

Analysis always does not mean breaking of substance into its ultimate constituents. Finding out the nature of substance and identity of its constituents is also analysis and is known as qualitative analysis. Qualitative analysis of inorganic salts means the identification of cations and anions present in the salt or a mixture of salts. Inorganic salts may be obtained by complete or partial neutralisation of acid with base or vice-versa. In the formation of a salt, the part contributed by the acid is called anion and the part contributed by the base is called cation. For example, in the salts CuSO_4 and NaCl , Cu^{2+} and Na^+ ions are cations and SO_4^{2-} and Cl^- ions are anions. Qualitative analysis is carried out on various scales. Amount of substance employed in these is different. In macro analysis, 0.1 to 0.5 g of substance and about 20 mL of solution is used. For semimicro analysis, 0.05 g substance and 1 mL solution is needed while for micro analysis amount required is very small. Qualitative analysis is carried out through the reactions which are easily perceptible to our senses such as sight and smell. Such reactions involve:

- (a) Formation of a precipitate
- (b) Change in colour
- (c) Evolution of gas etc.

Systematic analysis of an inorganic salt involves the following steps:

- (i) Preliminary examination of solid salt and its solution.
- (ii) Determination of anions by reactions carried out in solution (wet tests) and confirmatory tests.
- (iii) Determination of cations by reactions carried out in solution (wet tests) and confirmatory tests.

Preliminary examination of a salt often furnishes important information, which simplifies further course of analysis. Although these tests are not conclusive but sometimes they give quite important clues for the presence of certain anions or cations. These tests can be performed within 10-15 minutes. These involve noting the general appearance and physical properties, such as colour, smell, solubility etc. of the salt. These are named as dry tests.

Heating of dry salt, blow pipe test, flame tests, borax bead test, sodium carbonate bead test, charcoal cavity test etc. come under dry tests. Some of these tests are given later in this unit.

Solubility of a salt in water and the pH of aqueous solutions give important information about the nature of ions present in the salt. If a solution of the salt is acidic or basic in nature, this means that it is being hydrolysed in water. If the solution is basic in nature then salt may be some carbonate or sulphide etc. If the solution shows acidic nature then it may be an acid salt or salt of weak base and strong acid. In this case it is best to neutralise the solution with sodium carbonate before testing it for anions.

Gases evolved in the preliminary tests with dil. H_2SO_4 / dil. HCl and conc. H_2SO_4 also give good indication about the presence of acid radicals (See Tables 7.1 and 7.3). Preliminary tests should always be performed before starting the confirmatory tests for the ions.

EXPERIMENT 7.1

Aim

To detect one cation and one anion in the given salt from the following ions:

Cations - Pb^{2+} , Cu^{2+} , As^{3+} , Al^{3+} , Fe^{3+} , Mn^{2+} , Ni^{2+} , Zn^{2+} , Co^{2+} , Ca^{2+} , Sr^{2+} , Ba^{2+} , Mg^{2+} , NH_4^+

Anions - CO_3^{2-} , S^{2-} , SO_4^{2-} , NO_2^- , NO_3^- , Cl^- , Br^- , I^- , PO_4^{3-} , CH_3COO^- .

(Insoluble salts to be excluded)

Theory

Two basic principles of great use in the analysis are:

- (i) the Solubility product
- (ii) the Common ion effect.

When ionic product of a salt exceeds its solubility product, precipitation takes place. Ionic product of salt is controlled by making use of common ion effect which you have studied in the textbook of chemistry.

Material Required

- Boiling tube As per need
- Test tubes : As per requirement
- Measuring cylinder : One
- Test tube stand : One
- Test tube holder One
- Delivery tube : One
- Corks : As per need
- Filter paper : As per need
- Reagents : As per need

Step – I

Preliminary Test with Dilute Sulphuric Acid → In this test the action of dilute sulphuric acid (procedure is given below) on the salt is noted at room temperature and on warming.

Carbonate (CO_3^{2-}), sulphide (S^{2-}), sulphite (SO_3^{2-}), nitrite (NO_2^-) and acetate (CH_3COO^-) react with dilute sulphuric acid to evolve different gases. Study of the characteristics of the gases evolved gives information about the anions. Summary of characteristic properties of gases is given in Table 7.1 below.

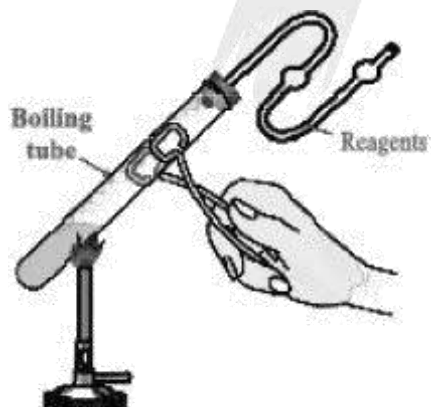


Fig. 7.1 Testing a Gas

Procedure

- (a) Take 0.1 g of the salt in a test tube and add 1 – 2 mL of dilute sulphuric acid. Observe the change, if any, at room temperature. If no gas is evolved, warm the content of the test tube. If gas is evolved test it by using the apparatus shown in Fig.7.1 and identify the gas evolved (See Table 7.1).

Table 7.1 : Preliminary test with dilute sulphuric acid

Observations	Inference	
	Gas Evolved	Possible Anion
A colourless, odourless gas is evolved with brisk effervescence, which turns lime water milky.	CO ₂	Carbonate (CO ₃ ²⁻)
Colourless gas with the smell of rotten eggs is evolved which turns lead acetate paper black.	H ₂ S	Sulphide (S ²⁻)
Colourless gas with a pungent smell, like burning sulphur which acidified potassium dichromate solution green.	SO ₂	Sulphite (SO ₃ ²⁻)
Brown fumes which turn acidified potassium iodide solution containing starch solution blue.	NO ₂	Nitrite (NO ₂ ⁻)
Colourless vapours with vinegar. Vapours turn blue litm	CH ₃ COOH ²	Acetate, (CH ₃ COO ⁻)

Confirmatory tests for CO₃²⁻, S²⁻, SO₃²⁻, NO₂⁻ and CH₃COO⁻

Confirmatory (wet) tests for anions are performed by using water extract when salt is soluble in water and by using sodium carbonate extract when salt is insoluble in water. Confirmation of CO₃²⁻ is done by using aqueous solution of the salt or by using solid salt as such because sodium carbonate extract contains carbonate ions. Water extract is made by dissolving salt in water. Preparation of sodium carbonate extract is given below.

Preparation of sodium carbonate extract

Take 1 g of salt in a porcelain dish or boiling tube. Mix about 3 g of solid sodium carbonate and add 15 mL of distilled water to it. Stir and boil the content for about 10 minutes. Cool, filter and collect the filtrate in a test tube and label it as sodium carbonate extract.

Confirmatory tests for acid radicals, which react with dilute sulphuric acid are given below in

Table 7.2.

Table 7.2 : Confirmatory tests for CO_3^{2-} , S^{2-} , SO_3^{2-} , NO_3^- , CH_3COO^-

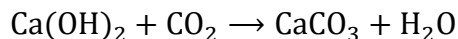
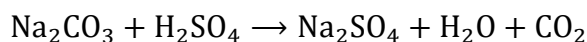
Anion	Confirmatory Test
Carbonate (CO_3^{2-})	Take 0.1 g of salt in a test tube, add dilute sulphuric acid. CO_2 gas is evolved with brisk effervescence which turns lime water milky. On passing the gas for some more time, milkiness disappears.
Sulphide (S^{2-})	Take 1 mL of water extract and make it alkaline by adding ammonium hydroxide or sodium carbonate extract. Add a drop of sodium nitroprusside solution. Purple or violet colouration appears.
Sulphite (SO_3^{2-})	(a) Take 1 mL of water extract or sodium carbonate extract in a test tube and add barium chloride solution. A white precipitate is formed which dissolves in dilute hydrochloric acid and sulphur dioxide gas is also evolved Take the precipitate of step (a) in a test tube and add a few drops of potassium permanganate solution acidified with dil. H_2SO_4 . Colour of potassium permanganate solution gets discharged.
Nitrite (NO_2^-)	(a) Take 1 mL of water extract in a test tube. Add a few drops of potassium iodide solution and a few drops of starch solution, acidify with acetic acid. Blue colour appears. Acidify 1 mL of water extract with acetic acid. Add (b) 3 drops of sulphanilic acid solution followed by 2 - 3 drops of l-naphthylamine reagent. Appearance of red colour indicates the presence of nitrite ion.
Acetate, (CH_3COO^-)	(a) Take 0.1 g of salt in a china dish. Add 1 mL of ethanol and 0.2 mL conc. H_2SO_4 and heat. Fruity odour confirms the presence of acetate ion. Take 0.1 g of salt in a test tube, add 1 – 2 mL distilled water, shake well filter if necessary. Add 1 to 2 mL neutral ferric chloride solution to the filtrate. Deep red colour appears which disappears on boiling and a brown-red precipitate is formed.

Chemistry of Confirmatory Tests

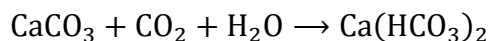
1. Test for Carbonate ion $[\text{CO}_3^{2-}]$

If there is effervescence with the evolution of a colourless and odourless gas on adding dil. H_2SO_4 to the solid salt, this indicates the presence of carbonate ion.

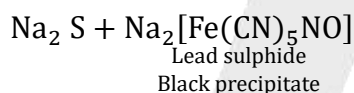
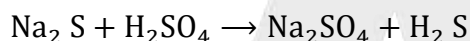
The gas turns lime water milky due to the formation of CaCO_3



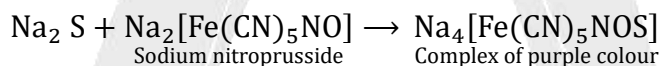
If CO_2 gas is passed in excess through lime water, the milkiness produced disappears due to the formation of calcium hydrogen carbonate which is soluble in water.

**2. Test for Sulphide ion $[\text{S}^{2-}]$**

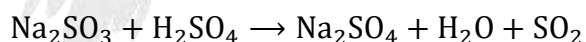
(a) With warm dilute H_2SO_4 a sulphide gives hydrogen sulphide gas which smells like rotten eggs. A piece of filter paper dipped in lead acetate solution turns black on exposure to the gas due to the formation of lead sulphide which is black in colour.



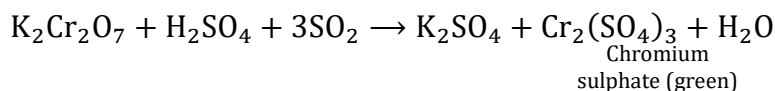
(b) If the salt is soluble in water, take the solution of salt in water make it alkaline with ammonium hydroxide and add sodium nitroprusside solution. If it is insoluble in water take sodium carbonate extract and add a few drops of sodium nitroprusside solution. Purple or violet colouration due to the formation of complex compound $\text{Na}_4[\text{Fe}(\text{CN})_5\text{NOS}]$ confirms the presence of sulphide ion in the salt.

**3. Test for Sulphite ion $[\text{SO}_3^{2-}]$**

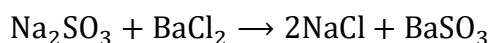
(a) On treating sulphite with warm dil. H_2SO_4 , SO_2 gas is evolved which is suffocating with the smell of burning sulphur.



The gas turns potassium dichromate paper acidified with dil. H_2SO_4 , green.

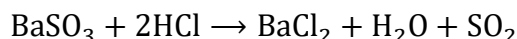


(b) An aqueous solution or sodium carbonate extract of the salt produces a white precipitate of barium sulphite on addition of barium chloride solution.

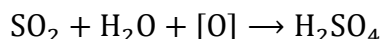
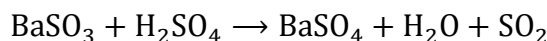


This precipitate gives following tests.

- (i) This precipitate on treatment with dilute HCl, dissolves due to decomposition of sulphite by dilute HCl. Evolved SO_2 gas can be tested.

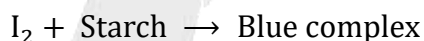
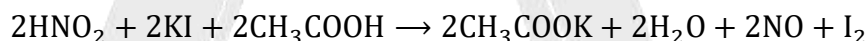
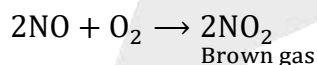
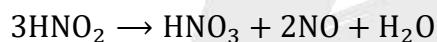


- (ii) Precipitate of sulphite decolourises acidified potassium permanganate solution.

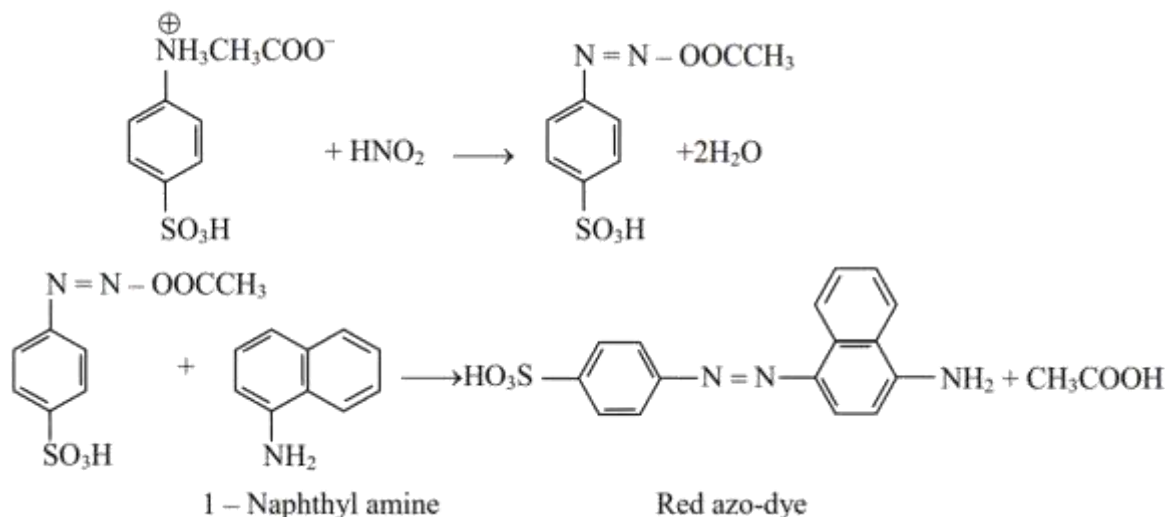


4. Test for Nitrite ion $[\text{NO}_2^-]$

- (a) On treating a solid nitrite with dil. H_2SO_4 and warming, reddish brown fumes of NO_2 gas are evolved. Addition of potassium iodide solution to the salt solution followed by freshly prepared starch solution and acidification with acetic acid produces blue colour. Alternatively, a filter paper moistened with potassium iodide and starch solution and a few drops of acetic acid turns blue on exposure to the gas, due to the interaction of liberated iodine with starch.

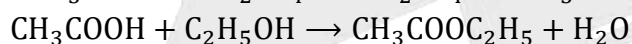
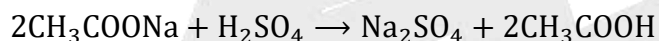


- (b) Sulphanilic acid - 1-naphthylamine reagent test (Griss-Ilosvay test) On adding sulphanilic acid and 1-naphthylamine reagent to the water extract or acidified with acetic acid, sulphanilic acid is diazotised in the reaction by nitrous acid formed. Diazotised acid couples with 1-naphthylamine to form a red azo-dye.



The test solution should be very dilute. In concentrated solutions reaction does not proceed beyond diazotisation.

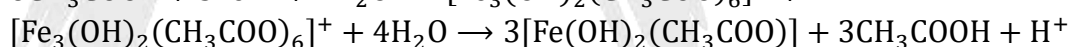
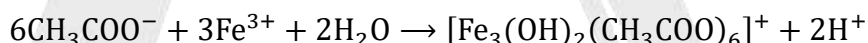
- (a) If the salt smells like vinegar on treatment with dil. H_2SO_4 , this indicates the presence of acetate ions. Take 0.1 g of salt in a china dish and add 1 mL of ethanol. Then add about 0.2 mL of conc H_2SO_4 and heat. Fruity odour of ethyl acetate indicates the presence of CH_3COO^- ion.



Ethylacetate

(Fruity odour)

- (b) Acetate gives deep red colour on reaction with neutral ferric chloride solution due to the formation of complex ion which decomposes on heating to give Iron (III) dihydroxyacetate as brown red precipitate.



Step-II

Preliminary Test with Concentrated Sulphuric Acid If no positive result is obtained from dil. H_2SO_4 test, take 0.1 g of salt in a test tube and 3-4 drops of conc. H_2SO_4 . Observe the change in the reaction mixture in cold and then warm it. Identify the gas evolved on heating (see Table 7.3).

Table 7.3 : Preliminary examination with concentrated sulphuric acid

Observations	Inference	
	Gas/Vapours Evolved	Possible Anion

(Inorganic Chemistry)

SALT ANALYSIS

A colourless gas with pungent smell, which gives dense white fumes when a rod dipped in ammonium hydroxide is brought near the mouth of the test tube.	HCl	Chloride, (Cl^-)
Reddish brown gas with a pungent odour is evolved. Intensity of reddish gas increases on heating the reaction mixture after addition of solid MnO_2 to the reaction mixture. Solution also acquires red colour.	Br_2 vapours	Bromide, (Br^-)
Violet vapours, which turn starch paper blue and a layer of violet sublimate is formed on the sides of the tube. Fumes become dense on adding MnO to the reaction mixture.	I_2 vapours	Iodide (I^-)
Brown fumes evolve which become dense upon heating the reaction mixture after addition of copper turnings and the solution acquires blue colour.	NOO_2	Nitrate, (NO_3^-)
Colourless, odourless gas is evolved which turns lime water milky and the gas coming out of lime water burns with a blue flame, if ignited.	CO and CO_2	Oxalate, ($\text{C}_2\text{O}_4^{2-}$)

Table 7.4 : confirmatory tests for Cl^- , Br^- , I^- , NO_3^- and $\text{C}_2\text{O}_4^{2-}$

Anion		Confirmatory Test
Chloride (Cl^-)	(a)	Take 0.1 g of salt in a test tube, add a pinch of manganese dioxide and 3-4 drops of conc. Sulphuric acid. Heat the reaction mixture. Greenish yellow chlorine gas is evolved which is detected by its pungent odour and bleaching action.
	(b)	Take 1 mL HNO_3 or take water extract and add silver nitrate solution. A curdy white precipitate is obtained which is soluble in ammonium hydroxide solution.
	(c)	Take 0.1 g salt and a pinch of solid potassium dichromate in a test tube, add conc. H_2SO_4 , heat and pass the gas evolved through sodium hydroxide solution. It becomes yellow. Divide the solution into two parts. Acidify one part with acetic acid and add lead acetate solution. A yellow precipitate is formed. Acidify the second part with dilute sulphuric acid and add 1 mL of amyl alcohol followed by 1 mL of 10% hydrogen peroxide. After gentle shaking the organic layer turns blue.

(Inorganic Chemistry)

SALT ANALYSIS

Bromide (Br^-)	(a)	Take 0.1 g of salt and a pinch of MnO_2 in a test tube. Add 3-4 drops conc. sulphuric acid and heat. Intense brown fumes are evolved.
	(b)	Neutralise 1 mL of sodium carbonate extract with hydrochloric acid (or take the water extract). Add 1 mL carbon tetrachloride (CCl_4)/ chloroform (CHCl_3)/ carbon disulphide. Now add an excess of chlorine water drop wise and shake the test tube. A brown colouration in the organic layer confirms the presence of bromide ion.
	(c)	Acidify 1 mL of sodium carbonate extract with dil. HNO_3 (or take 1 mL water extract) and add silver nitrate solution. A pale yellow precipitate soluble with difficulty in ammonium hydroxide solution is obtained.

Anion	Confirmatory Test
Nitrate (NO_3^-)	Take 1 mL of salt solution in water in a test tube. Add 2 mL of conc. H_2SO_4 and mix thoroughly. Cool the mixture under the tap. Add freshly prepared ferrous sulphate along the sides of the tube without shaking. A dark brown ring is formed at the junction of the two solution.
Oxalate ($\text{C}_2\text{O}_4^{2-}$)	<p>(a) Take 1 mL of water extract of sodium carbonate extract acidified with acetic acid and add calcium chloride solution. A white precipitate insoluble in ammonium oxalate and oxalic acid solution but soluble in dilute hydrochloric acid and dilute nitric acid is formed.</p> <p>(b) Take the precipitate from test (a) and dissolve it in dilute H_2SO_4. Add very dilute solution of KMnO_4 and warm. Colour of KMnO_4 solution is discharged. Pass the gas coming out through lime water. The lime water turns milky.</p>

Do Your Self - 1

1. NO_2^- ion can be destroyed by
 (A) Sulphamic acid (B) Thiourea
 (C) Urea (D) All of these

(Inorganic Chemistry)

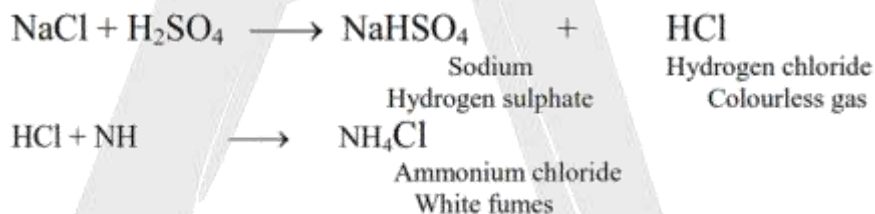
SALT ANALYSIS

2. CO_3^{2-} and $\text{S}_2\text{O}_3^{2-}$ can be distinguished by
 (A) CuSO_4 solution (B) BaCl_2 solution
 (C) $\text{Pb}(\text{OAc})_2$ solution (D) All of these
3. When AgNO_3 react with 'X' ion then initially no visible change occurs due to formation of water soluble complex. Then ion 'X' may be:
 (A) SO_3^{2-} (B) $\text{S}_2\text{O}_3^{2-}$
 (C) S^{2-} (D) CO_3^{2-}
4. NO_2^- and NO_3^- can be distinguished by which of the following reagent.
 (A) dil. H_2SO_4 (B) conc. H_2SO_4
 (C) Devarda's alloy + conc. NaOH (D) None of these
5. Which of the following gives a suffocating gas when treated with dilute HCl ?
 (A) carbonate (B) sulphite
 (C) sulphate (D) borate
6. A sodium salt of unknown anion when treated with MgCl_2 gives white precipitate only on boiling. The anion is:
 (A) SO_4^{2-} (B) HCO_3^- (C) CO_3^{2-} (D) NO_3^-

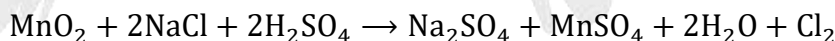
Chemistry of Confirmatory Tests

1. Test for Chloride ion $[\text{Cl}^-]$

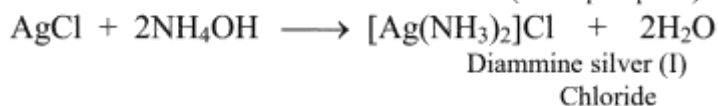
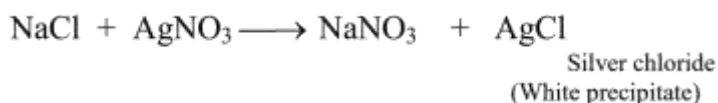
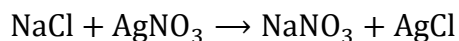
- (a) If on treatment with warm conc. H_2SO_4 the salt gives a colourless gas with pungent smell or if the gas which gives dense white fumes with ammonia solution, then the salt may contain Cl^- ions and the following reaction occurs.



- (b) If a salt gives effervescence on heating with conc. H_2SO_4 and MnO_2 and a light greenish yellow pungent gas is evolved, this indicates the presence of Cl^- ions.

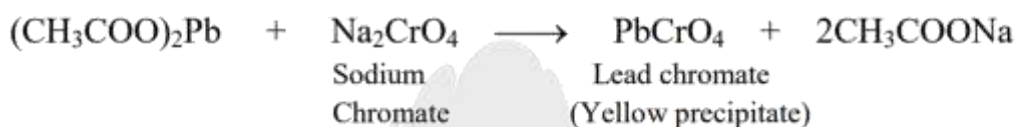
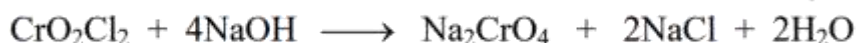
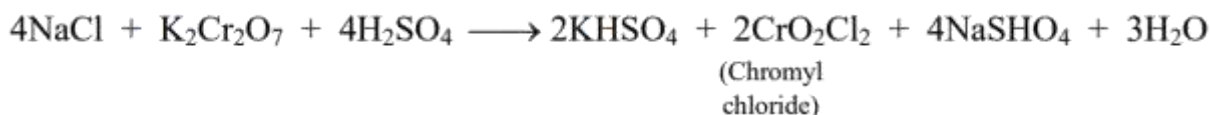


- (c) Salt solution acidified with dilute HNO_3 on addition of silver nitrate solution gives a curdy white precipitate soluble in ammonium hydroxide solution. This indicates the presence of Cl^- ions in the salt.

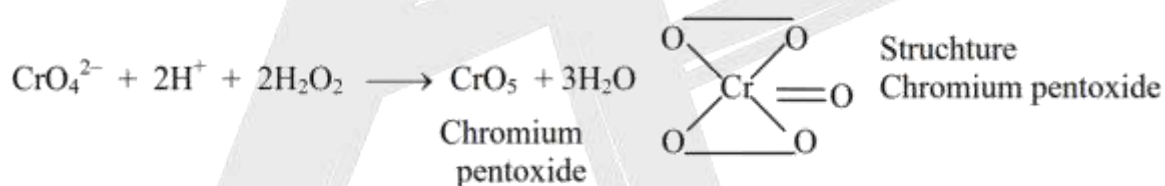


- (d) Mix a little amount of salt and an equal amount of solid potassium dichromate ($K_2Cr_2O_7$) in a test tube and add conc. H_2SO_4 to it. Heat the test tube and pass the

evolved gas through sodium hydroxide solution. If a yellow solution is obtained, divide the solution into two parts. Acidify the first part with acetic acid and then add lead acetate solution. Formation of a yellow precipitate of lead chromate confirms the presence of chloride ions in the salt. This test is called chromyl chloride test.

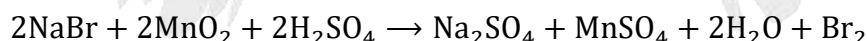
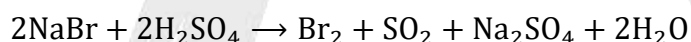


Acidify the second part with dilute sulphuric acid and add small amounts of amyl alcohol and then 1 mL of 10% hydrogen peroxide solution. On gentle shaking organic layer turns blue. CrO_4^{2-} ion formed in the reaction of chromyl chloride with sodium hydroxide reacts with hydrogen peroxide to form chromium pentoxide (CrO_5) (See structure) which dissolves in amyl alcohol to give blue colour.

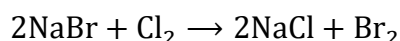


2. Test for Bromide ion (Br^-)

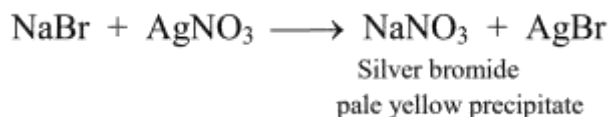
If on heating the salt with conc. H_2SO_4 reddish brown fumes of bromine are evolved in excess, this indicates the presence of Br ions. The fumes get intensified on addition of MnO_2 . Bromine vapours turn starch paper yellow.



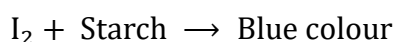
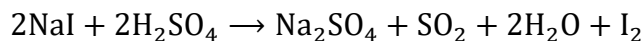
- (a) Add 1 mL of carbon tetrachloride (CCl_4)/ chloroform ($CHCl_3$) and excess of freshly prepared chlorine water drop wise to the salt solution in water or sodium carbonate extract neutralised with dilute HCl . Shake the test tube vigorously. The appearance of an orange brown colouration in the organic layer due to the dissolution of bromine in it, confirms the presence of bromide ions



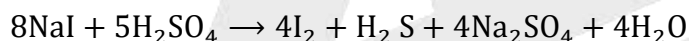
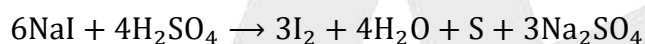
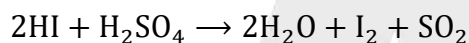
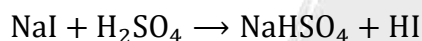
- (b) Acidify the sodium carbonate extract of the salt with dil. HNO_3 . Add silver nitrate ($AgNO_3$) solution and shake the test tube. A pale yellow precipitate is obtained which dissolves in ammonium hydroxide with difficulty.

3. Test for Iodide ion (I^-)

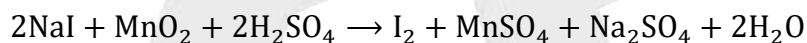
- (a) If on heating the salt with conc. H_2SO_4 , deep violet vapours with a pungent smell are evolved. These turns starch paper blue and a violet sublimate is formed on the sides of the test tube, it indicates the presence of I^- ions. Some HI, sulphur dioxide, hydrogen sulphide, and sulphur are also formed due to the following reactions.



Solution



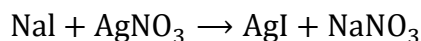
On adding MnO_2 to the reaction mixture, the violet vapours become dense.



- (b) Add 1 mL of CHCl_3 or CCl_4 and chlorine water in excess to the salt solution in water or sodium carbonate extract neutralised with dil. HCl and shake the test tube vigorously. Presence of violet colouration in the organic layer confirms the presence of iodide ions.

Iodine dissolves in the organic solvent and the solution becomes violet.

- (c) Acidify sodium carbonate extract of the salt with dil. HNO_3 and add AgNO_3 solution. Appearance of a yellow precipitate insoluble in excess of NH_4OH confirms the presence of iodide ions.



Silver iodide

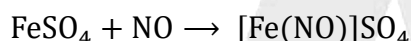
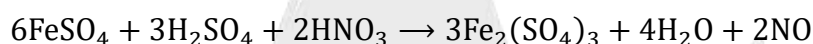
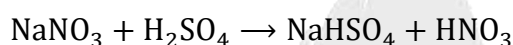
(Yellow precipitate)

- (b) Take 1 mL of an aqueous solution of the salt and add 2 mL conc. H_2SO_4 slowly. Mix the solutions thoroughly and cool the test tube under the tap. Now, add freshly prepared ferrous sulphate solution along the sides of the test tube dropwise so that it forms a layer on the top of the liquid already present in the test tube. A dark brown ring is formed at the junction of the two solutions due to the formation of nitroso ferrous

sulphate (Fig. 7.2). Alternatively first ferrous sulphate is added and then concentrated sulphuric acid is added.



Fig. 7.2 : Formation of brown ring

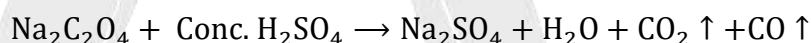


Nitroso ferrous sulphate

(Brown)

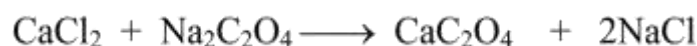
5. Test for Oxalate ion $[\text{C}_2\text{O}_4^{2-}]$

If carbon dioxide gas along with carbon monoxide gas is evolved in the preliminary examination with concentrated sulphuric acid, this gives indication about the presence of oxalate ion.



Oxalate is confirmed by the following tests:

- (a) Acidify sodium carbonate extract with acetic acid and add calcium chloride solution. A white precipitate of calcium oxalate, insoluble in ammonium oxalate and oxalic acid solution indicates the presence of oxalate ion.



Calcium oxalate

(White precipitate)

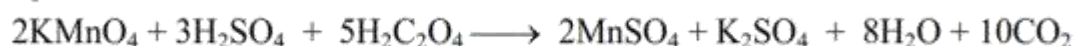
- (b) KMnO_4 test

Filter the precipitate from test (a). Add dil. H_2SO_4 to it followed by dilute KMnO_4 solution and warm. Pink colour of KMnO_4 is discharged:



Calcium sulphate

Oxalic acid



Pass the gas evolved through lime water. A white precipitate is formed which dissolves on passing the gas for some more time.

Step-III

Test for Sulphate and Phosphate

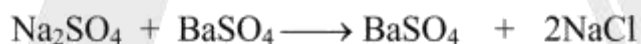
If no positive test is obtained in Steps-I and II, then tests for the presence of sulphate and phosphate ions are performed. These tests are summarised in Table 7.5.

Table 7.5 : Confirmatory tests for Sulphate and Phosphate

Ion	Confirmatory Test
Sulphate (SO_4^{2-})	(a) Take 1 mL water extract of the salt in water or sodium carbonate and after acidifying with dilute hydrochloric acid add BaCl_2 solution. White precipitate insoluble in conc. HCl or conc. HNO_3 is obtained. (b) Acidify the aqueous solution or sodium carbonate extract with acetic acid and add lead acetate solution. Appearance of white precipitate confirms the presence of SO_4^{2-} ion.
Phosphate (PO_4^{3-})	(a) Acidify sodium carbonate extract or the solution of the salt in water with conc. HNO_3 and add ammonium molybdate solution and heat to boiling. A canary yellow precipitate is formed

1. Test of Sulphate ions [SO_4^{2-}]

- (a) Aqueous solution or sodium carbonate extract of the salt acidified with acetic acid on addition of barium chloride gives a white precipitate of barium sulphate insoluble in conc. HCl or conc. HNO_3



Barium sulphate

(White precipitate)

- (b) Sulphate ions give white precipitate of lead sulphate when aqueous solution or sodium carbonate extract neutralised with acetic acid is treated with lead acetate solution.



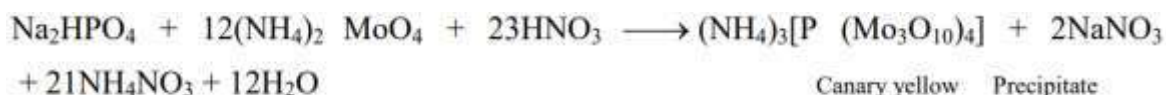
Lead sulphate

(White precipitate)

2. Test for Phosphate ion [PO_4^{3-}]

- (a) Add conc. HNO_3 and ammonium molybdate solution to the test solution containing phosphate ions and boil. A yellow colouration in solution or a canary yellow precipitate

of ammonium-phosphomolybdate, $(\text{NH}_4)_3[\text{P}(\text{Mo}_3\text{O}_{10})_4]$ is formed. Each oxygen of phosphate has been replaced by Mo_3O_{10} group.



Do Your Self - 2

- AgCl is soluble in
(A) Aqua regia (B) H_2SO_4
(C) dil. HCl (D) aNH₃
- Which is most soluble in water?
(A) AgCl (B) AgBr (C) AgI (D) AgF
- A salt gives violet vapours when treated with conc. H_2SO_4 , it contains
(A) Cl^- (B) I^- (C) Br^- (D) SO_3^-
- When chlorine water is added to an aqueous solution of potassium halide in presence of chloroform, a violet colour is obtained. On adding more of chlorine water, the violet colour disappears, and a colourless solution is obtained. This test confirms the presence of the following in aqueous solution
(A) Iodide (B) Bromide (C) Chloride (D) Iodide and bromide
- $\text{S}_2\text{O}_3^{2-}$ and S^{2-} can not be distinguished by
(A) $\text{Pb}(\text{OAc})_2$ solution (B) BaCl_2 solution
(C) Acidic KMnO_4 solution (D) dil. HCl solution
- SO_3^{2-} and $\text{S}_2\text{O}_3^{2-}$ can be distinguished by which of the following reagent.
(A) CaCl_2 solution (B) BaCl_2 solution
(C) (A) and (B) both (D) none of these two

SYSTEMATIC ANALYSIS OF CATIONS

The tests for cations may be carried out according to the following scheme.

Step - I : Preliminary Examination of the Salt for Identification of Cation

1. Colour Test

Observe the colour of the salt carefully, which may provide useful information about the cations. Table 7.6 gives the characteristic colours of the salts of some cations.

Table 7.6 Characteristic colours of the some metal ions

Ion	Confirmatory Test
Light green, Yellow, Brown	Fe^{2+} , Fe^{3+}
Blue	Cu^{2+}
Bright green	Ni^{2+}
Blue, Red Violet, Pink	Co^{2+}

Light pink

 Mn^{2+} **2. Dry Heating Test**

(i) Take about 0.1 g of the dry salt in a clean and dry test tube.

(ii) Heat the above test tube for about one minute and observe the colour of the residue when it is hot and also when it becomes cold. Observation of changes gives indications about the presence of cations, which may not be taken as conclusive evidence (see Table 7.7).

Table 7.7 : Inferences from the colour of the salt in cold and on heating

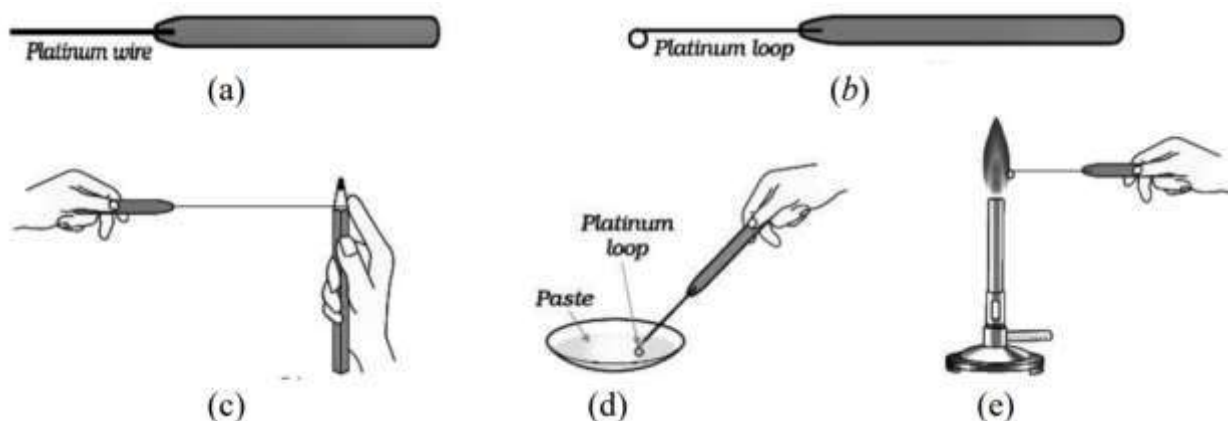
Colour when cold	Colour when hot	Inference
Blue	White	Cu^{2+}
Green	Dirty white or yellow	Fe^{2+}
White	Yellow	Zn^{2+}
Pink	Blue	Co^{2+}

3. Flame Test

The chlorides of several metals impart characteristic colour to the flame because they are volatile in non-luminous flame. This test is performed with the help of a platinum wire as follows :

- (i) Make a tiny loop at one end of a platinum wire.
- (ii) To clean the loop dip it into concentrated hydrochloric acid and hold it in a nonluminous flame (Fig. 7.3).
- (iii) Repeat step (ii) until the wire imparts no colour to the flame.
- (iv) Put 2-3 drops of concentrated hydrochloric acid on a clean watch glass and make a paste of a small quantity of the salt in it.
- (v) Dip the clean loop of the platinum wire in this paste and introduce the loop in the nonluminous (oxidising) flame (Fig. 7.3).
- (vi) Observe the colour of the flame first with the naked eye and then through a blue glass and identify

The metal ion with help of table 7.8



Performing flame test

Table 7.8 : Inference from the flame test

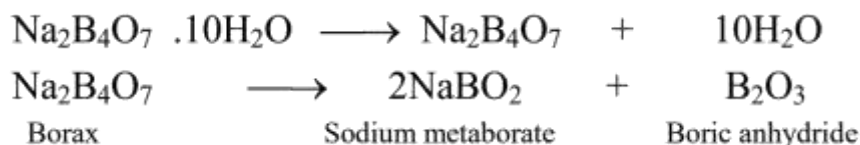
Colour fo the flame observed by naked eye	Colour of the flame observed through blue glass	Inference
Green flame with Blue centre	Same colour as observed	Cu^{2+}
without glass	Sr^{2+}	
Arimson red	Purple green	Ba^{2+}
Brick red	Bluish green	Ca^{2+}

4. Borax Bead Test

This test is employed only for coloured salts because borax reacts with metal salts to form metal borates or metals, which have characteristic colours.

- To perform this test make a loop at the end of the platinum wire and heat it in a flame till it is red hot.
- Dip the hot loop into borax powder and heat it again until borax forms a colourless transparent bead on the loop. Before dipping the borax bead in the test salt or mixture, confirm that the bead is transparent and colourless. If it is
- Dip the bead in a small quantity of the dry salt and again hold it in the flame.
- Observe the colour imparted to the bead in the non - luminous flame as well as in the luminous flame while it is hot and when it is cold (Fig. 7.4).
- To remove the bead from the platinum wire, heat it to redness and tap the platinum wire with your finger. (Fig.7.5).

On heating, borax loses its water of crystallisation and decomposes to give sodium metaborate and boric anhydride.



On treatment with metal salt, boric anhydride forms metaborate of the metal which gives different colours in oxidising and reducing flame. For example, in the case of copper sulphate, following reactions occur:

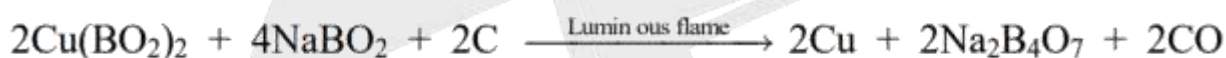


Two reactions may take place in the reducing flame:

(i) The blue $\text{Cu(BO}_2)_2$ is reduced to colourless cuprous metaborate as follows:



(ii) Cupric metaborate may be reduced to metallic copper and the bead appears red and opaque.



The preliminary identification of metal ion can be made from Table 7.9

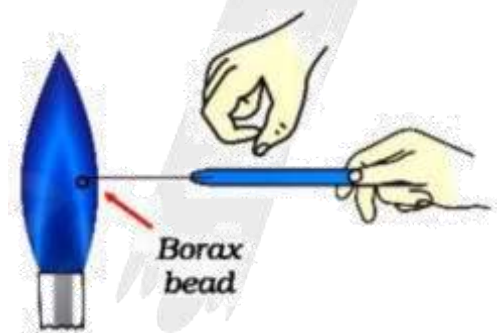


Fig. 7.5 : Removing borax bead

Table 7.9 : Inference from the borax bead test

Heating in oxidising (non-luminous) flame	Heating in reducing (luminous) flame	Inference		
Colour of the salt bead	Colour of the salt bead			
In cold	In hot	In cold	In hot	

Blue	Green	Red opaque	Colourless	Cu^{2+}
Reddish brown	Violet	Grey	Grey	Ni^{2+}
Light violet	Light violet	Colourless	Colourless	Ni^{2+}
Yellow	Yellowish brown	Green	Green	Fe^{3+}

5. Charcoal Cavity Test Metallic carbonate when heated in a charcoal cavity decomposes to give corresponding oxide. The oxide appears as a coloured residue in the cavity. Sometimes oxide may be reduced to metal by the carbon of the charcoal cavity.

The test may be performed as follows:

(i) Make a small cavity in a charcoal block with the help of a charcoal borer

Do not apply pressure otherwise it will crack [Fig.7.6 (a)].

(ii) Fill the cavity with about 0.2 g of the salt and about 0.5 g of anhydrous sodium carbonate.

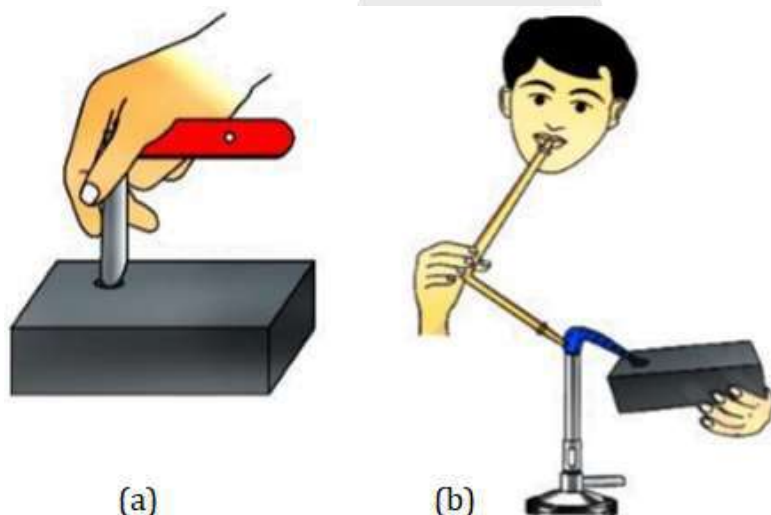
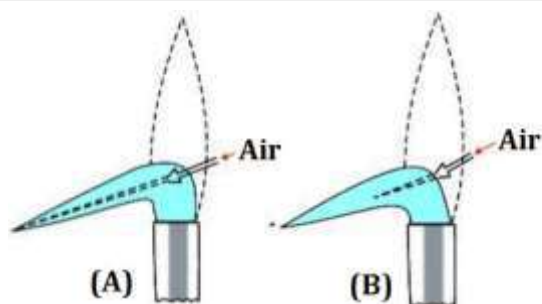


Fig. 7.6 : (a) Making charcoal cavity

(b) Heating salt in the cavity

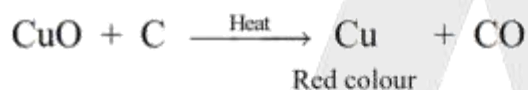
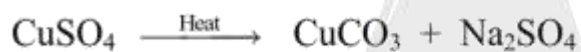
- (iii) Moisten the salt in the cavity with one or two drops of water, otherwise salt/mixture will blow away.
- (iv) Use a blow pipe to heat the salt in a luminous (reducing) flame and observe the colour of oxide/ metallic bead formed in the cavity both when hot and cold [Fig. (7.6 b)]. Obtain oxidising and reducing flame as shown in Fig. 7.7a and b.
- (v) Always bore a fresh cavity for testing the new salt



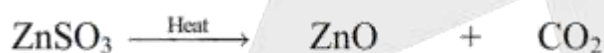
(a) Oxidising flame; and (b) Reducing flame

Fig - 7.7 : Obtaining oxidizing and reducing flame

When test is performed with CuSO_4 , the following change occurs.



In case of ZnSO_4



Yellow when hot,
White when cold

The metal ion can be inferred from Table 7.10 .

Table 7.10 : Inference from the charcoal cavity test

Observations	Inference
Yellow residue when hot and grey metal when cold	Pb^{2+}
White residue with the odour of garlic	As^{3+}
Brown residue	Cd^{2+}
Yellow residue when hot and white when cold	Zn^{2+}

6. Cobalt Nitrate Test

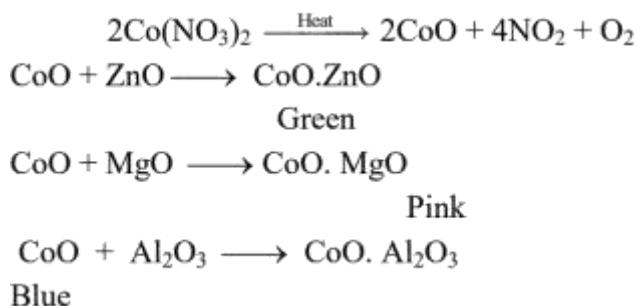
If the residue in the charcoal cavity is white, cobalt nitrate test is performed.

(i) Treat the residue with two or three drops of cobalt nitrate solution.

(ii) Heat it strongly in non-luminous flame with the help of a blow pipe and observe the colour of the residue.

On heating, cobalt nitrate decomposes into cobalt (II) oxide, which gives a characteristic colour with metal oxide present in the cavity.

Thus, with ZnO , Al_2O_3 and MgO , the following reactions occur.



Do Your self - 3

- Find the number of water of crystallization in microcosmic salt
(A) 5 (B) 4 (C) 6 (D) 10
- What is the colour of K^+ through cobalt/double blue glass
(A) Lilac, (B) Violet (C) Brick red (D) Crimson red
- Find the number of water of crystallization in microcosmic salt
(A) 5 (B) 4 (C) 6 (D) 10
- What is the colour of K^+ through cobalt/double blue glass
(A) Lilac, (B) Violet (C) Brick red (D) Crimson red
- What is the colour of $\text{CoO} \cdot \text{Al}_2\text{O}_3$ is
(A) pink (B) Thenard blue (C) Bluish white (D) None of these
- Sodium carbonate bead test generally used for compounds.
(A) Mn (B) Cr (C) Zn (D) Cu

Step-II : Wet Tests for Identification of Cations

The cations indicated by the preliminary tests given above are confirmed by systematic analysis given below.

The first essential step is to prepare a clear and transparent solution of the salt. This is called original solution. It is prepared as follows:

Preparation of Original Solution (O.S.)

To prepare the original solution, following steps are followed one after the other in a systematic order. In case the salt does not dissolve in a particular solvent even on heating, try the next solvent

The following solvents are tried:

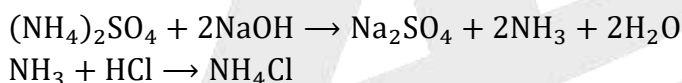
- Take a little amount of the salt in a clean boiling tube and add a few mL of distilled water and shake it. If the salt does not dissolved, heat the content of the boiling tube till the salt completely dissolves.
- If the salt is insoluble in water as detailed above, take fresh salt in a clean boiling tube and add a few mL of dil.HCl to it. If the salt is insoluble in cold, heat the boiling tube till the salt is completely dissolved.

3. If the salt does not dissolve either in water or in dilute HCl even on heating, try to dissolve it in a few mL of conc. HCl by heating.
4. If salt does not dissolve in conc. HCl, then dissolve it in dilute nitric acid.
5. If salt does not dissolve even in nitric acid then a mixture of conc. HCl and conc. HNO₃ in the ratio 3: 1 is tried. This mixture is called aqua regia. A salt not soluble in aqua regia is considered to be an insoluble salt.

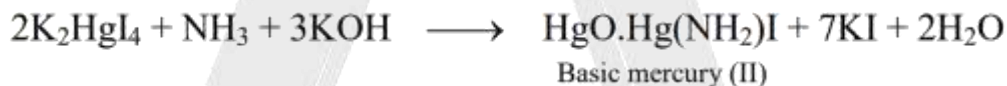
Group Analysis**(I) Analysis of Zero group cation (NH₄⁺ ion)**

- (a) Take 0.1 g of salt in a test tube and add 1 – 2 mL of NaOH solution to it and heat. If there is a smell of ammonia, this indicates the presence of ammonium ions. Bring a glass rod dipped in hydrochloric acid near the mouth of the test tube. White fumes are observed.
 - (b) Pass the gas through Nessler's reagent. Brown precipitate is obtained.
- Chemistry of Confirmatory Tests for NH₄⁺ ion

- (a) Ammonia gas evolved by the action of sodium hydroxide on ammonium salts reacts with hydrochloric acid to give ammonium chloride, which is visible as dense white fume.



On passing the gas through Nessler's reagent, a brown colouration or a precipitate of basic mercury(II) amido-iodine is formed.



amido-iodine

(Brown precipitate)

Basic mercury (II)

For the analysis of cations belonging to groups I-VI, the cations are precipitated from the original solution by using the group reagents (see Table 7.11) according to the scheme shown in the flow chart given below:

The separation of all the six groups is represented as below :

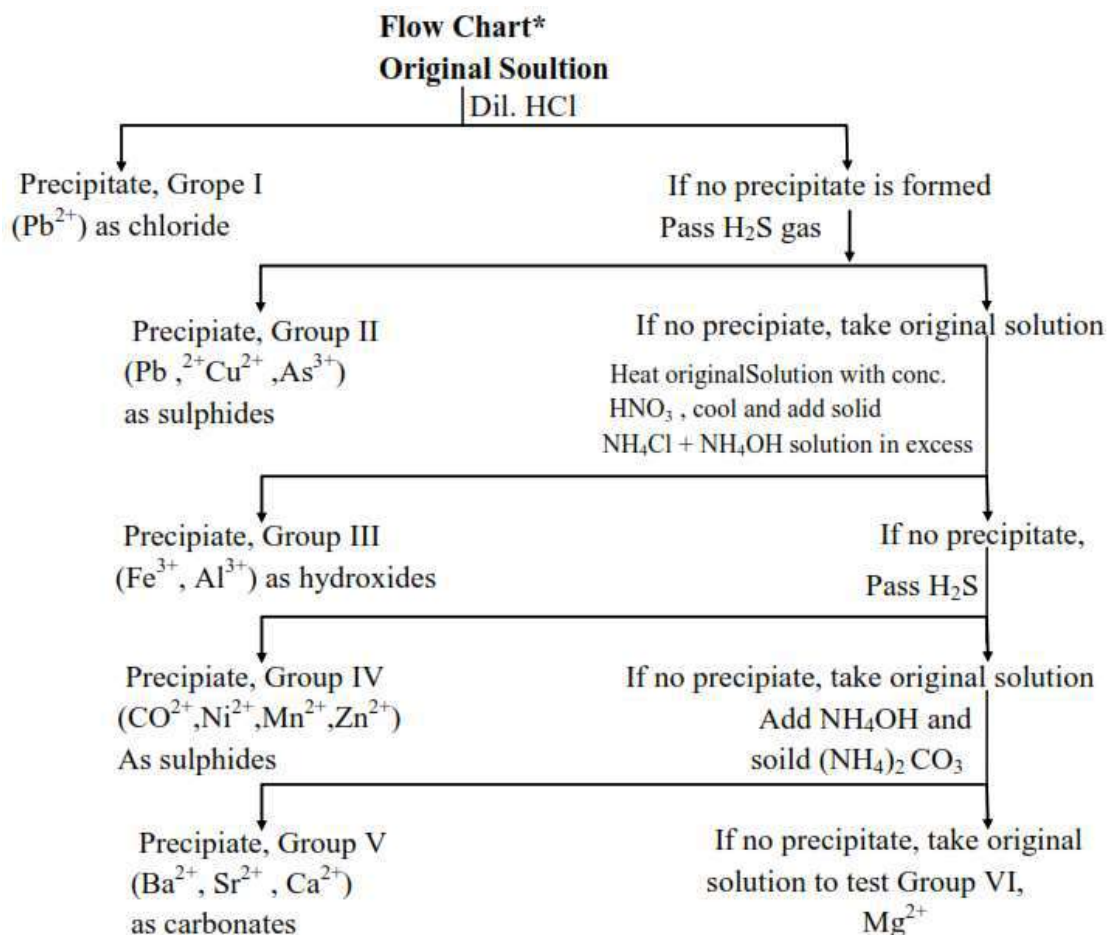


Table 7.11 : Group reagents for precipitating ions

Group	Cations*	Group Reagent
Group zero	NH ₄ ⁺	None
Group - I	Pb ²⁺	Dilute HCl
Group - II	Pb ²⁺ , Cu ²⁺ , As ³⁺	H ₂ S gas in presence of dil. HCl
Group - III	Al ³⁺ , Fe ³⁺	NH ₄ OH in presence of NH ₄ Cl
Group - IV	Co ²⁺ , Ni ²⁺ , Mn ²⁺ , Zn ²⁺	H ₂ S in presence of NH ₄ OH
Group - V	Ba ²⁺ , Sr ²⁺ , Ca ²⁺	(NH ₄) ₂ CO ₃ in presence of NH ₄ OH
Group - VI	Mg ²⁺	None

(II) Analysis of Group-I cations

Take a small amount of original solution (if prepared in hot conc. HCl) in a test tube and add

cold water to it and cool the test tube under tap water. If a white precipitate appears, this indicates the presence of Pb^{2+} ions in group -I. On the other hand, if the original solution is prepared in water and on addition of dil. HCl , a white precipitate appears, this may also be Pb^{2+} . Confirmatory tests are described below in Table 7.12

Table 7.12 : Confirmatory tests for Group-I cation (Pb^{2+})

Experiment	Observation
Dissolve the precipitate in hot water and divide the hot solution into three parts, 1. Add potassium iodide solution to the first part. 2. To the second part add potassium chromate solution. 3. To the third part of the hot solution add few drops of alcohol and dilute sulphuric acid.	A yellow precipitate is obtained. A yellow precipitate is obtained which is soluble, in NaOH and insoluble in ammonium acetate solution. A white precipitate is obtained which is soluble in ammonium acetate solution.

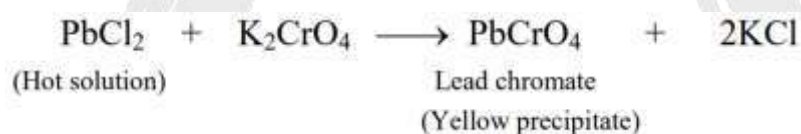
Chemistry of the Confirmatory Tests of Pb^{2+} ions

Lead is precipitated as lead chloride in the first group. The precipitate is soluble in hot water.

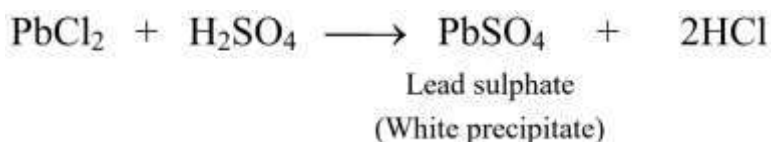
- On adding potassium iodide (KI) solution, a yellow precipitate of lead iodide is obtained which confirms the presence of Pb^{2+} ions.



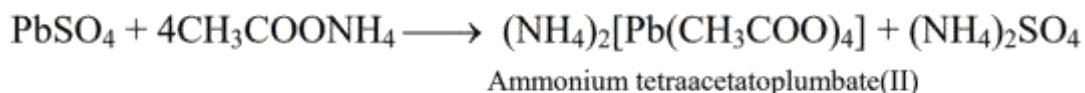
- On addition of potassium chromate (K_2CrO_4) solution a yellow precipitate of lead chromate is obtained. This confirms the presence of Pb^{2+} ions.



- A white precipitate of lead sulphate (PbSO_4) is formed on addition of alcohol followed by dil. H_2SO_4 .



Lead sulphate is soluble in ammonium acetate solution due to the formation of tetraacetatoplumbate(II) ions. This reaction may be promoted by addition of few drops of acetic acid.

**(III) Analysis of Group-II cations**

If group-I is absent, add excess of water to the same test tube. Warm the solution and pass H_2S gas for 1-2 minutes (Fig. 7.6). Shake the test tube. If a precipitate appears, this indicates the presence of group II cations. Pass more H_2S gas through the solution to ensure complete precipitation and separate the precipitate. If the colour of the precipitate is black, it indicates the presence of Cu^{2+} or Pb^{2+} ions. If it is yellow in colour, then presence of As^{3+} ions is indicated.

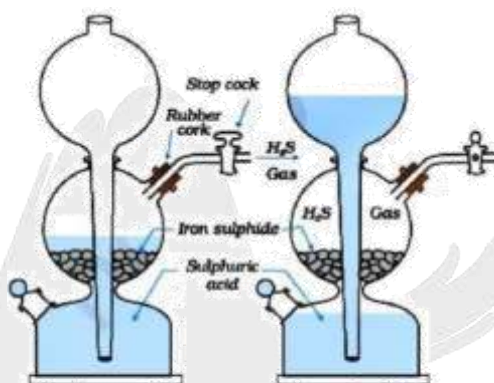


Fig 7.8 : Kipp's apparatus for preparation of H_2S gas

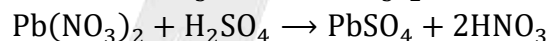
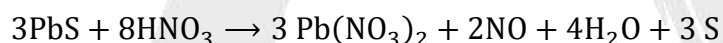
Take the precipitate of group-II in a test tube and add excess of yellow ammonium sulphide solution to it. Shake the test tube. If the precipitate is insoluble, group II-A (copper group) is present. If the precipitate is soluble, this indicates the presence of group-II B (arsenic group). Confirmatory tests for the groups II A and II B are given in Table 7.13.

Table 7.13 : Confirmatory tests for the groups II A and II B cations

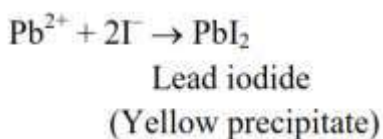
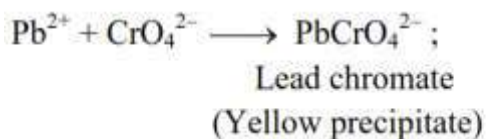
Black precipitate of Group II A ions (Pb^{2+} , Cu^{2+}) insoluble in yellow ammonium sulphide is formed.		If a yellow precipitate soluble in yellow ammonium sulphide is formed then As ion is present.
Boil the precipitate of Group II A with dilute nitric acid and add a few drops of alcohol and dil. H_2SO_4 .		Acidify this solution with dilute HCl. A yellow precipitate is formed. Heat the precipitate with concentrated nitric acid and add ammonium molybdate solution. A canary yellow precipitate is formed.
White precipitate confirms the presence of Pb^{2+} ions. Dissolve the precipitate in ammonium acetate solution. Acidify with acetic acid and divide the solution into two parts. (i) To the first part add potassium chromate solution, a yellow precipitate is formed. (ii) To the second part, add potassium iodide solution, a yellow precipitate is formed	If no precipitate is formed, add excess of ammonium hydroxide solution. A blue solution is obtained, acidify it with acetic acid and add potassium ferrocyanide solution. A chocolate brown precipitate is formed	

Group-II A (Copper Group)**Chemistry of confirmatory tests of Group-II A cations****1. Test for Lead ion (Pb^{2+})**

Lead sulphide precipitate dissolves in dilute HNO_3 . On adding dil. H_2SO_4 and a few drops of alcohol to this solution a white precipitate of lead sulphate appears. This indicates the presence of lead ions.



The white precipitate dissolves in ammonium acetate solution on boiling. When this solution is acidified with acetic acid and potassium chromate solution is added, a yellow precipitate of PbCrO_4 is formed. On adding potassium iodide solution, a yellow precipitate of lead iodide is formed.



(Inorganic Chemistry)

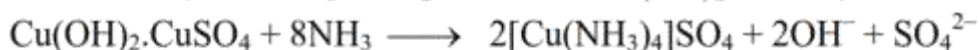
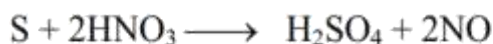
SALT ANALYSIS

2. Test for Copper ion (Cu^{2+})

(a) Copper sulphide dissolves in nitric acid due to the formation of copper nitrate.

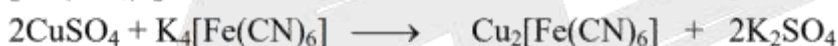
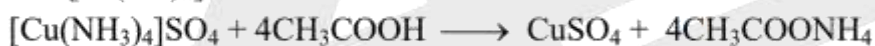
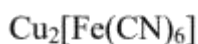


On heating the reaction mixture for long time, sulphur is oxidised to sulphate and copper sulphate is formed and the solution turns blue. A small amount of NH_4OH precipitates basic copper sulphate which is soluble in excess of ammonium hydroxide due to the formation of tetraamminecopper (II) complex.



Tetraamminecopper (II)
sulphate (Deep blue)

(b) The blue solution on acidification with acetic acid and then adding potassium ferrocyanide $[\text{K}_4\text{Fe}(\text{CN})_6]$ solution gives a chocolate colouration due to the formation of copper ferrocyanide i.e.



Potassium
hexacyanoferrate (II)

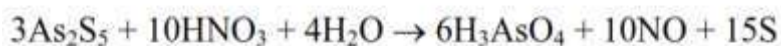
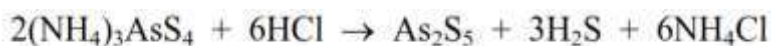
Copper
hexacyanoferrate (II)
(Chocolate brown precipitate)

Group-II B (Arsenic Group)

If group- II precipitate dissolves in yellow ammonium sulphide and the colour of the solution is yellow, this indicates the presence of As^{3+} ions. Ammonium thioarsenide formed on dissolution of As_2S_3 , decomposes with dil. HCl , and a yellow precipitate of arsenic (V) sulphide is formed which dissolves in concentrated nitric acid on heating due to the formation of arsenic acid. On adding ammonium molybdate solution to the reaction mixture and heating, a canary yellow precipitate is formed. This confirms the presence of As^{3+} ions.



Yellow ammonium
Sulphide



Arsenic acid



Arsenic acid

Ammonium Molybdate

Ammonium arsenomolybdate

(yellow precipitate)

(IV) Analysis of Group-III cations

If group-II is absent, take original solution and add 2-3 drops of conc. HNO_3 to oxidise Fe^{2+} ions to Fe^{3+} ions. Heat the solution for a few minutes. After cooling add a small amount of solid ammonium chloride (NH_4Cl) and an excess of ammonium hydroxide (NH_4OH) solution till it smells of ammonia. Shake the test tube. If a brown or white precipitate is formed, this indicates the presence of group III cations. Confirmatory tests of group-III cations are summarised in Table 7.14.

Observe the colour and the nature of the precipitate. A gelatinous white precipitate indicates the presence of aluminium ion (Al^{3+}). If the precipitate is brown in colour, this indicates the presence of ferric ions (Fe^{3+}).

Table 7.14 : Confirmatory test for Group-III cations

	Brown precipitate Fe^{3+}		White precipitate Al^{3+}
	Dissolve the precipitate in dilute HCl and divide the solution into two parts		Dissolve the white precipitate in dilute HCl and divide into two parts.
(a)	To the first part add potassium ferrocyanide solution [Potassium hexacyanoferrate (II)]. A blue precipitate/colouration appears.	(a)	To the first part add sodium hydroxide solution and warm. A white gelatinous precipitate soluble in excess of sodium hydroxide solution is obtained
(b)	To the second part add potassium thiocyanate solution. A blood red colouration appears.	(b)	To the second part first add blue litmus solution and then ammonium hydroxide solution drop by drop along the sides of the test tube. A blue floating mass in the colourless solution is obtained.

Do Your Self - 4

- Which of the following is not group-I cation though the chlorides of all cations are sparingly soluble in water.
(A) Ag^+ (B) Hg_2^{2+} (C) Cu^+ (D) Pb^{2+}
- Type of sulphide ppt may be obtained in the group-II ppt during group analysis.
(A) M_2S_3 (B) M_2S (C) MS (D) MS_2
- CrCl_3 solution + Na_2S solution \rightarrow ppt(A)
The correct formula and colour of A are
(A) Cr_2S_3 , Black (B) $\text{Cr}(\text{OH})_3$, Green
(C) $\text{Na}[\text{Cr}(\text{OH})_4]$, Green (D) None of these

(Inorganic Chemistry)

SALT ANALYSIS

4. Which of the following is soluble in yellow ammonium sulphide?
 (A) CuS (B) CdS (C) SnS (D) PbS
5. Which one of the following can be used in place of NH_4Cl for the identification of the third group radicals?
 (A) NH_4NO_3 (B) $(\text{NH}_4)_2\text{SO}_4$
 (C) $(\text{NH}_4)_2\text{S}$ (D) $(\text{NH}_4)_2\text{CO}_3$

Chemistry of confirmatory tests of Group - III cations

When original solution is heated with concentrated nitric acid, ferrous ion are oxidised to ferric ions.



Their group cations are precipitated as their hydroxides, which dissolve in dilute hydrochloric acid due to the formation of corresponding chlorides.

1. Test for Aluminium ions (Al^{3+})

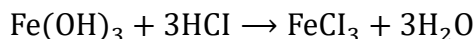
- (a) When the solution containing aluminium chloride is treated with sodium hydroxide a white gelatinous precipitate of aluminium hydroxide is formed which is soluble in excess of sodium hydroxide solution due to the formation of sodium meta aluminate.



White gelatinous
precipitate

Sodium
meta aluminate

- (b) In the second test when blue litmus is added to the solution, a red colouration is obtained due to the acidic nature of the solution. On addition of NH_4OH solution drop by drop, the solution becomes alkaline and aluminium hydroxide is precipitated. Aluminium hydroxide adsorbs blue colour from the solution and forms insoluble adsorption complex named 'lake'. Thus a blue mass floating in the colourless solution is obtained. The test is therefore called lake test.

2. Test for ferric ions (Fe^{3+}) Reddish brown precipitate of ferric hydroxide dissolves in hydrochloric acid and ferric chloride is formed.

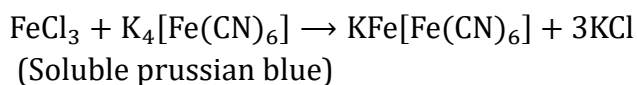
- (a) When the solution containing ferric chloride is treated with potassium ferrocyanide solution a blue precipitate/colouration is obtained. The colour of the precipitate is Prussian blue. It is ferric ferrocyanide. The reaction takes place as follows:



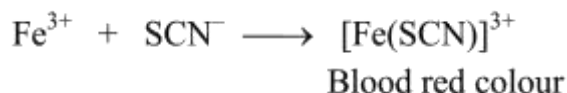
Potassium
ferrocyanide

Prussian blue
precipitate

If potassium hexacyanoferrate (II) (i.e. potassium ferrocyanide) is added in excess then a product of composition $\text{KFe}[\text{Fe}(\text{CN})_6]$ is formed. This tends to form a colloidal solution ('soluble Prussian blue') and cannot be filtered.



- (b) To the second part of the solution, add potassium thiocyanate (potassium sulphocyanide) solution. The appearance of a blood red colouration confirms the presence of Fe^{3+} ions.



(V) Analysis of group-IV cations

If group-III is absent, pass H_2S gas in the solution of group-III for a few minutes. If a precipitate appears (white, black or flesh coloured), this indicates the presence of group-IV cations. Table 7.15 gives a summary of confirmatory tests of group-IV cations.

Table 7.15 : Confirmatory test for Group - IV cations

White precipitate (Zn^{2+})	Flesh coloured precipitate (Mn^{2+})	Black precipitate ($\text{Ni}^{2+}, \text{Co}^{2+}$)
<p>Dissolve the precipitate in dilute HCl by boiling. Divide the solution into two parts</p> <p>(a) To the first part add sodium hydroxide solution. A white precipitate soluble in excess of sodium hydroxide solution confirms the presence of Zn^{2+} ions</p> <p>(b) Neutralise the second part with ammonium hydroxide solution and add potassium ferrocyanide solution. A bluish white precipitate appears</p>	<p>Dissolve the precipitate in dilute HCl by boiling, then add sodium hydroxide solution in excess. A white precipitate is formed which turns brown on keeping.</p>	<p>Dissolve the precipitate in aqua regia. Heat the solution to dryness and cool.</p> <p>Dissolve the residue in water and divide the solution into two parts.</p> <p>(a) To the first part of the solution add ammonium hydroxide solution till it becomes alkaline. Add a few drops of dimethyl glyoxime and shake the test tube. Formation of a bright red precipitate confirms the presence of Ni^{2+} ions.</p> <p>(b) Neutralise the second part with ammonium hydroxide solution. Acidify it with dilute acetic acid and add solid potassium nitrite. A yellow precipitate confirms the presence of Co^{2+} ions.</p>

Chemistry of confirmatory tests of Group-IV cations

Fourth group cations are precipitated as their sulphides. Observe the colour of the precipitate. A white colour of the precipitate indicates the presence of zinc ions, a flesh colour indicates the presence of manganese ions and a black colour indicates the presence of Ni^{2+} or Co^{2+} ions.

- Test for Zinc ion (Zn^{2+})
Zinc sulphide dissolves in hydrochloric acid to form zinc chloride.
$$\text{ZnS} + 2\text{HCl} \rightarrow \text{ZnCl}_2 + \text{H}_2\text{S}$$

- (a) On addition of sodium hydroxide solution it gives a white precipitate of zinc hydroxide, which is soluble in excess of NaOH solution on heating. This confirms the presence of Zn^{2+} ions.



Sodium zincate

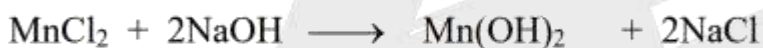
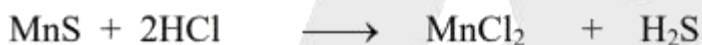
- (b) When potassium ferrocyanide $\text{K}_4[\text{Fe(CN)}_6]$ solution is added to the solution after neutralisation by NH_4OH solution, a white or a bluish white precipitate of zinc ferrocyanide appears.



Zinc Ferrocyanide

2. Test for Manganese ion (Mn^{2+})

Manganese sulphide precipitate dissolves in dil. HCl on boiling. On addition of NaOH solution in excess, a white precipitate of manganese hydroxide is formed which turns brown due to atmospheric oxidation into hydrated manganese dioxide.



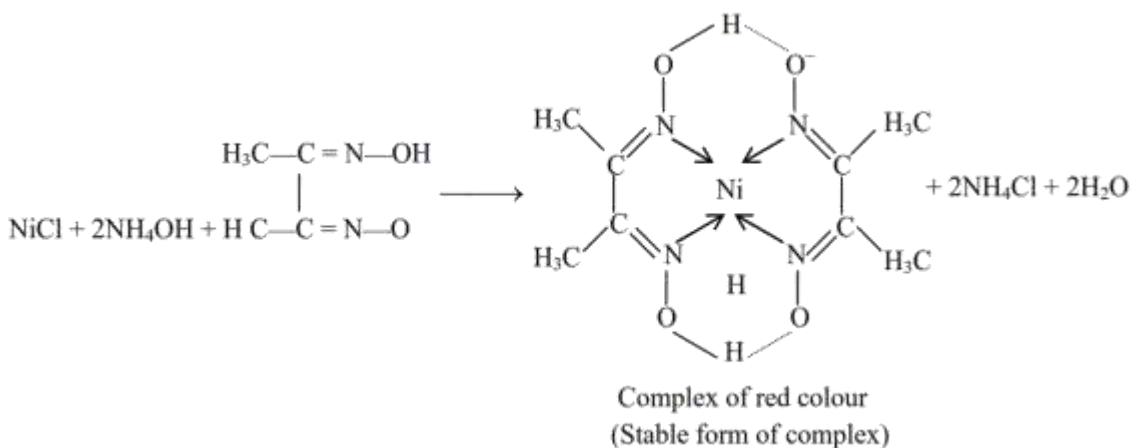
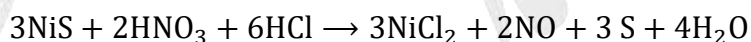
(White precipitate)



Hydrated manganese dioxide
(Brown colour)

3. Test for Nickel ion (Ni^{2+})

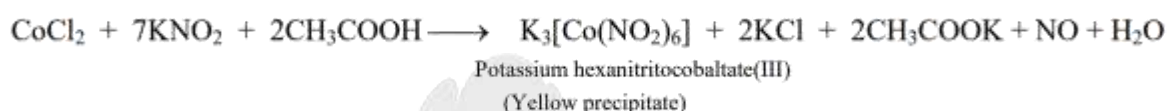
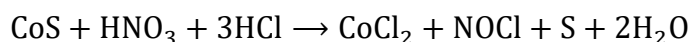
The black precipitate of nickel sulphide dissolves in aqua regia and the reaction takes place as follows:



After treatment with aqua regia nickel-chloride is obtained which is soluble in water. When dimethyl glyoxime is added to the aqueous solution of nickel chloride, made alkaline, by adding NH_4OH solution, a brilliant red precipitate is obtained.

4. Test for Cobalt ion (Co^{2+})

Cobalt sulphide dissolves in aqua regia in the same manner as nickel sulphide. When the aqueous solution of the residue obtained after treatment with aqua regia is treated with a strong solution of potassium nitrite after neutralisation with ammonium hydroxide and the solution is acidified with dilute acetic acid, a yellow precipitate of the complex of cobalt named potassium hexanitritocobaltate (III) is formed.



(VI) Analysis of Group-V cations

If group-IV is absent then take original solution and add a small amount of solid NH_4Cl and an excess of NH_4OH solution followed by solid ammonium carbonate $(\text{NH}_4)_2\text{CO}_3$. If a white precipitate appears, this indicates the presence of group- V cations.

Dissolve the white precipitate by boiling with dilute acetic acid and divide the solution into three parts one each for Ba^{2+} , Sr^{2+} and Ca^{2+} ions. Preserve a small amount of the precipitate for flame test. Summary of confirmatory tests is given in Table 7.16.

Dissolve the precipitate by boiling with dilute acetic acid and divide the solution into three parts one each for Ba^{2+} , Sr^{2+} and Ca^{2+} ions		
Ba^{2+} ions	Sr^{2+} ions	Ca^{2+} ions
(a) To the first part add potassium chromate solution. A yellow precipitate appears. (b) Perform the flame test with the preserved precipitate. A grassy green flame is obtained	(a) If barium is absent, take second part of the solution and add ammonium sulphate solution. Heat and scratch the sides of the test tube with a glass rod and cool. A white precipitate is formed. (b) the preserved precipitate. A crimson-red flame confirms the presence of Sr^{2+} ions.	(a) If both barium and strontium are absent, take the third part of the solution. Add ammonium oxalate solution and shake well. A white precipitate of calcium oxalate is obtained. (b) Perform the flame test with the preserved precipitate. A brick red flame, which looks greenish yellow through blue glass, confirms the presence of Ca^{2+} ions.

Chemistry of Confirmatory Tests of Group-V cations

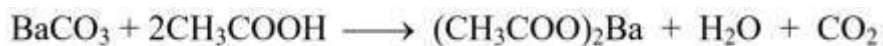
The Group-V cations are precipitated as their carbonates which dissolve in acetic acid due to the formation of corresponding acetates.

Chemistry of Confirmatory Tests of Group-V cations

The Group-V cations are precipitated as their carbonates which dissolve in acetic acid due to the formation of corresponding acetates.

1. Test for Barium ion (Ba^{2+})

- (a) **Potassium chromate** (K_2CrO_4) solution gives a yellow precipitate of barium chromate when the solution of fifth group precipitate in acetic acid is treated with it.

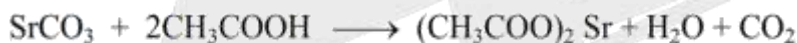


Barium chromate
(yellow precipitate)

- (b) **Flame test** : Take a platinum wire and dip it in conc. HCl. Heat it strongly until the wire does not impart any colour to the non-luminous flame. Now dip the wire in the paste of the (Group-V) precipitate in conc. HCl. Heat it in the flame. A grassy green colour of the flame confirms the presence of Ba^{2+} ions.

2. Test for Strontium ion (Sr^{2+})

- (a) **Solution** of V group precipitate in acetic acid gives a white precipitate of strontium sulphate with ammonium sulphate solution on heating and scratching the sides of the test tube with a glass rod.

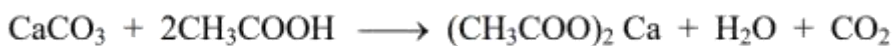


Strontium sulphate
(White Precipitate)

- (b) **Flame test** : Perform the flame test as given in the case of Ba^{2+} . A crimson red flame confirms the presence of Sr^{2+} ions.

3. Test for Calcium ion (Ca^{2+})

- (a) Solution of the fifth group precipitate in acetic acid gives a white precipitate with ammonium oxalate solution.



Ammonium
oxalate Calcium oxalate
(White precipitate)

- (b) **Flame test** : Perform the flame test as mentioned above. Calcium imparts brick red colour to the flame which looks greenish-yellow through blue glass.

(VII) Analysis of Group-VI cations

If group-V is absent then perform the test for Mg^{2+} ions as given below.

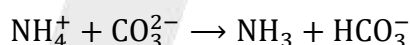
Do Your Self - 5

- The auxiliary reagent in group-IV reagent is
(A) H_2S (B) dil. HCl (C) NaOH (D) NH_4OH
- Which of the following ppt is not soluble in NH_4Cl solution.
(A) $\text{Zn}(\text{OH})_2$ (B) $\text{Mg}(\text{OH})_2$ (C) BaCO_3 (D) $\text{Ni}(\text{OH})_2$
- If NaOH is added to an aqueous solution of zinc ions a white ppt appears and on adding excess NaOH , the ppt dissolves. In this solution zinc exist in the
(A) cationic part (B) anionic part
(C) both in cationic and anionic parts (D) there is no zinc ion in the solution
- Colour of nickel chloride solution is
(A) pink (B) black (C) colourless (D) green
- In III group, NH_4Cl is added to decrease concentration of ammonium ion. We do not add $(\text{NH}_4)_2\text{SO}_4$ along with NH_4OH because
(A) $(\text{NH}_4)_2\text{SO}_4$ is insoluble in water
(B) It precipitate other insoluble sulphates
(C) It is weak electrolyte
(D) None of these
- Which is soluble in NH_4OH ?
(A) PbCl_2 (B) AgCl (C) PbSO_4 (D) CaCO_3

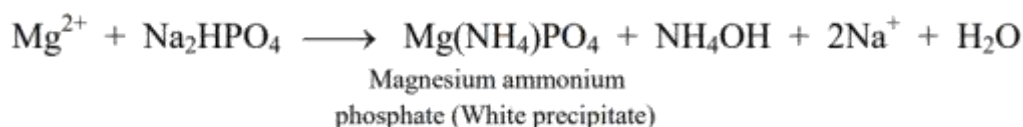
Chemistry of Confirmatory Tests of Group-VI cations

Test for Magnesium ion (Mg^{2+})

- (a) If group-V is absent then the solution may contain magnesium carbonate, which is soluble in water in the presence of ammonium salts because the equilibrium is shifted towards the right hand side.



The concentration of carbonate ions required to produce a precipitate is not attained. When disodium hydrogenphosphate solution is added and the inner walls of the test tube are scratched with a glass rod, a white crystalline precipitate of magnesium ammonium phosphate is formed which indicates the presence of Mg^{2+} ions



Note down the observations and the inferences of the qualitative analysis in tabular form as given in the specimen record

Precautions

(Inorganic Chemistry)**SALT ANALYSIS**

- (a) Always use an apron, an eye protector and hand gloves while working in the chemistry laboratory.
- (b) Before using any reagent or a chemical, read the label on the bottle carefully. Never use unlabelled reagent.
- (c) Do not mix chemicals and reagents unnecessarily. Never taste any chemical.
- (d) Be careful in smelling chemicals or vapours. Always fan the vapours gently towards your nose (Fig. 7.9).
- (e) Never add sodium metal to water or throw it in the sink or dustbin.
- (f) Always pour acid into water for dilution. Never add water to acid.
- (g) Be careful while heating the test tube. The test tube should never point towards yourself or towards your neighbours while heating or adding a reagent. Fig. 7.9 : How to smell a gas
- (h) Be careful while dealing with the explosive compounds, inflammable substances, poisonous gases, electric appliances, glass wares, flame and the hot substances.
- (i) Keep your working surroundings clean. Never throw papers and glass in the sink. Always use dustbin for this purpose.
- (j) Always wash your hands after the completion of the laboratory work.
- (k) Always use the reagents in minimum quantity. Use of reagents in excess, not only leads to wastage of chemicals but also causes damage to the environment.

DISCUSSION QUESTIONS

- (i) What is the difference between a qualitative and a quantitative analysis?
- (ii) Can we use glass rod instead of platinum wire for performing the flame test? Explain your answer.
- (iii) Why is platinum metal preferred to other metals for the flame test?
- (iv) Name the anions detected with the help of dilute H_2SO_4 ?
- (v) Why is dilute H_2SO_4 preferred over dilute HCl while testing anions?
- (vi) Name the anions detected by conc. H_2SO_4 .
- (vii) How is sodium carbonate extract prepared?
- (viii) What is lime water and what happens on passing carbon dioxide gas through it?
- (ix) Carbon dioxide gas and sulphur dioxide gas both turn lime water milky. How will you distinguish these two?

- (x) How will you test the presence of carbonate ion?
- (xi) What is the composition of dark brown ring which is formed at the junction of two layers in the ring test for nitrates?
- (xii) Name the radical confirmed by sodium nitroprusside test.
- (xiii) What is chromyl chloride test? How do you justify that CrO_2Cl_2 is acidic in nature?
- (xiv) Why do bromides and iodides not give tests similar to chromyl chloride test?
- (xv) Describe the layer test for bromide and iodide ions.
- (xvi) Why is silver nitrate solution stored in dark coloured bottles?
- (xvii) How do you test the presence of sulphide ion?
- (xviii) Why does iodine give a blue colour with starch solution?
- (xix) What is Nessler's reagent?
- (xx) Why is original solution for cations not prepared in conc. HNO_3 or H_2SO_4 ?
- (xxi) Why cannot conc. HCl be used as a group reagent in place of dil. HCl for the precipitation of Ist group cations?
- (xxii) How can one prevent the precipitation of Group-IV radicals, with the second group radicals?
- (xxiii) Why is it essential to boil off H_2S gas before precipitation of radicals of group-III?
- (xxiv) Why is heating with conc. nitric acid done before precipitation of group-III?
- (xxv) Can we use ammonium sulphate instead of ammonium chloride in group-III?
- (xxvi) Why is NH_4OH added before $(\text{NH}_4)_2\text{CO}_3$ solution while precipitating group- V cations?
- (xxvii) Why do we sometimes get a white precipitate in group-VI even if the salt does not contain Mg^{2+} radical?
- (xxviii) What is aqua regia?
- (xxix) Name a cation, which is not obtained from a metal.
- (xxx) How can you test the presence of ammonium ion?
- (xxxi) Why are the group-V radicals tested in the order Ba^{2+} , Sr^{2+} and Ca^{2+} ?
- (xxxii) Why does conc. HNO_3 kept in a bottle turn yellow in colour?
- (xxxiii) Why should the solution be concentrated before proceeding to group-V?

(xxxiv) Why is the reagent bottle containing sodium hydroxide solution never stoppered?

(xxxv) What do you understand by the term common ion effect?

(xxxvi) Why is zinc sulphide not precipitated in group-II?

SPECIMEN RECORD OF SALT ANALYSIS

Aim

To analyse the given salt for one anion and one cation present in it.

S. No.	Experiment	Observation	Inference
1.	Noted the colour of the given salt.	White	Cu^{2+} , Fe^{2+} , Ni^{2+} , Co^{2+} , Mn^{2+} are absent.
2.	Noted the smell of the salt.	No specific smell.	S^{2-} , SO_3^{2-} , CH_3COO^- may be absent.
3.	Heated 0.5 g of the salt in a dry test tube and noted the colour of the gas evolved and change in the colour of the residue on heating and cooling.	(i) No gas was evolved. (ii) No particular change in colour of the residue is observed when heated and when cooled.	(i) CO_3^{2-} may be present, NO_3^- , NO_2^- , Br^- may be absent. (ii) Zn^{2+} may be absent.
4.	Prepared a paste of the salt with conc. HCl and performed the flame test.	No distinct colour of the flame seen.	Ca^{2+} , Sr^{2+} , Ba^{2+} , Cu^{2+} may be absent.
5.	Borax bead test was not performed as the salt was white in colour.	-	-
6.	Treated 0.1 g of salt with 1 mL dil. H_2SO_4 and warmed.	No effervescence and evolution of vapours.	CO_3^{2-} , SO_3^{2-} , NO_2^- , CH_3COO^- absent
7.	Heated 0.1 g of salt with 1 mL conc. H_2SO_4 .	No gas evolved.	Cl^- , Br^- , I^- , NO_3^- , $\text{C}_2\text{O}_4^{2-}$ are absent.
8.	Acidified 1 mL of aqueous salt solution with conc. HNO_3 . Warmed the contents and then added 4-5 drops of ammonium molybdate solution.	No yellow precipitate	PO_4^{3-} absent.

EXERCISE - 1

ANIONS : Class A (Subgroup - I)

- The colour developed, when sodium sulphide is added to sodium nitroprusside is:
(A) Purple (B) yellow (C) red (D) black
- When a neutral or slightly alkaline solution of thiosulphate is treated with the $[\text{Ni}(\text{en})_3](\text{NO}_3)_2$ complex, then
(A) Green precipitate is obtained
(B) Brown precipitate is obtained
(C) Violet precipitate is obtained
(D) Yellow precipitate is obtained
- When $\text{S}_2\text{O}_3^{2-}$ react with solution of 'X' reagent then reaction is redox followed by precipitation then 'X' is:
(A) FeCl_3 solution (B) AgNO_3 solution
(C) CuSO_4 solution (D) None of these
- In the test for iodine, when I_2 is treated with sodium thiosulphate, $\text{Na}_2\text{S}_2\text{O}_3$
 $\text{Na}_2\text{S}_2\text{O}_3 + \text{I}_2 \rightarrow \text{NaI} + \dots$
(A) $\text{Na}_2\text{S}_4\text{O}_6$ (B) Na_2SO_4 (C) Na_2S (D) Na_3ISO_4
- When CH_3COONa heated with solid As_2O_3 then compound X is formed. The smell of compound X is
(A) Pungent smell (B) Rotten Fish smell
(C) Nauseating smell (D) Rotten egg smell
- KI solution + starch + solution of salt 'X' \rightarrow Deep blue solution. 'X' is/are -
(A) Na_2CO_3 (B) NaNO_2 (C) $\text{Ba}(\text{MnO}_4)_2$ (D) FeCl_3
- Solutions of sodium azide (NaN_3) and iodine (as KI_3) do not react but on addition of a trace of 'X' ion, which acts as a catalyst there is an immediate vigorous evolution of nitrogen. Then 'X' may be:
(A) $\text{S}_2\text{O}_3^{2-}$ (B) S^{2-} (C) SCN^- (D) All are correct.
- S^{2-} and SO_3^{2-} can be distinguished by using:
(A) $(\text{CH}_3\text{COO})_2\text{Pb}$ (B) $\text{Na}_2[\text{Fe}(\text{CN})_5\text{NO}]$
(C) both (a) and (b) (D) none of these
- Match the column

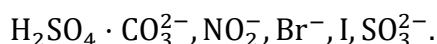
Column - I		Column - II	
(A)	S^{2-}	(P)	Produces white ppt. with excess AgNO_3
(B)	HSO_3^- milky	(Q)	Evolves gas with dil. HCl which turns lime Water

(Inorganic Chemistry)

SALT ANALYSIS

(C)	SO_3^{2-}	(R)	Evolves gas with dil. H_2SO_4 which does not turn Baryta water milky
(D)	$\text{S}_2\text{O}_3^{2-}$	(S)	Produces white ppt. white BaCl_2 solution.
		(T)	Produces white ppt. white BaCl_2 solution.

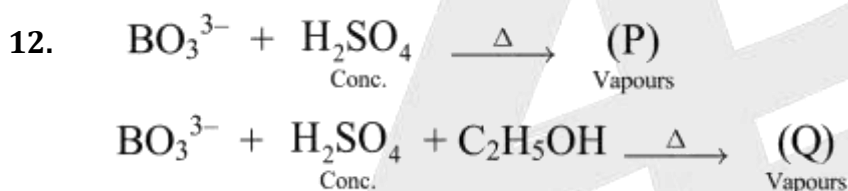
10. Find the number of acidic radical(s) which can form coloured gas when treated with dil.



Class A (Subgroup - II)

11. Chromyl chloride test is given by :-

(A) CH_3Cl (B) AgCl (C) Hg_2Cl_2 (D) NH_4Cl



P&Q are respectively-

(A) $\text{H}_3\text{BO}_3, \text{H}_3\text{BO}_3$ (B) $(\text{C}_2\text{H}_5)_3\text{BO}_3, \text{H}_3\text{BO}_3$
 (C) $(\text{C}_2\text{H}_5)_3\text{BO}_3, (\text{C}_2\text{H}_5)_3\text{BO}_3$ (D) $\text{H}_3\text{BO}_3, (\text{C}_2\text{H}_5)_3\text{BO}_3$

13. $\text{Na}_2\text{C}_2\text{O}_4 + \text{conc. H}_2\text{SO}_4 \xrightarrow{\text{Warmed}}$ gases evolved-
 Which of the following characteristic(s) is/are correct regarding gases evolved above -
 (A) It can turn the lime water milky
 (B) It can decolorise the acidic KMnO_4 solution
 (C) It can burn with blue flame
 (D) It can turn the PdCl_2 solution black

14. In layer test of I⁻ and Br⁻. If reddish-brown layer comes first then-
 (A) Br⁻ present (B) I⁻ absent
 (C) Both (A) and (B) (D) None of these All

Anions Of Class A

15. **Statement-1:** When H_2S gas is passed through Na-nitroprusside solution it gives purple colouration

Statement-2: H_2S is a weak acid

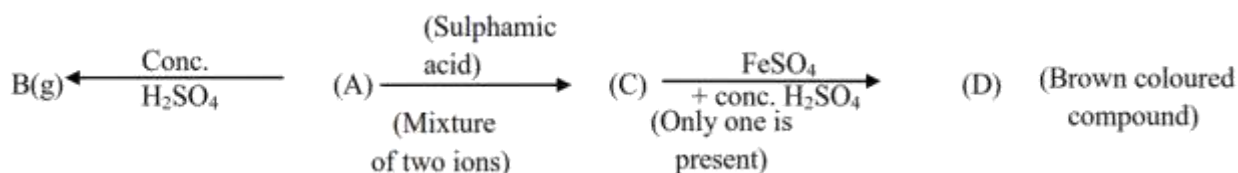
(A) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1
 (B) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(Inorganic Chemistry)

SALT ANALYSIS

- (C) Statement-1 is true, statement-2 is false.
(D) Statement-1 is false, statement-2 is true.
16. Identify the correct statement.
(A) The ppt of BaCO_3 is insoluble in dil HCl
(B) $\text{Hg}(\text{NO}_3)_2 + \text{Na}_2\text{S} \rightarrow$ white ppt of HgS
(C) $\text{Na}_2\text{CO}_3 + \text{Hg}(\text{NO}_3)_2 \rightarrow$ Reddish-brown ppt of $3\text{HgO} \cdot \text{HgCO}_3$
(D) H_2S turns lime water milky.
17. When the soda extract containing thiosulphate ion treated with excess of AgNO_3 solution followed by boiling, then.
(A) White precipitate is formed
(B) Black precipitate is formed
(C) brown precipitate is formed
(D) No ppt precipitate is formed
18. Which of the following thermal decomposition yields a basic as well as an acidic oxide
(A) Na_2CO_3 (B) CaCO_3 (C) NaNO_3 (D) All are correct
19. "Cacodyl oxide" is formed in the specific test of -
(A) Formate (B) Oxalate (C) Acetate (D) Nitrate
20. Choose the correct statement from the following-
(A) When KI is added to $\text{Pb}(\text{OAc})_2$ solution produces scarlet red ppt. of PbI_2
(B) Using AgNO_3 , acetate and oxalate can be distinguished
(C) 'AgCl' is insoluble in $\text{Na}_2\text{S}_2\text{O}_3$ solution
(D) Using (conc. $\text{H}_2\text{SO}_4 + \text{MnO}_2$), Cl^- and Br^- can be distinguished
21. An aqueous solution of gas (X) gives the white turbidity on passing H_2S in the solution. identify (X)
(A) NH_3 (B) SO_2 (C) CO_2 (D) None of these
22. $[\text{Fe}(\text{H}_2\text{O})_5\text{NO}]^{2+}$ is unstable because-
(A) It liberates NO gas on warming
(B) It liberates NO gas on shaking
(C) The charge of central atom is +1 (relatively low enough)
(D) None of these

Paragraph for Q. 23 to Q.26



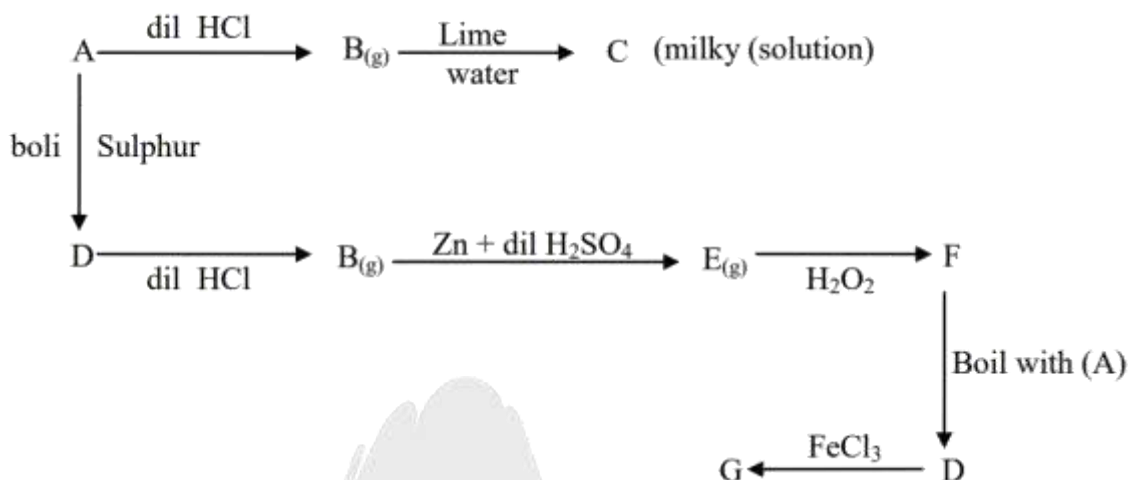
23. Identify mixture of ions (A)-
(A) NO_2^- and Br^- (B) NO_2^- and I^- (C) NO_2^- and NO_3^- (D) None of these
24. What is oxidation state of central atom of (D)
(A) +3 (B) +2 (C) +1 (D) Zero
25. Identify gas B-
(A) Br_2 (B) $\text{Br}_2 + \text{NO}_2$ (C) Only NO_2 (D) None of these

(Inorganic Chemistry)

SALT ANALYSIS

26. What is the hybridisation of central atom of D
 (A) d^2sp^3 (B) $sp^3 d^2$ (C) $sp^3 d$ (D) sp^3

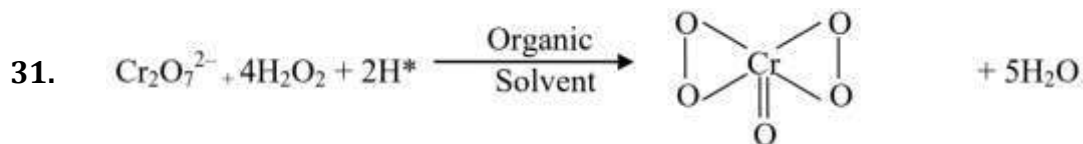
Paragraph for Q.27 to Q.29



27. Identify A
 (A) CO_3^{2-} (B) SO_3^{2-} (C) $S_2O_3^{2-}$ (D) none of these
28. When A react with $Pb(NO_3)_2$ then compound X is formed. Compound X is oxidized by atmospheric oxygen on boiling, then Y is formed what is the colour of Y
 (A) yellow (B) White (C) Black (D) Green
29. When gas E react with sodium nitroprusside then compound Z is formed. The colour of compound Z is:
 (A) Green (B) purple (C) Reddish brown (D) Black
30. Match the column:

Column I (Radicals)		Column II (Incorrect characteristics)	
(A)	$C_2O_4^{2-}$	(P)	Produces white ppt. with excess $AgNO_3$ solution
(B)	Br^-	(Q)	Produces coloured gas with hot conc. H_2SO_4
(C)	$CH_3CO_2^-$	(R)	Produces colourless gas with dil. H_2SO_4
(D)	NO_3^-	(S)	Produces no ppt. with $AgNO_3$ solution.
		(T)	Produces white ppt. with $BaCl_2$ solution

Class B



In above reaction amyl alcohol is recommended.

Dimethyl ether is not recommended for general use owing to its

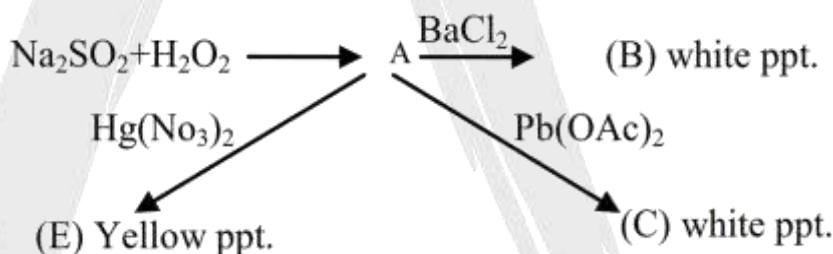
- (A) Highly non-flammable character
- (B) Highly inflammable character
- (C) Highly poisonous character
- (D) None of these

32. If barium sulphate is precipitated in a solution containing potassium permanganate it is coloured pink (violet) by
- (A) Absorption of some of the permanganate
 - (B) Adsorption of some of the permanganate
 - (C) Both (A) and (B)
 - (D) None of these

All Anions Of Class A & Class B

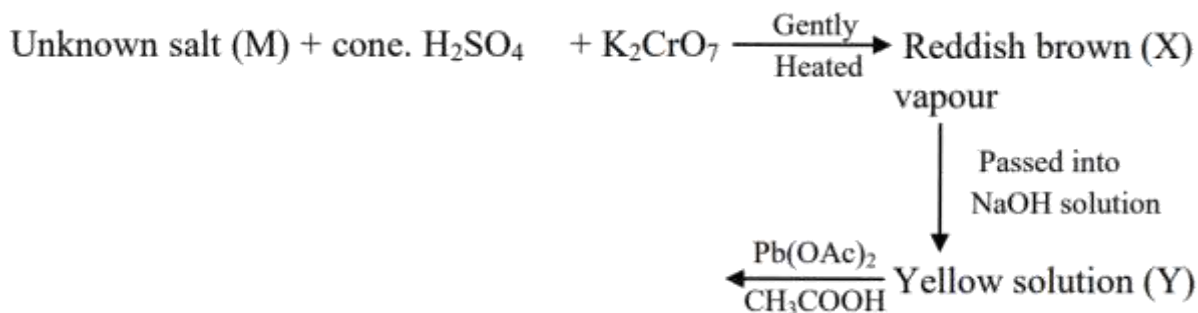
33. FeSO_4 solution can absorb " " gas.
- (A) CO
 - (B) NO
 - (C) CO and NO both
 - (D) Neither CO nor NO
34. Which of the following reagent(s) can show colour change when SO_2 gas is passed through it.
- (A) Bromine water
 - (B) Acidic potassium dichromate solution
 - (C) Acidic ferric chloride solution
 - (D) Chlorine water

Paragraph Q. 35 to Q. 37



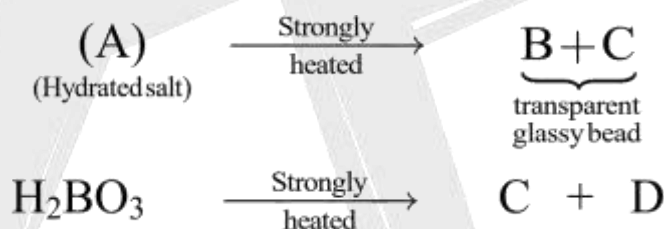
35. Identify A
- (A) $\text{Na}_2\text{S}_2\text{O}_3$
 - (B) Na_2SO_4
 - (C) Na_2S
 - (D) None of these
36. What is the formula of yellow ppt. (E)-
- (A) HgSO_4
 - (B) $2\text{HgSO}_4 \cdot \text{HgO}$
 - (C) $2\text{HgO} \cdot \text{HgSO}_4$
 - (D) None of these
37. What is the shape of Anionic part of (C)
- (A) Trigonal planar
 - (B) Tetrahedral
 - (C) TBP
 - (D) Square planar

Paragraph for Q.38 to Q.41



38. The salt (M) is/are
 (A) AgCl (B) $\text{NH}_4\text{Cl} + \text{NaBr}$ (C) NaBr (D) $\text{Ca(ClO}_4)_2$
39. How many non axial d-orbitals are involved in hybridisation of central atom of compound (X)
 (A) 2 (B) 3 (C) 4 (D) None of these
40. What is the formula of yellow ppt (Z)-
 (A) BaCrO_4 (B) Na_2CrO_4 (C) Ag_2CrO_4 (D) PbCrO_4
41. The correct formula of Canary yellow ppt and it is the test acid radical
 (A) $(\text{NH}_4)_2[\text{PMo}_{12}\text{O}_{40}]$ and phosphate
 (B) $(\text{NH}_4)\text{H}[\text{P}(\text{Mo}_3\text{O}_{10})_4]$ and sulphate
 (C) $(\text{NH}_4)_3[\text{P}(\text{Mo}_3\text{O}_{10})_4]$ and phosphate
 (D) $\text{Na}_3[\text{P}(\text{Mo}_3\text{O}_{10})_4]$ and phosphate

Paragraph for Q.42 to Q.45



42. Identify C-
 (A) $(\text{BN})_x$ (B) NaPO_3 (C) B_2O_3 (D) $\text{Mg}(\text{NH}_4)\text{PO}_4$
43. Find the number of water of crystallizations in (A)-
 (A) 4 (B) 5 (C) 10 (D) 24
44. How many X – O – X linkages are present in structure of A (X = central atom)-
 (A) 4 (B) 3 (C) 5 (D) 2
45. Find the number of tetrahedral and trigonal planar units in structure of A-
 (A) 2,1 (B) 2,2 (C) 2,4 (D) 5,2

WET TEST : GROUP ZERO

46. **Statement-1:** Test of NH_4^+ can not be done within group analysis

Statement-2: During group analysis several times NH_4^+ - compound is added at the different steps.

(A) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement 1

(B) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1

- (C) Statement-1 is false, statement- 2 is true.
 (D) Statement-1 is true, statement-2 is false.

GROUP – I

47. $\text{Cu}^{2+} + \text{KCN}$ (in excess) \rightarrow soluble complex (X). How many statements are correct regarding complex (X) –
 (i) the central atom has the co-ordination number of 6
 (ii) the central atom has the co-ordination number of 4
 (iii) the complex is sq.planar
 (iv) the complex is diamagnetic
 (v) the complex is paramagnetic
48. $\text{BiCl}_3 \xrightarrow{\text{KI}}$ black ppt (M) $\xrightarrow{\text{excess KI}}$ soluble complex (N)

Find the number of moles of I⁻ ions involved for the formation of per mole of (N).

GROUP – IIB

49. Sn^{2+} and Sn^{4+} can be distinguished by how many of the following methods
 (i) by passing H_2S in their solution (in acidic medium)
 (ii) by addition of NaOH in their solution
 (iii) by addition of excess NaOH in their solution
 (iv) by addition of dil. HCl in their solution
 (v) by addition of HgCl_2 solution in their solution

GROUP – II

50. Which fo the following yellow coloured sulphide is insouble in yellow ammonium sulphide.
 (A) SnS_2
 (B) As_2S_5
 (C) CdS
 (D) Bi_2S_3

GROUP – III

51. What is the group-III reagent is generally used for group analysis.
 (A) $\text{NH}_4\text{OH} + \text{NH}_4\text{NO}_3$ (B) $\text{NH}_4\text{Cl} + (\text{NH}_4)_2\text{CO}_3$
 (C) $\text{NH}_4\text{OH} + (\text{NH}_4)_2\text{SO}_4$ (D) $\text{NH}_4\text{OH} + \text{NH}_4\text{Cl}$
52. If reddish brown ppt (only) is obtained in group-III during group analysis, then oxidation state of Fe in the original sample may be
 (A) +2 (B) +3
 (C) +2 and +3 both (D) Neither +2 nor +3
53. If NH_4Cl is not added to the group-III reagent which of the following ppt could be obtained
 (A) $\text{Cr}(\text{OH})_2$ (B) $\text{Fe}(\text{OH})_3$ (C) $\text{Mn}(\text{OH})_2$ (D) $\text{Mg}(\text{OH})_2$

(Inorganic Chemistry)

SALT ANALYSIS

54. In which of the following cases blue ppt is obtained
 (A) $\text{Fe}^{2+} + [\text{Fe}(\text{CN})_6]^{3-} \rightarrow$ (B) $\text{Fe}^{2+} + [\text{Fe}(\text{CN})_6]^{4-} \rightarrow$
 (C) $\text{Fe}^{3+} + [\text{Fe}(\text{CN})_6]^{4-} \rightarrow$ (D) $\text{Fe}^{3+} + [\text{Fe}(\text{CN})_6]^{3-} \xrightarrow{\text{SnCl}_2}$
55. Find total number of conditions in which oxidation of Fe^{+2} (aq) ions to iron(III) takes place
 (i) On exposure to air (ii) On addition of conc. HNO_3
 (iii) On reaction with SnCl_2 (iv) On reaction with H_2O_2
 (v) On reaction with $\text{MnO}_4^-/\text{H}^+$ (vi) On reaction with KI
 (vii) On reaction with $\text{Cr}_2\text{O}_7^{2-}/\text{H}^+$

GROUP - IV

All Group Cations

56. Which of the following cation gives ppt in two groups during group analysis
 (A) Hg_2^{2+} (B) Hg_2^{2+} (C) Pb^{2+} (D) Cu^{2+}
57. Which of the following statement is incorrect?
 (A) Using KI , group-I cations can be distinguished
 (B) Using $(\text{Na}_2\text{CrO}_4 + \text{AcOH})$ solution, group-V cations can not be distinguished
 (C) Addition of CuSO_4 into the excess KSCN solution produces colourless solution.
 (D) All are incorrect
58. Which of the following cation produces coloured ppt with Na_2SO_4 solution -
 (A) Pb^{2+} solution (B) Ba^{2+} solution
 (C) Hg^{2+} solution (D) Ca^{2+} solution
59. Statement-1 : $(\text{KMnO}_4 + \text{ZnSO}_4)$ solution + BaCl_2 solution o white ppt. of BaSO_4
 Statement-2 : In ZnSO_4 and BaSO_4 both, SO_4^{2-} ion has tetrahedral shape.
 (A) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1
 (B) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1
 (C) Statement-1 is false, statement- 2 is true.
 (D) Statement-1 is true, statement-2 is false
60. What are the following steps are to be done before adding group-III reagent into the group-II filtrate.
 (A) Group-II filtrate is to be evaporated to dryness
 (B) Group-II filtrate is to be boiled of first
 (C) After boiling 2-3 drops of dil. H_2SO_4 is added and boiled again.
 (D) After boiling 2-3 drops of HNO_3 is added and boiled again.
61. NH_4^+ and K^+ ions can be distinguished by the use of following reagent
 (A) $\text{Na}_3[\text{Co}(\text{NO}_2)_6]$ (B) $\text{Na}_2[\text{PtCl}_6]$
 (C) HClO_4 or NaClO_4 (D) Boiling with NaOH
62. $\text{Na}_2\text{HPO}_4 + \text{Reagent 'M'} \rightarrow$ white ppt. The reagent 'M' is
 (A) BaCl_2 solution (B) AlCl_3 solution
 (C) MnSO_4 solution (D) FeCl_3 solution
63. Match the column

Column-I (Element)		Column-II (Correct characteristics)	
(A)	Ba	(P)	cation in solution produces brick red ppt. with
(B)	Pb	(Q)	cation in solution produces yellow ppt. with CrO_4^{2-}
(C)	Ag	(R)	corresponding salt produces apple green colour in the flame test
(D)	Ca	(S)	corresponding salt produces brick red colour in the flame test
		(T)	cation in solution produces no ppt. with CrO_4^{2-} ion

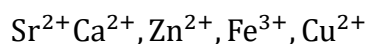
64. Match the column

Column-I Cation in solution		Column-I Correct characteristics when no where excess reagent is used	
(A)	Ag^+ and Pb^{2+}	(P)	can be distinguished by Na_2HPO_4 solution
(B)	Zn^{2+} and Mg^{2+}	(Q)	can be distinguished by dil.HCl
(C)	Pb^{2+} and Hg_2^{2+}	(R)	can be distinguished by KI solution
(D)	Ag^+ and Fe^{3+}	(S)	can be distinguished by dil.HCl

65. How many of the following gives green ppt.

- (i) $\text{CrCl}_3 + \text{NaOH} \rightarrow$
- (ii) $\text{CrCl}_3 + \text{excess NaOH} \rightarrow$
- (iii) $\text{NiCl}_2 + \text{excess NaOH} \rightarrow$
- (iv) $\text{NiCl}_2 + \text{excess NH}_4\text{OH} \rightarrow$
- (v) $\text{Hg}_2^{2+} + \text{KI} \rightarrow$

66. Find the no. of cation which gives white ppt with $\text{K}_4[\text{Fe}(\text{CN})_6]$



(Inorganic Chemistry)

SALT ANALYSIS

67. Unknown salt + Al-powder + NaOH (conc.) no gas comes out which turns Nessler's reagent brown. The salt may be
 (A) NaNO_2 (B) NaNO_3 (C) NH_4Cl (D) NH_4HCO_3
68. which of the following sulphide is yellow in colour ?
 (A) CuS (B) CdS (C) ZnS (D) CoS

Paragraph for Q. 69 to Q. 71

FeCl_3 solution + $(\text{NH}_4)_2\text{S} \xrightarrow{\text{Neutral medium}}$ Black ppt. (A) $\xrightarrow{\text{dil. H}_2\text{SO}_4}$ white ppt. (B) + gas (C)

While AlCl_3 solution + $(\text{NH}_4)_2\text{S} \rightarrow$ white ppt. (D).

69. What is the formula of black ppt (A)
 (A) Fe_2S_3 (B) FeS (C) $2\text{FeS} + \text{S}$ (D) $\text{FeS} + \text{Fe}(\text{OH})_3$
70. White ppt (D) is
 (A) Al_2S_3 (B) $\text{Al}_2\text{S}_3 + \text{S}$ (C) $\text{Al}(\text{OH})_3$ (D) $\text{Al}(\text{OH})_3 + \text{Al}$
71. White ppt (B) and gas (C) are-
 (A) S and SO_2 (B) H_2S and S
 (C) $\text{Fe}(\text{OH})_2$ and H_2S (D) S and H_2S

MISCELLANEOUS

72. $\text{CaC}_2\text{O}_4 + \text{AcOH} \xrightarrow[\text{Solution}]{\text{Na}_2\text{CO}_3}$ (X) ; then X is
 (A) Clear solution (B) White ppt. of CaCO_3 is obtained
 (C) No reaction (D) Yellow ppt. is obtained

EXERCISE - II

ANIONS : Class A (Subgroup - I)

1. **Statement-1:** On passing CO_2 gas through lime water, the solution turns milky. because
Statement-2: Acid-Base (neutralisation) reaction takes place.
 (A) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.
 (B) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.
 (C) Statement-1 is true, statement-2 is false.
 (D) Statement-1 is false, statement-2 is true
2. A substance on treatment with dil. H_2SO_4 liberates a colourless gas which produces (i) turbidity with baryta water and (ii) turns acidified dichromate solution green. The reaction indicates the presence of
 (A) CO_3^{2-} (B) S^{2-} (C) SO_3^{2-} (D) NO_2^-
3. Which of anions in the Column-I shows one or more observations from the column -II.

Column I		Column II	
(A)	S^{2-}	(P)	White ppt. with AgNO_3

(Inorganic Chemistry)

SALT ANALYSIS

(B)	NO_2^-	(Q)	Evolution of pungent smell gas with (Al + conc. NaOH)
(C)	SO_3^{2-}	(R)	Brown fumes with conc. H_2SO_4 (hot)
(D)	CH_3COO^-	(S)	Decolourises acidified KMnO_4

Class A (Subgroup - II)

4. When a mixture of solid NaCl , solid $\text{K}_2\text{Cr}_2\text{O}_7$ is heated with conc. H_2SO_4 , orange red vapours are obtained. These are of the compound
 (A) chromous chloride (B) chromyl chloride
 (C) chromic chloride (D) chromic sulphate
5. Which of the following will not give positive chromyl chloride test?
 (A) Copper chloride, CuCl_2 (B) Mercuric chloride, HgCl_2
 (C) Zinc chloride, ZnCl_2 (D) Anilinium chloride, $\text{C}_6\text{H}_5\text{NH}_3\text{Cl}$
6. When $\text{K}_2\text{Cr}_2\text{O}_7$ crystals are heated with conc. HCl , the gas evolved is
 (A) O_2 (B) Cl_2 (C) CrO_2Cl_2 (D) HCl
7. Sodium borate on reaction with conc. H_2SO_4 and $\text{C}_2\text{H}_5\text{OH}$ gives a compound A which burns with a green edged flame. The compound A is
 (A) $\text{H}_2\text{B}_7\text{O}_7$ (B) $(\text{C}_2\text{H}_5)_2\text{B}_4\text{O}_7$ (C) H_3BO_3 (D) $(\text{C}_2\text{H}_5)_3\text{BO}_3$
8. Nitrate is confirmed by ring test. The brown colour of the ring is due to formation of
 (A) ferrous nitrite (B) nitroso ferrous sulphate
 (C) ferrous nitrate (D) FeSO_4NO_2
9. When AgNO_3 is strongly heated, the products formed are
 (A) NO and NO_2 (B) NO_2 and O_2
 (C) NO_2 and N_2O (D) NO and O_2
10. Solution of chemical compound X reacts with AgNO_3 solution to form a white ppt. Y which dissolves in NH_4OH to give a complex Z. When Z is treated with dil. HNO_3 , Y reappears. The chemical compound X can be
 (A) NaCl (B) CH_3Cl (C) NaBr (D) NaI
11. When I_2 is passed through KCl , KF , KBr :
 (A) Cl_2 and Br_2 are evolved (B) Cl_2 is evolved
 (C) Cl_2 , F_2 and Br_2 are evolved (D) None of these

All Anions Of Class A

12. The acidic solution of a salt produced a deep blue colour with starch iodide solution. The salt may be
 (A) chloride (B) nitrite (C) acetate (D) bromide
13. A halide salt, on heating with conc. H_2SO_4 and MnO_2 , liberates brown vapour of
 (A) Br_2 (B) NO_2 (C) HBr (D) I_2

(Inorganic Chemistry)

SALT ANALYSIS

14. A metal salt solution forms a yellow ppt with potassium chromate in acetic acid, a white ppt with dilute sulphuric acid, but gives no ppt with sodium chloride or iodide, it is :
 (A) lead carbonate (B) basic lead carbonate
 (C) barium nitrate (D) strontium nitrate
15. Which of the following combines with Fe (II) ions to form a brown complex
 (A) N_2O (B) NO (C) N_2O_3 (D) N_2O_4
16. Which of the following does not react with AgCl ?
 (A) Na_2CO_3 (B) $NaNO_3$ (C) NH_4OH (D) $Na_2S_2O_3$
17. A salt (X) on treatment with dil. HCl produce a gas (y). Gas (y) is colourless gas with pungent odour, it produce turbidity of (z) when react with H_2S in water. x, y, z respectively
 (A) S^{2-} , H_2S , S (B) SO_3^{2-} , SO_2 , S
 (C) SO_4^{2-} , SO_3 , S (D) SO_3^{2-} , H_2S , SO_4^{2-}
18. A white salt is readily soluble in water and gives a colourless solution with a pH of about 9. The salt could be:
 (A) NH_4NO_3 (B) CH_3COONa
 (C) CH_3COONH_4 (D) $CaCO_3$
19. The brown ring test for NO_2^- and NO_3^- is due to the formation of complex ion with formula:
 (A) $[Fe(H_2O)_6]^{2+}$ (B) $[Fe(NO)(CN)_5]^{2-}$
 (C) $[Fe(H_2O)_5(NO)]^{2+}$ (D) $[Fe(H_2O)(NO)_5]^{2+}$
20. **Statement-1:** NO_2^- ion can not be detected by brown ring test in presence of NO_3^- ion.
Statement-2: Both NO_2^- and NO_3^- ions are confirmed by brown ring test.
 (A) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.
 (B) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.
 (C) Statement-1 is true, statement-2 is false.
 (D) Statement-1 is false, statement-2 is true.

Class B

21. CrO_3 dissolves in aqueous NaOH to give:
 (A) $Cr_2O_7^{2-}$ (B) CrO_4^{2-} (C) $Cr(OH)_3$ (D) $Cr(OH)_2$

All Anions Of Class A & Class B

22. Which of the following pairs of ions would be expected to form precipitate when dilute solution are mixed?
 (A) Na^+ , SO_4^{2-} (B) NH_4^+ , CO_3^{2-} (C) Na^+ , S_2^{2-} (D) Fe^{3+} , PO_4^{3-}
23. A metal salt solution gives a yellow ppt with silver nitrate. The ppt dissolves in dil. nitric acid as well as in ammonium hydroxide. The solution contains
 (A) bromide (B) iodide (C) phosphate (D) chromate

(Inorganic Chemistry)

SALT ANALYSIS

24. Nessler's reagent is used to detect
(A) Cr_4^{2-} (B) PO_4^{3-} (C) MnO_4^- (D) NH_4^+
25. A white solid is first heated with dil H_2SO_4 and then with conc. H_2SO_4 . No action was observed in either case. The solid salt contains
(A) sulphide (B) sulphite (C) thiosulphate (D) sulphate
26. On passing H_2S gas in II group sometimes the solution turns milky. It indicates the presence of
(A) oxidising agent (B) acidic salt (C) s-block cation (D) reducing agent.
27. A white sodium salt dissolves readily in water to give a solution which is neutral to litmus. When silver nitrate solution is added to the solution, a white precipitate is obtained which does not dissolve in dil. HNO_3 . The anion could be:
(A) Fe^{2+} (B) Ni^{2+} (C) Co^{2+} (D) Mn^{2+}

CATIONS : DRY TEST

28. Which metal salt gives a violet coloured bead in the borax bead test (oxidising flame, cold)?
(A) Fe^{2+} (B) Ni^{2+} (C) Co^{2+} (D) Mn^{2+}
29. In microcosmic salt bead test Co^{2+} produce blue bead due to the formation of-
(A) $\text{Cu}(\text{BO}_2)_2$ (B) NaCoPO_4 (C) $\text{Co}_2(\text{PO}_4)(\text{BO}_2)$ (D) NaPO_3
30. When copper nitrate is strongly heated, it is converted into
(A) Cu metal (B) cupric oxide (C) cuprous oxide (D) copper nitrate
31. Which of the following leaves no residue on heating?
(A) $\text{Pb}(\text{NO}_3)_2$ (B) NH_4NO_3 (C) $\text{Cu}(\text{NO}_3)_2$ (D) NaNO_3
32. Which of the following cations is detected by the flame test?
(A) NH_4^+ (B) K^+ (C) Mg^{2+} (D) Al^3

WET TEST : GROUP - I

GROUP - IIA

33. When bismuth chloride is poured into a large volume of water the white precipitate produced is
(A) $\text{Bi}(\text{OH})_3$ (B) Bi_2O_3 (C) BiOCl (D) Bi_2OCl_3
34. CuSO_4 decolourises on addition of excess KCN, the product is
(A) $[\text{Cu}(\text{CN})_4]^{2-}$.
(B) Cu^{2+} get reduced to form $[\text{Cu}(\text{CN})_4]^{3-}$
(C) $\text{Cu}(\text{CN})_2$
(D) CuCN
35. Which compound does not dissolve in hot dilute HNO_3 ?
(A) HgS (B) PbS (C) CuS (D) CdS
36. When H_2S gas is passed through the HCl containing aqueous solution of CuCl_2 , HgCl_2 , BiCl_3 and CoCl_2 , it does not precipitate out:
(A) CuS (B) HgS (C) Bi_2S_3 (D) CoS

GROUP - II

(Inorganic Chemistry)

SALT ANALYSIS

37. When excess of SnCl_2 is added to a solution of HgCl_2 , a white ppt turning grey is obtained. The grey colour is due to the formation of
(A) Hg_2Cl_2 (B) SnCl_4 (C) Sn (D) Hg

GROUP - III

38. In the precipitation of the iron group in qualitative analysis, ammonium chloride is added before adding ammonium hydroxide to
(A) decrease concentration of OH^- ions.
(B) prevent interference by phosphate ions.
(C) increase concentration of Cl^- ions.
(D) increase concentration of 4NH^+ ions.
39. Ferric ion forms a prussian blue coloured ppt. of
(A) $\text{K}_4[\text{Fe}(\text{CN})_6]$ (B) $\text{Fe}_4[\text{Fe}(\text{CN})_6]_3$
(C) KMnO_4 (D) $\text{Fe}(\text{OH})_3$
40. $\text{Fe}(\text{OH})_3$ can be separated from $\text{Al}(\text{OH})_3$ by addition of
(A) dil. HCl (B) NaCl solution
(C) NaOH solution (D) NH_4Cl and NH_4OH
41. Prussian blue is formed when
(A) ferrous sulphate reacts with FeCl_3 .
(B) ferric sulphate reacts with $\text{K}_4[\text{Fe}(\text{CN})_6]$
(C) Ammonium sulphate reacts with FeCl_3
(D) ferrous ammonium sulphate reacts with FeCl_3
42. What product is formed by mixing the solution of $\text{K}_4[\text{Fe}(\text{CN})_6]$ with the solution of FeCl_3 ?
(A) Ferro-ferricyanide (B) Ferri-ferrocyanide
(C) Ferri-ferricyanide (D) None of these
43. Turnbull's blue is a compound
(A) ferricyanide (B) ferro ferricyanide
(C) ferrous cyanide (D) ferri ferrocyanoide
44. An aqueous solution of FeSO_4 , $\text{Al}_2(\text{SO}_4)_3$ and chrome alum is heated with excess of Na_2O_2 and filtered. The materials obtained are:
(A) a colourless filtrate and a green residue.
(B) a yellow filtrate and a green residue.
(C) a yellow filtrate and a brown residue.
(D) a green filtrate and a brown residue.

GROUP - IV

45. Dimethyl glyoxime in a suitable solvent was refluxed for 10 minutes with pure pieces of nickel sheet, it will result in
(A) Red ppt (B) Blue ppt. (C) Yellow ppt. (D) No ppt.

GROUP - V

46. On the addition of a solution containing CrO_4^{2-} ions to the solution of Ba^{2+} , Sr^{2+} and Ca^{2+} ions, the ppt obtained first will be of
 (A) CaCrO_4 (B) SrCrO_4 (C) BaCrO_4 (D) a mixture of all the three

All Group Cations

47. Mark the compound which is soluble in hot water.
 (A) Lead chloride (B) Mercurous chloride
 (C) Strontium sulphate (D) Silver chloride
48. Sometimes yellow turbidity appears while passing H_2S gas even in the absence of II group radicals. This is because of
 (A) sulphur is present in the mixture as impurity.
 (B) IV group radicals are precipitated as sulphides.
 (C) the oxidation of H_2S gas by some acid radicals.
 (D) III group radicals are precipitated as hydroxides.
49. The ion that cannot be precipitated by H_2S and HCl is
 (A) Pb^{2+} (B) Cu^{2+} (C) Ag^+ (D) Ni^{2+}
50. Which one among the following pairs of ions cannot be separated by H_2S in dilute HCl ?
 (A) Bi^{3+} , Sn^{4+} (B) Al^{3+} , Hg^{2+} (C) Zn^{2+} , Cu^{2+} (D) Ni^{2+} , Cu^{2+}
51. A blue colouration is not obtained when
 (A) ammonium hydroxide dissolves in copper sulphate.
 (B) copper sulphate solution reacts with $\text{K}_4[\text{Fe}(\text{CN})_6]$.
 (C) ferric chloride reacts with sodium ferrocyanide.
 (D) anhydrous white CuSO_4 is dissolved in water.
52. AgCl dissolves in ammonia solution giving
 (A) Ag^+ , NH_4^+ and Cl^- (B) $\text{Ag}(\text{NH}_3)^+$ and Cl^-
 (C) $\text{Ag}_2(\text{NH}_3)^{2+}$ and (D) $\text{Ag}(\text{NH}_3)_2^+$ and Cl^-
53. A white crystalline substance dissolves in water. On passing H_2S gas in this solution, a black ppt is obtained. The black ppt dissolves completely in hot HNO_3 . On adding a few drops of conc. H_2SO_4 , a white ppt is obtained. This ppt is that of
 (A) BaSO_4 (B) SrSO_4 (C) PbSO_4 (D) CdSO_4
54. An aqueous solution of gas (X) gives the white turbidity on passing H_2S in the solution. Identify (X)
 (A) NH_3 (B) SO_2 (C) CO_2 (D) None of these
55. An aqueous solution of colourless metal sulphate M, gives a white ppt, with NH_4OH . This was soluble in excess of NH_4OH . On passing H_2S through this solution a white ppt is formed. The metal M in the salt is
 (A) Ca (B) Ba (C) Al (D) Zn

(Inorganic Chemistry)

SALT ANALYSIS

56. A pale green crystalline metal salt of M dissolves freely in water. On standing it gives a brown ppt on addition of aqueous NaOH. The metal salt solution also gives a black ppt on bubbling H_2S in basic medium. An aqueous solution of the metal salt decolourizes the pink colour of the permanganate solution. The metal in the metal salt solution is
(A) copper (B) aluminium (C) lead (D) iron
57. A mixture of chlorides of copper, cadmium, chromium, iron and aluminium was dissolved in water acidified with HCl and hydrogen sulphide gas was passed for sufficient time. It was filtered, boiled and a few drops of nitric acid were added while boiling. To this solution ammonium chloride and sodium hydroxide were added in excess and filtered. The filtrate shall give test for
(A) sodium and iron ion
(B) sodium, chromium and aluminium ion
(C) aluminium and iron ion
(D) sodium, iron, cadmium and aluminium ion
58. A metal is burnt in air and the ash on moistening smells of ammonia. The metal is
(A) Na (B) Fe (C) Mg (D) Al
59. A white ppt obtained in a analysis of a mixture becomes black on treatment with NH_4OH . It may be
(A) $PbCl_2$ (B) $AgCl$ (C) $HgCl_2$ (D) Hg_2Cl_2
60. Which of the following compound on reaction with NaOH and Na_2O_2 gives yellow colour?
(A) $Cr(OH)_3$ (B) $Zn(OH)_2$ (C) $Al(OH)_3$ (D) None of these
61. An aqueous solution of a substance gives a white ppt. on treatment with dil. HCl, which dissolves on heating. When hydrogen sulphide is passed through the hot acidic solution, a black ppt. is obtained. The substance is a
(A) Hg^{2+} salt (B) Cu^{2+} salt (C) Ag^+ salt (D) Pb^{2+} salt
62. Which one of the following does not produce metallic sulphide with H_2S ?
(A) $ZnCl_2$ (Neutral soln) (B) $CdCl_2$
(C) $CoCl_2$ (D) $CuCl_2$
63. Which of the following gives a precipitate with $Pb(NO_3)_2$ but not with $Ba(NO_3)_2$?
(A) Sodium chloride (B) Sodium acetate
(C) Sodium nitrate (D) Sodium hydrogen phosphate
64. A chloride dissolves appreciably in cold water. When placed on a platinum wire in Bunsen flame no distinctive colour is noticed, the cation would be:
(A) Mg^{2+} (B) Ba^{2+} (C) Pb^{2+} (D) Ca^{2+}
65. A mixture of two salts is not water soluble but dissolves completely in dil HCl to form a colourless solution. The mixture could be:
(A) $AgNO_3$ and KBr (B) $BaCO_3$ and ZnS
(C) $FeCl_3$ and $CaCO_3$ (D) $Mn(NO_3)_2$ and $MgSO_4$
66. Three separate samples of a solution of a single salt gave these results. One formed a white precipitate with excess of ammonia solution, one formed a white precipitate with dil NaCl solution and one formed a black precipitate with H_2S . The salt could be:
(A) $AgNO_3$ (B) $Pb(NO_3)_2$ (C) $Hg(NO_3)_2$ (D) $MnSO_4$
67. Which one of the following ionic species will impart colour to an aqueous solution?
(A) Ti^{4+} (B) Cu^+ (C) Zn^{2+} (D) Cr^{3+}

(Inorganic Chemistry)

SALT ANALYSIS

68. When a substance A reacts with water it produces a combustible gas B and a solution of substance C in water. When another substance D reacts with this solution of C, it also produces the same gas B on warming but D can produce gas B on reaction with dilute sulphuric acid at room temperature. A imparts a deep golden yellow colour a smokeless flame to Bunsen burner. A, B, C and D respectively are:
 (A) Na, H₂, NaOH, Zn (B) K, H₂, KOH, Al
 (C) Ca, H₂, Ca(OH)₂, Sn (D) CaC₂, C₂H₂, Ca(OH)₂, Fe
69. Which is not dissolved by dil HCl ?
 (A) ZnS (B) MnS (C) BaSO₃ (D) BaSO₄
70. In Nessler's reagent, the ion present is:
 (A) HgI²⁻ (B) HgI₄²⁺ (C) Hg⁺ (D) Hg²⁺
71. In Nessler's reagent, the ion present is:
 (A) HgI²⁻ (B) HgI₄²⁺ (C) Hg⁺ (D) Hg²⁺
72. The cations present in slightly acidic solution are Fe³⁺, Zn²⁺ and Cu²⁺. The reagent which when added in excess to this solution would identify and separate Fe³⁺ in one step is:
 (A) 2M HCl (B) 6M NH₃ (C) 6M NaOH (D) H₂ S gas
73. In the separation of Cu²⁺ and Cd²⁺ in 2nd group qualitative analysis of cation, tetrammine copper (II) sulphate and tetrammine cadmium (II) sulphate react with KCN to form the corresponding cyano complexes. Which one of the following pairs of the complexes and their relative stability enables the separation of Cu²⁺ and Cd²⁺ ?
 (A) K₃[Cu(CN)₄] more stable and K₂[Cd(CN)₄] less stable.
 (B) K₂[Cu(CN)₄] less stable and K₂[Cd(CN)₄] more stable.
 (C) K₂[Cu(CN)₄] more stable and K₂[Cd(CN)₄] less stable
 (D) K₃[Cu(CN)₄] less stable and K₂[Cd(CN)₄] more stable.
74. Which one has the minimum solubility product?
 (A) AgI (B) AlCl₃ (C) BaCl₂ (D) NH₄Cl
75. Which of the following sulphate is insoluble in water?
 (A) CuSO₄ (B) CdSO₄ (C) PbSO₄ (D) Bi₂(SO₄)₃
76. A metal 'X' on heating in nitrogen gas gives 'Y'. 'Y' on treatment with H₂O gives a colourless gas which when passed through CuSO₄ solution gives a blue colour Y is:
 (A) Mg(NO₃)₂ (B) Mg₃N₂ (C) NH₃ (D) MgO
77. Which of the following gives blood red colour with KSCN ?
 (A) Cu²⁺ (B) Fe³⁺ (C) Al³⁺ (D) Zn²⁺
78. The metal ion which is precipitated when H₂ S is passed with HCl :
 (A) Zn²⁺ (B) Ni²⁺ (C) Cd²⁺ (D) Mn²⁺
79. Which one of the following metal sulphide has maximum solubility in water?
 (A) HgS, K_{sp} = 10⁻⁵⁴ (B) CdS, K_{sp} = 10⁻³⁰
 (C) FeS, K_{sp} = 10⁻²⁰ (D) ZnS, K_{sp} = 10⁻²²
80. Identify the correct order of solubility of Na₂S, CuS and ZnS in aqueous medium is:
 (A) CuS > ZnS > Na₂S (B) ZnS > Na₂S > CuS
 (C) Na₂S > CuS > ZnS (D) Na₂S > ZnS > CuS
81. Mark the correct statement:
 (A) I group basic radicals precipitate as chlorides

(Inorganic Chemistry)

SALT ANALYSIS

- (B) IV group basic radicals precipitates as sulphides.
 (C) V group basic radicals precipitates as carbonates.
 (D) All the above statement are correct.

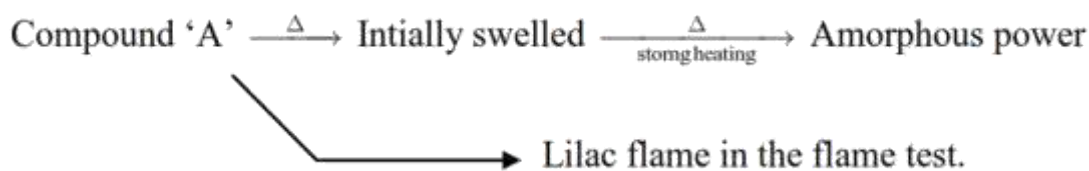
82. MgSO_4 on reaction with NH_4OH and Na_2HPO_4 forms a white crystalline precipitate. What is its formula?
 (A) $\text{Mg}(\text{NH}_4)\text{PO}_4$ (B) $\text{Mg}_3(\text{PO}_4)_2$
 (C) $\text{MgCl}_2 \cdot \text{MgSO}_4$ (D) MgSO_4

MISCELLANEOUS

83. Nessler's reagent is
 (A) K_2HgI_4 (B) $\text{K}_2\text{HgI}_4 + \text{KOH}$
 (C) $\text{K}_2\text{HgI}_2 + \text{KOH}$ (D) $\text{K}_2\text{HgI}_4 + \text{KI}$
84. A salt on treatment with dil. HCl gives a pungent smelling gas and a yellow precipitate. The salt gives green flame when tested. The solution gives a yellow precipitate with potassium chromate. The salt is:
 (A) NiSO_4 (B) BaS_2O_3
 (C) PbS_2O_3 (D) CuSO_4
85. $\text{B}(\text{OH})_3 + \text{NaOH} \rightarrow \text{Na}[\text{B}(\text{OH})_4] + \text{H}_2\text{O}$
 How can this reaction is made to proceed in forward direction?
 (A) addition of cis 1,2 diol (B) addition of borax
 (C) addition of trans 1,2 diol (D) addition of Na_2HPO_4
86. An element (X) forms compounds of the formula XCl_3 , X_2O_5 and Ca_3X_2 , but does not form XCl_5 . Which of the following is the element X?
 (A) B (B) Al (C) N (D) P
87. Which of the following is not a preliminary test used to detect ions:
 (A) borax bead test (B) flame test
 (C) brown ring test (D) cobalt nitrate test
88. Potassium chromate solution is added to an aqueous solution of a metal chloride. The precipitate thus obtained are insoluble in acetic acid. These are subjected to flame test, the colour of the flame is:
 (A) Lilac (B) Apple green (C) Crimson red (D) Golden yellow

COMPREHENSION

Question No. 88 to 90 (3 questions)



89. Compound 'A' is having water of crystallization by the number of
 (A) 10 (B) 20 (C) 24 (D) 36
90. The compound 'B' is having oxidation state of
 (A) zero (B) II (C) III (D) IV
91. The hybridization of compound 'C' is
 (A) sp^3 (B) sp^3d (C) d^2sp^3 (D) d^3s

Question No. 91 to 93 (3 questions)

A white solid A reacts with dilute H_2SO_4 to produce a colourless gas B and a colourless solution C. The reaction between B and acidified dichromate yields a green solution and a slightly coloured precipitate D. The substance D, when burnt in air, gives a gas E which reacts with B to yield D and a colourless liquids. Anhydrous copper sulphate turns blue with this colourless liquid. The addition of aqueous NH_3 or NaOH to C produces a precipitate that dissolves in an excess of the reagent to form a clear solution.

Answer the following questions based on above passage.

91. Which of the following gases are B and E respectively?
 (A) CO_2 and SO_2 (B) SO_2 and H_2S
 (C) H_2S and SO_2 (D) CO_2 and H_2S
92. What would appear if the gas B is passed through an aqueous solution of $\text{Pb}(\text{NO}_3)_2$?
 (A) white precipitate soluble in hot dilute HNO_3
 (B) A black precipitate soluble in hot dilute HNO_3
 (C) A black precipitate insoluble in hot dilute HNO_3
 (D) A yellow precipitate soluble in hot concentrated HNO_3
93. Suppose the solution obtained by the treatment of the solution C with an excess of NaOH is acidified with acetic acid and the gas B is passed through it. Which of the following will be obtained?
 (A) Colourless solution (B) Yellow precipitate
 (C) Black precipitate (D) White precipitate
94. Match the column
- | Column I | Column II |
|---|-----------|
| (A) Its oxide is amphoteric | (P) Pb |
| (B) Metal acetate $\xrightarrow{\Delta}$ acetone + metal carbonate | (Q) Zn |
| (C) Metal carbonate $\xrightarrow{\Delta}$ metal oxide + CO_2 ↑ | (R) Na |
| (D) Metal nitrate $\xrightarrow{\Delta}$ metal oxide + NO_2 ↑ + O_2 ↑ | (S) Li |

JEE MAINS

1. How do we differentiate between Fe^{3+} and Cr^{3+} in qualitative analyses gp. III :-
[AIEEE - 2002]
(A) By taking excess of NH_4OH
(B) By increasing NH_4^+ ion concentration
(C) By decreasing OH^- ion concentration
(D) Both (B) and (C)
2. Which statement is correct :-
[AIEEE-2003]
(A) Fe^{3+} ions give deep green precipitate with $\text{K}_2[\text{Fe}(\text{CN})_6]$
(B) On heating K^+ , Ca^{2+} and HCO_3^- ions, we get a precipitate of $\text{K}_2[\text{Ca}(\text{CO}_3)_2]$
(C) Manganese salts give a violet borax bead test in reducing flame
(D) From a mixed precipitate of AgCl and AgI ammonia solution dissolves only AgCl
3. Which of the following compounds is not colored yellow ?
[JEE(Main) 2015]
(A) $\text{Zn}_2[\text{Fe}(\text{CN})_6]$ (B) $\text{K}_3[\text{Co}(\text{NO}_2)_6]$
(C) $(\text{NH}_4)_3[\text{As}(\text{Mo}_3\text{O}_{10})_4]$ (D) BaCrO_4
4. A solution containing a group-IV cation gives a precipitate on passing, H_2S . A solution of this precipitate in dil. HCl produces a white precipitate with NaOH solution and bluish-white precipitate with basic potassium ferrocyanide. The cation is :
[JEE(Main) 2017]
(A) Mn^{2+} (B) Zn^{2+} (C) Ni^{2+} (D) Co^{2+}
5. The cation that will not be precipitated by H_2S in the presence of dil HCl is: [JEE(Main) 2017]
(A) Pb^{2+} (B) As^{3+} (C) Co^{2+} (D) Cu^{2+}
6. An aqueous solution of a salt X turns blood red on treatment with SCN^- and blue on treatment with $\text{K}_4[\text{Fe}(\text{CN})_6]$.
[JEE(Main) 2017]
X also gives a positive chromyl chloride test. The salt X is :
(A) CuCl_2 (B) $\text{Cu}(\text{NO}_3)_2$ (C) FeCl_3 (D) $\text{Fe}(\text{NO}_3)_3$
7. The compound that does not produce nitrogen gas by the thermal decomposition is
[JEE(Main) 2018]
(A) $(\text{NH}_4)_2\text{Cr}_2\text{O}_7$ (B) NH_4NO_2 (C) $(\text{NH}_4)_2\text{SO}_4$ (D) $\text{Ba}(\text{N}_3)_2$
8. An alkali is titrated against an acid with methyl orange as indicator, which of the following is a correct combination?
[Main 2018]
- | | Base | Acid | End point |
|-----|--------|--------|-----------------------|
| (a) | Weak | Strong | Colourless to pink |
| (b) | Strong | Strong | Pinkish red to yellow |
| (c) | Weak | Strong | Yellow to Pinkish red |
| (d) | Strong | Strong | Pink to colourless |
9. While titrating dilute HCl solution with aqueous NaOH , which of the following will not be required?
[Main Sep. 02, 2020 (I)]

(Inorganic Chemistry)

SALT ANALYSIS

- (a) Burette and porcelain tile (b) Pipette and distilled water
(c) Clamp and phenolphthalein (d) Bunsen burner and measuring cylinder

10. If you spill a chemical toilet cleaning liquid on your hand, your first aid would be :

[Main Sep. 02, 2020 (II)]

- (a) vinegar (b) aqueous NaOH (c) aqueous NaHCO_3 (d) aqueous NH_3

11. To an aqueous solution containing ions such as Al^{3+} , Zn^{2+} , Ca^{2+} , Fe^{3+} , Ni^{2+} , Ba^{2+} and Cu^{2+} was added conc. HCl, followed by H_2S . The total number of cations precipitated during this reaction is/are :

[Main July 27, 2021 (II)]

- (a) 1 (b) 3 (c) 4 (d) 2

12. Which of the following compound is added to the sodium extract before addition of silver nitrate for testing of halogens?

[Main Feb. 25, 2021 (II)]

- (a) Hydrochloric acid (b) Sodium hydroxide
(c) Ammonia (d) Nitric acid

13. Consider the sulphides HgS , PbS , CuS , Sb_2S_3 , As_2S_3 and CdS . Number of these sulphides soluble in 50% HNO_3 is

[Main Aug. 31, 2021 (I)]

14. When 10 mL an aqueous solution of KMnO_4 was titrated in acidic medium, equal volume of 0.1M of an aqueous solution of ferrous sulphate was required for complete discharge of colour. The strength of KMnO_4 in grams per litre is $\times 10^{-2}$.

(Nearest integer) [Atomic mass of K = 39, Mn = 55, O = 16]

[Main Aug. 27, 2021 (I)]

15. 10.0 mL of 0.05M KMnO_4 solution was consumed in a titration with 10.0 mL of given oxalic acid dihydrate solution. The strength of given oxalic acid solution is $\times 10^{-2}$ g/L.

[Main July 27, 2021 (II)]

16. Fe^{3+} cation gives a prussian blue precipitate on addition of potassium ferrocyanide solution due to the formation of:

[Main July 27, 2022 (II)]

- (a) $[\text{Fe}(\text{H}_2\text{O})_6]_2[\text{Fe}(\text{CN})_6]$ (b) $\text{Fe}_2[\text{Fe}(\text{CN})_6]_2$
(c) $\text{Fe}_3[\text{Fe}(\text{OH})_2(\text{CN})_4]_2$ (d) $\text{Fe}_4[\text{Fe}(\text{CN})_6]_3$

17. The dark purple colour of KMnO_4 disappears in the titration with oxalic acid in acidic medium. The overall change in the oxidation number of manganese in the reaction is: **[Main July 26, 2022 (I)]**
- (a) 5 (b) 1 (c) 7
18. A white precipitate was formed when BaCl_2 was added to water extract of an inorganic salt. Further, a gas 'X' with characteristic odour was released when the formed white precipitate was dissolved in dilute HCl. The anion present in the inorganic salt is : **[Main June 29, 2022 (II)]**
- (a) I^- (b) SO_3^{2-} (c) S^{2-} (d) NO_2^-
19. During the qualitative analysis of salt with cation y^{2+} , addition of a reagent (X) to alkaline solution of the salt gives a bright red precipitate. The reagent (X) and the cation (y^{2+}) present respectively are: **[Main June 24, 2022 (I)]**
- (a) Dimethylglyoxime and Ni^{2+} (b) Dimethylglyoxime and Co^{2+}
 (c) Nessler's reagent and Hg^{2+} (d) Nessler's reagent and Ni^{2+}
20. In the flame test of a mixture of salts, a green flame with blue centre was observed. Which one of the following cations may be present? **[Main June 24, 2022 (II)]**
- (a) Cu^{2+} (b) Sr^{2+} (c) Ba^{2+} (d) Ca^{2+}
21. The normality of H_2SO_4 in the solution obtained on mixing 100 mL of $0.1\text{M}\text{H}_2\text{SO}_4$ with 50 mL of 0.1MNaOH is $\times 10^{-1}$ N. (Nearest integer) **[Main July 27, 2022, (II)]**
22. 20 mL of $0.02\text{MK}_2\text{Cr}_2\text{O}_7$ solution is used for the titration of 10 mL of Fe^{2+} solution in the acidic medium. The molarity of Fe^{2+} solution is (Nearest Integer) $\times 10^{-2}\text{M}$. **[Main July 27, 2022 (I)]**
23. 20 mL of 0.02M hypo solution is used for the titration of 10 mL of copper sulphate solution, in the presence of excess of KI using starch as an indicator. The molarity of Cu^{2+} is found to be
 Given : $2\text{Cu}^{2+} + 4\text{I}^- \rightarrow \text{Cu}_2\text{I}_2 + \text{I}_2$ $\text{I}_2 + 2\text{S}_2\text{O}_3^{2-} \rightarrow 2\text{I}^- + \text{S}_4\text{O}_6^{2-}$ **[Main July 26, 2022 (II)]**
24. An ammoniacal metal salt solution gives a brilliant red precipitate on addition of dimethylglyoxime. The metal ion is:
 (A) Cu^{2+} (B) Fe^{2+} (C) Ni^{2+} (D) Co^{2+}

25. Match the List-I with List-II :

[Main, Jan 2023]

List-I	List-II
Cations	Group reagents
A \rightarrow Pb^{2+} , Cu^{2+}	i) H_2S gas in presence of dilute HCl
B \rightarrow Al^{3+} , Fe^{3+}	ii) $(\text{NH}_4)_2\text{CO}_3$ in presence of NH_4OH
C \rightarrow Co^{2+} , Ni^{2+}	iii) NH_4OH in presence of NH_4Cl
D \rightarrow Ba^{2+} , Ca^{2+}	iv) H_2S in presence of NH_4OH

Correct match is –

(A) A \rightarrow iv, B \rightarrow ii, C \rightarrow iii, D \rightarrow I(B) A \rightarrow i, B \rightarrow iii, C \rightarrow iv, D \rightarrow ii(C) A \rightarrow iii, B \rightarrow i, C \rightarrow iv, D \rightarrow ii(D) A \rightarrow i, B \rightarrow iii, C \rightarrow ii, D \rightarrow iv26. Formation of which complex, among the following, is not a confirmatory test of Pb^{2+} ions

(A) lead sulphate

(B) lead nitrate

(C) lead chromate

(D) lead iodide

[Main, April 2023]

27. When a solution of mixture having two inorganic salts was treated with freshly prepared ferrous sulphate in acidic medium, a dark brown ring was formed whereas on treatment with neutral FeCl_3 . it gave deep red colour which disappeared on boiling and a brown red ppt was formed. The mixture contains

[Main, April 2023]

(A) $\text{C}_2\text{O}_4^{2-}$ & NO_3^- (B) SO_3^{2-} & $\text{C}_2\text{O}_4^{2-}$ (C) CH_3COO^- & NO_3^- (D) SO_3^{2-} & CH_3COO^-

JEE-ADVANCED

1. A solution of colourless salt H on boiling with excess NaOH produces a non-flammable gas. The gas evolution ceases after sometime. Upon addition of Zn dust to the same solution, the gas evolution restarts. The colourless salt(s) H is (are) [JEE 2008]
- (A) NH_4NO_3 (B) NH_4NO_2
(C) NH_4Cl (D) $(\text{NH}_4)_2\text{SO}_4$

Paragraph for Question Nos. 2 to 4

p-Amino-N, N-dimethylaniline is added to a strongly acidic solution of X. The resulting solution is treated with a few drops of aqueous solution of Y to yield blue coloration due to the formation of methylene blue. Treatment of the aqueous solution of Y with the reagent potassium hexacyanoferrate(II) leads to the formation of an intense blue precipitate. The precipitate dissolves on excess addition of the reagent. Similarly, treatment of the solution of Y with the solution of potassium hexacyanoferrate(III) leads to a brown coloration due to the formation of Z. [JEE 2009]

2. The compound X is
(A) NaNO_3 (B) NaCl (C) Na_2SO_4 (D) Na_2S
3. The compound Y is
(A) MgCl_2 (B) FeCl_2 (C) FeCl_3 (D) ZnCl_2
4. The compound Z is
(A) $\text{Mg}_2[\text{Fe}(\text{CN})_6]$ (B) $\text{Fe}[\text{Fe}(\text{CN})_6]$
(C) $\text{Fe}_4[\text{Fe}(\text{CN})_6]_3$ (D) $\text{K}_2\text{Zn}_3[\text{Fe}(\text{CN})_6]_2$
5. Match each of the reactions given in Column I with the corresponding product(s) given in Column II. [JEE 2009]

Column I

- (A) $\text{Cu} + \text{dil. HNO}_3$
(B) $\text{Cu} + \text{conc. HNO}_3$
(C) $\text{Zn} + \text{dil. HNO}_3$
(D) $\text{Zn} + \text{conc. HNO}_3$

Column II

- (P) NO
(Q) NO_2
(R) N_2O
(S) $\text{Cu}(\text{NO}_3)_2$
(T) $\text{Zn}(\text{NO}_3)_2$

6. Passing H_2S gas into a mixture of Mn^{2+} , Ni^{2+} , Cu^{2+} and Hg^{2+} ions in an acidified aqueous solution precipitates [JEE 2011]
- (A) CuS and HgS (B) MnS and CuS
(C) MnS and NiS (D) NiS and HgS
7. Reduction of the metal centre in aqueous permanganate ion involves - [JEE 2011]
- (A) 3 electrons in neutral medium (B) 5 electrons in neutral medium
(C) 3 electrons in alkaline medium (D) 5 electrons in acidic medium
8. The equilibrium [JEE 2011]
- $$2\text{Cu}^{\text{I}} \rightleftharpoons \text{Cu}^{\text{O}} + \text{Cu}^{\text{II}}$$

in aqueous medium at 25°C shifts towards the left in the presence of
 (A) NO_3^- (B) Cl^- (C) SCN^- (D) CN^-

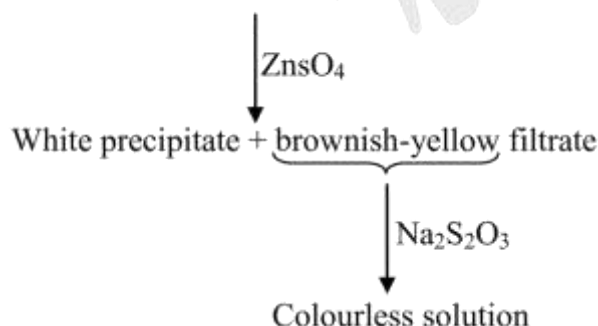
Paragraph for Questions Nos. 9 to 11

When a metal rod M is dipped into an aqueous colourless concentrated solution of compound N, the solution turns light blue. Addition of aqueous NaCl to the blue solution gives a white precipitate O. Addition of aqueous NH_3 dissolves O and gives an intense blue solution.

[JEE 2011]

9. The metal rod M is -
 (A) Fe (B) Cu (C) Ni (D) Co
10. The compound N is -
 (A) AgNO_3 (B) $\text{Zn(NO}_3)_2$ (C) $\text{Al(NO}_3)_3$ (D) $\text{Pb(NO}_3)_2$
11. The final solution contains -
 (A) $[\text{Pb(NH}_3)_4]^{2+}$ and $[\text{CoCl}_4]^{2-}$ (B) $[\text{Al(NH}_3)_4]^{3+}$ and $[\text{Cu(NH}_3)_4]^{2+}$
 (C) $[\text{Ag(NH}_3)_2]^+$ and $[\text{Cu(NH}_3)_4]^{2+}$ (D) $[\text{Ag(NH}_3)_2]^+$ and $[\text{Ni(NH}_3)_6]^{2+}$
12. Which of the following hydrogen halides react(s) with AgNO_3 (aq) to give a precipitate that dissolves in $\text{Na}_2\text{S}_2\text{O}_3$ (aq) :
 (A) HCl (B) HF (C) HBr (D) HI **[JEE 2012]**
13. The reaction of white phosphorus with aqueous NaOH gives phosphine along with another phosphorus containing compound. The reaction type ; the oxidation states of phosphorus in phosphine and the other product are respectively **[JEE 2012]**
 (A) redox reaction ; -3 and -5
 (B) redox reaction; +3 and +5
 (C) disproportionation reaction ; -3 and +1
 (D) disproportionation reaction ; -3 and +3
14. For the given aqueous reactions, which of the statement(s) is (are) true ? **[JEE 2012]**

Excess KI + $\text{K}_3[\text{Fe(CN)}_6] \xrightarrow{\text{dilute H}_2\text{SO}_4} \text{brownish-yellow solution}$



- (A) The first reaction is a redox reaction.
 (B) White precipitate is $\text{Zn}_3[\text{Fe(CN)}_6]_2$.
 (C) Addition of filtrate to starch solution gives blue colour.
 (D) White precipitate is soluble in NaOH solution.

15. Upon treatment with ammoniacal H_2S , the metal ion that precipitates as a sulfide is –

[JEE 2013]

- (A) Fe(III) (B) Al(III) (C) Mg(II) (D) Zn(II)

Paragraph for Question 16 and 17

An aqueous solution of a mixture of two inorganic salts, when treated with dilute HCl , gave a precipitate (P) and a filtrate (Q). The precipitate (P) was found to dissolve in hot water. The filtrate (Q) remained unchanged, when treated with H_2S in a dilute mineral acid medium. However, it gave a precipitate (R) with H_2S in an ammoniacal medium. The precipitate R gave a coloured solution (S), when treated with H_2O_2 in an aqueous NaOH medium.

16. The coloured solution (S) contains

[JEE 2013]

- (A) $\text{Fe}_2(\text{SO}_4)_3$ (B) CuSO_4
(C) ZnSO_4 (D) Na_2CrO_4

17. The precipitate (P) contains

[JEE 2013]

- (A) Pb^{2+} (B) Hg_2^{2+} (C) Ag^+ (D) Hg^{2+}

18. Among PbS , CuS , HgS , MnS , Ag_2S , NiS , CoS , Bi_2S_3 and SnS_2 , the total number of BLACK coloured sulphides is :

[JEE(Advanced) 2014]

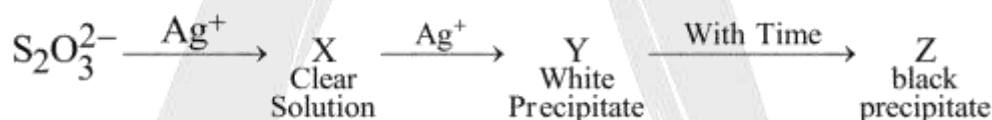
19. The pair(s) of ions where BOTH the ions are precipitated upon passing H_2S gas in presence of dilute HCl , is(are)

[JEE(Advanced) 2015]

- (A) Ba^{2+} , Zn^{2+} (B) Bi^{3+} , Fe^{3+}
(C) Cu^{2+} , Pb^{2+} (D) Hg^{2+} , Bi^{3+}

20. In the following reaction sequence in aqueous solution, the species X, Y and Z, respectively, are

[JEE(Advanced) 2016]



- (A) $[\text{Ag}(\text{S}_2\text{O}_3)_2]^{3-}$, $\text{Ag}_2\text{S}_2\text{O}_3$, Ag_2S (B) $[\text{Ag}(\text{S}_2\text{O}_3)_3]^{5-}$, Ag_2SO_3 , Ag_2S
(C) $[\text{Ag}(\text{SO}_3)_2]^{3-}$, $\text{Ag}_2\text{S}_2\text{O}_3$, Ag (D) $[\text{Ag}(\text{SO}_3)_3]^{3-}$, Ag_2SO_4 , Ag

21. The reagent(s) that can selectively precipitate S^{2-} from a mixture of S^{2-} and SO_4^{2-} in aqueous solution is(are)

[JEE(Advanced) 2016]

- (A) CuCl_2 (B) BaCl_2 (C) $\text{Pb}(\text{OOCCH}_3)_2$ (D) $\text{Na}_2[\text{Fe}(\text{CN})_5\text{NO}]$

22. Which of the following combination will produce H_2 gas?

[JEE(Advanced) 2017]

- (A) Au metal and NaCN (aq) in the presence of air
(B) Fe metal and conc. HNO_3
(C) Zn metal and NaOH (aq)
(D) Cu metal and conc. HNO_3

23. The compound(s) which generate(s) N_2 gas upon thermal decomposition below 300°C is (are)

[JEE(Advanced) 2018]

- (A) NH_4NO_3 (B) $(\text{NH}_4)_2\text{Cr}_2\text{O}_7$
(C) $\text{Ba}(\text{N}_3)_2$ (D) Mg_3N_2

24. The correct option(s) to distinguish nitrate salts of Mn^{2+} and Cu^{2+} taken separately is (are) [JEE(Advanced) 2018]
 (A) Mn^{2+} shows the characteristic green colour in the flame test
 (B) Only Cu^{2+} shows the formation of precipitate by passing H_2S in acidic medium
 (C) Only Mn^{2+} shows the formation of precipitate by passing H_2S in faintly basic medium
 (D) Cu^{2+}/Cu has higher reduction potential than Mn^{2+}/Mn (measured under similar conditions)
25. The green colour produced in the borax bead test of a chromium(III) salt is due to [JEE(Advanced) 2019]
 (1) CrB (2) Cr_2O_3 (3) $\text{Cr}(\text{BO}_2)_3$ (4) $\text{Cr}_2(\text{B}_4\text{O}_7)_3$
26. Consider the following reactions (unbalanced) [JEE(Advanced) 2019]
 $\text{Zn} + \text{hot conc. H}_2\text{SO}_4 \rightarrow \text{G} + \text{R} + \text{X}$
 $\text{Zn} + \text{conc. NaOH} \rightarrow \text{T} + \text{Q}$
 $\text{G} + \text{H}_2\text{S} + \text{NH}_4\text{OH} \rightarrow \text{Z (a precipitate)} + \text{X} + \text{Y}$
 Choose the correct option(s)
 (1) Z is dirty white in colour (2) Bond order of Q is 1 in its ground state
 (3) The oxidation state of Zn in T is +1 (4) R is a V-shaped molecule
27. With reference to aqua regia, choose the correct option(s) [Adv. 2019]
 (a) Reaction of gold with aqua regia produces NO_2 in the absence of air
 (b) Reaction of gold with aqua regia produces an anion having Au in +3 oxidation state
 (c) Aqua regia is prepared by mixing conc. HCl and conc. HNO_3 in 3:1(v/v) ratio
 (d) The yellow colour of aqua regia is due to the presence of NOCl and Cl_2
28. 5.00 mL of 0.10M oxalic acid solution taken in a conical flask is titrated against NaOH from a burette using phenolphthalein indicator. The volume of NaOH required for the appearance of permanent faint pink color is tabulated below for five experiments. What is the concentration, in molarity, of the NaOH solution? [Adv. 2020]

Exp. No.	Vol. of NaOH (mL)
1	12.5
2	10*5
3	9.0
4	9.0
5	9.0

Paragraph for Question 29 and 30

The reaction of $\text{K}_3[\text{Fe}(\text{CN})_6]$ with freshly prepared FeSO_4 solution produces a dark blue precipitate called Turnbull's blue, Reaction of $\text{K}_4[\text{Fe}(\text{CN})_6]$ with the FeSO_4 solution in complete absence of air produces a white precipitate X, which turns blue in air. Mixing the FeSO_4 solution with NaNO_3 , followed by a slow addition of concentrated H_2SO_4 through the side of the test tube produces a brown ring. [Adv. 2021]

29. Precipitate X is
 (a) $\text{Fe}_4[\text{Fe}(\text{CN})_6]_3$ (b) $\text{Fe}[\text{Fe}(\text{CN})_6]$ (c) $\text{K}_2\text{Fe}[\text{Fe}(\text{CN})_6]$ (d) $\text{KFe}[\text{Fe}(\text{CN})_6]$
30. Among the following, the brown ring is due to the formation of [Adv. 2021]
 (a) $[\text{Fe}(\text{NO})_2(\text{SO}_4)_2]^{2-}$ (b) $[\text{Fe}(\text{NO})_2(\text{H}_2\text{O})_4]^{3+}$
 (c) $[\text{Fe}(\text{NO})_4(\text{SO}_4)_2]$ (d) $[\text{Fe}(\text{NO})(\text{H}_2\text{O})_5]^{2+}$

31. A mixture of two salts is used to prepare a solution S, which gives the following results :

[Adv. 2021]

White Precipitate (S) only $\xleftarrow[\text{Room temperature}]{\text{Dilute NaOH(aq.)}}$ S
(aq. solution of the salts)

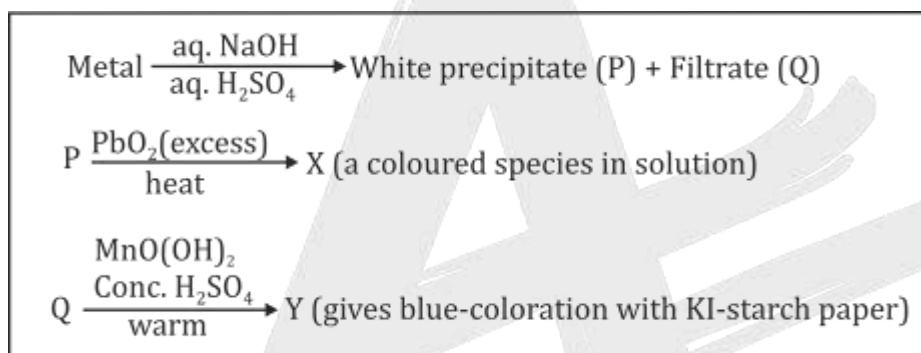
$\xrightarrow[\text{Room temperature}]{\text{Dilute HCl(aq.)}}$ White Precipitate (s) only

(a) $\text{Pb}(\text{NO}_3)_2$ and $\text{Zn}(\text{NO}_3)_2$ (b) $\text{Pb}(\text{NO}_3)_2$ and $\text{Bi}(\text{NO}_3)_3$ (c) AgNO_3 and $\text{Bi}(\text{NO}_3)_3$ (d) $\text{Pb}(\text{NO}_3)_2$ and $\text{Hg}(\text{NO}_3)_2$

32. The treatment of an aqueous solution of 3.74 g of $\text{Cu}(\text{NO}_3)_2$ with excess KI results in a brown solution along with the formation of a precipitate. Passing H_2S through this brown solution gives another precipitate X. The amount of X (in g) is $\text{Cu} = 63, \text{I} = 127$ [Adv. 2022]

33. In the scheme given below, X and Y, respectively, are

[Adv. 2023]

(A) CrO_4^{2-} and Br_2 (B) MnO_4^{2-} and Cl_2 (C) MnO_4^- and Cl_2 (D) MnSO_4 and HOCl

ANSWER KEY

EXERCISE # I

- | | | | | | | |
|--|---|--|---------|---------|------------|-----------|
| 1. (A) | 2. (C) | 3. (C) | 4. (A) | 5. (C) | 6. (BCD) | 7. (D) |
| 8. (C) | 9. (A) → R,S; (B) → Q; (C) → P,Q,S,T; (D) → P,Q,S,T | 10. (1) | 11. (D) | | | |
| 12. (D) | 13. (ACD) | 14. (C) | 15. (D) | 16. (C) | 17. (B) | 18. (B) |
| 19. (C) | 20. (D) | 21. (B) | 22. (C) | 23. (C) | 24. (C) | 25. (C) |
| 26. (B) | 27. (B) | 28. (B) | 29. (B) | | | |
| 30. (A) → Q,R,S; (B) → P,R,S,T; (C) → Q,S,T; (D) → P,R,T | | | | | 31. (B) | 32. (B) |
| 33. (B) | 34. (ABC) | 35. (B) | 36. (C) | 37. (B) | 38. (B) | 39. (B) |
| 40. (D) | 41. (C) | 42. (C) | 43. (C) | 44. (C) | 45. (B) | 46. (A) |
| 47. (2) | 48. (4) | 49. (2) | 50. (C) | 51. (D) | 52. (ABC) | 53. (BCD) |
| 54. (ACD) | 55. (5) | 56. (C) | 57. (D) | 58. (C) | 59. (C) | 60. (BD) |
| 61. (CD) | 62. (AB) | 63. (A) → Q,R; (B) → Q; (C) → P; (D) → S,T | | | | |
| 64. (A) → P,S; (B) → T; (C) → R,S; (D) → Q,R,S,T | | | 65. (3) | 66. (2) | 67. (ABCD) | |
| 68. (B) | 69. (C) | 70. (C) | 71. (D) | 72. (C) | | |

EXERCISE # II

- | | | | |
|--|-----------|---|---------|
| 1. (B) | 2. (C) | 3. (A) → S; (B) → P,Q,R,S; (C) → P,S; (D) → P | 4. (B) |
| 5. (B) | 6. (B) | 7. (D) | 8. (B) |
| 9. (B) | 10. (A) | 11. (D) | |
| 12. (B) | 13. (A) | 14. (C) | 15. (B) |
| 16. (B) | 17. (B) | 18. (B) | |
| 19. (C) | 20. (D) | 21. (B) | 22. (D) |
| 23. (C) | 24. (D) | 25. (D) | |
| 26. (A) | 27. (B) | 28. (D) | 29. (B) |
| 30. (B) | 31. (B) | 32. (B) | |
| 33. (C) | 34. (B) | 35. (A) | 36. (D) |
| 37. (D) | 38. (A) | 39. (B) | |
| 40. (C) | 41. (B) | 42. (B) | 43. (B) |
| 44. (C) | 45. (D) | 46. (C) | |
| 47. (A) | 48. (C) | 49. (D) | 50. (A) |
| 51. (B) | 52. (D) | 53. (C) | |
| 54. (B) | 55. (D) | 56. (D) | 57. (B) |
| 58. (C) | 59. (D) | 60. (A) | |
| 61. (D) | 62. (A,C) | 63. (A) | 64. (A) |
| 65. (B) | 66. (B) | 67. (D) | |
| 68. (A) | 69. (D) | 70. (B) | 71. (B) |
| 72. (A) | 73. (A) | 74. (C) | |
| 75. (B) | 76. (B) | 77. (C) | 78. (C) |
| 79. (D) | 80. (D) | 81. (A) | |
| 82. (B) | 83. (B) | 84. (A) | 85. (C) |
| 86. (C) | 87. (B) | 88. (C) | |
| 89. (C) | 90. (D) | 91. (C) | 92. (B) |
| 93. (D) | | | |
| 94. (A) → P,Q; (B) → R; (C) → P,Q,S; (D) → P,Q,S | | | |

JEE MAINS

- | | | | | | | |
|-----------|------------|---------|---------|---------|---------|--------|
| 1. (D) | 2. (D) | 3. (A) | 4. (B) | 5. (C) | 6. (C) | 7. (C) |
| 8. (c) | 9. (d) | 10. (c) | 11. (a) | 12. (d) | 13. (4) | |
| 14. (316) | 15. (1575) | 16. (d) | 17. (a) | 18. (b) | 19. (a) | |

(Inorganic Chemistry)

SALT ANALYSIS

20. (a) 21. (1) 22. (24) 23. (4) 24. (C) 25. (B) 26. (B)
27. (C)

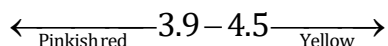
JEE-ADVANCED

1. (AB) 2. (D) 3. (C) 4. (B)
5. (A) \rightarrow P,S; (B) \rightarrow Q,S; (C) \rightarrow R,T; (D) \rightarrow Q, T 6. (A) 7. (ACD) 8. (BCD)
9. (B) 10. (A) 11. (C) 12. (ACD) 13. (C) 14. (ACD) 15. (D)
16. (D) 17. (A) 18. (7) 19. (C) 20. (A) 21. (A OR A,C)
22. (C) 23. (BC) 24. (BD) 25. (3) 26. (1,2,4) 27. (b,c,d) 28. (0.10)
29. (c) 30. (d) 31. (a,b) 32. (0.32) 33. (C)



SOLUTION
JEE MAINS

8. pH range for methyl orange is



Generally, weak bases have pH greater than 7. When methyl orange is added to a weak basic solution, solution becomes yellow. This solution is then titrated against a strong acid at the end point pH will be less than 3.1.

∴ Solution becomes pinkish red.

9. In this acid base titration, Bunsen burner and measuring cylinder are of no use while other laboratory equipments will be required, i.e., phenol phthalein, burette and pipette.
10. In toilet cleaning liquid, the main constituent is HCl , which can cause skin burn, so it should be treated with $NaHCO_3$, which can easily neutralize the acid.
11. Al^{3+} and Fe^{3+} sulphides hydrolyse in water Ni^{2+} and Zn^{2+} require basic medium with H_2S to form ppt. Ca^{2+} and Ba^{2+} Sulphides are soluble, hence only CuS ppt will form.
12. For the test of halogens, it is necessary to remove $NaCN$ and Na_2S from the sodium extract if nitrogen and sulphur are present. This is done by boiling the sodium extract with conc. HNO_3 . If $NaCN$ and Na_2S are not decomposed, white or black ppt of $AgCN$ and Ag_2S respectively are formed with $AgNO_3$ solution.
13. PbS , CuS , As_2S_3 , CdS are soluble in 50% HNO_3 . HgS , Sb_2S_3 are insoluble in 50% HNO_3 .
14. Let molarity of $KMnO_4 = x$
 $KMnO_4 + FeSO_4 \rightarrow Fe_2(SO_4)_3 + Mn^{2+}$
 $n = 5 \quad n = 1$
 Equivalents of $KMnO_4 =$ Equivalents of $FeSO_4$
 $(5 \times x \times 10 \text{ mL}) = 1 \times 0.1 \times 10 \text{ mL}$
 $x = 0.02M$
 Molar mass of $KMnO_4 = 158 \text{ g/mol}$
 Strength = Molarity \times Molar mass = $0.02 \times 158 = \frac{3.16 \text{ g}}{L}$

(Inorganic Chemistry)

SALT ANALYSIS

15. According to law of chemical equivalence, equivalent of KMnO_4 = equivalent of oxalic acid

$$N_1 V_1 = N_2 V_2$$

$$M_1 \times nf \times V_1 = M_2 \times nf \times V_2 \quad (N = M \times nf)$$

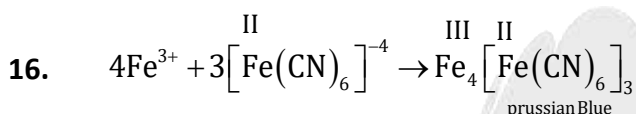
$$0.05 \times 5 \times 10 = M_2 \times 2 \times 10$$

$$M_2 = \frac{0.05 \times 5}{2} = 0.125$$

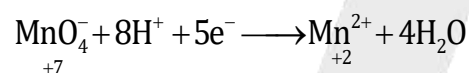
$$\text{Strength of oxalic acid} = \text{Molarity} \times \text{Molar mass}$$

$$= 0.125 \times 126 = 15.75 = 1575 \times 10^{-2} \text{ g/L}$$

$$\text{Strength of oxalic acid} = \text{Molarity} \times \text{Molar mass} = 0.125 \times 126 = 15.75 = 1575 \times 10^{-2} \text{ g/L}$$



17. In acidic medium the reaction for KMnO_4 is



$$\text{Change in oxidation state is} = 7 - 2 = 5.$$

18. Salt is dissolved in water to form a solution. Barium chloride test is performed for the confirmation of sulphite ions.

If the ppt formed after addition of BaCl_2 are dissolved in dil. HCl then sulphite ions are present and if the ppt remain undissolved then the ion is sulphate.



20.	Ion	Colour of the flame
(A)	Cu^{+2}	green flame with blue centre
(B)	Sr^{2+}	Crimson Red
(C)	Ba^{2+}	Apple green
(D)	Ca^{2+}	Brick red

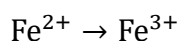
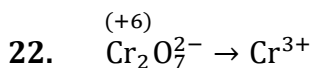
21. No. of equivalents of $\text{H}_2\text{SO}_4 = 100 \times 0.1 \times 2 = 20$

$$\text{No. of equivalents of NaOH} = 50 \times 0.1 = 5$$

No. of equivalents of H_2SO_4 left = $20 - 5 = 15$

Total volume = $(100 + 50) = 150 \text{ mL} \Rightarrow 150 \times x = 15$

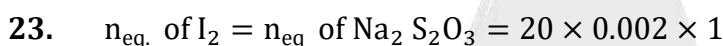
$$x = \frac{1}{10} = 0.1 \text{ N} = 1 \times 10^{-1} \text{ N}$$



Equivalents of $\text{K}_2\text{Cr}_2\text{O}_7 \equiv \text{Eq. of Fe}^{2+}$

(Molarity \times n.f. \times volume) of $\text{K}_2\text{Cr}_2\text{O}_7 \equiv$ (Molarity \times n.f. \times volume) of Fe^{2+}

$$\Rightarrow 0.02 \times 6 \times 20 = M \times 1 \times 10 \Rightarrow M = 0.24 = 24 \times 10^{-2}$$



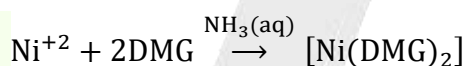
$$2 \times n_{\text{mol of I}_2} = 0.4$$

$$n_{\text{mol of I}_2} = 0.2 \text{ m mol}$$

$$n_{\text{mol of Cu}^{2+}} = 0.2 \times 2 \times 10^{-3}$$

$$[\text{Cu}^{2+}] = \frac{0.4 \times 10^{-3}}{10 \times 10^{-3}} = 0.04 = 4 \times 10^{-2}$$

24. The solution must contain Ni^{2+} as it forms a complex with dimethyl glyoxime (DMG) giving $[\text{Ni}(\text{DMG})_2]$ which is rose-red in colour.



Rosy Red complex

25.

Cations	Group No.	Group reagent
$\text{Pb}^{+2}, \text{Cu}^{+2}$	II	$\text{H}_2\text{S}(\text{g})$ in presence of dilHCl
$\text{Al}^{+3}, \text{Fe}^{+3}$	III	NH_4OH in presence of NH_4Cl
$\text{CO}^{+2}, \text{Ni}^{+2}$	IV	H_2S in presence of NH_4OH
$\text{Ba}^{+2}, \text{Ca}^{+2}$	V	$(\text{NH}_4)_2\text{CO}_3$ in presence of NH_4OH

26. $\because \text{Pb}(\text{NO}_3)_2$ is a soluble colourless compound so it cannot be used in confirmatory test of Pb^{+2} ion.

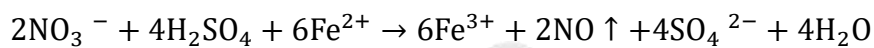
27. $\text{CH}_3\text{COO}^- + \text{FeCl}_3 \rightarrow \text{Fe}(\text{CH}_3\text{COO})_3$ or $[\text{Fe}_3(\text{OH})_2(\text{CH}_3\text{COO})_6]^+$

Blood red colour

$\downarrow \Delta$

$\text{Fe}(\text{OH})_2(\text{CH}_3\text{COO}) \downarrow$

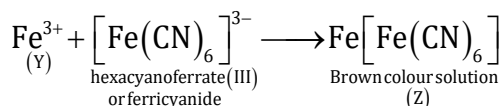
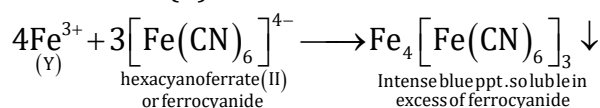
Red-brown precipitate



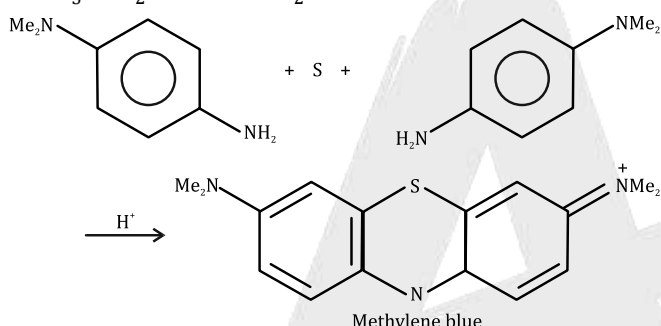
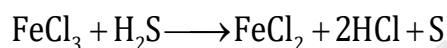
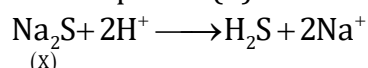
Brown

(2-4)

Reaction of (Y) indicates that it is Fe^{3+} salt.



Since the product formed (methylene blue) has sulphur in its structure, it should be supplied by the compound (X) which is thus Na_2S .



26. Aqua regia is a mixture of conc. HCl and conc. HNO_3 in 3 : 1 ratio. When gold dissolves in aqua regia, the species formed in which gold is in +3 oxidation state. In the absence of air the reaction between gold and aquaregia
- $$Au + HNO_3 + 4HCl \rightarrow H^+ + [AuCl_4]^- + 2H_2O + NO$$
- NO_2 will not be produced. Yellow colour is due its decomposition into $NOCl$ and Cl_2 .
- $$3HCl + HNO_3 \rightarrow NOCl + Cl_2 + 2H_2O$$

27. No. of eq. of oxalic acid = No. of eq. of $NaOH$
Using average of the $NaOH$ volume used in five experiments (V_{NaOH}) avg. = 10 mL
- $$\frac{5.00 \times 10}{1000} \times 2 = \frac{10.0 \times M_{NaOH}}{1000} \times 1$$
- $\therefore M_{NaOH} = 0.10 \text{ mol/L}$

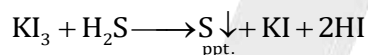
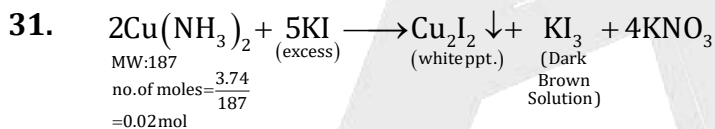
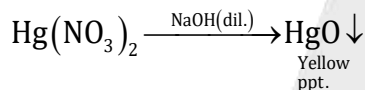
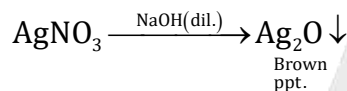
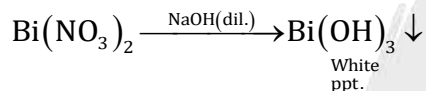
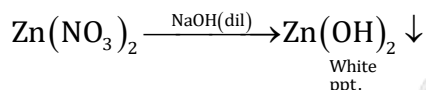
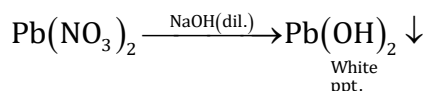
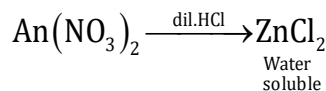
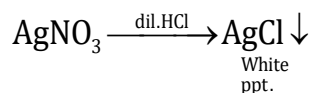
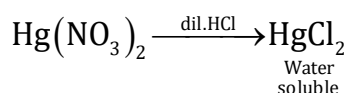
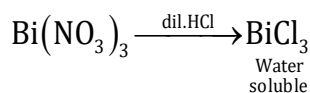
- 28.
- $$K_4[Fe(CN)_6] \xrightarrow[\text{absence of air}]{FeSO_4} K_2[Fe(Fe(CN)_6)]$$
- white precipitate(x)
- $$\downarrow \text{Air}$$
- $$Fe_4[Fe(CN)_6]_3$$
- (Prussian Blue)

29. $FeSO_4$ solution $\xrightarrow[\text{slow addition of conc. } H_2SO_4]{NaNO_3} [Fe(H_2O)_5NO]SO_4$
- (Brown ring complex)

30. $Pb(NO_3)_2 \xrightarrow{\text{dil. } HCl} PbCl \downarrow$
- White ppt.

(Inorganic Chemistry)

SALT ANALYSIS



2 mol of $\text{Cu}(\text{NO}_3)_2$ produces 1 mole of KI_3 which is further produces – s 1 mol of S precipitate.

∴ 0.02 mol of $\text{Cu}(\text{NO}_3)_2$ Will produce 0.01 mol

$$\text{S} = 0.01 \times 32\text{g} = 0.32\text{g of S}$$

