PART II

Qualitative Salt Analysis

QUALITATIVE SALT ANALYSIS:

It is the analysis which involves the detection, identification and confirmation of the radicals present in a salt.

SALT:

It is an ionic compound which is formed by the neutralization (other than water) of an acid with a base. e.g.,

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

Base Acid Salt Water

A salt is made up of two parts.

(i) Acid Radical:

The part of a salt which comes from an acid during neutralization is called acid radical.

Acid radicals bear negative charge e.g., CO_3^{2-}, Cl^{1-}, CH_3COO^{1-}, SO_4^{2-}

(H^+ is also an acid radical but it bears positive charge)

(ii) Basic Radical:

The part of a salt bearing positive charge and which comes from a base during neutralization is called a basic radical. Basic radicals are usually metal cations. e.g., Ca^{2+}, Na^+, K^+, Al^{3+} (NH_4^+ is a basic radical but it is not a metal cation).

DRY TEST:

The test which is directly performed with a dry salt without making its solution is called a dry test. e.g., Flame test, Borax bead test, Filter ash test etc.

WET TEST:

A test, performed with the solution of a salt is called we test. e.g., Ring test, Lake test, Layer test etc.

For salt analysis, radicals are divided into six basic groups and three acidic groups.

BASIC RADICALS:

Group-I: Silver (Ag^{+1}), Plumbous (Pb^{2+}), Mercurous (Hg_2^{2+}).

Group-II: Cupric (Cu^{2+}), Cadmium (Cd^{2+}), Lead (Pb^{2+}), Mercuric (Hg^{2+}), Bismith (Bi^{3+}), Arsenic (As^{3+}), Antimony (Sb^{3+}), Tin (Sn^{2+}).

Group-III: Aminium (Al^{3+}), Ferrous (Fe^{2+}), Ferric (Fe^{3+}), Chromium (Cr^{3+}).

Group-IV: Nickel (Ni^{2+}), Cobalt (Co^{2+}), Zinc (Zn^{2+}), Manganese (Mn^{2+}).

Group-V: Barium (Ba^{2+}), Strontium (Sr^{2+}), Calcium (Ca^{2+}).

Group-VI: Magnesium (Mg^{2+}), Sodium (Na^+), Potasium (K^+), Ammonium (NH_4^+).

TOTAL NUMBER OF BASIC RADICALS:

Group-I	=	*3 radicals*
Group-II	=	*8 radicals*
Group-III	=	*3 radicals*
Group-IV	=	*4 radicals*
Group-V	=	*3 radicals*
Group-VI	=	*4 radicals*
Total	=	*25 radicals*

ACID RADICALS:

(i) Dilute Acid Group:

Carbonate (CO_3^{2-}) Bicarbonate (HCO_3^{1-}) Nitrite (NO_2^{1-}), Sulphide (S^{2-}), Sulphite (SO_3^{2-}), Thiosulphate $S_2O_3^{2-}$

(ii) Concentrated H_2SO_4 Group:

Chloride ($\bar{C}l$), Bromide ($\bar{B}r$), Iodide ($\bar{I}$), Nitrate (NO_3^{1-}, Acetate (CH_3COO^{1-}), Oxalate ($C_2O_4^{2-}$)

(iii) Special Group:

Sulphate (SO_4^{2-}), Phosphate (PO_4^{3-})

TOTAL NUMBER OF ACID RADICALS:

Dilute acid group	=	*6 radicals*
Concentrated H_2SO_4 group	=	*6 radicals*
Special group	=	*2 radicals*
Total	=	*14 radicals*

Acid Radicals

All acid radicals are detected by dry tests except sulphate (SO_4^{2-} and phosphate (PO_4^{3-} of special group.

Detection of Radicals of Dilute Acid Group:

Radicals of dilute acid group are detected by treating the salt with dilute H_2SO_4 or dil. HCl.

Detection of Radicals of Concentrated H_2SO_4 Group:

Radicals of concentrated H_2SO_4 group are detected by treating the salt with concentrated H_2SO_4 and heat.

Detection of Special Group Radicals:

Radicals of special group cannot be detected by dry tests. $BaCl_2$+ Conc. HCl solution is used to detect and differentiate between SO_4^{2-} and PO_4^{3-}.

(1) Dilute Acid Group: CO_3^{2-}, HCO_3^{1-}, NO_2^{1-}, S^{2-}, SO_3^{2-}, $S_2O_3^{2-}$

(2) Conc H_2SO Group: Cl^{1-}, Br^{1-}, I^{1-} NO_3^{1-}, CH_3COO^{1-}, $C_2O_4^{2-}$

(3) Special Group: SO_4^{2-}, PO_4^{3-}

Experiment	Observation	Inference
Salt + dilute H_2SO_4	i. Colourless, odourless gas (CO_2) evolved which turns lime water milky.	May be CO_3^{2-} or HCO_3^-.
	ii. Colourless gas with rotten egg smell (H_2S), turns lead acetate $Pb(CH_3COO)_2$ paper black.	S^{2-} indicated.
	iii. Colourless gas with burning sulphur smell (SO_2), turns acidified K_2CrO_7 paper green.	May be SO_3^{2-} or $S_2O_3^{2-}$.
	iv. Reddish brown gas with pungent smell (NO_2), turns $FeSO_4$ paper brown black.	NO_2^- indicated.

dil. HCl can also be used instead of dil. H_2SO_4 for the detection of radicals of dilute acid gorup.

Preparation of Original Solution (O.S) for Acid Radicals:

(i) Effectively soluble salts are just mixed with distilled water to get their original solution.

(ii) For sparingly soluble salts, mix salt with Na_2CO_3, (1:4) boil the mixture with water in test tube. Filter it and to the filterate add acetic acid (CH_3COOH) till no effervescence. and add NH_4OH till ammonical smell is obtained

Preparation Of Original Solution For Basic Radicals:

(i) Dissolve the salt is distilled water. If transparent solution is formed. It is original solution (O.S).

(ii) If the salt is insoluble in water, dissolve the salt in the following reagents in the given order:

(i) Dilute HCl (ii) Conc. HCl

(iii) Dilute HNO_3 (iv) Conc. HNO_3

(v) Aqua regia (Conc. HCl (3 parts) + Conc. HNO_3 (1 part)

Preliminary Examination Of The Salt

1. Colour:

	Observation	*Inference*
(i)	Blue / bluish green	Cu^{+2}
(ii)	Light green	Fe^{+2}
(iii)	Yellow	Fe^{+3}
(iv)	Light pink	Mn^{+2}
	Dark pink	Co^{+2}
(v)	Bright green	Ni^{+2}
(vi)	Dark green	Cr^{+3}

2. Odour:

	Observation	*Inference*
(i)	Rotten eggs smell	S^{-2}
(ii)	Vinegar like smell	CH_3COO^{1-}
(iii)	Ammonical smell	NH_4^+

3. Appearance:

	Observation	*Inference*
(i)	Amorphous	may be CO_3^{2-}
(ii)	Light powder	Carbonates of Bi^{+3}, Zn^{+2}, Mg^{+2}
(iii)	Crystalline and heavy	Pb^{+2}, Hg^{+2}, Ba^{+2}
(iv)	White but blackens when exposed to air	Pb^{+2}, Bi^{+3}

4. Dry Heating:

(a) Change in colour:

	Observation	*Inference*
(i)	Blue to white	$CuSO_4 . 5H_2O$
(ii)	Light green to white	$FeSO_4 . 7H_2O$
(iii)	Deep pink to blue, violet or green	Co^{+2}
(iv)	Green to yellow	$NiCl_2 . 2H_2O$

(b) Change in physical state:

Observation	*Inference*
(i) Salt crackles	$NaCl, KI, KBr, Pb(NO_3)_2$
(ii) Salt swells up	PO_4^{-3} or Alum
(iii) White sublime with smell of NH_3	NH_4^+
(iv) Grey sublimes	Hg^{+2}
(v) Yellow sublime	$S_2O_3^{2-}$
(vi) Black sublime with garlic smell	As^{+3}

(C) Evolution of gas:

	Observation	*Inference*
(i)	Colourless gas (CO_2) turns lime water milky	CO_3^{2-} , HCO_3^{1-}
(ii)	Colourless gas (CO) burns with blue flame	$C_2O_4^{2-}$
(iii)	A gas having rotten eggs smell (H_2S) turns bad acetate paper black	S^{2-}
(iv)	A gas having pungent smell like burning sulphur (SO_2) turns K_2CrO_7 paper green	SO_3^{2-} , $S_2O_3^{2-}$
(v)	Vinegar like smell	CH_3COO^{1-}
(vi)	Colourless gas having pungent smell (HCl gas) which gives white dense fumes with NH_4OH	Cl^{1-}
(vii)	Reddish brown gas (NO_2), turns $FeSO_4$ black	NO_2^{1-} , NO_3^{1-}

DRY TEST

1. Flame Test:

Make a paste of the salt with conc. HCl on a watch glass. Take a little paste on the clean platinum wire and introduce into the non-luminous flame of the burner. Note the colour of the flame.

Observation	*Inference*
Blue or green	Cu^{+2}
Apple green	Ba^{+2}
Crimson red	Sr^{+2}
Brick red	Ca^{+2}
Golden yellow	Na^{+}
Violet	K^{+}

2. Filter Ash Test:

Take a small quantity of the salt and add few drops of cobalt nitrate solution and shake well. Dip a piece of filter paper into the solution and dry it. Burn the filter paper on the flame and note the colour of the ash.

	Observation	*Inference*
(i)	Bluish green	Sn^{+2}
(ii)	Blue	Al^{+3}
(iii)	Green	Zn^{+2}
(iv)	Pink	Mg^{+2}

3. Borax Bead Test (For Coloured Slats):

Make a loop of platinum wire and heat it. Dip the hot wire in borax. Borax attaches with the wire due to its low melting point and transparent colourless bread is formed. Put small quantity of coloured salt on the borat bead and heat it again. Note the colour of the bead in the oxidizing flame and reducing flame in the cold state and hot state.

	Oxidizing flame	*Reducing flame*	*Inference*
(i)	Green when hot, blue when cold	Colourless when hot, opaque red when cold	Cu^{+2}
(ii)	Green in hot and in cold state	Green in hot and in cold state	Cr^{+3}
(iii)	Yellow in hot and in cold state	Green in hot and in cold state	Fe^{+2}
(iv)	Blue in hot and in cold state	Colourless in hot and in cold state	Co^{+2}
(v)	Violet in hot and in cold state	Colourless in hot and in cold state	Mn^{+2}
(vi)	Reddish brown in hot and in cold state	Grey or black in hot and in cold state	Ni^{+2}

4. Char Coal Cavity Test:

Mix powdered salt with twice the amount of fusion mixture ($Na_2CO_3 + K_2CO_3$). Fill this mixture in the cavity of the charcoal block and add 1-2 drops of water. Heat the mixture with blow pipe. Note the colour of residue left in the cavity as well as incrustation if formed.

	Observation	*Inference*
(i)	Bright white bead	Ag^{+} salt
(ii)	White bead which marks paper	Pb^{+2} salt
(iii)	The substance deflagrates	NO_2^{1-}, NO_3^{1-} salts
(iv)	Residue yellow when hot, white when cold	Sn^{+2}, Zn^{+2} salts
(v)	Residue reddish brown yellow on fusion with solid $Na_2S_2O_3$	Cd^{+2} salts

(vi) Residue white Ba^{+2}, Sr^{+2}, Ca^{+2} salts

(vii) Residue scales of metal Cu^{+2} salts

(viii) Orange red incrustation when hot, yellow when cold Bi^{+3} salts

(ix) Yellow incrustation when hot, dirty white when cold Sn^{+2} salts

Viva Voce

Q.1 Why we make the paste of the salt with conc. HCl for the flame test?

Ans. When the salt is mixed with conc. HCl their chloride are formed. The chlorides are more volatile than the other anions.

Q.2 Why colour is imparted when the salt is heated on the bunsen burner with pt. wire?

Ans. When the salt is heated, the electrons in the valence shell go to the high energy level and are excited. When they come back, they impart characteristic colour.

Q.3 Why pt. wire is used for the flame test?

Ans. Pt. wire impart no colour of its own, therefore it is used in the flame test.

Q.4 Can we use any other material to perform flame test?

Ans. Yes! graphite or Nichrome wire can also be used.

Q.5 Can we use glass rod or copper wire in the flame test?

Ans. No! copper wire or glass rod cannot be used because they impart characteristic colour.

Q.6 Name the radicals for which flame test in performed.

Ans. Cu^{+2}, Ba^{+2}, Sr^{+2}, Ca^{+2}, Na^{+1}, K^{+1}.

Q.7 Name the radicals for which filter ash test is used.

Ans. Sn^{+2}, Al^{+3}, Zn^{+2}, Mg^{+2}.

Q.8 What is the formula of Borax (tincal)?

Ans. $Na_2B_4O_7 . 10H_2O$

Q.9 What is the chemistry of Borax Bead test?

Ans. When borax is heated, sod-metaborate and B_2O_3 are formed metal oxides react with B_2O_3 to form media borates having coloured bead.

$$Na_2B_4O_7 . 7H_2O \xrightarrow{\Delta} 2NaBO_2 + B_2O_3 + 7H_2O$$

$$2Co(NO_3)_2 \longrightarrow 2CoO + 4NO_2 + O_2$$

$$CoO + B_2O_3 \longrightarrow \underbrace{Co(BO_2)_2}_{\text{blue bead}}$$

Q.10 What is deflagration?

Ans. Some oxidizing agents like NO_2^{1-} NO_3^{1-} and ClO_3^{1-} cause a very rapid combustion of glowing charcoal. It is called deflagration.

Q.11 How pt. wire is washed?

Ans. Dip the pt. wire in conc. HCl and heat on the flame.

Q.12 What is the chemistry of filter ash test?

Ans. Cobalt nitrate on heating forms CoO. It reacts with metal oxides to form an addition product.

$$2Co(NO_3)_2 \longrightarrow 2CoO + 4NO_2 + O_2$$

$$CoO + ZnO \longrightarrow \underbrace{CoO \,.\, ZnO}_{\text{green ash}}$$

Q.13 What is the chemistry of charcoal cavity test?

Ans. The salt is heated with Na_2CO_3 to form metal oxide. Metal oxide is reduced to metal by charcoal which is reducing agent.

$$Na_2CO_3 + CuSO_4 \longrightarrow CuO + CO_2 + Na_2SO_4$$

$$CuO + C \longrightarrow Cu + CO$$

Q.14 What is the difference between a gas an vapours?

Ans. The substance which exists as a gas at the room temperature is called a gas. For example: N_2, O_2, CO_2, SO_2, etc.

The gaseous form of a substance which exist as a liquid or a solid at the room temperature. For example: water vapours, bromine vapours.

Experiment No-1

Experiment	Observation	Inference
Dry Test:		
1. Salt + dil. H_2SO_4	Colourless, odourless gas is evolved with effervescence (CO_2)	Dilute and group (CO_3^{2-}, HCO_3^-, S^{2-}, SO_3^{2-}, $S_2O_3^{2-}$, NO_2^-) is present.
2. Passed the above gas through lime water, $Ca(OH)_2$.	Lime water turns milky ($CaCO_3$)	May be CO_3^{2-} or HCO_3^-
3. Salt + water and shake	Insoluble in H_2O.	Insoluble CO_3^{2-} Is present and confirmed.

Result: Acid Radical = CO_3^{2-} (insoluble)

Experiment No-2

Experiment	Observation	Inference
Dry Test:		
1. Salt + dil. H_2SO_4	Colourless, odourless gas is evolved with effervescence.	Dilute acid group (CO_3^{2-}, HCO_3^-, NO_2^-, S^{2-}, SO_3^{2-}, $S_2O_3^{2-}$) is present.
2. Passed the above gas through lime water [$Ca(OH)_2$].	Lime water turns milky (CO_2)	May be CO_3^{2-} or HCO_3^-.
3. Salt + water and shake	Salt is soluble in water.	May be HCO_3^- or soluble CO_3^{2-}.
Confirmatory Tests:		
4. O.S + $MgSO_4$	White ppt. in cold state.	CO_3^{2-} is confirmed.
5. O.S + $CaCl_2$	Whits ppt. in cold state.	CO_3^{2-} is confirmed.

CHEMICAL REACTIONS: ***Result:*** Acid Radical = CO_3^{2-} (soluble)

Test -1: $Na_2CO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O + CO_2$

Test 2: $Ca(OH)_2 + CO_2 \longrightarrow CaCO_3\downarrow + H_2O$
(white ppt.)

Test -3: $Na_2CO_3 + MgSO_4 \longrightarrow Na_2SO_4 + MgCO_3\downarrow$
(white ppt.)

Test -4: $Na_2CO_3 + CaCl_2 \longrightarrow 2NaCl + CaCO_3\downarrow$
(white ppt.)

Experiment No-3

Experiment	Observation	Inference
Dry Test:		
1. Salt + dil. H_2SO_4	Colourless, odourless gas evolved with effervescence.	Dilute acid group (CO_3^{2-}, HCO_3^-, S^{2-}, SO_3^{2-}, $S_2O_3^{2-}$, NO_2^-) is present.
2. Passed above gas through lime water [$Ca(OH)_2$].	Lime water turns milky (CO_2)	May be CO_3^{2-} or HCO_3^-.
3. Salt + water + shake	Salt is soluble.	HCO_3^- or soluble CO_3^{2-} indicated.
Confirmatory Tests:		
4. O.S + $CaCl_{2(sol)}$	White ppt. on boiling.	HCO_3^- is confirmed.
5. O.S + $MgSO_{4(sol)}$	White ppt. on boiling.	HCO_3^- is confirmed.

Result: Acid Radical = Bicarbonate (HCO_3^-)

CHEMICAL REACTIONS:

Test -4:

$$2NaHCO_3 + CaCl_2 \longrightarrow 2NaCl + Ca(HCO_3)_2$$

$$Ca(HCO_3)_2 \xrightarrow{\text{boiling}} CaCO_3\downarrow + H_2O + CO_2$$

(white ppt.)

Test -5:

$$2NaHCO_3 + MgSO_4 \longrightarrow Na_2SO_4 + Mg(HCO_3)_2$$

$$Mg(HCO_3)_2 \xrightarrow{\text{boiling}} MgCO_3\downarrow + H_2O + CO_2$$

(white ppt.)

Experiment No-4

Experiment	Observation	Inference
Dry Test:		
1. Salt + dil. H_2SO_4	A colourless gas having rotten egg smell is evolved.	Dilute acid group (CO_3^{2-}, HCO_3^-, S^{2-}, SO_3^{2-}, $S_2O_3^{2-}$, NO_2^-) is present.
2. Test the gas with lead acetate $Pb(CH_3OO)_2$ paper.	Paper turned black (PbS)	H_2S gas and S^{2-} is indicated.
Confirmatory Tests:		
3. O.S + $CdCl_{2(sol)}$	Yellow ppt.	S^{2-} is confirmed.
4. O.S + $Pb(CH_3COO)_{2(sol)}$	Black ppt.	S^{2-} is confirmed.
5. O.S + Sodium nitro prusside $Na_2[Fe(CN)_5NO]_{(sol)}$	Violet colour	S^{2-} is confirmed.

Result: Acid Radical = Sulphide (S^{2-})

CHEMICAL REACTIONS:

Test -1: $Na_2S + H_2SO_4 \longrightarrow Na_2SO_4 + H_2S$

Test -2: $H_2S + Pb(CH_3COO)_2 \longrightarrow 2CH_3COOH + PbS\downarrow$ (black ppt.)

Test -3: $Na_2S + CdCl_2 \longrightarrow 2NaCl + CdS$ (yellow ppt.)

Test -4: $Na_2S + Pb(HCOO)_2 \longrightarrow 2CH_3COONa + PbS$ (black ppt.)

Test -5: $Na_2S + Na_2[Fe(CN)_5NO] \longrightarrow Na_4[Fe(CN)_5NOS]$ (violet colour)

Experiment No-5

Experiment	Observation	Inference
Dry Test:		
1. Salt + dil. H_2SO_4	A colourless gas with burning sulphur smell is evolved.	Dilute acid group (CO_3^{2-}, HCO_3^-, S^{2-}, SO_3^{2-}, $S_2O_3^{2-}$, NO_2^-) is present.
2. Tested the above gas with acidified $K_2Cr_2O_7$ paper.	Paper turned green $Cr_2(SO_4)_3$	SO_2 gas; may be SO_3^{2-} or $S_2O_3^{2-}$.
3. Noted the contents of the test tube.	No yellow mass in test tube.	SO_3^{2-} indicated and $S_2O_3^{2-}$ is absent.
Confirmatory Tests:		
4. O.S + dil. H_2SO_4 + $KMnO_{4(sol)}$	Purple colour of $KMnO_4$ is discharged.	SO_3^{2-} is confirmed.
5. O.S + Br_2 water	Brown colour of Br_2 is discharged.	SO_3^{2-} is confirmed.
6. O.S + $Pb(CH_3COO)_{2(sol)}$	White ppt.	SO_3^{2-} is confirmed.

Result: Acid Radical = Sulphite (SO_3^{2-})

CHEMICAL REACTIONS:

Test-1: $Na_2CO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O + SO_2 \uparrow$

Test-2: $3SO_2 + H_2SO_4 + K_2Cr_2O_7 \longrightarrow K_2SO_4 + Cr_2(SO_4)_3 + H_2O$ (green colour)

Test-3: $Na_2SO_3 + 3H_2SO_4 + 2KMnO_4$ (purple) $\longrightarrow K_2SO_4 + 2MnSO_4 + 5Na_2SO_4 + 3H_2O$

Test-4: $Na_2SO_3 + Br_2 + H_2O$ (Brown) $\longrightarrow Na_2SO_4 + 2HBr$

Test-5: $Na_2SO_3 + Pb(CH_3COO)_2 \longrightarrow 2CH_3COONa + PbSO_3 \downarrow$ (white ppt.)

Experiment No-6

Experiment	Observation	Inference
Dry Test:		
1. Salt + dil. H_2SO_4	A colourless gas with burning sulphur smell is evolved.	Dilute acid group (CO_3^{2-}, HCO_3^-, S^{2-}, SO_3^{2-}, $S_2O_3^{-2}$, NO_2^-) is present.
2. Tested the gas with acidified $K_2Cr_2O_7$ paper.	Paper turned green.	SO_2 gas, may be SO_3^{2-} or $S_2O_3^{2-}$.
3. Noted the contents of above test tube.	A yellow mass is present.	SO_3^{2-} is absent and $S_2O_3^{2-}$ indicated.
Confirmatory Tests:		
4. O.S + $AgNO_{3(sol)}$	White ppt. changed to yellow, brown and finally black	$S_2O_3^{2-}$ is confirmed.
5. O.S + I_2 solution	Brown colour of I_2 solution is discharged.	$S_2O_3^{2-}$ is confirmed.
6. O.S + $FeCl_{3(sol)}$	Violet colouration.	$S_2O_3^{2-}$ is confirmed.
7. O.S + $Pb(CH_3COO)_{2(sol)}$	White ppt, blacken on heating.	$S_2O_3^{2-}$ is confirmed.

Result: **Acid Radical = Thiosulphate ($S_2O_3^{2-}$)**

CHEMICAL REACTIONS:

Test -1: $Na_2S_2O_3 + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O + SO_2\uparrow + S\downarrow$ (yellow mass)

Test -4: $Na_2S_2O_3 + 2AgNO_3 \longrightarrow 2NaNO_3 + Ag_2S_2O_3\downarrow$ (white ppt.)

$Ag_2S_2O_3 + O_2 \xrightarrow[\text{white, yellow, brown to}]{\text{colour changes from}} Ag_2O + 2SO_2$

(air) (black)

Test -5: $2Na_2S_2O_3 + I_{2(sol)} \longrightarrow 2NaI + Na_2S_4O_6$

(brown) Sodium tetra-thionate(colourless)

Test -6: $3Na_2S_2O_3 + 2FeCl_3 \longrightarrow Fe_2(S_2O_3)_3 + 6NaCl$ (violet)

Test -7: $Na_2S_2O_3 + Pb(CH_3COO)_2 \longrightarrow 2CH_3COONa + PbS_2O_3\downarrow$ (white)

$PbS_2O_3 + H_2O \xrightarrow{\text{Heat}} PbS + H_2SO_4$ (black)

Experiment No-7

Experiment	Observation	Inference
Dry Test:		
1. Salt + dil. H_2SO_4	A brown gas with pungent smell is evolved.	Dilute acid group (CO_3^{2-}, HCO_3^-, S^{2-}, SO_3^{2-}, $S_2O_3^{2-}$, NO_2^-) is present.
2. Tested the gas with $FeSO_4$ paper.	Paper turned brown black.	NO_2 and NO gases; NO_2^{-1} is indicated.
Confirmatory Tests:		
3. O.S + dil. H_2SO_4 + $KMnO_{4(sol)}$	Purple colour of $KMnO_4$ is discharged.	NO_2^- is confirmed.
4. O.S + dil. H_2SO_4 $FeSO_{4(sol)}$	Black brown colouration	NO_2^- is confirmed.
5. O.S + dil. H_2SO_4 + $KI_{(sol)}$ + Starch Solution	Deep blue colour	NO_2^- is confirmed.

Result: Acid Radical = Nitrite (NO_2^-)

CHEMICAL REACTIONS:

Test -1: $2NaNO_2 + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O + NO\uparrow + NO_2\uparrow$ (brown)

Test -2: $FeSO_4 + NO + 5H_2O \longrightarrow [Fe(H_2O)_5NO]SO_4$

black brown

penta aqua nitroso iron (II) sulphate

OR

hydrated nitroso ferrous sulphate

Test -3: $5NaNO_2 + 3H_2SO_4 + 2KMnO_4 \longrightarrow K_2SO_4 + 2MnSO_4 + 5NaNO_2 + 3H_2O$

Test -4: $2NaNO_2 + H_2SO_4 + FeSO_4 \longrightarrow Na_2SO_4 + Fe(NO)SO_4 + H_2O$ (black brown)

Test -5: $2NaNO_2 + 2KI + H_2SO_4 \longrightarrow K_2SO_4 + Na_2SO_4 + I_2 + 2H_2O$

$I_{2(sol)}$ + Starch solution $\longrightarrow$ Starch I_2 complex (deep blue)

Viva Voce

(Dilute Acid Group)

1. CO_2 gas turns lime water milky due to the formation of **$CaCO_3$**.
2. All carbonates are insoluble in water except the **carbonates of Na^+, K^+ and NH_4^+** which are soluble in water.
3. Some important chemical formulas.
   - *(a)* Lime water $Ca(OH)_2$
   - *(b)* Sodium nitroprusside $Na_2[Fe(CN)_5NO]$
   - *(c)* Nitroso ferrous sulphate $Fe(NO)SO_4$
   - *(d)* Lead acetate $Pb(CH_3COO)_2$
   - *(e)* Potasium permagnate $KMnO_4$
4. All **bicarbonates are soluble** in water.

5. (a) CO_2 gas:	Physical Properties	Chemical Test
It is evolved from CO_3^{2-} or HCO_3^-.	It is colourless, odourless gas.	It turns lime water milky.
(b) H_2S gas: It is evolved from S^{2-} salts.	It is colourless, gas, has rotten egg smell.	It turns lead acetate $[Pb(CH_3COO)_2]$ paper black.
(c) SO_2 gas: It is evolved from SO_3^{2-} and $S_2O_3^{2-}$ salts.	It is colourless gas and has burning sulphur smell.	It turns acidified $K_2Cr_2O_7$ paper green.
(d) NO and NO_2 gases: Evolved from NO_2^- salts.	NO is colourless but NO_2 is brown gas both have pungent smell.	NO turns $FeSO_4$ paper black brown.

CONCENTRATED H_2SO_4 GROUP:

(Cl^-, Br^-, I^-, CH_3COO^-, $C_2O_4^{2-}$, NO_3^-)

Experiment	Observation	Inference
Salt + Conc. H_2SO_4 + Heat	i. Colourless gas with pungent smell (HCl) which gives dense white fumes with NH_4OH.	Cl^- is indicated.
	ii. A reddish brown pungent smell vapours (Br_2) turns starch paper yellow	Br^- is indicated.
	iii. Violet vapours (I_2) turn starch paper blue.	I^- is indicated.
	iv. Vinegar smell vapours (CH_3COOH) which are colourless.	CH_3COO^- indicated.
	v. A colourless, odourless gas turns lime water milky (CO_2), burns with blue flame (CO).	$C_2O_4^{2-}$ is indicated.
	vi. A brown gas (NO_2), turns $FeSO_4$ paper black brown.	NO_3^- is indicated.

DISTINCTION BETWEEN Br^- And NO_3^-

	Bromide (Br^-)		Nitrate (NO_3^-)
(i)	Brown gas (Br_2) is evolved when Br^- salts are treated with Conc. H_2SO_4 and heat.	(i)	Brown gas (NO_2) is evolved when NO_3^- salts are treated with conc. H_2SO_4 and heat.
(ii)	Vapours of Br_2 turn starch paper to yellow.	(ii)	Brown NO_2 gas turns $FeSO_4$ paper black brown.
(iii)	No more gas is evolved by addition of paper pellet.	(iii)	More gas is evolved by the addition of paper pellet or copper turning.
(iv)	Solution in test tube is reddish brown.	(iv)	Contents of test tube are clear and colourless.

Experiment No-8

Experiment	Observation	Inference
1. Salt + dil. H_2SO_4	No gas is evolved.	Dilute acid group (CO_3^{2-}, HCO_3^-, S^{2-}, SO_3^{2-}, $S_2O_3^{2-}$, NO_2^-) is absent.
2. Salt + Conc. H_2SO_4 + Heat	A colourless gas is evolved with pungent smell.	Conc. H_2SO_4group is present (Cl^-, Br^-, I^-, CH_3COO^-, $C_2O_4^{2-}$, NO_3^-)
3. Tested the gas with NH_4OH rod.	White dense fumes.	May be Cl^-.
Confirmatory Tests:		
4. O.S + $AgNO_{3(sol)}$	White ppt. soluble in NH_4OH.	Cl^- confirmed.
5. Salt + $MnO_{2(solid)}$ + Conc. H_2SO_4 + Heat	Greenish yellow gas (Cl_2) is evolved.	Cl^- is confirmed.
6. **Chromyl Chloride Test:**		
i. Salt + $K_2Cr_2O_{7(solid)}$ (1 : 1) + Conc. H_2SO_4 + Heat	Reddish brown chromyl chloride gas (CrO_2Cl_2) is evolved.	Cl^- is confirmed.
ii. Pass above gas through $NaOH_{(sol)}$ then add $Pb(CH_3COO)_{2(sol)}$	Yellow ppt.	Cl^- is confirmed.

Result: Acid Radical = Chloride (Cl^-)

CHEMICAL REACTIONS:

Test -2: $NaCl + H_2SO_4 \xrightarrow{Heat} NaHSO_4 + HCl$

Test -3: $HCl + NH_4OH \longrightarrow NH_4Cl + H_2O$
(white fumes)

Test -4: $NaCl_{(aq)} + AgNO_{3(aq)} \longrightarrow AgCl\downarrow + NaNO_{3(aq)}$
(white ppt.)

$AgCl + 2NH_4OH \longrightarrow Ag(NH_3)_2Cl + 2H_2O$
(soluble)

Test -5: $2NaCl + MnO_2 + 3H_2SO_4 \longrightarrow MnSO_4 + 2NaHSO_4 + 2H_2O + Cl_2\uparrow$
(yellow green)

Chromyl Chloride Test:

Test -6: (a) $4NaCl + K_2Cr_2O_7 + 3H_2SO_4 \longrightarrow K_2SO_4 + 2Na_2SO_4 + 2CrO_2Cl_2 + 3H_2O$
(brown)

(b) $CrO_2Cl_2 + 2NaOH \longrightarrow Na_2CrO_4 + 2HCl$

$Na_2CrO_4 + Pb(CH_3COO)_2 \longrightarrow 2CH_3COONa + PbCrO_4\downarrow$
(yellow ppt.)

Experiment No-9

Experiment	Observation	Inference
Dry Test:		
1. Salt + dil. H_2SO_4	No gas is evolved.	Dilute acid group (HCO_3^-, CO_3^{2-}, S^{2-}, SO_3^{2-}, $S_2O_3^{2-}$, NO_2^-) absent.
2. Salt + Con. H_2SO_4 + Heat	Reddish brown vapours are evolved (Br_2)	Conc. H_2SO_4 group (Cl^-, Br^-, I^-, CH_3COO^-, $C_2O_4^{2-}$, NO_3^-) present.
3. Put a paper pellet in test tube.	No increase in evolution of brown gas.	NO_3^- is absent, Br^- indicated.
4. Tested the gas with starch paper.	Paper turned yellow and contents of test tube are red.	Br^- is indicated.
Confirmatory Tests:		
5. O.S + $AgNO_{3(sol)}$	Pale yellow ppt. partially soluble in NH_4OH.	Br^- confirmed.
6. Salt + $MnO_{2(solid)}$ + Conc. H_2SO_4 + Heat	Reddish brown gas (Br_2) is evolved.	Br^- is confirmed.
7. **Layer Test:** O.S + dilute H_2SO_4 + $KMnO_{4(sol)}$ + CS_2 and shaked it (CCl_4 can also be used instead of CS_2)	Orange colour in organic layer.	Br^- is confirmed.

CHEMICAL REACTIONS:

Result: Acid Radical = Bromide (Br^-)

Test -2:

$$NaBr + H_2SO_4 \longrightarrow NaHSO_4 + HBr$$

$$2HBr + H_2SO_4 \longrightarrow SO_2 + 2H_2O + Br_2 \uparrow$$

(brown gas)

Test -5:

$$NaBr + AgNO_3 \longrightarrow NaNO_3 + AgBr \downarrow$$

(pale yellow)

Test -6:

$$2NaBr + MnO_2 + 3H_2SO_4 \xrightarrow{Heat} 2NaHSO_4 + MnSO_4 + H_2O + Br_2 \uparrow$$

(red brown gas)

Experiment No-10

Experiment	Observation	Inference
Dry Test:		
1. Salt + dil. H_2SO_4	No gas is evolved.	Dilute acid group (CO_3^{2-}, HCO_3^-, S^{2-}, SO_3^{2-}, $S_2O_3^{2-}$, NO_2^-) absent.
2. Salt + Concentrated H_2SO_4 + Heat	Violet vapours are evolved	Conc. H_2SO_4 group (Cl^-, Br^-, I^-, CH_3COO^-, $C_2O_4^{2-}$, NO_3^-) present.
3. Tested violet vapours with starch paper	Starch paper turned blue	I^- is indicated.
Confirmatory Tests:		
4. O.S + $AgNO_{3(sol)}$	Yellow ppt. insoluble in NH_4OH	I^- is confirmed.
5. O.S + $Pb(CH_3COO)_{2(sol)}$	Bright yellow ppt (PbI_2)	I^- is confirmed.
6. Salt + $MnO_{2(solid)}$ + Con. H_2SO_4 + Heat	Violet vapours (I_2) are evolved	I^- is confirmed.
7. **Layer Test:** O.S + dil. H_2SO_4 + $KMnO_4$ + $CS_{2(sol)}$ and shake	Violet colour in organic layer	I^- is confirmed.

Result: Acid Radial = Iodide (I^-)

CHEMICAL REACTIONS:

Test -2: $2KI + 2H_2SO_4 \longrightarrow K_2SO_4 + I_2\uparrow + SO_2 + 2H_2O$ (violet)

Test -4: $KI_{(sol)} + AgNO_{3(sol)} \longrightarrow KNO_3 + AgI\downarrow$ (yellow ppt)

Test -5: $2KI_{(aq)} + Pb(CH_3COO)_{2(aq)} \longrightarrow 2CH_3COOK + PbI_2\downarrow$ (bright yellow)

Test -6: $2KI + 2H_2SO_4 + MnO_2 \xrightarrow{Heat} K_2SO_4 + MnSO_4 + 2H_2O + I_2\uparrow$ (violet)

Experiment No-11

Experiment	Observation	Inference
Dry Test:		
1. Salt + dil. H_2SO_4	No gas is evolved	Dilute acid group (CO_3^{2-}, HCO_3^-, S^{2-}, SO_3^{2-}, $S_2O_3^{2-}$, NO_2^-) absent.
2. Salt + Conc. H_2SO_4 + Heat	A colourless gas is evolved	Conc.H_2SO_4 group (Cl^-, Br^-, I^-, CH_3COO^-, $C_2O_4^{2-}$, NO_3^-) is present.
3. Noted the smell of gas	Vinegar smell	CH_3COO^- is indicated.
Confirmatory Tests:		
4. O.S + $FeCl_{3(sol)}$	Red colour which changes to brown ppt. on heating	CH_3COO^- is confirmed.
5. **Esterification:** O.S + Ethyl alcohol + Few drops of conc. H_2SO_4 and heat gently	Fruity smell of ethyl acetate (Ester)	CH_3COO^- is confirmed.
6. **Palm Test:** Salt + Oxalic acid (solid) (1 : 1) on the palm + One drop of water and rub. Smell the palm.	Vinegar smell	CH_3COO^- is confirmed.

Result: Acid Radical = Acetate (CH_3COO^-)

CHEMICAL REACTIONS:

Test -2: $2CH_3COONa + H_2SO_4 \xrightarrow{Heat} Na_2SO_4 + 2CH_3COOH\uparrow$ (vinegar smell)

Test -4: $3CH_3COONa + FeCl_3 \longrightarrow Fe(CH_3COO)_3 + 3NaCl$ (red colour)

Test -5: $C_2H_5OH + H_2SO_4 + CH_3COONa \xrightarrow{Heat} CH_3COOC_2H_5 + NaHSO_4 + H_2O$ (fruity smell)

Test -6: $(COOH)_2 + 2CH_3COONa \longrightarrow Na_2C_2O_4 + 2CH_3COOH\uparrow$ (vinegar smell)

Experiment No-12

Experiment	Observation	Inference
Dry Test:		
1. Salt + dilute H_2SO_4	No gas is evolved	Dilute and group (CO_3^{2-}, HCO_3^-, S^{2-}, SO_3^{2-}, $S_2O_3^{2-}$, NO_2^-) absent.
2. Salt + Concentrated H_2SO_4 + Heat	A colourless, odourless gas is evolved	Conc. H_2SO_4 group (Cl^-, Br^-, I^-, CH_3COO^-, $C_2O_4^{2-}$, NO_3^-) present.
3. Pass above gas through line water	Line water $Ca(OH)_2$ turns milky (CO_2)	$C_2O_4^{2-}$ is indicated.
4. Bring the burning paper near the mouth of test tube	Gas burnt with blue flame (CO)	$C_2O_4^{2-}$ is indicated.
Confirmatory Tests:		
5. O.S + dilute H_2SO_4 + $KMnO_4$ solution + Heat	Colour of $KMnO_4$ is discharged on heating	$C_2O_4^{2-}$ is confirmed.
6. O.S + $CaCl_{2(sol)}$	White ppt. soluble in conc. HCl	$C_2O_4^{2-}$ is confirmed.

Result: Acid Radical = Oxalate ($C_2O_4^{2-}$)

CHEMICAL REACTIONS:

Test -2: $Na_2C_2O_4 + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O + CO_2\uparrow + CO\uparrow$

Test -5: $5Na_2C_2O_4 + 2KMnO_4 + 8H_2SO_4 \xrightarrow{Heat} K_2SO_4 + 2MnSO_4 + 5Na_2SO_4 + 8H_2O + 10CO_2$

Test -6: $Na_2C_2O_{4(aq)} + CaCl_{2(aq)} \longrightarrow CaC_2O_4\downarrow + 2NaCl$ (white ppt)

Experiment No-13

Experiment	Observation	Inference
Dry Test:		
1. Salt + dilute H_2SO_4	No gas is evolved	Dilute acid group (CO_3^{2-}, HCO_3^-, S^{2-}, SO_3^{2-}, $S_2O_3^{2-}$ NO_2^-) absent.
2. Salt + Concentrated H_2SO_4 + Heat	A reddish brown gas is evolved	Conc. H_2SO_4 group (Cl^-, Br^-, I^-, $CH_3COO_3^-$, $C_2O_4^{2-}$, NO_3^-) present.
3. Put a paper pellet in the test tube	Evolution of brown gas (NO_2) is increased	May be NO_3^-
Confirmatory Tests:		
4. O.S + $NaOH_{(sol)}$ + Zn dust and heat	Evolution of NH_3 gas	NO_3^- is confirmed.
5. O.S + Diphenylamine $(C_6H_5)_2NH$	Deep blue colouration	NO_3^- is confirmed.
6. **Ring Test:** O.S + Fresh $FeSO_4$ + Conc. H_2SO_4 along the walls of test tube	Dark brown ring is formed at the junction of two solutions	NO_3^- is confirmed.

Result: Acid Radical = Nitrate (NO_3^-)

CHEMICAL REACTIONS:

Test -2:

$$NaNO_3 + H_2SO_4 \longrightarrow NaHSO_4 + HNO_3$$

$$2HNO_3 \longrightarrow 2NO_2 \uparrow + H_2O + \frac{1}{2}O_2$$

(brown gas)

Test -4:

$$NaNO_3 + NaOH + Zn \longrightarrow NH_3 + Na_2ZnO_2$$

Test -5:

$$NO_3^- + (C_6H_5)_2NH \longrightarrow [(C_6H_5)_2N(NO_3)]H^+$$

Dipheny amine — blue colour

Test -6: **Ring Test:**

$$2NaNO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + 2HNO_3$$

$$6FeSO_4 + 2HNO_3 + 3H_2SO_4 \longrightarrow 3Fe_2(SO_4)_3 + 2NO + 4H_2O$$

$$FeSO_4 + NO \longrightarrow Fe(NO)SO_4$$

brown ring

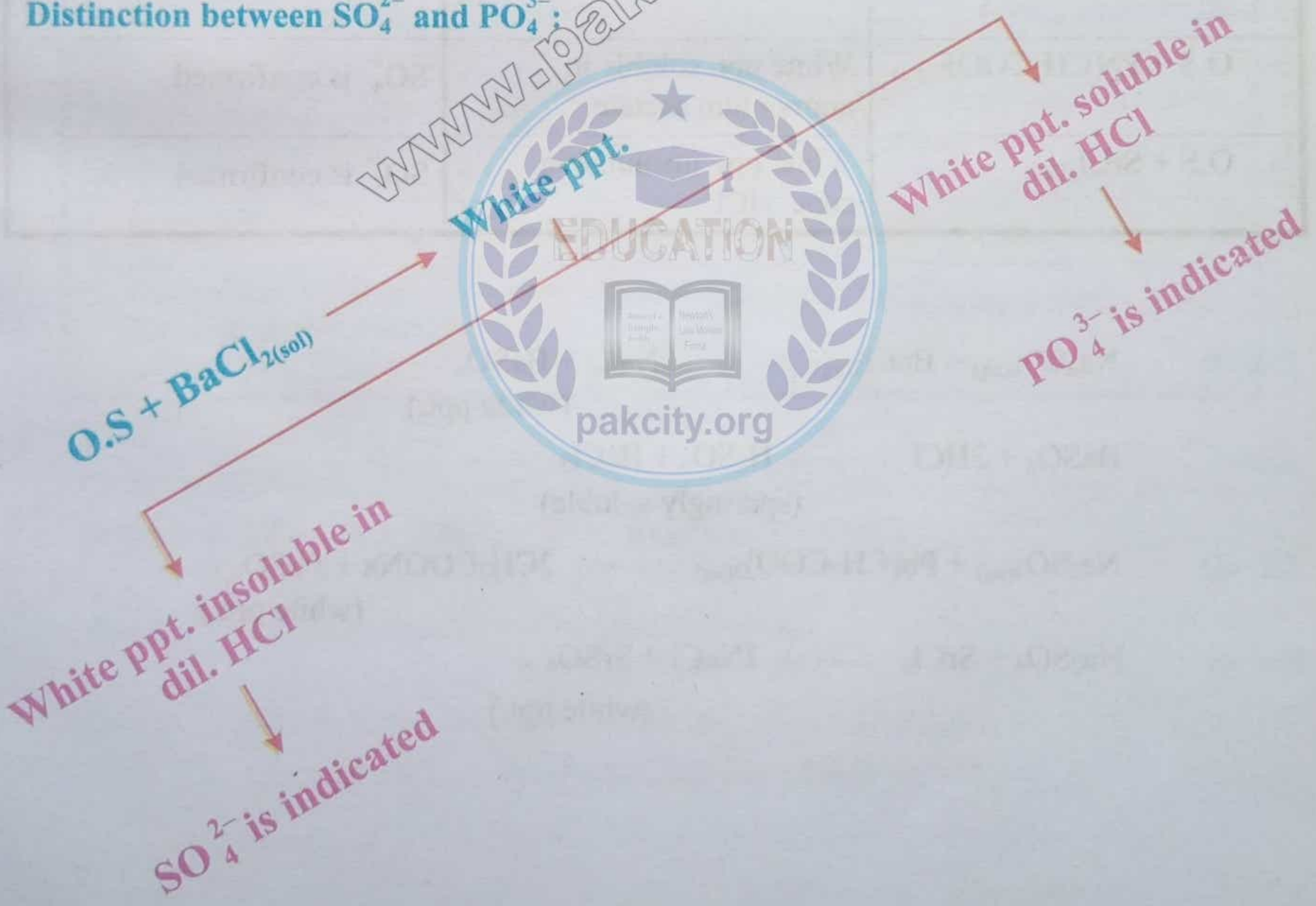
Viva Voce

1. We cannot use **conc. HCl** instead of conc. H_2SO_4 because concentrated H_2SO_4 group contain Cl^- ions and we are also introducing Cl^- ions from HCl.
2. Chemical formulas of some important compounds are:
   - (i) Chromyl Chloride gas CrO_2Cl_2
   - (ii) Diphenyl amine $(C_6H_5)_2NH$
   - (iii) Oxalic acid $(COOH)_2$ or $\begin{vmatrix} COOH \\ COOH \end{vmatrix}$ or $H_2C_2O_4$

Special Group

Special group includes the radicals sulphate (SO_4^{2-}) and phosphate (PO_4^{3-}). Salts containing SO_4^{2-} or PO_4^{3-} radicals evolve no gas with dilute or concentrated H_2SO_4 even on heating.

Distinction between SO_4^{2-} and PO_4^{3-}:



Experiment No-14

Experiment	Observation	Inference
Dry Test:		
1. Salt + dilute H_2SO_4	No gas is evolved	Dilute acid group (HCO_3^-, CO_3^{2-}, S^{2-}, SO_3^{2-}; $S_2O_3^{2-}$, NO_2^-) absent.
2. Salt + Concentrated H_2SO_4 + Heat	No gas is evolved	Concentrated H_2SO_4 group (Cl^-, Br^-, I^-, CH_3COO^-, $C_2O_4^{2-}$, NO_3^-) absent.
Indication Test:		
3. O.S + $BaCl_{2(sol)}$	White ppt.	May be SO_4^{2-} is indicated.
4. Above ppt. + dil. HCl	ppt. is insoluble	PO_4^{3-} absent, SO_4^{2-} is indicated.
Confirmatory Tests:		
5. O.S + $Pb(CH_3COO)_{2(sol)}$	White ppt. soluble in ammonium acetate	SO_4^{2-} is confirmed.
6. O.S + $SrCl_{2(sol)}$	White ppt. insoluble in conc. HCl	SO_4^{2-} is confirmed.

CHEMICAL REACTIONS:

Test -3: $Na_2SO_{4(aq)} + BaCl_{2(aq)} \longrightarrow 2NaCl + BaSO_4 \downarrow$ (white ppt.)

Test -4: $BaSO_4 + 2HCl \longrightarrow H_2SO_4 + BaCl_2$ (sparingly soluble)

Test -5: $Na_2SO_{4(aq)} + Pb(CH_3COO)_{2(aq)} \longrightarrow 2CH_3COONa + PbSO_4 \downarrow$ (white ppt.)

Test -6: $Na_2SO_4 + SrCl_2 \longrightarrow 2NaCl + SrSO_4 \downarrow$ (white ppt.)

Experiment No-15

Experiment	Observation	Inference
Dry Test:		
1. Salt + dilute H_2SO_4	No gas is evolved	Dilute acid group (CO_3^{2-}, HCO_3^-, S^{2-}, SO_3^{2-}, $S_2O_3^{2-}$, NO_2^-) absent.
2. Salt + Conc. H_2SO_4 + Heat	No gas is evolved	Concentrated H_2SO_4 group (Cl^-, Br^-, I^-, CH_3OO^-, $C_2O_4^{2-}$, NO_3^-) absent. As both dilute and concentrated groups are absent so special group (SO_4^{2-} PO_4^{3-}) is present.
Indication Test:		
3. O.S + $BaCl_{2(sol)}$	White ppt.	May be SO_4^{2-} or PO_4^{3-}.
4. Above ppt. + dil. HCl	ppt. is soluble	SO_4^{2-} absent, PO_4^{3-} indicated.
Confirmatory Tests:		
5. O.S + $FeCl_{3(sol)}$	Yellow ppt.	PO_4^{3-} is confirmed.
6. O.S + Conc. HNO_3 + Ammonium molybdate $(NH_4)_2MoO_4$ + Heat	Yellow colour or ppt.	PO_4^{3-} is confirmed.

CHEMICAL REACTIONS:

Result: Acid Radical = Phosphate (PO_4^{3-})

Test -3: $2Na_3PO_4 + 3BaCl_2 \longrightarrow Ba_3(PO_4)_2\downarrow + 6NaCl$ (With ppt.)

Test -5: $Na_3PO_4 + FeCl_3 \longrightarrow 3NaCl + FePO_4\downarrow$ (yellow ppt.)

Test -6: $Na_3PO_4 + 12(NH_4)_2MoO_4 + 24HNO_3 \xrightarrow{Heat} (NH_4)_3PO_4 + 12MoO_3 . 6H_2O + 4NH_4NO_3 + 3NaNO_3 + 6H_2O$

Viva Voce

1. Ammonium molybedate = $(NH_4)_2MoO_4$
   Ammonium acetate = CH_3COONH_4
2. White ppt. of PO_4^{3-} with $BaCl_2$ are soluble in dil. HCl whereas that of SO_4^{2-} are insoluble in dil. HCl.

Basic Radicals

Basic radicals are total 26 in number and are divided into following six groups depending upon the formation of insoluble compounds (in the form of precipitates) by the addition of various group reagents.

Group radicals	Group reagent	Precipitated as	Insoluble products and their colours
I. Ag^+, Pb^{2+}, Hg_2^{2+}	Dilute HCl	Chlorides	AgCl, $PbCl_2$ and Hg_2Cl_2 all are of white colour.
II. Cd^{2+}, Hg^{2+}, Bi^{3+}, Pb^{2+}, Cu^{2+}, As^{3+}, Sb^{3+}, Sn^{2+}	Dilute HCl + H_2S	Sulphides	HgS, PbS, Bi_2S_3, CuS all are black, SnS is brown, CdS is yellow, As_2S_3 pale yellow and Sb_2S_3 is of orange colour
III. Al^{3+}, Fe^{2+}, Fe^{3+}, Cr^{3+}	$NH_4Cl_{(solid)}$ + boil + cool + NH_4OH	Hydroxides	$Al(OH)_3$ gelatinous white, $Cr(OH)_3$ dirty green, $Fe(OH)_3$ red brown ppt.
IV. Ni^{2+}, Co^{2+}, Zn^{2+}, Mn^{2+}	$NH_4Cl_{(s)}$ + boil + cool + $NH_4OH_{(sol)}$ + H_2S	Sulphides	NiS, CoS are black, ZnS is white and MnS is of flesh or buff colour.
V. Ba^{2+}, Sr^{2+}, Ca^{2+}	$NH_4Cl_{(s)}$ + boil + cool + $NH_4OH_{(sol)}$ + $(NH_4)_2CO_3$	Carbonates	$CaCO_3$, $BaCO_3$, $SrCO_3$ all have white ppt.
VI. Mg^{2+}, Na^+, K^+, NH_4^+	No group reagent	–	–

Group-I

$(Ag^{+}, Hg_2^{2+}, Pb^{2+})$

Experiment	Observation	Inference
O.S + dilute HCl	White ppt.	Group-I (Ag^{+}, Pb^{2+}, Hg_2^{2+}) is present.
Above white ppt. + NH_4OH	**i.** ppt. soluble	Ag^{+} is indicated.
	ii. ppt. insoluble	Pb^{2+} is indicated.
	iii. ppt. turns black	Hg_2^{2+} is indicated.

Experiment No-1

Experiment	Observation	Inference
Dry Test:		
1. Noted the colour of salt.	White salt	Cu^{2+}, Fe^{2+}, Fe^{3+}, Cr^{3+}, Ni^{2+}, Co^{2+} and Mn^{2+} are absent.
2. Noted the smell of salt.	No smell of NH_3	NH_4^+ is absent.
3. Flame Tests:		
Made the paste of salt with conc. HCl and brought this paste with pt. wire over flame.	No characteristic flame	Na^+, K^+, Cu^{2+}, Ca^{2+}, Ba^{2+}, Sr^{2+} are absent.
4. Filter Ash Tests:		
Salt + $Co(NO_3)_2$.Solution Dipped a strip of filter paper in this solution and burnt it on flame, noted the colour of ash.	No characteristic ash	Sn^{2+}, Al^{3+}, Zn^{2+} and Mg^{2+} are absent.
Wet Tests:		
5. O.S + dilute HCl	White ppt.	Group-I (Ag^+, Pb^{2+}, Hg_2^{2+}) is present.
6. Above ppt. + NH_4OH	ppt. soluble	Ag^+ is indicated.
Confirmatory Test:		
7. O.S + $K_2CrO_{4(sol)}$	Brick red ppt. (Ag_2CrO_4)	Ag^+ is confirmed.
8. O.S + $KI_{(sol)}$	Yellow ppt. of AgI	Ag^+ is confirmed.

Result: Basic Radical = Silver (Ag^+)

CHEMICAL REACTIONS:

Test -5: $AgNO_3 + HCl \longrightarrow HNO_3 + AgCl\downarrow$ (white ppt.)

Test -6: $AgCl + 2NH_4OH \longrightarrow Ag(NH_3)_2Cl + H_2O$ (soluble)

Test -7: $2AgNO_3 + K_2CrO_4 \longrightarrow 2KNO_3 + Ag_2CrO_4\downarrow$ (brick red)

Test -8: $AgNO_3 + KI \longrightarrow KNO_3 + AgI\downarrow$ (yellow ppt.)

Experiment No-2

Experiment	Observation	Inference
Dry Test:		
1. Note the colour of salt	White salt	Cu^{2+}, Fe^{2+}, Fe^{3+}, Cr^{3+}, Ni^{2+}, Co^{2+}, Mn^{2+} are absent.
2. Noted the smell of salt	No NH_3 smell	NH_4^+ is absent.
3. Apply the flame test	No characteristic flame	Na^+, K^+, Cu^{2+}, Ca^{2+}, Ba^{2+}, Sr^{2+} are absent.
4. Apply filter ash test	No characteristic ash	Sn^{2+}, Al^{3+}, Zn^{2+} and Mg^{2+} are absent.
Wet Tests:		
5. O.S + dil. HCl	White ppt.	Group-I (Ag^+, Hg_2^{2+}, Pb^{2+}) is present.
6. Above ppt. + NH_4OH	ppt. are insoluble	Pb^{2+} is indicated.
Confirmatory Tests:		
7. O.S + $K_2CrO_{4(sol)}$	Yellow ppt. ($PbCrO_4$)	Pb^{2+} is indicated.
8. O.S + $KI_{(sol)}$	Bright yellow ppt. (PbI_2)	Pb^{2+} is confirmed.
9. O.S + $Na_2S_{(sol)}$	Black ppt. (PbS)	Pb^{2+} is confirmed.

Result: Basic Radical = Lead (Pb^{2+})

CHEMICAL REACTIONS:

Test -5: $Pb(CH_3COO)_2 + 2HCl \longrightarrow 2CH_3COOH + PbCl_2 \downarrow$ (white ppt.)

Test -7: $Pb(CH_3COO)_{2(sol)} + K_2CrO_{4(sol)} \longrightarrow 2CH_3COOK + PbCrO_4 \downarrow$ (yellow ppt.)

Test -8: $Pb(CH_3COO)_2 + 2KI \longrightarrow 2CH_3COOK + PbI_2 \downarrow$ (bright yellow ppt.)

Test -9: $Pb(CH_3COO)_2 + Na_2S_{(sol)} \longrightarrow 2CH_3COONa + PbS \downarrow$ (black ppt.)

Experiment No-3

Experiment	Observation	Inference
Dry Test:		
1. Noted the colour of salt	White salt	Cu^{2+}, Fe^{2+}, Fe^{3+}, Cr^{3+}, Co^{2+}, Ni^{2+} and Mn^{2+} are absent.
2. Noted the smell of salt	No NH_3 smell	NH_4^+ is absent.
3. Apply flame test	No characteristic flame	Na^+, K^+, Cu^{2+}, Ca^{2+}, Ba^{2+} and Sr^{2+} are absent.
4. Apply filter ash test	No characteristic ash	Sn^{2+}, Al^{3+}, Zn^{2+} and Mg^{2+} are absent.
Wet Tests:		
5. O.S + dilute HCl	White ppt.	Group-I (Ag^+, Hg_2^{2+}, Pb^{2+}) is present.
6. Above ppt. + NH_4OH	ppt. turned black	Hg_2^{2+} is indicated.
Confirmatory Tests:		
7. O.S + $KI_{(sol)}$	Dirty green ppt. (Hg_2I_2)	Hg_2^{2+} is confirmed.
8. O.S + $K_2CrO_{4(sol)}$	Red brown ppt. (Hg_2CrO_4)	Hg_2^{2+} is confirmed.

Result: Basic Radical = Mercurous (Hg_2^{+2})

CHEMICAL REACTIONS:

Test -5: $Hg_2(NO_3)_2 + 2HCl \longrightarrow 2HNO_3 + Hg_2Cl_2 \downarrow$ (white ppt.)

Test -6: $Hg_2Cl_2 + 2NH_4OH \longrightarrow NH_4Cl + Hg(NH_2)Cl + Hg \downarrow + 2H_2O$ (dark grey)

Test -7: $Hg_2(NO_3)_2 + 2KI \longrightarrow 2KNO_3 + 2HgI(Hg_2I_2) \downarrow$ (dirty green)

Test -8: $Hg_2(NO_3)_2 + K_2CrO_4 \longrightarrow 2KNO_3 + Hg_2CrO_4 \downarrow$ (red brown ppt.)

Group-II

Cd^{2+}, Hg^{2+}, Pb^{2+}, Bi^{3+}, Cu^{2+}, As^{3+}, Sb^{3+}, Sn^{2+}

II group ppts. + yellow ammonium sulphide $(NH_4)_2S_x$ + Warm)

Precipitate are insoluble, Group-II A (Cd^{2+}, Hg^{2+}, Pb^{2+}, Bi^{3+}, Cu^{2+})

Precipitate soluble, Group-II B (As^{3+}, Sb^{3+}, Sn^{2+})

GROUP-IIA

- Yellow ppt. insoluble in $(NH_4)_2S_x$. Cd^{2+} is indicated
- Black ppt. insoluble in $(NH_4)_2S_x$. Salt is blue or bluish green Cu^{2+} is indicated
- Black ppt. insoluble in $(NH_4)_2S_x$. Salt is white. May be Hg^{2+}, Bi^{3+}, Pb^{2+}

(Above ppt. + 50% HNO_3) + Boil

- Precipitate insoluble in 50% HNO_3. Hg^{2+} is indicated
- Precipitate soluble in 50% HNO_3. Make two portions
  - 1st portion + dilute H_2SO_4 white ppt. indicated the Pb^{2+}
  - 2nd portion + NH_4OH white ppt. indicated Bi^{3+}

GROUP-IIB

- Pale yellow ppt. soluble in $(NH_4)_2S_x$. Salt is white As^{3+} is indicated.
- Orange ppt. soluble in $(NH_4)_2S_x$. Sb^{3+} is indicated
- Dark brown ppt. soluble in $(NH_4)_2S_x$ Sn^{2+} is indicated

Experiment No-4

Experiment	Observation	Inference
Dry Test:		
1. Noted the colour of salt	White salt	Cu^{2+}, Cr^{3+}, Fe^{2+}, Fe^{3+}, Ni^{2+}, Co^{2+}, Mn^{2+} are absent.
2. Noted the smell of salt	No smell of NH_3	NH_4^+ is absent.
3. Brought paste of salt in HCl over flame with pt. wire	No characteristic flame	Cu^{2+}, Na^+, K^+, Ca^{2+}, Ba^{2+}, Sr^{2+} are absent.
4. Dip a filter paper strip in the solution of salt and $Co(NO_3)_2$. Burn this filter paper	No characteristic ash	Sn^{2+}, Al^{3+}, Zn^{2+}, Mg^{2+} are absent.
Wet Tests:		
5. O.S + dilute HCl	No white ppt.	Group-I (Ag^+, Pb^{2+}, Hg_2^{2+}) absent.
6. O.S + dilute HCl + H_2S gas	A ppt. is formed.	Group-II (Cd^{2+}, Bi^{3+}, Hg^{2+}, Pb^{2+}, Cu^{2+}, As^{3+}, Sb^{3+}, Sn^{2+}) is present.
7. Above ppt. + yellow ammonium sulphide $(NH_4)_2S_x$ + warmed	Precipitate is insoluble	Group-IIA (Cd^{2+}, Hg^{2+}, Bi^{3+}, Cu^{2+}, Pb^{2+}) is indicated.
8. Noted the colour	Yellow ppt. (CdS)	Cd^{2+} is indicated.
Confirmatory Tests:		
9. O.S + $NaOH_{(sol)}$	White ppt. soluble in NH_4OH	Cd^{2+} is confirmed.
10. O.S + $NH_4OH_{(sol)}$	White ppt. soluble in excess of NH_4OH	Cd^{2+} is confirmed.

Result: Basic Radical = Cadmium (Cd^{2+})

CHEMICAL REACTIONS:

Test-6: $CdCl_2 + H_2S \longrightarrow 2HCl + CdS\downarrow$ (yellow ppt.)

Test-9: $CdCl_2 + 2NaOH \longrightarrow Cd(OH)_2\downarrow + 2NaCl$ (white ppt.)

Test-10: $CdCl_2 + 2NH_4OH \longrightarrow Cd(OH)_2\downarrow + 2NH_4Cl$

Experiment No-5

Experiment	Observation	Inference
Dry Test:		
1. Noted the colour of salt	White salt	Cu^{2+}, Cr^{3+}, Fe^{2+}, Fe^{3+}, Ni^{2+}, Co^{2+}, Mn^{2+} are absent.
2. Noted the smell of salt	No NH_3 smell	NH_4^+ is absent.
Flame Tests:		
3. Make the paste of salt with conc. HCl and apply to flame with pt. wire	No characteristic flame	Cu^{2+}, Na^+, K^+, Ca^{2+}, Ba^{2+}, Sr^{2+} are absent.
Filter Ash Tests:		
4. Salt is dissolved in $Co(NO_3)_2$. Dipped a piece of filter paper in this solution and burnt	No characteristic ash	Sn^{2+}, Al^{3+}, Zn^{2+}, Mg^{2+} are absent.
Wet Tests:		
5. O.S + dilute HCl	No ppt.	Group-I (Ag^+, Hg_2^{2+}, Pb^{2+}) absent.
6. O.S + dil. HCl + H_2S gas	ppts formed (black)	Group-II (Cd^{2+}, Cu^{2+}, Bi^{3+}, Hg^{2+}, Pb^{2+}, As^{3+}, Sb^{3+}, Sn^{2+}) present.
7. Above ppt. + yellow ammonium sulphide $(NH_4)_2S_x$ + warm	Precipitates are insoluble	Group-IIA (Cu^{2+}, Cd^{2+}, Bi^{3+}, Hg^{2+}, Pb^{2+}) present.
8. ppt. of test 6 + 50% HNO_3 + boiling	ppt. is insoluble	Hg^{2+} is indicated.
Confirmatory Tests:		
9. O.S + $NaOH_{(sol)}$	Yellow ppt. (HgO)	Hg^{2+} is confirmed.
10. O.S + $KI_{(sol)}$	Red ppt. (HgI_2)	Hg^{2+} is confirmed.
11. O.S + Stannous chloride ($SnCl_{2(sol)}$)	White ppt. (Hg_2Cl_2) turned grey in excess of $SnCl_2$	Hg^{2+} is confirmed.

Result: Basic Radical = Mercuric (Hg^{2+})

CHEMICAL REACTIONS:

Test -6: $HgCl_2 + H_2S \longrightarrow 2HCl + HgS\downarrow$ (black ppt.)

Test -9: $HgCl_2 + 2NaOH \longrightarrow 2NaCl + H_2O + HgO\downarrow$ (yellow ppt.)

Test -10: $HgCl_2 + 2KI \longrightarrow 2KCl + HgI_2\downarrow$ (red ppt.)

Test -11: $HgCl_2 + SnCl_2 \longrightarrow Hg_2Cl_2\downarrow + SnCl_4$ (white)

$HgCl_2 + SnCl_2 \longrightarrow SnCl_4 + 2Hg\downarrow$ (grey)

EXPERIMENT No. 6

Experiment	Observation	Inference
Dry Test:		
1. Noted the colour of salt	White salt	Cu^{2+}, Cr^{3+}, Fe^{2+}, Fe^{3+}, Ni^{2+}, Co^{2+}, Mn^{2+} are absent.
2. Noted the smell of salt	No smell of NH_3	NH_4^+ is absent.
Flame Test:		
3. Made the paste of salt with conc. HCl and performed flame test with pt. wire **Filter Ash Test:**	No characteristic flame	Na^+, K^+, Cu^{2+}, Ca^{2+}, Ba^{2+}, Sr^{2+} are absent.
4. Dipped a filter paper strip in salt and $Co(NO_3)_2$ solution and burnt it on flame.	No characteristic ash	Sn^{2+}, Al^{3+}, Mg^{2+}, Zn^{2+} are absent.
Wet Tests:		
5. O.S + dilute HCl	No ppt.	Group-I (Ag^+, Hg_2^{2+}, Pb^{2+}) is absent.

6. O.S + dil. $HCl + H_2S$	Black ppt.	Group-II (Cd^{2+}, Cu^{2+}, Bi^{3+}, Hg^{2+}, Pb^{2+}, Sn^{2+}, As^{3+}, Sb^{3+}) present.
7. Above ppt. + yellow ammonium sulphide $(NH_4)_2S_x$ + warm	ppt. is insoluble	Group-IIA (Cu^{2+}, Cd^{2+}, Hg^{2+}, Pb^{2+}, Bi^{3+}) is present.
8. ppt. of test 6 + 50% HNO_3 and boil	ppt is soluble	May be Pb^{2+} or Bi^{3+}.
9. A portion of test 8 solution + dil. H_2SO_4	No white ppt.	Pb^{2+} is absent.
10. 2^{nd} portion of test 8 solution + NH_4OH	A white ppt. is formed.	Bi^{3+} is indicated.
Confirmatory Tests:		
11. O.S + Sodium stanite ($SnCl_2$: NaOH) (1 : 1)	Black ppt.	Bi^{3+} is confirmed.
12. O.S + $NaOH_{(sol)}$	White ppt. soluble in excess	Bi^{3+} is confirmed.
13. O.S + dil. HCl + excess water	Milk like white colour (BiOCl) →	Bi^{3+} is confirmed.

Result: Basic Radical = Bismuth (Bi^{3+})

CHEMICAL REACTIONS:

Test -6: $2Bi(NO_3)_3 + 3H_2S \longrightarrow 6HNO_3 + Bi_2S_3 \downarrow$ (black ppt.)

Test -9: $Bi(NO_3)_2 + H_2SO_4 \longrightarrow$ No reaction

Test -10: $Bi(NO_3)_3 + 3NH_4OH \longrightarrow 3NH_4NO_3 + Bi(OH)_3 \downarrow$ (white ppt.)

Test -11: $2Bi(NO_3)_3 + 3Na_2SnO_2 + 6NaOH \longrightarrow 3Na_2SnO_3 + 6NaNO_3 + 3H_2O + 2Bi$ (black ppt.)

Test -12: $Bi(NO_3)_3 + 3NaOH \longrightarrow 3NaNO_3 + Bi(OH_3) \downarrow$ (white ppt.)

Test -13: $Bi(NO_3)_3 + 3HCl \longrightarrow 3HNO_3 + BiCl_3$

$2BiCl_3 + 2H_2O \longrightarrow 4HCl + 2BiOCl$ (artificial milk)

Experiment No-7

Experiment	Observation	Inference
Dry Test:		
1. Noted the colour of salt	White salt	Cu^{2+}, Cr^{3+}, Fe^{2+}, Fe^{3+}, Ni^{2+}, Co^{2+}, Mn^{2+} are absent.
2. Noted the smell of salt	No smell of NH_3	NH_4^+ is absent.
Flame Test:		
3. Made the paste of salt with conc. HCl and burn this paste on flame with pt. wire	No characteristic flame	Na^+, K^+, Cu^{2+}, Ca^{2+}, Ba^{2+}, Sr^{2+} are absent.
Filter Ash Test:		
4. Dipped a filter paper strip in a solution of salt and cobalt nitrate and burnt it	No characteristic ash	Sn^{2+}, Al^{3+}, Mg^{2+} and Zn^{2+} are absent.
Wet Tests:		
5. O.S + dilute HCl	No ppt.	Group-I (Ag^+, Hg_2^{2+}, Pb^{2+}) is absent.
6. O.S + dil. HCl + H_2S gas	Black ppt.	Group-II (Cd^{2+}, Bi^{3+}, Hg_2^{2+} Pb^{2+}, Cu^{2+}, As^{3+}, Sb^{3+}) present.
7. Above ppt. + yellow ammonium sulphide $(NH_4)_2S_x$ and warm	ppts are insoluble	Group-IIA (Cu^{2+}, Cd^{2+}, Pb^{2+}, Hg^{2+}, Bi^{3+}) present.
8. ppt. of test 6 + 50% HNO_3 and boil	ppt. are soluble	May be Bi^{3+} or Pb^{2+}.
9. One portion of test 8 solution + $NH_4OH_{(excess)}$	No white ppt.	Bi^{3+} is absent.
10. Second portion of test 8 solution + dilute H_2SO_4	A white ppt. is formed	Pb^{2+} is indicated.
Confirmatory Tests:		
11. O.S + $KI_{(sol)}$	Bright yellow ppt. (PbI_2)	Pb^{2+} is confirmed.
12. O.S + $K_2CrO_{4(sol)}$	Yellow ppt. ($PbCrO_4$)	Pb^{2+} is confirmed.
13. O.S + $Na_2S_{(sol)}$	Black ppt. (PbS)	Pb^{2+} is confirmed.

Result: Basic Radical = Lead (Pb^{2+})

CHEMICAL REACTIONS:

Test-6: $PbCl_2 + H_2S \longrightarrow 2HCl + PbS\downarrow$ (black ppt.)

Test-10: $Pb(NO_3)_2 + H_2SO_4 \longrightarrow 2HNO_3 + PbSO_4\downarrow$ (white ppt.)

Test-11: $Pb(NO_3)_2 + 2KI \longrightarrow 2KNO_3 + PbI_2\downarrow$ yellow ppt.)

Test-12: $Pb(NO_3)_2 + K_2Cr_2O_4 \longrightarrow 2KNO_3 + PbCrO_4\downarrow$ (yellow ppt.)

Test-13: $Pb(NO_3)_2 + Na_2S \longrightarrow 2NaNO_3 + PbS\downarrow$ (black ppt.)

EXPERIMENT No-8

Experiment	Observation	Inference
Dry Test:		
1. Noted the colour of salt	Blue salt	May be Cu^{2+}.
2. Noted the smell of salt	No smell of NH_3	NH_4^+ is absent.
Flame Test:		
3. Made a paste of salt with conc. HCl and burnt it on flame with pt. wire	Bluish green flame	Cu^{2+} is indicated.
4. Dipped a filter paper strip in salt and $Co(NO_3)_2$ solution and burnt it	No characteristic ash	Sn^{2+}, Al^{3+}, Mg^{2+} and Zn^{2+} absent.
Wet Tests:		
5. O.S + dil. HCl	No ppt.	Group-I (Ag^+, Hg_2^{2+}, Pb^{2+}) is absent.
6. O.S + dil. HCl + H_2S gas	Black ppt.	Group-II (Cd^{2+}, Hg^{2+}, Pb^{2+}, Bi^{3+}, Cu^{2+}, Sn^{2+}, Sb^{3+}, As^{3+})
7. Above ppt. + $(NH_4)_2S_x$ and warm	Precipitates are insoluble	Group-IIA (Cu^{2+}, Cd^{2+}, Hg^{2+}, Pb^{2+}, Bi^{3+}) present.
8. Noted the colour of salt and ppt.	Precipitates are black but salt is blue	Cu^{2+} is indicated.
Confirmatory Tests:		
9. O.S + $NaOH_{(sol)}$	Blue ppt. turned black on heating	Cu^{2+} is confirmed.
10. O.S + potassium ferrocyanide $K_4[Fe(CN)_6]_{(sol)}$	Chocolate red ppt.	Cu^{2+} is confirmed.

Result: Basic Radical = Copper (Cu^{2+})

CHEMICAL REACTIONS:

Test -6: $CuSO_4 + H_2S \longrightarrow H_2SO_4 + CuS \downarrow$
(black ppt.)

Test -9: $CuSO_4 + 2NaOH \longrightarrow Na_2SO_4 + Cu(OH)_2 \downarrow$
(blue ppt.)

Test -10: $CuSO_4 + K_4[Fe(CN)_6] \longrightarrow 2K_2SO_4 + Cu_2[Fe(CN)_6] \downarrow$
pot. ferrocyanide (chocolate red)

Experiment No-9

Experiment	Observation	Inference
Dry Test:		
1. Noted the colour of salt	White salt	Cu^{2+}, Cr^{3+}, Fe^{2+}, Fe^{3+}, Ni^{2+}, Co^{2+}, Mn^{2+} are absent.
2. Noted the smell of salt	No smell of NH_3	NH_4^+ is absent.
Flame Test:		
3. Made a paste of salt with conc. HCl and burn it on the flame with pt. wire	No characteristic flame	Na^+, K^+, Cu^{2+}, Ca^{2+}, Ba^{2+}, Sr^{2+} are absent.
Filter Ash Test:		
4. Dipped a filter paper strip in the solution of salt and cobalt nitrate $Co(NO_3)_2$. Burnt that strip and noted the ash	No characteristic colour of ash	Sn^{2+}, Al^{3+}, Zn^{2+}, Mg^{2+} are absent.
Wet Tests:		
5. O.S + dilute HCl	No precipitates	Group-I (Ag^+, Pb^{2+}, Hg_2^{2+}) is absent.
6. O.S + dil. HCl + H_2S gas	Precipitates of orange colour	Group-II (Cd^{2+}, Hg^{2+}, Pb^{2+}, Bi^{3+}, Cu^{2+}, Sn^{2+}, Sb^{3+}, As^{3+}) is present.
7. Above orange ppt. + $(NH_4)_2S_x$ + Heat	Precipitates are soluble	Group-IIB (Sn^{2+}, As^{3+}, Sb^{3+}) is present.
8. Noted the colour of precipitates	Orange ppt.	Sb^{3+} is indicated.

Confirmatory Tests:		
9. O.S + dilute HCl + Tin(Sn) foil	Black velvety deposit over tin.	Sb^{3+} is confirmed.
10. O.S + $NaOH_{(sol)}$	White ppt. $Sb(OH)_3$	Sb^{3+} is confirmed.
11. O.S + HCl + $H_2O_{(excess)}$	White ppt. (SbOCl) soluble in tartaric acid	Sb^{3+} is confirmed.

Result: Basic Radicals = Antimony (Sb^{3+})

CHEMICAL REACTIONS:

Test -6: $2SbCl_3 + 3H_2S \longrightarrow 6HCl + Sb_2S_3 \downarrow$ (orange ppt.)

Test -9: $2SbCl_3 + 3Sn \longrightarrow 3SnCl_2 + 2Sb$ (black ppt.)

Test -10: $SbCl_3 + 3NaOH \longrightarrow 3NaCl + Sb(OH)_3 \downarrow$ (white ppt.)

Test -11: $SbCl_3 + H_2O \longrightarrow 2HCl + SbOCl \downarrow$ (white ppt.)

Experiment No-10

Experiment	Observation	Inference
Dry Test:		
1. Noted the colour of salt	White salt	Cu^{2+}, Cr^{3+}, Fe^{2+}, Fe^{3+}, Ni^{2+}, Co^{2+}, Mn^{2+} are absent.
2. Noted the smell of salt	No smell of ammonia (NH_3)	NH_4^+ is absent.
Flame Test:		
3. Made a paste of salt with conc. HCl and burnt on the flame with pt. wire	No characteristic flame	Na^+, K^+, Cu^{2+}, Ca^{2+}, Ba^{2+}, Sr^{2+} are absent.
Filter Ash Test:		
4. Dipped a filter paper strip in a solution of salt and $Co(NO_3)_2$. Burnt filter paper strip.	No characteristic ash	Sn^{2+}, Al^{3+}, Mg^{2+}, Zn^{2+} are absent.
Wet Tests:		
5. O.S + dilute HCl	No precipitates	Group-I (Ag^+, Hg_2^{2+}, Pb^{2+}) is absent.
6. O.S + dil. HCl + $H_2S_{(gas)}$	Dirty yellow ppt. are formed	Group-II (Cd^{2+}, Hg^{2+}, Pb^{2+}, Bi^{3+}, Cu^{2+}, Sn^{2+}, Sb^{3+}, As^{3+}) is present.
7. Above ppt. + yellow ammonium sulphide $(NH_4)_2S_x$ + Heat	Precipitates are dissolved	Group-IIB (As^{3+}, Sb^{3+}, Sn^{2+}) is present.
8. Noted the colour of precipitates	Dirty yellow	As^{3+} is indicated.
Confirmatory Tests:		
9. O.S + $NaOH_{(sol)}$	White ppt. $As(OH)_3$ soluble in excess of reagent	As^{3+} is confirmed.
10. O.S + $KI_{(sol)}$	Yellow colour or ppt.	As^{3+} is confirmed.

Result: Basic Radical = Arsenic (As^{3+})

CHEMICAL REACTIONS:

Test -6: $2AsCl_3 + 3H_2S \longrightarrow 6HCl + As_2S_3 \downarrow$ (dirty yellow ppt.)

Test -9: $AsCl_{3(aq)} + 3NaOH_{(aq)} \longrightarrow 3NaCl_{(aq)} + As(OH)_3 \downarrow$ (white ppt.)

Test -10: $AsCl_{3(aq)} + 3KI_{(aq)} \longrightarrow 3KCl + AsI_3 \downarrow$ (yellow ppt.)

Experiment No-11

Experiment	Observation	Inference
Dry Test:		
1. Noted the colour of salt	Salt is white	Cu^{2+}, Cr^{3+}, Fe^{2+}, Fe^{3+}, Ni^{2+}, Co^{2+}, Mn^{2+} are absent.
2. Noted the smell of salt	No smell of ammonia (NH_3)	NH_4^+ is absent.
Flame Test:		
3. Made a paste of salt with conc. HCl and burnt it on flame with platinum wire	No characteristic flame	Na^+, K^+, Cu^{2+}, Ca^{2+}, Ba^{2+}, Sr^{2+} are absent.
Filter Ash Test:		
4. Dipped a filter paper strip in a solution of salt and $Co(NO_3)_2$ and burnt this strip on flame	Bluish green ash is formed	Sn^{2+} is indicated.
Wet Tests:		
5. O.S + dilute HCl	No precipitates	Group-I (Ag^+, Hg_2^{2+}, Pb^{2+}) is present.
6. O.S + dil. HCl + $H_2S_{(gas)}$	Brown ppt.	Group-II (Cd^{2+}, Bi^{3+}, Pb^{2+}, Hg^{2+}, Cu^{2+}, Sn^{2+}, As^{3+}, Sb^{3+}) is present.
7. Above ppt. + $(NH_4)_2S_x$ and heat	Precipitates are dissolved	Group-IIB (As^{3+}, Sn^{2+}, Sb^{3+}) present.
8. Noted the colour of precipitates	Dark brown ppt.	Sn^{2+} is indicated.
Confirmatory Tests:		
9. O.S + $NaOH_{(sol)}$	White ppt. $Sn(OH)_2$ soluble in excess of NaOH	Sn^{2+} is confirmed.
10. O.S + $HgCl_{2(sol)}$	White ppt. (Hg_2Cl_2) which turn grey in excess of $HgCl_2$	Sn^{2+} is conformed.

Result: Basic Radical = Stannous (Sn^{2+})

CHEMICAL REACTIONS:

Test -6: $SnCl_2 + H_2S \longrightarrow 2HCl + SnS \downarrow$ (brown ppt.)

Test -9: $SnCl_2 + 2NaOH \longrightarrow Sn(OH)_2 \downarrow + 2NaCl$ (white ppt.)

Test -10: $SnCl_2 + 2HgCl_2 \longrightarrow SnCl_4 + Hg_2Cl_2 \downarrow$ (white ppt.)

$Hg_2Cl_2 + SnCl_2 \longrightarrow SnCl_4 + 2Hg \downarrow$ (grey)

Viva Voce

1. The chemicals which helps in distinguishing a set of radicals from the other radicals are called **group reagent**.
2. AgCl becomes soluble in excess NH_4OH due to **complex $[Ag(NH_3)_2]Cl$** formation.
3. AgCl, $PbCl_2$ and Hg_2Cl_2 are three insoluble chlorides
4. Concentrated HCl cannot be used as group reagent in Group -I because $PbCl_2$ is soluble in concentrated HCl.
5. Yellow ammonium sulphide is $(NH_4)_2S_x$. It contain free sulphur in it which is **yellow**.
6. Dilute HCl is added before passing H_2S gas for detection of Group -II radicals to suppress the ionization of H_2S **(common ion effect)**

$$HCl \rightleftharpoons H^+ + Cl^-$$
$$H_2S \rightleftharpoons 2H^+ + S^{2-}$$

suppression of ionization — **common ions**

In this way sulphides of IV groups are not formed.

7. $CuSO_4 . 5H_2O$ is called **blue vitriol**.
8. BiOCl (Bismuth oxychloride) is called **artificial milk**.

Q: Why $AgNO_3$ in kept an Coloured bottles?

Ans: $AgNO_3$ decomposes to its oxide in direct sunlight.
Therefor to avoide decomposition it is stored in coloured bottles.

Group-III

$(Al^{3+}Fe^{2+}, Fe^{3+}, Cr^{3+})$

GROUP REAGENT:

O.S + $NH_4Cl_{(s)}$ + boil + cool + NH_4OH in excess

- White gelatinous ppt. of $Al(OH)_3$ → Al^{3+} is indicated
- Reddish brown ppt. of $Fe(OH)_3$ → May be Fe^{2+} or Fe^{3+}. If salt is light green → Fe^{2+}
- Dirty green ppt. of $Cr(OH)_3$ → Cr^{3+} is indicated

If salt is yellow / brown = Fe^{3+}

Note:

If the salt is light green, conc. HNO_3 will be added and boiled before the addition of NH_4Cl. Nitric acid is added to oxidise Fe^{2+} ions. If Fe^{2+} is not oxidized to Fe^{3+}, then it is not precipitated in Group-III because the solubility of $Fe(OH)_2$ is very high.

Hint:

After the absence of Group -I and II, make original solution and add some NaOH solution in it. If precipitate is formed, Group III, IV, V and Mg^{2+} of Group VI are present. If no ppt. is formed, the basic radical will be Na^+, K^+ or NH_4^+.

Experiment No-12

Experiment	Observation	Inference
Dry Test:		
1. Noted the colour of salt	Light green salt	May be Fe^{2+}.
2. Noted the smell of salt	No smell of ammonia (NH_3)	NH_4^+ is absent.
Flame Test:		
3. Made a paste of salt with conc. HCl and burnt it on flame with pt. wire	No characteristic flame	Na^+, K^+, Cu^{2+}, Ca^{2+}, Ba^{2+}, Sr^{2+} are absent.
Filter Ash Test:		
4. Dipped a filter paper strip in $Co(NO_3)_2$ solution with salt. Burnt it and noted the ash	No characteristic ash	Sn^{2+}, Al^{3+}, Mg^{2+}, Zn^{2+} are absent.
Wet Tests:		
5. O.S + dilute HCl	No ppt.	Group-I (Ag^+, Hg_2^{2+}, Pb^{2+}) is absent.
6. O.S + dil. HCl + H_2S gas gas	No ppt.	Group-II (Cd^{2+}, Hg^{2+}, Pb^{2+}, Bi^{3+}, Cu^{2+}, As^{3+}, Sb^{3+}, Sn^{2+}) is absent.
7. O.S + conc. HNO_3 + $NH_4Cl_{(s)}$ + boil + cool NH_4OH in excess	Red brown ppt. $Fe(OH)_3$	Group-III (Fe^{2+}, Fe^{3+}, Cr^{3+}, Al^{3+}) is present.
8. Noted the colour of salt and ppt.	Salt is light green, ppt. are red brown	Fe^{2+} is indicated.
Confirmatory Tests:		
9. O.S + $NaOH_{(sol)}$	Green ppt. $Fe(OH)_2$	Fe^{2+} is confirmed.
10. O.S + Pot. ferricyanide $K_3[Fe(CN)_6]_{(sol)}$	Deep blue ppt. $Fe_3[Fe(CN)_6]_2$	Fe^{2+} is confirmed.
11. O.S + $Na_2CO_{3(sol)}$	Greenish white ppt. ($FeCO_3$)	Fe^{2+} is confirmed.

CHEMICAL REACTIONS:

Result: Basic Radical = Ferrous (Fe^{2+})

Test -7:
$$6FeSO_4 + 2HNO_3(conc.) + 3H_2SO_4 \longrightarrow 3Fe_2(SO_4)_3 + 2NO + 4H_2O$$
$$Fe_2(SO_4)_3 + 6NH_4OH \longrightarrow 3(NH_4)_2SO_4 + 2Fe(OH)_3\downarrow$$
(red brown ppt.)

Test -9:
$$FeSO_4 + 2NaOH \longrightarrow Na_2SO_4 + Fe(OH)_2\downarrow$$
(green ppt.)

Test -10:
$$3FeSO_4 + 2K_3[Fe(CN)_6]_{(sol)} \longrightarrow Fe_3[Fe(CN_6]_2 + 3K_2SO_4$$
pot. ferricyanide — deep blue colour

Test -11:
$$FeSO_4 + Na_2CO_{3(sol)} \longrightarrow FeCO_3\downarrow + Na_2CO_3$$
(green dish white ppt.)

Experiment No-13

Experiment	Observation	Inference
Dry Test:		
1. Noted the colour of salt	Brownish yellow salt	May be Fe^{3+}.
2. Noted the smell of salt	No smell of NH_3	NH_4^+ is absent.
Flame Test:		
3. Made a paste of salt with conc. HCl and burnt it on the flame with pt. wire	No characteristic flame	Na^+, K^+, Cu^{2+}, Ca^{2+}, Ba^{2+}, Sr^{2+} are absent.
Filter Ash Test:		
4. Dipped a filter paper strip in salt and $Co(NO_3)_2$ solution and burnt it.	No characteristic ash	Sn^{2+}, Al^{3+}, Mg^{2+}, Zn^{2+} are absent.
Wet Tests:		
5. O.S + dilute HCl	No ppt.	Group-I (Ag^+, Hg_2^{2+}, Pb^{2+}) is absent.
6. O.S + dil. HCl + H_2S gas	No ppt.	Group-II (Cd^{2+}, Bi^{3+}, Hg^{2+}, Pb^{2+}, Cu^{2+}, Sn^{2+}, As^{3+}, Sb^{3+}) is present.
7. O.S + $NH_4Cl_{(s)}$ + boil + cool + NH_4OH in excess	Red brown ppt.	Group-III (Fe^{2+}, Fe^{3+}, Cr^{3+} Al^{3+}). May be Fe^{2+} or Fe^{3+}.
8. Noted the colour of salt and ppt.	Salt is brownish yellow, ppt. are red brown	Fe^{3+} is indicated.
Confirmatory Tests:		
9. O.S + $NaOH_{(sol)}$	Red brown ppt. $Fe(OH)_3$	Fe^{3+} is confirmed.
10. O.S + Ammonium sulphocyanide $NH_4SCN_{(sol)}$	Blood red ppt. $Fe(SCN)_3$.	Fe^{3+} is confirmed.
11. O.S + pot. ferrocyanide $K_4[Fe(CN)_6]_{(sol)}$	Deep blue ppt.	Fe^{3+} is confirmed.

Result: Basic Radical = Ferric (Fe^{3+})

CHEMICAL REACTIONS.

Test -7: $FeCl_3 + 3NH_4OH \longrightarrow 3NH_4Cl + Fe(OH)_3 \downarrow$
(red brown ppt.)

Test -9: $FeCl_3 + 3NaOH \longrightarrow 3NaCl + Fe(OH)_3 \downarrow$

Test -10: $FeCl_3 + 3NH_4SCN \longrightarrow 3NH_4Cl + Fe(SCN)_3 \downarrow$
ammonium sulphocyanide (blood red ppt.)

Test -11: $4FeCl_3 + 3K_4[Fe(CN)_6] \longrightarrow Fe_4[Fe(CN)_6]_3 + 12KCl$
(deep blue)

Experiment No-14

Experiment	Observation	Inference
Dry Test:		
1. Noted the colour of salt	Dark green colour	May be Cr^{3+} or Ni^{2+}.
2. Noted the smell of salt	No smell of NH_3	NH_4^+ is absent.
Flame Test:		
3. Make a paste of salt with conc. HCl and burnt it an flame with pt. wire	No characteristic flame	Na^+, K^+, Cu^{2+}, Ca^{2+}, Ba^{2+}, Sr^{2+} are absent.
Filter Ash Test:		
4. Dipped a filter paper strip in a solution of salt and $Co(NO_3)_2$ and burnt it.	No characteristic ash	Sn^{2+}, Al^{3+}, Mg^{2+}, Zn^{2+} are absent.
Wet Tests:		
5. O.S + dilute HCl	No precipitates	Group-I (Ag^+, Hg_2^{2+}, Pb^{2+}) is absent.
Wet Tests:		
6. O.S + dilute Hcl + H_2S gas	No precipitates	Group-II (Cd^{2+}, Bi^{3+}, Hg^{2+}, Pb^{2+}, Cu^{2+}, Sn^{2+}, As^{3+}, Sb^{3+}) is present.
7. O.S + $NH_4Cl_{(s)}$ + boil + cool + $NH_4OH_{(excess)}$	Dirty green precipitates	Group-III (Fe^{2+}, Fe^{3+}, Cr^{3+}, Al^{3+}) is present.
8. Noted the colour of salt and ppt.	Dark green salt, dirty green ppt.	Cr^{3+} is indicated.
Confirmatory Tests:		
9. O.S + $NaOH_{(sol)}$	Green ppt. $Cr(OH)_3$	Cr^{3+} is confirmed.
10. O.S + Disodium hydrogen phosphate $Na_2HPO_{4(sol)}$	Green ppt. $CrPO_4$	Cr^{3+} is confirmed.

Result: Basic Radical = Chromium (Cr^{3+})

CHEMICAL REACTIONS:

Test -7: $CrCl_3 + 3NH_4OH \longrightarrow 3NH_4Cl + Cr(OH)_3 \downarrow$ (green ppt.)

Test -9: $CrCl_3 + 3NaOH \longrightarrow 3NaOH + Cr(OH)_3$

Test -10: $CrCl_3 + Na_2HPO_4 \longrightarrow 2NaCl + HCl + CrPO_4 \downarrow$ (green ppt.)

Experiment No-15

Experiment	Observation	Inference
Dry Test:		
1. Noted the colour of salt	White salt	Cu^{2+}, Cr^{3+}, Fe^{2+}, Fe^{3+}, Ni^{2+}, Co^{2+}, Mn^{2+} are absent.
2. Noted the smell of salt	No smell of NH_3	NH_4^+ is absent.
Flame Test:		
3. Made a paste of salt with conc. HCl and burnt it on flame with pt. wire	No characteristic flame	Na^+, K^+, Cu^{2+}, Ca^{2+}, Ba^{2+}, Sr^{2+} are absent.
Filter Ash Test:		
4. Dipped a filter paper strip in a solution of salt and $Co(NO_3)_2$ and burnt it.	Blue ash	May be Al^{3+}.
Wet Tests:		
5. O.S + dilute HCl	No precipitates	Group-I (Ag^+, Hg_2^{2+}, Pb^{2+}) is absent.
6. O.S + dil. HCl + H_2S gas	No precipitates	Group-II (Cd^{2+}, Bi^{3+}, Hg^{2+}, Pb^{2+}, Cu^{2+}, Sn^{2+}, As^{3+}, Sb^{3+}) is absent.
7. O.S + $NH_4Cl_{(s)}$ + boil + cool + $NH_4OH_{(excess)}$	Gelatinous white ppt.	Group-III (Fe^{2+}, Fe^{3+}, Cr^{3+}, Al^{3+}) is present.
8. Noted the colour of salt and of precipitates	White salt and white gelatinous precipitates	Al^{3+} is indicated.
Confirmatory Tests:		
9. O.S + $NaOH_{(sol)}$	White gelatinous ppt. soluble in excess NaOH	Al^{3+} is confirmed.
10. O.S + $Na_3PO_{4(sol)}$	White ppt. ($AlPO_4$)	Al^{3+} is confirmed.
11. Lake Test:		
O.S + few drops of litmus solution + dil. HCl + NH_4OH	Blue precipitates float over colourless solution	Al^{3+} is confirmed.

Result: Basic Radical = Aluminium (Al^{3+})

CHEMICAL REACTIONS :

Test -7: $Al_2(SO_4)_3 + 6NH_4OH \longrightarrow 3(NH_4)_2SO_4 + 2Al(OH)_3 \downarrow$ (white ppt.)

Test -9: $Al_2(SO_4)_3 + 6NaOH \longrightarrow 3Na_2SO_4 + 2Al(OH)_3 \downarrow$

$Al(OH)_3 + NaOH \longrightarrow NaAlO_2 + 2H_2O$ (soluble)

Test -10: $Al_2(SO_4)_3 + 2Na_3PO_4 \longrightarrow 3Na_2SO_4 + 2AlPO_4 \downarrow$ (white ppt.)

VIVA VOCE

Distinction between Fe^{2+} and Fe^{3+}:

1. Ferrous (Fe^{2+}) salts are light green whereas ferric (Fe^{3+}) salts are brownish yellow.
2. Fe^{2+} gives green ppt. with NaOH solution whereas Fe^{3+} gives brownish yellow ppt.
3. Fe^{2+} gives blue ppt. with potassium ferricyanide whereas Fe^{3+} gives blue ppt. with pot. ferrocyanide.
4. After boiling with NH_4Cl, cool and add excess of NH_4OH solution as group reagent in Group III. NH_4Cl **suppresses the ionization of NH_4OH** by common ion effect so that Group IV and V radicals are not precipitated as hydroxide.

$NH_4Cl \rightleftharpoons NH_4^+ + Cl^-$

$NH_4OH \rightleftharpoons NH_4^+ + OH^-$

supression of ionization — common ions

5.

(i)	Blue vitriol	$CuSO_4 . 5H_2O$
(ii)	Green vitriol	$FeSO_4 . 7H_2O$
(iii)	Potash alum	$K_2SO_4 . Al_2(SO_4)_3 . 24H_2O$
(iv)	Mohr's salt	$FeSO_4 . (NH_4)_2SO_4 . 6H_2O$
(v)	Potassium ferrocyanide	$K_4[Fe(CN)_6]$
(vi)	Potassium ferricyanide	$K_3[Fe(CN)_6]$
(vii)	Ammonium sulphocyanide	NH_4SCN

Group-IV

GROUP REAGENT: $(Ni^{2+}, Co^{2+}, Zn^{2+} Mn^{2+})$

O.S + $NH_4Cl_{(solid)}$ + boil + cool + $NH_4OH_{(excess)}$ + $H_2S_{(gas)}$

- **Black ppt.**
  - **Dark pink salt is indicated** → Co^{2+} is indicated
  - **Black precipitates, salt is green** → Ni^{2+} is indicated
- **White precipitates** → Zn^{2+} is indicated
- **Flesh or buff colour precipitate** → Mn^{2+} is indicated

Experiment No-16

Experiment	Observation	Inference
Dry Test:		
1. Noted the colour of salt	Dark green Bright green	May be Cr^{3+} or Ni^{2+}.
2. Noted the smell of salt	No smell of NH_3	NH_4^+ is absent.
Flame Test:		
3. Made a paste of salt with conc. HCl and burnt it on flame with pt. wire	No characteristic flame	Na^+, K^+, Cu^{2+}, Ca^{2+}, Ba^{2+}, Sr^{2+} are absent.
Filter Ash Test:		
4. Dipped a filter paper strip in a solution of salt and $Co(NO_3)_2$. Burnt it on flame	No characteristic ash	Sn^{2+}, Al^{3+}, Mg^{2+}, Zn^{2+} are absent.
Wet Tests:		
5. O.S + dilute HCl	No precipitates	Group-I (Ag^+, Hg^{2+}, Pb^{2+}) is absent.
6. O.S + dil. HCl + H_2S gas	No precipitates	Group-II (Cd^{2+}, Hg^{2+}, Bi^{3+}, Pb^{2+}, Cu^{2+}, Sn^{2+}, As^{3+}, Sb^{3+}) is absent.
7. O.S + $NH_4Cl_{(s)}$ + boil + cool + NH_4OH	No precipitates	Group-III (Fe^{2+}, Fe^{3+}, Cr^{3+}, Al^{3+}) absent.
8. O.S + $NH_4Cl_{(s)}$ + boil + cool + $NH_4OH_{(excess)}$ + $H_2S_{(gas)}$	Black precipitates	Group-IV (Ni^{2+}, Co^{2+}, Mn^{2+}, Zn^{2+}) is present.
9. Noted the colour of salt and ppt.	Salt is dark green, ppt. are black Bright	Ni^{2+} is indicated.
Confirmatory Tests:	Bright	
10. O.S + $NaOH_{(sol)}$	Dark green ppt. $Ni(OH)_2$	Ni^{2+} is confirmed.
DMG Test:		
11. O.S + NH_4OH + Dimethyl glyoxime (DMG) solution	Rose red ppt.	Ni^{2+} is confirmed.

Result: Basic Radical = Nickle (Ni^{2+})

Experiment No-17

Experiment	Observation	Inference
Dry Test:		
1. Noted the colour of salt	Dark pink	May be Co^{2+}.
2. Noted the smell of salt	No smell of NH_3	NH_4^+ is absent.
Flame Test:		
3. Made a paste of salt with conc. HCl and burnt it on flame with pt. wire	No characteristic flame	Na^+, K^+, Cu^{2+}, Ca^{2+}, Ba^{2+}, Sr^{2+} are absent.
Filter Ash Test:		
4. Dipped a filter paper strip in a solution of salt and $Co(NO_3)_2$ and burnt	No characteristic ash	Sn^{2+}, Al^{3+}, Zn^{2+}, Mg^{2+} are absent.
Wet Tests:		
5. O.S + dilute HCl	No precipitates	Group-I (Ag^+, Hg_2^{2+}, Pb^{2+}) is absent.
6. O.S + dil. HCl + $H_2S_{(gas)}$	No precipitates	Group-II (Cd^{2+}, Bi^{3+}, Pb^{2+}, Hg^{2+}, Cu^{2+}, Sn^{2+}, Sb^{3+}, As^{3+}) is absent.
7. O.S + $NH_4Cl_{(s)}$ + boil + cool + $NH_4OH_{(excess)}$	No precipitates	Group-III (Fe^{2+}, Fe^{3+}, Cr^{3+}, Al^{3+}) absent.
8. O.S + $NH_4Cl_{(s)}$ + boil + cool + $NH_4OH_{(excess)}$ + $H_2S_{(gas)}$	Black precipitates	Group-IV (Ni^{2+}, Co^{2+}, Mn^{2+}, Zn^{2+}) is present.
9. Noted the colour of salt and ppt.	Salt is dark pink and ppt. are black	Co^{2+} is indicated.
Confirmatory Tests:		
10. O.S + $NaOH_{(sol)}$	Violet ppt. $Co(OH)_2$	Co^{2+} is confirmed.
11. O.S + dil. CH_3COOH + $KNO_{2(solid)}$ + Heat	Bright yellow ppt. $K_3[Co(NO_2)_6]$	Co^{2+} is confirmed.
12. O.S + $Na_2HPO_{4(sol)}$	Violet ppt. $Co_3(PO_4)_2$	Co^{2+} is confirmed.

Result: Basic Radical = Cobalt (Co^{2+})

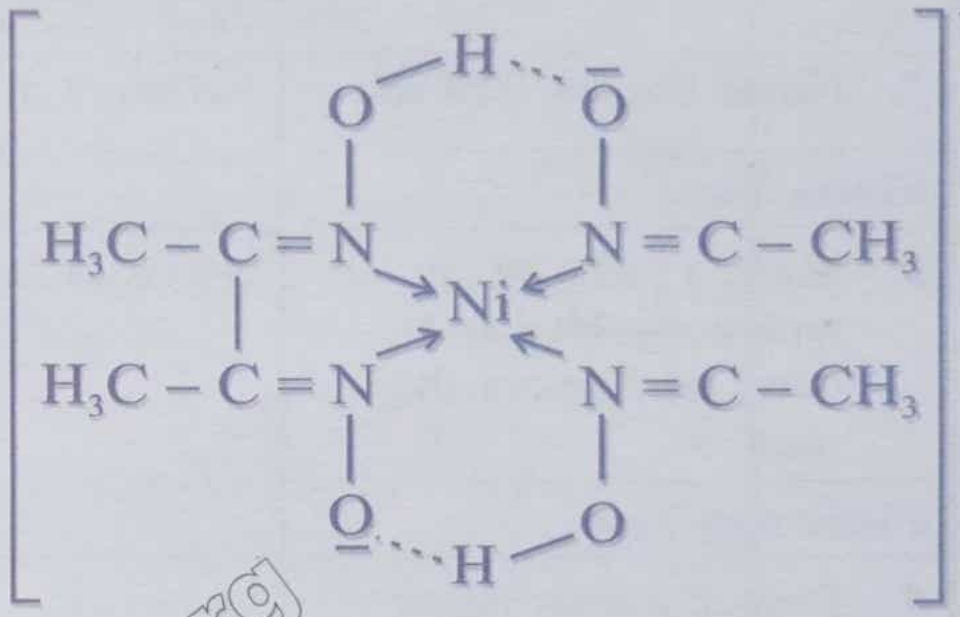
CHEMICAL REACTIONS:

For Nickle Ni^{2+})

Test -8: $NiCl_2 + H_2S \longrightarrow 2HCl + NiS\downarrow$
(black ppt.)

Test -10: $NiCl_2 + 2NaOH \longrightarrow 2NaCl + Ni(OH)_2\downarrow$
(green ppt.)

Test-11: $NiCl_2 + 2NH_4OH + \begin{matrix} CH_3C = NOH \\ | \\ CH_3C = NOH \end{matrix} \longrightarrow$



CHEMICAL REACTIONS:

(For Cobalt Co^{2+})

Test -8: $CoCl_2 + H_2S \longrightarrow 2HCl + CoS\downarrow$
(black ppt.)

Test -10: $CoCl_2 + 2NaOH \longrightarrow 2NaCl + Co(OH)_2\downarrow$
(violet ppt.)

Test -11: $CoCl_2 + CH_3COOH + 6KNO_2 \longrightarrow K_3[Co(NO_2)_6] + CH_3COOK + 2KCl$
(potassium nitrite) (yellow ppt.)

Test -12: $3CoCl_2 + 2Na_2HPO_4 \longrightarrow 4NaCl + 2HCl + Co_3(PO_4)_2\downarrow$
(violet ppt.)

Experiment No-18

Experiment	Observation	Inference
Dry Test:		
1. Noted the colour of salt	White salt	Cu^{2+}, Cr^{2+}, Fe^{3+}, Fe^{3+}, Ni^{2+}, Co^{2+}, Mn^{2+} are absent.
2. Noted the smell of salt	No smell of NH_3	NH_4^+ is absent.
Flame Test:		
3. Made a paste of salt with conc. HCl and burnt on flame with pt. wire	No characteristic flame	Na^+, K^+, Cu^{2+}, Ca^{2+}, Ba^{2+}, Sr^{2+} are absent.
Filter Ash Test:		
4. Dipped a filter paper strip in a solution of salt and $Co(NO_3)_2$ and burnt it	Green ash	May be Zn^{2+}.
Wet Tests:		
5. O.S + dilute HCl	No precipitates	Group-I (Ag^+, Hg_2^{2+}, Pb^{2+}) is absent.
6. O.S + dil. HCl + $H_2S_{(gas)}$	No precipitates	Group-II (Cd^{2+}, Hg^{2+}, Bi^{3+}, Pb^{2+}, Cu^{2+}, Sn^{2+}, Sb^{3+}, As^{3+}) is present.
7. O.S + $NH_4Cl_{(s)}$ + boil + cool + $NH_4OH_{(excess)}$	No precipitates	Group-III (Fe^{2+}, Fe^{3+}, Cr^{3+}, Al^{3+}) is absent.
8. O.S + $NH_4Cl_{(s)}$ + boil + cool + $NH_4OH_{(excess)}$ + $H_2S_{(gas)}$	White precipitates	Group-IV (Ni^{2+}, Co^{2+}, Mn^{2+}, Zn^{2+}) is present.
9. Noted the colour of salt and ppt.	Both salt and precipitates are white	Zn^{2+} is indicated.
Confirmatory Tests:		
10. O.S + $NaOH_{(sol)}$	White ppt. soluble in excess of NaOH	Zn^{2+} is confirmed.
11. O.S + Potassium ferrocyanide $K_4[Fe(CN)_6]$ solution	White ppt.	Zn^{2+} is confirmed.

Result: Basic Radical = Zinc (Zn^{2+})

Experiment No-19

Experiment	Observation	Inference
Dry Test:		
1. Noted the colour of salt	Light pink salt	May be Mn^{2+}.
2. Noted the smell of salt	No smell of NH_3	NH_4^+ is absent.
Flame Test:		
3. Made a paste of salt with conc. HCl and burnt on flame with pt. wire	No characteristic flame	Na^+, K^+, Cu^{2+}, Ca^{2+}, Ba^{2+}, Sr^{2+} are absent.
Filter Ash Test:		
4. Dipped a filter paper strip in a solution of salt $Co(NO_3)_2$ and burnt	No characteristic ash	Sn^{2+}, Al^{3+}, Mg^{2+}, Zn^{2+} are absent.
Wet Tests:		
5. O.S + dilute HCl	No precipitates	Group-I (Ag^+, Hg_2^{2+}, Pb^{2+}) is absent.
6. O.S + dil. HCl + $H_2S_{(gas)}$	No precipitates	Group-II (Cd^{2+}, Bi^{3+}, Hg^{2+}, Pb^{2+}, Cu^{2+}, Sn^{2+}, As^{3+}, Sb^{3+}) is present.
7. O.S + $NH_4Cl_{(s)}$ + boil + cool + $NH_4OH_{(excess)}$	No precipitate	Group-III (Fe^{2+}, Fe^{3+}, Cr^{3+}, Al^{3+}) is absent.
8. O.S + $NH_4Cl_{(s)}$ + boil + cool + $NH_4OH_{(excess)}$ + $H_2S_{(gas)}$	Light pink ppt.	Group-IV (Ni^{2+}, Co^{2+}, Mn^{2+}, Zn^{2+}) is present.
9. Noted the colour of salt and ppt.	Salt is light pink as well as precipitates	Mn^{2+} is indicated.
Confirmatory Tests:		
10. O.S + $NaOH_{(sol)}$	White ppt. turned brown in air	Mn^{2+} is confirmed.
11. O.S + $Na_2HPO_{4(sol)}$	White ppt. $Mn_3(PO_4)_2$	Mn^{2+} is confirmed.

Result: Basic Radical = Manganese (Mn^{2+})

CHEMICAL REACTIONS:

Test -8: $MnCl_2 + H_2S \longrightarrow 2HCl + MnS\downarrow$
(light pink ppt.)

Test -10: $MnCl_2 + 2NaOH \longrightarrow 2NaCl + Mn(OH)_2\downarrow$
white ppt.

$Mn(OH)_2 + H_2O + [O] \longrightarrow MnO_2 . 2H_2O$
(brown ppt.)

Test -11: $3MnCl_2 + 2Na_2HPO_4 \longrightarrow 4NaCl + 2HCl + Mn_3(PO_4)_2\downarrow$
(white ppt.)

CHEMICAL REACTIONS:

Test -8: $ZnCl_2 + H_2S \longrightarrow 2HCl + ZnS\downarrow$
(white ppt.)

Test -10: $ZnCl_2 + 2NaOH \longrightarrow 2NaCl + Zn(OH)_2\downarrow$
(white ppt.)

$Zn(OH)_2 + 2NaOH \longrightarrow Na_2ZnO_2 + 2H_2O$
Sodium zincate
soluble

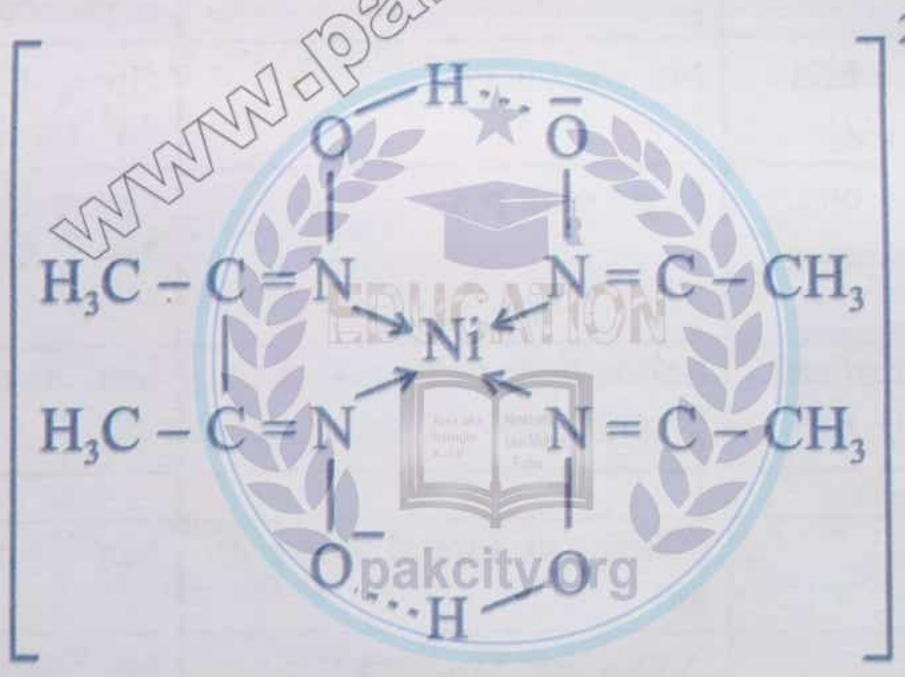
Test -11: $2ZnCl_2 + K_4[Fe(CN)_6] \longrightarrow Zn_2[Fe(CN)_6]\downarrow + 4KCl$
(white ppt.)

VIVA VOCE

1. The structural formula of Dimethyl glyoxime (DMG) is

$$CH_3-C(=N-OH)-C(=N-OH)-CH_3$$

2. Chemical composition of rose red ppt. of Ni^{2+} salt with DMG is shown as



3. Philosopher's wool — ZnO
4. White vitriol — $ZnSO_4 . 7H_2O$
5. To precipitate the sulphides of 4th group radicals, higher concentration of S^{2-} ions is required. So NH_4OH is passed before adding H_2S. The ionization of H_2S is driven forward by reacting H^+ ions (of H_2S) with OH-ions provided by NH_4OH

$$H_2S \rightleftharpoons 2H^+ + S^{2-}$$
$$2NH_4OH \rightleftharpoons 2NH_4^+ + 2OH^-$$
$$2H^+ + 2OH^- \longrightarrow 2H_2O$$

Hence more S^{2-} ions are formed **(Le-Chatelier's principle)**

Group-V

(Ba^{2+}, Sr^{2+}, Ca^{2+})

GROUP REAGENT:

O.S + $NH_4Cl_{(s)}$ + boil + cool + $NH_4OH_{(excess)}$ + $(NH_4)_2CO_3$

↓

White precipitates

Above white ppt + CH_3COOH + Shake

↓

Precipitates are dissolved

(Make three portions of this solution)

1st portion + $K_2CrO_{4(sol)}$ → ↓ → **Yellow precipitates** → ↓ → **Ba^{2+} is indicated**

2nd portion + $(NH_4)SO_{4(sol)}$ → ↓ → **White precipitates** → ↓ → **Sr^{2+} is indicated**

3rd portion + $(NH_4)_2C_2O_4$ → ↓ → **White precipitates** → ↓ → **Ca^{2+} is indicated**

Experiment No-20

Experiment	Observation	Inference
Dry Test:		
1. Noted the colour of salt	White salt	Cu^{2+}, Cr^{3+}, Fe^{2+}, Fe^{3+}, Ni^{2+}, Co^{2+}, Mn^{2+} are absent.
2. Noted the smell of salt	No smell of NH_3	NH_4^+ is absent.
Flame Test:		
3. Made a paste of salt with conc. HCl and burnt on flame with pt. wire	Apple green flame	May be Ba^{2+}.
Filter Ash Test:		
4. Dipped a filter paper strip in a solution of salt and $Co(NO_3)_2$ and burnt it	No characteristic ash	Sn^{2+}, Al^{3+}, Mg^{2+}, Zn^{2+} are absent.
Wet Tests:		
5. O.S + dilute HCl	No precipitates	Group-I (Ag^+, Hg_2^{2+}, Pb^{2+}) is absent.
6. O.S + dil. HCl + $H_2S_{(gas)}$	No precipitates	Group-II (Cd^{2+}, Hg^{2+}, Bi^{3+}, Pb^{2+}, Cu^{2+}, Sn^{2+}, As^{3+}, Sb^{3+}) is absent.
7. O.S + $NH_4Cl_{(s)}$ + boil + cool + $NH_4OH_{(excess)}$	No precipitates	Group-III (Fe^{2+}, Fe^{3+}, Cr^{3+}, Al^{3+}) is absent.
8. O.S + $NH_4Cl_{(s)}$ + boil + cool + $NH_4OH_{(excess)}$ + $H_2S_{(gas)}$	No precipitates	Group-IV (Ni^{2+}, Co^{2+}, Mn^{2+}, Zn^{2+}) is absent.
9. O.S + NH_4Cl + boil + Cool + $NH_4OH_{(excess)}$ + $(NH_4)_2CO_3$	White precipitates	Group-V (Ca^{2+}, Ba^{2+}, Sr^{2+}) is present.
10. Above ppt. is dissolved in CH_3COOH and made three parts. 1st part + $(NH_4)_2SO_{4(sol)}$	Now white precipitates	Sr^{2+} is absent.
11. 2nd part + $(NH_4)_2C_2O_{4(sol)}$	No white precipitates	Ca^{2+} is absent.
12. 3rd part + $K_2CrO_{4(sol)}$	Yellow ppt. of $BaCrO_4$	Ba^{2+} is indicated.
Confirmatory Tests:		
13. O.S + dilute H_2SO_4	White ppt. ($BaSO_4$)	Ba^{2+} is confirmed.
14. O.S + $(NH_4)_2C_2O_{4(sol)}$	White ppt. (BaC_2O_4)	Ba^{2+} is confirmed.

CHEMICAL REACTIONS:

Result: Basic Radical = Barium (Ba^{2+})

Test-9: $BaCl_2 + (NH_4)_2CO_3 \longrightarrow 2NH_4Cl + BaCO_3 \downarrow$ (white ppt.)

Test-12: $Ba(CH_3COO)_2 + K_2CrO_4 \longrightarrow 2CH_3COOK + BaCrO_4 \downarrow$ (yellow ppt.)

Experiment No-21

Experiment	Observation	Inference
Dry Test:		
1. Noted the colour of salt	White salt	Cu^{2+}, Cr^{3+}, Fe^{2+}, Fe^{3+}, Ni^{2+}, Co^{2+}, Mn^{2+} are absent.
2. Noted the smell of salt	No smell of NH_3	NH_4^+ is absent.
Flame Test:		
3. Made a paste of salt with conc. HCl and burnt it on flame with pt. wire	Crimson red flame	May be Sr^{2+}
Filter Ash Test:		
4. Dipped a filter paper strip in a solution of salt and $Co(NO_3)_2$ and burnt it	No characteristic ash	Sn^{2+}, Al^{3+}, Zn^{2+}, Mg^{2+} are absent.
Wet Tests:		
5. O.S + dilute HCl	No precipitates	Group-I (Ag^+, Hg_2^{2+}, Pb^{2+}) is absent.
6. O.S + dilute HCl + $H_2S_{(gas)}$	No precipitates	Group-II (Cd^{2+}, Bi^{3+}, Hg^{2+}, Pb^{2+}, Cu^{2+}, Sn^{2+}, As^{3+}, Sb^{3+}) is present.
7. O.S + $NH_4Cl_{(s)}$ + boil + cool + $NH_4OH_{(excess)}$	No precipitates	Group-III (Fe^{2+}, Fe^{3+}, Cr^{3+}, Al^{3+}) is absent.
8. O.S + $NH_4Cl_{(s)}$ + boil + cool + $NH_4OH_{(excess)}$	No precipitates	Group-IV (Ni^{2+}, Co^{2+}, Mn^{2+}, Zn^{2+}) is absent.
9. O.S + NH_4cl + boil + cool + $NH_4OH_{(excess)}$ + $(NH_4)_2CO_{3(sol)}$	White precipitates	Group-V (Ca^{2+}, Ba^{2+}, Sr^{2+}) is absent.
10. Above ppt. is dissolved in CH_3COOH and made three parts. 1st part + $K_2CrO_{4(sol)}$	No yellow precipitates	Ba^{2+} is absent.
11. 2nd part + $(NH_4)_2C_2O_{4(sol)}$	No white ppt.	Ca^{2+} is absent.
12. 3rd part + $(NH_4)_2SO_{4(sol)}$	White ppt.	Sr^{2+} is indicated.
Confirmatory Tests:		
13. O.S + dil. H_2SO_4	White ppt.	Sr^{2+} is confirmed.
14. O.S + $Na_2HPO_{4(sol)}$	White ppt.	Sr^{2+} is confirmed.

Result: Basic Radical = Strontium (Sr^{2+})

Experiment No-22

Experiment	Observation	Inference
Dry Test:		
1. Noted the colour of salt	White salt	Cu^{2+}, Cr^{3+}, Fe^{2+}, Fe^{3+}, Ni^{2+}, Co^{2+}, Mn^{2+} are absent.
2. Noted the smell of salt	No smell of NH_3	NH_4^+ is absent.
Flame Test:		
3. Made a paste of salt with conc. HCl and burnt on flame with pt. wire	Brick red flame	May be Ca^{2+}.
Filter Ash Test:		
4. Dipped a filter paper strip in a solution of salt and $Co(NO_3)_2$. Burnt it on the flame	No characteristic ash	Sn^{2+}, Al^{3+}, Zn^{2+}, Mg^{2+} are absent.
Wet Tests:		
5. O.S + dilute HCl	No precipitates	Group-I (Ag^+, Hg_2^{2+}, Pb^{2+}) is absent.
6. O.S + dil. HCl + $H_2S_{(gas)}$	No precipitates	Group-II (Cd^{2+}, Hg^{2+}, Pb^{2+}, Bi^{3+}, Cu^{2+}, Sn^{2+}, As^{3+}, Sb^{3+}) is absent.
7. O.S + $NH_4Cl_{(s)}$ + boil + cool + $NH_4OH_{(excess)}$	No precipitates	Group-III (Fe^{2+}, Fe^{3+}, Cr^{3+}, Al^{3+}) is absent.
8. O.S + $NH_4Cl_{(s)}$ + boil + cool + $NH_4OH_{(excess)}$ + $H_2S_{(gas)}$	No precipitates	Group-IV (Ni^{2+}, Co^{2+}, Mn^{2+}, Zn^{2+}) is absent.
9. O.S + $NH_4Cl_{(s)}$ + boil + cool + $NH_4OH_{(excess)}$ $(NH_4)_2CO_3$	White precipitates	Group-V (Ca^{2+}, Ba^{2+}, Sr^{2+}) is present.

10. Dissolve above ppt. in CH_3COOH and make three parts. 1st part + $K_2CrO_{4(sol)}$	No yellow precipitate	Ba^{2+} is absent.
11. 2nd part + $(NH_4)_2SO_{4(sol)}$	No white ppt.	Sr^{2+} is absent.
12. 3rd part + $(NH_4)_2C_2O_4$ solution **Confirmatory Tests:**	White ppt. (CaC_2O_4)	Ca^{2+} is indicated.
13. O.S + $Na_2HPO_{4(sol)}$	White ppt. $Ca_3(PO_4)_2$	Ca^{2+} is confirmed.
14. O.S + dil. H_2SO_4	White ppt. $CaSO_4$	Ca^{2+} is confirmed.
15. O.S + $NH_4Cl_{(s)}$ + $K_4[Fe(CN)_6]_{(sol)}$	White ppt. $CaK_2[Fe(CN)_6]$	Ca^{2+} is confirmed.

Result: Basic Radical = Calcium (Ca^{2+})

CHEMICAL REACTIONS:

Test -9: $CaCl_2 + (NH_4)_2CO_3 \longrightarrow 2NH_4Cl + CaCO_3 \downarrow$ (white ppt.)

Test -12: $Ca(CH_3COO)_2 + (NH_4)_2C_2O_4 \longrightarrow 2CH_3COONH_4 + CaC_2O_4 \downarrow$ (white ppt.)

Test -13: $3CaCl_2 + 2Na_2HPO_4 \longrightarrow 4NaCl + Ca_3(PO_4)_2 \downarrow + 2HCl$ (white ppt.)

Test -14: $CaCl_2 + H_2SO_4 \longrightarrow 2HCl + CaSO_4 \downarrow$ (white ppt.)

Test -15: $CaCl_2 + K_4[Fe(CN)_6] \longrightarrow 2KCl + CaK_2[Fe(CN)_6] \downarrow$
pot. ferrocyanide (white ppt.)

CHEMICAL RE ACTIONS:

Test -9: $SrCl_2 + (NH_4)_2CO_2 \longrightarrow 2NH_4Cl + SrCO_3 \downarrow$ (white ppt.)

Test -12: $Sr(CH_3COO)_2 + (NH_4)_2SO_4 \longrightarrow 2CH_3COONH_4 + SrSO_4 \downarrow$ (white ppt.)

Test -14: $SrCl_2 + Na_2HPO_4 \longrightarrow 2NaCl + SrHPO_4 \downarrow$ (white ppt.)

VIVA VOCE

1. **NH_4Cl** suppress the dissociation of $(NH_4)_2CO_3$ into NH_4^+ and CO_3^{2-} ions by **common ion effect**

$$2NH_4Cl \rightleftharpoons 2NH_4^+ + 2Cl^-$$

$$(NH_4)_2CO_3 \rightleftharpoons 2NH_4^+ + CO_3^{2-}$$

supression of ionization — **common ions**

Due to less concentration of CO_3^{2-} ions Mg^{2+} of group VI is not precipitated as $MgCO_3$.

2. Gypsum $CaSO_4 . 2H_2O$
3. Plaster of parts $(CaSO_4)_2 . H_2O$
4. Bleaching powder $Ca(OCl)Cl$
5. Ammonium oxalate $(NH_4)_2C_2O_4$

Group-VI

(Mg^{2+} Na^+, K^+, NH_4^+)

GROUP REAGENT:

There is no group reagent for Group VI. If first five groups are absent, 6th group is present. The radicals of group VI are detected by applying the individual tests.

1. **Identification of Na^+:**

O.S + KOH + Pot. pyroantimonate ($K_2H_2Sb_2O_7$), scratch the sides of test tube by glass rod.

↓

White precipitates indicate Na^+

2. **Identification of K^+:**

O.S + CH_3COOH + Sodium cobaltinitrite $Na_3[Co(NO_2)_6]$

↓

Yellow precipitates indicate K^+

3. **Identification of NH_4^+:**

Salt + $NaOH_{(sol)}$ + Boil

↓

NH_3 gas evolved, give white fumes with HCl rod it indicate NH_4^+.

4. **Identification of Mg^{2+}:**

O.S + $NH_4Cl_{(s)}$ + NH_4OH + Diammonium hydrogenphosphate $(NH_4)_2HPO_4$ (solution)

↓

White crystalline precipitates indicate Mg^{2+}

Experiment No-23

Experiment	Observation	Inference
Dry Test:		
1. Noted the colour of salt	White salt	Cu^{2+}, Cr^{3+}, Fe^{2+}, Fe^{3+}, Ni^{2+}, Co^{2+}, Mn^{2+} are absent.
2. Noted the smell of salt	No smell of NH_3 gas	NH_4^+ is absent.
Flame Test:		
3. Made a paste of salt with conc. HCl and burnt on flame with pt. wire	No characteristic flame	Na^+, K^+, Cu^{2+}, Ca^{2+}, Ba^{2+}, Sr^{2+} are absent.
4. Dipped a filter paper strip in a solution of salt and $Co(NO_3)_2$ and burnt it. Noted the colour of ash	Pink ash is formed	May be Mg^{2+}.
Wet Tests:		
5. O.S + dilute HCl	No precipitates	Group-I (Ag^+, Hg_2^{2+}, Pb^{2+}) is absent.
6. O.S + dilute HCl + $H_2S_{(gas)}$	No precipitates	Group-II (Cd^{2+}, Hg^{2+}, Pb^{2+}, Bi^{3+}, Cu^{2+}, Sn^{2+}, As^{3+}, Sb^{3+}) is present.
7. O.S + $NH_4Cl_{(s)}$ + boil + cool + $NH_4OH_{(excess)}$	No precipitates	Group-III (Fe^{2+}, Fe^{3+}, Cr^{3+}, Al^{3+}) is absent.
8. O.S + $NH_4Cl_{(s)}$ + bo il + cool + $NH_4OH_{(excess)}$ + $H_2S_{(gas)}$	No precipitates	Group-IV (Ni^{2+}, Co^{2+}, Mn^{2+}, Zn^{2+}) is absent.
9. O.S + $NH_4Cl_{(s)}$ + boil + cool + $NH_4OH_{(excess)}$ + $(NH_4)_2CO_3$	No precipitates	Group-V (Ca^{2+}, Ba^{2+}, Sr^{2+}) is absent. As first five groups are absent so Group V I is present.
10. Salt + $NaOH_{(sol)}$ + heat	No smell of NH_3	NH_4^+ is absent.
11. O.S + KOH + $K_2H_2Sb_2O_7$ (Pot. pyroantimonate)$_{(Sol)}$ and scratch the sides of test tube.	No white precipitates	Na^+ is absent.

12. $O.S + CH_3COOH + Na_3[Co(NO_2)_6]_{(sol)}$	No yellow precipitates	K^+ is absent.
13. $O.S + NH_4Cl_{(s)} + boil + cool + NH_4OH + (NH_4)_2HPO_4$	White ppt.	Mg^{2+} is indicated.
Confirmatory Tests:		
14. $O.S + NaOH_{(sol)}$	White ppt.	Mg^{2+} is confirmed.
15. $O.S + Na_2CO_{3(sol)}$	White ppt.	Mg^{2+} is confirmed.
16. $O.S + (NH_4)_2CO_{3(sol)}$	White ppt.	Mg^{2+} is confirmed.

Result: Basic Radical = Magnesium (Mg^{2+})

CHEMICA REACTIONS:

Test -13: $MgSO_4 + (NH_4)_2HPO_4 \longrightarrow (NH_4)_2SO_4 + MgHPO_4 \downarrow$ (white ppt.)

Test -14: $MgSO_4 + 2NaOH \longrightarrow Na_2SO_4 + Mg(OH)_2 \downarrow$ (white ppt.)

Test -15: $MgSO_4 + Na_2CO_3 \longrightarrow Na_2SO_4 + MgCO_3 \downarrow$ (white ppt.)

Experiment No-24

Experiment	Observation	Inference
Dry Test:		
1. Noted the colour of salt	White salt	Cu^{2+}, Cr^{3+}, Fe^{2+}, Fe^{3+}, Ni^{2+}, Co^{2+}, Mn^{2+} are absent.
2. Noted the smell of salt	No smell of NH_3	NH_4^+ is absent.
Flame Test:		
3. Made a paste of salt with conc. HCl and burnt on flame with pt. wire	Golden yellow flame	May be Na^+.
Filter Ash Test:		
4. Dipped a filter paper strip in a solution of salt and $Co(NO_3)_2$ and burnt	NO characteristic ash	Sn^{2+}, Al^{3+}, Zn^{2+}, Mg^{2+} are absent.
Wet Tests:		
5. O.S + dilute HCl	No precipitates	Group-I (Ag^+, Hg_2^{2+}, Pb^{2+}) is absent.
6. O.S + dilute HCl + $H_2S_{(gas)}$	No precipitates	Group-II (Cd^{2+}, Hg^{2+}, Bi^{3+}, Pb^{2+}, Cu^{2+}, Sn^{2+}, As^{3+}, Sb^{3+}) is absent.
7. O.S + $NH_4Cl_{(s)}$ + boil + cool + $NH_4OH_{(excess)}$	No precipitates	Group-III (Fe^{2+}, Fe^{3+}, Cr^{3+}, Al^{3+}) is absent.
8. O.S + $NH_4Cl_{(s)}$ + boil + cool + $NH_4OH_{(excess)}$ + $H_2S_{(gas)}$	No precipitates	Group-IV (Ni^{2+}, Co^{2+}, Mn^{2+}, Zn^{2+}) is absent.
9. O.S + $NH_4Cl_{(s)}$ + boil + cool + $NH_4OH_{(excess)}$ + $(NH_4)_2CO_3$	No precipitates	Group-V (Ca^{2+}, Ba^{2+}, Sr^{2+}) is absent. As first five groups are absent so group VI is present.
10. Salt + $NaOH_{(sol)}$ + boil	No smell of NH_3	NH_4^+ is absent.
11. O.S + CH_3COOH + Sod. cobaltinitrite $Na_3[Co(NO_2)_6]$ solution	No yellow ppt.	K^+ is absent.

12. O.S + $NH_4cl_{(s)}$ + NH_4OH + $(NH_4)_2HPO_{4(sol)}$,	No white precipitates	Mg^{2+} is absent.
13. O.S + KOH + Pot. pyroantimonate $K_2H_2Sb_2O_{7(sol)}$ and scratch the walls of test tube.	White ppt. ($Na_2H_2Sb_2O_7$)	Na^+ is indicated.
Confirmatory Tests:		
14. O.S + Zinc uranyl acetate solution	Yellow ppt.	Na^+ is confirmed.
15. Applied flame test	Golden yellow flame	Na^+ is confirmed.

Result: Basci Radical = Sodium (Na^+)

CHEMICAL REACTIONS:

Test -13: $2NaCl + K_2H_2Sb_2O_{7(sol)} \longrightarrow 2KCl + Na_2H_2Sb_2O_7 \downarrow$

Pot. pyroantimonate (whiteppt.)

Test -14: $NaCl + 3UO_2(CH_3COO)_2 \cdot Zn(CH_3COO)_2 \longrightarrow NaZn(UO_2)_3(CH_3COO)_9 \downarrow$

yellow crystal

Experiment No-25

Experiment	Observation	Inference
Dry Test:		
1. Noted the colour of salt	White salt	Cu^{2+}, Cr^{3+}, Fe^{2+}, Fe^{3+}, Ni^{2+}, Co^{2+}, Mn^{2+} are absent.
2. Noted the smell of salt	No smell of NH_3	NH_4^+ is absent.
Flame Test:		
3. Made a paste of salt with conc. HCl and burnt on flame with pt. wire	Violet flame	May be K^+.
Filter Ash Test:		
4. Dipped a filter paper strip in a solution of salt and $Co(NO_3)_2$ and burnt	No characteristic ash	Sn^{2+}, Al^{3+}, Zn^{2+}, Mg^{2+} are absent.
Wet Tests:		
5. O.S + dilute HCl	No precipitate	Group-I (Ag^+, Hg_2^{2+}, Pb^{2+}) is absent.
6. O.S + dilute HCl + $H_2S_{(gas)}$	No precipitates	Group-II (Cd^{2+}, Hg_2^{2+}, Pb^{2+}, Bi^{3+}, Cu^{2+}, Sn^{2+}, As^{3+}, Sb^{3+}) is present.
7. O.S + $NH_4Cl_{(s)}$ + boil + cool + $NH_4OH_{(excess)}$	No precipitates	Group-III (Fe^{2+}, Fe^{3+}, Cr^{3+}, Al^{3+}) is absent.
8. O.S + $NH_4Cl_{(s)}$ + boil + cool + $NH_4OH_{(excess)}$ + $(NH_4)_2CO_3$	No precipitates	Group-IV (Ni^{2+}, Co^{2+}, Mn^{2+}, Zn^{2+}) is absent.
9. O.S + $NH_4Cl_{(s)}$ + boil + cool + $NH_4OH_{(excess)}$ + $(NH_4)_2CO_3$	No precipitates	Group-V (Ca^{2+}, Ba^{2+}, Sr^{2+}) is absent. As first fire groups are absent so group VI is present.
10. O.S + $NH_4Cl_{(s)}$ + boil + cool + $NH_4OH_{(excess)}$ + $(NH_4)_2HPO_{4(sol)}$	No white ppt.	Mg^{2+} is absent.
11. Salt + $NaOH_{(sol)}$ and heat	No smell of NH_3 gas	NH_4^+ is absent.

12. O.S + KOH + $K_2H_2Sb_2O_7$ (solution) and scratch the walls of test tube with glass rod.	No white ppt.	Na^+ is absent.
13. O.S + CH_3COOH + Sod. cobaltinitrite $Na_3[Co(NO_2)_6]$	Yellow ppt.	K^+ is indicated.
Confirmatory Tests:		
14. O.S + picric acid O.S + Tartaric acid	Yellow needle like crystals White crystalline ppt.	K^+ is conformed. K^+ is confirmed.

Result: Potassium (K^+)

CHEMICAL REACTIONS:

Test -13: $3KNO_3 + Na_3[Co(NO_2)_6] \xrightarrow{CH_3COOH} 3NaNO_3 + K_3[Co(NO_2)_6]$ (yellow ppt.)

Test-14:

Test -15: $2KNO_3$ + Tartaric acid → Potassiumtartarate

Tartaric acid: $CH(OH)COOH$ | $CH(OH)COOH$

Potassiumtartarate: $CH(OH)COO^-K^+$ | $CH(OH)COOK^+$

(white crystals)

Experiment No-26

Experiment	Observation	Inference
Dry Test:		
1. Noted the colour of salt	White salt	Cu^{2+}, Cr^{3+}, Fe^{2+}, Fe^{3+}, Ni^{2+}, Co^{2+}, Mn^{2+} are absent.
2. Noted the smell of salt	NH_3 smell	May be NH_4^+
Flame Test:		
3. Made a paste of salt with conc. HCl and burnt on flame with pt. wire.	No characteristic flame	Na^+, K^+, Cu^{2+}, Ca^{2+}, Ba^{2+}, Sr^{2+} are absent.
Filter Ash Test:		
4. Dipped a filter paper strip in a solution of salt and $Co(NO_3)_2$ and burnt it	No characteristic ash	Sn^{2+}, Al^{3+}, Zn^{2+}, Mg^{2+} are absent.
Wet Tests:		
5. O.S + dilute HCl	No precipitates	Group-I (Ag^+, Hg_2^{2+}, Pb^{2+}) is absent.
6. O.S + dilute HCl + $H_2S_{(gas)}$	No precipitates	Group-II (Cd^{2+}, Hg^{2+}, Pb^{2+}, Bi^{3+}, Cu^{2+}, Sn^{2+}, As^{3+}, Sb^{3+}) is present.
7. O.S + $NH_4Cl_{(s)}$ + boil + cool + $NH_4OH_{(excess)}$	No precipitates	Group-III (Fe^{2+}, Fe^{3+}, Cr^{3+}, Al^{3+}) is absent.
8. O.S + $NH_4Cl_{(s)}$ + boil + cool + $NH_4OH_{(excess)}$ + $H_2S_{(gas)}$	No precipitates	Group-IV (Ni^{2+}, Co^{2+}, Mn^{2+}, Zn^{2+}) absent.
9. O.S + $NH_4Cl_{(s)}$ + boil + cool + $NH_4OH_{(excess)}$ + $(NH_4)_2CO_3$	No precipitates	Group-V (Ca^{2+}, Ba^{2+}, Sr^{2+}) is absent. As first five group are absent so Group VI is present.
10. O.S + $NH_4Cl_{(s)}$ + boil + cool + NH_4OH + $(NH_4)_2HPO_4$	No white ppt.	Mg^{2+} is absent.
11. O.S + CH_3COOH + Sod. cobaltinitrite $Na_3[Co(NO_2)_6]_{(sol)}$	No yellow ppt.	K^+ is absent.

12. O.S + KOH + $K_2H_2Sb_2O_{7\,(sol)}$	No white ppt.	Na^+ is absent.
13. Salt + NaOH and heat	NH_3 gas is evolved, it gave dense white fumes with HCl	NH_4^+ is indicated.
Confirmatory Tests:		
14. O.S + Picric acid	Yellow needle like crystals	NH_4^+ is confirmed.
15. O.S + $NaOH_{(sol)}$ + Nesslers reagent (K_2HgI_4)	Brown ppt.	NH_4^+ is confirmed.

Result: Basic Radical = Ammonium (NH_4^+)

CHEMICAL REACTIONS:

Test -13:

$$NH_4Cl + NaOH \xrightarrow{Heat} NaCl + H_2O + NH_3 \downarrow$$

$$NH_3 + HCl \longrightarrow NH_4Cl \text{ (Dense white fumes)}$$

Test -14:

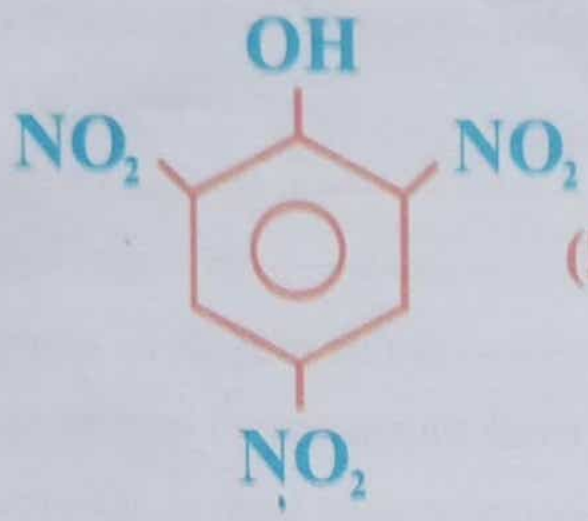
Test -15:

$$NH_4Cl + NaOH + K_2HgI_4 \longrightarrow KCl + NaI + NH_2Hg_2I_3 + H_2O$$

Nessler's reagent — (Brown ppts.)

Viva Voce

1. Picric acid



(2, 4, 6 trinitrophenol)

2. Tartaric acid — $CH(OH)COOH$ | $CH(OH)COOH$
3. Nessler's reagent — K_2HgI_4
4. Potassium pyroantimonate — $K_2H_2Sb_2O_7$
5. Sodium cobaltinitrite — $Na_3[Co(NO_2)_6]$
6. Zinc uranyl acetate — $ZnUO_2(CH_3COO)_4$
7. Epsom salt — $MgSO_4 . 7H_2O$
8. Glauber's salt — $Na_2SO_4 . 10H_2O$
9. Backing soda — $NaHCO_3$
10. Washing soda — $Na_2CO_3 . 10\,H_2O$
11. Soda ash — Na_2CO_3
12. Pearl ash — K_2CO_3
13. The substance which absorb moisture from air and remain in solid state is called **hygroscopic** e.g., NaOH.
14. The substance which absorbs moisture from air and changes into liquid state is called **deliquescent** e.g., $CaCl_2$.
15. The substance which loses water of crystallization at room temperature is called **efflorescent**. e.g., $Na_2CO_3 . 10H_2O$ (washing soda).