Qualitative Analysis

The practical book for:

General Chemistry (I) course

For 1st year University Students.

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A practical book

INTRODUCTION

Chemical analysis can be either qualitative or quantitative in character. In qualitative analysis we want to know elements or characteristic chemical species are present. Although it might be possible to gain some idea of how much of each component is present. The major point of the qualitative analysis is simply to determine whether the component of interest is present at a level above the minimum required for detection. On the other hand, in a quantitative analysis we are interested in the relative amounts of the components present.

This book is about qualitative and quantitative inorganic analysis. It contains the background theory as well as experimental procedures that the student will need to carry out a laboratory program of chemical analysis.

Cations and their analyses are discussed group by group and the same on dealing with anions. A systematic concise procedure for detection of each group anions and cations is summarized in a specific table followed by tables prepared for student practice for each cation or anion.

A simple systematic part for quantitative analysis is also included in this book.

Some important analyses are described for student. By doing so this book slows student to observe descriptive chemical reacts and to test principles spelled out in the pages of their textbooks. In

addition, students are challenged to apply their knowledge in the laboratory.

ABBREVIATIONS OF COMMON USE

Word or sentence	Abbreviation	Word or sentence	Abbreviation
Ammonium	Amm.	Equivalent weight	Eq.wt.
Bolling point	S.P.	Example	ex.
Cubic	c.c.	And so on	etc.
centimeter	Cm.	Gram	gm.
Concentrated	Conc.	That is to say	i.e.
Concentration	Concn.	Insoluble	Insol.
Compound	cpd.	Molecular weight	Mol.wt.
Conical flask	C.F.	Melting point	M.P.
Dilute	dil.	Potassium	Pot.
Different	diff.	Solution	Soln.
Precipitate	ppt.	Sodium	Sod.
to precipitate	pptate.	Test tube	T.T.
precipitation	pptn.	Volume	Vol.
Saturates	Sat.	Excess	xss.
Soluble	sol.	Round Bottom Flask	R.B.F
Heat	Δ	Flat Bottom Flask	F.B.F

CHEMICAL ANALYSIS

Chemical analysis is divided into two main classes:

I) Qualitative analysis:

This type of analysis involves the investigation and identify cation of substances in its simplest or complicate forms. In this connection, the constituent element or group of elements, and the way in which these elements are combined to form the substance, are identified.

II) Quantitative Analysis:

The object of quantitative analysis is to determine the actual amounts of the constituents of a compound, and the amount of material dissolved in solution.

Depending upon the tools used, or the procedures followed to perform the analysis, it can be classified into 3 main classes:

A. **Volumetric analysis**, i.e. determination of the constituents by titration.
B. **Gravimetric analysis**: i.e. determination of the constituents by precipitation.
C. **Instrumental analysis**: i.e. determination of the constituents by the used of instruments and apparatus.

QUALITATIVE ANALYSIS

Radicals:

When an acid e.g. HCl is made to react with a base, e.g NaOH. a salt, NaCl and water are formed according to the following equation:

$$\mathbf{HCl + NaOH \rightarrow NaCl + H_2O}$$

acid + base → salt + water

The part of the salt, which is derived from the base, Na, is called the "basic radical", whereas the other part, which is derived from the acid, is termed " acidic radical".

Analysis of a simple salt:

Dealing with a simple salt, the various stops enquired for its identification can be gathered as follows:

1. Preliminary tests.
2. Analysis for acidic radicals.
3. Analysis for basic radicals.

1) preliminary Tests:

These tests are usually termed "Dry Tests" since they are carried out on the material in its dry state. These tests cannot be considered as final and conclusive, but however they furnish valuable indication of the presence of certain acid and basic radicals.

The preliminary tests include:

A. <u>Physical properties:</u>

This involves the examination of the physical properties of the salt such as color, crystalline form and solubility of the substance is checked with the following solvents in the same order as cited:

1. Water; cold then hot.
2. Dil. HCl; cold then hot.
3. Conc. HCl; cold then hot.
4. Dil. HNO_3; cold then hot.
5. Conc. HNO_3; cold then hot.
6. Aqua Regie: 3 vols. conc. HCl + 1 vol. conc. HNO_3
7. Effect of Heat:

When a small amount of the solid is heated in a hard dry test tube, some changes may occur which can throw some light on the identity of the salt. These changes may include:

1. Decomposition e.g. copper carbonate

$$CuCO_3 \xrightarrow{\Delta} CuO\ (black) + CO_2$$

2. Change of color, e.g. Zinc oxide is colored white, but when heated it becomes yellow and upon cooling it returns white again.
3. Loss of water of crystallization, e.g. Copper sulphate

$$\underset{\text{Blue}}{\mathbf{CuSO_4.5\ H_2O}} \xrightarrow[-5H_2O]{\Delta} \underset{\text{White}}{\mathbf{CuSO_4}} \xrightarrow{+5H_2O} \underset{\text{Blue}}{\mathbf{CuSO_4\ .5\ H_20}}$$

4. **Sublimation**: Some compounds e.g ammonium chloride transforms directly from the solid state to the vapor state.

B. <u>Flame Test</u>

It was found that some metals give characteristic colors to the flame when their volatile compound e.g. chloride are heated on a platinum wire in the oxidizing zone of the flame.

In this experiment: A clean Pt wire (or glass rode) is dipped into a conc. HCl then in the dry substance and heated in the flame. Different colors are produced by different basic radicals:

Copper: Green Calcium: Brick red

Strontium: Crimson red Barium: Apple green

Sodium: Golden yellow Potassium: Pale violet.

ACIDIC RADICALS

Our study is restricted here to only fourteen acidic radicals of the most famous ones. They can be classified towards: dil. HCl and hot conc. H_2SO_4 as follows:

I- Dil. HCl group	**II- Hot conc. H_2SO_4 group**	**III- Miscellaneous group**
Carbonate CO_3^{-2}	Chloride Cl^-	Sulphate SO_4^{-2}
Blicabonate HCO_3^-	Bromides Br^-	Borate $B_4O_7^{-2}$
Sulphide S^{-2}	Iodides I^-	Arsenate AsO_4^{-3}
Sulphite SO_3^{-2}	Nitrates NO_3^-	Phosphate PO_4^{-3}
Thiosulphate $S_2O_3^{-2}$		
Nitrites NO_2^-		

It is to be noted that all radicals of one group reacts with the so called " Group Reagent " which is dil. HCl in the first group and hot conc. H_2SO_4 in the second group to give off characteristic gases and vapors. The radicals in the miscellaneous group do not react with either dil. HCl or conc. H_2SO_4

1. **Dilute Hydrochloric acid Group**

This group includes radicals of unstable acids which upon reaction with dil. HCI decompose readily giving off characteristic gases as illustrated by the equations:

$$\mathbf{Na_2CO_3 + 2\ HCl \rightarrow 2\ NaCl + CO_2 + H_2O}$$

$$\mathbf{NaHCO_3 + HCl \rightarrow NaCl + CO_2 + H_2O}$$

$$\mathbf{Na_2S + 2\ HCl \rightarrow 2\ NaCl + H_2S}$$

$$\mathbf{Na_2SO_3 + 2\ HCl \rightarrow 2\ NaCl + SO_2 + H_2O}$$

$$\mathbf{Na_2S_2O_3 + 2\ HCl \rightarrow 2\ NaCl + SO_2 + S + H_2O}$$

$$\mathbf{2\ NaNO_3 + 2\ HCl \rightarrow 2\ NaCl + 2\ NO + H_2O}$$

$$\mathbf{2\ NO + O_2 \rightarrow 2\ NO_2}$$

Experiment	Carbonate Na_2CO_3	Biocarbonate e.g.$NaHCO_3$	Sulphide e.g Na_2S	Sulphite e.g. Na_2SO_3	Thiosulphate e.g. $Na_2S_2O_3$	Nitrite NO_2^-
solid + dil. HCl heat if necessary	Effervescence & evolution of CO_2 which detected by rendering lime water turbid	As carbonate	Evolution of H_2S gas detected by its bad odor and blackening a lead acetate paper	Evolution of SO_2 gas detected by its suffocating odor & rendering an acid chromate paper green	As sulphite but soln. becomes turbid due to sepn. of colloidal Sulphur	Red-brown fumes due to combination of NO and O_2 of air& turns blue
2) Slon. + $AgNO_3$	white ppt of Ag_2CO_3 sol. in dil. HNO_3	As carbonate but on heating	Black ppt. of Ag_2S sol. in hot dil. HNO_3	White ppt. of Ag_2SO_3 sol. in xss. of sulphite and in NH_4OH	White ppt. Ag_2SO_3 sol. in xss. $AgNO_3$. It turns yellow, orange then black Ag_2S	White ppt. from conc. solns.
3) Slon. + $BaCl_2$ soln.	White ppt. of $BaCO_3$ sol. in dil. HCl and HNO_3	As carbonate but on heating		White ppt. of $BaSO_3$ sol. in dil. HCl and HNO_3	White ppt. from conc. solns.	

Experiment	Observation & results
i- Carbonates & Biocarbonate:	
1) Soln.+ $HgCl_2$ soln.	**Reddish brawn ppt. of basic mercuric carbonate $HgCO_3$**
2) Soln. + $HgSO_4$ soln.	
ii-Sulphides:	
1) Soln. + NaOH soln. + sodium nitropruoside $Na_2Fe(CN)_5$ NO	**Purple coloration due to form of a comp. structured as: $Na_4Fe(CN)_5NO$.**
2) Soln. + lead acetate $Pb(C_2H_3O_2)_2$	**Black ppt. sol. in hot dil. NHO_3**
iii- Sulphites. Thiosulpates and Nitrites:	
(Reducing properties)	
1) One drop of KMO_4 + dil H_2SO_4 soln.	**Decolorization due to form. Of $MnSO_4$.**
2) One drop of $K_2Cr_2O_2$ + dil H_2SO_4 soln.	**Development of green color due to Cr^{+3}**
3) One drop of I_2 + dil H_2SO_4 soln.	**decolorization due to form of iodide**
iv-Nitrites: (Oxidizing properties)	
1) Ferrous sulphate ($FeSO_4$) soln. + dil.H_2SO_4 soln.	**Brown color due to formation of Fe(NO)SO.**
2)1ml. pot. Thiocyanate (KCNS)+1ml dil. H_2SO_4 soln.	**Blood red color which discharges on boiling.**
v- Sulphites and Thiosulphates	
Soln. + Ferric chloride Soln. ($FeCl_3$)	
1) Thiosulphate	**Dark violet color disappears on warming or standing**
2) Sulphite	**Red color suffering no changes on standing.**

Detection of Carbonate CO_3^{-2}

Experiment	Observation	Result
Solid + dil. HCl		
Soln. + $AgNO_3$ soln.		
Soln.+ $BaCl_2$ soln.		
Soln.+ $HgCl_2$ soln.		
Soln. + $HgSO_4$ soln.		
Physical Prop.		

Detection of the Sulphide S^{-2}

Experiment	Observation	Result
Solid + dil. HCl		
Soln. + $AgNO_3$ soln.		
Soln. + NaOH soln.		
Sod. Nitophrouside		
Soln. + lead acetate		
Physical Prop:		

Detection of the Sulphite SO_3^{-2}

Experiment	Observation	Result
Solid + dil. HCl		
Soln.+ $AgNO_3$ soln.		
Soln. + $BaCl_2$ soln.		
Soln. + drop of $KMnO_4$+ dil. H_2SO_4		
Soln. + drop of $K_2Cr_2O_2$ Soln. + dil. H_2SO_4		
Soln. + drop of I_2		
Soln. + dil. H_2SO_4		
Physical Prop. :		

Detection of the Thiosulphate $S_2O_3^{-2}$

Experiment	Observation	Result
Solid + dil. HCl (Heat gently) Soln.+ $AgNO_3$ soln. Soln. + drop of $KMnO_4$ soln. + dil. H_2SO_4 Soln.+ drop of $K_2Cr_2O_7$ soln. + dil. H_2SO_4 Soln. + $FeSO_4$ soln. + dil. H_2SO_4 Soln. + 1ml. KCNS soln. +1 ml. dil. H_2SO_4 Physical Prop. :		

Detection of the nitrite radical NO_2^-

Experiment	Observation	Result
Solid + dil. HCl		
Soln.+ $AgNO_3$ soln.		
Soln.+$BaCl_2$ soln.		
Soln. + drop of $KMnO_4$+ dil. H_2SO_4		
Soln.+ drop of $K_2Cr_2O_7$ soln. + dil. H_2SO_4		
Soln.+ drop of I_2 soln. + dil. H_2SO_4		
Physical Prop. :		

II-Concentrated Sulphuric Acid Group:

The group includes radicals belonging to acids such stronger than those of the previous group, and therefore they are not affected by dil. HCl. When the salt is treated with conc. H_2SO_4, the corresponding acids are liberated which may further decompose as following:

$$\mathbf{NaCl + H_2SO_4 \rightarrow NaHSO_4 + HCl}$$

$$\mathbf{KBr + H_2SO_4 \rightarrow KHSO_4 + HBr;}$$

$$\mathbf{2\ HBr + H_2SO_4 \rightarrow Br_2 + SO_2 + 2H_2O}$$

$$\mathbf{KI + H_2SO_4 \rightarrow K\ HSO_4 + HI;}$$

$$\mathbf{2\ HI + H_2SO_4 \rightarrow I_2 + SO_2 + 2H_2O}$$

$$\mathbf{NaNO_3 + H_2SO_4 \rightarrow NaHSO_4 + HNO_3;}$$

$$\mathbf{4\ HNO_3 \rightarrow 4\ NO_2 + O_2 + 2H_2O}$$

(A) General Tests for Hot Conc. H_2SO_4 group.

Experiment	**Chloride e.g. NaCl**	**Bromide e.g. NaBr**	**Iodide e.g. KI**	**Nitrate e.g.$NaNO_3$**
Solid + conc. H_2SO_4 heat	Evolution of HCl gas detected by rendering blue litmus paper red	Evolution of red brown vapors of Br_2 and HBr and soln. becomes orange	Evolution of vapors of I_2 detected by turning starch paper blue.	Red brown vap. of NO_2 after long heating
2 Solid + H_2O_2+ conc. H_2SO_4 heat	Evolution of Cl_2 gas detected by its yellow green color and bleaching action on litmus paper	Evolution of Br_2 gas detected by its red brown color and bleaching action on litmus and turning starch paper yellow	Same as above	
3 Soln.+ $AgNO_3$ soln.	White crudy ppt. sol. in NH_4OH and insol. in dil.	Pale yellow curdy ppt. sol. in conc. NH_4OH and insol. in dil. HNO_3	Yellow curdy ppt. insol. in both NH_4OH and NaOH	
Soln., lead acetate soln.	White ppt. of $PbCl_2$ sol. in boiling water	White cryst. ppt. in boiling water	Yellow ppt. of PbI_2 sol. in boiling water	

(B) Special Tests for Hot Conc. H_2SO_4 group.

Experiment	Observation & Results
(i) Bromides & Iodides:	
Soln. Chlorine water	
Bromide ----------	Solution becomes pale orange.
Iodide ----------	Solution becomes yellow brown
Reactn. mix + few mls. chloroform ($CHCl_3$)	
Bromide----------	Chloroform layer is colored red brown.
Iodide----------	Chloroform layer is colored violet.
(ii) Iodides	
1-Soln.+ $HgCl_2$ soln.	A scarlet red ppt. of Hgl_2 sol. in xss. soln.
2-Soln. + $CuSO_4$ soln.	A ppt. of cuprous iodide Cu_2I_2 colored dirty brown due to liberation of I_2
3. Reactn. mix. + Na_2SO_3 soln.	Disappearance of brown color of iodine.
(iii) Nitrates:	
1-Brown Ring Test:	
soln. + cold sat. $FeSO_4$ soln. + 2 ml. Conc. H_2SO_4, drop by drop to form a separate layer.	A brown ring is formed at the interface due to the formation of the compound $Fe(NO)SO_4$
2- Ammonia Test	
soln. + Zinc dust (Al) + NaOH, Heat.	Ammonia gas (NH_3) evolves which is detected by its odor and by turning a red litmus paper blue

Detection of the Chloride Radical (Cl^-)

Experiment	Observation	Result
Solid + conc. H_2SO_4 heat.		
Solid+MnO_2 +conc. H_2SO_4 heat.		
Soln. +$AgNO_3$ soln.		
Soln.+ lead acetate soln.		
Physical Prop.:		

Detection of the Bromide Radical (Br^-)

Experiment	Observation	Result
Solid +conc. H_2SO_4 heat. Solid + MnO_2 + conc. H_2SO_4 heat. Soln. + $AgNO_3$ soln. Soln.+ lead acetate soln. Soln. + chlorine water. reaction mixture of 5 + few ml's of chloroform. Physical Prop.:		

Detection of the Iodide Radical (I^-)

Experiment	Observation	Result
1. Solid + conc. H_2SO_4, heat. 2. Solid + MnO_2 + conc. H_2SO_4 heat. 3. Soln. + $AgNO_3$ soln. 4. Soln.+ lead acetate soln. 5. Soln. + chlorine water. 6. Reaction mixture of 5 + few ml's of chloroform. 7. Soln. +$HgCl_2$ soln. 8. Soln. $CusO_4$ soln. 9. Reaction mixture of 8 + $Na_2S_2O_3$ soln. **Physical Prop.:**		

Detection of the Nitrate Radical (NO_3^-)

Experiment	Observation	Result
1. Solid + conc. H_2SO_4 heat. 2. Soln. + $AgNO_3$ Soln. 3. Brown ring test: Soln. + saturated $FeSO_4$ soln. + 2 ml. conc. H_2SO_4 drop by drop without shaking. 4. Ammonia test: Soln. + Zn(or Al) + NaOH heat. Physical Prop.:		

III Miscellaneous Group

This group includes the remaining acid radicals which are not affected by either dil. HCl or hot conc.H_2SO_4

(A) General Tests:

Experiment	**Sluphate e.g Na_2SO_4**	**Borate e.g. $Na_2B_4O_7$**	**Phosphate e.g.Na_2HPO_4**
1. Soln. + $AgNO_3$ soln.	Sluphate e.g. Na_2SO_4	White ppt. $AgBO_3$ sol. in NH_4OH and acetic acid	Yellow ppt. of Ag_3PO_4 sol. in NH_4OH and dil. HNO_3
2. Soln. + $BaCl_2$	White ppt. of $BaSO_4$ from Conc. solns. only	White ppt. of $Ba_3(BO_3)_2$ from conc. solns. sol. in xss. $BaCl_2$ and dil. HCl and HNO_3	White ppt. of $BaHPO_4$ From neutral soln. sol. in dil. mineral acids and acetic acid.
3. Soln.+Magnesia mixture ($MgCl_2$ +NH_4Cl+H_4OH)			White ppt. of $HgNH_4PO_4$ sol. in acetic acid and in mineral acids

B) Special Tests:

Experiment	**Observation & Results**
i- Sulphate:	
Soln. + acetate soln.	White ppt. of $PbSO_4$ sol. In Amm. acetate.
ii- Borate:	
1) Soln. + one drop of ph.ph.	Pink color which is decolorized by dil. glycerol. The color appears on heating and disappears on cooling.
2) Conc. soln. conc. HCl.	White ppt. of boric acid H_3BO_4
iii- Phosphate:	
1) Soln. + amm. molybdate + 2 ml. conc. HNO_3	Cream yellow ppt. sol. in dil. HCl. But insol. in acetic acid
2) Soln. $FeCl_3$ soln.	

Detection of the Sulphate Radical (SO_4^{-2})

Experiment	Observation	Result
1. Soln. + $AgNO_3$ soln.		
2. Soln.+ $BaCl_2$ soln.		
3. Soln. + lead acetate soln.		
4. Soln + $SrCl_2$ soln.		
Physical Prop.:		

Detection of the Borate Radical $(B_4O_7)^{--}$

Experiment	Observation	Result
1. Soln. + $AgNO_3$ soln.		
2. Soln. + One drop of ph.ph. and heating.		
3. Conc. soln. + conc. HCl.		
Physical Prop. :		

Detection of the Phosphate Radical (HPO_4^{--})

Experiment	Observation	Result
1. Soln. + $AgNO_3$ soln.		
2. Soln. + Magnesia mix. ($Mg+NH_3Cl+NH_4OH$).		
3. Soln. + amm. Molybdate+ 2 ml. conc. HNO_3.		
4. Soln. +$FeCl_3$ soln.		
Physical Prop.:		

General Scheme for identification of the Acid Radical carry on the following experiments in the given order, to define the group to which the radical belongs:

1-Test for the presence of dil. HCI group:

Solid + dil. HCl, heat if necessary, characteristic of gases:

Observation	Conclusion	Confirm tests
a) Effervescence & evolution of a gas that causes turbidity for lime water.	Gas is CO_2 & radical may be carbonate or bicarbonate.	(1) If the salt is insol. So the radical is carbonate without any confirmation. (2) +ve result on cold: **carbonate.** (3) +ve result after heating: **bicarbonate**. * **$BaCl_3$** ---White ppt. sol. in dil. HC1. * **$HgCI_2$** ----Red brown ppt. * **$AgNO_3$**-----White ppt. sol. in dil. HC1
b) A gas of bad odor & blackens a lead acetate paper.	Gas is H_2S & radical may be sulphide	**$AgNO_3$** → Black ppt. **HaOH** + sod. nitropresside -- violet color. **$CdSO_4$**--- canary yellow ppt.
c) A gas of suffocating odor and turns and acid dichromate paper green.	Gas is SO_2 & radical may be sulphite	* **$AgNO_3$**------White ppt. **Acid I_2**-----Decolor **$BaCl_2$**----- White ppt. sol. in dil. HCl
d) A gas as in (c) but soln. becomes turbid (white yellow).	Gas is SO_2 & turbidity is **S** & the radical may be thiosulphate.	**$AgNO_3$** ----- White ppt. ----- yellow ---- black. **I_2**-------Decolor. **$FeCl_3$**------Violet color, vanishes gradually
e) A gas that becomes red brown at mouth of tube & soln. becomes blue.	Gas is NO and the radical may be nitrite.	***$AgNO_3$** - White pp. **Acid I_2** ---Decolor. **$FeSO_4$ + acid**---- Brown color.

2-Test for the presence of hot conc. H_2SO_4 group

Solid + conc. H_2SO_4, heat mildly then strongly characteristic of gases.

Observation	Conclusion	Confirm tests
a) Evolution of a gas that turns blue litmus paper into red.	Gas is HCl & the radical may be Cl^-	*$AgNO_3$----White cruddy ppt. *$Pb(Ac)_2$----- White ppt. sol. in boiling water. *$Hg(NO_2)_2$---White silky ppt.
b) Evolution of red brown fumes & soln. becomes red color	Gases are Br_2 & the radical may be bromide	*$AgNO_3$ ----Pale yellow ppt. *$Pb(Ac)_2$----- White ppt. sol. in boiling H_2O *MnO_4^- + conc. H_2SO_4 ------- red brown fumes.
c) Evolution of violet fumes which turns starch paper to blue color	Gas are I_2 & The radical may be iodide.	*$AgNO_3$-----yellow ppt. *$HgCl_2$------Scarlet red ppt. sol. in the xss iodide *$CuSO_4$-----Dirty white ppt. clarifies with $S_2O_3^{-2}$
d) Evolution of red brown fumes after long heating.	Gases are NO_2 & the radical may be nitrate	*Brown ring test + ve. *Zn(NaOH)heat ----NH_3 gas. *Cu +conc. H_2SO_4-------Red Brown fumes

3-Tests for the pressure of the miscellaneous group:

(A) Soln. + $AgNO_3$→ppt.

(B) Soln. +$BaCl_2$→ppt.

Conclusion
May be Sulphate: * (A) Soln. + $AgNO_3$→ White ppt. * Soln. + $(Pb(Ac)_2$-- White ppt from conc. soln. * (B) Soln. + $BaCl_2$→ White ppt. insol. in HCl
May be Borate: * (A) Soln. + $AgNO_3$→ White ppt. sol. in NH_4OH & acetic Acid * Soln. + $HgCl_2$------ Red brown ppt. *(B) Soln. + $BaCl_2$→ White ppt. sol. in xss. $BaCl_2$ & HCl *Soln. + Conc. HCl ------White crystals.
May be Phosphate: *(A) Soln. + $AgNO_3$→ Yellow ppt. sol. in NH_4OH & Acids. * *Soln. + $FeCl_3$ -- Cream yellow ppt. *(B) Soln. +$BaCl_2$→ White ppt. sol in acids. * Soln. + Mg mix-----White ppt * Soln. + Amm. moilybdate + conc.HNO_3 --- Yellow ppt.

Unknown No. ( )

Experiment	Observation	Result
Physical Prop. :		

BASIC RADICALS

The famous basic radicals can be classified into six groups according to their behavior towards certain reagent. The "Group reagent" which will precipitate down any one of the members of a given group when present in solution. The following table includes this classification.

It is to be noted that most of the tests for basic radicals are carried out in solution. If the substance is insoluble in water, its solubility will be tried with the previously mentioned solvents in the given order.

The use of these solvents changes only the acid radical and has no effect on the basic radical or the salt under test.

Analytical Group

Group	Reagent	Metals	Cations
I	dil. HCl	Sliver (Hg)Mercurous Lead	Ag^{+} Hg_2^{+2} Pb^{++}
II	H_2S (Acidic medium) HCl	(Hg) Mercuric Copper Bismuth Cadmium	Hg^{+2} Cu^{++} BI^{+++} Cd^{+2}
III	[NH_4Cl + NH_4OH]	Iron Aluminum Chromium	Fe^{+2},Fe^{+3} Al^{+3} Cr^{+3}
IV	$(NH_4)_2S$ + [NH_4Cl+NH_4OH]	Zinc Manganese Nickel Cobalt	Zn^{+2} Mn^{+2} Ni^{+2} Co^{+2}
V	$(NH_4)_2CO_3$ + [NH_4Cl+NH_4OH]	Calcium Barium Strontium	Ca^{+2} Ba^{+2} Sr^{+2}
VI	No specific reagent	Magnesium Potassium Sodium Ammonium	Mg^{+2} K^{+} Na^{+} NH_4^{+}

(dil. HCl group)

It includes basic radicals for silver (Ag^{+}), Mercurous (Hg_2^{2+}), and lead (Pb^{++}). The group reagent is dil. HCl which forms ppt. of the corresponding chlorides.

Tests	**Silver e.g.$AgNO_3$**	**Lead e.g $Pb(NO_3)_2$**	**Mercurous e.g. $Hg_2(NO_3)_2$**
1) Soln. + dil HCl acid.	White curdy ppt. of AgCl sol. in NH_4OH and $Na_2S_2O_3$ but insol. in dil. HNO_3	White ppt. of $PbCl_2$ from cold conc. solns. sol. in hot water and separates on cooling.	White ppt. of Hg_2Cl_2 insol. in cold dil. acids but sol. in aqua Regia (3HCl:1HNO_3)conc.
2) Soln. +H_2S soln.	Black ppt. of Ag_2S insol. in HN_4OH but sol. in HNO_3	Black ppt. of PbS sol. in hot dil. HNO_3	Immediate black ppt. of Hg_2S.
3) Soln. + KI soln.	Yellow ppt. of AgI insol. in both NH_4OH & dil. HNO_3	Yellow ppt. of PbI_2 sol. in boiling water and separates on cooling in golden yellow plates.	Yellowish green ppt. of Hg_2I_2 sol. in xss KI.
4) Soln + K_2CrO_4 soln.	Brown-red ppt. of Ag_2CrO_4 sol. in dil. HNO_3 & HN_4OH but insol. in dil. acetic acid	Yellow ppt. of $PbCrO_4$ insol. in acetic acid but sol. in Hydroxides & HNO_3	Brown ppt. of Hg_2CrO_4 on cold which becomes red on boiling.
5) Soln. + NaOH soln.	Brown ppt. of Ag_2O insol. in xss. NaOH but sol. in xss. NH_4OH	White ppt. of $Pb(OH)_2$ sol. in xss. NaOH	Black ppt. of Hg_2O insol. in xss NaOH

(B) Special tests for dil. HCl Group

Experiment	Observation and results
i-Sliver: 1) Soln. +2 drops $Na_2S_2O_3$	White ppt. sol. in xss. $Na_2S_2O_3$, it turns yellow, orange then black.
2) Soln. + sod. phosphate	White ppt. of AgOH sol. in Xss KOH to Form K Ag $(OH)_2$.
ii-Lead: soln. + dil.H_2SO_4	White ppt. of $PbSO_4$
iii- Mercurous mercury:	
1) Soln. + pot. Nitrate soln.	Yellow ppt. sol. in HNO_3 and NH_4OH
2)Soln.+stannous chloride soln.	Dark grey ppt. of metallic Hg

Detection of Silver Ag^{+}

Experiment	Observation	Result
1) Soln. + dil. HCl 2) Soln.+ H_2S soln. 3) Soln. + KI soln. 4)Soln.+K_2CrO_4 soln. 5) Soln.+ NaOH soln. 6) Soln. + 2 drops of $Na_2S_2O_3$ soln. 7) Soln. + sod. phosphate soln. Physical Prop.:		

Detection of Lead (Pb^{++})

Experiment	Observation	Result
1) Soln. + dil. HC1 2) Soln. +H_2S soln. 3) Soln. +KI soln. 4)Soln.+K_2CrO_4 soln. 5) Soln.+ NaOH soln. 6) Soln. + dil. H_2SO_4 Physical Prop.:		

Detection of Mercurous (Hg_2^{++})

Experiment	Observation	Result
1) Soln.+ dil. HCl 2) Soln. + H_2S soln. 3) Soln. + KI soln. 4)Soln.+K_2CrO_4 soln. 5)Soln. + NaOH soln. 6) Soln.+ KNO_3 soln. 7) Soln. + stannous chloride soln. Physical Prop.:		

Group II (H_2S Group)

The group includes metal cations which are precipitated as Sulphides by H_2S hot HCl-acidified solution. The members of the group are classified into two subgroups according to the solubility of their sulphides in hot yellow ammonium sulphide as follows:-

1) Subgroup (II A) or Copper Group: It contains mercuric mercury, bismuth, copper and cadmium whose sulphides are insol. in hot yellow amm. sulphide.

2) Subgroup (II B) or Arsenics Group: It contains arsenic antimony and tin, the sulphides of which are soluble in hot yellow amm. sulphide, Experimental details are omitted.

Group (II A) Copper Group

The reaction of the members of the copper group with the group reagent which consists of dil. HCl and H_2S to form insol. Sulphides is represented by the following equations:-

$HgCl_2 + H_2S \rightarrow HgS + 2HCl$ (black).

$Bi(NO_3)_3 + H_2S \rightarrow Bi_2S_3 + 3\ HNO_3$ (brown)

$CuSO_4 + H_2S \rightarrow CuS + H_2SO_4$ (black).

$CdSO_4 + H_2S \rightarrow CdS + H_2SO_4$ (yellow)

(A) General Tests for gr. II A

Tests	Mercuric e.g.$HgCl_2$	Bismuth e.g. $Bi(NO_3)_3$	Copper e.g.$CuSO_4$	Cadmium e.g.$CdSO_4$
1) Soln. + HCl dil. (till Acidic) Warm + H_2S	White ppt. at first of $Hg_3Cl_2S_2$ which changes to yellow brown and finally black (HgS)	Brown ppt. of Bi_2S_3 insol. In yellow amm. Sulphide but sol. in hot dil. HNO_3	Black ppt. of CuS insol. in yellow amm. sulphide but sol. in dil. HNO_3 + KCN soln.	Yellow ppt. of CdS insol. in yellow amm. sulphide but sol. in hot dil. HNO_3
2) Soln. + NaOH soln.	Red-brown ppt. of the basic chloride that changes to yellow HgO	White ppt. of $Bi(OH)_3$ sol. in dill mineral acids	Blue ppt. of $Cu(OH)_2$ changes to black ppt. of CuO on heating	White ppt. of $Cd(OH)_2$
3) Soln. + NH_4OH soln.	White ppt. of amino mercuric chloride to yellow HgO	White basic slat insol. in xss. NH_4OH	A pale blue ppt. of the basic salt sol. in xss. NH_4OH to give a deep blue color.	White pp. of $Cd(OH)_2$ sol. in xss. NH_4OH
4) Soln. + KI soln.	Scarlet red ppt. of HgI_2 sol. in xss. KI to form K_2HgI_4	Dark brown ppt. of BiI_3 sol. in xss. KI to give a yellow soln. upon dilution, the brown ppt. reform.	White ppt. of Cu_2I_2 together with a brown solution due to liberation of I_2	

(B) Special Tests for gr.(IIA)

Experiment	Results and observations
i- Mercuric Hg:	
1-Soln. + Sn Cl_2 soln.	White ppt. of $HgCl_2$ which changes to grey-black ppt. with xss. of $SnCl_2$
2-Soln. + $(NH_4)_2CO_3$ soln.	Red-brown ppt. of basic carbonate.
ii- Bismuth:	
1-Soln. + xss. water	A white ppt. of the basic salt $Bi(OH)_3$, sol. in dil mineral acids, but insol. in tartaric acid soln. (contrary to Sb). and in solutions of alkali hydroxides (contrary to Sb).
2-Soln.+ sod. Stannite $Na_2(SnO_2)$ (Stannous Chloride +xss. NaOH)	Black ppt. of finely divided Bi.
iii-Copper:	
1-Slon. + pot. Ferrocyanide $K_2Fe(CN)_6$	Red brown ppt. of cupric ferrocyanide $Cu_2Fe(CN)_6$ insol. in dil acids but sol. in as NH_4OH to a blue
2-Soln.+ KCN	soln.yellow ppt. of $Cu(CN)_2$ which decomposes to white $Cu_2(CN)_2$ that dissolves. In xss. KCN to form
iv-Cadmium	$K_3Cu(CN)_4$.
1-Soln. +KCN	white ppt. of Cd(CN) + sol. in xss. KCN, on passing H_2S in the resulting solution, a yellow ppt. of CdS forms (contrary to Cu).
2-Soln. + $K_2Fe(CN)_6$	White ppt. of cadmium ferrocyancide.

Unknown No. ( )

Experiment	Observation	Result
Physical Prop. :		

GROUP III

Ammonium Hydroxide Group

Members of this group are Ferrous Iron, Ferric Iron, Chromium and Aluminum, The group reagent is composite consists of NH_4Cl and NH_4OH that form insoluble hydroxides as illustrated by the following equations:

$$\mathbf{FeSO_4 + 2\ NH_4OH \rightarrow Fe(OH)_2 + (NH_4)_2SO_4\ (dirty\ green)}$$

$$\mathbf{FeCl_3 + 3\ NH_4OH \rightarrow Fe(OH)_3 + 3NH_4Cl\ (red\text{-}brown)}$$

$$\mathbf{Al_2(SO_4)_3 + 6\ NH_4OH \rightarrow Al(OH)_3 + 3(NH_4)_2SO_4\ (white)}$$

$$\mathbf{CrCl_3 + 3NH_4OH \rightarrow Cr(OH)_3 + 3NH_4Cl\ (dirty\ green)}$$

(A) General Tests for Gr. III

Tests	Ferrous e.g. $FeSO_4$	Ferric e.g. $FeCl_3$	Aluminum e.g.$AI_2(SO_4)_3$	Chromium e.g. $CrCl_3$
1) Soln. + NH_4Cl + NH_4OH till alkaline	Dirty green ppt. of $Fe(OH)_2$ insol. in alk. Hydroxides but sol. in dil. mineral acids	Red-brown gelatinous ppt. of $Fe(OH)_3$ insol. in alk. Hydroxides but disol. in acids.	White gelatinous ppt. of $Al(OH)_3$ slightly sol. in xss. NH_4OH	Grey green gelat. ppt. of $Cr(OH)_3$ slightly sol. in xss. NH_4OH to give a violet soln. & reppt. on boiling.
2) Soln. + NaOH	Same as above	Same as above	White gelate. ppt. $Al(OH)_3$ sol. in xss. NaOH to Sod. aluminate $NaAlO_2$	Grey green ppt. sol. in acids & in xss. NaOH to give green soln. of $NaCrO_2$
3) Soln + NH_2HPO_4		Pale yellow ppt. $FePO_4$ insol. in acetic acid but sol. in mineral acid & alk. solns.	White gelate. ppt. of $AlPO_4$ insol. in acetic but sol. in mineral acids + alk. solns.	Green ppt. of $CrPO_4$ sol. in dil. mineral acids & insol. in acetic acid.

(B) Special Tests for Gr. III

Experiment	Results and observations
1- Ferrous Iron	
1) Soln. + pot. Ferricycanide $K_3Fe(CN)_6$.	Deep blue ppt. (Turnbul's blue).
2) soln. + KCN ----------	Yellowish white ppt. of ferrous cyanide sol. in xss. KCN to form a yellow soln. of $K_4Fe(CN)_6$.
3) soln. + H_2S + NH_4OH---------	A black ppt. of FeS.
4) soln. + pot. Ferrocyanide $K_4[Fe(CN)_6]$. ----------	NO ppt.
5) soln. + pot.thiocyanate KCNS	NO color.
ii- Ferric iron	
1) soln. +$K_3Fe(CN)_6$ ----------	An intense blue ppt. of Prussian blue.
2) soln. + KCNS ----------	Blood red colour decolorized by $HgCl_2$
3) soln. + (neutral) + $Na_2S_2O_3$	A violet, red colour that quickly disappears.
4) soln. + sod. acetate.	
iii- Aluminium:	
1) soln. + Na_2CO_3	White ppt. of $Al(OH)_3$ sol. in xss. of Na_2CO_3
2) soln. (neutral) + xss. sod. acetate then boil.----------	A voluminous ppt. of basic acetate $Al(Ac)_2$.
iv- Chromium	
soln. + xss. NaOH + small quantity of sod. peroxide.	A yellow solution.

Unknown No. ( )

Experiment	Observation	Result
Physical Prop. :		

Unknown No. ( )

Experiment	Observation	Result
Physical Prop. :		

Unknown No. ( )

Experiment	Observation	Result
Physical Prop. :		

Unknown No. ( )

Experiment	Observation	Result
Physical Prop. :		

GROUP(IV)

Ammonium Sulphide Group

This group contains divalent metal cations of Zinc, Manganese. Nickel and Cobalt. the group reagent consists of NH_4Cl, NH_4OH and $(NH_4)_2S$ or H_2S that forms insol. sulphide in alk. medium according to the following equations: -

$ZnSO_4 + (NH_4)_2S \rightarrow ZnS + (NH)_2SO_4$ (white).

$MnCl_2 + (NH_4)_2S \rightarrow MnS + 2\ NH_4Cl$ (flesh).

$Co(NH_3)_2 + (NH_4)_2S \rightarrow CoS + 2\ NH_4NO_3$ (black).

$NiCl_2 + (NH_4)_2S \rightarrow NiS + 2\ NH_4Cl$ (black).

(A) General Tests for Gr. IV

Tests	Zinc	Manganese	Cobalt	Nickel
1) Soln. + NH_4Cl + NH_4OH (till just alk.) + H_2S	White ppt. of ZnS sol. in dil. mineral acids.	Fleshy ppt. of MnS, becomes brown in air.	Black ppt. of CdS. sol. in conc. HNO_3 with separation of S.	Black ppt. of NiS sol. in hot conc. HNO_3
2) Soln. +NaOH or NH_4OH.	White gelat. ppt. of $Zn(OH)_2$ sol. in xss. alk. forming Na_2ZnO_2 and also sol. in dil. acids.	White ppt. of $Mn(OH)_2$. becomes brown in air insol. in xss. alkail	A blue ppt. is formed on cold, whereas a pink ppt. which turns brown is formed with xss. alkali and heating.	Green ppt. of $Ni(OH)_2$ insol. in NaOH but sol.in NH_4OH and amm. slats to form green-blue solns.
3) Soln. + Na_2CO_3 Or $(NH_4)_2CO_3$	White ppt. of basic carbonate sol. in xss. $(NH_4)_2CO_3$	White ppt. of $MnCO_3$	Red ppt. of basic salt sol. in xss. $(NH_4)_2CO_3$	Apple green ppt. $NiCO_3$ sol. in xss. $(NH_4)_2CO_3$
4) slon. + KCN	White ppt. of $Zn(CN)_2$ sol. in xss. KCN	Brown ppt. of $Mn(CN)_2$ sol. in xss. KCN to a brown soln. that gives green ppt. on heating.	Red-brown ppt. of $Co(CN)_2$ sol. in xss. KCN to a brown soln. of $K_4Co(CN)_6$	Light green ppt. $Ni(CN)_2$ sol. In xss. KCN to give $K_2Ni(CN)_4$

(B) Special Tests for Gr. IV

Experiment	Results and observations
i- Zinc	
1) Soln. + NH_4Cl sod. phosphate (Na_2HPO_4)	White ppt. of $Zn(NH_4)PO_4$ sol. in NH_4OH and dil. acids.
2) soln. + pot. ferrocyanide	White ppt. of $Zn_2Fe(CN)_6$
ii- Manganese	
1) soln. + NH_4OH + ferrocyanide.	Fleshy ppt. of $Mn(NH_4)PO_4$
2) soln. + pot. Ferrocynide.	Brown ppt. of $Mn_2Fe(CN)_6$
3) soln + lead peroxide + conc. HNO_3, boil, dil with H_2O, allow to stand and settle.	The supernatant liquid is colored violet due to formation of MnO_4^-
iii- Cobalt:	
1) soln. + NH_4CNS	Blue solution due to form of $(NH_4)_2Co(CNS)_4$.
2) (soln. + (acetic) + xss. KNO_2	Yellow ppt. of $K_3Co(NO_2)_6$
3) soln. + pot. ferrocyanide	Brown-red ppt. of $Co_3Fe(CN)6$ insol. in dil. HC1
iv- Nickel	
1)soln. +NH_4OH till (alk.) + dimethyl glyxime ($C_4H_8O_2H_2$)	Red ppt. of Nickel dimethyl glyoxime

Unknown No. ( )

Experiment	Observation	Result
Physical Prop. :		

Unknown No. ( )

Experiment	Observation	Result
Physical Prop. :		

Unknown No. ( )

Experiment	Observation	Result
Physical Prop. :		

GROUP V

Ammonium Carbonate Group

This group presents the only example where metals of the same group of periodic table form an independent group of basic radicals. It contains the divalent metal cations of calcium, strontium and barium which occupy group II A in the periodic table. The group reagent consists of NH_4Cl (avoid xss.), then NH_4OH till just alk., and $(NH_4)_2CO_3$ which form insol. Carbonates from hot (60° C) solutions.

$$\mathbf{CaCl_2 + (NH_4)_2CO_3 \rightarrow CaCO_3 + 2\ NH_4Cl}$$

$$\mathbf{SrBr_2 + (NH_4)_2CO_3 \rightarrow SrCO_3 + 2\ NH_4Br}$$

$$\mathbf{BaCl_2 + (NH_4)_2CO_3 \rightarrow BaCO_3 + 2\ NH_4Cl}$$

(A) General Tests for Gr. V

Tests	Calcium	Strontium	Barium
1) Soln. + NH_4Cl (few) + NH_4OH (till just alk.) + $(NH_4)_2CO_3$.	White ppt. of $CaCO_3$ sol. in dil. acids.	White ppt. of $SrCO_3$ sol. in dill. acids.	White ppt. of $BaCO_3$ sol. in dil. acid
2) Soln. + $Ca(OH)_2$ just alk.) + Amm. oxalate.	White ppt. of CaC_2O_4 insol. in acetic & sol. in mineral acids.	White ppt. of SrC_2O_4 insol. in acetic & sol. in mineral acid.	White ppt. of BaC_2O_4 sol. in mineral acids.
3) Soln. + $CaSO_4$ soln.	No ppt.	White ppt. of $SrSO_4$ insol. in $(NH_4)_2CO_3$	Heavy white ppt. of $BaSO_4$ insol. in dil. acids.
4) slon. + sod. carbonate	White ppt. sol. in mineral acids & acetic acid.	Same as Ca.	Same as Ca
5) soln. (conc.) + K_2CrO_4	Yellow ppt. of $CaCrO_4$ sol. in acetic acid.	Yellow ppt. sol. in acetic acid.	Yellow ppt. from neutral soln. insol. in acetic acid
Flame test	Brick---red color.	Crimson red color	Apple green color

(B) Special Tests for Group V

	Experiment	Observation & Result
Calcium: Soln. (conc.)	+ NH_4Cl + pot. Ferrocyanate	A white ppt. is formed especially on standing

Unknown No. ( )

Experiment	Observation	Result
Physical Prop. :		

Unknown No. ( )

Experiment	Observation	Result
Physical Prop. :		

Unknown No. ( )

Experiment	Observation	Result
Physical Prop. :		

GROUP VI

The Alkali Group

This group contains those cations which are not ppted. by any of the previously mentioned group reagents. Those radicals are sodium (Na^+), potassium (K^+), ammonium (NH_4^+) and Magnesium (Mg^{++}).

Experiment	Observation + Results
i-Magnesium (Mg):	
1) soln. + NH_4Cl + NH_4OH + Na_2HPO_4.	White ppt. of $Hg(NH_4)PO_4$ sol. in acids.
2) soln. + NaOH	**White ppt. insol in xss. NaOH, sol. in amm. salts.**
3) soln. + $(NH_3)_2CO_3$ or Na_2CO_3.	White ppt. of heating sol. in amm. salts.
ii- Ammonium (NH_4^+) :	Ammonia gas evolves detected by, odor and turning red litmus blue.
1) solid t conc. NaOH, heat.	
2) soln. + Nessler's reagent K_2HgI_4	**Brown ppt. or brown-yellow coloration.**
3)soln. + sat. sod. Hydrogen tartarate (or tartaric acid soln.)	White ppt. of amm. acid tartarate.
4) soln. + sod. Cobalti nitrite $Na_3[Co(NO_2)_6]$.	**Yellow ppt. of $(NH_4)_3Co(NO_2)_6$.**
5) soln. + few drops KI + one drop sat. sod. hypochlorite (NaOCl).	A black ppt. of $NaHI_2$, is formed
6) Solid, heat.	**Decompa., evolution of NH_3 gas and condentsation of white ppt. on colder part of T.T.**

(B) Special Tests for Group (VI)

The Alkali Group

(continued)

Experiment	Results and observations
iii- Potassium (K^+):	
1) soln. + NH_3 Co $(NO_2)_6$	Yellow ppt. especially on warming.
2) soln. + sat. tartaric acid, scratch.	**White ppt. from conc. solns.**
3) soln. + perchloric acid or $NaClO_4$.	White crystalline ppt. of $KClO_4$.
4) Carnot's test : one drop dil. Bismuth nitrated + 2 drops dil. $Na_2S_2O_4$ + 10 ml alcohol + neutral soln.	**A yellow ppt. of pot. Bismuth Thiosulphate.**
5) Flame test.	Pale violet color
iv- Sodium:	
1) soln. +Na_3 $Co(HO_2)_6$	No ppt.
2) soln. + tartaric acid	**No ppt.**
3) soln.+ pot. dihydrogen antimonite.	White crystalline ppt. of sod. dihydrogen antimonite after scratching
4) flame test.	**Golden yellow coloration.**

Unknown No. ( )

Experiment	Observation	Result
Physical Prop. :		

Unknown No. ( )

Experiment	Observation	Result
Physical Prop. :		

Unknown No. ( )

Experiment	Observation	Result
Physical Prop. :		

Some Important Remarks:

i-Dissolution:

1) Powder the solid and then try its solubility in the solvent scheme previously mentioned in the given order.

2) If the solid dissolves in dil. HCl then group I is absent.

3) If the substance dissolved in conc. HCl the soln. should be diluted with dil. HCl before adding the group reagent otherwise BiOCl.

4) lf all reagents up to aqua-regia fail to dissolve the substance. The solid is fused some of its weight with dry Na_2CO_3 and extract the fused mass with a little boiling water and filter. Dissolve residue in dil. HNO_3 and test the resulting soln. for basic radical. The filtrate on the other hand can be sued for the detection of acid radicals.

5) A substance may dissolve on heating but reppts. on cooling as $PbCl_2$, so one must cool the solution before carrying out the tests. If any ppt. is formed on cooling, another solvent must bestride.

6) If a concentrated acid is used the solution must be diluted with water then cooled.

7) It is preferable in case of HNO_3& aqua-regia to evaporate till dryness then dissolve residue in water (nitrates interfere with the identification of gr. II, by oxidizing H_2S into yellow-white colloidal S).

ii-Some difficulties

1) If there is a bismuth salt, a white ppt. may be formed on adding HCl and thus gr. I may be suspected. Once the ppt. dissolves in xss. water gr. is absent. Better add H_2S on the white ppt. if it does not turn black then gr. I is absent.

2) If a thiosulphate is present a white ppt. is formed sometime after adding HCl which soon turns yellow especially on warming due to separation of colloidal Sulphur which can be separated by boiling the soln. with a place of filter paper and filtering.

3) If a white ppt. is formed upon addition of dil. HCl as a reagent for gr. I, it will be either from gr. I, Bi from Gr. II ppt. disappears it is Bi or Sb. Then add H_2S, if it turns black it is from gr. (I) otherwise it is Bi or Sb.

4) If the concn. of dil. HCl used in gr. It is somewhat higher Cd may escape precipitation with the gr. regent in this case neutralization of the acidic soln. with NH_4OH causes appearance of the yellow ppt.

5) If the amount of NH_4Cl added in the reagent of gr III is not sufficient, members of the coming groups may precipitate. In this case add more NH_4Cl, if ppt. dissolves gr. III is absent; if not gr. III is present.

6) Solution must be quite alk. for identification of both gr. (IV) & (V).

7) Bicarbonates may give the carbonate tests on acid due to impurities of carbonates.

8)Testing for nitrates requires prolonged heating with conc. H_2SO_4 and adding a piece of Cu metal before ascertaining absence of nitrate.

9)Testing for miscellaneous group requires relatively concentrated solutions.

GENERAL SCHEME FOR IDENTIFICATION OF SIMPLE INORGANIC UNKNOWNS

A-Report on the physical properties as:

1) Color 2) Crystalline state 3) Solubility (Action on litmus).

B-Identification of the Basic Radical:

Cary on the following ten tests in the given order

1-test for the presence of NH_4^+ Solid, NaOH soln. conc. heat

Observation	Conclusion	Confirm tests
Evolution of gases that turns red litmus blue and have charact. odor	Gas in NH_3 & the basic radical may be ammonia.	*Nessler's reag. yellow color or ppt. *$Na_3[Co(NO_2)_6]$ -- yellow Ppt. *KI + NaOCl----- Black ppt.

2-Test for the presence of group (I)

soln. (cold) dil. HCl----------Heavy white ppt.

Observation	Conclusion	Confirm tests
a- white ppt. sol. in NH_4OH & turn violet by heat.	ppt. is AgCl and the radical may be Ag^{+}	*H_2S---- black ppt. sol. in NHO_3 and insol. in NH_4OH. *KCN---- white ppt. sol. in xss. KCN. *K_2CrO_4 (neutral)- red brown ppt.
b-white ppt. blackens with	ppt. is Hg_2Cl_2 and the radical may be Hg_2^{+2}	*H_2S--- black ppt. insol. In NHO_3 * $SnCl_2$---- -white ppt. turns grey with xss.
c-white ppt. insol. in NH_4OH	ppt. is $PbCl_2$ and the radical may be Pb^{++}	H_2S ----- black ppt. sol. in hot HNO_3 K_2CrO_4----- yellow ppt. insol. in acetic and sol. in nitric NaOH----- white ppt. sol. in XSS

3-Test for group (IIA)

Soln.+ dil. HCl, hot to 60° C + H_2S -- Colored ppt. insol. in yellow $(NH_4)_2S$

Observation	Conclusion	Confirm tests on soln.
a) Black ppt. insol. in conc. HNO_3	ppt. is HgS and radical may be Hg^{++}	*NaOH-- yellow or red ppt. *KI-----violet ppt. sol. in xss. KI *Na_2CO_3------red brown ppt.
b) Black ppt. sol. in conc. HNO_3 to give a blue soln.	ppt. is CuS and radical may be Cu^{++}	*KI----dirty white ppt. *HN_4OH-----pale blue ppt. sol. in xss. *NH_4OH + $K_4Fe(CN)_6$---red brown ppt. insol. in acids and sol. in NH_4OH
c) Brown ppt. sol in conc. HNO_3 colorless soln.	ppt. is Bi_2S_3 & radical may be Bi^{+3}	*NaOH-- white ppt. that change to yellow on boiling. *H_2O---- formn. of white ppt. Na_2SnO_2-- -- black ppt.
d) Canarian yellow ppt. sol. in conc. HNO_3 to give a color-less soln.	ppt. is CdS & radical may be Cd^{++}	NaOH white ppt. insol in xss. KCN- white ppt. sol. in xss. $K_3Fe(CN)_6$ -- -white ppt.

4-Test for group (III) 1 ml. soln. + 2 ml. NH_4Cl +NH_4OH (till just alk.) ppt.

Observation	Conclusion	Confirm tests
a) white gelat. ppt. sol. in NaOH	ppt. is $Al(OH)_3$ + radical may be aluminum.	*Na_2CO_3---- white ppt. sol. in xss. $NaCO_3$ *Na_2HPO_4--- white gelat. pp. sol. in acids & bases.
b) Dirty green ppt sol. in acids only	ppt. is $Fe(OH)_2$ and radical may be ferrous	*$(NH_4)_2S$ ---- white ppt. *pot. Ferricyanide -- Blue ppt KCN----- yellow white ppt. sol. in xss. KCN
c) Dirty green ppt. sol. in acids and bases	ppt. is $Cr(OH)_3$ & radical may be chromium	KCNS---- No blood red coloration. *NaOH---- Grey green ppt. sol. in xss. Ha_2HPO ----green ppt. sol. In dil. Mineral acids. *xss. NaOH+ Na_2O_2 ----yellow soln.
d) Red brown ppt.	ppt. is $Fe(OH)_3$ & radical may be Fe^{+3}	Pot. Ferrocyanide ----- Blue ppt. KCNS -----Blood red colour. Na_2HO_4 --- cream yellow ppt. insol. in acetic.

5- Test for group (IV) 1 ml. soln. +1 ml. NH_4OH (till alk.) + H_4S (xss.) ppt.

Observation	Conclusion	Confirm tests
a) white gelat. ppt. sol. in acids.	ppt. is ZnS & radical may be Zinc.	*NaOH---- white ppt. sol. in *KCH----white ppt. sol. in XSS. *NHCI + Na_2HPO_4--- white ppt.
b) Fleshy ppt. sol. in acids only.	ppt. is MnS and radical may be Manganese.	*NaOH---white ppt. which changes to brown.. *KCN----brown ppt. sol. in XSS to brown soln.. *Pot. Ferrocyanide--- brown ppt.
c) Black ppt. insol.in acids soln. + dimethyl glyoxime + NH_4OH red ppt.	ppt. is NiS & radical may be Ni	* NaOH-- Apple green ppt. sol. in acid * KCN--- pale. green ppt. sol. in X *$(NH_4)_2CO_3$----- apple green ppt. sol. in xss.
d) Black ppt. insol. in Acids. soln. + NH_4OH+ dimethyl Glyoxime no ppt.	ppt. is CoS & radical may be Cobalt	*KCNS -- Blue soln. *Acetic acid + xss. KNO_3---- yellow ppt. *Acetic acid + xss. KNO_2----yellow ppt. *KCN---- pale green ppt. sol. in xss. KCN

6- Test for group (V) 1 ml. soln. + 1 ml. NH_4Cl + NH_4OH(till alk.) + $(NH_4)_2CO_3$ white ppt.

Observation	Conclusion	Confirm tests
a) white ppt. & brick red color for flame.	pp. is $CaCO_3$& radical may be Calcium.	*$CaSO_4$--- -no ppt. *K_2CrO_4 --yellow ppt. sol. in dil acetic $K_3Fe(CN)_6$ (NH_4Cl)--- white ppt. after time.
b) white ppt. & crimson red color for flame.	ppt. lin $SrCO_3$ & radical may be Strontium.	*$CaSO_4$---- white ppt. form conc. solutions K_2CrO_4---- yellow ppt. sol. in hot acetic * sod. phosphate -white ppt. sol. in acids.
c) white ppt. & apple green color for flame.	ppt. is Ba CO_3 & radical may be Barium.	*$CaSO_4$ --- Immediate white ppt. *K_2CrO_4-- -- yellow ppt. insol. In acetic *Sod. phosphate--white ppt. sol. in acids.

7-Test for group (VI)

Mg^{++} soln. + NH_4Cl + NH_4OH (alk.) Na_2HPO_4 white ppt.

Conclusion	Confirm tests
ppt. is $Mg(NH_4)PO_4$ + radical may be Mg.	*NaOH----- white ppt. insol. in xss. NaOH sol. in amm. salts *Na_2CO_3 --- white ppt., on heating

8-Test for K^+

Carnot's test: One drop dil. $Bi(NO_3)_3$ + 2 drops $Na_2S_2O_3$ + 10 ml alcohol + neutral soln… yellow ppt.

Conclusion	Confirm tests
ppt. is pot bismuth thiosulphate and radical may be Potassium.	*$Na_3Co(NO_2)_6$ ----yellow ppt. on warning *Sat. tartaric acid soln. ---white ppt. *Perchloric acid-- -- white ppt. *flame test-- Pale violet.

9-Test for Na^+

flame test ----- Golden yellow color

Conclusion	Confirm tests
Radical may be Na.	*$NaCo(NO_2)_6$ ---no ppt. *Tartaric acid---- no ppt. *Pot. Hydrogen antimonite -----white ppt.