt (ii) O.S + **$K_3[Fe(CN)_6]$** Pot.ferricyanide(Soln.) = Deep blue ppt

Fe^{+3} (i) O.S + **NaOH** = brown ppt (ii) O.S + **Amm.Sulphocyanide** (NH_4SCN) = Blood red Coloration

Al^{+3} (i) O.S + **NaOH** = White gelatinous ppt (ii) **Lake Test :** O.S + Few drops litmus solution+ Dil.HCl + NH_4OH (soln) = blue ppt float over colorless solution

Cr^{+3} (i) O.S + **NaOH** = Green ppt (ii) O.S + **Na_2HPO_4** Sod.Phosphate (Soln) = Green ppt

• Confirmatory Test of Group IV –

Ni^{+2} (i) O.S + **NaOH** = Dark green ppt (ii) O.S + **Dimethyle glyoxime** (DMG) (soln) = rose red ppt.

Co^{+2} (i) O.S + **NaOH** = Violet ppt (ii) O.S + **Na_2HPO_4** [Sod.Phosphate = Violet ppt]

Zn^{+2} (i) O.S + **NaOH** = White ppt (ii) O.S + **Na_2HPO_4** [Sod.Phosphate = White ppt

Mn^{+2} (i) O.S + **NaOH** = White ppt (ii) O.S + **Na_2HPO_4** = White ppt Which turns brown in air

• Confirmatory Test of Group V –

Ba^{+2} (i) O.S + **Dilute H_2SO_4** = White ppt (ii) O.S + **Na_2HPO_4** [Sod.Phosphate = White ppt

Sr^{+2} (i) O.S + **Dilute H_2SO_4** = White ppt (ii) O.S + **Na_2HPO_4** [Sod.Phosphate = White ppt

Ca^{+2} (i) O.S + **Dilute H_2SO_4** = White ppt (ii) O.S + **Na_2HPO_4** [Sod.Phosphate = White ppt

Confirmatory Test of Group VI –

Na^{+} (i) O.S + **KOH + Pot.Pyroantimonate** -- $K_2H_2Sb_2O_7$ = White ppt (ii) O.S + **Zinc Uranyl acetate** $UO_2(CH_3COOH)_2.Zn(CH_3COOH)_2$ = yellow ppt

K^{+} (i) O.S + **Picric acid** – $C_6H_2OH(NO_2)_3$ –Yellow Needle like crystals (ii) O.S + **Tartaric acid** – $[CH(OH)COOH]_2$ = white ppt

NH^{+} (i) O.S + **Picric acid** – $C_6H_2OH(NO_2)_3$ –Yellow Needle like crystals (ii) O.S + **Nessler's reagent** = brown ppt

Mg^{+2} (i) O.S + **NaOH** (Soln) = White ppt (ii) O.S + **Na_2CO_3** (Soln) = White ppt

Most Important Radicals Which need to learn

- **Acid Radicals:** CO_3^{-2} (Soluble & Insoluble), HCO_3 , Cl^- , CH_3COO^- ,NO_3^- ,SO_4^{-2} , PO_4^{-3} ..... **7 Radicals**
- **Basic Radicals :** Na^+ , K^+, Mg^{+2} , Ca^{+2} , Ba^{+2} , Zn^{+2} , Al^{+3} , Cu^{+2} , Cd^{+2} , Pb^{+2} ..... **10 Radicals**

NOTE : If someone learns the above only 17 Radicals he/she would be able to write the following 55 Salts in BISE Lahore Exams

Sr.No	Sodium	Sr.No	Potassium	Sr.No	Magnesium	Sr.No	Calcium	Sr.No	Barium
1	Na_2CO_3	13	K_2CO_3	24	$MgSO_4$	35	$CaCO_3$	45	$BaCO_3$
2	$NaHCO_3$	14	$KHCO_3$	25	$MgCO_3$	36	$CaCl_2$	46	$BaCl_2$
3	NaCl	15	KCl	26	$MgCl_2$	37	$CaSO_4$	47	$BaNO_3$
4	Na_2SO_4	16	K_2SO_4	27	$MgNO_3$	38	$Ca_2(PO_4)_3$	48	$BaSO_4$
5	$NaNO_3$	17	KNO_3	28	$Mg_2(PO_4)_3$			49	$Ba(CH_3COO)_2$
6	Na_2HPO_4								
7	$NaCH_3COO$		**Zinc**		**Cadmium**		**Copper**		**Lead**
	Aluminum	18	$ZnCO_3$	29	$CdCO_3$	39	$CuCO_3$	50	$PbCO_3$
8	$AlCl_3$	19	$ZnCl_2$	30	$CdCl_2$	40	$CuCl_2$	51	$PbCl_2$
9	$Al(CH_3COO)_3$	20	$Zn(CH_3COO)_2$	31	$Cd(CH_3COO)_2$	41	$Cu(CH_3COO)_2$	52	$PbNO_3$
10	$AlNO_3$	21	$Zn(NO_3)_2$	32	$Cd(NO_3)_2$	42	$Cu(NO_3)_2$	53	$PbSO_4$
11	$Al_2(SO_4)_3$	22	$ZnSO_4$	33	$CdSO_4$	43	$CuSO_4$	54	$Pb_2H(PO_4)$
12	$AlPO_4$	23	$Zn_3(PO_4)_2$	34		44	$Cu_3(PO_4)_2$	55	$Pb(CH_3COO)_2$

Most Important / Frequently Repeated Salts In BISE Lahore Exams.

1	$Pb(CH_3COO)_2$	6	Na_2CO_3
2	$PbSO_4$	7	$NaHCO_3$
3	$CuSO_4$	8	$NaCl$
4	$CuCl_2$	9	Na_2SO_4
5	$CdCl_2$		

Intermediate Chemistry Practicals
Learning Tips

Part 1 – Titrations

There are seven types of calculations / applications regardless either the titration is Acid - Base, Redox or Iodimetry. If a student wants to learn all titrations easily, he/she can follow the following guidelines carefully.

- **Similarity of Procedures**

  There are only 3 types of procedures (except solubility experiment) which belong to all the titrations with a minor difference of two few words which may be the name of solution and indicator according to it.

- **A general procedure**

  1. Fill the burette with the given solution of Acid/$KMnO_4$/$Na_2S_2O_3$ with the help of funnel and note the initial reading for Acid- Base, Redox and Iodimetric respectively.

  2. (for acid – base Titration) Pipette out 10cm^3 of Base solution and add 2 to 3 drops of Indicator (Methyl Orange/Phenolphthalein in case of acid – base titration .

  2. (For Redox Titration) Pipette out 10cm^3 of $FeSO_4$/Mohr's Salt/Oxalic Acid or any Oxalatesolution and add ½ test tube of Dil. H_2SO_4 (Heating

  2. (For Iodimetric Titration)Pipette out 10cm^3 ofIodine solution and add a test tube of water, titrate with $Na_2S_2O_3$till paleyellow color appears then add starch solution as an indicator.

  3. Titrate with the solution taken in the burette tillight pink colorappearsin case of acid -base / redox titration and blue to colorless in case of Iodimetry.

  4. Repeat the titration three times to get concordant readings.

- **Importance of Standardization**

  It's really important to note that 1st part of every calculation is standardization.

- **Similar experiments/calculations**

  The seven types of experiments can be learnt in groups based on similarity.

  For example, There are some experiments of Percentage Composition and it is important to note that calculating Percentage Purity/Impurity and Percentage Oxidation is also very similar.

- **The Results**

By: Sir Timothious Rasheed

It is important to write result. Almost 90% of result is written in the statement of experiment.

For example,

Experiment: The given solution contains 30g of impure Iodine sol. dissolved per dm^3Determine *percentage purity of the sample* volumetrically.

Result: The *percentage purity of the sample* is 80%

Part 2 – Salt Analysis

In Salt Analysis there are 14 Acidic and 26 Basic radicals. If somebody learns these radicals individually, he/she can write hundreds of salts having different combination of radicals. **For example**, Sodium "Na" have 14 salt combinations with Acidic radicals i.e. Na_2CO_3, $NaHCO_3$, $Na_2S_2O_3$, NaCl, etc.

Analysis of Acid & Basic Radicals is done by the following three steps.

- **Group identification of an Acidic Radical:** 1st of all solid salt is taken in the dry test tube then Dil. or Conc. H_2SO_4 is added to check the reaction.
  - **(i)** If reaction takes place with Dil. H_2SO_4. Dilute Acid group will be indicated.
  - **(ii)** If reaction takes place with Conc. H_2SO_4. Conc. Acid group will be indicated.
  - **(iii)** If no reaction with Dil.H_2SO_4 or Conc. H_2SO_4,Special group will be indicated

- **Radical Identification:** If a student learns color and odor of gases/fumes (after adding acid) it'll make Identification of an Acidic Radical easy for all Acidic Radicals which will lead to correct Confirmatory Tests.

- **Group identification of Basic Radical** always starts with Dry Tests.
  Steps for Dry Tests are same for all 26 Basic Radicals which makes it not only very easy but also 2 marks out of 6 for sure only if you learn 3 steps having few lines under these headings.
  1. Color of Salt **2.**Flame Test **3.**Filter ash Test

- **Group Reagents:** Without learning Group Reagents of Basic Radicals, a student can't start the proper sequence of all required steps in scheme.
- **Colored Radicals:** It's really important to learn all colored radicals because it is necessary to write them in every scheme of Basic Radicals.

Learning Tips

- **Color of Flame:** Learn Basic Radicals which show colors of flames as it's part of every scheme of Basic Radicals.
- **Color of Ash:** Learn Basic Radicals which show characteristic colors of ash upon Filter Ash Test as it is part of every scheme of Basic Radicals.
- **Flow Sheet**: Make flow sheet of steps either for Acidic or Basic Radical before you learn. It will help you to learn the sequence of all steps in a single flow.
- **Comparison of Solutions:** Compare the solutions used for confirmatory tests because in some groups (Acidic/Basic) same solutions are used for all confirmatory tests of all radicals of the same group.

Note: Never write the name of radical even if you know at the start of Salt Scheme. It should be at the end as "Result". Examiner in LHR Board Exam can ask, "How you can find the results before performing Salt Analysis?"

Exp. No.	Statement
01	Standardize the given solution of HCl and also calculate volume required to prepare 500cm³ of 0.025M HCl. You are provide 0.1M NaOH.

Principle: It is an acid base titration.

Standard solution: 0.1 M NaOH.

Indicator: Phenolphthalein.

End point: Light pink.

Chemical equation:

$$HCl + NaOH \longrightarrow NaCl + H_2O$$

Procedure:

1. Fill the burette with the given solution of acid with the help of funnel and note the initial readings.
2. Pipette out 10 cm^3 of base solution and add in it 1-2 drops of indicator (phenolphalein).
3. Titrate it with the solution taken in the burette till light pink color appears and get the final readings.
4. Repeat the titration three times to get concordant readings.

Exp. No. 01

Observations and calculation

Sr. No	Initial reading (cm^3) V	final reading (cm^3)	Volume used (cm^3)
1.	0.00	10.00	10.00
2.	10.00	20.00	10.00
3.	20.00	30.00	10.00

Concordant reading: 10.00cm^3

HCl | NaOH

$\frac{M_1V_1}{n_1}$ | $\frac{M_2V_2}{n_2}$

$\frac{M_1 \times 10.0}{1}$ | $\frac{0.1 \times 10.0}{1}$

$$M_1 = \frac{0.1 \times 10.0 \times 1}{1 \times 10.0}$$

Given HCl | Required HCl

M_1V_1 | M_2V_2

$0.1 \times V_1$ | 0.025×500

$$V_1 = \frac{0.025 \times 500}{0.1}$$

$$V_1 = 125 cm^3$$

Results: 125cm^3 of 0.1 M HCl is required to Prepare 500cm^3 of 0.025M HCl

Exp. No.	Statement
02	Prepare the standard solution of Oxalic acid and with its help standardize the given solution of NaOH.

Principle: It is an acid base titration.

Standard solution: 0.05 M oxalic acid.

Indicator: Phenolphthalein.

End point: Light pink.

Chemical equation:

$$\begin{matrix} COOH \\ | \\ COOH \end{matrix} + 2NaOH \longrightarrow \begin{matrix} COONa \\ | \\ COONa \end{matrix} + 2H_2O$$

Procedure:

1. Fill the burette with the given solution of acid with the help of funnel and take the initial readings.
2. Pipette out 10 cm^3 of base solution and add in it 1-2 drops of phenolphthalein.
3. Titrate it with the solution taken in the burette till light pink colour appears and note the final readings.
4. Repeat the titration three times to get concordant readings.

Exp. NO. 02

Observation and calculations

Sr No	Initial reading (cm^3)	final reading (cm^3)	Volume used (cm^3)
1.	0.00	10.00	10.00
2.	10.00	20.00	10.00
3.	20.00	30.00	10.00

Concordant reading: 10.00cm^3

NaOH

$$\frac{M_1V_1}{n_1}$$

$$\frac{M_1 \times 10.0}{2}$$

Oxalic acid

$$\frac{M_2V_2}{n_2}$$

$$\frac{0.05 \times 10.0}{1}$$

$$M_1 = \frac{0.05 \times 10.0 \times 2}{1 \times 10.0}$$

$$M_1 = 0.1\ M$$

Result = Molarity of NaOH = 0.1M

Experiment No.1 (Acidic Radical)

Experiment	Observation	Inference
• **Detection of Group**		
1. Salt + dilute H_2SO_4	Colourless and odorless gas evolved with effervescence	Dilute Acid group (CO_3^{-2}, HCO_3^-, S^{-2}, SO_3^{-2}, $S_2O_2^{-2}$, NO_3^-) is present.
2. Test the gas with lime water $Ca(OH_2)$	Turns milky	CO_3^{-2} or HCO_3^- may be present
3. Salt + Distilled water	Salt is insolube	Insolube carbonate Confirmed
• **Result**		
The acid radical is CO_3^{-2} (Insolube carbonate)		

Experiment No. 2 (Acidic Radical)

	Experiment	Observation	Inference
•	**Detection of Group**		
1.	Salt + Dilute H_2SO_4	Colourless and odourless gas evolved with effervescence	Dilute Acid group (CO_3^{-2}, HCO_3^-, S^{-2}, $S_2O_3^-$, NO_2^-) is present
•	**Detection of Radical**		
2.	Test the gas with lime water	Turns milky	CO_3^{-2} or HCO_3^- may be present
•	**Confirmatory test**		
3.	O.S + $CaCl_2$	White ppt in cold state	CO_3^{-2} (solube) confirmed
4.	O.S + $MgSO_4$	White ppt in cold state	CO_3^{-2} (solube) confirmed
•	**Result**		
	The acid radical	is CO_3^- (solube carbonate)	

Experiment No. 3 (Acidic Radical).

Experiment	Observation	Inference
• **Detection of Group**		
1. Salt + Dilute H_2SO_4	Colourless and odorless gas evolved with effervescence	Dilute acid group (CO_3^{-2}, HCO_3^-, S^{-2}, $S_2O_3^-$, NO_2^-) is present
• **Detection of Radical**		
2. Test the gas with lime water $Ca(OH)_2$	Turns milky	CO_3^{-2} or HCO_3^- may be present
• **Confirmatory test**		
3. O.S + $CaCl_2$	White ppt on heating	HCO_3^- confirmed
4. O.S + $MgSO_4$	White ppt on heating	HCO_3^- confirmed
• **Result** The acid radical is HCO_3^- (Bicarbonate)		

01-09-2023

Experiment No. 4 (Acidic Radical)

	Experiment	Observation	Inference
•	**Detection of Group**		
1.	Salt + Dilute H_2SO_4	Colourless and odorless gas evolved with effervescence	Dilute Acid group (CO_3^{2-}, HCO_3^-, S^{-2}, SO_3^{-2}, $S_2O_3^{-2}$, NO_2^-)
•	**Detection of Radical**		
2.	Test the gas with Lead Acetate $(CH_3COO)_2Pb$ Paper / solution	Turns black	S^{-2} indicated
•	**Confirmatory Tests**		
3.	O.S + $AgNO_3$	Black ppt	S^{-2} confirmed
4.	O.S + $CdCl_2$	Black ppt	S^{-2} confirmed
•	**Result**		
	The acid radical is S^{-2} (Sulphide).		

Experiment No.5 (Acidic Radical)

Experiment	Observation	Inference
• **Detection of Group**		
1. Salt + Dilute H_2SO_4	Colorless having sulphur burning gas smell evolved	Dilute acid group (CO_3^{-2}, HCO_3^-, S^{-2}, SO_3^{-2} $S_2O_3^{-2}$, NO^{-2})
• **Detection of Radical**		
2. Test the gas with pot dichromate ($K_2Cr_2O_7$) paper / solution	Clear green solution	SO_3^{-2} indicated
• **Confirmatory Tests**		
3. O.S + $AgNO_3$	White ppt	SO_3^{-2} confirmed
4. O.S + Acidified $KMnO_4$	$KMnO_4$ color discharged	SO_3^{-2} confirmed
• **Result** The acid radical	is SO_3^{-2} (Sulphide)	

Experiment No. 6 (Acidic Radical)

	Experiment	Observation	Inference
•	**Detection of Group**		
1.	Salt + Dilute H_2SO_4	Colorless having sulphur burning gas smell evolved	Dilute Acid group (CO_3^{-2}, HCO_3^-, S^{-2}, $S_2O_3^{-2}$)
•	**Detection of Radical**		
2.	Test the gas with Potassium dichromate ($K_2Cr_2O_2$) paper solution	Green ppt formed	$S_2O_3^{-2}$ indicated
•	**Confirmatory Tests**		
3.	O.S + $AgNO_3$	Yellow, brown and finally black ppt	$S_2O_3^{-2}$ confirmed
4.	O.S + Acidified $KMnO_4$	$KMnO_4$ color discharged	$S_2O_3^{-2}$ confirmed
•	**Result**		
	The acid radical is $S_2O_3^{-2}$ (Thiosulphate)		

Experiment No.7 (Acidic Radical)

Experiment	Observation	Inference
• **Detection of Group**		
1. Salt + Dilute H_2SO_4	Brown gas with punget smell evolved	Dilute Acid group (CO_3^{-2}, HCO_3^-, S^{-2}, SO_3^{-2}, $S_2O_3^{-2}$, NO_2^-) is present
• **Detection of Radical**		
2. Test the gas with $FeSO_4$ solution / Paper	Turns black	NO_2^- indicated
• **Confirmatory Tests**		
3. O.S + Acidified $KMnO_4$	$KMnO_4$ color discharged	NO_2^- confirmed
4. O.S + diphenylamine $(C_6H_5)_2NH$	Deep blue coloration	NO_2^- confirmed
• **Result** The acid radical is NO_2^- (nitrate)		

Experiment No. 38 (Basic Radical)

Experiment	Observation	Inference
Dry Tests		
Color of salt		
Note the color of salt	white in color	Coloured radicals (Cu^{+2}, Fe^{+2}, Cr^{+3}, Ni^{+2}, Co^{+2})
Flame Test		
Made the paste of salt + Conc. HCl Take some paste to the flame	golden yellow flame produced	Na^{+} may be present
Filter Ash Test		
Dip a filter paper strip in the mixture of salt + $Co(NO_3)_2$, dry ignite	No characteristic ash produced	Sn^{+2}, Al^{+3}, Zn^{+2}, Mg^{+2} are absent
Wet Tests		
O.S + Dilute HCl	no ppt	Group I (Ag^{+}, Hg_2^{+2}, Pb^{+2}) is absent
O.S + Dilute HCl + H_2S gas/water	No ppt formed	Group II (Cu^{+2}, Cd^{+2}, Hg_2^{+2})
O.S + NH_4Cl boil, cool + NH_4OH excess	No ppt formed	Group III (Fe^{+2}, Fe^{+3}, Al^{+3})
O.S + NH_4Cl boil + H_2S	No ppt formed	Group IV (Mn^{+2}, Ni^{+2}, Co^{+2}, Zn^{+2})

	Experiment	Observation	Inference
•	**Absence of five groups indicates 6th**		
6.	O.S + KOH + Pot. Pyroantimoate ($K_2H_2Sb_2O_7$)	No white ppt	Na^+ is absent
7.	O.S + NaOH + heat	No smell of $NH_{3(g)}$	NH_4^+ is absent
8.	O.S + NH_4Cl, cool + NH_4OH + $(NH_4)_2HPO_4$	No white ppt	Mg^{+2} is absent
9.	O.S + CH_3COOH + Sod. Cobaltnitrite	Yellow ppt	K^+ is indicated
•	**Confirmatory Tests**		
1.	O.S + Picric acid ($C_6H_2(OH)(NO_2)_3$)	Yellow ppt	K^+ is confirmed
2.	O.S + Tartaric acid ($CH(OH)COOH_2$)	White ppt	K^+ is confirmed
•	**Result**		
	The basic radical is K^+ (Potassium)		

22/09/23

For Your Chemistry Practical Exam