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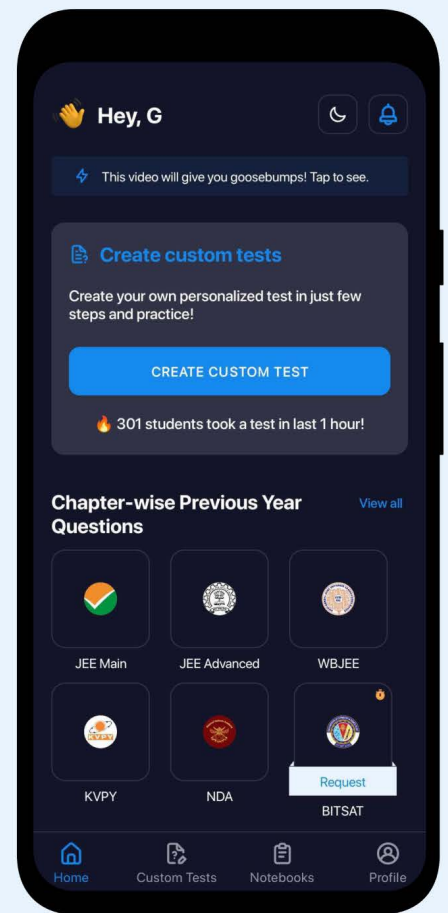


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QUALITATIVE ANALYSIS

QUALITATIVE ANALYSIS

Classification of Anions

Methods available for the detection of anions are not as systematic as those used for the detection of cations. Furthermore anions are classified essentially on the basis of process employed.

Class A : Includes anions that are identified by volatile products obtained on treatment with acids. It is further divided into two sub groups.

- (i) Gases evolved with dil. HCl/dil H_2SO_4
- (ii) Gases or acid vapours evolved with conc. H_2SO_4

Class B : Includes anions that are identified by their reactions in solution.

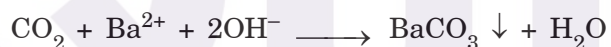
Class A : (i) Anions which evolve gases on reaction with dil. HCl/dil. H_2SO_4 .

1. Carbonate CO_3^{2-}

- (i) Dilute HCl : It gives effervescence, due to the evolution of carbon dioxide



The gas gives white turbidity with lime water and baryta water.

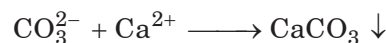
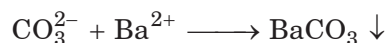


On prolonged passage of carbon dioxide in lime water, the turbidity slowly disappears due to the formation of soluble hydrogen carbonate of calcium.

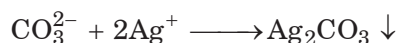


The following tests performed with then aqueous salts solution.

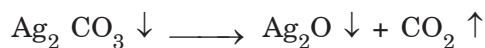
- (ii) **Barium chloride or Calcium chloride solution :** White ppt. of barium or calcium carbonate is obtained, which is soluble in mineral acid.



- (iii) **Silver nitrate solution :** White ppt. of silver carbonate is obtained.



The ppt. so obtained is soluble in nitric acid and in ammonia, the ppt. becomes yellow or brown on addition of excess reagent and same may also happened if the mixture is boiled, due to the formation of silver oxide.



2. Sulphides (S^{2-})

(i) Dilute HCl or dilute H_2SO_4

Sulphide on treatment with dilute HCl or dilute H_2SO_4 gives a pungent smelling gas, H_2S (smell of rotten eggs).



The blackening of filter paper moistened with lead acetate solution may identify the gas.



Shining black

Alternatively, a filter paper moistened with cadmium acetate solution turns yellow.



Yellow ppt

(ii) Silver nitrate solution

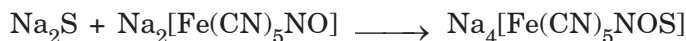
With AgNO_3 solution, sulphides gives a black precipitate of silver sulphide insoluble in cold but soluble in hot dilute nitric acid.



Black ppt

(iii) Sodium nitroprusside solution

With sodium nitroprusside solution, ionic sulphide gives a purple colour in alkaline medium.



Purple colour

No reaction occurs with solutions of hydrogen sulphide or free gas. In however, filter paper moistened with a solution of the reagent is made alkaline with sodium hydroxide or ammonia solution, a purple colouration is produced with free hydrogen sulphide also.

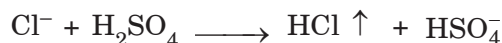
Class A (ii) : Gases or acid vapours evolved with conc. sulphuric acid. It includes Cl^- , Br^- , I^- , NO_3^-

3. Chloride (Cl^-)

Most chloride are soluble in water except Hg_2Cl_2 , CuCl , AgCl , PbCl_2 , BiOCl and SbOCl . PbCl_2 is soluble in hot water.

(i) Concentrated H_2SO_4

With concentrated H_2SO_4 , chlorides gives vapours of HCl .



Vapour evolved

- (a) turns blue litmus paper red.
- (b) gives white fumes of NH_4Cl when a glass rod moistened with aqueous ammonia solution is brought close to the mouth of test tube.

(ii) Manganese dioxide and concentrated sulphuric acid

When a solid chloride is treated with MnO_2 and concentrated H_2SO_4 , yellowish-green coloured gas (Cl_2) is evolved.



Yellowish green

(iii) Silver nitrate solution

Chlorides on treatment with AgNO_3 solution gives a white curdy precipitate of AgCl insoluble in water and in dilute nitric acid but soluble in dilute ammonia solution due to the formation of soluble complex.



White curdy ppt



Soluble

(iv) Lead acetate solution

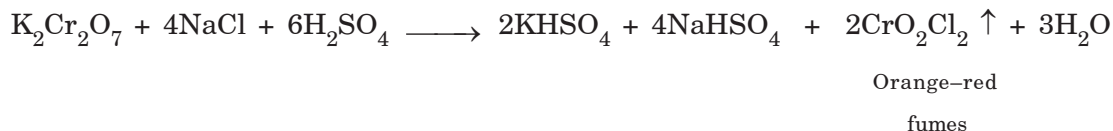
With $(\text{CH}_3\text{CO}_2)_2\text{Pb}$ solution, chlorides gives a white precipitate of lead chloride.



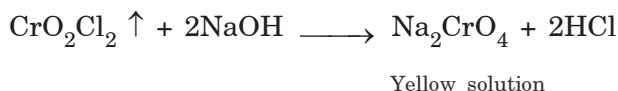
White ppt

(v) Chromyl chloride test

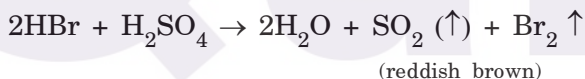
When a mixture containing chloride ion is heated with $\text{K}_2\text{Cr}_2\text{O}_7$ and concentrated H_2SO_4 , deep orange-red fumes of chromyl chloride (CrO_2Cl_2) are formed.



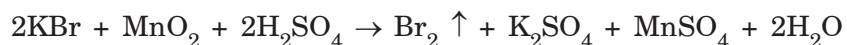
When chromyl chloride vapours are passed into sodium hydroxide solution, a yellow solution of sodium chromate is formed, which when treated with lead acetate gives yellow precipitate of lead chromate.

**4. Bromide (Br^-)**

(i) **Conc. H_2SO_4** : It gives reddish brown vapours of bromine.

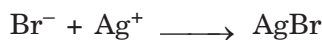


(ii) **Manganese dioxide and conc. sulphuric acid** : When a mix of solid bromide, MnO_2 and conc. H_2SO_4 is heated reddish brown vapours of bromine are evolved.



(iii) The following tests are performed with the salt solution.

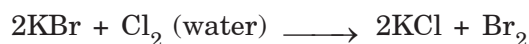
(a) **Silver nitrate solution** : A pale yellow ppt. of silver bromide is obtained. This ppt is sparingly soluble in dil but readily soluble in conc. ammonia solution and insoluble in dil. HNO_3 .



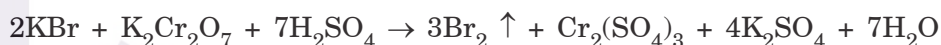
- (b) **Lead acetate solution :** White crystalline ppt. of lead bromide which is soluble in boiling water.



- (c) **Chlorine water :** When this solution is added to a solution of bromide and chloroform free bromine is liberated, which colours the organic layer orange-red.



- (d) **Potassium dichromate & conc. H_2SO_4 :** When a mixture of solid bromide, $\text{K}_2\text{Cr}_2\text{O}_7$, and conc. H_2SO_4 is heated and passing the evolved vapours into water, a yellowish brown solution is obtained.

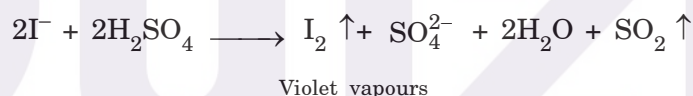


5. Iodide (I^-)

Iodides are generally soluble in water except AgI , Hg_2I_2 , HgI_2 , CuI and PbI_2 .

(i) Concentrated H_2SO_4

With concentrated H_2SO_4 , iodides gives violet vapours of iodine on warming.



(ii) Silver nitrate solution

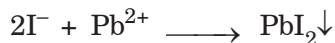
With AgNO_3 solution, iodides form a yellow curdy precipitate of silver iodide, which is very slightly soluble in concentrated ammonia solution, but is completely insoluble in dilute HNO_3 .



Yellow curdy ppt

(iii) Lead acetate solution

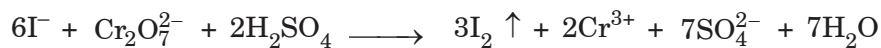
With $(\text{CH}_3\text{CO}_2)_2\text{Pb}$ solution, a yellow precipitate of lead iodide (PbI_2) is formed, which is soluble in hot water forming a colourless solution and yielding golden-yellow plates on cooling.



Yellow ppt

(iv) Potassium dichromate and concentrated sulphuric acid

When iodides are warmed with $\text{K}_2\text{Cr}_2\text{O}_7$ and concentrated H_2SO_4 , iodine is liberated.



Violet vapours

(v) Chlorine water

When this reagent is added dropwise to a solution of an iodide, free iodine is liberated, which colours the solution brown and on shaking with CS_2 , CHCl_3 or CCl_4 , it dissolves in organic layer forming a violet solution, which settles below the aqueous layer.

**(vi) Copper sulphate solution**

With CuSO_4 solution, iodide produces a brown precipitate consisting of a mixture of copper (I) iodide and iodine. On addition of hypo ($\text{Na}_2\text{S}_2\text{O}_3$) to the solution, brown precipitate changes to white (colourless).



Brown ppt

**(vii) Mercury(II) chloride solution**

With HgCl_2 solution, iodide gives a scarlet precipitate of HgI_2 .



Scarlet ppt

The precipitate dissolves in excess of KI, forming tetraiodomercurate(II) complex.



Soluble

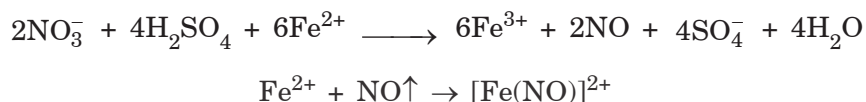
5. Nitrate (NO_3^-)

- (i) **Conc. H_2SO_4** : It gives reddish-brown vapours of nitrogen dioxide



The following tests are performed with the salt solution

- (ii) **Brown ring test** : When a freshly prepared solution of iron (II) sulphate is added to nitrate solution & conc. H_2SO_4 is poured slowly down the side of the test tube, a brown ring is obtained.



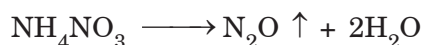
On shaking and warming the mix, the brown colour disappears, nitric oxide is evolved and a yellow solution of Iron(III) ions remains.

Action of heat : The result varies with the metal

- (1) Nitrates of sodium and potassium evolve oxygen (test with glowing splint) & leave solid nitrites (brown fumes with dilute acid).



- (2) Ammonium nitrate yields dinitrogen oxide & steam.



- (3) Nitrates of the noble metals leave a residue of the metal and a mix of nitrogen dioxide and oxygen is evolved.



- (4) Nitrates of other metals, such as those of lead and copper, evolve oxygen and nitrogen dioxide and leave a residue of the oxide.

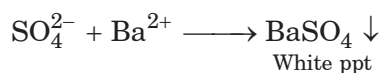


(B) Group 'B' Radicals**7. Sulphate (SO_4^{2-})**

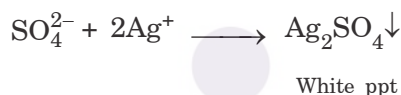
Sulphate of barium, strontium and lead are practically insoluble in water, those of calcium and mercury(II) are slightly soluble and most of the remaining metallic sulphates are soluble.

(i) Barium chloride solution

On adding BaCl_2 solution to a sulphate salt solution, a white precipitate of barium sulphate (BaSO_4) insoluble in warm dilute hydrochloric acid and in dilute nitric acid but moderately soluble in boiling concentrated hydrochloric acid is formed.

**(ii) Silver nitrate solution**

With silver nitrate solution, SO_4^{2-} gives a white crystalline precipitate of silver sulphate.

**(iii) Mercury(II) nitrate solution**

With $\text{Hg}(\text{NO}_3)_2$ solution, sulphates form a yellow precipitate of basic mercury(II) sulphate.

**Physical appearance of inorganic salts**

Sr No.	Salt	Colour
1	MnO , MnO_2 , FeO , CuO , Co_3O_4 , Ni_2O_3 , sulfides of Ag^+ , Cu^+ , Cu^{2+} , Fe^{2+} , CO^{2+} , Pb^{2+} , Hg^{2+}	Black
2	Hydrated Cu^{2+} salts	Blue
3	HgO , HgI_2 , Pb_3O_4	Red
4	Cr^{3+} , Cr^{6+} , Ni^{2+} , Hydrated Fe^{2+} salts	Green
5	Hydrated Mn^{2+} salts	Light Pink
6	KO_2 , $\text{K}_2\text{Cr}_2\text{O}_7$, Sb_2S_3 , ferricyanides	Orange
7	Hydrated Co^{2+} salts	Reddish Pink
8	Chromates AgBr , AgI , PbI_2 , CdS	Yellow
9	CdO , Fe_2O_3 , PbO_2 , CuCrO_4	Dark brown

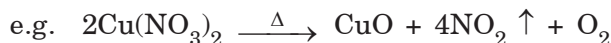
Effect of Heating

1. When a gas is evolved

(a) Coloured gas :

- (i) NO_2 , (Brown) turns starch Iodine paper blue.

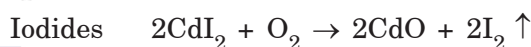
Substance : Nitrites and Nitrates of heavy metals



- (ii) Br_2 (Reddish Brown) turns starch paper yellow



- (iii) I_2 (Violet) turns starch paper blue



- (iv) Cl_2 (Greenish yellow) bleaches moist litmus paper



(moisture)

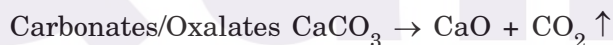


(b) Colourless gas (odourless)

- (i) O_2 – supports glowing

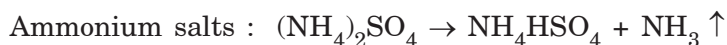


- (ii) CO_2 – Turns lime water milky



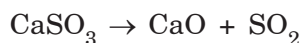
(c) Colourless gas (with odour)

- (i) NH_3 – turns red litmus blue



- (ii) SO_2 – Smell of burning sulphur, turns acidified $\text{K}_2\text{Cr}_2\text{O}_7$ paper green

Sulphites, thiosulphates

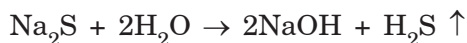


- (iii) HCl – pungent smell, white fumes with ammonia

hydrates chlorides



- (iv) H_2S – Smell of rotten eggs, turns lead acetate paper black
sulphides.



2. A residue (oxide) is left and colour

- (i) Yellow (on hot) & white (on cold) – ZnO
- (ii) Reddish brown (hot) yellow (cold) – PbO
- (iii) Black (hot) Red (cold) – HgO , Pb_3O_4
- (iv) Black (hot) Red Brown (cold) – Fe_2O_3

3. Substance melts : Salts of alkali metals & salts having water of crystallisation.

4. Substance makes crackling noise : NaCl , KI , $\text{Pb}(\text{NO}_3)_2$, $\text{Ba}(\text{NO}_3)_2$

5. Substance Swells : Alums, borates & phosphates

6. Substance sublimes & colour of sublimate is :

- (a) White : HgCl_2 , Hg_2Cl_2 , AlCl_3 , As_2O_3 , Sb_2O_3
- (b) Yellow : As_2S_3 , HgI_2 turns red on burning with glass rod
- (c) Blue Black or Violet : Iodides

BASIC RADICALS

Separation of basic radicals into groups

For systematic analysis, the basic radicals have been classified into groups. Each group has a reagent, which shows the presence of the basic radical belonging to that particular group. It is necessary that the radical is completely removed in the respective group by using excess of group reagent, otherwise its presence creates difficulty in higher group.

Group	Group reagent	Basic radical	Composition and colour of the precipitate	
1.	Dilute HCl	Ag^+ Pb^{2+} Hg_2^{2+}	AgCl : white PbCl_2 : white Hg_2Cl_2 : white	Chloride insoluble in cold dilute HCl
2.	H_2S in presence of dilute HCl	Hg^{2+} Pb^{2+} Bi^{3+} Cu^{2+} Cd^{2+}	HgS : black PbS : black Bi_2S_3 : black CuS : black CdS : yellow	Sulphides insoluble in dilute HCl

Group	Group reagent	Basic radical	Composition and colour of the precipitate
3.	NH_4OH in presence of NH_4Cl	Fe^{3+} Cr^{3+} Al^{3+}	$\text{Fe}(\text{OH})_3$: reddish brown $\text{Cr}(\text{OH})_3$: green $\text{Al}(\text{OH})_3$: white } Hydroxides are insoluble in NH_4OH
4.	H_2S in presence of NH_4OH	Zn^{2+} Mn^{2+}	ZnS : greenish white MnS : buff } Sulphides are insoluble in NH_4OH
5.	$(\text{NH}_4)_2\text{CO}_3$ in presence of NH_4OH	Ba^{2+} Ca^{2+}	BaCO_3 : white CaCO_3 : white } Carbonates are insoluble
6.	Na_2HPO_4	Mg^{2+}	$\text{Mg}(\text{NH}_4)\text{PO}_4$:
7.	NaOH	NH_4^+	Ammonia gas is evolved.

It should be noted that :

- Group I radicals (Ag^+ , Pb^{2+} , Hg_2^{2+}) are precipitated as chlorides because the solubility product of these chlorides (AgCl , PbCl_2 , Hg_2Cl_2) is less than the solubility products of chlorides of all other metal ions, which remain in solution.
- Group II radicals are precipitated as sulphides because of their low solubility, whereas sulphide of other metals remain in solution because of their high solubility products. HCl acts as a source of H^+ , which decreases the concentration of S^{2-} due to common ion effect. Hence, the decreased concentration of S^{2-} is only sufficient to precipitate the Group II metals ions as sulphides.
- Group III A radicals are precipitated as hydroxides and the NH_4Cl suppresses the ionisation of NH_4OH so that only the group III A cations are precipitated as hydroxide because of their low solubility product.

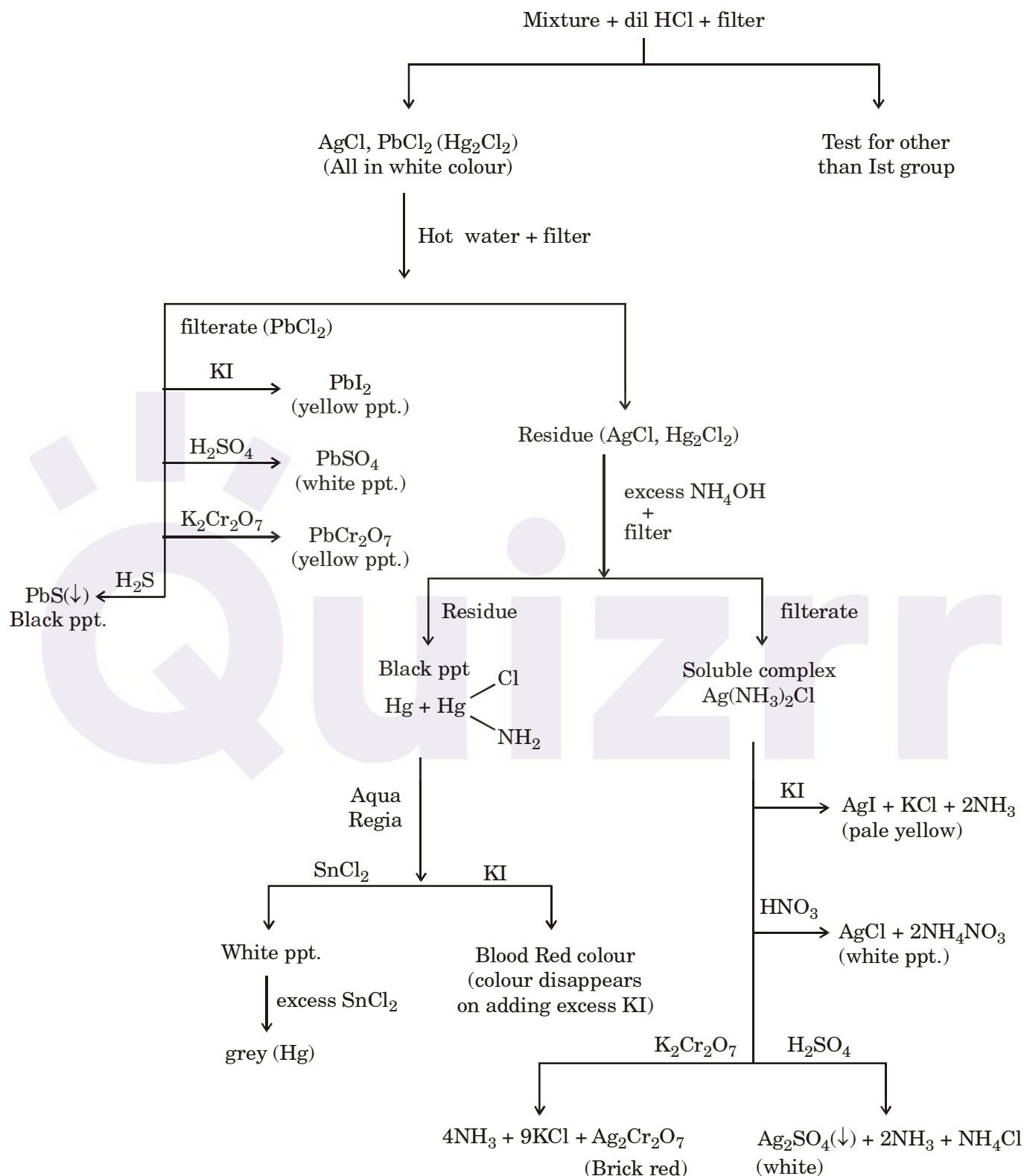
- (i) Excess of NH_4Cl should not be added, else manganese will precipitate as $\text{MnO}_2 \cdot \text{H}_2\text{O}$
 - (ii) $(\text{NH}_4)_2\text{SO}_4$ cannot be used in place of NH_4Cl because the SO_4^{2-} will give precipitate of BaSO_4 .
 - (iii) NH_4NO_3 cannot be used in place of NH_4Cl as NO_3^- ions will oxidise Mn^{2+} to Mn^{3+} and thus, $\text{Mn}(\text{OH})_3$ will be precipitated in III A group.
4. Ammonium hydroxide increases the ionisation of H_2S by removing H^+ from H_2S as unionised water.



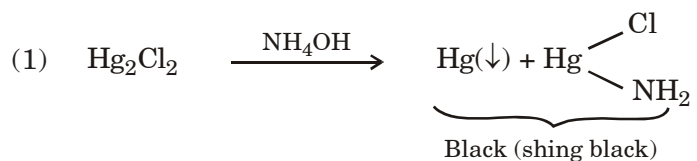
Now the excess of S^{2-} ions is available and hence the ionic product of group III B exceeds their solubility product and will be precipitated. In case H_2S is passed through a neutral solution, incomplete precipitation will take place due to the formation of HCl , which decreases the ionisation of H_2S . For example,



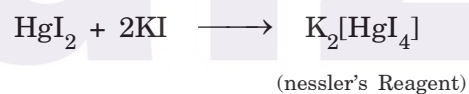
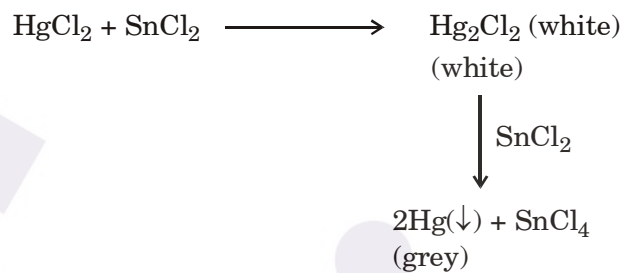
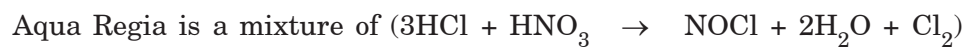
Group I



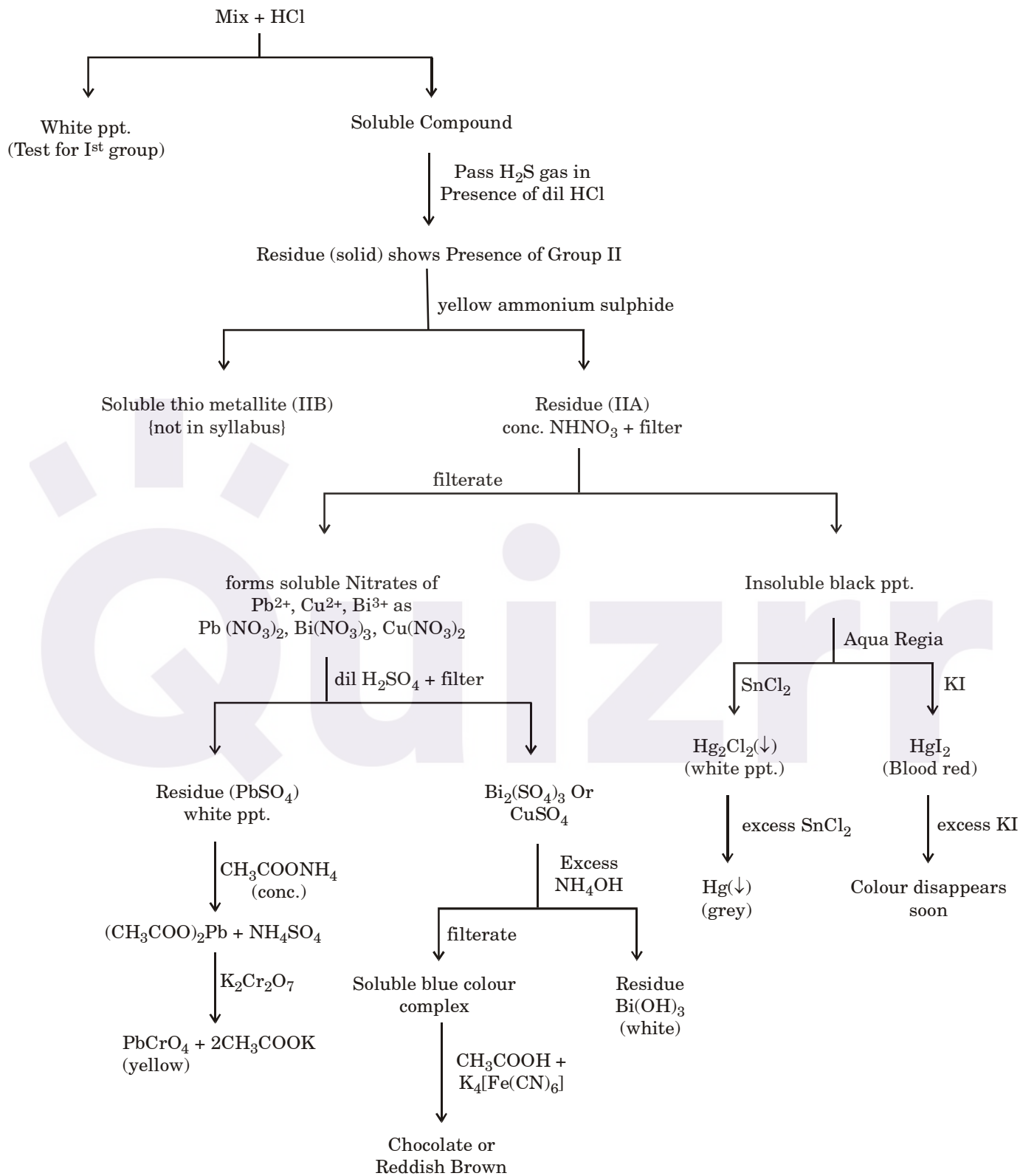
Some Salient Reactions :

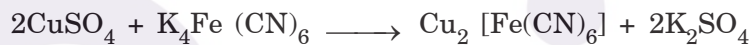
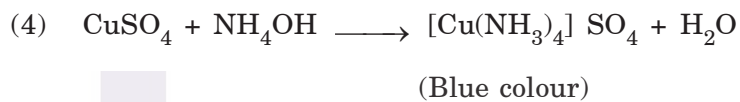
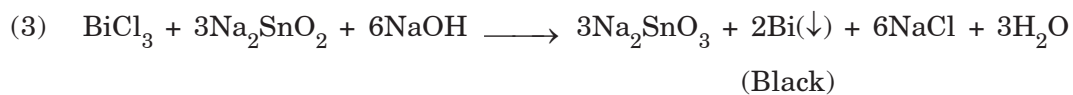
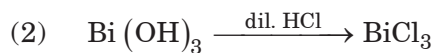
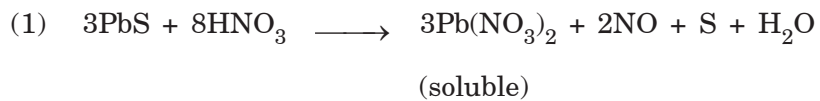


- (2) Aqua Regia is a very strong oxidizing agent and it converts the black precipitate into soluble HgCl_2 .

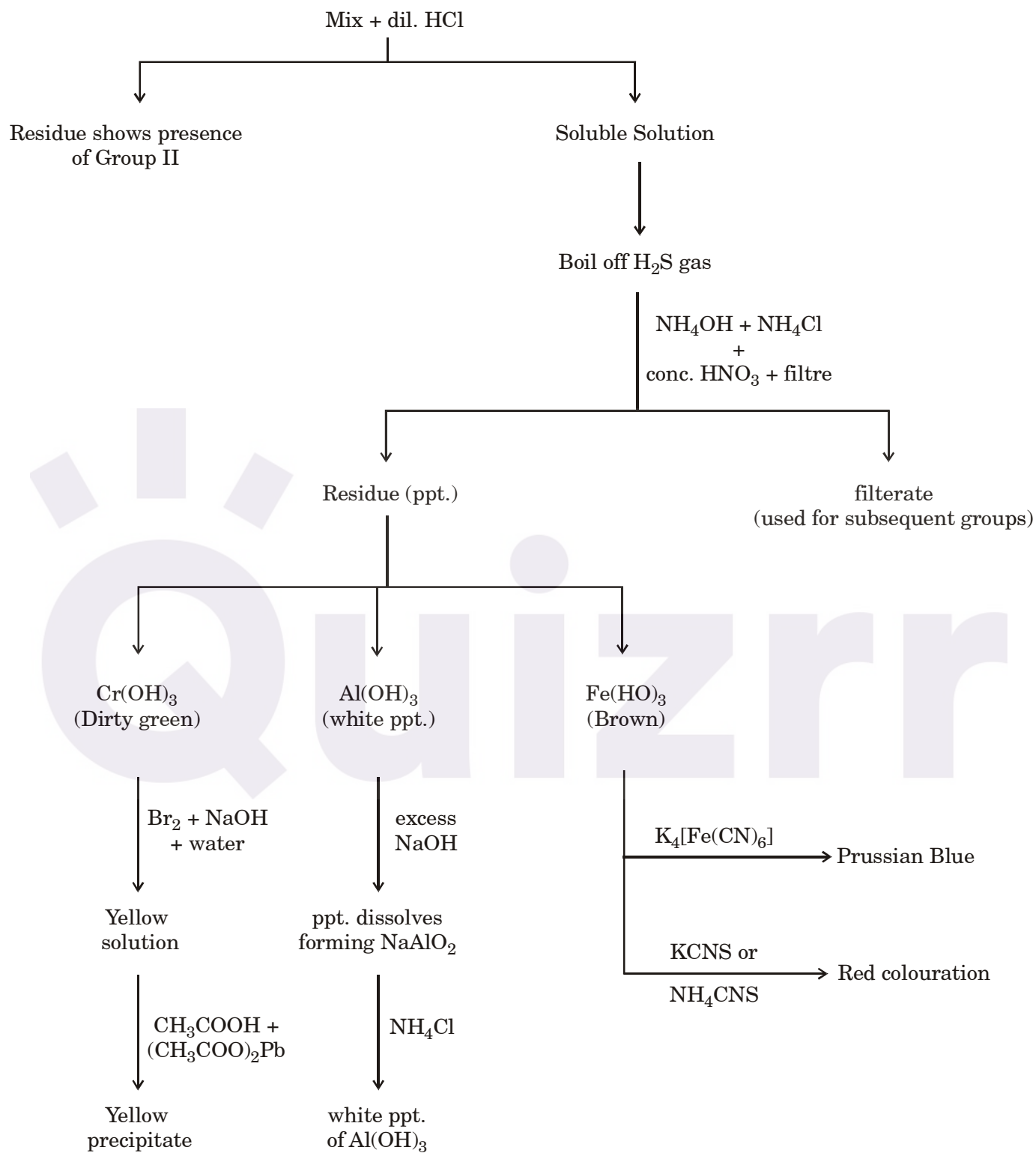


Group II



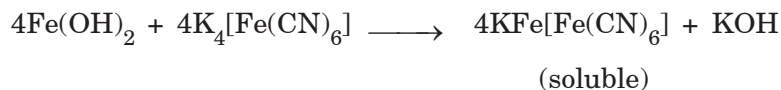
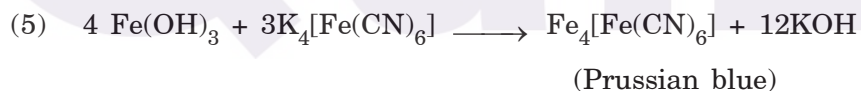
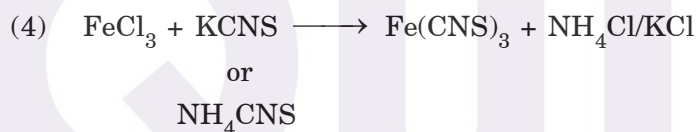
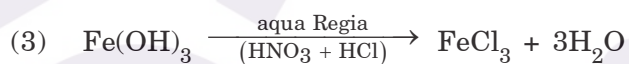
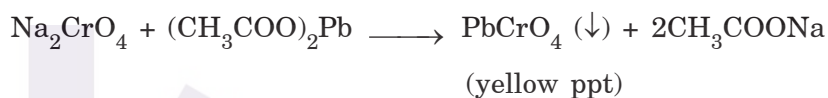
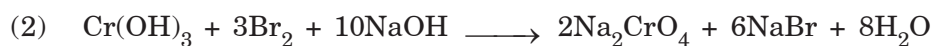
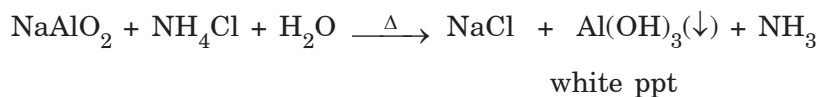
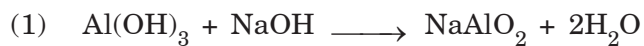
Some Salient Reactions

Chocolate or
reddish brown

Group III

Note :

Initially HNO_3 was added to convert Fe^{2+} (light green) into Fe^{3+} (deep yellow)

Some salient reactions :

* These reactions can be used to distinguish between Fe^{2+} and Fe^{3+}

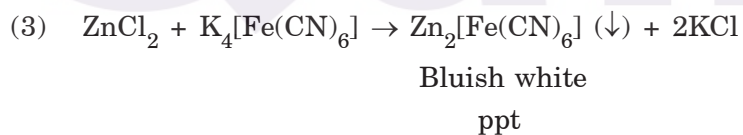
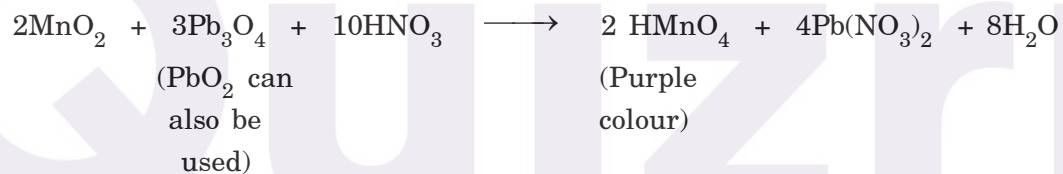
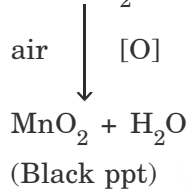
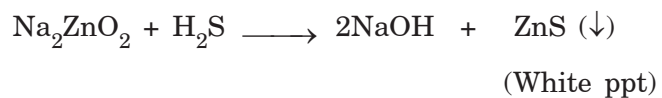
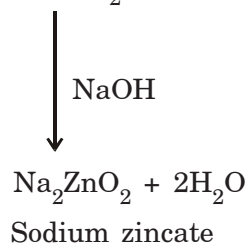
Group IVfiltrate from IIIrd Group $\text{NH}_4\text{OH} + \text{NH}_4\text{Cl}$

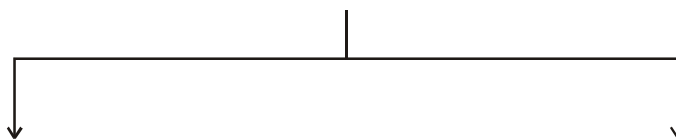
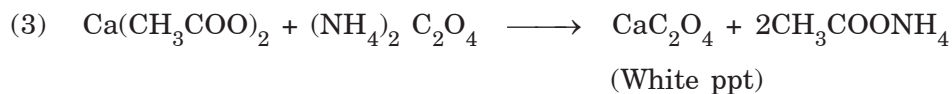
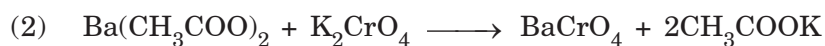
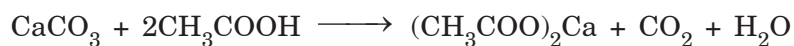
Heat

 H_2S

Residue

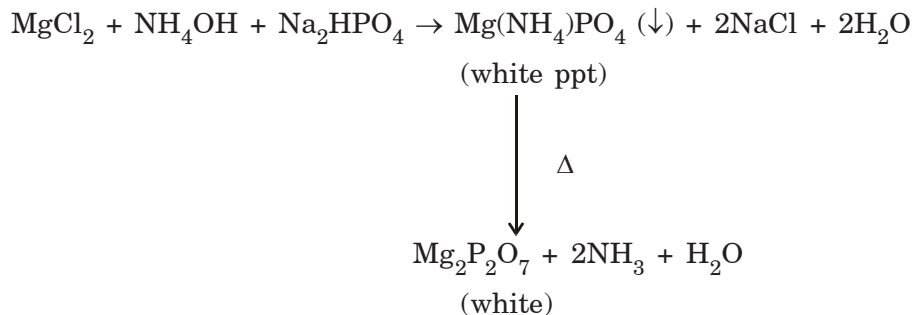
filtrate for
subsequent GroupsBuff coloured
(MnS) $\text{dil HCl} + \text{NaOH} + \text{Br}_2 + \text{H}_2\text{O}$ Black ppt. of MnO_2 $\text{conc. HNO}_3 + \text{Pb}_3\text{O}_4$ (red lead)Purple coloured
solutionWhite ppt.
(ZnS) $\text{dil HCl} + \text{NaOH}$ Soluble compound Na_2ZnO_2 H_2S White ppt.
of ZnS

Some salient reactions

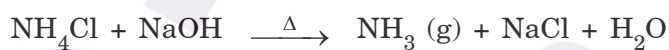
Group VFilterate from IVth groupBoil off H₂S gas and add solid
NH₄Cl and NH₄OH followed by
(NH₄)₂CO₃ solutionWhite ppt. shows presence
of Group VFilterate use for
subsequent groupsCH₃COOHK₂CrO₄Yellow ppt. of
BaCrO₄(NH₄)₂C₂O₄White ppt. of
CaC₂O₄**Some Salient Reactions**

Group VI (Mg^{2+})

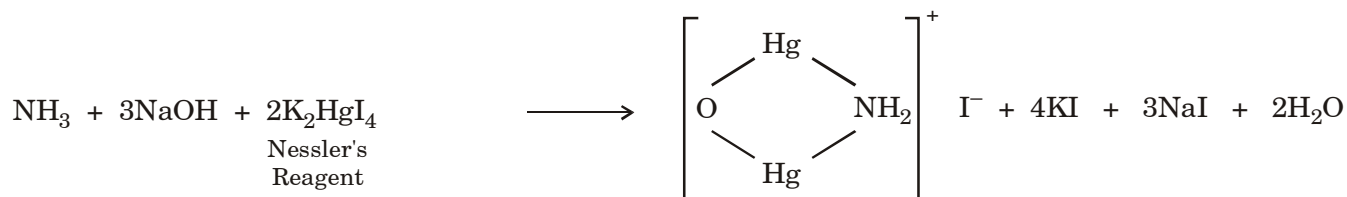
Filterate of group V + NH_4OH + $\text{Na}_2\text{HPO}_4 \rightarrow$ a fine crystalline ppt on scratching the side of the test tube.

**Group zero : (NH_4^+)**

- Salt + $\text{NaOH} \xrightarrow{\Delta}$ gas giving white fumes with HCl



- Salt + $\text{NaOH} \xrightarrow{\Delta}$ gas $\xrightarrow{\text{add Nesler's Reagent}}$ Brown ppt or brown or yellow colouration (oxydimercuri ammonium iodide) called iodide of Millon's base.



Solubility Trends

- | | dil. HNO_3 | NH_4OH | Hypo soln | CN^- soln. |
|-----------------------|---------------------|------------------------|-----------|---------------------|
| 1. AgCl | | 3 | 3 | 3 |
| AgBr | | 3 | 3 | 3 |
| AgI | | | 3 | 3 |
| Ag_2S | 3 | | 3 | 3 |
- All water insoluble black metal sulphide are soluble in hot and dil. HNO_3 except HgS . (Soluble in aqua regia)
 - FeS is the only black metal sulphide soluble in non- oxidising acid.
 - In general Pb salts are soluble in dil. HNO_3 & Ex. NaOH Soln.
 - All water insoluble $\text{C}_2\text{O}_4^{2-}$ salts are insoluble in acetic acid except BaC_2O_4 (white).

Dry Tests

Dry tests are of great importance as these tests give clear indications of the presence of certain radicals. The following tests are performed in dry state :

- Flame test
- Borax bead test
- Microcosmic salt bead test

(i) Flame test

Some volatile salts impart characteristic colour to the non-luminous flame. The chlorides of the metals are more volatile in comparison to other salts. The metal chloride volatilises and its thermal ionisation takes place.



The cations impart a characteristic colour to the flame as these absorb energy from the flame and transmit the same as light of characteristic colour.

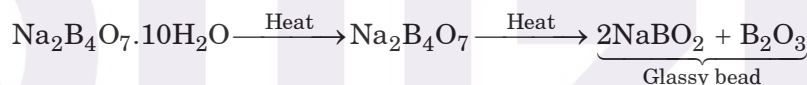
Procedure : The platinum wire fused in a glass rod is heated in the flame till it imparts colourless flame. This is achieved by dipping the wire in conc. HCl and heating it. The process is repeated till it gives a colourless flame. The tip of the wire is now dipped in conc. HCl and then into the substance. The tip of the wire is strongly heated in the non-luminous flame and the colour of the flame is observed by the naked eye.

	Colour of flame	Inference
1.	Golden yellow	Sodium
2.	Violet	Potassium
3.	Brick red	Calcium
4.	Crimson red	Strontium
5.	Apple green	Barium
6.	Green with a blue centre	Copper

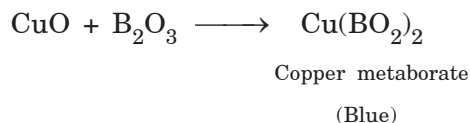
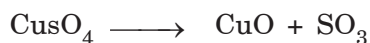
Note : Flame test should not be performed in the presence of As, Sb, Bi, Sn and Pb as these radicals form alloy with platinum and hence, the wire is spoiled.

(ii) Borax bead test

On heating borax the colourless glassy bead formed consists of sodium metaborate and boric anhydride.

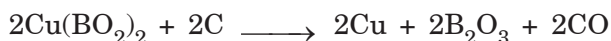
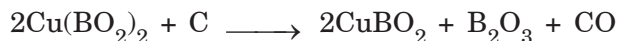


On heating with a coloured salt, the glassy bead forms a coloured metaborate in oxidising flame.



The metaborates possess different characteristic colours. The shade of the colour gives a clue regarding the presence of the radical.

However, in reducing flame the colours may be different due to different reactions. For example, copper metaborate may be reduced to colourless cuprous metaborate or to metallic copper, which appears red and opaque.



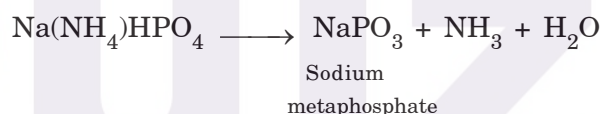
Procedure : The free end of a platinum wire is coiled into a small loop and heated in the Bunsen flame until red hot. It is dipped in borax and again heated, when borax swells up and then fused into a glassy bead.

The bead is moistened with water and dipped in the coloured salt. It is now heated first in the oxidising flame and then in the reducing flame and colours are noted in both the flames in hot and cold conditions.

Metal	Colour of the bead in			
	Oxidising flame		Reducing flame	
	Hot	Cold	Hot	Cold
Copper	Green	Blue	Colourless	Brown-red
Iron	Brown-yellow	Pale-yellow	Bottle green	Bottle-green
Chromium	Green	Green	Green	Green
Cobalt	Blue	Blue	Blue	Blue
Manganese	Violet	Amethyst red	Grey	Grey
Nickel	Violet	Brown	Grey	Grey

(iii) **Microcosmic salt bead test**

This test is similar to borax bead test. When microcosmic salt is heated, a colourless transparent bead of sodium metaphosphate is formed.



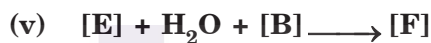
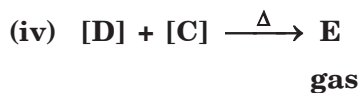
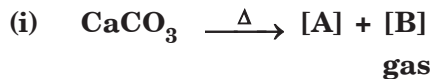
Sodium metaphosphate combines with metallic oxides to form orthophosphates which are usually coloured. The shade of the colour gives a clue regarding the presence of metal. Like borax bead test, colours are noted both in oxidising and reducing flames in hot and cold conditions.

Metal	Colour of the bead in			
	Oxidising flame		Reducing flame	
	Hot	Cold	Hot	Cold
Copper	Green	Blue	Colourless	Red
Iron	Yellow or reddish-brown	Yellow	Yellow	Colourless
Chromium	Green	Green	Green	Green
Manganese	Violet	Violet	Colourless	Colourless
Nickel	Brown	Brown	—	Grey

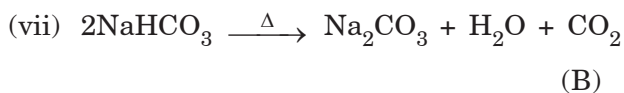
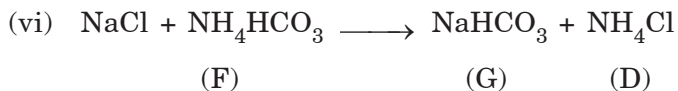
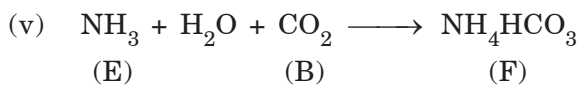
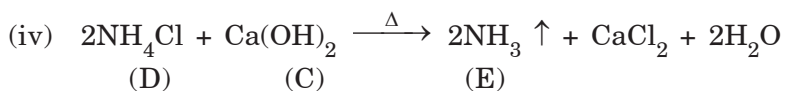
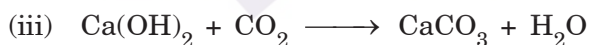
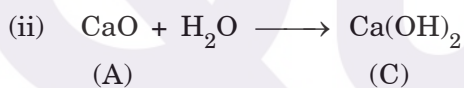
SOLVED EXAMPLES

Example 1

Complete the following reactions :



Solution :



Example 2**True or False :**

- (a) The carbonates of barium and calcium are soluble in acid.
- (b) Copper sulphate forms a violet colour with potassium ferrocyanide solution.
- (c) Ammonium sulphate can be used in place of ammonium chloride in third group.

Solution :

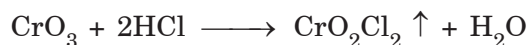
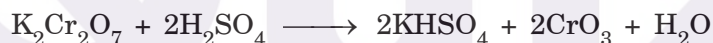
- (a) True
- (b) False. Chocolate precipitate.
- (c) False. Sulphates of V group radicals will be precipitated.

Example 3

When a crystalline compound (X) is heated with $K_2Cr_2O_7$ and concentrated H_2SO_4 , a reddish-brown gas (A) is evolved. On passing (A) into caustic soda, a yellow coloured solution of (B) is obtained. Neutralizing the solution of (B) with acetic acid and on subsequent addition of lead acetate, a yellow precipitate of (C) is obtained. When (X) is heated with NaOH, a colourless gas is evolved and on passing this gas into K_2HgI_4 solution, a reddish-brown precipitate (D) is formed. Identify (A), (B), (C), (D) and (X). Write the equation of reactions involved.

Solution :

The given information in the question infers that compound (X) should be NH_4Cl .



(A)

Reddish-brown gas



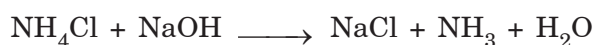
(B)

Yellow coloured solution

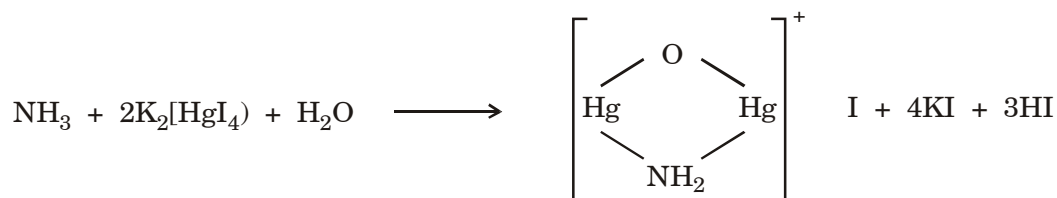


(C)

Yellow ppt



Colourless gas



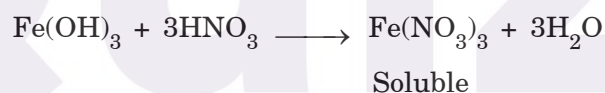
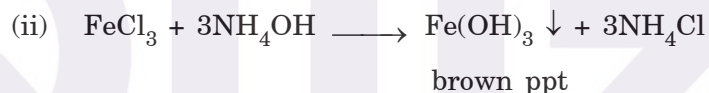
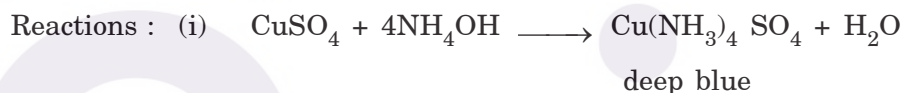
Example 4

An aqueous solution of gas (X) shows the following reaction

- (i) It turns red litmus blue
- (ii) When added in excess to a copper sulphate solution, a deep blue colour is obtained
- (iii) On addition of FeCl_3 solution a brown ppt soluble in dilute nitric acid is obtained.

Identify (X) and give equations for the reactions at step (ii) & (iii)

Solution :



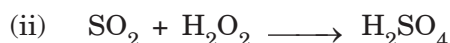
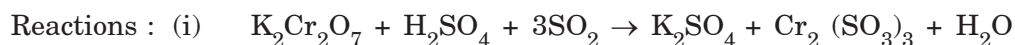
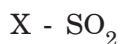
Example 5

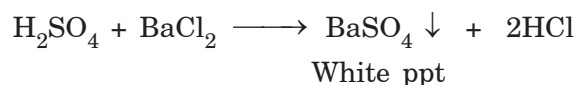
An aqueous solution of a gas (X) gives the following reactions :

- (i) It decolourizes an acidified $\text{K}_2\text{Cr}_2\text{O}_7$ solution
- (ii) On boiling with H_2O_2 , cooling it and then adding an aqueous solution of BaCl_2 , a white ppt insoluble in dilute HCl is obtained.
- (iii) On passing H_2S into the solution, turbidity is obtained.

Identify (X) and given equations for the steps (i), (ii), (iii).

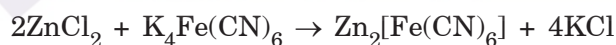
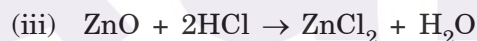
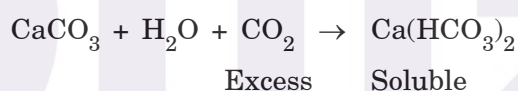
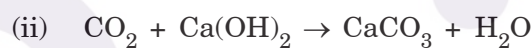
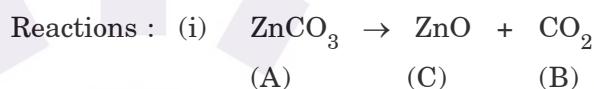
Solution :



**Example 6**

A white amorphous powder (A) on strongly heating gives a colourless non-combustible gas (B) and solid (C). The gas (B) turns lime water milky and turbidity disappears with the passage of excess of gas. The solution of (C) in dilute HCl gives a white ppt. with an aqueous solution of $\text{K}_4[\text{Fe}(\text{CN})_6]$. The solution of (A) in dilute HCl gives a white ppt. (D) on passing H_2S in presence of excess of NH_4OH . Identify (A) to (D) by giving chemical equations.

Solution :

**Example 7**

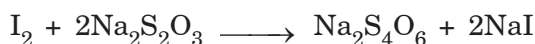
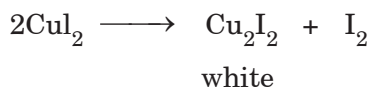
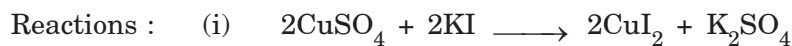
A certain compound (X) is used in laboratory for analysis. Its aq. solution gave the following reactions.

- (i) On addition to copper sulphate solution, a brown ppt. is obtained which turns white on addition of excess of $\text{Na}_2\text{S}_2\text{O}_3$ solution.
- (ii) On addition to Ag^+ ion solution, a yellow ppt. is obtained which is insoluble in NH_4OH .

Identify (X), giving reactions.

Solution :

X - KI



Yellow ppt.

The white ppt. of Cu_2I_2 is coloured brown due to the presence of I_2 . On adding sodium thiosulphate, I_2 is consumed. Therefore, the ppt appears white.

Example 8

An aqueous solution of inorganic compound (X) gives the following reactions :

- (i) With an aq. solution of barium chloride a ppt. insoluble in dil. HCl is obtained.
- (ii) Addition of excess of KI gives a brown ppt. which turns white on addition of excess of hypo.
- (iii) With an aqueous solution of $\text{K}_4[\text{Fe}(\text{CN})_6]$ a chocolate coloured ppt. is obtained.

Identify (X) and give equations for the reactions for (i), (ii) and (iii) observations.

Solution :

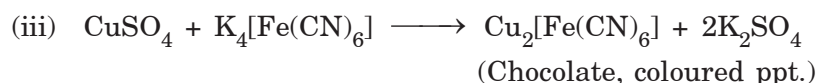
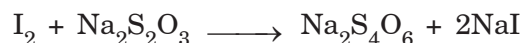
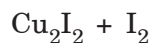
X - CuSO_4



White ppt
(insoluble in HCl)

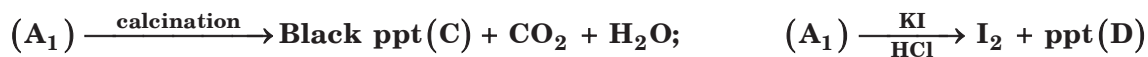


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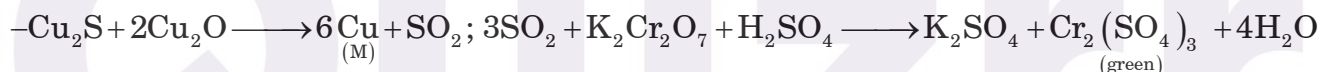
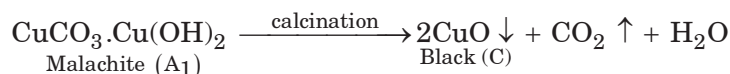
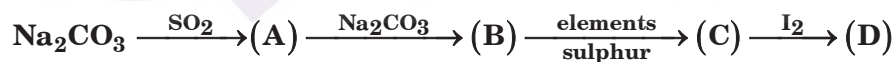
Example 9

Two ores of the same metal (M) are (A₁) and (A₂).



Identify (M), (A₁), (A₂), (C), (D) and (G).

Solution :

**Example 10**

Find (A), (B), (C) and (D). Give oxidation state of sulphur in each compound.

Solution :



Oxidation state of sulphur in (A) is + 4, in (B) is also + 4, in (C) is + 2 and in (D) is + 5/2.

Example 11

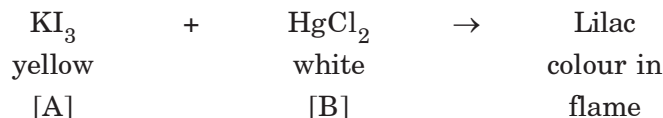
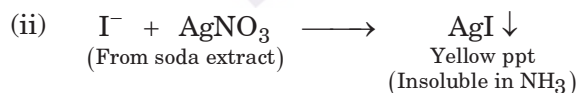
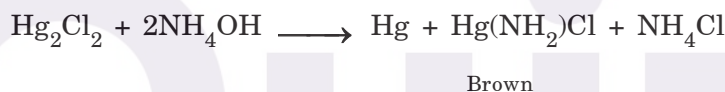
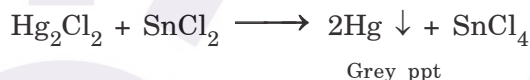
A mixture consisting of A (yellow solid) and B (colourless solid) gives lilac colour in flame.

- Mixture gives black precipitate C on passing H₂S gas in acidic medium.
- C is soluble in aqua-regia and on adding SnCl₂, it gives white precipitate, which finally turns to greyish black precipitate D.

(i) The sodium carbonate extract of the salt A with $\text{CCl}_4/\text{FeCl}_3$ gives a violet layer.

(ii) The sodium carbonate extract of the salt A gives yellow precipitate in AgNO_3 solution, which is insoluble in NH_3 . Identify A and B and the precipitate C and D.

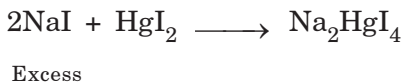
(A) : Kl_3 (B) : HgCl_2 (C) : HgS (D) : Hg



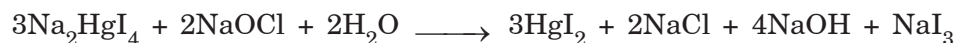
An aqueous solution containing one mole of HgI_2 and two mole of NaI is orange in colour. On addition of excess NaI the solution becomes colourless. The orange colour reappears on subsequent addition of NaOCl . Explain with equations.

Solution :

A solution containing one mole of HgI_2 and two mole of NaI is orange in colour due to the partial solubility of HgI_2 . On addition of excess of NaI , the colourless complex Na_2HgI_4 is formed.



The Na_2HgI_4 on addition of NaOCl , oxidises as :

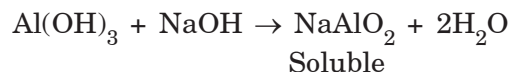
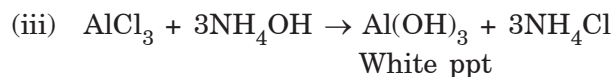
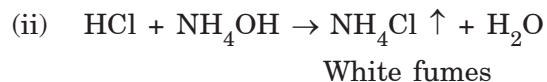
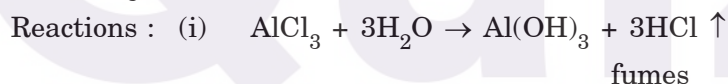


Thus, colour of partially soluble HgI_2 is restored.

Example 13

An inorganic Lewis acid (X) shows the following reactions :

- (i) It fumes in moist air.
- (ii) The intensity of fumes increases when a rod dipped in NH_4OH is brought near it.
- (iii) An acidic solution of (X) on addition of NH_4Cl and NH_4OH gives a precipitate which dissolves in NaOH solution.
- (iv) An acidic solution of (X) does not give a precipitate with H_2S . Identify (X) and give chemical equation for steps (i) to (iii).

Solution :**Example 14**

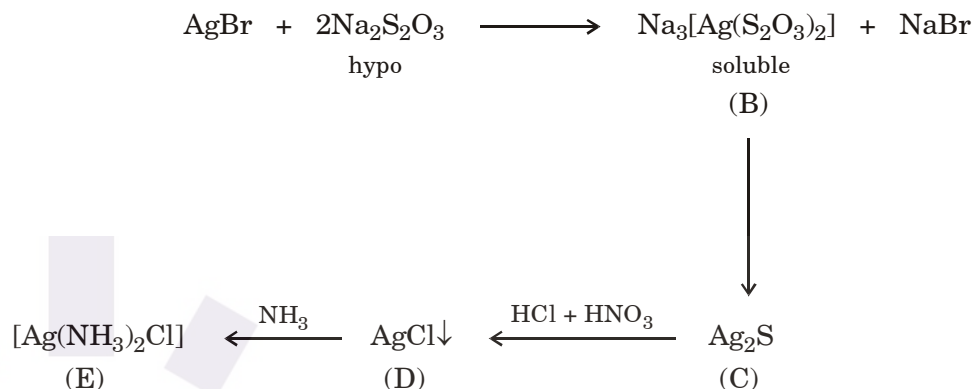
- (i) A black mineral (A) on treatment with dilute sodium cyanide solution in presence of air gives a clear solution of (B) and (C).
- (ii) The solution of (B) on reaction with zinc gives a precipitate of metal (D).

Example 16

(A) is yellow coloured solid partially soluble in aqueous NH_3 . (A) is soluble in $\text{Na}_2\text{S}_2\text{O}_3$ (hypo) solution forming a complex (B) which on heating is converted into (C) (black). (C) is converted into white ppt (D) on reaction with HCl and HNO_3 . (D) is soluble in aqueous NH_3 forming (E). Identify (A), (B), (C), (D) and (E) and explain reactions.

Solution :

(A) is AgBr (present in photographic plate)

**Example 17**

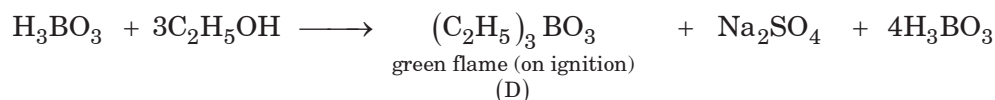
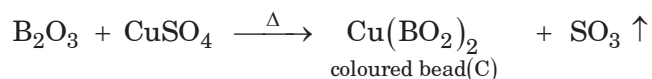
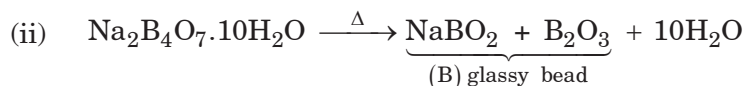
Identify (A), (B), (C) and (D) based on following observations :

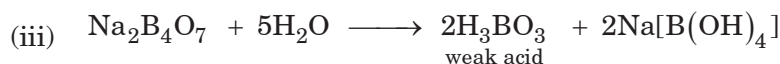
- (i) $(\text{A}) \xrightarrow{\Delta} \text{glassy transparent bead (B) on platinum wire (B)} + \text{CuSO}_4 \longrightarrow \text{coloured bead (C)}$
- (ii) $(\text{A}) + \text{conc. H}_2\text{SO}_4 + \text{CH}_3\text{CH}_2\text{OH} \xrightarrow{\text{ignite}} \text{green flame (D)}$
- (iii) Aqueous solution of (A) is alkaline.

Solution :

- (i) (A) forms glassy transparent bead which is characteristic property of borax.

\Rightarrow (A) is borax ($\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$)





$\text{Na}[\text{B}(\text{OH})_4]$ reacts with acid (HCl) hence aqueous solution (A) is alkaline.

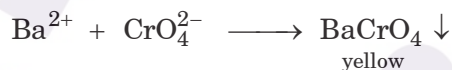
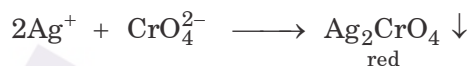
Example 18

Name one common reagent that can precipitate or react and differentiate following pairs :

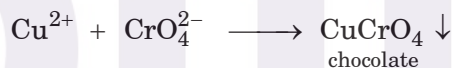
- | | |
|---|---|
| (a) Ag^+ and Ba^{2+} | (b) Cu^{2+} and Pb^{2+} |
| (c) I^- and Cl^- | (d) I^- and Br^- |
| (v) SO_3^{2-} and SO_4^{2-} | (f) Fe^{3+} and Cu^{2+} |

Solution :

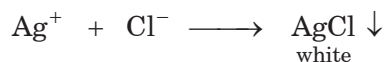
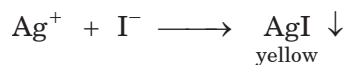
(a) K_2CrO_4 :



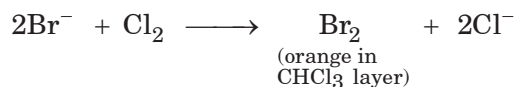
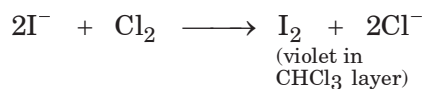
(b) K_2CrO_4 :

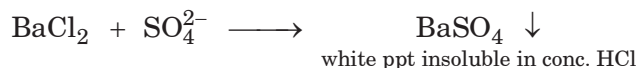
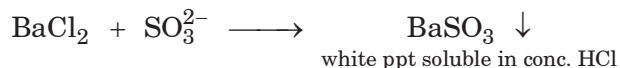
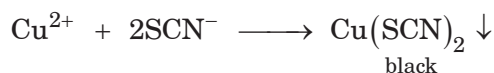


(c) AgNO_3 :



(d) Cl_2 water + CHCl_3 :



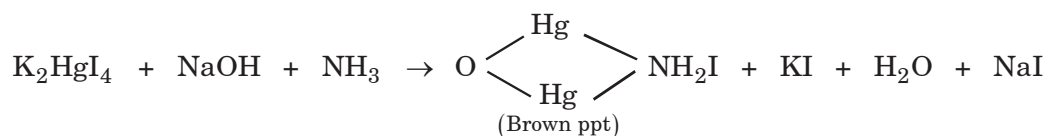
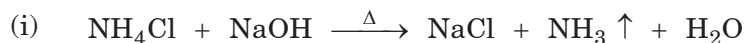
(e) BaCl_2 :(f) NH_4SCN :**Example 19**

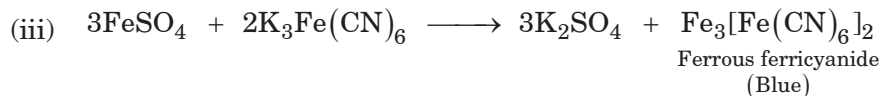
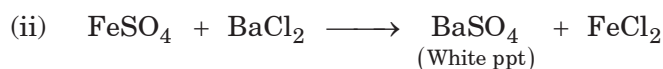
The gas liberated on heating a mixture of two salts with NaOH, gives a reddish brown precipitate with an alkaline solution of K_2HgI_4 . The aqueous solution of mixture on treatment with BaCl_2 gives a white precipitate which is sparingly soluble in conc. HCl. On heating the mixture with $\text{K}_2\text{Cr}_2\text{O}_7$ and conc. H_2SO_4 , red vapours (A) are produced. The aqueous solution of mixture gives a deep blue colouration (B) with potassium ferricyanide. Identify the radicals in given mixture and write the balanced equation for formation of (A) and (B).

Solution :

- (i) Gas given by heating mixture with NaOH gives brown ppt with Nessler's reagent K_2HgI_4 . It shows that the salt is an ammonium salt.
- (ii) BaCl_2 solution gives white precipitate sparingly soluble in HCl. It shows the presence of SO_4^{2-} ion in the mixture
- (iii) Blue colour with $\text{K}_3\text{Fe}(\text{CN})_6$ indicates the presence of Fe^{2+} ion.
- (iv) Mixture + $\text{K}_2\text{Cr}_2\text{O}_7 \xrightarrow[\Delta]{\text{H}_2\text{SO}_4}$ Red vapours (CrO_2Cl_2)
(A)

It shows that the mixture contains Cl^- ion. Reactions involved may be given as :



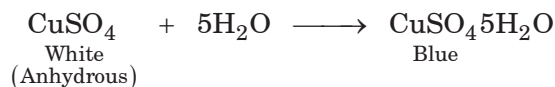
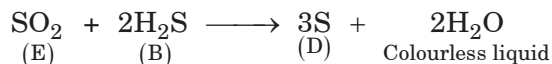
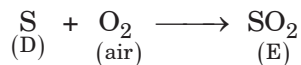
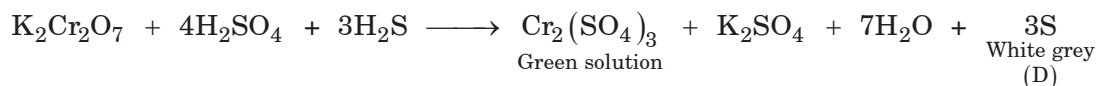


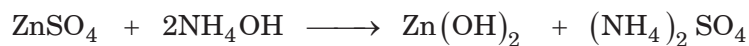
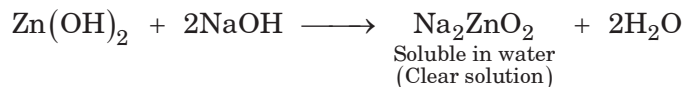
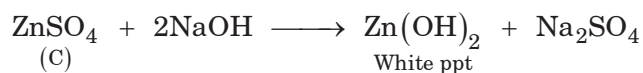
Example 20

A white substance (A) reacts with dilute H_2SO_4 to produce a colourless gas (B) and a colourless solution (C). The reaction between (B) and acidified K_2CrO_7 solution produces a green solution and a slightly coloured precipitate (D). The substance (D) burns in air to produce a gas (E) which reacts with (B) to yield (D) and a colourless liquid. Anhydrous copper sulphate is turned blue on addition of this colourless liquid. Addition of aqueous NH_3 or NaOH to (C) produces first a precipitate, which dissolves in the excess of respective reagent to produce a clear solution in each case. Identify (A), (B), (C), (D) and (E) write the equations of the reactions involved.

Solution :

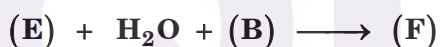
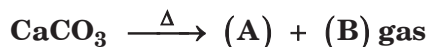
The white substance (A) is ZnS .





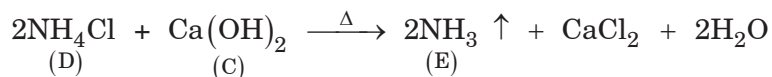
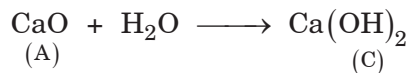
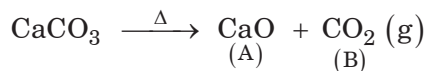
Example 21

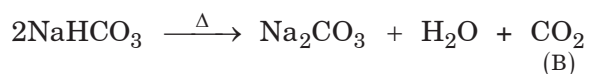
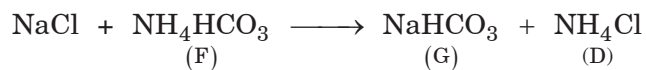
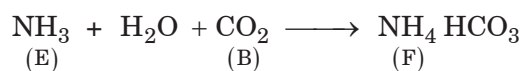
Identify (A) to (G) in the following scheme and name the process.



Solution :

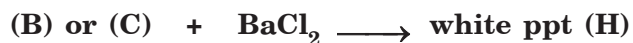
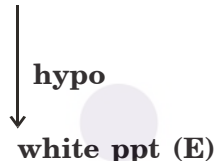
Scheme represents the Solvay process of manufacture of Na_2CO_3 .



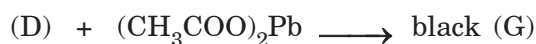


Example 22

Identify (A), (B), (C)..... (H) in the following and explain reactions :



Solution :

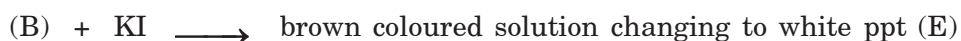


\Rightarrow (D) is H_2S gas and (G) is PbS

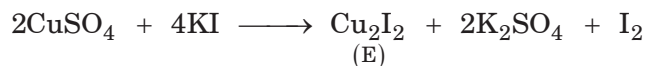
\Rightarrow (A) also has S^{2-}



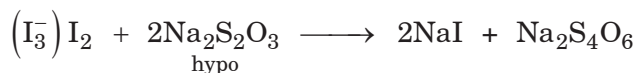
(B) and (C) both are sulphates as confirmed by white ppt (H) with BaCl_2



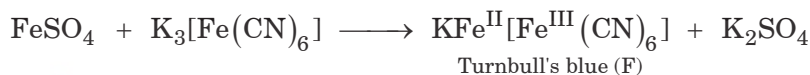
Thus, (B) is CuSO_4



Due to KI_3 , solution appears reddish brown. On adding hypo, I_2 disappears and white ppt of Cu_2I_2 appears.



(C) decolorises $\text{MnO}_4^- / \text{H}^+$. (C) also gives blue colour with $\text{K}_3[\text{Fe}(\text{CN})_6]$ thus (C) is FeSO_4 .



(A) : $\text{CuS} + \text{FeS}$ (CuFeS_2)

(B) : CuSO_4

(C) : FeSO_4

(D) : H_2S

(E) : Cu_2I_2

(F) : $\text{KFe}^{\text{II}}[\text{Fe}^{\text{III}}(\text{CN})_6]$

(G) : PbS

(H) : BaSO_4

(I) : CuS

Example 23

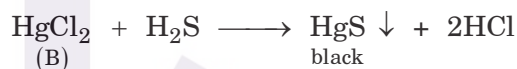
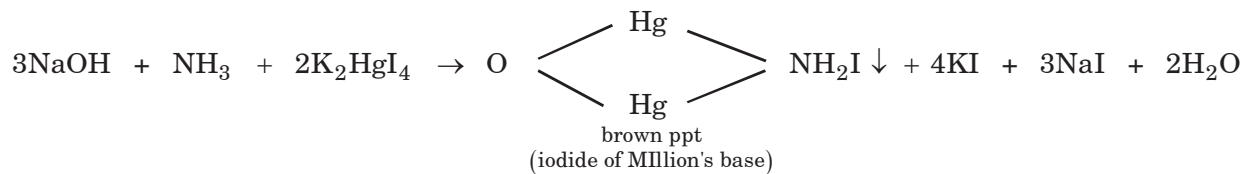
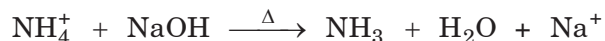
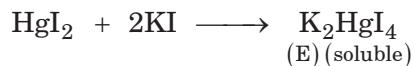
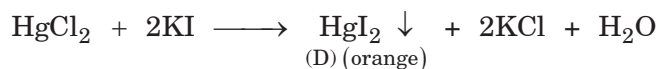
Black coloured (insoluble in H_2O) solid (A) does not dissolve in dil. HNO_3 . Aqua regia can dissolve (A) forming (B). (B) gives yellow ppt. (C) with NaOH . (B) also gives orange ppt (D) with KI ; (D) dissolves in excess of KI forming (E). (E) gives brown ppt with NH_4^+ salt in presence of NaOH . (A) is precipitated if H_2S gas is passed into solution of (B) in dil. HCl . Identify (A) to (E) and explain reactions.

Solution :

(A) is insoluble in dil. HNO_3 .

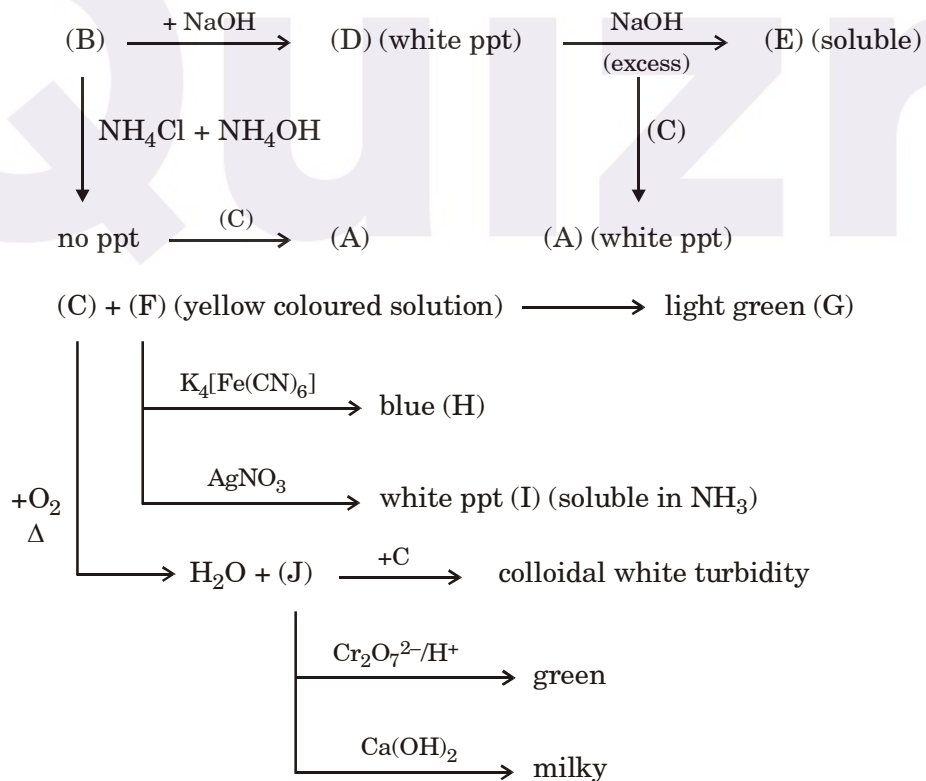
\Rightarrow (A) is of group II (copper sub-group) and is HgS [only HgS (black) is insoluble in dil. HNO_3]





Example 24

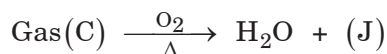
Colourless salt, (A) (insoluble in water) + dil. $\text{H}_2\text{SO}_4 \longrightarrow \text{(B)} + \text{C(g)}$



Identify (A) to (J) and explain reactions.

Solution :

Gas (C) is vital compound in this scheme.



⇒ (J) is SO_2

⇒ (C) is H_2S (giving H_2O and SO_2 by combustion in O_2).

(B) gives white ppt only if (C) is passed into its ammoniacal solution containing NH_4Cl ($\text{NH}_4\text{OH} + \text{NH}_4\text{Cl}$)

⇒ (B) has Zn^{2+} and (B) is ZnSO_4

⇒ (A) is ZnS

(F) gives blue colour with $\text{K}_4[\text{Fe}(\text{CN})_6]$

⇒ (F) has Fe^{3+} ion

(F) gives white ppt with AgNO_3

⇒ (F) has Cl^- ion. Thus, F is FeCl_3 .

Explanation :