GOVERNMENT POLYTECHNIC NABARANGPUR

LABORATORY MANUAL

FOR

ENGINEERING CHEMISTRY

Semester :- 1st / 2nd

Department of Mathematics and Science

Student' Name

Roll No:- Year:-

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Sl. No	Name of Experiment	Date of Expt. Performed	Page No	Marks/ Grades	Signature of Faculty

PREPARATION OF CARBON DIOXIDE (CO_2) GAS

Experiment No:- 1

Date :- Branch :- Section :-

Name:- Regd. No.:- Marks/Grades :-

Signature of the Faculty

Aim of Experiment :- To prepare Carbon dioxide(CO_2) gas in the laboratory and to study its properties.

Objectives Of The Experiment :-

On completion of this experiment, the students will be able to:

(i)Name and specify the chemicals, which are used to prepare CO_2 gas in the laboratory.

(ii) Describe the physical and chemical properties of the gas

(iii) Test carbonate radical in the given salt sample.

(iv) Describe the procedure for preparation of the gas in the laboratory.

(v) state the precautions and the safety measures.

Apparatus Required :-

(1) Woulfe's bottle, (2) Thistle Funnel, (3) Delivery Tube bent twice at right angles, (4) Rubber Cork, (4) Cork borer, (6) Gas jar with lid, (7) few test tubes, (8) Bunsen Burner

Chemicals Required :-

(1) Marble Chips ($CaCO_3$), (2) dilute Hydrochloric Acid (HCl), (3) Lime Water ($Ca(OH)_2$), (4) Blue Litmus Paper, (5) Magnesium Ribbon, (6) dilute NaOH solution, (7) Phenolpthalein indicator, etc.

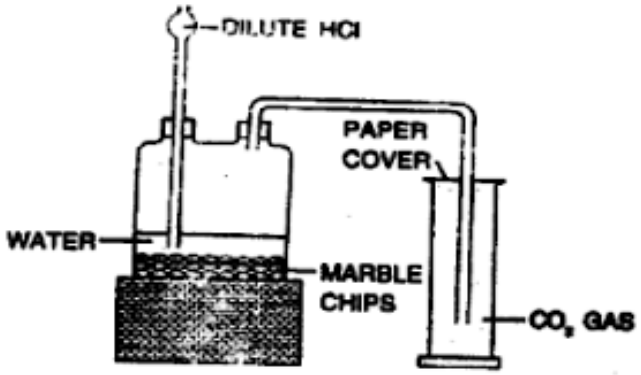
Principle :-

Carbon Dioxide (CO_2)gas can be prepared in the laboratory by the action of dilute Hydrochloric acid (HCl) on marble chips ($CaCO_3$). The gas being heavier than air is collected by the up ward displacement of air in the gas jar.

Chemical Reaction :-

$$CaCO_{3(s)} + \text{dil. } 2HCl \text{ ----------} \rightarrow CaCl_2 + H_2O_{(l)} + CO_2\uparrow$$

Diagram:-



Procedure :-

- Take a clean Woulfe's bottle fitted with bored rubber cork at its two openings.
- Introduce some marble chips into the Woulfe's bottle by removing one rubber cork.
- Cover the marble chips with little amount of water.
- Insert the thistle funnel through one of the rubber cork such that the end of the thistle funnel should reach to the bottom of the Woulfe's bottle.
- Insert one end of the delivery tube in to the Woulfe's bottle through the other rubber cork in such a manner that it must be present at the upper half of woulfe's bottle.

- Make the fitted apparatus perfectly air tight by using a lubricant or paraffin wax.
- Insert the other end of the delivery tube deep into the gas jar covered with a lid.
- Add some dilute HCL through the thistle funnel .
- See the reaction between the acid and marble chips which evolve CO_2 gas.
- Collect the gas in the gas jar after few seconds of starting of the reaction.
- The gas being heavier than air, must be collected in the gas jar by up ward displacement of air.
- Collect the gas in different gas jars or test tubes and study its various properties.

Properties :-

Experiment	Observation	Inference
Physical properties :-		
(1) Observe the colour of the gas	The gas is colourless	CO_2 gas is colourless
(2) Observe the odour of the gas	The gas has no odour	CO_2 gas is odourless
(3) Introduce a burning match stick /jute stick into a test tube containing CO_2 gas.	The match stick get extinguished.	CO_2 gas is neither combustible nor a supporter of combustion, rather it extinguishes the flame.
(4) Invert a test tube `filled with the gas over another empty test tube. Then insert a burning match stick in to the lower test tube	The burning match stick gets extinguished showing the presence of CO_2 in the lower test tube	The gas is heavier than air an it is neither combustible nor a supporter of combustion
(5) Collect CO_2 gas in a test tube, put your thumb at its mouth and invert it into a trough of water.	Water level in side the test tube rises slowly.	Carbon Dioxide (CO_2) gas is sparingly soluble in water.
Chemical Properties :-		
(1) Introduce a blue litmus paper in to the above solution present in the test tube.	Blue litmus papers turned red	Carbon Dioxide (CO_2) gas is acidic in nature. $CO_2 + H_2O \text{ ----------}\rightarrow H_2CO_3$
(2) Show a moist blue litmus paper to the evolved gas.	Blue litmus papers turned red	Carbon Dioxide (CO_2) gas is acidic in nature. $CO_2 + H_2O \text{ ----------}\rightarrow H_2CO_3$
(3) Pass the evolved gas into a test tube containing lime water ($Ca(OH)_2$)		
(a) At first slowly in less amount	(a)Lime water turned milky	(a)Milkyness is due to the formation of insoluble $CaCO_3$ ppt. $Ca(OH)_2 + CO_2 \text{ ------}\rightarrow CaCO_3 + H_2O$
(b) Then pass CO_2 gas in excess	(b)Milkyness disappeared	(b)This is due to formation of soluble $Ca(HCO_3)_2$ solution $CaCO_3 + H_2O + CO_2 \text{ ----}\rightarrow Ca(HCO_3)_2$

(c) Now heat the above solution	(c)Milkyness again reappeared	(c)This is due to the expulsion of excess CO_2 gas on heating $Ca(HCO_3)_2$ ----→ $CaCO_3 + H_2O + CO_2$
(4) Introduce a burning magnesium ribbon into a test tube containing CO_2 gas	The magnesium ribbon burns vigorously producing white fumes and black residue.	Black residue is due to formation of carbon black and white powder is due to formation of MgO. $2Mg + CO_2$ -----→ $2MgO + C$
(5) Add few drops of water in to the test tube and shake it well, then put a red litmus paper in to the test tube	The red litmus paper turned blue	H_2O combines with MgO to form $Mg(OH)_2$ which is alkaline $MgO + H_2O$ -------→ $Mg(OH)_2$
(6) Pass the gas through alkaline phenolphthalein solution	The pink colour of solution become colourless.	Carbon dioxide (CO_2) gas is acidic in nature.
(7) Add methyl orange indicator to the aqueous solution of CO_2 gas	Orange colour of solution changes to red	CO_2 gas is acidic in nature.

Precautions :-

(1) The apparatus must be perfectly air tight.
(2) The thistle funnel must reach to the bottom of Woulfe's bottle and must dip inside the acid.
(3) Smaller pieces of marble chips must be introduced through the opening of Woulfe's bottle, otherwise it may stick at the opening.
(4) The delivery tube must be present at the upper half of bottle.
(5) Acid must be added in very small amount at regular intervals.

Viva – Voice Questions :-

(1) What are the apparatus required for this experiment?
(2) Write the chemical formula of marble chip.
(3) Can we use $CaCO_3$ powder for preparation of CO_2 gas?
(4) Why marble chips are used instead of $CaCO_3$ powder?
(5) Write the chemicals used for preparation of CO_2 gas.
(6) How can you prepare dilute HCl?
(7) Hydrochloric acid is a strong or weak acid? Give reason.
(8) Explain the acidic nature of CO_2 gas?
(9) What happens when CO_2 gas is passed through alkaline phenolphthalein solution?
(10) What happens when moist blue and red litmus papers are shown to CO_2 gas?
(11) How CO_2 gas is collected?
(12) What are the apparatus required for preparation of CO_2 gas?
(13) How can you prepare CO_2 gas in laboratory?
(14) Why moist blue litmus paper turns red on exposure to CO_2 gas?

(15)Write two methods of preparation of CO_2 gas.
(16)What happens when a burning match stick is introduced into a jar containing CO_2 gas?
(17) What happens when methyl orange indicator is added to aqueous solution of CO_2 gas?
(18)What happens when CO_2 gas is passed through lime water first in less amount and then in excess?
(19)Write the reactions involved between CO_2 gas and lime water.
(20)What is the formula of lime water?
(21) Why lime water turns milky when less amount of CO_2 gas is passed through it? Give Equation.
(22) Why milky colour disappears on passage of excess CO_2 gas through lime water? Give Equation.
(23)What happens when colourless $Ca(HCO_3)_2$ solution will be warmed strongly? Give Equation.
(24)What happens when a burning magnesium is introduced into gas jar containing CO_2 gas? Give Equation.
(25)Write two uses of CO_2 gas.
(26)What is dry ice?
(27)How can you test that CO_2 gas is heavier than air?
(28)Can sulphuric acid (H_2SO_4) be used in place of HCl for preparation of CO_2 gas?
(29)What type of bonding is present in CO_2 ?
(30)Why smaller pieces of marble chips are required?
(31)Why the thistle funnel is inserted deep to the bottom of the Woulfe's bottle?
(32)How can you test the solubility of CO_2 gas?

PREPARATION OF AMMONIA (NH_3) GAS

Experiment No:-2

Date :- Branch :- Section :-

Name:- Regd. No.:- Marks/Grades :-

Signature of the Faculty

Aim of Experiment :- To prepare Ammonia(NH_3) gas in the laboratory and to study its properties.

Objectives Of The Experiment :-

On completion of this experiment, the students will be able to:

(i)Name and specify the chemicals, which are used to prepare NH_3 gas in the laboratory.

(ii) Describe the physical and chemical properties of the gas

(iii) Test carbonate radical in the given salt sample.

(iv) Describe the procedure for preparation of the gas in the laboratory.

(v) State the precautions and the safety measures.

Apparatus Required :-

(1)Hard Glass Test Tube, (2) Rubber Cork, (3)Cork borer, (4)Delivery tube bent at right angle, (5) Gas Jar with lid, (6) Iron Clamp Stand with Clamps, (7) Bunsen Burner , (8) Few Test Tubes

Chemicals Required :-

(1)Solid Ammonium Chloride (NH_4Cl) , (2) Powdered Quick Lime (CaO) or Dry Slaked Lime [$Ca(OH)_2$], (3) Red Litmus paper, (4) Nessler's Reagent (5) Conc. Hydrochloric Acid (HCl), (6) Copper Sulphate Solution, (7) Ferric Chloride ($FeCl_3$) Solution.

Principle :-

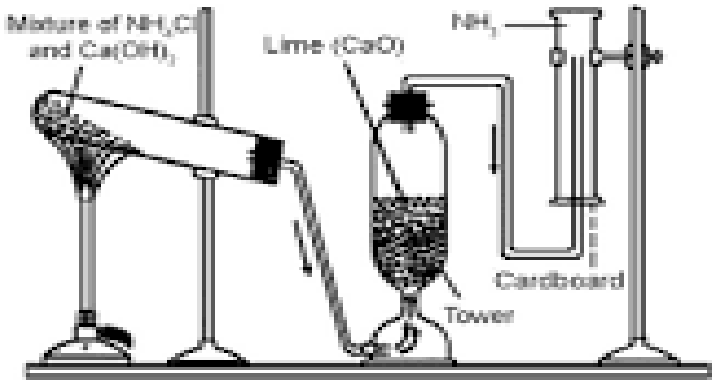
In the laboratory Ammonia gas is prepared by heating an intimate mixture of solid Ammonium Chloride(NH_4Cl) and dry Quick Lime (CaO) or dry Slaked Lime[$Ca(OH)_2$] in the proportion 1:3 in a hard glass test tube. The ammonia (NH_3) gas being lighter than air can be collected in the gas jar by the down ward displacement of air . Pure and dry ammonia (NH_3) gas can be obtained by passing the gas first through a tower of CaO before collecting it in a gas jar.

Chemical Equation :-

$$2NH_4Cl + CaO \longrightarrow CaCl_2 + H_2O + 2NH_3\uparrow$$

$$2NH_4Cl + Ca(OH)_2 \longrightarrow CaCl_2 + 2H_2O + 2NH_3\uparrow$$

Diagram :-



Procedure :-

- Prepare an intimate mixture of solid NH_4Cl and dry CaO or $Ca(OH)_2$ in the proportion 1:3 .
- Take a dry and clean hard glass test tube and fill the mixture in the test tube about half of its volume.
- Replace the rubber cork fitted with the delivery tube immediately.
- Fit the hard glass test tube in the iron clamp stand in such a manner that the mouth of the test tube will be slightly downward.
- Now heat the hard glass test tube slowly by the Bunsen Burner.
- Collect the evolved gas in the gas jar by the downward displacement of air.

Properties :-

Experiment	Observation	Inference
Physical Properties :-		
(1) Observe the colour of the gas	The gas is colourless	Ammonia (NH_3) gas is colourless
(2) Observe the odour of the gas	Pungent odour	Ammonia (NH_3) gas has characteristic pungent odour
(3) Introduce a burning match stick in to a jar containing Ammonia (NH_3) gas .	Match stick burns for a while and then extinguished	Ammonia (NH_3) gas is neither combustible nor a supporter of combustion.
(4) Invert an empty test tube over another test tube filled with Ammonia (NH_3) gas and after few seconds insert a moist red litmus paper in to the 1st test tube.	The litmus paper turned blue as Ammonia (NH_3) gas enters in it	Ammonia (NH_3) gas is lighter than air and it is alkaline in nature.
(5) Collect the gas in a test tube and invert it into a trough of water by keeping the thumb at its mouth.	Water rushed in to the test tube	Ammonia (NH_3) gas is highly soluble in water. $NH_3 + H_2O \text{ -----}\rightarrow NH_4OH$
Chemical properties :-		

(1) Show a moist red litmus paper to the evolved gas.	The moist red litmus paper turned blue.	Ammonia (NH_3) gas is alkaline in nature.
(2) Show a glass rod dipped in conc. Hydrochloric acid (HCl) to the evolved gas.	Dense white fumes are produced	Dense white fumes are NH_4Cl vapour $NH_3 + HCl \dashrightarrow NH_4Cl$
(3) Pass the through Nessler's reagent taken in a test tube.	A brown precipitate forms	Brown ppt. is due to the formation of iodide of Millon's base [H2N-HgO-HgI]
(4)Pass the ammonia gas through ferric chloride solution (5)Pass the gas through copper sulphate($CuSO_4$) solution	A brown precipitate forms	Brown ppt. is due to the formation of ferric hydroxide [$Fe(OH)_3$] $6\ NH_4OH + 2FeCl3 \rightarrow 2Fe(OH)_3 + 6NH_4Cl$
(a) first in small quantity	A bluish white precipitate forms	It is due to formation of [$Cu(OH)_2$] ppt
(b) then in excess of NH_3 gas	A deep blue coloration/ solution forms	Deep blue solution is due to the formation of soluble copper complex $[Cu(NH_3)_4](OH)_2$ [tetramine cupric hydroxide complex]
(6) Pass the gas through phenolphthalein solution	The solution turns pink	NH_3 gas is alkaline in nature.

Precaution :-

(1) The hard glass test tube should be clamped to the stand with its mouth slightly downward.
(2) The apparatus should be perfectly air tight.
(3) The gas should be collected only after completely removing air from the apparatus.
(4) The open end of the gas jar should be covered with a card board through which the delivery tube is inserted.
(5) The end of the delivery tube should touch the bottom of the gas jar.
(6) Heating of hard glass test tube should be done slowly.
(7) Deep inhalation of the gas must be avoided.

Viva Voice Questions :-

(1) Write the principle of preparation of ammonia gas in laboratory?
(2) What is the principle of collection of ammonia gas?
(3) Write the apparatus required for preparation of ammonia gas?
(4) What are the chemicals required for ammonia gas?
(5) While clamping the hard glass test tube, its mouth is present slightly downward. Why?
(6) Write the physical properties of ammonia gas?

(7) What is the odour of ammonia gas?
(8) What happens when a glass rod dipped in conc HCl is shown to the ammonia gas?
(9) What happens when a test tube filled with ammonia gas is inverted into a trough of water?
(10) Explain a test to show that ammonia is lighter than air?
(11) Which compound is required to dry ammonia gas?
(12) Why conc. Sulphuric acid is not used to dry ammonia gas ?
(13) Write two tests to show that ammonia is alkaline in nature?
(14) What happens when ammonia gas is passed through Nessler's reagent? Give equation ?
(15) What happens when ammonia gas is passed through ferric chloride solution? Give equation?
(16) Ammonia gas has rotten egg / pungent/ irritating/ sweet odour.
(17) Ammonia is sparingly / insoluble / highly soluble in water?
(18) What happens when ammonia gas is passed through copper sulphate solution in small quantities?
(19) What happens when ammonia gas is passed through copper sulphate solution in excess?
(20) Ammonia gas turns blue litmus to red / red litmus to blue?
(21) Write the uses of ammonia gas?
(22) What happens when ammonia gas is passed through phenolphthalein solution?
(23) What is the combustibility property of ammonia?
(24) Can NaOH or KOH be used in place of CaO or $Ca(OH)_2$ for preparation of ammonia?
(25) What is that compound (brown precipitate) which forms when ammonia gas is passed through nessler's reagent?

PREPARATION OF COPPER SULPHATE CRYSTAL

Experiment No:- 3

Date :- Branch :- Section :-

Name:- Regd. No.:- Marks/Grades :-

Signature of the Faculty

Aim of the Experiment :- To prepare Copper Sulphate ($CuSO_4$) crystals from Copper Carbonate ($CuCO_3$) powder.

Objectives Of The Experiment :-

On completion of this experiment, the students will be able to:

(i)Separate the water soluble components from insoluble components.

(ii) Prepare the crystals from different solutions by the process of evaporation.

(iii) Prepare the different types of solutions like unsaturated, saturated and supersaturated solution.

(iv) Perform decantation, filtration and crystallization.

Apparatus Required :-

(1) Beaker (2) Glass rod (3) Funnel (4) Filter Stand (5) Porcelain Basin (6) Tripod Stand (7) Tong (8)Wire Gauze (9) Bunsen Burner (10) Filter Paper

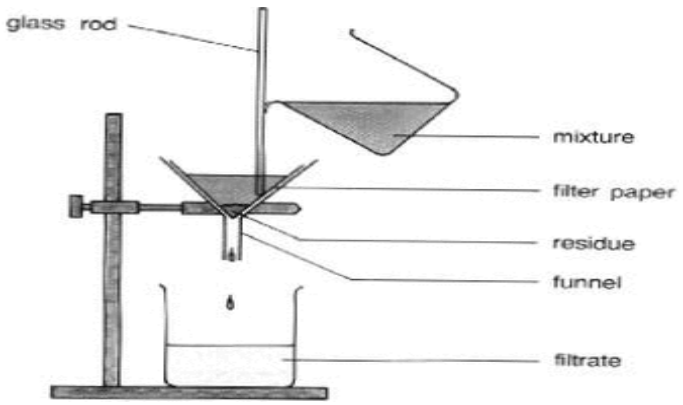
Chemicals Required :- (1) Copper Carbonate ($CuCO_3$) powder and (2) dilute Sulphuric Acid (H_2SO_4)

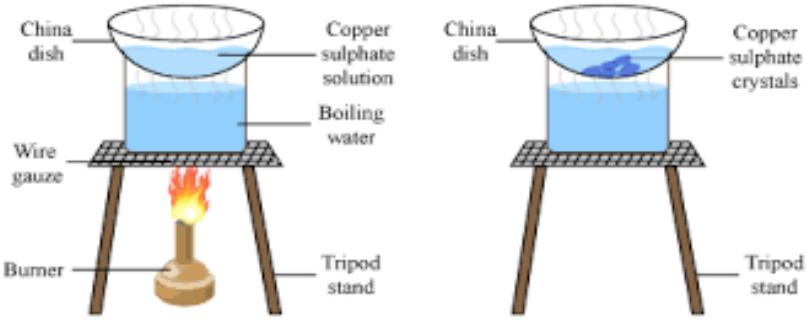
Principle :- Greenish Copper Carbonate ($CuCO_3$) powder reacts with dilute Sulphuric Acid (H_2SO_4) to form Copper Sulphate solution and liberates Carbon Dioxide (CO_2). The content is then filtered off and the filtrate is concentrated on heating (evaporation). Evaporation continues till crystallisation point reaches. Then the solution is cooled and mother liquor is decanted off to get deep blue crystals of $CuSO_4$.

Chemical Equation :-

$$CuCO_3 + H_2SO_4 \dashrightarrow CUSO_4 + H_2O + CO_2\uparrow$$

Diagram :-





Procedure :- The preparation of Copper Sulphate crystals from Copper Carbonate involves following steps.

(A) **Preparation of Saturated solution** :-

- Take about 20 ml of dilute Sulphuric acid in a beaker.
- Add supplied Copper Carbonate ($CuCO_3$) power gradually to this acid in small quantities with constant stirring.
- Continue addition of the of the powder till a small quantity of Copper Carbonate ($CuCO_3$) is left behind.
- Heat the resulting solution slightly to expel the dissolved CO_2 gas.
- Take the filter paper and four fold it.
- Prepare a cone of filter paper by taking three folds in one side and one fold in the other side.
- Take a funnel and insert the cone made by the filter paper in to it.
- Filter the solution from beaker to the porcelain basin .
- The solution must be transfered from the beaker to the filter paper cone slowly with the help of a glass rod.
- Wash the insoluble component present in the cone with the distilled water so as to make it free from soluble component.

(B) **Concentrating the Filtrate** :-

- Evaporate the filtrate in the porcelain basin with constant stirring.
- Continue the process of evaporation till a drop of the liquid solution forms crystals on the tip of glass rod when blown on it. This state is termed as **Crystallisation point**.

(C) **Crystallisation** :-

- Cool the hot solution (after reaching crystallisation point) slowly in air to start the process of crystallisation.
- If required, keep the hot porcelain basin containing the solution over a beaker full of water for quicker cooling.

(D) **Drying and Crystals** :-

- Decant off the saturated mother liquor present over the crystals after the crystallisation is over.
- Transfer the deep blue crystals present in the porcelain basin to a filter paper and spread to dry.

Precautions :-

- Minimum amount of dilute sulphuric acid (H_2SO_4) should be used to prepare the solution .
- The solution should be slightly acidic , other wise the salt may get hrdrolysed
- The solution should not be heated beyond crystallisation point.
- The concentration of solution must be carried with constant stirring
- Crystals should never be dried by heating.

Viva voice Questions :-

1. Define crystallisation.
2. Define solubility.
3. Define filtration.
4. Why the solution is not concentrated or heated to dryness during crystallisation?
5. What is decantation?
6. Decantation and filtration which is a better process and why?
7. Why the saturated solution be cooled slowly?
8. What is blue vitriol?
9. What are hydrates?
10. What are anhydrous salts?
11. What is seeding ?
12. Aqueous solution of Copper Sulphate solution acidic or basic or neutral?
13. What is efflorescence?
14. What is the colour and structure of anhydrous Copper Sulphate ?
15. Why excess H_2SO_4 acid is not used for dissolving $CuCO_3$ powder ?
16. What is crystallisation point ?
17. Define mother liquor .
18. Write the reaction between anhydrous $CuCO_3$ and dilute H_2SO_4 .
19. Why the $CuSO_4$ solution be prepared slightly acidic ?
20. Can CuO be used instead of $CuCO_3$ powder for preparation of blue vitriol? If yes, then write the reaction.
21. Write two uses of $CuSO_4.5H_2O$?
22. Mention two other salts which can be prepared by this method .
23. Why a glass rod is used to transfer the solution from beaker to the filter paper cone in the funnel?
24. How can one check the crystallisation point ?
25. How a filter paper cone be prepared?

SIMPLE ACID – BASE TITRATIONS (ACIDIMETRY)

	Experiment No:- 4	
Date :-	Branch :-	Section :-
Name:-	Regd. No.:-	Marks/Grades :-
		Signature of the Faculty

Aim of Experiment :- To determine the strength of an unknown acid solution by titrating it against a standard alkali solution of strength.....N/10.

Objectives Of The Experiment :-

On completion of this experiment, the students will be able to:

(i)Prepare solutions of different concentrations.

(ii) Perform the different type of titration by using different types indicators.

(iii) Calculate the strength of the solution.

(iv) Acquire knowledge about acidimetry, alkalimetry, standard solution, normal solution, different types of indicators.

Apparatus Required :- (1) Burette (50ml capacity), (2)Burette stand with clamp, (3) Pipette (20ml/ 10ml capacity),(4) Conical flask, (5)Glazed Porcelain tile,(6) Beakers(2nos.) , (7) Reagent Bottles (2nos.), (8) Volumetric Flask, (9) Measuring Cylinder, (10) Chemical Balance, (11) Funnel, (12) Wash Bottle

Chemicals Required :- (1) Alkali solution, (2) Standard Acid solution, (3) Indicator (methyl orange) solution.

Theory :- A known volume of the given alkali is titrated against the supplied acid of known strength using methyl orange indicator and the volume of acid required for neutralisation is determined. The strength of the given alkali is then determined from the relation

$$V_A \cdot S_A = V_B \cdot S_B$$

Where V_A = Volume of Acid Consumed,

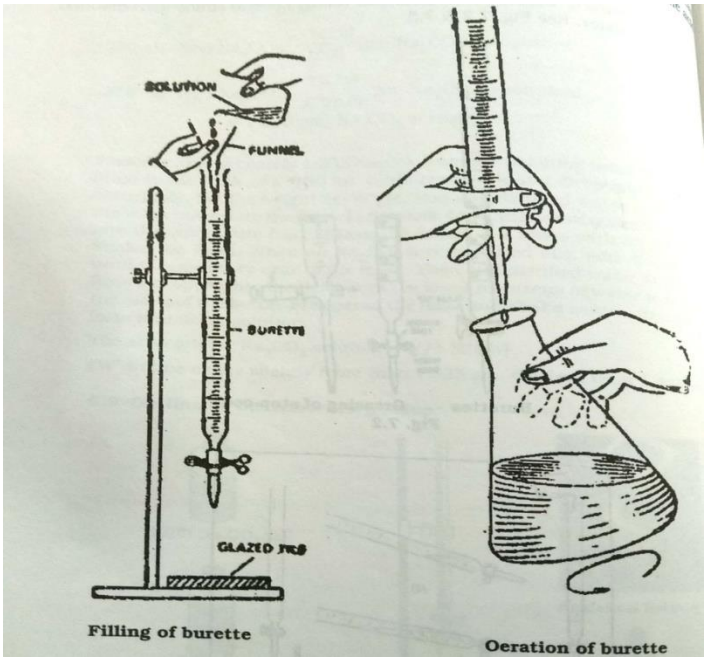
S_A = Strength of Acid Solution

V_B = Volume of Alkali solution taken

S_B = Strength of Alkali solution = ...N/10

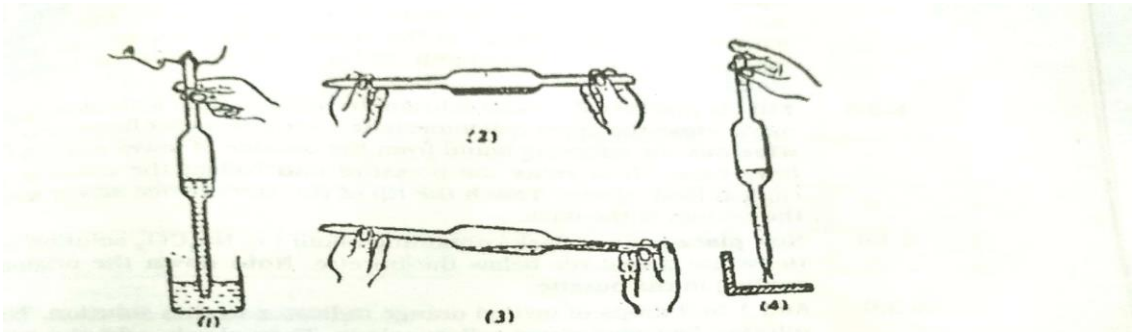
Ionic Equation :- $H_3O^+ + OH^- \dashrightarrow 2H_2O$

Diagram :-

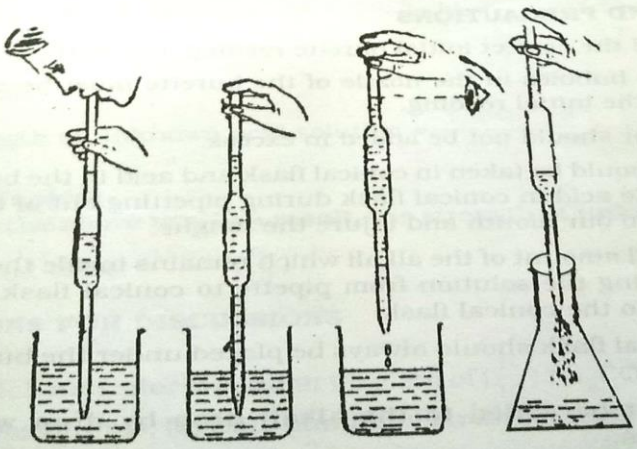


Filling of burette

Oeration of burette



Rinsing of pipette



Use of pipette

Procedure :-

- Wash the burette, pipette and conical flask thoroughly with tap water first and then rinse with distilled water for thrice.
- Now rinse the burette thrice with few ml of the acid solution and reject the washings.
- Then fill the burette with the given acid solution to a little above zero mark. Open the stop cock for a while in order to fill the jet with the acid solution and to remove the air bubbles (if any).
- Clamp the burette to the burette stand in a vertical position.
- Now, rinse the pipette with the supplied alkali solution thrice and reject the washings.
- Pipette out 10ml of the alkali solution into the conical flask.
- After transferring the alkali solution, gently touch the tip of the pipette to the inner side of the conical flask twice.
- Now, add one drop of the methyl orange indicator to the alkali solution in the conical flask.
- Keep the conical flask on the glazed porcelain tile under the burette.
- Note the initial burette reading avoiding the parallax error.
- Now, open the stop cock of the burette and run down the acid solution slowly into the conical flask with constant stirring of the contents of the conical flask.
- Continue the slow addition of the acid solution and shaking of the conical flask till the pale yellow or straw yellow colour of the solution in the conical flask just turns to light pink.
- This stage is termed as neutralisation point.
- Discontinue the addition of acid solution from burette and note the final burette reading.
- The difference between the final burette reading and initial burette reading gives the volume of acid consumed.
- Repeat the titration till three concordant readings are obtained.

Observation / Tabulation :-

Sl.No.	Volume of Alkali taken in ml	Burette Reading		Volume of Acid Consumed (F − I) in ml	Concordant Reading
		Initial (I)	Final (F)		
1	10	0.1	10.2	10.1	Rough (Example)
2	10				
3	10				
4	10				
5	10				

Calculation :-

Let, V_A = Volume of Acid Consumed, (from Table)

S_A = Strength of Acid Solution (to be calculated)

V_B = Volume of Alkali solution taken = 10 ml

S_B = Strength of Alkali solution = ...N/10 (given)

Applying normality equation, $\mathbf{V_A \cdot S_A = V_B \cdot S_B}$

$$\mathbf{S_A = V_B \times S_B / V_A}$$

Conclusion :- The strength of the given alkali solution is determined as .....N/10.

Precaution :-

(1) Air bubbles should not be present in the jet and inner walls of the burette.
(2) Correct burette reading must be taken by using anti-parallax card.
(3) Acid solution must be taken in the burette only.
(4) The conical flask should never be rinsed with the acid or alkali solution.
(5) After transferring the alkali solution into the conical flask, the remaining solution at the tip of pipette should not be blown into conical flask.
(6) Indicator solution should not added in excess.
(7) Acid solution should be added slowly with constant stirring of the contents of conical flask.

Viva- voice Questions :-

(1) What do you mean by volumetric analysis?
(2) What is titration?
(3) Define titrant and titrate?
(4) What are acidimetry and alkalimetry ?
(5) Define a standard solution?
(6) What do you mean by concentration / strength of solutions?
(7) Define an indicator?
(8) Name few indicators which are used during acid – base titration?
(9) Define gram equivalent weight and gram equivalent?
(10) What is molality and normality?
(11) 10 grams of caustic soda is how much gram equivalents?
(12) What is the principle of titration?
(13) Why rinsing is necessary?
(14) Why conical flask is not rinsed with acid or alkali?
(15) What is an anti parallax card?
(16) Why one should not hold the pipette from its bulb?
(17) Why the last drop of the solution be not blown from its bulb?
(18) Why one or two drops of indicator should always be used?
(19) Define the end point or neutralisation point?
(20) How can you detect the neutralisation point?
(21) Why mostly decinormal(N/10) solutions are used rather than normal(N) or centinormal(N/100) solutions?
(22) Which solutions are required to rinse the burette and pipette?
(23) To prepare 2 litres of solution, how much amount of sodium carbonate is required?
(24) Why presence of air bubbles is not preferred in the burette while filling the acid solution?
(25) Why stirring of conical flask and slow addition of acid is required?
(26) What are the colours of methyl orange and phenolphthalein solutions in acidic, alkali and neutral mediums?
(27) How the strength of the solution can be determined?

SIMPLE ACID – BASE TITRATIONS (ACIDIMETRY)

	Experiment No:- 4	
Date :-	Branch :-	Section :-
Name:-	Regd. No.:-	Marks/Grades :-
		Signature of the Faculty

Aim of Experiment :- To determine the strength of an unknown acid solution by titrating it against a standard alkali solution of strength.....N/10.

Objectives Of The Experiment :-

On completion of this experiment, the students will be able to:

(i)Prepare solutions of different concentrations.

(ii) Perform the different type of titration by using different types indicators.

(iii) Calculate the strength of the solution.

(iv) Acquire knowledge about acidimetry, alkalimetry, standard solution, normal solution, different types of indicators.

Apparatus Required :- (1) Burette (50ml capacity), (2)Burette stand with clamp, (3) Pipette (20ml/ 10ml capacity),(4) Conical flask, (5)Glazed Porcelain tile,(6) Beakers(2nos.) , (7) Reagent Bottles (2nos.), (8) Volumetric Flask, (9) Measuring Cylinder, (10) Chemical Balance, (11) Funnel, (12) Wash Bottle

Chemicals Required :- (1) Alkali solution, (2) Standard Acid solution, (3) Indicator (methyl orange) solution.

Theory :- A known volume of the given alkali is titrated against the supplied acid of known strength using methyl orange indicator and the volume of acid required for neutralisation is determined. The strength of the given alkali is then determined from the relation

$$V_A \cdot S_A = V_B \cdot S_B$$

Where V_A = Volume of Acid Consumed,

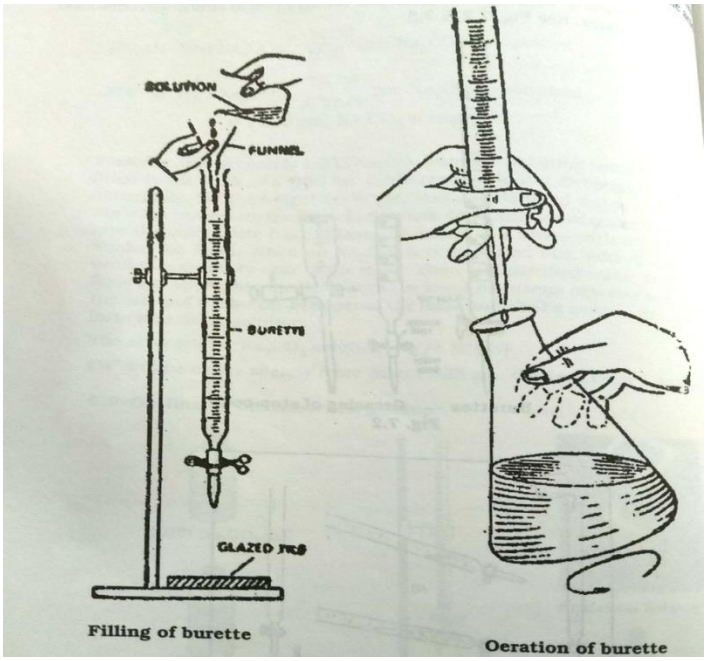
S_A = Strength of Acid Solution

V_B = Volume of Alkali solution taken

S_B = Strength of Alkali solution = ...N/10

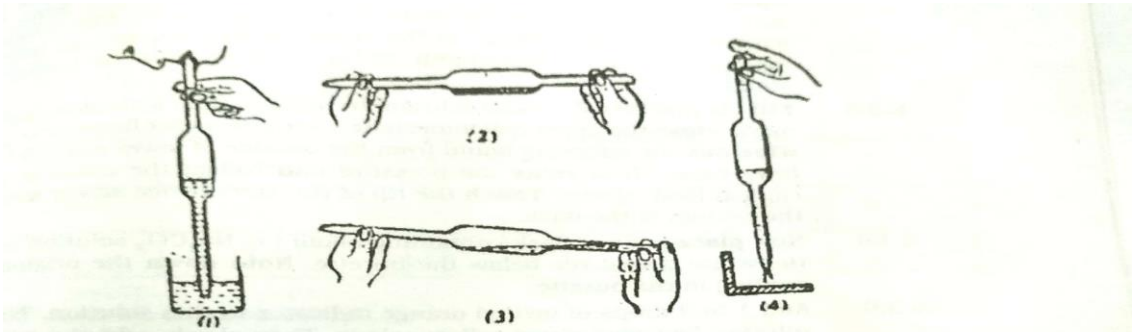
Ionic Equation :- $H_3O^+ + OH^- \dashrightarrow 2H_2O$

Diagram :-

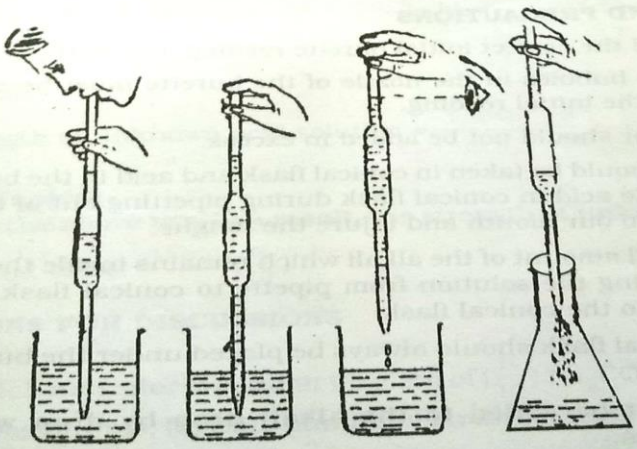


Filling of burette

Oeration of burette



Rinsing of pipette



Use of pipette

Procedure :-

- Wash the burette, pipette and conical flask thoroughly with tap water first and then rinse with distilled water for thrice.
- Now rinse the burette thrice with few ml of the acid solution and reject the washings.
- Then fill the burette with the given acid solution to a little above zero mark. Open the stop cock for a while in order to fill the jet with the acid solution and to remove the air bubbles (if any).
- Clamp the burette to the burette stand in a vertical position.
- Now, rinse the pipette with the supplied alkali solution thrice and reject the washings.
- Pipette out 10ml of the alkali solution into the conical flask.
- After transferring the alkali solution, gently touch the tip of the pipette to the inner side of the conical flask twice.
- Now, add one drop of the methyl orange indicator to the alkali solution in the conical flask.
- Keep the conical flask on the glazed porcelain tile under the burette.
- Note the initial burette reading avoiding the parallax error.
- Now, open the stop cock of the burette and run down the acid solution slowly into the conical flask with constant stirring of the contents of the conical flask.
- Continue the slow addition of the acid solution and shaking of the conical flask till the pale yellow or straw yellow colour of the solution in the conical flask just turns to light pink.
- This stage is termed as neutralisation point.
- Discontinue the addition of acid solution from burette and note the final burette reading.
- The difference between the final burette reading and initial burette reading gives the volume of acid consumed.
- Repeat the titration till three concordant readings are obtained.

Observation / Tabulation :-

Sl.No.	Volume of Alkali taken in ml	Burette Reading		Volume of Acid Consumed (F – I) in ml	Concordant Reading
		Initial (I)	Final (F)		
1	10	0.1	10.2	10.1	Rough (Example)
2	10				
3	10				
4	10				
5	10				

Calculation :-

Let, V_A = Volume of Acid Consumed, (from Table)

S_A = Strength of Acid Solution (to be calculated)

V_B = Volume of Alkali solution taken = 10 ml

S_B = Strength of Alkali solution = ...N/10 (given)

Applying normality equation, $\mathbf{V_A \cdot S_A = V_B \cdot S_B}$

$$\mathbf{S_A = V_B \times S_B / V_A}$$

Conclusion :- The strength of the given alkali solution is determined as .....N/10.

Precaution :-

(1) Air bubbles should not be present in the jet and inner walls of the burette.
(8) Correct burette reading must be taken by using anti-parallax card.
(9) Acid solution must be taken in the burette only.
(10) The conical flask should never be rinsed with the acid or alkali solution.
(11) After transferring the alkali solution into the conical flask, the remaining solution at the tip of pipette should not be blown into conical flask.
(12) Indicator solution should not added in excess.
(13) Acid solution should be added slowly with constant stirring of the contents of conical flask.

Viva- voice Questions :-

(28) What do you mean by volumetric analysis?
(29) What is titration?
(30) Define titrant and titrate?
(31) What are acidimetry and alkalimetry ?
(32) Define a standard solution?
(33) What do you mean by concentration / strength of solutions?
(34) Define an indicator?
(35) Name few indicators which are used during acid – base titration?
(36) Define gram equivalent weight and gram equivalent?
(37) What is molality and normality?
(38) 10 grams of caustic soda is how much gram equivalents?
(39) What is the principle of titration?
(40) Why rinsing is necessary?
(41) Why conical flask is not rinsed with acid or alkali?
(42) What is an anti parallax card?
(43) Why one should not hold the pipette from its bulb?
(44) Why the last drop of the solution be not blown from its bulb?
(45) Why one or two drops of indicator should always be used?
(46) Define the end point or neutralisation point?
(47) How can you detect the neutralisation point?
(48) Why mostly decinormal(N/10) solutions are used rather than normal(N) or centinormal(N/100) solutions?
(49) Which solutions are required to rinse the burette and pipette?
(50) To prepare 2 litres of solution, how much amount of sodium carbonate is required?
(51) Why presence of air bubbles is not preferred in the burette while filling the acid solution?
(52) Why stirring of conical flask and slow addition of acid is required?
(53) What are the colours of methyl orange and phenolphthalein solutions in acidic, alkali and neutral mediums?
(54) How the strength of the solution can be determined?

Test for Known Acid Radical

	Experiment No:- 6	
Date :-	Branch :-	Section :-
Name:-	Regd. No.:-	Marks/Grades :-
		Signature of the Faculty

(1) **Dry and Confirmatory Test for Acid Radicals** :-

The acid radicals are classified into three groups depending upon their reactions with certain reagents

Group	Acid Radicals	Group Reagents
I	CO_3^{-2}, SO_3^{-2}, S^{-2}, NO_2^-	Dil. HCl
II	Cl^-, Br^-, I^-, NO_3^-	Conc. H_2SO_4
III	SO_4^{-2}	Dil. HCl + $BaCl_2$
	$PO4^{-3}$	Conc. HNO_3 + Ammonium Molybdate $[(NH_4)_2MoO_4]$-

(A) **Action with dilute Hydrochloric Acid (HCl)** :-

Experiment	Observation	Inference
Take 2 ml of dil. HCl in a clean test tube and warm it. Then add a pinch of salt to it	(a)Effervescence takes place with evolution of colourless and odourless gas.	Gas may be CO_2 and radical may be carbonate (CO_3^{2-}) $CO_3^{2-} + HCl \dashrightarrow Cl^- + H_2O + CO_2\uparrow$ (perform confirmatory test)
	Or	
	(b)effervescence takes place with evolution of colourless gas having rotten egg smell	Gas may be H_2S and radical may be Sulphide (S^{2-}) $S^{2-} + 2HCl \dashrightarrow 2Cl^- + H_2S\uparrow$ (perform confirmatory test)
	or	
	(b)effervescence takes place with evolution of colourless gas having burning sulphur smell	Gas may be SO_2 and radical may be Sulphite (SO_3^{2-}) $SO_3^{2-} + 2HCl \dashrightarrow 2Cl^- + H_2O + SO_2$ (perform confirmatory test)
	or	
	Reddish brown fume having pungent odour evolves	Gas may be NO_2 and radical may be Nitrite (NO_2^-) $NO_2^- + 2HCl \dashrightarrow 2Cl^- + H_2O + NO_2$ (perform confirmatory test)
	*No effervescence takes place	*Both CO_3^{2-} and S^{2-} radicals are absent

Confirmatory Test for Carbonate (CO_3^{2-}) Radical :-

Experiment	Observation	Inference
(a)Show a glowing splinter to the above colourless and odourless gas	The glowing splinter extinguishes	The gas is CO_2 and radical is CO_3^{2-}
(b)Pass the gas through lime water first in less quantity and then excess	At first lime water turns milky which disappears on excess passage of gas	The evolved CO_2 gas turns limewater milky due to formation of insoluble $CaCO_3$ ppt. Milkyness disappears due to formation of soluble $Ca(HCO_3)_2$ $Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$ $CaCO_3 + H_2O + CO_2 \rightarrow Ca(HCO_3)_2$ Carbonate (CO_3^{2-}) radical confirmed

Confirmatory Test for Sulphide (S^{2-}) Radical :-

Experiment	Observation	Inference
Show a filter paper soaked in lead acetate solution to the above rotten egg smell gas	Lead Acetate paper turns Black	The H_2S gas turns lead acetate paper black due to formation of PbS $Pb(CH_3COO)_2 + H_2S \rightarrow 2CH_3COOH + PbS$ Sulphide (S^{2-}) Radical confirmed

(B) **Action with Conc. Sulphuric acid (H_2SO_4)** :-

Experiment	Observation	Inference
Take 1 ml of Conc. H_2SO_4 in a clean test tube and warm it. Then add a pinch of salt to it	(a)Effervescence takes place with evolution of colourless fuming gas having pungent smell	Gas may be HCl and the radical may be Cl^- $2Cl^- + H_2SO_4 \dashrightarrow SO_4^{2-} + 2HCl$
	(b) Effervescence takes place with evolution of reddish brown gas fuming in moist air	Gas may be HBr and the radical may be Br^- $2Br^- + H_2SO_4 \dashrightarrow SO_4^{2-} + 2HBr$
	(c)) Effervescence takes place with evolution of dark violet vapours which condenses at the cooler part of the test tube as black particle	Vapours may be iodine (I_2) and radical may be I^- $2I^- + H_2SO_4 \dashrightarrow SO_4^{2-} + 2HI$ $2HI + H_2SO_4 \dashrightarrow I_2 + 2H_2O + SO_2$
	(d) Effervescence takes place with evolution of brown fumes and pungent smell	Brown fumes are the NO_2 vapours, radical may be NO_3^- $NO_3^- + H_2SO_4 \dashrightarrow SO_4^{2-} + 2HNO_3$ $4HNO_3 \dashrightarrow 2H_2O + 4NO_2 + O_2$

Confirmatory Test for Chloride (Cl^-) Radical :-

Experiment	Observation	Inference
(a)Show a glass rod dipped in Conc. NH_4OH sol^n to the evolved colourless, fuming gas having pungent smell	The gas forms dense white fumes	The HCl gas forms dense white fumes with NH_4OH sol^n due to formation of NH_4Cl vapours. $NH_3 + HCl \dashrightarrow NH_4Cl$
(b)Take about 1 ml of Conc. H_2SO_4 in a test tube and add a pinch of salt to it, followed by little of MnO_2 powder and heat the content strongly.	A greenish yellow gas forms which turns starch-iodide paper to blue.	Cl_2 gas is formed by combination of MnO_2 with Conc. H_2SO_4. This Cl_2 gas reacts with KI from starch iodide to liberate iodine(I_2). $2KI + Cl_2 \dashrightarrow 2KCl + I_2$
(c)Take 2 ml of saturated salt solution. Acidify it with dil. HNO_3 and add silver nitrate ($AgNO_3$) solution to it.	A curdy white Precipitate forms	The curdy white ppt. is due to formation of AgCl $Cl^- + AgNO_3 \dashrightarrow AgCl \downarrow + NO_3^-$
(i)Divide the above curdy white ppt. In to two parts . To the first part add dil. HNO_3	The white ppt. is insoluble in HNO_3	HNO_3 can not dissolve AgCl
(ii) To the 2nd part add dilute ammonium hydroxide (dil. NH_4OH) solution.	The white ppt. is soluble in dil NH_4OH	This is due to the formation of soluble$[Ag(NH_3)_2]Cl$ complex. $AgCl + 2NH_4OH \dashrightarrow [Ag(NH_3)_2]Cl + 2H_2O$ Chloride (Cl^-) radical confirmed

Confirmatory Test for Nitrate (NO_3^-) Radical :-

Experiment	Observation	Inference
(a)Take 1 ml of 50% conc. H_2SO_4 in a clean test tube. Add few pieces of copper turnings and little salt to it. Then heat it gently.	Copious evolution of deep brown vapours occur and the resulting solution in the test tube turns blue / green. $3Cu + 8HNO_3 \dashrightarrow$	Brown fumes are the NO_2 vapours and blue colour is due to formation of $Cu(NO_3)_2$ $3\,Cu(NO_3)_2 + 2NO + 4H_2O$ $2NO \dashrightarrow 2NO_2\uparrow$
(b)Show a filter paper soaked in freshly prepared $FeSO_4$ solution to evolved brown vapours	The filter paper turns black/ brown	This is due to the formation of $[Fe(NO)]SO_4$ complex
(c)Take 1ml of saturated salt solution in a test tube. Then add equal volume (1ml) of Conc. H_2SO_4 to it. Cool the test tube under running tap water. Then add freshly prepared $FeSO_4$ solution to it carefully through the side of test tube	A deep and thin brown ring forms at the junction of two liquid layers. The ring disappears on shaking. $6FeSO_4 + 2HNO_3 + 3H_2SO_4 \dashrightarrow$	This is due to the formation of $[Fe(NO)]SO_4$ complex $NO_3^- + H_2SO_4 \dashrightarrow KHSO_4 + HNO_3$ $3Fe_2(SO_4)_3 + 2NO + 4H_2O$ $FeSO_4 + NO \dashrightarrow [Fe(NO)]SO_4$ Nitrate (NO_3^-) radical confirmed

Confirmatory Test for Sulphate (SO_4^{2-}) Radical :- (Action of Dil. HCl and $BaCl_2$)

Experiment	Observation	Inference
Take 1 ml of salt solution in a clean test tube and acidify it with dil. HCl. Then add Barium Chloride ($BaCl_2$) to it.	A white precipitate forms which is insoluble in Conc. HCl even on boiling.	The white precipitate is barium sulphate ($BaSO_4$) $SO_4^{2-} + BaCl_2 \dashrightarrow BaSO_4 + 2Cl^-$ Sulphate(SO_4^{2-}) radical confirmed.

TEST FOR KNOWN BASIC RADICAL

	Experiment No:- 7	
Date :-	Branch :-	Section :-
Name:-	Regd. No.:-	Marks/Grades :-
		Signature of the Faculty

(A)Heating in a Dry Test Tube :-

Experiment	Observation	inference
Take a pinch of salt in a clean and dry test tube. Heat it for 3 to 4 minutes or until no further change takes place.	(i)**The salt changes its colour**	
	(a) yellow when hot and white when cold	Zn salts
	(b) black on heating	Cu, Mn, Ni salts
	(c) blue on heating	Co salts
	(d) Brown when hot and cold	Cd salts
	(e)reddish brown when hot and yellow when cold	Pb or Bi salts
	(ii)**The salts decrepitates** (produces cracking sound)	Crystalline salts of alkali or alkaline earth metals
	(iii)**the salt melts on heating and solidifies on cooling**	salts of alkali or alkaline earth metals
	(iv) **the salt volatilises out completely forming a white sublimate**	Ammonium, arsenic or mercury salts
	(v)a gas or vapour is given out	
	(a) water vapours condense at cooler part of test tube.	Salts having water of crystallisation
	(b)a colourless and odourless gas which turns lime water milky	Salts of carbonates or bicarbonates
	(c)a reddish brown gas which turns a filter paper dipped in $FeSO_4$ Solution to black	Nitrates or nitrites of heavy metals
	(d)a colourless and pungent smelling gas Which turns red litmus paper to blue	Certain Ammonium salts
	(e)a colourless and odourless gas which forms which rekindles a glowing splinter	Nitrates of Na or K
	(f) a colourless gas with burning sulphur smell forms.	Sulphate or sulphite salts
	(g) a colourless gas with irritating smell which Fumes in moist air forms.	Hydrated chloride salts
	(h) a colourless gas with rotten egg smell forms	Hydrated sulphides
	(i) greenish yellow gas with irritating smell forms	Unstable chlorides
	(j) reddish brown gas with irritating smell forms	Unstable bromides
	(k) dark violet vapours form	Certain iodides

(B)Charcoal Cavity Heating :-

Experiment	Observation	inference
Take a small quantity of the salt in a charcoal cavity and heat it strongly in oxidising flame with the help of a blow pipe.	(a)Salt produces cracking sound (decrepitates)	Crystalline salts of alkali metal like Na, K
	(b)salt volatilises out completely forming white fumes.	Volatile salts like ammonium arsenic, mercury, etc.(perform sodalime test and bulb tube test).
	(c)salt deflagrates (suddenly catches fire and burns vigorously)	Nitrates or nitrites
	(d)salt melts and sinks into the charcoal cavity on heating and reappears on cooling	Alkali or alkaline earth metals (flame test to be performed)
	(d)the salt may or may not melt, but (i) leaves a white a white infusible and incandescent residue	Aluminium, magnesium salts
	(ii) salt becomes yellow when hot and white when cold	Zinc salt (perform cobalt nitrate test)
	(e)The original salt is coloured and leaves coloured residue in the cavity after heating.	Co, Cr, Cu, Fe, Ni, Mn etc salts
	(f)original salt is white and leaves coloured residue after heating Or Salt melts at first and finally leaves an infusible residue with incrustation around the cavity.	Pb, Bi, Sb, Ag, Sn, Cu, etc salts

(C)Cobalt Nitrate Test :-

Experiment	Observation	inference
Heat a pinch of salt in the charcoal cavity in oxidising flame with the help of blow pipe till an infusible and incandescent residue is obtained . Then moisten the residue with a drop of cobalt nitrate sol^{n} and heat again in oxidising flame and note the colour of residue	(i) Blue (ii) Green (iii) Light pink (iv) Dirty green (v) Grey	Al salt Zn salt Mg Salt Sn salt Ca, Ba or Sr salts

(DFlame Test :-

Experiment	Observation		inference
	Colour of flame through naked eye	**Colour of flame through double blue glass**	
Clean a platinum wire (fixed in a glass rod) by repeatedly heating it in a non-luminous flame of Bunsen burner and at once dipping it in Conc. HCl taken on a watch glass. Continue heating till it imparts no colour to the flame . Moisten the platinum wire with Conc. HCl and touch it with a little of the salt. Now, heat it in the non-luminous flame and note the colour of the flame both in naked eye and through double blue glass.	(i)Persistent golden yellow (ii) Violet (iii) Brick red (iv)Crimson red (v)Yellowish green (vi)Bluish green	Colourless Crimson red Light green Crimson red Bluish green Bluish green	Na Salts K Salts Ca Salts Sr Salts Ba Salts Cu Salts

Wet / Confirmatory Test for Basic Radicals

Experiment No:- 8

Date :- Branch :- Section :-

Name:- Regd. No.:- Marks/Grades :-

Signature of the Faculty

(Separation in to Groups)

Add dilute HCl to salt solution or prepare salt solution with dilute HCl and filter

<table>
<tr><td>Residue-1</td><td colspan="5">Filtrate - 1</td></tr>
<tr><td rowspan="6">No Residue
(Radicals Like
Pb^{2+}, Hg_2^{2+},Ag^+
are absent)</td><td colspan="5">Warm the filtrate and then pass H_2S gas till complete precipitation and then filter</td></tr>
<tr><td>Residue - 2</td><td colspan="4">Filtrate -2</td></tr>
<tr><td rowspan="4">No Residue
(Radicals like Hg^{2+}, Cu^{2+},Bi^{3+},Cd^{2+},As^{3+}, Sb^{3+},Sn^{2+}
are absent)</td><td colspan="4">Warm the filtrate slightly. Then saturate it with solid NH_4Cl followed by dilute NH_4OH solution and then filter</td></tr>
<tr><td>Residue -3</td><td colspan="3">Filtrate -3</td></tr>
<tr><td rowspan="3">No Residue
(Radicals like Al^{3+}, Fe^{3+} and Cr^{3+} are Absent)</td><td colspan="3">Warm the filtrate slightly and then pass H_2S gas till complete precipitation and filter</td></tr>
<tr><td>Residue -4</td><td colspan="2">Filtrate -4</td></tr>
<tr><td>No Residue
Radicals likeCo^{2+}, Ni^{2+} ,Zn^{2+}, Mn^{2+}
are absent)</td><td colspan="2">Saturate the filtrate with $(NH_4)_2CO_3$ Solution followed by solid NH_4Cl and dilute NH_4OH and filter.</td></tr>
<tr><td colspan="3"></td><td>Residue -5</td><td>Filtrate -5</td></tr>
<tr><td colspan="3"></td><td>No Residue
(Radicals like
Ba^{2+},Sr^{2+}, Ca^{2+}
Are absent)</td><td>Group V radicals like
Na^+, K^+, Mg^{2+}, NH_4^+
are present.
(Do individual tests)</td></tr>
</table>

Confirmatory Test for Copper (II) Radical :- (Cu^{2+} Radical) :-

Experiment	Observation	Inference
(a)Take 2 ml of salt solution in a test tube. Add 1 ml of dil. HCl to it and warm slightly. Then pass H_2S gas through the solution.	Black precipitate forms	The black ppt. is due to formation of CuS. Cu^{2+} Radical confirmed
(b)Add dilute NH_4OH drop wise to 1 ml of salt solution and then in excess.	At first a bluish white ppt. forms which turns to deep blue coloration with excess NH_4OH solution.	Bluish white ppt is due to formation of $CuSO_4$. $Cu(OH)_2$ complex. Deep blue coloration is due to formation of $[Cu(NH_3)_2]SO_4$
(c)Add potassium ferrocyanide $K_4[Fe(CN)_6]$ solution to 1 ml of salt solution.	A brown ppt. of cupric ferrocyanide Forms	Cu^{2+} Radical confirmed
(d)Add potassium iodide solution to 1 ml of salt solution.	A white ppt of Cu_2I_2 forms with liberation of Iodine gas.	Cu^{2+} Radical confirmed

Confirmatory Test for Aluminium (Al^{3+}) Radical :-

Experiment	Observation	Inference
(a)Take 1ml of salt solution in a test tube. Add solid NH_4Cl to it till saturation followed by dilute NH_4OH solution till alkaline. Then add dilute NaOH solution first dropwise and then in excess.	A white ppt. first forms which dissolves in excess dilute NaOH.	White ppt. is due to formation of $Al(OH)_3$ which dissolves with excess NaOH due to formation of $NaAlO_2$ $Al^{3+} + 3NaOH \rightarrow Al(OH)_3\downarrow + 3Na^+$ $Al(OH)_3 + NaOH \rightarrow NaAlO_2 + 2H_2O$ Al^{3+} Radical confirmed.
(b)take 1 ml salt solution in a test tube and add disodium hydrogen phosphate (Na_2HPO_4) solution to it.	A gelatinous white ppt. ($AlPO_4$) forms which is soluble in dilute mineral acids	Gelatinous white ppt. is due to formation of $AlPO_4$ with dilute mineral acids corresponding Al salts are formed $Al^{3+} + 2Na_2HPO_4 \rightarrow AlPO_4 + NaH_2PO_4 + 3Na^+$ $2\ AlPO_4 + 3H_2SO_4 \rightarrow Al_2(SO_4)_3 + 2H_3PO_4$ Al^{3+} Radical confirmed.

Confirmatory Test for Zinc (Zn^{2+} Radical) :-

Experiment	Observation	Inference
(a)Take 1 ml of salt solution in a test tube . Add solid NH_4Cl to it till saturation followed by dilute NH_4OH solution till alkaline. Pass H_2S gas through it.	White ppt. forms	White ppt. is due to formation of ZnS. $Zn^{2+} + H_2S \dashrightarrow ZnS\downarrow + H^+$ Zn^{2+} Radical confirmed.
(b)Take 1 ml of salt solution in a test tube . Then add potassium ferrocyanide solution drop by drop.	White ppt. forms	White ppt. is due to formation of $Zn_2[Fe(CN)_6]$ Zinc ferrocyanide. $Zn^{2+} + K_4[Fe(CN)_6] \rightarrow Zn_2[Fe(CN)_6]\downarrow + K^+$ Zn^{2+} Radical confirmed.
(c) Take 1 ml of salt solution in a test tube . Then adddil. NaOH solution drop by drop and then excess.	Gelatinous white ppt. is obtained which is soluble in excess NaOH solution.	Gelatinous white ppt. is due to formation of $Zn(OH)_2$ which forms Na_2ZnO_2 (sodium zincate)with excess of NaOH. $Zn^{2+} + 2NaOH \rightarrow Zn(OH)_2\downarrow + 2\ Na^+$ $Zn(OH)_2 + 2NaOH \rightarrow Na_2ZnO_2 + 2H_2O$ Zn^{2+} Radical confirmed.

Confirmatory Test for Calcium (Ca^{2+} Radical) :-

Experiment	Observation	Inference
(a)Take 1 ml of salt solution in a test tube. Add solid NH_4Cl to it till saturation followed by dilute NH_4OH solution till alkaline. Then add saturated solution of ammonium carbonate $(NH_4)_2CO_3$.	A white ppt. forms.	The white ppt. is due to formation of calcium carbonate($CaCO_3$). $Ca^{2+} + (NH_4)_2CO_3 \rightarrow CaCO_3\downarrow + 2NH_4^+$ Ca^{2+} radical is confirmed.

(b)Dissolve the above white ppt. in a minimum amount of dil. acetic acid (CH_3COOH). Boil to expel CO2 gas and then add $(NH_4)_2C_2O_4$ (ammonium oxalate) solution to it.	A white ppt. forms. Which is soluble in mineral acids but insoluble in dil. CH_3COOH. $CaCO_3 + 2CH_3COOH \rightarrow$ $Ca(CH_3COO)_2 + (NH_4)_2C_2O_4 \rightarrow$	The white ppt. is due to formation of calcium oxalate(CaC_2O_4). $Ca(CH_3COO)_2 + CO_2 + H_2O$ $CaC_2O_4 + 2CH_3COONH_4$ Ca^{2+} radical is confirmed.

Confirmatory Test for Magnesium (Mg^{2+} Radical) :-

Experiment	Observation	Inference
(a)Take 1 ml of salt solution in a test tube. Add solid NH_4Cl to it till saturation followed by dilute NH_4OH solution till alkaline. Then add disodium hydrogen phosphate (Na_2HPO_4) solution to it.	A white ppt. forms $Mg^{2+} + NH_4OH + Na_2HPO_4 \text{ ----}\rightarrow$	White ppt. is due to formation of magnesium ammonium phosphate. $Mg(NH_4)PO_4 + 2Na^+ + H_2O$ Mg^{2+} radical is confirmed.
(b) Take 1 ml of salt solution in a test tube. Add 1ml of dil. HCl. Then add few drops of Magneson reagent followed by addition of dil. NaOH solution in excess.	A blue ppt. forms	Magneson reagent (p-nitro benzene azo resorcinol) reacts with NaOH to form blue coloured ppt. Mg^{2+} radical is confirmed.

Confirmatory Test for Ammonium (NH_4^+ Radical) :-

Experiment	Observation	Inference
(a)Take 1 ml of salt solution in a test tube. Add 1ml of dil. NaOH solution to it and boil.	Ammonia (NH_3) gas evolves	NaOH forms ammonia (NH_3) gas with ammonium salt. $NH_4^+ + NaOH \rightarrow NaNO_3 + NH_3\uparrow + H_2O$ NH_4^+ radical is confirmed.
(b)Show a glass rod dipped in conc HCl to the above gas.	Dense white fumes formed	Dense white fumes are due to formation of vapours of NH_4Cl. $NH_3 + HCl \rightarrow NH_4Cl$ NH_4^+ radical is confirmed
(c)Take 1 ml of salt solution in a test tube. Add 1ml of Nessler's reagent.	A brown ppt. forms	Brown ppt. is due to formation of iodide of Millon's base [H2N-HgO-HgI]. NH_4^+ radical is confirmed

Confirmatory Test for Sodium (Na^+ Radical) :-

Experiment	Observation	Inference
Take 2 ml of salt solution in a clean test tube. Add 1 ml of potassium pyroantimonate solution to it..	A white crystalline ppt. forms.	White ppt. is due to the formation of sodium pyroantimonate. $Na^+ + K_2H_2Sb_2O_7 \rightarrow Na_2H_2Sb_2O_7 + K^+$ Na^+ radical is confirmed

Confirmatory Test for Potassium (K^+ Radical) :-

Experiment	Observation	Inference
Take 1ml of salt solution in a clean test tube. Add 6 to 7 drops of cobalt nitrate{$Co(NO_3)_2$] solution followed by sodium nitrate($NaNO_3$) and dil. Acetic acid (CH_3COOH)	A Yellow PPt. forms	Yellow ppt. is due to the formation of sodium cobaltic nitrite. K^+ radical is confirmed

Test For Unknown Acid Radicals

	Experiment No:- 9	
Date :-	Branch :-	Section :-
Name:-	Regd. No.:-	Marks/Grades :-
		Signature of the Faculty

(**A)Study of Physical Properties** :-

(a) Colour of the salt :-
(b) Structure of the salt :- Crystalline / amorphous
(c) Solubility :- (i) cold water :-
(ii) Hot water :-
(iii) Dil. HCl :-
(iv) Conc. HCl :-
(v) Conc. H_2SO_4 :-
(vi) Aqua Regia :-

(If the salt is soluble in any step then next steps should not be tested)

Dry and Confirmatory Test for Acid Radicals :-

The acid radicals are classified into three groups depending upon their reactions with certain reagents

Group	Acid Radicals	Group Reagents
I	CO_3^{-2}, SO_3^{-2}, S^{-2}, NO_2^-	Dil. HCl
II	Cl^-, Br^-, I^-, NO_3^-	Conc. H_2SO_4
III	SO_4^{-2}	Dil. HCl + $BaCl_2$
	$PO4^{-3}$	Conc. HNO_3 + Ammonium Molybdate [$(NH_4)_2MoO_4$]

(A) Action with dilute Hydrochloric Acid (HCl) :-

Experiment	Observation	Inference
Take 2 ml of dil. HCl in a clean test tube and warm it. Then add a pinch of salt to it	(a)Effervescence takes place with evolution of colourless and odourless gas. Or (b)effervescence takes place with evolution of colourless gas having rotten egg smell *No effervescence takes place	Gas may be CO_2 and radical may be carbonate (CO_3^{2-}) CO_3^{2-} + HCl ---→ Cl^- +H_2O +CO_2↑ (perform confirmatory test) Gas may be H_2S and radical may be Sulphide (S^{2-}) S^{2-} + 2HCl ---→ $2Cl^-$ + H_2S↑ (perform confirmatory test) *Both CO_3^{2-} and S^{2-} radicals are absent

Confirmatory Test for Carbonate (CO_3^{2-}) Radical :-

Experiment	Observation	Inference
(a)Show a glowing splinter to the above colourless and odourless gas	The glowing splinter extinguishes	The gas is CO_2 and radical is CO_3^{2-}
(b)Pass the gas through lime water first in less quantity and then excess	At first lime water turns milky which disappears on excess passage of gas	The evolved CO_2 gas turns limewater milky due to formation of insoluble $CaCO_3$ ppt. Milkyness disappears due to formation of soluble $Ca(HCO_3)_2$ $Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$ $CaCO_3 + H_2O + CO_2 \rightarrow Ca(HCO_3)_2$ Carbonate (CO_3^{2-}) radical confirmed

Confirmatory Test for Sulphide (S^{2-}) Radical :-

Experiment	Observation	Inference
Show a filter paper soaked in lead acetate solution to the above rotten egg smell gas	Lead Acetate paper turns Black	The H_2S gas turns lead acetate paper black due to formation of PbS $Pb(CH_3COO)_2 + H_2S \rightarrow 2CH_3COOH + PbS$ Sulphide (S^{2-}) Radical confirmed

(B) Action with Conc. Sulphuric acid (H_2SO_4) :-

Experiment	Observation	Inference
Take 1 ml of Conc. H_2SO_4 in a clean test tube and warm it. Then add a pinch of salt to it	(a)Effervescence takes place with evolution of colourless fuming gas having pungent smell	Gas may be HCl and the radical may be Cl^- $2Cl^- + H_2SO_4 \dashrightarrow SO_4^{2-} + 2HCl$
	(b) Effervescence takes place with evolution of reddish brown gas fuming in moist air	Gas may be HBr and the radical may be Br^- $2Br^- + H_2SO_4 \dashrightarrow SO_4^{2-} + 2HBr$
	(c)) Effervescence takes place with evolution of dark violet vapours which condenses at the cooler part of the test tube as black particle	Vapours may be iodine (I_2) and radical may be I^- $2I^- + H_2SO_4 \dashrightarrow SO_4^{2-} + 2HI$ $2HI + H_2SO_4 \dashrightarrow I_2 + 2H_2O + SO_2$
	(d) Effervescence takes place with evolution of brown fumes and pungent smell	Brown fumes are the NO_2 vapours, radical may be NO_3^- $NO_3^- + H_2SO_4 \dashrightarrow SO_4^{2-} + 2HNO_3$ $4HNO_3 \dashrightarrow 2H_2O + 4NO_2 + O_2$

Confirmatory Test for Chloride (Cl^-) Radical :-

Experiment	Observation	Inference
(a)Show a glass rod dipped in Conc. NH_4OH sol^n to the evolved colourless, fuming gas having pungent smell	The gas forms dense white fumes	The HCl gas forms dense white fumes with NH_4OH sol^n due to formation of NH_4Cl vapours. $NH_3 + HCl \dashrightarrow NH_4Cl$
(b)Take about 1 ml of Conc. H_2SO_4 in a test tube and add a pinch of salt to it, followed by little of MnO_2 powder and heat the content strongly.	A greenish yellow gas forms which turns starch-iodide paper to blue.	Cl_2 gas is formed by combination of MnO_2 with Conc. H_2SO_4. This Cl_2 gas reacts with KI from starch iodide to liberate iodine(I_2). $2KI + Cl_2 \dashrightarrow 2KCl + I_2$
(c)Take 2 ml of saturated salt solution. Acidify it with dil. HNO_3 and add silver nitrate ($AgNO_3$) solution to it.	A curdy white Precipitate forms	The curdy white ppt. is due to formation of AgCl $Cl^- + AgNO_3 \dashrightarrow AgCl \downarrow + NO_3^-$
(i)Divide the above curdy white ppt. In to two parts . To the first part add dil. HNO_3	The white ppt. is insoluble in HNO_3	HNO_3 can not dissolve AgCl
(ii) To the 2nd part add dilute ammonium hydroxide (dil. NH_4OH) solution.	The white ppt. is soluble in dil NH_4OH	This is due to the formation of soluble$[Ag(NH_3)_2]Cl$ complex. $AgCl + 2NH_4OH \dashrightarrow [Ag(NH_3)_2]Cl + 2H_2O$ Chloride (Cl^-) radical confirmed

Confirmatory Test for Nitrate (NO_3^-) Radical :-

Experiment	Observation	Inference
(a)Take 1 ml of 50% conc. H_2SO_4 in a clean test tube. Add few pieces of copper turnings and little salt to it. Then heat it gently.	Copious evolution of deep brown vapours occur and the resulting solution in the test tube turns blue / green. $3Cu + 8HNO_3 \dashrightarrow$	Brown fumes are the NO_2 vapours and blue colour is due to formation of $Cu(NO_3)_2$ $3\,Cu(NO_3)_2 + 2NO + 4H_2O$ $2NO \dashrightarrow 2NO_2\uparrow$
(b)Show a filter paper soaked in freshly prepared $FeSO_4$ solution to evolved brown vapours	The filter paper turns black/ brown	This is due to the formation of $[Fe(NO)]SO_4$ complex
(c)Take 1ml of saturated salt solution in a test tube. Then add equal volume (1ml) of Conc. H_2SO_4 to it. Cool the test tube under running tap water. Then add freshly prepared $FeSO_4$ solution to it carefully through the side of test tube	A deep and thin brown ring forms at the junction of two liquid layers. The ring disappears on shaking. $6FeSO_4 + 2HNO_3 + 3H_2SO_4 \dashrightarrow$	This is due to the formation of $[Fe(NO)]SO_4$ complex $NO_3^- + H_2SO_4 \dashrightarrow KHSO_4 + HNO_3$ $3Fe_2(SO_4)_3 + 2NO + 4H_2O$ $FeSO_4 + NO \dashrightarrow [Fe(NO)]SO_4$ Nitrate (NO_3^-) radical confirmed

Confirmatory Test for Sulphate (SO_4^{2-}) Radical :- (Action of Dil. HCl and $BaCl_2$)

Experiment	Observation	Inference
Take 1 ml of salt solution in a clean test tube and acidify it with dil. HCl. Then add Barium Chloride ($BaCl_2$) to it.	A white precipitate forms which is insoluble in Conc. HCl even on boiling.	The white precipitate is barium sulphate ($BaSO_4$) $SO_4^{2-} + BaCl_2 \dashrightarrow BaSO_4 + 2Cl^-$ Sulphate(SO_4^{2-}) radical confirmed.

Test For Unknown Basic Radicals

	Experiment No:- 10	
Date :-	Branch :-	Section :-
Name:-	Regd. No.:-	Marks/Grades :-
		Signature of the Faculty

(C)**Study of Physical Properties** :-

(d) Colour of the salt :-

(e) Structure of the salt :- Crystalline / amorphous

(f) Solubility :- (i) cold water :-

(ii) Hot water :-

(iii) Dil. HCl :-

(iv) Conc. HCl :-

(v) Conc. H_2SO_4 :-

(vi) Aqua Regia :-

(If the salt is soluble in any step then next steps should not be tested)

(A)Heating in a Dry Test Tube :-

Experiment	Observation	inference
Take a pinch of salt in a clean and dry test tube. Heat it for 3 to 4 minutes or until no further change takes place.	(i)**The salt changes its colour** (a) yellow when hot and white when cold (b) black on heating (c) blue on heating (d) Brown when hot and cold (e)reddish brown when hot and yellow when cold	 Zn salts Cu, Mn, Ni salts Co salts Cd salts Pb or Bi salts
	(ii)**The salts decrepitates** (produces cracking sound)	Crystalline salts of alkali or alkaline earth metals
	(iii)**the salt melts on heating and solidifies on cooling**	salts of alkali or alkaline earth metals
	(iv) **the salt volatilises out completely forming a white sublimate**	Ammonium, arsenic or mercury salts
	(v)a gas or vapour is given out (a) water vapours condense at cooler part of test tube. (b)a colourless and odourless gas which turns lime water milky (c)a reddish brown gas which turns a filter paper dipped in $FeSO_4$ Solution to black (d)a colourless and pungent smelling gas Which turns red litmus paper to blue	 Salts having water of crystallisation Salts of carbonates or bicarbonates Nitrates or nitrites of heavy metals Certain Ammonium salts

	(e)a colourless and odourless gas which forms which rekindles a glowing splinter	Nitrates of Na or K
	(f) a colourless gas with burning sulphur smell forms.	Sulphate or sulphite salts
	(g) a colourless gas with irritating smell which Fumes in moist air forms.	Hydrated chloride salts
	(h) a colourless gas with rotten egg smell forms	Hydrated sulphides
	(i) greenish yellow gas with irritating smell forms	Unstable chlorides
	(j) reddish brown gas with irritating smell forms	Unstable bromides
	(k) dark violet vapours form	Certain iodides

(B)Charcoal Cavity Heating :-

Experiment	Observation	inference
Take a small quantity of the salt in a charcoal cavity and heat it strongly in oxidising flame with the help of a blow pipe.	(a)Salt produces cracking sound (decrepitates)	Crystalline salts of alkali metal like Na, K
	(b)salt volatilises out completely forming white fumes.	Volatile salts like ammonium arsenic, mercury, etc.(perform sodalime test and bulb tube test).
	(c)salt deflagrates (suddenly catches fire and burns vigorously)	Nitrates or nitrites
	(d)salt melts and sinks into the charcoal cavity on heating and reappears on cooling	Alkali or alkaline earth metals (flame test to be performed)
	(d)the salt may or may not melt, but (i) leaves a white a white infusible and incandescent residue	Aluminium, magnesium salts
	(ii) salt becomes yellow when hot and white when cold	Zinc salt (perform cobalt nitrate test)
	(e)The original salt is coloured and leaves coloured residue in the cavity after heating.	Co, Cr, Cu, Fe, Ni, Mn etc salts
	(f)original salt is white and leaves coloured residue after heating Or Salt melts at first and finally leaves an infusible residue with incrustation around the cavity.	Pb, Bi, Sb, Ag, Sn, Cu, etc salts

(C)Cobalt Nitrate Test :-

Experiment	Observation		inference
Heat a pinch of salt in the charcoal cavity in oxidising flame with the help of blow pipe till an infusible and incandescent residue is obtained . Then moisten the residue with a drop of cobalt nitrate sol^{n} and heat again in oxidising flame and note the colour of residue	(i)	Blue	Al salt
	(ii)	Green	Zn salt
	(iii)	Light pink	Mg Salt
	(iv)	Dirty green	Sn salt
	(v)	Grey	Ca, Ba or Sr salts

(DFlame Test :-

Experiment	Observation		inference
	Colour of flame through naked eye	**Colour of flame through double blue glass**	
Clean a platinum wire (fixed in a glass rod) by repeatedly heating it in a non-luminous flame of Bunsen burner and at once dipping it in Conc. HCl taken on a watch glass. Continue heating till it imparts no colour to the flame . Moisten the platinum wire with Conc. HCl and touch it with a little of the salt. Now, heat it in the non-luminous flame and note the colour of the flame both in naked eye and through double blue glass.	(i)Persistent golden yellow (ii) Violet (iii) Brick red (iv)Crimson red (v)Yellowish green (vi)Bluish green	Colourless Crimson red Light green Crimson red Bluish green Bluish green	Na Salts K Salts Ca Salts Sr Salts Ba Salts Cu Salts

(Since white salts will be given to students then there is no need to perform Borax –Bead test, Charcoal Reduction Test, Sodalime Test and Bulb Tube Test.)

Wet / Confirmatory Test for Basic Radicals :-

(Separation in to Groups)

Add dilute HCl to salt solution or prepare salt solution with dilute HCl and filter

<table>
<tr><td>Residue-1</td><td colspan="5">Filtrate - 1</td></tr>
<tr><td rowspan="9">No Residue (Radicals Like Pb^{2+}, Hg_2^{2+},Ag^{+} are absent)</td><td colspan="5">Warm the filtrate and then pass H_2S gas till complete precipitation and then filter</td></tr>
<tr><td>Residue - 2</td><td colspan="4">Filtrate -2</td></tr>
<tr><td rowspan="8">No Residue (Radicals like Hg^{2+}, Cu^{2+},Bi^{3+},Cd^{2+},As^{3+}, Sb^{3+},Sn^{2+} are absent)</td><td colspan="4">Warm the filtrate slightly. Then saturate it with solid NH_4Cl followed by dilute NH_4OH solution and then filter</td></tr>
<tr><td>Residue -3</td><td colspan="3">Filtrate -3</td></tr>
<tr><td rowspan="7">No Residue (Radicals like Al^{3+}, Fe^{3+} and Cr^{3+} are Absent)</td><td colspan="3">Warm the filtrate slightly and then pass H_2S gas till complete precipitation and filter</td></tr>
<tr><td>Residue -4</td><td colspan="2">Filtrate -4</td></tr>
<tr><td rowspan="5">No Residue Radicals likeCo^{2+}, Ni^{2+} ,Zn^{2+}, Mn^{2+} are absent)</td><td colspan="2">Saturate the filtrate with $(NH_4)_2CO_3$ Solution followed by solid NH_4Cl and dilute NH_4OH and filter.</td></tr>
<tr><td>Residue -5</td><td>Filtrate -5</td></tr>
<tr><td rowspan="4">No Residue (Radicals like Ba^{2+},Sr^{2+}, Ca^{2+} Are absent)</td><td rowspan="4">Group V radicals like Na^{+}, K^{+}, Mg^{2+}, NH_4^{+} are present. (Do individual tests)</td></tr>
</table>

Confirmatory Test for Copper (II) Radical :- (Cu^{2+} Radical) :-

Experiment	Observation	Inference
(a)Take 2 ml of salt solution in a test tube. Add 1 ml of dil. HCl to it and warm slightly. Then pass H_2S gas through the solution.	Black precipitate forms	The black ppt. is due to formation of CuS. Cu^{2+} Radical confirmed
(b)Add dilute NH_4OH drop wise to 1 ml of salt solution and then in excess.	At first a bluish white ppt. forms which turns to deep blue coloration with excess NH_4OH solution.	Bluish white ppt is due to formation of $CuSO_4$. $Cu(OH)_2$ complex. Deep blue coloration is due to formation of $[Cu(NH_3)_2]SO_4$
(c)Add potassium ferrocyanide $K_4[Fe(CN)_6]$ solution to 1 ml of salt solution.	A brown ppt. of cupric ferrocyanide Forms	Cu^{2+} Radical confirmed
(d)Add potassium iodide solution to 1 ml of salt solution.	A white ppt of Cu_2I_2 forms with liberation of Iodine gas.	Cu^{2+} Radical confirmed

Confirmatory Test for Aluminium (Al^{3+}) Radical :-

Experiment	Observation	Inference
(a)Take 1ml of salt solution in a test tube. Add solid NH_4Cl to it till saturation followed by dilute NH_4OH solution till alkaline. Then add dilute NaOH solution first dropwise and then in excess.	A white ppt. first forms which dissolves in excess dilute NaOH.	White ppt. is due to formation of $Al(OH)_3$ which dissolves with excess NaOH due to formation of $NaAlO_2$ $Al^{3+} + 3NaOH \dashrightarrow Al(OH)_3\downarrow + 3Na^+$ $Al(OH)_3 + NaOH \dashrightarrow NaAlO_2 + 2H_2O$ Al^{3+} Radical confirmed.
(b)take 1 ml salt solution in a test tube and add disodium hydrogen phosphate (Na_2HPO_4) solution to it.	A gelatinous white ppt. ($AlPO_4$) forms which is soluble in dilute mineral acids	Gelatinous white ppt. is due to formation of $AlPO_4$ with dilute mineral acids corresponding Al salts are formed $Al^{3+} + 2Na_2HPO_4 \dashrightarrow AlPO_4 + NaH_2PO_4 + 3Na^+$ $2\ AlPO_4 + 3H_2SO_4 \dashrightarrow Al_2(SO_4)_3 + 2H_3PO_4$ Al^{3+} Radical confirmed.

Confirmatory Test for Zinc (Zn^{2+} Radical) :-

Experiment	Observation	Inference
(a)Take 1 ml of salt solution in a test tube . Add solid NH_4Cl to it till saturation followed by dilute NH_4OH solution till alkaline. Pass H_2S gas through it.	White ppt. forms	White ppt. is due to formation of ZnS. $Zn^{2+} + H_2S \dashrightarrow ZnS\downarrow + H^+$ Zn^{2+} Radical confirmed.
(b)Take 1 ml of salt solution in a test tube . Then add potassium ferrocyanide solution drop by drop.	White ppt. forms	White ppt. is due to formation of $Zn_2[Fe(CN)_6]$ Zinc ferrocyanide. $Zn^{2+} + K_4[Fe(CN)_6] \dashrightarrow Zn_2[Fe(CN)_6]\downarrow + K^+$

		Zn^{2+} Radical confirmed.
(c) Take 1 ml of salt solution in a test tube . Then adddil. NaOH solution drop by drop and then excess.	Gelatinous white ppt. is obtained which is soluble in excess NaOH solution.	Gelatinous white ppt. is due to formation of $Zn(OH)_2$ which forms Na_2ZnO_2 (sodium zincate)with excess of NaOH. $Zn^{2+} + 2NaOH \rightarrow Zn(OH)_2\downarrow + 2\,Na^+$ $Zn(OH)_2 + 2NaOH \rightarrow Na_2ZnO_2 + 2H_2O$ Zn^{2+} Radical confirmed.

Confirmatory Test for Calcium (Ca^{2+} Radical) :-

Experiment	Observation	Inference
(a)Take 1 ml of salt solution in a test tube. Add solid NH_4Cl to it till saturation followed by dilute NH_4OH solution till alkaline. Then add saturated solution of ammonium carbonate $(NH_4)_2CO_3$.	A white ppt. forms.	The white ppt. is due to formation of calcium carbonate($CaCO_3$). $Ca^{2+} + (NH_4)_2CO_3 \rightarrow CaCO_3\downarrow + 2NH_4^+$ Ca^{2+} radical is confirmed.
(b)Dissolve the above white ppt. in a minimum amount of dil. acetic acid (CH_3COOH). Boil to expel CO2 gas and then add $(NH_4)_2C_2O_4$ (ammonium oxalate) solution to it.	A white ppt. forms. Which is soluble in mineral acids but insoluble in dil. CH_3COOH. $CaCO_3 + 2CH_3COOH \rightarrow$ $Ca(CH_3COO)_2 + (NH_4)_2C_2O_4 \rightarrow$	The white ppt. is due to formation of calcium oxalate(CaC_2O_4). $Ca(CH_3COO)_2 + CO_2 + H_2O$ $CaC_2O_4 + 2CH_3COONH_4$ Ca^{2+} radical is confirmed.

Confirmatory Test for Magnesium (Mg^{2+} Radical) :-

Experiment	Observation	Inference
(a)Take 1 ml of salt solution in a test tube. Add solid NH_4Cl to it till saturation followed by dilute NH_4OH solution till alkaline. Then add disodium hydrogen phosphate (Na_2HPO_4) solution to it.	A white ppt. forms $Mg^{2+} + NH_4OH + Na_2HPO_4 \dashrightarrow$	White ppt. is due to formation of magnesium ammonium phosphate. $Mg(NH_4)PO_4 + 2Na^+ + H_2O$ Mg^{2+} radical is confirmed.
(b) Take 1 ml of salt solution in a test tube. Add 1ml of dil. HCl. Then add few drops of Magneson reagent followed by addition of dil. NaOH solution in excess.	A blue ppt. forms	Magneson reagent (p-nitro benzene azo resorcinol) reacts with NaOH to form blue coloured ppt. Mg^{2+} radical is confirmed.

Confirmatory Test for Ammonium (NH_4^+ Radical) :-

Experiment	Observation	Inference
(a)Take 1 ml of salt solution in a test tube. Add 1ml of dil. NaOH solution to it and boil.	Ammonia (NH_3) gas evolves	NaOH forms ammonia (NH_3) gas with ammonium salt. $NH_4^+ + NaOH \rightarrow NaNO_3 + NH_3\uparrow + H_2O$ NH_4^+ radical is confirmed.
(b)Show a glass rod dipped in conc	Dense white fumes formed	Dense white fumes are due to formation

HCl to the above gas.		of vapours of NH_4Cl. $NH_3 + HCl \dashrightarrow NH_4Cl$ NH_4^+ radical is confirmed
(c)Take 1 ml of salt solution in a test tube. Add 1ml of Nessler's reagent.	A brown ppt. forms	Brown ppt. is due to formation of iodide of Millon's base [H2N-HgO-HgI]. NH_4^+ radical is confirmed

Confirmatory Test for Sodium (Na^+ Radical) :-

Experiment	Observation	Inference
Take 2 ml of salt solution in a clean test tube. Add 1 ml of potassium pyroantimonate solution to it..	A white crystalline ppt. forms.	White ppt. is due to the formation of sodium pyroantimonate. $Na^+ + K_2H_2Sb_2O_7 \dashrightarrow Na_2H_2Sb_2O_7 + K^+$ Na^+ radical is confirmed

Confirmatory Test for Potassium (K^+ Radical) :-

Experiment	Observation	Inference
Take 1ml of salt solution in a clean test tube. Add 6 to 7 drops of cobalt nitrate{$Co(NO_3)_2$] solution followed by sodium nitrate($NaNO_3$) and dil. Acetic acid (CH_3COOH)	A Yellow PPt. forms	Yellow ppt. is due to the formation of sodium cobaltic nitrite. K^+ radical is confirmed

Viva - Voice Questions :-

(1) Define a salt?
(2) Define a radical?
(3) What are basic radicals?
(4) What are acid radicals?
(5) Name five divalent/ bivalent acid radicals?
(6) Name five divalent/ bivalent basic radicals?
(7) Name five monovalent acid radicals?
(8) Name five monovalent basic radicals?
(9) Name five trivalent radicals?
(10) What are compound and simple radicals? Name three of each.
(11) How dry test tube heating is performed?
(12) What happens when ammonium salts are heated in a dry test tube?
(13) What happens when zinc salts are heated in a dry test tube?
(14) Which salts will decripitate on heating?
(15) What happens when alkali or alkaline earth metal salts are heated in a dry test tube?
(16) Which salts will sublime on heating?
(17) How charcoal cavity test is performed?
(18) Why only one drop of cobalt nitrate is added during cobalt nitrate test?
(19) What happens to aluminium and zinc salts in cobalt nitrate test?

(20)Why conc. HCl is used in flame test?
(21)How flame test is performed?
(22)What are the colours of the flame for sodium salts in flame test?
(23)What are the colours of the flame for potassium salts in flame test?
(24)What are the colours of the flame for calcium salts in flame test?
(25)Why nichrome or platinum wires are used for flame test?
(26)Why certain salts swell on heating?
(27)What is the chemistry of flame test?
(28)Why do inorganic salts ionise when dissolved in water?
(29)Differentiate between lime water and milk of lime?
(30)Why dilute hydrochloric acid is preferred than sulphuric acid for dry test of acid radicals?
(31)Why lime water is stored in stoppered bottles?
(32)Why ammonium hydroxide is stored in stoppered bottles?
(33)What happens when dilute HCl is added to $MgCO_3$ salt?
(34)What happens when dilute HCl is added to Na_2S salt?
(35)Name the gas which evolves when dil. HCl is added to carbonate salts and how can you test it ?
(36)Name the gas which evolves when dil. HCl is added to sulphide salts and how can you test it ?
(37)Name the gas which evolves when conc. H_2SO_4 is added to chloride salts and how can you test it ?
(38)Write the reaction between dil. HCl and sodium carbonate?
(39)Write the reaction between dil. HCl and ferrous sulphide?
(40)Write the reaction between conc. H_2SO_4 and aluminium chloride?
(41)Tel the confirmatory test for nitrate radical?
(42)Tell the confirmatory test for chloride radical?
(43)Which acid radical is concerned with barium chloride solution?
(44)Write the confirmatory test for sulphate radical?
(45)The brown coloured ring appears due to formation of which compound?
(46)What happens when a glass rod dipped in ammonium hydroxide is shown to the gas evolved when KCl is treated with conc. H_2SO_4 ?
(47)Which gas evolves when a sulphide salt is treated with dil. HCl?
(48)What are the odours of CO_2, H_2S, NO_2, HCl gases?
(49)What are the confirmatory tests of chloride radical?
(50)Why, freshly prepared ferrous sulphate solution is required for brown ring test?
(51)What is the confirmatory test for sodium radical?
(52)What is the confirmatory test for potassium radical?
(53)What is the confirmatory test for calcium radical?
(54)What is the confirmatory test for Zinc radical?
(55)What is the confirmatory test for Aluminium radical?
(56)What is the confirmatory test for Magnesium radical?
(57)What is the confirmatory test for Ammonium radical?
(58)What is the confirmatory test for copper (II) radical?
(59)What is the confirmatory test for Magnesium radical?
(60)What will happen if the solution is not made acidic before passing H_2S gas for testing Cu2+ in second group?