QUALITATIVE ANALYSIS (ANION)

CONTENTS

JEE(Advanced) Syllabus

Principles of Qualitative Analysis: Groups I to V (only Ag^{+}, Hg^{2+}, Cu^{2+}, Pb^{2+}, Bi^{3+}, Fe^{3+}, Cr^{3+}, Al^{3+}, Ca^{2+}, Ba^{2+}, Zn^{2+}, Mn^{2+} and Mg^{2+}); Nitrate, halides (excluding fluoride), sulphate and sulphide.

JEE(Main) Syllabus

Chemical Principle involved in the qualitative salt analysis :
Cations - Pb^{2+}, Cu^{2+}, Al^{3+}, Fe^{3+}, Zn^{2+}, Ni^{2+}, Ca^{2+}, Ba^{2+}, Mg^{2+}, NH_4^{+}.
Anions - CO_3^{2-}, S^{2-}, SO_4^{2-}, NO_3^{-}, NO_2^{-}, Cl^{-}, Br^{-}, I^{-}.
(Insoluble salts excluded).

QUALITATIVE ANALYSIS (Anion)

PART-1

Introduction :

Qualitative analysis involves the detection of cation(s) and anion(s) of a salt or a mixture of salts.
The systematic procedure for qualitative analysis of an inorganic salt involves the following steps :

(a) Preliminary tests

- Physical appearance (colour and smell).
- Dry heating test.
- Flame test.
- Borax bead test.
- Charcoal cavity test.
- Charcoal cavity and cobalt nitrate test.

(b) Wet tests for acid radicals.

(c) Wet tests (group analysis) for basic radicals.

Section (A) : Heating in dry test tube

1. Physical appearance (smell).

Table : 1
Physical Examination

Take a pinch of the salt between your fingers and rub with a drop of water	
Smell	**Inference**
Ammoniacal smell	NH_4^+
Vinegar like smell	CH_3COO^-
Smell like that of rotten eggs	S^{2-}

2. Dry Heating Test :

This test is performed by heating a small amount of mixture in a dry test tube. Quite valuable information can be generated by carefully performing and noting the observations here. On heating some salts undergo decomposition thus evolving the gases or may undergo characteristic changes in the colour of residue. These observations are tabulated below along with the inferences that you can draw.

Table : 2

	Observation	**Inference**
1.	**Gas evolved**	
	(a) Colourless and odourless gas	
	CO_2 gas – turns lime water milky	CO_3^{2-}
	(b) Colourless gas with odour	
	(i) H_2S gas – Smells like rotten eggs, turns lead acetate paper black.	Hydrated S^{2-} or S^{2-}
	(ii) SO_2 gas – Characteristic suffocating smell of burning sulphur turns acidified potassium dichromate solution or paper green.	SO_3^{2-}
	(iii) HCl gas – Pungent smell, white fumes with ammonia, white precipitate with silver nitrate solution.	Cl^-
	(iv) Acetic acid vapours–Characteristic vinegar like smell.	CH_3COO^-
	(v) NH_3 gas– Characteristic smell, turns Nessler's solution brown.	NH_4^+
	(c) Coloured gases – Pungent smell	
	(i) NO_2 gas – Reddish brown, turns ferrous sulphate solution brownish black.	NO_2^- or NO_3^-
	(ii) Cl_2 gas – Greenish yellow, turns starch iodide paper blue.	Cl^-
	(iii) Br_2 vapours – Reddish brown, turns starch paper orange red.	Br^-
	(iv) I_2 vapours – Dark violet, turns starch paper blue.	I^-

2.	**Sublimate formed**	
	(a) White sublimate	NH_4^+
	(b) Black sublimate accompanied by violet vapours.	I^-
3.	**Fusion**	
	The mixture fuses.	Alkali metal salts or salt containing water of crystallisation.
4.	**Swelling**	
	The mixture swells up into voluminous mass.	PO_4^{3-}, BO_3^{3-} indicated
5.	**Residue**	
	(i) Yellow when hot, white when cold.	Zn^{2+}
	(ii) Brown when hot and yellow when cold.	Pb^{2+}
	(iii) Original salt blue becomes white on heating.	Hydrated $CuSO_4$ indicated
	(iv) Coloured salt becomes brown or black on indicated.	Co^{2+}, Fe^{2+}, Fe^{3+}, Cr^{3+}, Cu^{2+}, Ni^{2+}, Mn^{2+} heating.

Note :

- Use a perfectly dry test–tube for performing thes test. While drying a test–tube, keeps it in slanting position with its mouth slightly downwards so that the drops of water which condense on the upper cooler parts, do not fall back on the hot bottom, as this may break the tube.
- For testing a gas, a filter paper strip dipped in the appropriate reagent is brought near the mouth of the test tube or alternatively the reagent is taken in a gas–detector and the gas is passed through it.

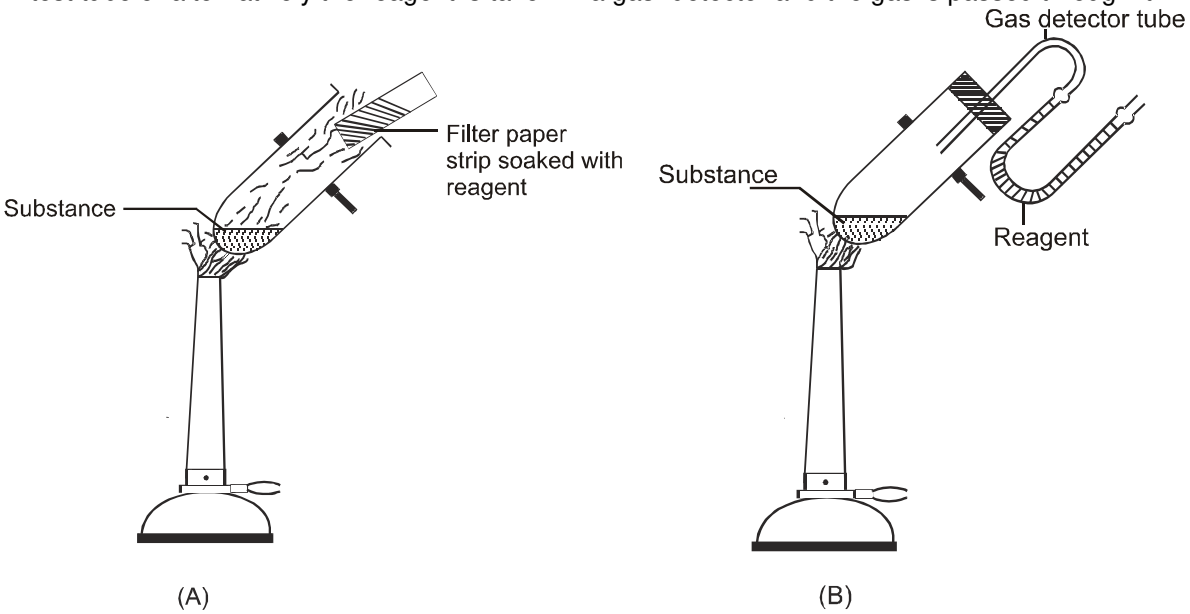


Figure : Detection of gas evolved.

- Do not heat the tube strongly at one point as it may break.

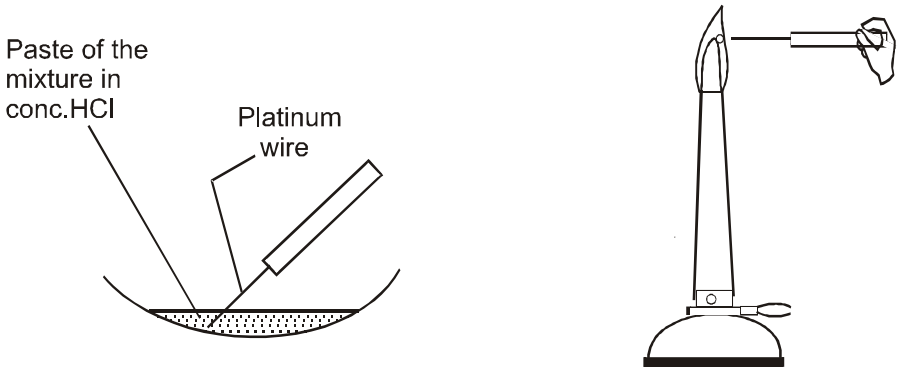
Section (B) : Flame and borax bead test

3. Flame test :

The chlorides of the metals are more volatile as compared to other salts and these are prepared in situ by mixing the compounds with a little concentrated hydrochloric acid. On heating in a non-luminous Bunsen flame they are volatilized and impart a characteristic colour to the flame as these absorb energy from the flame and transmit the same as light as characteristic colour.

Table : 3

Colour of Flame	Inference
Crimson Red / Carmine Red	Lithium
Golden yellow	Sodium
Violet/Lilac	Potassium
Brick red	Calcium
Crimson	Strontium
Apple Green/Yellowish Green	Barium
Green with a Blue centre/Greenish Blue	Copper



(A) Dipping the platinum wire in the paste of salt and HCl.

(B) Introducing the wire in the flame

Figure : Flame test

4. Borax Bead test :

On Heating borax forms a colourless glassy bead of $NaBO_2$ and B_2O_3.

$Na_2B_4O_7.10H_2O \xrightarrow{\Delta} Na_2B_4O_7 \xrightarrow{\Delta} 2NaBO_2 + B_2O_3$

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

For example, in oxidising flame copper salts give blue bead.

$CuSO_4 \longrightarrow CuO + SO_3$; $CuO + B_2O_3 \longrightarrow Cu(BO_2)_2$ (blue bead)

However, in reducing flame the colours may be different due to different reactions.

$2Cu(BO_2)_2 + C \longrightarrow 2CuBO_2 + B_2O_3 + CO$

$2Cu(BO_2)_2 + 2C \longrightarrow 2Cu$ (brown red/red and opaque bead) $+ 2B_2O_3 + 2CO$.

Following metals impart a characteristic colour to the Bunsen flame :

Na, Li, K, Sr, Rb, Cs, Be, Ca, Cu

Table : 4

Metal	Colour in oxidising flame		Colour in reducing flame	
	When Hot	When Cold	When Hot	When Cold
Copper	Green	Blue	Colourless	Brown red
Iron	Brown yellow	Pale yellow/Yellow	Bottle green	Bottle green
Chromium	Yellow	Green	Green	Green
Cobalt	Blue	Blue	Blue	Blue
Manganese	Violet/Amethyst	Red/Amethyst	Grey/Colourless	Grey/Colourless
Nickel	Violet	Brown/Reddish brown	Grey	Grey

☞ Non luminous flame is called oxidising flame. ☞ Luminous flame is called reducing flame.

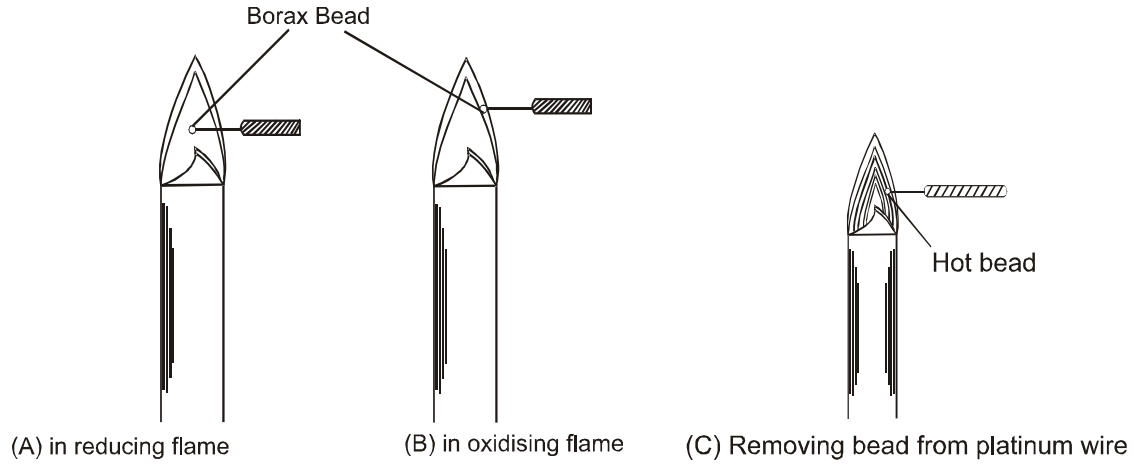


Figure : Borax bead test

☞ All acid radicals which are in JEE syllabus are colourless and diamagnetic. Hence the colour of the salts is only due to the basic radicals.

5. Charcoal Cavity Test :

This test is based on the fact that metallic carbonates when heated in a charcoal cavity decompose to give corresponding oxides. The oxides appear as coloured incrustation or residue in the cavity. In certain cases, the oxides formed partially undergo reduction to the metallic state producing metallic beads or scales.

Example :

(a) $ZnSO_4 + Na_2CO_3 \longrightarrow ZnCO_3 + Na_2SO_4$

$ZnCO_3 \longrightarrow ZnO$ (Yellow when hot, white when cold) $+ CO_2\uparrow$

(b) $CuSO_4 + Na_2CO_3 \longrightarrow CuCO_3 + Na_2SO_4$

$CuCO_3 \longrightarrow CuO + CO_2\uparrow$

$CuO + C \longrightarrow Cu$ (Reddish scales) $+ CO\uparrow$

Table : 5

Observation		Inference
Incrustation or Residue	**Metallic bead**	
Yellow when hot, white when cold	None	Zn^{2+}
Brown when hot, yellow when cold	Grey bead which marks the paper	Pb^{2+}
No characteristic residue	Red beads or scales	Cu^{2+}
White residue which glows on heating	None	Ba^{2+},Ca^{2+}, Mg^{2+}
Black	None	Nothing definite–generally coloured salt

6. Cobalt Nitrate Test :

In case the residue is white in colour after charcoal cavity test, add a drop of cobalt nitrate in the charcoal cavity. A drop of water is then added and the mass is heated in an oxidising flame using blow pipe. It is cooled and one or two drops of cobalt nitrate solution is added and then again heated in the oxidising flame. Different metal salts give different coloured mass as given in the table. To illustrate :

$ZnSO_4 + Na_2CO_3 \longrightarrow ZnCO_3 + Na_2SO_4$; $ZnCO_3 \longrightarrow ZnO + CO_2$

$2Co(NO_3)_2 \longrightarrow 2CoO + 4NO_2 + O_2$; $ZnO + CoO \longrightarrow ZnO.CoO$ (or $CoZnO_2$) (Rinmann's green)

Table : 6

S.No.	Metal	Colour of the mass
1.	Zinc	Green
2.	Aluminium	Blue
3.	Magnesium	Pink
4.	Tin	Bluish – green

Table : 7

SOLUBILITY CHART

S.No.	Anion	Solubility / Exception
1.	CO_3^{2-}	Except carbonates of alkali metals and of ammonium, all other normal carbonates are insoluble.
2.	SO_3^{2-}	Only the sulphites of the alkali metals and of ammonium are water soluble. The sulphite of other metals are either sparingly soluble or insoluble.
3.	S^{2-}	The acid, normal and polysulphide of alkali metals are soluble in water. The normal sulphides of most other metals are insoluble; those of the alkaline earths are sparingly soluble, but are gradually changed by contact with water into soluble hydrogen sulphides.
4.	NO_2^-, NO_3^-	Almost all nitrites and nitrates are soluble in water. $AgNO_2$ is sparingly soluble. Nitrates of mercury and bismuth give basic salts on treatment with water. These are soluble in dilute nitric acid.
5.	CH_3COO^-	Acetates are water soluble except Ag(I) and Hg(II) acetates which are sparingly soluble.
6.	Cl^-	Most chlorides are soluble in water. $PbCl_2$ (sparingly soluble in cold but readily soluble in boiling water), Hg_2Cl_2, AgCl, CuCl, BiOCl, SbOCl and Hg_2OCl_2 are insoluble in water.
7.	Br^-	Silver, mercury(I) and copper(I), bromides are insoluble. Lead bromide is sparingly soluble in cold but more soluble in boiling water. All other bromides are soluble in water.
8.	I^-	Silver, mercury(I), mercury(II), copper(I), lead and bismuth(III) iodides are the least soluble salts. All other iodides are water soluble.
9.	SO_4^{2-}	The sulphates of barium, silver lead are insoluble in water, those of calcium and mercury(II) are slightly soluble. Some basic sulphates of mercury, bismuth and chromium are also insoluble, but these dissolves in dilute hydrochloric or nitric acid.
10.	PO_4^{3-}	The phosphate of the alkali metals, with the exception of lithium and ammonium, are soluble in water; the primary phosphate of the alkaline earth metals are soluble. All the phosphates of the other metals and also the secondary and tertiary phosphate of the alkaline earth metals are sparingly soluble or insoluble in water.

Analysis of ANIONS (Acidic Radicals) :

Analysis of anions (acidic radicals) can be broadly divided in to two groups.

(A) **GROUP 'A' RADICALS :** It involves those anions which are characterised by volatile products by reaction with HCl/ H_2SO_4 It is further subdivided in to two groups as given below.

(a) Dilute Sulphuric acid/Dilute Hydrochloric acid : The anions of this group liberate gases or acid vapours with dilute sulphuric acid/hydrochloric acid.

Table : 8

Observation	Inference	
	Gas	Radical
Effervescence with the evolution of a colourless and odourless gas which turns lime water milky.	CO_2	CO_3^{2-}
Evolution of colourless gas having smell of rotten egg which turns lead acetate paper black.	H_2S	S^{2-}
Colourless gas having suffocating odour (like burning sulphur) which turns acidified $K_2Cr_2O_7$ paper green.	SO_2	SO_3^{2-}

Evolution of reddish brown pungent smelling gas which turns		
(i) $FeSO_4$ solution brownish-black and	NO_2	NO_2^-
(ii) wet starch –iodide paper blue. Colourless gas having smell of vinegar.	HAC(g)	CH_3COO^-
No peculiar gas is evolved.	–	All above are absent

(b) Concentrated Sulphuric acid group : The anions of this group liberate acid vapours or gases with conc. H_2SO_4.

Table : 9

Observation	Inference	
	Gas	**Radical**
Colourless gas with pungent smell which gives dense white fumes with a glass rod dipped in NH_4OH.	HCl	Cl^-
Reddish brown gas with pungent smell, intensity of reddish brown fumes increases on addition of a pinch of solid MnO_2. Also it turns starch paper orange red.	Br_2	Br^-
Evolution of violet vapours which turns starch paper blue.	I_2	I^-
Evolution of reddish brown fumes which intensifies on addition of copper turnings or bits of filter paper.	NO_2	NO_3^-
Starch iodide paper develops a blue–black spot due to the formation of a I_2–starch complex. (NO_2 liberated acts as oxidising agent).		

(B) GROUP 'B' RADICALS : Anions of this group do not give acid vapours or gases with dilute as well as concentrated H_2SO_4 but are characterised by their specific reactions in solutions. This group is further sub divided into two groups based on the type of the reactions.

(a) Oxidation and reduction in solutions : CrO_4^{2-}, $Cr_2O_7^{2-}$ etc.

(b) Precipitation reactions : These are given by SO_4^{2-}, PO_4^{3-} etc.

Table : 10

Observation	Inference
W.E. or S.E. + $BaCl_2$(aq) White precipitate insoluble in dil. HCl and HNO_3	SO_4^{2-}
W.E or S.E + conc. HNO_3 (1–2 mL) + ammonium molybdate and boil $\rightarrow$ Canary yellow precipitate	PO_4^{3-}

☞ W.E. = Water extract. (Salt is dissolved in distilled water)

☞ S.E. = Sodium carbonate extract

Preparation of sodium carbonate extract :

Take 1-2 g of salt/salts mixture and three times the amount of pure solid sodium carbonate in a borosil conical flask. Add 20 mL of distilled water and boil the contents for 10 minutes. Cool the solution and then filter. The Filtrate is termed as "Sodium carbonate extract".

Sodium carbonate reacts with the inorganic salt to form water soluble sodium salt of the acid radical.

$$BaCl_2 + Na_2CO_3 \longrightarrow BaCO_3 \downarrow \text{(white)} + 2NaCl \text{ (aq)}$$

$$Cd_3(PO_4)_2 + 3Na_2CO_3 \longrightarrow 3CdCO_3 \downarrow + 2Na_3PO_4 \text{ (aq)}$$

Sodium carbonate extract is used when

(a) salt is only partially soluble in water or insoluble

(b) cations interfere with the tests for acid radicals or the coloured salt solutions may be too intense in colour that the test results are not too clear.

☞ As sodium carbonate extract contains excess of sodium carbonate, it should be neutralised with a suitable acid before proceeding for analysis of an anion.

Note : S.E. is not used for testing CO_3^{2-} or HCO_3^- ions.

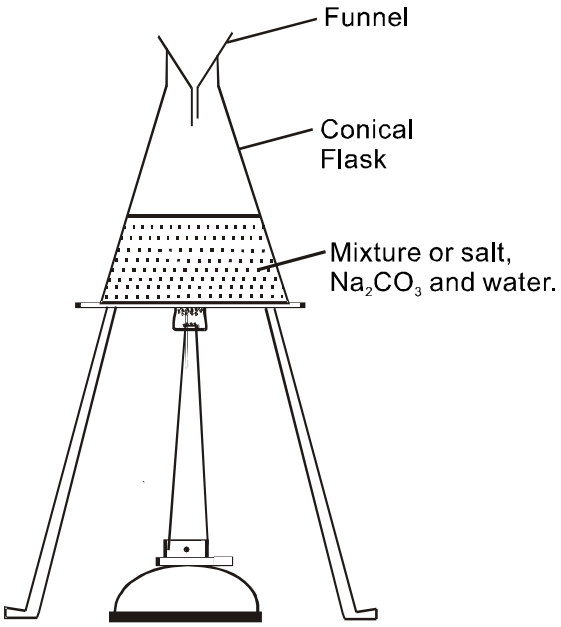


Figure : Preparation of sodium carbonate extract

Individual tests :

Section (C) : dil. HCl / dil. H_2SO_4 group

(A) GROUP 'A' RADICALS :

(a) DILUTE SULPHURIC ACID/DILUTE HYDROCHLORIC ACID GROUP :

1. CARBONATE ION (CO_3^{2-}) :

- Dilute H_2SO_4 test : A colourless odourless gas is evolved with brisk effervescence.

  $CaCO_3 + H_2SO_4 \longrightarrow CaSO_4 + H_2O + CO_2\uparrow$

- Lime water/Baryta water ($Ba(OH)_2$) test : The liberated gas can be identified by its property of rendering lime water (or baryta water) turbid.

  $CO_2 + Ca(OH)_2 \longrightarrow$ **$CaCO_3\downarrow$ (milky)** $+ H_2O$

  On prolonged passage of CO_2 the milkiness disappears.

  $CaCO_3 + CO_2 + H_2O \longrightarrow Ca(HCO_3)_2$ (soluble) $\xrightarrow{\Delta} CaCO_3\downarrow + H_2O + CO_2$

- Magnesium sulphate test (for soluble carbonates) :

  $CO_3^{2-}(aq) + MgSO_4(aq) \longrightarrow$ **$MgCO_3\downarrow$ (white)** $+ SO_4^{2-}(aq)$

- Silver nitrate solution : **White precipitate** is formed

  $CO_3^{2-} + Ag^+ \longrightarrow Ag_2CO_3\downarrow$

  White precipitate is soluble in HNO_3 and ammonia. The precipitate becomes yellow or brown upon addition of excess reagent owing to the formation of silver oxide ; the same happens if the mixture is boiled.

  $Ag_2CO_3 \longrightarrow Ag_2O\downarrow + CO_2\uparrow$

☞ Phenolphthalein is turned pink by soluble carbonates and colourless by soluble hydrogen carbonates.

☞ Mercury(II) chloride does not form precipitate with hydrogen carbonate ions, while in a solution of normal carbonates a **reddish–brown** precipitate of basic mercury(II) carbonate ($3HgO.HgCO_3 = Hg_4O_3CO_3$) is formed.

$CO_3^{2-} + 4Hg^{2+} + 3H_2O \longrightarrow$ **$Hg_4O_3.CO_3\downarrow$** $+ 6H^+$

Note: Lime water milky test is also shown by SO_2 but CO_2 does not turn the filter paper soaked in acidified $K_2Cr_2O_7$ green.

☞ Soluble bicarbonates give white precipitate with $MgSO_4$ (aq) / $MgCl_2$(aq) only on heating.

$Mg^{2+} + 2HCO_3^- \longrightarrow Mg(HCO_3)_2 \xrightarrow{\Delta} MgCO_3\downarrow + H_2O + CO_2$

☞ **Action of heat :**

Bicarbonates : $2NaHCO_3 \longrightarrow Na_2CO_3 + H_2O + CO_2$

Carbonates : Except carbonates of Na, K, Rb, Cs ; the Li_2CO_3 and all alkaline earth metals decompose as given below :

$Li_2CO_3 \longrightarrow Li_2O + CO_2$; $MgCO_3 \longrightarrow MgO + CO_2$; $Ag_2CO_3 \longrightarrow 2Ag + CO_2$

☞ $CaCO_3 \xrightarrow{\Delta} CaO + CO_2$

2. SULPHITE ION (SO_3^{2-}) :

- **Dilute H_2SO_4 test :** Decomposition of salt is more rapidly on warming, with the evolution of sulphur dioxide.

  $CaSO_3 + H_2SO_4 \longrightarrow CaSO_4 + H_2O + \mathbf{SO_2} \uparrow$

  SO_2 has suffocating odour of burning sulphur.
- **Acidified potassium dichromate test :** The filter paper dipped in acidified $K_2Cr_2O_7$ turns green.

  $Cr_2O_7^{2-} + 2H^+ + 3SO_2 \longrightarrow \mathbf{2Cr^{3+}\ (green)} + 3SO_4^{2-} + H_2O$.
- **Barium chloride/Strontium chloride solution :** White precipitate of barium (or strontium) sulphite is obtained.

  $SO_3^{2-} + Ba^{2+}/Sr^{2+} \longrightarrow \mathbf{BaSO_3/SrSO_3} \downarrow \mathbf{(white).}$

☞ White precipitate dissolves in dilute HCl, when sulphur dioxide is evolved.

$BaSO_3 \downarrow + 2H^+ \longrightarrow Ba^{2+} + SO_2 \uparrow + H_2O$.

White precipitate ($BaSO_3$) on standing is slowly oxidised to sulphate which is insoluble in dilute mineral acids. This change is rapidly effected by warming with bromine water, a little concentrated nitric acid or with hydrogen peroxide.

$2\ BaSO_3 \downarrow + O_2 \longrightarrow 2\ BaSO_4 \downarrow$

$BaSO_3 \downarrow + Br_2 + H_2O \longrightarrow 2\ BaSO_4 \downarrow + 2\ HBr$

Hence, reddish brown colour of bromine water is decolourised.

$3BaSO_3 \downarrow + 2\ HNO_3 \longrightarrow 3\ BaSO_4 \downarrow + 2NO \uparrow + H_2O$

$BaSO_3 \downarrow + H_2O_2 \longrightarrow BaSO_4 \downarrow + H_2O$

☞ These reactions are not given by carbonates (distinction from carbonates).

- **Zinc and sulphuric acid test :** Hydrogen sulphide gas is evolved.

  $SO_3^{2-} + 3Zn^{2+} + 8H^+ \longrightarrow \mathbf{H_2S} \uparrow + 3Zn^{2+} + 3H_2O$
- **Lime water test :** A white turbidity is formed. The precipitate dissolves on prolonged passage of the gas, due to the formation of hydrogen sulphite ions.

  $Ca(OH)_2 + SO_2 \longrightarrow \mathbf{CaSO_3(milky)} + H_2O$

  $CaSO_3 \downarrow + SO_2 + H_2O \longrightarrow \mathbf{Ca(HSO_3)_2\ (soluble)}$

☞ A turbidity is also produced by carbonates; sulphur dioxide must therefore be first removed when testing for the latter. This may be affected by adding potassium dichromate solution to the test–tube before acidifying. The dichromate oxidizes and destroys the sulphur dioxide without affecting the carbon dioxide.

- **Lead acetate or lead nitrate solution : White precipitate** of $PbSO_3$ is obtained.

  $SO_3^{2-} + Pb^{2+} \longrightarrow \mathbf{PbSO_3} \downarrow \mathbf{(white)}$

White precipitate gets soluble in dil. HNO_3 on boiling. The precipitate is oxidized by atmospheric oxygen and $PbSO_4$ is formed.

$2PbSO_3 \downarrow + O_2 \longrightarrow 2PbSO_4 \downarrow$

3. SULPHIDE ION (S^{2-}) :

- **Dilute H_2SO_4 test :** Pungent smelling gas like that of rotten egg is obtained.

  $S^{2-} + 2H^+ \longrightarrow \mathbf{H_2S} \uparrow$
- **Lead acetate test :** Filter paper moistened with lead acetate solution turns black.

  $(CH_3COO)_2Pb + H_2S \longrightarrow PbS \downarrow (black) + 2CH_3COOH$.
- **Sodium nitroprusside test : Purple** coloration is obtained.

  $S^{2-} + [Fe(CN)_5(NO)]^{2-} \longrightarrow \mathbf{[Fe(CN)_5NOS]^{4-}\ (purple).}$

It is a ligand change reaction not a redox where NO^+ changes to $(NOS)^{-1}$.

No reaction occurs with solution of H_2S or free gas. If however, filter paper moistened with a solution of the reagent is made alkaline with NaOH or NH_3 solution, a purple colouration is produced with free H_2S also.

Note: H_2S does not provide sufficient concentration of S^{2-} ions so that it does not give sodium nitroprusside test. Solubility is low 0.1 M and K_1 is just 10^{-7}.

- **Cadmium carbonate suspension/ Cadmium acetate solution :** Yellow precipitate is formed.
  $Na_2S + CdCO_3 \longrightarrow CdS \downarrow + Na_2CO_3$

☞ Filter paper moistened with cadmium acetate when brought in contact with evolving gas it turns **yellow.**
$S^{2-} + 2H^+ \longrightarrow H_2S$; $H_2S + Cd^{2+} \longrightarrow$ **CdS ↓ (yellow)** $+ 2H^+$.

- **Silver nitrate solution : Black precipitate** is formed which is insoluble in cold, but soluble in hot, dilute nitric acid.
  $Ag^+ + S^{2-} \longrightarrow$ **Ag_2S ↓(black)**
- **Methylene blue test :** NN–Dimethyl–p–phenylenediamine is converted by iron(III) chloride and hydrogen sulphide in strongly acid solution into the water–soluble dyestuff, methylene blue. This is a sensitive test for soluble sulphides and hydrogen sulphide.

4. NITRITE ION (NO_2^-) :

- **Dilute H_2SO_4 test :** Solid nitrite in cold produces a transient pale blue liquid (due to the presence of free nitrous acid, HNO_2 or its anhydride, N_2O_3) first and then evolution of pungent smelling reddish **brown vapours** of NO_2 takes place.
  $NO_2^- + H^+ \longrightarrow HNO_2$; $(2HNO_2 \longrightarrow H_2O + N_2O_3)$;
  $3HNO_2 \longrightarrow HNO_3 + 2NO + H_2O$; $2NO + O_2 \longrightarrow$ **$2NO_2$**↑
- **Starch iodide test :** The addition of a nitrite solution to a solution of potassium iodide, followed by acidification with acetic acid or with dilute sulphuric acid, results in the liberation of iodine, which may be identified by the blue colour produced with starch paste. A similar result is obtained by dipping potassium iodide–starch paper moistened with a little dilute acid into the solution.
  $2NO_2^- + 3I^- + 4CH_3COOH \longrightarrow I_3^- + 2NO \uparrow + 4CH_3COO^- + 2H_2O$
  Starch + $I_3^- \longrightarrow$ **Blue (starch iodine adsorption complex)**
- **Ferrous sulphate test (Brown ring test) :** When the nitrite solution is added carefully to a concentrated solution of iron(II) sulphate acidified with dilute acetic acid or dilute sulphuric acid, a brown ring appears due to the formation of $[Fe(H_2O)_5NO]SO_4$ at the junction of the two liquids. If the addition has not been made slowly and caustiously, a brown colouration results.
  $NO_2^- + CH_3COOH \longrightarrow HNO_2 + CH_3COO^-$
  $3HNO_2 \longrightarrow H_2O + HNO_3 + 2NO \uparrow$
  $Fe^{2+} + SO_4^{2-} + NO \uparrow \longrightarrow$ **$[Fe(H_2O)_5 NO]SO_4$ (brown ring complex)**
- **Thiourea test :** When a dilute acetic acid solution of a nitrite is treated with a little solid thiourea, nitrogen is evolved and thiocyanic acid is produced. The latter may be identified by the red colour produced with dilute HCl and $FeCl_3$ solution.
  $NaNO_2 + CH_3COOH \longrightarrow HNO_2 + CH_3COONa$
  $HNO_2 + H_2NCSNH_2$(s) (thiourea) $\longrightarrow N_2 + HSCN + 2H_2O$
  $FeCl_3 + 3HSCN \xrightarrow{\text{dil. HCl}}$ **$Fe(SCN)_3$ (blood red colouration)** $+ 3HCl$
- **Acidified potassium permanganate solution : Pink colour of $KMnO_4$ is decolourised** by a solution of a nitrite, but no gas is evolved.
  $5\ NO_2^- + 2\ MnO_4^- + 6\ H^+ \longrightarrow 5\ NO_3^- + 2\ Mn^{2+} + 3\ H_2O$
- **Silver nitrate solution : White crystalline precipitate** of silver nitrite from concentrated solutions.
  $NO_2^- + Ag^+ \longrightarrow$ **$AgNO_2$** ↓ (white)

5. ACETATE ION (CH_3COO^-)

- With dilute H_2SO_4 a vinegar like smell is obtained.
  $(CH_3COO)_2Ca + H_2SO_4 \longrightarrow 2CH_3COOH + CaSO_4$
- **Neutral ferric chloride test :** A **deep red/ blood red** colouration (no precipitate) indicates the presence of acetate.
  $6CH_3COO^- + 3Fe^{3+} + 2H_2O \longrightarrow$ **$[Fe_3(OH)_2(CH_3COO)_6]^+$** $+ 2H^+$

☞ When solution is diluted with water and boiled, brownish red precipitate of basic iron (III) acetate is obtained.
$[Fe_3(OH)_2(CH_3COO)_6]^+ + 4H_2O \xrightarrow{\text{Boil}} 3Fe(OH)_2CH_3COO \downarrow + 3CH_3COOH + H^+$

- **Silver nitrate solution test :** A white crystalline precipitate is produced in concentrated solution in the cold.
  $CH_3COO^- + Ag^+ \rightleftharpoons$ **CH_3COOAg ↓(white)**
  Precipitate is more soluble in boiling water and readily soluble in dilute ammonia solution.

Section (D) : Conc. H_2SO_4 group

(b) CONC. H_2SO_4 GROUP :

1. CHLORIDE ION (Cl^-) :

- **Concentrated H_2SO_4 test : Colourless pungent smelling gas (HCl)** is evolved which gives fumes of NH_4Cl when a glass rod dipped in aq. ammonia is brought in contact with evolving gas.

  $Cl^- + H_2SO_4 \longrightarrow$ **HCl** $+ HSO_4^-$

- $NH_4OH + HCl \longrightarrow$ **$NH_4Cl \uparrow$ (white fumes)** $+ H_2O$.

☞ $2NaCl + MnO_2 + 2H_2SO_4$ (conc.) $\longrightarrow Na_2SO_4 + MnSO_4 + 2H_2O + Cl_2$

- **Silver nitrate test :**

  $Cl^- + Ag^+ \longrightarrow$ **AgCl ↓ (white)**

  With sodium arsenite it is converted into **yellow precipitate** (distinction from AgBr and AgI) but insoluble in dilute nitric acid.

  $3AgCl\downarrow + AsO_3^{3-} \longrightarrow$ **$Ag_3AsO_3\downarrow$ (yellow)** $+ 3Cl^-$.

☞ White precipitate is soluble in aqueous ammonia and precipitate reappears with HNO_3.

$AgCl + 2NH_4OH$ **$[Ag(NH_3)_2]Cl$ (Soluble)** $+ 2H_2O$

$[Ag(NH_3)_2]Cl + 2H^+ \longrightarrow AgCl \downarrow + 2NH_4^+$.

- **Chromyl chloride test :**

  $4Cl^-(s) + Cr_2O_7^{2-}(s) + 6H^+$ (conc.) $\longrightarrow$ **$2CrO_2Cl_2$ (deep red vapours)** $+ 3H_2O$

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

$CrO_2Cl_2 + 4OH^- \longrightarrow CrO_4^{2-} + 2Cl^- + 2H_2O$

$CrO_4^{2-} + Pb^{+2} \longrightarrow$ **$PbCrO_4 \downarrow$ (yellow)**

Note :

1. Heavy metal chlorides such as Hg_2Cl_2, $HgCl_2$, $SnCl_2$, AgCl, $PbCl_2$ and $SbCl_3$, CuCl do not respond to this test due to their high covalent character as a result of which sufficient free Cl^- are not available. This test is given generally by ionic chlorides.
2. Test should be carried out in a dry test tube otherwise chromic acid will be formed.

   $CrO_2Cl_2 + 2H_2O \longrightarrow H_2CrO_4 + 2HCl$
3. Br^- and I^- must be absent for this test because they are oxidized by $Cr_2O_7^{2-}$ into Br_2 (brown vapours) and I_2 (violet vapours) respectively. Both Br_2 and I_2 produce colourless solution with NaOH solution.
4. NO_2^-, NO_3^- and ClO_2^- radicals also interfere with this test and so should be absent.

2. BROMIDE ION (Br^-) :

- **Concentrated H_2SO_4 test :** First a **reddish-brown solution** is formed, then reddish-brown bromine vapour accompanies the hydrogen bromide (fuming in moist air) is evolved.

  $2NaBr + H_2SO_4 \longrightarrow Na_2SO_4 + 2HBr$

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

☞ $2KBr + MnO_2 + 2H_2SO_4 \longrightarrow Br_2\uparrow + K_2SO_4 + MnSO_4 + 2H_2O$

- **Silver nitrate test : Pale yellow precipitate** is formed

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

☞ Yellow precipitate is partially soluble in dilute aqueous ammonia but readily dissolves in concentrated ammonia solution.

$AgBr + 2NH_4OH \longrightarrow [Ag(NH_3)_2]\ Br + H_2O$

- **Lead acetate test :** Bromides on treatment with lead acetate solution, gives a **white crystalline precipitate** of lead bromide, which is soluble in boiling water giving colourless solution.

  $2Br^- + Pb^{+2} \longrightarrow$ **$PbBr_2 \downarrow$** (white)

- **Chlorine water test (organic layer test) :** When to a sodium carbonate extract of metal bromide containing CCl_4, $CHCl_3$ or CS_2, chlorine water is added and the content is shaken and then allow to settle down reddish brown colour is obtained in organic layer.

  $2Br^- + Cl_2 \longrightarrow 2Cl^- + Br_2 \uparrow$.

  $Br_2 + CHCl_3 / CCl_4 \longrightarrow$ **Br_2** dissolve to give **reddish brown colour in organic layer.**

With excess of chlorine water, the bromine is converted into yellow bromine monochloride and a **pale yellow solution** results.

$Br_2 \uparrow + Cl_2 \uparrow \longrightarrow$ **2BrCl**

- **Starch paper test :** When starch paper is brought in contact with evolving bromine gas orange red spots are produced.

  Br_2 + starch $\longrightarrow$ **starch bromine adsorption complex (orange red)**

- **Potassium dichromate and concentrated H_2SO_4 :** When a mixture of solid bromide, $K_2Cr_2O_7$ and concentrated H_2SO_4 is heated and evolved vapours are passed through water, a orange red solution is obtained.

  $6KBr + K_2Cr_2O_7 + 7H_2SO_4 \longrightarrow 3Br_2\uparrow + Cr_2(SO_4)_3 + 4K_2SO_4 + 7H_2O$

3. IODIDE ION (I^-) :

- **Concentrated H_2SO_4 test : Pungent smelling violet vapours** are evolved.

  $2NaI + H_2SO_4 \longrightarrow Na_2SO_4 + 2HI$

  $2HI + H_2SO_4 \longrightarrow$ **$I_2\uparrow$ (dark violet)** $+ 2H_2O + SO_2$

☞ Evolution of dark violet fumes intensifies on adding a pinch of MnO_2.

$3I^- + MnO_2 + 2H_2SO_4 \longrightarrow I_3^- \uparrow + Mn^{2+} + 2SO_4^{2-} + 2H_2S$

- **Starch paper test :** Iodides are readily oxidised in acid solution to free iodine; the free iodine may than be identified by **deep blue colouration** produced with starch solution.

  $3I^- + 2NO_2^- + 4H^+ \longrightarrow I_3^- + 2NO \uparrow + 2H_2O$.

- **Silver nitrate test :** Bright yellow precipitate is formed.

  $I^- + Ag^+ \longrightarrow$ **$AgI\downarrow$ (bright yellow)**

☞ Bright yellow precipitate is **insoluble** in dilute aqueous ammonia but is partially soluble in concentrated ammonia solution.

- **Chlorine water test (organic layer test) :** When chlorine water is added to a solution of iodide, free iodine is liberated which colours the solution brown and on shaking with CS_2, $CHCl_3$ or CCl_4, it dissolves in organic layer forming a violet solution, which settles below the aqueous layer.

  $2NaI + Cl_2 \longrightarrow 2NaCl + I_2$

  $I_2 + CHCl_3 \longrightarrow$ **I_2 dissolves to give violet colour in organic layer.**

- **Lead acetate solution :** A yellow precipitate is formed which is soluble in hot water forming a colourless solution and yielding golden yellow plates ('spangles') on cooling.

  $2I^- + Pb^{+2} \longrightarrow$ **$PbI_2\downarrow$(yellow)**

- **Potassium dichromate and concentrated sulphuric acid : Violet vapours** are liberated, and no chromate is present in distillate.

  $6I^- + Cr_2O_7^2 + 2H_2SO_4 \longrightarrow 3I_2 + Cr^{3+} + 7SO_4^{2-} + 7H_2O$

☞ **Action of heat :** Most of halides are stable but few decompose as

$2FeCl_3 \longrightarrow 2FeCl_2 + Cl_2$; $MgCl_2.6H_2O \longrightarrow MgO + 2HCl + 5H_2O$

$Hg_2Cl_2 \longrightarrow HgCl_2 + Hg$; $NH_4Cl \longrightarrow NH_3 + HCl$

$2CuI_2 \longrightarrow CuI + I_2$ (without heating)

Solvent / Precipitate	NH_3	HNO_3	$Na_2S_2O_3$	NaCN/KCN
AgCl	Completely soluble	Insoluble	Soluble	Soluble
AgBr	Partially soluble	Insoluble	Soluble	Soluble
AgI	Insoluble	Insoluble	Soluble	Soluble

Note : In NH_3, Ag^+ forms soluble complex of $[Ag(NH_3)_2]^+$
In $Na_3S_2O_3$, Ag^+ forms soluble complex of $[Ag(S_2O_3)_2]^{3-}$
In NaCN, Ag^+ forms soluble complex of $[Ag(CN)_2]^-$

4. NITRATE ION (NO_3^-) :

- **Concentrated H_2SO_4 test : Pungent smelling reddish brown vapours** are evolved.

  $4NO_3^- + 2H_2SO_4 \longrightarrow$ **$4NO_2\uparrow$** $+ O_2 + 2SO_4^{2-} + 2H_2O$

☞ Addition of bright copper turnings or paper pellets intensifies the evolution of reddish brown gas.

$2NO_3^- + 4H_2SO_4 + 3Cu \longrightarrow 3Cu^{2+} + 2NO \uparrow + 4SO_4^{2-} + 4H_2O$; $2NO \uparrow + O_2 \longrightarrow 2NO_2 \uparrow$

4 C (paper pellet) $+ 4HNO_3 \longrightarrow 2H_2O + 4NO_2 + 4CO_2$.

- **Brown ring test :** When a freshly prepared saturated solution of iron (II) sulphate is added to nitrate solution and then concentrated H_2SO_4 is added slowly from the side of the test tube, a **brown ring** is obtained at the junction of two layers.

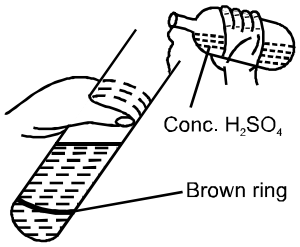


Figure : Brown ring test

$NaNO_3 + H_2SO_4 \longrightarrow NaHSO_4 + HNO_3$

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

or $2NO_3^- + 4H_2SO_4 + 6Fe^{2+} \longrightarrow 6Fe^{3+} + 2NO \downarrow + 4SO_4^{2-} + 4H_2O.$

$Fe^{2+} + NO \uparrow + 5H_2O \longrightarrow$ **$[Fe^{I}(H_2O)_5\ NO^+]^{2+}$ (brown ring).**

Some important points related to brown ring test are :

Note :

1. Shaking and warming are not allowed for this test because on shaking and warming the mixture, NO escapes and a yellow solution of iron(III) ions is obtained.
2. Bromides and iodides interfere in brown ring test as liberated halogens obscure the brown ring. Nitrites also interfere the brown ring test and can be removed by adding a little sulphamic acid, or urea.

   $H_2NHSO_3 + NO_2^- \longrightarrow N_2 \uparrow + SO_4^{2-} + H^+ + H_2O$

   $NO_2^- + H^+ \xrightarrow{HCl} HNO_2$

   $CO(NH_2)_2 + 2HNO_2 \longrightarrow 2N_2 \uparrow + CO_2 \uparrow + 3H_2O$
3. $FeSO_4$ solution must be freshly prepared because Fe^{2+} ion is very reactive towards aerial oxidation and gets converted to Fe^{3+}, which does not give this test.

- **Diphenyl amine test : Blue ring** is formed at the junction of two liquids (reagent and nitrate salt solutions).

  $NaNO_3 + H_2SO_4 \longrightarrow NaHSO_4 + HNO_3$

  $2HNO_3 \longrightarrow H_2O + 2NO_2 + [O]$

  $2C_6H_5NHC_6H_5 + [O] \longrightarrow$ **$(C_6H_5)_2\ N - N\ (C_6H_5)_2$ (blue ring)** $+ H_2O.$

☞ This test is also given by various oxidising agents like CrO_4^{2-}, $Cr_2O_7^{2-}$, ClO_3^-, BrO_3^-, IO_3^-, NO_2^- etc.

To distinguish Br_2 with NO_2 (both are reddish brown gases)

(a) Br_2 + starch–iodide paper → Blue black colour spots do not develop immediately as Br_2 is a weaker oxidising agent whereas NO_2 being strong oxidising agent develops the blue black colour immediately.

(b) Bromine develops orange–red colour spots on starch paper.

Section (E) : Precipitation Reactions

(B) GROUP 'B' RADICALS :

Group of anions which do not give any gas with dilute as well as concentrated H_2SO_4 in cold but give precipitate with certain reagents :

These acid radicals are identified in inorganic salts by their individual tests as given below

1. SULPHATE ION (SO_4^{2-}) :

- **Barium chloride test :**

  W.E. or S.E. + Barium chloride (aq) ⟶ White precipitate

  $Na_2SO_4 + BaCl_2 \longrightarrow$ **$BaSO_4 \downarrow$ (white)** $+ 2NaCl.$

☞ White precipitate is insoluble in warm dil. HNO_3 as well as HCl but moderately soluble in boiling concentrated hydrochloric acid and conc. H_2SO_4.

$PbSO_4 + H_2SO_4 \longrightarrow$ **$PbHSO_4$(soluble)**

- **Lead acetate test :**

  W.E. or S.E. + Lead acetate ⟶ white precipitate

  $Na_2SO_4 + (CH_3COO)_2Pb \longrightarrow$ **$PbSO_4 \downarrow$ (White)** $+ 2CH_3COONa$

☞ White precipitate soluble in excess of hot ammonium acetate and ammonium tartrate.

$PbSO_4 + 2CH_3COONH_4 \longrightarrow$ **$(NH_4)_2[Pb(CH_3COO)_4]$ soluble.** + $(NH_4)_2SO_4$

$PbSO_4 + (NH_4)_2C_4H_4O_6 \longrightarrow (NH_4)_2SO_4$ + **$(NH_4)_2[Pb(C_4H_4O_6)_2]$soluble**

- **Match stick test :**

(a) W.E. or S.E. + Barium chloride ⟶ white precipitate

$Na_2SO_4 + BaCl_2 \longrightarrow 2NaCl +$ **$BaSO_4\downarrow$ (white)**

(b) White precipitate + Na_2CO_3(s) mix and apply the paste on the end of the carbonized match stick or a wooden splinter. Put it in the reducing flame.

$BaSO_4$ (s) + Na_2CO_3(s) ⟶ Na_2SO_4 + **$BaCO_3\downarrow$ (white)**

$Na_2SO_4 + 4C \longrightarrow Na_2S + 4CO$

(c) Now dip the match stick in sodium nitroprusside solution, purple colour near the fused mass is developed.

$Na_2S + Na_2[Fe(CN)_5NO] \longrightarrow$ **$Na_4[Fe(CN)_5NOS]$ (purple)**

- **Silver nitrate test : White precipitate** is obtained.

$SO_4^{2-} + 2Ag^+ \longrightarrow$ **$Ag_2SO_4\downarrow$ (white ppt.)**

2. PHOSPHATE ION (PO_4^{3-}) :

- **Ammonium molybdate test :**

$Na_2HPO_4(aq) + 12(NH_4)_2MoO_4 + 23HNO_3 \rightarrow (NH_4)_3[P(Mo_3O_{10})_4]\downarrow$ **(canary yellow)** $+ 2NaNO_3 + 21NH_4NO_3 + 12H_2O$

☞ Some times ammonium phosphomolybdate is also represented by the formula **$(NH_4)_3PO_4.12MoO_3$**

- **Magnesium nitrate or magnesia mixture test :** W.E. or S.E + Magnesium nitrate reagent (3-4 mL) and allows to stand for 4-5 minutes, white crystalline precipitate is formed.

Na_2HPO_4 (aq) + $Mg(NO_3)_2$ (aq) + NH_4OH(aq) ⟶ **$Mg(NH_4)PO_4\downarrow$ (white)** $+ 2NaNO_3 + H_2O$

Magnesia mixture is a solution containing $MgCl_2$, NH_4Cl and a little aqueous NH_3.

☞ PO_4^{3-} also gives $BaCl_2$ test due to the formation of white precipitate of $Ba_3(PO_4)_2$. So phosphate test should be carried out first and then conclude if PO_4^{3-} is present or absent before proceeding with the test for SO_4^{2-}.

- **Silver nitrate solution : Yellow precipitate i**s formed which is soluble in dilute ammonia and in dilute nitric acid.

$PO_4^{3-} + 3Ag^+ \longrightarrow$ **$Ag_3PO_4\downarrow$(yellow)**

$Ag_3PO_4\downarrow + 6NH_3 \longrightarrow 3[Ag(NH_3)_2]^+ + PO_4^{3-}$;

$Ag_3PO_4\downarrow + 2H^+ \longrightarrow H_2PO_4^- + 3Ag^+$

- **Iron (III) chloride solution : Yellowish-white precipitate of $FePO_4$** is obtained

$HPO_4^{2-} + Fe^{3+} \longrightarrow$ **$FePO_4\downarrow$**

3. BORATE ION (BO_3^{3-}) :

Salt (0.2 g) + conc. H_2SO_4 (1 mL) + Ethyl alcohol (4-5 mL) mix in a test tube and then heat. Ignite the evolved vapours with the help of Bunsen flame, **green edged flame** is obtained.

$2Na_3BO_3 + 3H_2SO_4 \longrightarrow 3Na_2SO_4 + 2H_3BO_3$

$3C_2H_5OH + H_3BO_3 \longrightarrow$ **$(C_2H_5)_3BO_3$ or $(C_2H_5O)_3B$** $+ 3H_2O$

Note :

1. Use of methyl alcohol is preferred due to high volatility of the product formed is $B(OMe)_3$
2. Copper and barium salts also interfere with this test because they give similar green flame and so should be absent.

MISCELLANEOUS SOLVED PROBLEMS (MSPs)

1. Pink colour of acidified $KMnO_4$ is decolourised but there is no evolution of any gas. This may happen with the compound containing the following acid radical.
(A) SO_3^{2-} (B) NO_2^- (C) S^{2-} (D) All of these

Ans. **(D)**

Sol. (A) $5SO_3^{2-} + 2MnO_4^- + 6H^+ \longrightarrow 2Mn^{2+} + 5SO_4^{2-} + 3H_2O$
(B) $2MnO_4^- + 5NO_2^- + 6H^+ \longrightarrow 2Mn^{2+} + 5NO_3^- + 3H_2O$
(C) $2MnO_4^- + H_2S + 6H^+ \longrightarrow 2Mn^{2+} + 5S \downarrow + 8H_2O$

2. 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) Disodium hydrogen phosphate

Ans. **(A)**

Sol. (A) $Pb^{2+} + 2Cl^- \longrightarrow PbCl_2\downarrow$ (white) ; $Ba^{2+} + 2Cl^- \longrightarrow BaCl_2$ (water soluble)
(B) $(CH_3COO)_2$ Pb and $(CH_3COO)_2Ba$ both are water soluble salts.
(C) Nitrates are mostly soluble in water
(D) $3Pb^{2+} + 2HPO_4^{2-} \longrightarrow Pb_3(PO_4)_2 \downarrow$ (white) $+ 2H^+$; $Ba^{2+} + HPO_4^{2-} \longrightarrow BaHPO_4 \downarrow$ (white)

3. When H_2S gas is passed through an ammonical salt solution X, a slightly white precipitate is formed. The X can be :
(A) a cobalt salt (B) a lead salt (C) a zinc salt (D) a silver salt

Ans. **(C)**

Sol. $Zn^{2+} + H_2S \longrightarrow ZnS \downarrow$ (white) $+ 2H^+$

4. Which anion does not liberate any gas with dilute as well as conc. H_2SO_4.
(A) NO_2^- (B) NO_3^- (C) SO_3^{2-} (D) SO_4^{2-}

Ans. **(D)**

5. A salt having BO_3^{3-} on burning with alcohol and conc. H_2SO_4 gives, which colour edge flame.
(A) green (B) yellow (C) red (D) white

Ans. **(A)**

Sol. $3Na_3BO_3 + 3H_2SO_4 \longrightarrow 3Na_2SO_4 + 2H_3BO_3$
$3C_2H_5OH + H_3BO_3 \longrightarrow (C_2H_5)_3BO_3 + 3H_2O$
(green)

6. When solution of KCl, KF and KBr are treated with I_2 ?
(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

Ans. **(D)**

Sol. I_2 is weak oxidising agent.
It does not oxidise the F^-, Cl^-, Br^-.

7. A mixture when rubbed with organic acid smells like vinegar. It contains :
(A) Sulphate (B) Nitrate (C) Nitrite (D) Acetate

Ans. **(D)**

8. Nitrate & Nitrite both give brown ring test, can be distinguish by –
(A) $HOSO_2NH_2$ (Sulphonic acid) (B) $NH_2HgO.HgI$ (Million base)
(C) $FeSO_4$ (D) None

Ans. **(A)**

9. Which reagent is used to remove SO_4^{2-} or Cl^- from water?
(A) NaOH (B) $Pb(NO_3)_2$ (C) $BaSO_4$ (D) KOH

Ans. **(B)**

Sol. $Pb^{2+} + SO_4^{2+} \longrightarrow PbSO_4 \downarrow$ (ppt)
$Pb^{2+} + Cl^- \longrightarrow PbCl_2 \downarrow$ (ppt)
Others does not from precipitate with both anions.

10.* Which of the following statements is/are correct for chromyl chloride test?
(A) Formation of chromyl chloride vapour (B) Liberation of chlorine gas
(C) Formation of lead chromate (D) Formation of reddish-brown vapour

Ans. **(A,C,D)**

Sol. $Cl^- + K_2Cr_2O_7 + H^+ \longrightarrow \underset{\text{(Chromyl chloride)}}{CrO_2Cl_2}$ (red-brown vapour) $\xrightarrow{NaOH} \underset{\text{Yellow (sodium chromate)}}{Na_2CrO_4} \xrightarrow{(CH_3COO)_2Pb} \underset{\text{Lead chromate (Yellow)}}{PbCrO_4}$

11.* Which of the following statements are incorrect?
(A) In thiourea test for nitrite, a green coloured solution is obtained.
(B) It is not necessary to carried out the chromyl chloride test in a dry test tube.
(C) Suspension of $CdCO_3$ gives black precipitate with Na_2S solution.
(D) In $PbNO_3$, the brown ring test can be performed with its water extract.

Ans. **(A,B,C,D)**

Sol. It is deep red colouration due to the formation of $Fe(SCN)_3$.
In presence of moisture, $CrO_2Cl_2 + H_2O \longrightarrow H_2CrO_4 + HCl$.
CdS (Yellow precipitate).
White precipitate of $PbSO_4$ is formed and hence brown ring is not visible.

12.* Conc. H_2SO_4 will not give any gas with :
(A) $ZnSO_4$ (B) $Ba_3(PO_4)_2$ (C) $Mg_3(BO_2)_2$ (D) $NaNO_3$

Ans. **(A,B,C)**

Sol. Only NO_3^- belong to conc. H_2SO_4 anion group.

13. Why does only the organic layer assure colour and not the aqueous layer when the tests for halides are done ?

Ans. Both Br_2 and I_2 are covalent. They have preference for organic layer.

14. What will happen when free bromine, iodine and chlorine separately react with a yellow dye stuff, fluorescein?

Ans. With free bromine it will convert into red tetra bromo fluorescein and with iodine into the red violet coloured iodoeosin. But chlorine tends to bleach the reagent.

Exercise-1

Marked questions are recommended for Revision.

PART - I : SUBJECTIVE QUESTIONS

Section (A) : Heating in dry test tube

A-1. What is importance of dry tests and it is applicable to which kind of substances ?

A-2. Give the observation when each of the following is heated in a dry test tube. Also give balanced equations :
(a) $HgCO_3$ (b) NH_4NO_2
(c) (NH_4Cl + $NaNO_3$) mixture (d) $Pb(NO_3)_2$

Section (B) : Flame and borax bead test

B-1. Why compounds shows colours in flame test ?

B-2. Is intensity of colour in flame test, depends upon the concentration of metal present ?

B-3. Why is a green flame not obtained in the case of barium sulphate or barium phosphate ?

B-4. Colourless salt (A) $\xrightarrow[740°C]{\Delta}$ (B) + (C) $\xrightarrow{Cu^{2+},\Delta}$ blue coloured bead (D)
Identify the compound (A), (B), (C) and (D).

Section (C) : dil. HCl / dil. H_2SO_4 group

C-1. Why is sodium carbonate extract acidified before performing the confirmatory test for anions ?

C-2. Can sodium carbonate extract be used test for CO_3^{2-} ions ?

C-3. What will happen if a solution of $Ca(HCO_3)_2$, formed by passing the carbon dioxide through a milky solution of $CaCO_3$ for a longer time if, ammonia solution is added ?

C-4. What will happen if bromine water is added in a white precipitate of $BaSO_3$?

C-5. Salt (A) + lime water $\longrightarrow$ white precipitate $\downarrow$
white precipitate + prolong passage of gas (B) $\longrightarrow$ it forms soluble salt (C), gas (B) has burning sulphur smell Identify the anion of salt (A) and (C).

C-6. What will happen ? (Also write the chemical equations) .
(a) When a filter paper moistened with potassium iodate and starch solution is brought in contact with sulphur dioxide gas.
(b) When H_2S gas is made to react with sodium tetrahydroxidoplumbate(II) solution.
(c) When sulphite reacts with dilute H_2SO_4 in presence of zinc

C-7. A nitrite solution is added to a saturated solution of iron(II) acidified with dilute acetic acid or with dilute sulphuric acid. If any reactions occurs then write the name and chemical composition of the products formed. Also write the chemical equations involved.

Section (D) : Conc. H_2SO_4 group

D-1. Why is it necessary to test for the acid radicals first with dil. H_2SO_4 and then with conc. H_2SO_4?

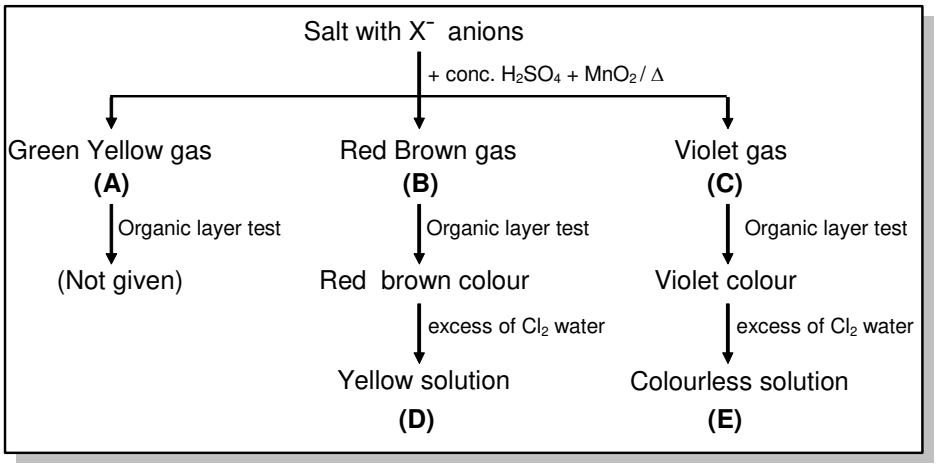
D-2. Why chromyl chloride test is carried out in a dry test tube ?

D-3. Why bromides and iodides do not respond to chromyl chloride test ?

D-4. NaCl on heating with conc. H_2SO_4 gives HCl where as NaBr and NaI give Br_2 and I_2 respetively, why?

D-5. Dilute Hydrochloric acid contains chloride ions but it doesnot give positive chromyl chloride test, why ?

D-6.



Identify the gas A, B and C.

D-7. Why heavy metal chlorides such as Hg_2Cl_2, AgCl, $PbCl_2$ etc. do not respond to chromyl chloride test.

D-8. Why is a freshly prepared solution of $FeSO_4$ used for the detection of nitrate and nitrite ?

Section (E) : Precipitation Reactions

E-1. Cu^{2+} and Ba^{2+} interfere in the flame test for borate, why ?

E-2. In which of the following reagents, the white precipitate of $PbSO_4$ is soluble ?
dilute HCl, hot concentrated H_2SO_4, ammonium acetate (6M), ammonium tartrate 6M in the presence of ammonia, sodium hydroxide solution.

E-3. How will you distinguish between sulphite and sulphate ions ?

PART - II : ONLY ONE OPTION CORRECT TYPE

Section (A) : Heating in dry test tube

A-1. When a metal sulphate is heated in dry test tube, the colour changes from blue to white. Then metal sulphate may be :
(A) $BaSO_4$ (B) $CuSO_4.5H_2O$ (C) Na_2SO_4 (D) None of these

A-2. Which of the following can not evolve more than one gas (vapour) if heated in dry test tube.
(A) $NaNO_3(s)$ (B) $MgCO_3(s)$ (C) $FeSO_4(s)$ (D) $(NH_4)_2Cr_2O_7(s)$

A-3. On heating, a white amorphous inorganic compound becomes yellow and on cooling, turns white again.The salt may be
(A) $PbCO_3$ (B) $MgCO_3$ (C) $ZnCO_3$ (D) K_2CO_3

A-4. Which of the following metal carbonates liberate. $CO_2(g)$ on heating :
(A) Na_2CO_3 (B) K_2CO_3 (C) Rb_2CO_3 (D) Ag_2CO_3

A-5. In which of the following reactions a brown coloured gas is evolved ?
(A) KBr (s) + dil. $H_2SO_4 \longrightarrow$ (B) $NH_4NO_2 \xrightarrow{\Delta}$
(C) $NaNO_3 \xrightarrow[800^oC]{\Delta}$ (D) $AgNO_3(s)$ + conc. $H_2SO_4 \longrightarrow$

Section (B) : Flame and borax bead test

B-1. Why is concentrated HCl used to dissolve the given metal salt in the flame test ?
(A) strong acids produce better flame test.
(B) HCl is volatile
(C) Volatile metal chloride produce better flame test.
(D) sharper coloured are seen in the flame in presence of Cl^- ions.

B-2. The hottest part of the flame of a Bunsen burner is the
(A) Blue Zone (B) Zone of complete combustion
(C) Zone fo partial combustion (D) All parts of the flame are equally hot.

B-3. Metal **(M)** shows crimson red colour in flame test and its halide is deliquescent then metal **(M)** could be:
(A) Li (B) Mg (C) Ca (D) Ba

B-4. In Borax bead test, metal oxides react with B_2O_3 and form a coloured bead. This bead contains.
(A) orthoborate ion (B) metaborate ion (C) double oxide (D) tetraborate ion

B-5. Which one of the following ions does not give borax bead test :
(A) Cr^{3+} (B) Cu^{2+} (C) Mn^{2+} (D) Zn^{2+}

B-6. In the Borax bead test of Co^{2+}, the blue colour of bead is due to the formation of :
(A) B_2O_3 (B) Co_3B_2 (C) $Co(BO_2)_2$ (D) CoO

B-7. A salt gives white residue in charcoal cavity test but in cobalt nitrate test it gives pink mass. It represents:
(A) Zn^{+2} (B) Al^{+3} (C) Mg^{+2} (D) PO_4^{-3}

Section (C) : dil. HCl / dil. H_2SO_4 group

C-1. Which of the following anions are identified by dil. HCl :
(A) NO_2^-, NO_3^-, CO_3^{2-} (B) NO_2^-, NO_3^-, SO_3^{2-} (C) S^{2-}, SO_3^{2-}, NO_2^- (D) CH_3COO^-, I^-, CO_3^{2-}

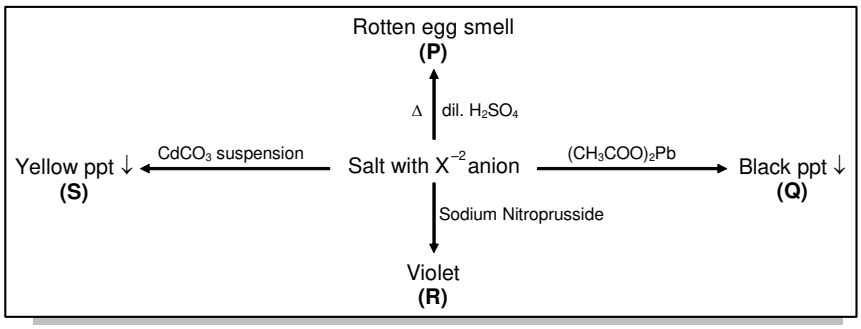
C-2. Two inorganic compounds **A** and **B** were heated in a dry test tube. **A** evolved a colourless gas which turned lead acetate paper black and **B** evolved a gas which turned lime water milky. The anions in **A** and **B** respectively are :
(A) SO_3^{2-}, CO_3^{2-} (B) S^{2-}, CO_3^{2-} (C) PO_4^{3-}, HSO_3^- (D) S^{2-}, NO_3^-

C-3. If addition of conc. H_2SO_4 is made to an unknown salt, a colourless and odourless gas is produced then which of the following can be present ?
(A) CO_3^{2-} (B) S^{2-} (C) Cl^- (D) NO_3^-

C-4. A gas turns lime water milky and acidified $K_2Cr_2O_7$ solution green then gas is :
(A) HCl (B) H_2S (C) SO_2 (D) CO_2

C-5. A gas has smell like rotten egg and turns lead acetate paper black. The gas is :
(A) NO_2 (B) H_2S (C) CO_2 (D) SO_2

C-6.



Anion (X^{2-}) is:
(A) CO_3^{2-} (B) SO_3^{2-} (C) S^{2-} (D) $S_2O_3^{2-}$

C-7. The acidic solution of a salt produces blue colour with KI starch solution. The reaction indicates the presence of :
(A) Sulphite (B) Bromide (C) Nitrite (D) Chloride

C-8. Sulphide ion reacts with $Na_2[Fe(CN)_5NO]$ to form a purple coloured compound (X). In this reaction oxidation state of iron.
(A) changes from +2 to +3 (B) changes from +3 to +2
(C) changes from +2 to +4 (D) does not change.

Section (D) : Conc. H_2SO_4 group

D-1. Which of the following pair of anions are identified by conc. H_2SO_4.
(A) NO_3^-, CO_3^{2-} (B) Cl^-, NO_3^- (C) Br^-, CO_3^{2-} (D) CO_3^{2-}, CH_3COO^-

D-2. Which of the following anion behaves in a different manner than other on heating with conc. H_2SO_4?
(A) Cl^- (B) I^-
(C) Br^- (D) All behave in a similar manner

D-3. Which of the following reagents turns white precipitate of AgCl yellow ?
(A) $NaNO_3$ (B) Na_3AsO_3 (C) Na_3AsO_4 (D) NaCN

D-4. A Unknown salt **(S)** when heated with dil. H_2SO_4 does not evolve brown vapours but with conc. H_2SO_4 brown vapours are obtained. The vapours when brought in contact with $AgNO_3$ solution do not give any precipitate. The salt **(S)** contains.
(A) NO_2^- (B) NO_3^- (C) I^- (D) Br^-

D-5. When a mixture of solid NaCl and solid $K_2Cr_2O_7$ is heated with concentrated H_2SO_4, deep red vapours are obtained. This is due to the formation of :
(A) chromous chloride (B) chromyl chloride (C) chromic chloride (D) chromic sulphate

D-6. AgCl dissolves in ammonia solution giving :
(A) Ag^+, NH_4^+ and Cl^- (B) $[Ag(NH_3)]^+$ and Cl^-
(C) $[Ag_2(NH_3)]^{2+}$ and Cl^- (D) $[Ag(NH_3)_2]^+$ and Cl^-

D-7. A mixture upon adding conc. H_2SO_4 gives deep red fumes. Mixture may contain the anions pair :
(A) $Cr_2O_7^{2-}$ and Cl^- (B) Br^- and $Cr_2O_7^{2-}$ (C) NO_3^- and Cl^- (D) CrO_4^{2-} and NO_3^{2-}

D-8. A solution of a salt in concentrated H_2SO_4 produced a deep blue colour with starch iodide solution. The salt may contain :
(A) chloride (B) carbonate (C) acetate (D) bromide

D-9. A colourless solution of a compound gives a precipitate with $AgNO_3$ solution but no precipitate with a solution of Na_2CO_3. The action of concentrated H_2SO_4 on the compound liberates a suffocating reddish brown gas. The compound is :
(A) $Ba(CH_3COO)_2$ (B) $CaCl_2$ (C) NaI (D) NaBr

D-10. Which of the following gas turn starch iodide paper blue?
(A) CO_2 (B) SO_2 (C) NO_2 (D) H_2S

D-11. 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) $FeSO_4 .NO_2$

Section (E) : Precipitation Reactions

E-1. When a mixture containing phosphate is heated with conc. HNO_3 and ammonium molybdate solution, a canary yellow precipitate is formed. The formula of the yellow precipitate is :
(A) $(NH_4)_3PO_4$ (B) $(NH_4)_3PO_4.12MoO_4$ (C) $(NH_4)_3PO_4.12MoO_3$ (D) $(NH_4)_3PO_4.(NH_4)_2MO_4$

E-2. A metal salt solution gives a yellow precipitate with silver nitrate. The precipitate dissolves in dil. Nitric acid as well as in ammonium hydroxide. The solution contains.
(A) Br^- (B) I^- (C) PO_4^{3-} (D) SO_4^{2-}

PART - III : MATCH THE COLUMN

1. Match the anions with the changes observed on qualitative analysis :

	Column-I		Column-II
(A)	SO_4^{2-}	(p)	Canary yellow ppt. with ammonium molybdate.
(B)	NO_3^-	(q)	Brown ring test.
(C)	NO_2^-	(r)	White ppt. with $BaCl_2$ solution.
(D)	PO_4^{3-}	(s)	Yellow ppt. with $AgNO_3$ solution.
		(t)	White ppt. with $AgNO_3$ solution.

2. Match the reagent which are used in qualitative analysis of given anions :

	Column-I		**Column-II**
(A)	$AgNO_3$ solution	(p)	CO_3^{2-}
(B)	$BaCl_2$ solution	(q)	Cl^-
(C)	$Pb(NO_3)_2$ solution	(r)	S^{2-}
(D)	Acidified $KMnO_4$ solution	(s)	NO_2^-

Exercise-2

Marked questions are recommended for Revision.

PART - I : ONLY ONE OPTION CORRECT TYPE

1. The compound formed in the borax bead test of Cu^{2+} ion in oxidising flame is :
(A) Cu (B) $CuBO_2$ (C) $Cu(BO_2)_2$ (D) None of these

2. A fire work gave bright crimson red light. It probably contained a salt of :
(A) Ca (B) Sr (C) Ba (D) Mg

3. Alkali metal salt "X" gives a pale violet colour in flame test "X" is :
(A) NaCl (B) LiCl (C) KCl (D) None of these

4. Borax bead is responded generally by :
(A) Alkali metal salt (B) Alkaline earth metals
(C) p-block metal salt (D) d-block metal salt

5. Salt of Anion A
- $\xrightarrow{\text{dil. } H_2SO_4}$ Colourless gas with brick effervescence
- $\xrightarrow{AgNO_3}$ White ppt $\xrightarrow{\text{boil}}$ Turns black
- $\xrightarrow[K_2Cr_2O_7]{\text{Acidic}}$ Green colour

Shape of anion A will be :
(A) Tetrahedral (B) Trigonal planer
(C) Trigonal pyramidal (D) Linear

6. Which of the following anions are producing same gas on treatment with (Zn + dil. H_2SO_4).
I : SO_3^{2-} II : HSO_3^- III : S^{2-} IV : Cl^-
(A) I and II only (B) I, II and III only
(C) I, II, III and IV (D) I, III and IV only

7. Consider the following reaction; Nitrite + Acetic acid + Thiourea $\longrightarrow N_2\uparrow + HSCN + 2H_2O$. Formation of the product in the above reaction can be identified by :
(A) $FeCl_3$ / dilute HCl, when blood red colour appears.
(B) $FeCl_3$ / dilute HCl, when blue colour appears.
(C) $K_2Cr_2O_7$ / HCl, when green colour appears.
(D) $KMnO_4$ / HCl, when colourless solution is formed.

8. 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) CO_3^{2-} (B) Cl^- (C) SO_3^{2-} (D) S^{2-}

9. A salt solution of Cd^{2+} in dilute HCl, on treatment with a solution of $BaCl_2$ gives a white precipitate, which is insoluble in concentrated HNO_3. Anion in the salt may be :
(A) SO_4^{2-} (B) CO_3^{2-} (C) NO_2^- (D) S^{2-}

10. $Na_2SO_4 + BaCl_2 \longrightarrow$ White precipitate $\xrightarrow{\text{Fuse this precipitate on charcoal with } Na_2CO_3 \text{ and extract the soluble substance with } H_2O}$ Aqueous solution.

Add dil H_2SO_4 and heat the solution

Gas 'G' is evolved

The gas 'G' will show which of the following property ?
(A) It turns lead acetate filter paper black.
(B) It turns acidified $K_2Cr_2O_7$ filter paper green.
(C) It produces purple colouration on filter paper moistened with sodium nitroprusside already made alkaline with sodium hydroxide.
(D) All of these

11. Sodium borate on reaction with conc. H_2SO_4 and C_2H_5OH gives a compound **(A)** which burns with a green edged flame. The compound **(A)** is :
(A) $H_2B_4O_7$ (B) $(C_2H_5)_2B_4O_7$ (C) H_3BO_3 (D) $(C_2H_5)_3BO_3$

PART - II : SINGLE AND DOUBLE VALUE INTEGER TYPE

1. How many compounds liberate NH_3 on heating from the following?
(i) $(NH_4)_2SO_4$ (ii) $(NH_4)_2CO_3$ (iii) NH_4Cl
(iv) NH_4NO_3 (v) $(NH_4)_2Cr_2O_7$

2. How many of following metals impart a characteristic colour to the Bunsen flame ?
(i) Na (ii) Li (iii) K (iv) Ba
(v) Sr (vi) Mg (vii) Rb (viii) Cs
(ix) Be (x) Ca (xi) Cu

3. Number of ions which are identified by dil. HCl from the following.
(i) SO_4^{2-} (ii) CO_3^{2-} (iii) SO_3^{2-} (iv) HCO_3^-
(v) NO_2^- (vi) NO_3^- (vii) CH_3COO^- (viii) PO_4^{3-}

4. Find the total number of acidic radical which produce volatile product with dil HCl :
(i) SO_4^{2-} (ii) I^- (iii) NO_2^- (iv) NO_3^-
(v) SO_3^{2-} (vi) HCO_3^-

5. $Na_2S + Na_2[Fe(CN)_5NO] \longrightarrow$ "X" (Violet colour)
The total number of possible isomers for complex "X" is, provided the ambident behaviour of CN^- is not considered.

6. NaCl + Solid $K_2Cr_2O_7$ + Conc. $H_2SO_4 \longrightarrow$ "X" (reddish brown fumes)
How many axial-d-orbital are involved in hybridization of "X" ?

7. $Fe^{2+} + NO_3^- + H_2SO_4$(conc.) $\rightarrow$ 'X' (Brown ring complex)
The magnetic moment of complex 'X' to its nearest integer is :

8. How many anions evolve brownish gas when treated with dil./conc. HCl ?
(i) CO_3^{2-} (ii) SO_3^{2-} (iii) NO_2^- (iv) Cl^-
(v) Br^- (vi) NO_3^- (vii) CH_3COO^-

9. Na_2CO_3, NaCl, $NaNO_2$, Na_2SO_3, NaBr, CH_3COONa are separately treated with $AgNO_3$ solution. In How many cases white precipitate is/are obtained.

10. BO_3^{3-} + conc. $H_2SO_4 + CH_3CH_2–OH \xrightarrow{\text{ignite}}$ 'A' (green flame)
What is the oxidation number of central atom in Compound 'A' that is responsible for green flame ?

11. $NaCl\ (s) \xrightarrow{MnO_2 / Conc.H_2SO_4} X\ (g)$

$NaCl\ (s) \xrightarrow{K_2Cr_2O_7 / Conc.\ H_2SO_4} Y\ (g)$

a = difference in the oxidation number of Cl in the product X and product Y, respectively
b = total number of atom in X and Y
c = total number of lone pair in X
then calculate a + b + c = ?

PART - III : ONE OR MORE THAN ONE OPTION CORRECT TYPE

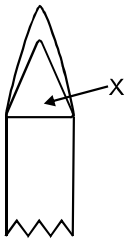
1. Which of the following salt liberates a colourless gas on acidification with dil. H_2SO_4 ?
(A) KNO_2 (B) Na_2CO_3 (C) $NaNO_2$ (D) $NaHCO_3$

2. Which of the following salts release reddish brown gas when heated in a dry test tube?
(A) $LiNO_3$ (B) KNO_3 (C) $Pb(NO_3)_2$ (D) $AgNO_3$

3. Which of the following can decompose on heating to give CO_2?
(A) Li_2CO_3 (B) Na_2CO_3 (C) $KHCO_3$ (D) $BaCO_3$

4. Metals which do not give flame test?
(A) Be (B) Li (C) Mg (D) Ba

5. In the following diagram bunsen flame the (X) represent.



(A) Oxidising zone
(B) Reducing zone
(C) Lower temperature zone
(D) Hottest portion of flame

6. Metal salts, which respond to Borax bead test?
(A) Nickel salts (B) Copper salts (C) Cobalt salts (D) Aluminium salts

7. Which of the following gases turn lime water milky when passed throught it.
(A) SO_2 (B) CO_2 (C) HCl (D) H_2S

8. A (mixture of two anions) $\xrightarrow{AgNO_3 \text{ solutions}}$ "B" (White crystalline precipitate)

A (mixture of two anions) $\xrightarrow{Zn+dil/H_2SO_4}$ C (g) $\xrightarrow{(CH_3COO)_2Pb}$ "D" (Black ppt.)

Then A may have :
(A) CO_3^{2-}, Br^- (B) Br^-, S^{2-} (C) CH_3COO^-, S^{2-} (D) CH_3COO^-, SO_3^{2-}

9. S^{2-} and SO_3^{2-} can be distinguished by :
(A) $(CH_3COO)_2Pb$
(B) $Cr_2O_7^{2-}$ / H^+
(C) $Na_2[Fe(CN)_5NO]$
(D) Zn + dil. H_2SO_4 followed by $(CH_3COO)_2Pb$

10. Which statements is/ are correct about **sodium nitroprusside** test?
(A) This test is used for detection of S^{2-} anion.
(B) H_2S also gives positive test.
(C) Formation of $Na_2[Fe(H_2O)_5NOS]$ complex confirm the presence of S^{2-} anion.
(D) Iron has +2 oxidation state in sodiumthionitroprusside complex.

11. Which statement(s) is/are correct about **Brown ring test** ?
(A) This test is given by NO_2^-, NO_3^- anions.
(B) Brown ring test depend upon the reduction of NO_2^- and NO_3^- to Nitric oxide.
(C) Brown ring is formed due to formation of $[Fe(H_2O)_5NO]_2(SO_4)_3$
(D) Charge on NO in brown ring complex is +1.

12. Which of the following metal chloride will give chromyl chloride test ?
(A) NaCl (B) KCl (C) AgCl (D) $SbCl_3$

13. Which of the following will be completely or partially dissolved in NH_4OH ?
(A) AgCl (B) AgBr (C) AgI (D) $BaSO_4$

14. Reddish-brown gas is obtained when the following are treated with conc. H_2SO_4?
(A) Br^- (B) NO_2^- (C) NO_3^- (D) SO_3^{2-}

15. Each of these are added to a mixture of aqueous solutions of iodide and $CHCl_3$ separately. Which will give a positive test for iodine when the solutions are vigorously mixed?
(A) NaCl solution (B) NaBr solution (C) Chlorine water (D) Bromine water

16. $\underset{\text{(mixture of two anions)}}{\overset{\mathbf{A}}{}} \xrightarrow[\text{excess of } BaCl_2]{\text{Cold}}$ white ppt. $\xrightarrow{\text{filtered}}$ (Filtrate) $\xrightarrow{\text{boil}}$ White ppt $\downarrow$.

Anion of **(A)** could be :
(A) SO_3^{2-}, HSO_3^- (B) CO_3^{2-}, SO_3^{2-} (C) SO_3^{2-}, HCO_3^- (D) None of these

PART - IV : COMPREHENSION

*** Marked Questions may have more than one correct option.**
Read the following passage carefully and answer the questions.

Comprehension # 1

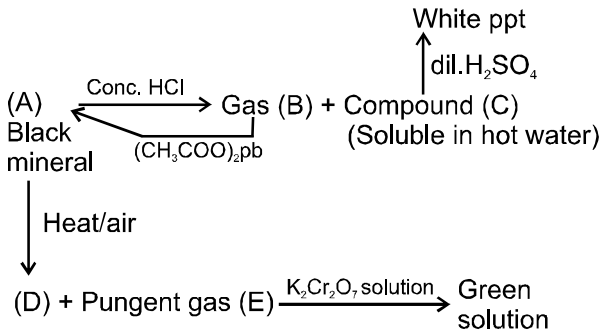
Step-I **Step-II** **Step-III**

$$\underset{(\text{chloride salt})}{A} \xrightarrow[\text{conc. } H_2SO_4]{K_2Cr_2O_7} B \xrightarrow[\text{dil NaOH solution}]{\text{passed through}} C \xrightarrow[\& \, Pb(CH_3COO)_2 \text{ is added}]{\text{acidified with } CH_3COOH} D$$

1. 'A' can be :
(A) $PbCl_2$ (B) $SbCl_3$ (C) $SnCl_2$ (D) RbCl

2.* In step-III if $Pb(CH_3COO)_2$ is added without acidifying the solution with CH_3COOH then possible product may be:
(A) $PbCrO_4$ (B) $Na_2Cr_2O_7$ (C) Na_2CrO_4 (D) Na_2PbO_2

Comprehension # 2



3. Gas (B) on passing through cadmium acetate solution will give :
(A) Black ppt (B) Yellow ppt (C) Orange ppt (D) White ppt

4. Gas (B) and (E) are respectively :
(A) H_2S, NH_3 (B) H_2S, SO_2 (C) SO_2, H_2S (D) H_2S, CO_2

Comprehension # 3

Answer Q.5, Q.6 and Q.7 by appropriately matching the information given in the three columns of the following table.

In the following three tables, information regarding Qualitative analysis of anion is given					
Column-1		**Column-2**		**Column-3**	
(I)	SO_3^{2-}	(i)	Reaction with $AgNO_3$	(P)	Precipitate is obtained
(II)	Cl^-	(ii)	Pungent smelling product with conc. H_2SO_4	(Q)	Product is coloured gas.
(III)	NO_2^-	(iii)	Form X_2 with $K_2Cr_2O_7$(s) + conc. H_2SO_4	(R)	Product formed is soluble in excess NH_3.
(IV)	Br^-	(iv)	Reaction with $Pb(NO_3)_2$(aq)	(S)	Product gives blue colour with starch iodide solution.

5. Select the only correct option.
(A) (I) (i) (P) (B) (II) (ii) (Q) (C) (I) (ii) (S) (D) (II) (iii) (Q)

6. Select the only incorrect option.
(A) (III) (i) (P) (B) (I) (ii) (Q) (C) (IV) (i) (R) (D) (IV) (ii) (Q)

7. Select the only incorrect option.
(A) (III) (ii) (Q) (B) (IV) (ii) (S) (C) (II) (iv) (P) (D) (II) (ii) (S)

Exercise-3

*** Marked Questions may have more than one correct option.**

PART - I : JEE (ADVANCED) / IIT-JEE PROBLEMS (PREVIOUS YEARS)

1. The acidic aqueous solution of Ferrous ion forms a brown complex in the presence of NO_3^- by the following two steps : **[JEE 1993]**
$[Fe(H_2O)_6]^{2+} + NO_3^- + H^+ \longrightarrow$ ..... + $[Fe(H_2O)_6]^{3+} + H_2O$
$[Fe(H_2O)_6]^{2+}$ + ... + H_2O
Complete and balance the equations.

2. In nitroprusside ion the iron and NO exist. They exist as Fe^{II} and NO^+ rather than Fe^{III} and NO. These forms can be differentiated by : **[JEE 1998]**
(A) estimating the concentration of Iron.
(B) measuring the concentration of CN.
(C) measuring the solid state magnetic moment.
(D) thermally decomposing the compound.

3. **Assertion :** Sulphate is estimated as $BaSO_4$ and not as $MgSO_4$.
Reason : Ionic radius of Mg^{2+} is smaller than that of Ba^{2+}. **[JEE 1998]**
(A) Both Assertion and Reason are true and Reason is the correct explanation of Assertion.
(B) Both Assertion and Reason are true but Reason is not correct explanation of Assertion.
(C) Assertion is true but Reason is false.
(D) Assertion is false but Reason is true.

4. A gas 'X' is passed through water to form a saturated solution. The aqueous solution on treatment with silver nitrate gives a white precipitate. The saturated aqueous solution also dissolves magnesium ribbon with evolution of a colourless gas 'Y'. Identify 'X' and 'Y'? **[JEE 2002(S), 3/90]**
(A) X = CO_2, Y = Cl_2 (B) X = Cl_2, Y = CO_2 (C) X = Cl_2, Y = H_2 (D) X = H_2, Y = Cl_2

5. [X] + $H_2SO_4 \longrightarrow$ [Y] a colourless gas with irritating smell;
[Y] + $K_2Cr_2O_7$ + $H_2SO_4 \longrightarrow$ green solution.
[X] and [Y] is : **[JEE 2003(S), 3/84]**
(A) SO_3^{2-}, SO_2 (B) Cl^-, HCl (C) S^{2-}, H_2S (D) CO_3^{2-}, CO_2

6. A dilute aqueous solution of a sodium salt forms white precipitate with $MgCl_2$, only after boiling. The anion of the sodium salt is : **[JEE 2004(S), 3/84]**
(A) HCO_3^- (B) CO_3^{2-} (C) NO_3^- (D) SO_4^{2-}

7. The species present in solution when CO_2 is dissolved in water are : **[JEE 2006, 5/184]**
(A) CO_2, H_2CO_3, HCO_3^-, CO_3^{2-} (B) HCO_3^-, CO_3^{2-}
(C) CO_3^{2-}, HCO_3^- (D) CO_2, H_2CO_3

8.* 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, 4/120]**
(A) $CuCl_2$ (B) $BaCl_2$ (C) $Pb(OOCCH_3)_2$ (D) $Na_2[Fe(CN)_5NO]$

PART - II : JEE (MAIN) / AIEEE PROBLEMS (PREVIOUS YEARS)

JEE(MAIN) ONLINE PROBLEMS

1. Sodium extract is heated with concentrated HNO_3 before testing for halogens because : **[JEE(Main) 2016 Online (10-04-16), 4/120]**
(1) Ag reacts faster with halides in acidic medium.
(2) Silver halides are totally insoluble in nitric acid.
(3) Ag_2S and AgCN are soluble in acidic medium.
(4) S^{2-} and CN^-, if present, are decomposed by conc. HNO_3 and hence do not interfere in the test.

2. 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 aforementioned solution, a white precipitate is obtained which does not dissolve in dilute nitric acid. The anion is : **[JEE(Main) 2018 Online (15-04-18), 4/120]**
(1) CO_3^{2-} (2) SO_4^{2-} (3) S^{2-} (4) Cl^-

Answers

EXERCISE - 1

PART - I

A-1. The dry test give information in short time and also provides a clue about the presence or absence of certain substances so wet analysis may be modified and shortened.
It is applicable to solid substances.

A-2. (a) $HgCO_3 \xrightarrow{\Delta} Hg + CO_2\uparrow + \frac{1}{2}O_2\uparrow$

(b) $NH_4NO_2 \xrightarrow{\Delta} N_2\uparrow + 2H_2O\uparrow$ (no solid residue)

(c) $NH_4Cl + NaNO_3$ (mixture) $\xrightarrow{\Delta} NaCl + N_2O\uparrow + 2H_2O\uparrow$

(d) $Pb(NO_3)_2 \xrightarrow{\Delta} PbO + 2NO_2\uparrow + \frac{1}{2}O_2\uparrow$

B-1. When compound is heated, the electrons gain energy and can jump into the empty orbitals at higher level. Higher levels are energetically unstable so electrons tend to fall back and transmit the light as characteristic colour.

B-2. Yes, because intensity of the absorbed light is proportional to the concentration of element in the flame.

B-3. Both barium sulphate and barium phosphate are insoluble and cannot be easily converted into chlorides.Therefore, the green flame is either indistinct or visible with difficulty.

B-4. $Na_2B_4O_7.10H_2O \xrightarrow[740°C]{\Delta} 2NaBO_2 + B_2O_3 \xrightarrow{Cu^{2+},\Delta} Cu(BO_2)_2$

(A) (B+C) (Blue bead) (D)

C-1. Sodium carbonate extract in addition to the sodium salts of anions contain carbonate also. On heating with the test reagent carbonates of certain metals precipitate which interfere in the detection of acid redicals. Because of this, Na_2CO_3 is decomposed by adding HCl, HNO_3, H_2SO_4, depending upon the nature of test.

C-2. No, because it already contains CO_3^{2-} ions.

C-3. White precipitate of $CaCO_3$ is formed.
$Ca(HCO_3)_2 + 2\,NH_3 \longrightarrow (NH_4)_2CO_3 + CaCO_3\downarrow$

C-4. Colour of bromine water is discharged according to the following reaction.
$BaSO_3 + Br_2 + H_2O \longrightarrow BaSO_4\downarrow$ (white) $+ 2HBr$

C-5. (A) = SO_3^{-2} (C) = HSO_3^- (Lime water test)

C-6. **(a)** Blue colouration develops due to the formation of iodine gas.

$5\,SO_2 + 2IO_3^- + 4\,H_2O \longrightarrow I_2 + 5\,SO_4^{2-} + 2\,H^+$

I_2 + Starch $\longrightarrow$ Blue (starch iodine adsorption complex)

(b) Black precipitate is formed owing to the formation of PbS.

$[Pb(OH)_4]|^{2-} + H_2S \longrightarrow PbS\downarrow + 2OH^- + 2\,H_2O$

(c) $SO_3^{2-} + 3\,Zn + 8\,H^+ \longrightarrow H_2S + 3\,Zn^{2+} + 3\,H_2O$

C-7. $NO_2^- + CH_3COOH \longrightarrow HNO_2 + CH_3COO^-$

$3\,HNO_2 \longrightarrow H_2O + HNO_3 + 2\,NO\uparrow$

$NO\uparrow + Fe^{2+} + SO_4^{2-} \longrightarrow [FeNO]SO_4$ (Nitroso ferrous sulphate)

D-1. There are some ions like, SO_3^{2-}, S^{2-}, NO_2^- and CH_3COO^- which can react with dilute/conc. H_2SO_4 whereas ions like Cl^- , Br^-, I^- , $NO_3^{\ominus}$, etc. react only with con. H_2SO_4.
Now if conc. H_2SO_4 is used first then the anions of both the types will react. Hence, it is desired to test acid radicals first with dilute H_2SO_4 and then with conc. H_2SO_4.

D-2. Because in presence of water, chromyl chloride forms the chromic acid.
$$CrO_2Cl_2 + 2H_2O \longrightarrow H_2CrO_4 + 2HCl$$

D-3. Because chromyl bromide (CrO_2Br_2) and chromyl iodide. (CrO_2I_2) compounds are unstable and are not formed. In such case bromine and iodine are evolved

D-4. HBr and HI are reducing agent where as H_2SO_4 is oxidizing agent and thus Br_2 and I_2 are formed.
$NaCl + H_2SO_4 \rightarrow NaHSO_4 + HCl$
$NaBr / NaI + H_2SO_4 \rightarrow NaHSO_4 + HBr/HI$
$HBr/HI + H_2SO_4 \rightarrow Br_2/I_2 + SO_2 + 2H_2O$

D-5. Because in presence of water chromic acid is obtained in place of chromyl chloride.

D-6. A = Cl_2 ; B = Br_2 ; C = I_2

D-7. Because heavy metal chlorides are partially dissociated. This test is given generally by Ionic chloride.

D-8. This is because Fe^{2+} ions on long standing are oxidised to Fe^{3+} ions which are not used for the detection of nitrate and nitrite.

E-1. Because they also impart green colour to flame.

E-2. Not in dilute HCl but dissolves in all other reagents.
$PbSO_4 \downarrow + H_2SO_4 \longrightarrow Pb^{2+} + 2\ HSO_4^-$; $PbSO_4 \downarrow + 4\ CH_3COO^- \longrightarrow [Pb(CH_3COO)_4]^{2-} + SO_4^{2-}$
$PbSO_4 \downarrow + 2\ C_6H_4O_6^{2-} \longrightarrow [Pb(C_6H_4O_6)_2]^{2-} + SO_4^{2-}$
$PbSO_4 \downarrow + 4\ OH^- \longrightarrow [Pb(OH)_4]^{2-} + SO_4^{2-}$

E-3. $BaCl_2$ gives a white precipitate. with both sulphite and sulphate ions.
$BaSO_3$ is soluble in conc.HCl whereas $BaSO_4$ is insoluble in conc.HCl.
$SO_3^{2-} + MnO_4^- + H^+ \longrightarrow Mn^{2+}$ (colourless)
$SO_4^{2-} + MnO_4^- + H^+ \longrightarrow$ (No colour change)

PART - II

A-1.	(B)	**A-2.**	(B)	**A-3.**	(C)	**A-4.**	(D)	**A-5.**	(D)
B-1.	(C)	**B-2.**	(B)	**B-3.**	(A)	**B-4.**	(B)	**B-5.**	(D)
B-6.	(C)	**B-7.**	(C)	**C-1.**	(C)	**C-2.**	(B)	**C-3.**	(A)
C-4.	(C)	**C-5.**	(B)	**C-6.**	(C)	**C-7.**	(C)	**C-8.**	(D)
D-1.	(B)	**D-2.**	(A)	**D-3.**	(B)	**D-4.**	(B)	**D-5.**	(B)
D-6.	(D)	**D-7.**	(A)	**D-8.**	(D)	**D-9.**	(D)	**D-10.**	(C)
D-11.	(B)	**E-1.**	(C)	**E-2.**	(C)				

PART - III

1. (A) - (r,t); (B) - (q); (C) - (q,t); (D) - (p,r,s)

2. (A) - (p,q,r,s); (B) - (p); (C) - (p,q,r); (D) - (q,r,s)

EXERCISE - 2

PART - I

1.	(C)	**2.**	(B)	**3.**	(C)	**4.**	(D)	**5.**	(C)
6.	(B)	**7.**	(A)	**8.**	(B)	**9.**	(A)	**10.**	(D)
11.	(D)								

PART - II

1.	3 (i, ii, iii)	**2.**	9 (All, except vi and ix)			**3.**	5 (ii, iii, iv, v, vii)
4.	3 (iii, v, vi)	**5.**	3	**6.**	0	**7.**	4
8.	1 (only iii)	**9.**	5 (All except NaBr)			**10.**	3
11.	14 (a = 1, b = 7, c = 6)						

PART - III

1.	(BD)	**2.**	(ACD)	**3.**	(ACD)	**4.**	(AC)	**5.**	(BC)
6.	(ABC)	**7.**	(AB)	**8.**	(D)	**9.**	(ABC)	**10.**	(AD)
11.	(ABD)	**12.**	(AB)	**13.**	(ABC)	**14.**	(ABC)	**15.**	(CD)
16.	(AC)								

PART - IV

1.	(D)	**2.**	(AD)	**3.**	(B)	**4.**	(B)	**5._**	(A)
6._	(B)	**7._**	(D)						

EXERCISE - 3

PART - I

1. $3[Fe(H_2O)_6]^{2+} + NO_3^- + H^+ \longrightarrow NO + 3[Fe(H_2O)_6]^{3+}$

$[Fe(H_2O)_6]^{2+} + NO \longrightarrow [Fe(H_2O)_5NO]^{2+} + H_2O$

2.	(C)	**3.**	(B)	**4.**	(C)	**5.**	(A)	**6.**	(A)
7.	(A)	**8.***	(A or AC)						

PART - II

JEE(MAIN) ONLINE PROBLEMS

1.	(4)	**2.**	(4)

Additional Problems for Self Practice (APSP)

✍ **Marked questions are recommended for Revision.**

This Section is not meant for classroom discussion. It is being given to promote self-study and self testing amongst the Resonance students.

PART - I : PRACTICE TEST-1 (IIT-JEE (MAIN Pattern))

Max. Time : 1 Hr. **Max. Marks : 120**

Important Instructions

1. The test is of **1 hour** duration.
2. The Test Booklet consists of **30** questions. The maximum marks are **120.**
3. Each question is allotted **4 (four)** marks for correct response.
4. Candidates will be awarded marks as stated above in Instructions No. 3 for correct response of each question. ¼ **(one fourth)** marks will be deducted for indicating incorrect response of each question. No deduction from the total score will be made if no response is indicated for an item in the answer sheet.
5. There is only one correct response for each question. Filling up more than one response in any question will be treated as wrong response and marks for wrong response will be deducted accordingly as per instructions 4 above.

1. When a salt is heated with dilute H_2SO_4 and $KMnO_4$ solution, the pink colour of $KMnO_4$ is discharged, the salt is :
(1) a sulphite (2) a carbonate (3) a nitrate (4) a bicarbonate

2. Solution of a salt in dilute H_2SO_4 or acetic acid produces deep blue colour with starch iodide solution. The salt contains :
(1) Br^- (2) I^- (3) Cl^- (4) NO_2^-

3. A test tube containing a nitrate and another containing a bromide and MnO_2 are treated with concentrated H_2SO_4. The reddish brown fumes evolved are passed through water. The water will be coloured by :
(1) the nitrate (2) the bromide (3) both (4) none of the two

4. Which of the following combines with Fe(II) ions to form a brown complex?
(1) N_2O (2) NO (3) N_2O_5 (4) N_2O_4

5. Colourless salt (A) + dil. H_2SO_4 or CH_3COOH + KI $\longrightarrow$ blue colour with starch. (A) can be
(1) K_2SO_3 (2) Na_2CO_3 (3) NH_4NO_2 (4) NH_4Cl

6. There are four test tubes containing dilute HCl, $BaCl_2$, $HgCl_2$ and KNO_3 solutions. Which of the following reagents will help in the identification of $BaCl_2$?
(1) NaOH (2) K_2CrO_4 (3) $AgNO_3$ (4) both (2) and (3)

7. Which one of the following ions does not give borax bead test ?
(1) Cr^{3+} (2) Cu^{2+} (3) Mn^{2+} (4) Zn^{2+}

8. A brick red colour is imparted to Bunsen flame by a :
(1) Ca salt (2) Sr salt (3) Na salt (4) Co salt

9. Which one of the following metal salts produces a blue coloured bead in cobalt nitrate charcoal cavity test ?
(1) Zn^{2+} (2) Mg^{2+} (3) Sn^{2+} (4) Al^{3+}

10. $BaCl_2$ solution gives a white precipitate with a solution of a salt, which dissolves in dilute hydrochloric acid with the evolution of colourless, pungent smelling gas. The gas as well as the salt both are used as bleaching agent in the textile industries. The salt contains:
(1) sulphite (2) sulphide (3) acetate (4) carbonate

11. Pink colour of acidified $KMnO_4$ is decolourised but there is no evolution of any gas. This may happen with the compound containing the following acid radical.
(1) SO_3^{2-} (2) NO_2^- (3) S^{2-} (4) All of these

12. When KI is added to acidified solution of sodium nitrite :
(1) NO gas is liberated and I_2 is set free (2) N_2 gas is liberated and HI is produced
(3) N_2O gas is liberated and I_2 is set free (4) N_2 gas is liberated and HOI is produced

13. Zinc pieces are added to acidified solution of SO_3^{2-}. Gas liberated can :
(1) turn lead acetate paper black (2) turn lime water milky
(3) give white precipitate with $AgNO_3$ solution (4) None of these

14. A substance on treatment with dilute 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 :
(1) CO_3^{2-} (2) S^{2-} (3) SO_3^{2-} (4) NO_2^-

15. Ammonium molybdate test is used for the estimation of :
(1) PO_4^{3-} (2) NO_3^- (3) SO_3^{2-} (4) SO_4^{2-}

16. A colourless gas is dissolved in water and the resulting solution turns red litmus blue; the gas may have been which one of the following ?
(1) HCl (2) H_2S (3) SO_2 (4) NH_3

17. When Ag reacts with conc. HCl, then products will be:
(1) AgCl, Cl_2 (2) AgCl, H_2 (3) AgCl, H_2, Cl_2 (4) None of these

18. Which of the following salt will evolve sulphur dioxide gas along with formation of yellowish turbidity when treated with dilute H_2SO_4 ?
(1) Sodium sulphide (2) Sodium sulphite
(3) Sodium thiosulphate (4) Sodium sulphate

19. Aqueous solution of a salt + $MgSO_4$ solution $\longrightarrow$ no precipitate in cold $\xrightarrow{\text{Heating}}$ White precipitate appears. The salt contains the acidic radical :
(1) CO_3^{2-} (2) HCO_3^- (3) SO_3^{2-} (4) $C_2O_4^{2-}$

20. In the test for iodine, I_2 is treated with sodium thiosulphate ($Na_2S_2O_3$) :
$Na_2S_2O_3 + I_2 \longrightarrow NaI + ...$
(1) $Na_2S_4O_6$ (2) Na_2SO_4 (3) Na_2S (4) Na_3ISO_4

21. With Cr_2O_3, colour of the bead in sodium carbonate bead test is :
(1) red (2) blue (3) yellow (4) green

22. Which metal gives violet colour in oxidising flame when heated with borax ?
(1) Fe (2) Pb (3) Co (4) Mn

23. KBr, on reaction with conc. H_2SO_4, gives reddish-brown gas :
(1) Bromine (2) Mixture of bromine and HBr
(3) HBr (4) NO_2

24. An inorganic salt when heated evolves coloured gas which bleaches moist litmus paper. The evolved gas is :
(1) NO_2 (2) SO_2 (3) N_2O (4) I_2

25. Which of the following halide is soluble in water ?
(1) AgF (2) AgCl (3) AgBr (4) AgI

26. Which of the following radical can not be confirmed by using dil. HCl :
(1) S^{2-} (2) $S_2O_3^{2-}$ (3) NO_3^- (4)

27. When $K_2Cr_2O_7$ is heated with conc. H_2SO_4 and soluble chloride such as KCl :
(1) red vapours of CrO_2Cl_2 are evolved (2) Cl^- ion is oxidized to Cl_2 gas
(3) $CrCl_3$ is formed (4) $Cr_2O_7^{2-}$ ion is reduced to green Cr^{3+} ion

28. A white solid imparts a violet colour to a Bunsen flame. On being heated with concentrated H_2SO_4, the solid gives violet vapours that turn starch paper blue. The salt may be :
(1) KI (2) NaI (3) MgI_2 (4) $CaBr_2$

29. NaCl, NaBr, NaI mixture on adding conc. H_2SO_4 gives gases, respectively :
(1) HCl, HBr, HI (2) HCl, Br_2, I_2 (3) Cl_2, Br_2, I_2 (4) None of these

30. Potassium chromate solution is added to an aqueous solution of a metal chloride. The yellow precipitate thus obtained is insoluble in acetic acid. The precipitate is subjected to flame test, the colour of the flame is:
(1) lilac (2) apple green (3) crimson red (4) brick red

Practice Test-1 (IIT-JEE (Main Pattern))

OBJECTIVE RESPONSE SHEET (ORS)

Que.	1	2	3	4	5	6	7	8	9	10
Ans.										
Que.	11	12	13	14	15	16	17	18	19	20
Ans.										
Que.	21	22	23	24	25	26	27	28	29	30
Ans.										

PART - II : NATIONAL STANDARD EXAMINATION IN CHEMISTRY (NSEC) STAGE-I

1. Which of the metal chloride is insoluble in cold water but dissolves in hot water ? **[NSEC-2002]**
(A) $BiCl_3$ (B) $SnCl_4$ (C) $PbCl_2$ (D) AgCl.

2. A colourless salt when heated imparts lilac colour to the bunsen flame. It turns red litmus blue. The salt is **[NSEC-2004]**
(A) Na_2CO_3 (B) KNO_3 (C) $NaNO_3$ (D) K_2CO_3.

3. The brown compound formed in the ring test for nitrates contains the ion **[NSEC-2005]**
(A) $[Fe(H_2O)_5NO]^{3+}$ (B) $[Fe(H_2O)_5NO]^{2+}$
(C) $[Fe(H_2O)_5NO]^{4+}$ (D) $[Fe(H_2O)_5NO]^{+}$.

4. Sodium nitroprusside $Na_2[Fe(CN)_5NO]$ is used as a reagent for the detection of **[NSEC-2005]**
(A) sulphur (B) nitrogen (C) bromine (D) iodine.

5. The brown ring test for NO_2^- and NO_3^- is due to formation of complex ion with formula : **[NSEC-2006]**
(A) $[Fe(H_2O)_6]^{2+}$ (B) $[Fe(CN)_5(NO)]^{2-}$ (C) $[Fe(H_2O)_5(NO)]^{2+}$ (D) $[Fe(H_2O)(NO)_5]^{2+}$

6. Concentrated sulphuric acid on reaction with NaCl, NaBr and NaI produces HCl, bromine and iodine respectively.What order of oxidizing ability of halogens with reference to sulphuric acid can be established on the basis of this reaction ? **[NSEC-2007]**
(A) $H_2SO_4 > I_2 > Br_2 > Cl_2$ (B) $Cl_2 > H_2SO_4 > Br_2 > I_2$
(C) $H_2SO_4 > Cl_2 > Br_2 > I_2$ (D) $Cl_2 > Br_2 > I_2 > H_2SO_4$

7. Silver nitrate solution when added to a colorless aqueous solution E forms a white precipitate which dissolves in excess of E. If the white precipitate is heated with water it turns black and the supernatant solution gives a white precipitate with acidified barrum nitrate solution. Therefore, E is : **[NSEC-2015]**
(A) Na_2S (B) $Na_2S_2O_3$ (C) Na_2SO_3 (D) Na_2SO_4

8. If a dilute solution of aqueous NH_3 is saturated with H_2S then the product formed is : **[NSEC-2016]**
(A) $(NH_4)_2S$ (B) NH_4HS (C) $(NH_4)_2S_x$ (D) $NH_4OH + S$

9. A colorless water-soluble compound on strong heating liberates a brown colored gas and leaves a yellow residue that turns white on cooling. An aqueous solution of the original solid gives a white precipitate with $(NH_4)_2S$. The original solid is : **[NSEC-2016]**
(A) $Zn(NO_3)_2$ (B) $Ca(NO_3)_2$ (C) $Al(NO_3)_3$ (D) $NaNO_3$

PART - III : HIGH LEVEL PROBLEMS (HLP)

ONLY ONE OPTION CORRECT TYPE

1. What are the products formed when an aqueous solution of magnesium bicarbonate is boiled?
(A) $MgCO_3$, H_2O, CO_2 (B) $Mg(HCO_3)_2$, H_2O (C) $Mg(OH)_2$, H_2O (D) Mg, CO, H_2O

2. NaX (Sodium salt of particular anion 'X') gives brisk effervescence of Y with dilute HCl. On heating, NaX evolves gas Y which can be completely absorbed in conc. KOH solution and is colorless odourless gas. Hence X and Y respectively are :
(A) HSO_3^- ,SO_2 (B) HS^- & H_2S (C) HCO_3^-, CO_2 (D) $HC_2O_4^-$ & CO_2 + CO

3. White precipitate of AgCl turns to greyish or black when :
(A) reacts with Na_3AsO_3 (B) exposed to sunlight
(C) reacts with K_2CrO_4 (D) reacts with concentrated HCl

4. A mixture is known to contain NO_3^- and NO_2^-. Before performing ring test for NO_3^-, the aqueous solution should be made free of NO_2^-. This is done by heating aqueous extract with :
(A) conc. HNO_3 (B) dil HNO_3 (C) urea (D) zinc dust

5. Which of the following will not react with each other when heated together ?
(A) BeO + MgO (B) Li_2CO_3 + BeO (C) MgO + $CaCO_3$ (D) $MgCO_3$ + Al_2O_3

6. An aqueous solution of salt containing an acidic radical $\mathbf{X^-}$ reacts with sodium hypochlorite in neutral medium. The gas evolved produces blue black colour spot on the starch paper. The anion $\mathbf{X^-}$ is :
(A) CH_3COO^- (B) Br^- (C) I^- (D) NO_2^-

7. Precipitate of $PbSO_4$ is soluble in :
(A) ammonium acetate (6M) (B) dilute HCl
(C) dilute H_2SO_4 (D) none of these

8. Which of the following pair of acidic radical can be distinguished by using dil H_2SO_4?
(I) $C_2O_4^{2-}$ and NO_3^- (II) NO_3^- and NO_2^-
(III) Cl^- and Br^- (IV) HCO_3^- and CO_3^{2-}
(A) I and II (B) II only (C) II and IV (D) III and IV

MATCH THE COLUMN

9. $CuCO_3$ was strongly heated to obtain a residue A and gas B. The residue obtained was treated with a salt of sodium 'X' and oxide Y, which produced a blue colored glassy compound C on heating in oxidizing flame. The same combination of X and Y gave a green colored glassy compound D when $Cr_2(SO_4)_3$ was heated with them in oxidizing flame. Match the following accordingly :

(A)	A	(P)	$Cu(BO_2)_2$
(B)	B	(Q)	Na_2CO_3
(C)	C	(R)	CuO
(D)	X	(S)	CO
		(T)	Cu_2O
		(U)	CO_2
		(V)	$NaBO_2$
		(W)	$Cr(BO_2)_2$

SINGLE AND DOUBLE VALUE INTEGER TYPE

10. A metal salt evolves the dark violet fumes of (X) with MnO_2 and this (X) gives the deep blue colouration with starch solution. Then number of lone pair on central atom in (X).

11. How many of the following will volatilize on heating leaving no solid residue ?
(i) $NaNO_3$ (ii) NH_4NO_3 (iii) $Ca(H_2PO_2)$ (iv) NH_4HCO_3
(v) $N_2H_5HSO_3$ (vi) $AlCl_3$ (vii) $[Cu(NH_3)_4]SO_4$ (viii) $FeSO_4.7H_2O$

12. $Na_2S + Na_2[Fe(CN)_5NO] \rightarrow$ "A" (Violet Color)
In Complex "A", number of type of ambidentate ligand is/are "a" and number of d-orbital involved in hybridisation is/are "b" Then 7a + 8 b will be :

ONE OR MORE THAN ONE OPTIONS CORRECT TYPE

13. Heating which of the following salts in a dry test tube may cause a change in their colour ?
(A) $ZnCO_3$ (white) (B) $Co(NO_3)_2.6H_2O$ (red)
(C) $FeSO_4.6H_2O$ (green) (D) $MnSO_4$ (faint pink)

14. Which of the following combinations will give yellowish precipitate in an aqueous medium ?
(A) $AgNO_3 + NaBr$ (B) $(CH_3COO)_2Pb + Na_2CrO_4$
(C) $AgCl + Na_3AsO_3$ (D) $AgNO_3 + NaNO_2$

15. Which of the following produce red coloured flame during flame test ?
(A) Li (B) Ca^{2+} (C) Sr^{2+} (D) Ba^{2+}

16 When Borax is heated it forms a colourless glassy bead because of formation of :
(A) B_2H_6 (B) $NaBO_2$ (C) B_2O_3 (D) $Na_2B_4O_7$

17. Which of the following anion(s) is/are easily removed from aqueous solution by precipitation?
(A) Cl^- (B) SO_4^{2-} (C) NO_3^- (D) CO_3^{2-}

18. H_2S and SO_2 can be distinguished by :
(A) Litmus paper (B) MnO_4^-/H^+ (C) $(CH_3COO)_2Pb$ (D) None of these

COMPREHENSION

Read the following passage carefully and answer the questions.

Comprehension #

When compound (A) is treated with conc. H_2SO_4, a reddish brown colour gas (B) is evolved. To this solution, a solution of (C) is added slowly from the side of the test tube, a blue ring is obtained at the junction of two layers due to formation of (D).

19. Gas (B) may be :
(A) Cl_2 (B) Br_2 (C) I_2 (D) NO_2

20. Compound (D) has formula :
(A) $C_6H_5NH–C_6H_5$ (B) $(C_6H_5)_2N–N(C_6H_5)_2$
(C) $C_6H_5–NH–NH–C_6H_5$ (D) $C_6H_5-NH-\underset{\underset{O}{\downarrow}}{N}-C_6H_5$

21. Which compound gives same test as compound (A)
(A) NaCl (B) NaBr (C) Na_2CrO_4 (D) Na_2S

PART - IV : PRACTICE TEST-2 (IIT-JEE (ADVANCED Pattern))

Max. Time : 1 Hr. **Max. Marks : 66**

Important Instructions

A. General :

1. The test is of 1 hour duration.
2. The Test Booklet consists of 22 questions. The maximum marks are 66.

B. Question Paper Format :

3. Each part consists of five sections.
4. Section-1 contains 7 multiple choice questions. Each question has four choices (A), (B), (C) and (D) out of which ONE is correct.
5. Section-2 contains 5 multiple choice questions. Each question has four choices (A), (B), (C) and (D) out of which ONE OR MORE THAN ONE are correct.
6. Section-3 contains 6 questions. The answer to each of the questions is a single-digit integer, ranging from 0 to 9 (both inclusive).
7. Section-4 contains 1 paragraphs each describing theory, experiment and data etc. 3 questions relate to paragraph. Each question pertaining to a partcular passage should have only one correct answer among the four given choices (A), (B), (C) and (D).
8. Section-5 contains 1 multiple choice questions. Question has two lists (list-1 : P, Q, R and S; List-2 : 1, 2, 3 and 4). The options for the correct match are provided as (A), (B), (C) and (D) out of which ONLY ONE is correct.

C. Marking Scheme :

9. For each question in Section-1, 4 and 5 you will be awarded 3 marks if you darken the bubble corresponding to the correct answer and zero mark if no bubble is darkened. In all other cases, minus one (– 1) mark will be awarded.
10. For each question in Section-2, you will be awarded 3 marks. If you darken all the bubble(s) corresponding to the correct answer(s) and zero mark. If no bubbles are darkened. No negative marks will be answered for incorrect answer in this section.
11. For each question in Section-3, you will be awarded 3 marks if you darken only the bubble corresponding to the correct answer and zero mark if no bubble is darkened. No negative marks will be awarded for incorrect answer in this section.

SECTION-1 : (Only One option correct Type)

This section contains 7 multiple choice questions. Each questions has four choices (A), (B), (C) and (D) out of which Only ONE option is correct.

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1. An inorganic salt when heated with concentrated H_2SO_4 evolves a colourless pungent smelling gas but with concentrated H_2SO_4 and MnO_2, evolves a coloured pungent smelling gas which bleaches moist litmus paper. The coloured gas is :

(A) NO_2 (B) Cl_2 (C) Br_2 (D) I_2

2. Chromyl chloride vapours are dissolved in water and acetic acid and barium acetate solution is added, then:

(A) the solution will remain colourless. (B) the solution will become dark green.
(C) a yellow solution will be obtained. (D) a yellow precipitate will be obtained.

3. When CS_2 layer containing both Br_2 and I_2 (2 : 1) is shaken with excess of chlorine (Cl_2) water, the violet colour due to I_2 disappears and a pale yellow colour appears in the solution. The disappearance of violet colour and appearance of pale yellow colour is due to the formation of :

(A) I_3^- and Br_2 respectively. (B) HIO_3 and BrCl respectively.
(C) ICl and BrCl respectively. (D) I^- and Br^- respectively.

4. A metal salt solution gives a yellow precipitate with silver nitrate. The precipitate dissolves in dilute nitric acid as well as in dilute ammonia solution. The solution contains :
(A) bromide ions (B) iodide ions
(C) phosphate ions (D) chromate ions

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 $C_6H_5NH_3Cl$.

6. A white sodium salt dissolves 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 dilute HNO_3. The anion is
(A) CO_3^{2-} (B) Cl^- (C) SO_3^{2-} (D) S^{2-}

7. A one litre flask is full of reddish brown bromine fumes. The intensity of brown colour of vapour will not decrease appreciably on adding to the flask some :
(A) pieces of marble (B) animal charcoal powder
(C) carbon tetrachloride (D) carbondisulphide

Section-2 : (One or More than one options correct Type)

This section contains 5 multipole choice questions. Each questions has four choices (A), (B), (C) and (D) out of which ONE or MORE THAN ONE are correct.

8. Which of the following statements is/are incorrect ?
(A) A filter paper moistened with cadmium acetate solution turns yellow, when brought in contact with H_2S gas.
(B) Both carbonate ions as well as bicarbonate ions in the solutions, give reddish-brown precipitate with mercury(II) chloride.
(C) Sulphites in presence of zinc, reacts with dilute H_2SO_4 to liberate SO_3 gas.
(D) A filter paper moistened with KIO_3 and starch turns blue in contact with SO_2 vapours.

9. Which of the following reagents can be used for making the distinction between AgCl and AgI ?
(A) Sodium arsenite solution. (B) Dilute ammonia solution.
(C) Potassium cyanide solution. (D) Dilute HNO_3.

10. Which of the following statement(s) is/are correct with respect to bromide ions ?
(A) KBr on heating with MnO_2 and concentrated H_2SO_4 liberates Br_2 and SO_2 gases.
(B) KBr on heating with concentrated H_2SO_4 liberates Br_2 and SO_2 gases.
(C) KBr forms HBr with concentrated H_3PO_4.
(D) KBr(s) liberates Br_2 on gentle warming with concentrated H_2SO_4 and $K_2Cr_2O_7$(s).

11. Which of the following imparts green/apple green colour to the Bunsen flame ?
(A) Calcium chloride (B) Volatile boron trifluoride
(C) Barium chloride (D) Ethoxy borate

12. What final product(s) is/are formed in the following series of reactions ?
Concentrated borax solution + silver nitrate solution $\longrightarrow$ Precipitate $\xrightarrow[\text{boiling}]{H_2O}$ Products (final)
(A) Ag_3BO_3 (B) Ag_2O (C) H_3BO_3 (D) $AgBO_2$

Section-3 : (One Integer Value Correct Type.)

This section contains 6 questions. Each question, when worked out will result in one integer from 0 to 9 (both inclusive)

13. How many of following metals give Borax bead test.
Sc, Ti, V, Cr, Mn, Co, Ni, Cu, Zn

14. How many of the following salts impart characteristic colours to the Bunsen flame ?
NaCl, KCl, $CuCl_2$, $BaCl_2$, $CaCl_2$, $SrCl_2$, $ZnCl_2$, $MgCl_2$, $AlCl_3$

15. How many of the following liberate coloured vapour/gas with concentrated H_2SO_4?
$KCl(s) + K_2Cr_2O_7(s)$, $KNO_2(s)$, $KI(s)$, $KBr(s)$, $KCl(s)$
$KBr(s) + MnO_2(s)$, KNO_3, $KCI(s) + MnO_2$, K_2SO_3

16. Which of the following statements is/are incorrect
(I) Filter paper moistened with cadmium acetate and lead acetate turn black and yellow respectively, when brought in contact with H_2S gas.
(II) Sulphites in presence of Zinc, reacts with dilute H_2SO_4 to liberate H_2S gas.
(III) Stability of carbonates decrease with increasing metallic character.
(IV) Borax bead test is responded generally by p and d block metal salts.
(V) Sodium chloride on heating with aqueous solution of $K_2Cr_2O_7$ and concentrated H_2SO_4 produced white fumes.

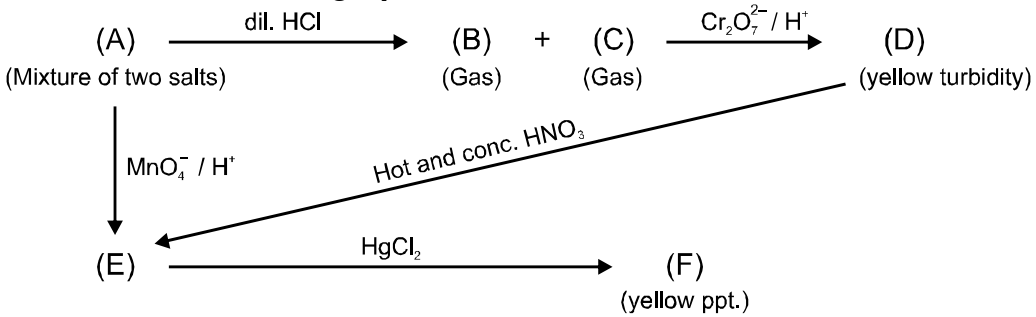
17. How many B–O–B bond(s)(per molecule) is/are present in compound which is used in Borax bead test?

18. In brown ring complex, if number of ambidentate is/are "a" and oxidation state of iron is/are "b" then a + b =?

SECTION-4 : Comprehension Type (Only One options correct)

This section contains 1 paragraphs, each describing theory, experiments, data etc. 3 questions relate to the paragraph. Each question has only one correct answer among the four given options (A), (B), (C) and (D)

Paragraph For Questions 19 to 21



19. Find the anion(s) :
(A) SO_3^{2-} (B) SO_3^{2-} , S^{2-} (C) SO_3^{2-} , CO_3^{2-} (D) $S_2O_3^{2-}$

20. Find out (E) :
(A) S^{2-} (B) CO_3^{2-} (C) $S_2O_3^{2-}$ (D) SO_4^{2-}

21. Find out (F) :
(A) $HgSO_4.2HgO$ (B) $HgSO_4.3HgO$ (C) $HgSO_4$ (D) $Hg_2SO_4.3HgO$

SECTION-5 : Matching List Type (Only One options correct)

This section contains 1 questions, each having two matching lists. Choices for the correct combination of elements from List-I and List-II are given as options (A), (B), (C) and (D) out of which one is correct.

22. Match List-I with List-II and select the correct answer using the codes given below the lists :

	List-I		**List-II**
P.	White turbidity	1.	$IO_3^- + SO_2 + \text{starch} \longrightarrow$
Q.	Rotten egg smell	2.	$SO_2 + MnO_4^- \longrightarrow$
R.	Colourless solution	3.	$Zn + NaOH + SO_2 \longrightarrow$
S.	Blue colour	4.	$CO_2 + Ca(OH)_2 \longrightarrow$

Code :

	P	Q	R	S		P	Q	R	S
(A)	1	3	2	4	(B)	3	2	4	1
(C)	4	3	2	1	(D)	4	1	2	3

Practice Test-2 (IIT-JEE (ADVANCED Pattern)

OBJECTIVE RESPONSE SHEET (ORS)

Que.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Ans.										
Que.	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Ans.										
Que.	**21**	**22**								
Ans.										

APSP Answers

PART - I

1.	(1)	**2.**	(4)	**3.**	(2)	**4.**	(2)	**5.**	(3)
6.	(2)	**7.**	(4)	**8.**	(1)	**9.**	(4)	**10.**	(1)
11.	(4)	**12.**	(1)	**13.**	(1)	**14.**	(3)	**15.**	(1)
16.	(4)	**17.**	(4)	**18.**	(3)	**19.**	(2)	**20.**	(1)
21.	(4)	**22.**	(4)	**23.**	(1)	**24.**	(1)	**25.**	(1)
26.	(3)	**27.**	(1)	**28.**	(1)	**29.**	(2)	**30.**	(2)

PART - II

1.	(C)	**2.**	(D)	**3.**	(B)	**4.**	(A)	**5.**	(C)
6.	(B)	**7.**	(B)	**8.**	(B)	**9.**	(A)		

PART - III

1.	(A)	**2.**	(C)	**3.**	(B)	**4.**	(C)	**5.**	(C)
6.	(C)	**7.**	(A)	**8.**	(B)	**9.**	A→R, B→U, C→P, D→V		
10.	3	**11.**	4 (ii, iv, v, vi)	**12.**	30	**13.**	(ABCD)	**14.**	(AB)
15.	(ABC)	**16**	(BC)	**17.**	(ABD)	**18.**	(ABC)	**19.**	(D)
20.	(B)	**21.**	(C)						

PART - IV

1.	(B)	**2.**	(D)	**3.^**	(B)	**4.**	(C)	**5.**	(B)
6.	(B)	**7.**	(A)	**8.**	(BC)	**9.**	(AB)	**10.**	(BCD)
11.	(BCD)	**12.**	(BC)	**13.**	5	**14.**	6	**15.**	7
16.	4 (I), (III), (IV) & (V)			**17.**	5	**18.**	1	**19.**	(B)
20.	(D)	**21.**	(A)	**22.**	(C)				

APSP Solutions

PART - I

1. SO_3^{2-} reduces $KMnO_4$ to colourless Mn^{2+}

$5SO_3^{2-} + 2MnO_4^- + 6H^+ \longrightarrow 2Mn^{2+} + 5SO_4^{2-} + 3H_2O$

2. Nitrite ion liberates I_2 from potassium iodide turning starch blue.

$2NO_2^- + 3I^- + 4CH_3COOH \longrightarrow I_3^- + 2NO\uparrow + 4CH_3COO^- + 2H_2O$

I_2 + starch $\longrightarrow$ blue colour

3. NO_3^- gives NO_2 with concentrated H_2SO_4 which on passing through water form colourless $HNO_3(\ell)$ and $HNO_2(\ell)$. Br^- + MnO_2 on heating with concentrated H_2SO_4 gives Br_2 gas which on passing through water imparts it a reddish brown colour.

4. $Fe^{2+} + NO + 5H_2O \longrightarrow [Fe(H_2O)_5NO]^{2+}$ (brown complex)

5. $2NO_2^- + 3I^- + 4CH_3COOH \longrightarrow I_3^- + 2NO\uparrow + 4CH_3COO^- + 2H_2O$.

I_3^- + starch $\longrightarrow$ blue colouration.

6. $Ba^{2+} + CrO_4^{2-} \longrightarrow BaCrO_4\downarrow$ (yellow); $Ag^+ + Cl^- \longrightarrow AgCl\downarrow$ (white).

7. Zn^{2+} is colourless and borax bead test is given by coloured ions such as Cu^{2+}, Mn^{2+}, Fe^{3+} etc.

8. Ca salts impart brick red colour to the flame.

9. $Al_2O_3.CoO$ formed in the test is blue in colour. It is called as thenard's blue.

10. $Ba^{2+} + SO_3^{2-} \longrightarrow BaSO_3\downarrow$ (white)

$BaSO_3 + 2HCl \longrightarrow BaCl_2 + SO_2$(colourless pungent smelling gas) + H_2O

SO_3^{2-} and SO_2 both act as bleaching agent.

11. (1) $5SO_3^{2-} + 2MnO_4^- + 6H^+ \longrightarrow 2Mn^{2+} + 5SO_4^{2-} + 3H_2O$

(2) $2MnO_4^- + 5NO_2^- + 6H^+ \longrightarrow 2Mn^{2+} + 5NO_3^- + 3H_2O$

(3) $2MnO_4^- + H_2S + 6H^+ \longrightarrow 2Mn^{2+} + 5S\downarrow + 8H_2O$

12. $NO_2^- + 2I^- + 4CH_3COOH \longrightarrow I_2 + 2NO\uparrow + 4\ CH_3COO^- + 2H_2O$

13. $SO_3^{2-} + Zn + 8H^+ \longrightarrow H_2S\uparrow + 3Zn^{2+} + 3H_2O$

$Pb^{2+} + S^{2-} \longrightarrow PbS\downarrow$ (black)

$Ag^+ + S^{2-} \longrightarrow Ag_2S\downarrow$ (black)

14. $SO_3^{2-} + Ba(OH)_2 \longrightarrow BaSO_3\downarrow$ (white) + $2OH^-$.

$3SO_2 + Cr_2O_7^{2-} + 2H^+ \longrightarrow 2Cr^{3+}$ (green colour solution) + $3SO_4^{2-} + H_2O$.

16. NH_3 is basic.

17. E°_{SRP} of Ag = 0.80 V, E°_{SRP} of Cl^- = 1.36 V, E°_{SRP} of H^+ = 0.00 V. So Ag can not oxidize Cl^- and can not reduce H^+.

18. $S_2O_3^{2-}$ + dil.$H_2SO_4 \xrightarrow{\Delta} SO_2\uparrow$ (Suffocating gas) $2Cl^- + S\downarrow$ (yellow turbidity or white turbidity) + H_2O

19. $HCO_3^- + Mg^{2+} \rightarrow Mg(HCO_3)_2$ (No PPt) $\xrightarrow{\Delta} Mg\ CO_3\downarrow$

23. $KBr + H_2SO_4 \longrightarrow KHSO_4 + HBr$, $2HBr + 9\ H_2SO_4 \longrightarrow Br_2 + 2H_2O + SO_2$

24. Some nitrates on heating give NO_2 which bleaches moist litmus paper due to its oxidizing nature.

25. Solubility order; Ag F > AgCl > AgBr > AgI

26. $S^{2-} + 2HCl \xrightarrow{\Delta} H_2S\downarrow + 2Cl^-$
Rotten egg smell (Specific smell)
$S_2O_3^{2-} + HCl \xrightarrow{\Delta} SO_2\uparrow$ (Suffocating gas) + $2Cl^-$ + S $\downarrow$ (yellow turbidity or white turbidity) + H_2O
$NO_2^- + HCl \xrightarrow{\Delta} HNO_2 + Cl^- \rightarrow NO\uparrow$ (colourless) $\xrightarrow{\text{atmospheric air}} NO_2\uparrow$ (Brown colour gas)

27. $KCl + H_2SO_4 + K_2Cr_2O_7 \longrightarrow CrO_2Cl_2$ (Chromyl Chloride test)

28. $K \rightarrow$ violet colour in flame test
$2I^- +$ conc. $H_2SO_4 \rightarrow HI + SO_4^{2-}$; $HI + H_2SO_4 \rightarrow I_2 + H_2O + SO_2$
I_2 + starch $\rightarrow$ blue colour.

29. HBr and HI are strong reducing agents and are oxidized by H_2SO_4 to Br_2 and I_2, respectively.

30. Ba^{2+} salts gives yellow precipitate with K_2CrO_4 solution and this precipitate is not soluble in CH_3COOH.
Ba^{2+} ions gives apple green colour in the flame test.

PART - III

1. $2Mg(HCO_3)_2 \rightarrow 2MgCO_3 + CO_2 + H_2O$

2. $NaHCO_3 + HCl \longrightarrow NaCl + H_2O + CO_2\uparrow$
(NaX) (Y)
$2NaHCO_3 \xrightarrow{\Delta} Na_2CO_3 + H_2O + CO_2\uparrow$
$CO_2 + 2KOH \longrightarrow K_2CO_3 + H_2O$
CO_2 is colourless & odourless gas.

3. $2\,AgCl \xrightarrow{h\nu} 2\,Ag\downarrow$ (black) + $Cl_2\uparrow$.

4. $NO_2^- + H^+ \longrightarrow HNO_2$
$CO(NH_2)_2 + HNO_2 \longrightarrow 2N_2\uparrow + CO_2\uparrow + 3H_2O$

5. $BeO + MgO \xrightarrow{\Delta} MgBeO_2$
$Li_2CO_3 + BeO \xrightarrow{\Delta} Li_2BeO_2 + CO_2\uparrow$
$MgCO_3 + Al_2O_3 \xrightarrow{\Delta} Mg(AlO_2) + CO_2\uparrow$

6. $OCl^- + 3I^- + H_2O \longrightarrow I_3^- + 2OH^- + Cl^-$
I_3^- + starch $\longrightarrow$ blue -black spot on starch paper appears due to the formation of iodine-starch adsorption complex.

7. $PbSO_4 + 2CH_3COONH_4 \longrightarrow (NH_4)_2SO_4 + (NH_4)_2[Pb(CH_3COO)_4]$

8. (I) $\begin{cases} \rightarrow C_2O_4^{2-} + 2H^+ \xrightarrow{\text{dil.}H_2SO_4} \text{No vapours or gas is evolved} \\ \rightarrow NO_3^- : \text{No reaction with dil. } H_2SO_4 \end{cases}$

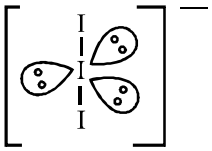
(II) $\begin{cases} \rightarrow NO_3^- : \text{No reaction with dil.} H_2SO_4 \xrightarrow{\text{disproportionation}} HNO_3 + NO\uparrow \xrightarrow{\text{atm.air}} NO_2\uparrow \\ \rightarrow NO_2^- + H^+ \xrightarrow{\text{dil.}H_2SO_4} HNO_2 \end{cases}$
Hence, distincition is posssible.

(III) Both Cl^- and Br^- have no reaction with dil. H_2SO_4.
(IV) Both HCO_3^- and CO_3^{2-} produce $CO_2\uparrow$ which evolves with efferverscences.

9. $CuCO_3 \xrightarrow{\Delta} CuO\downarrow + CO_2\uparrow$
(A) (B)
(X)
$CuO + \underbrace{NaBO_2 + B_2O_3}_{\text{Borax bead}} \longrightarrow \underbrace{Cu(BO_2)_2}_{\text{(C) Blue bead}} + NaBO_2$
$Cr_2(SO_4)_3 \xrightarrow[\text{Bead test}]{\text{Borax}}$ Green colored metaborate

10. $3I^- + MnO_2 + H_2SO_4 \longrightarrow I_3^-\uparrow + Mn^{2+} + SO_4^{2-} + H_2S$

I_3^- + starch $\rightarrow$ Blue color due to starch Iodine complex



11. $NH_4NO_3 \xrightarrow{\Delta} N_2O\uparrow + 2H_2O\uparrow$

$NH_4HCO_3 \xrightarrow[\Delta]{} NH_3\uparrow + H_2O\uparrow + CO_2\uparrow$

$N_2H_5HSO_3 \xrightarrow[\Delta]{} N_2H_4\uparrow + H_2O\uparrow + SO_2\uparrow$

$AlCl_3 \xrightarrow[\Delta]{} AlCl_3(g)$ (sublimes)

12. $A \equiv Na_4[Fe(CN)_5NOS]$

Ambidentate ligand [a] = CN^-, NOS^-

$a = 2$

Hybridisation $\Rightarrow d^2sp^3 \Rightarrow b = 2$

$7a + 8b = 30$

13. $ZnCO_3 \xrightarrow[\Delta]{} ZnO + CO_2\uparrow$. ZnO is yellow when hot.

(white)

$Co(NO_3)_2.6H_2O \xrightarrow[\Delta]{} CoO$ (black) $+ 2NO_2\uparrow + \frac{1}{2}O_2\uparrow + 6H_2O\uparrow$

$2FeSO_4.6H_2O \xrightarrow[\Delta]{} Fe_2O_3$ (brown) $+ SO_2\uparrow + SO_3\uparrow + 6H_2O\uparrow$

$3MnSO_4 \xrightarrow[\Delta]{} Mn_3O_4 + 2SO_2\uparrow + SO_3\uparrow$

(faint pink) (black)

14. $AgNO_3 + NaBr \longrightarrow AgBr\downarrow$ (Yellow ppt.)

$Pb^{2+} + CrO_4^{2-} \longrightarrow PbCrO_4\downarrow$ (Yellow ppt.)

$AgCl + Na_3AsO_3 \longrightarrow Ag_3AsO_3\downarrow$ (Yellow ppt.)

$Ag^+ + NO_2^- \longrightarrow AgNO_2\downarrow$ (White ppt.)

16 $Na_2B_4O_7.10H_2O \xrightarrow{\Delta} Na_2B_4O_7 \xrightarrow{\Delta} \underset{\text{glassy bead}}{2NaBO_2} + B_2O_3$

17. All nitrate are water soluble.

18. H_2S, SO_2 both are acidic so turns blue litmus red but SO_2 is a bleaching agent which turns red litmus colourless.

MnO_4^-/H^+ oxidising agent, so SO_2 is oxidised to SO_4^{2-} & H_2S is oxidized to sulphur

$2MnO_4^- + 5SO_2 + 2H_2O \rightarrow 2Mn^{+2} + 5SO_4^{-2} + 4H^+$

$2MnO_4^- + 5H_2S + 6H^+ \rightarrow 2Mn^{+2} + \underset{\text{(yellow)}}{5S} + 8H_2O$

$Pb^{2+} + S^{2-} \longrightarrow PbS$ - (black ppt.), SO_2 will not give black precipitate so can be distinguished.

(19-21) $NaNO_3 + H_2SO_4 \longrightarrow NaHSO_4 + HNO_3$

(A)

$2HNO_3 \longrightarrow H_2O + 2NO_2\uparrow + [O]$

(B)

$2C_6H_5NHC_6H_5 + [O] \longrightarrow (C_6H_5)_2N\text{–}N(C_6H_5)_2 + H_2O$

blue ring (D)

This testing also given by various oxidizing agent like CrO_4^{2-}, $Cr_2O_7^{2-}$, ClO_3^- etc.

PART - IV

1. $Cl^- + H_2SO_4 \longrightarrow HCl \uparrow$ (colourless) + HSO_4^-
$MnO(OH)_2 + 2H_2SO_4 + 2Cl^- \longrightarrow Mn^{2+} + Cl_2 \uparrow$ (yellowish green) + $2SO_4^{2-} + 3H_2O$
$Cl_2 + H_2O \longrightarrow 2HCl + [O]$
Litmus + [O] $\longrightarrow$ colourless oxidised form
Cl_2 is a yellowish green gas which bleaches litmus paper by oxidation.

2. $CrO_2Cl_2 + 2H_2O \longrightarrow H_2CrO_4 + 2HCl$
$H_2CrO_4 + (CH_3COO)_2Ba \longrightarrow BaCrO_4\downarrow$ (Yellow) + $2CH_3COOH$

3. $5Cl_2 + I_2 + 6H_2O \longrightarrow 2HIO_3$ (colourless) + $10HCl$
$Br_2 + Cl_2 \rightleftharpoons 2BrCl$ (pale yellow)

4. Ag_3PO_4 is yellow precipitate which is soluble in both dilute ammonia solution and dilute HNO_3.
$HPO_4^{2-} + 3Ag^+ \longrightarrow Ag_3PO_4\downarrow + H^+$
$Ag_3PO_4 + 2H^+ \longrightarrow H_2PO_4^-\downarrow + 3Ag^+$;
$Ag_3PO_4\downarrow + 6NH_3 \longrightarrow 3[Ag(NH_3)_2]^+ + PO_4^{3-}$
Pale yellow precipitate of AgBr is not soluble in dilute HNO_3; bright yellow precipitate of AgI is not soluble in both; Ag_2CrO_4 is obtained as red precipitate.

5. $HgCl_2$ fails to give positive chromyl chloride test because of its covalent nature i.e., it does not dissociate to give Cl^-.

6. $NaCl + AgNO_3 \longrightarrow AgCl\downarrow$ (white) + $NaNO_3$; $Ag_2S\downarrow$ (black).
Ag_2CO_3 and Ag_2SO_3 dissolves in dilute HNO_3 liberating CO_2 and SO_2 respectively.
Both Ag_2CO_3 and Ag_2SO_3 are white. AgCl is white but insoluble in dilute HNO_3. NaCl solution is neutral to litmus as it is a salt of strong acid and strong base.

7. Marble ($CaCO_3$) do not react, adsorb, absorb or dissolve Br_2. As such there is no change in colour of Br_2. Remaining dissolves or absorb or adsorb bromine.

8. (A) Cd^{2+} (aq) + H_2S (g) $\longrightarrow CdS\downarrow$ (yellow) + $2H^+$ (aq)
(B) $CO_3^{2-} + 4Hg^{2+} + 3H_2O \longrightarrow HgCO_3.3HgO\downarrow$ (reddish-brown) + $6H^+$
HCO_3^- (aq) does not give precipitate.
(C) $SO_3^{2-} + 3Zn + 8H^+ \longrightarrow H_2S \uparrow + 3Zn^{2+} + 3H_2O$
(D) $5SO_2 + 2IO_3^- + 4H_2O \longrightarrow I_2 + 5SO_4^{2-} + 8H^+$

9. (A) $3AgCl\downarrow + AsO_3^{3-} \longrightarrow Ag_3AsO_3\downarrow$ (yellow) + $3Cl^-$
AgI is unaffected by this treatment.
(B) $AgCl + 2NH_3 \longrightarrow [Ag(NH_3)_2]Cl$
AgI is not soluble in dilute ammonia solution.
(C) Both soluble in potassium cyanide, forming soluble complexes.
(D) Both insoluble in dilute HNO_3.

10. (A) $2KBr + MnO_2 + 2H_2SO_4 \longrightarrow Br_2\uparrow + 2K^+ + Mn^{2+} + 2SO_4^{2-} + 2H_2O$
(B) $2KBr + 2H_2SO_4 \longrightarrow Br_2\uparrow + SO_2\uparrow + SO_4^{2-} + 2K^+ + 2H_2O$
(C) $KBr + H_3PO_4 \longrightarrow HBr + H_2PO_4^- + K^+$
(D) $6KBr + K_2Cr_2O_7 + 7H_2SO_4 \longrightarrow 3Br_2 + 2Cr^{3+} + 2K^+ + 7SO_4^{2-} + 7H_2O$

11. BF_3 colour the flame green; $B(OC_2H_5)_3$ burns with green edged flame ; Barium chloride (volatile) gives apple green colour to flame.

12. $B_4O_7^{2-} + 4Ag^+ + H_2O \longrightarrow 4AgBO_2\downarrow$ (white) + $2H^+$
$2AgBO_2\downarrow + 3H_2O \xrightarrow[\Delta/H_2O]{\text{Hydrolysis}} Ag_2O\downarrow$ (brown) + $2H_3BO_3$

13. Cr, Mn, Fe, Co, Ni, Cu give Borax bead test.

14. NaCl-Golden yellow; KCl-Lilac; $CuCl_2$-bluish-green, $BaCl_2$-Apple green; $SrCl_2$-Crimson; $CaCl_2$-Brick red.

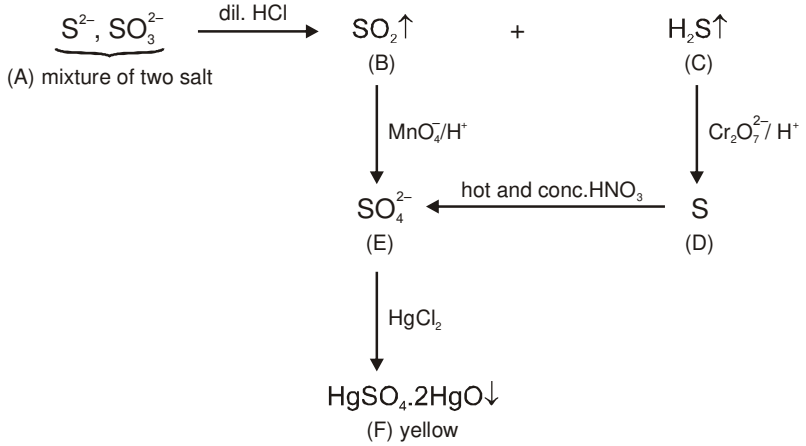
15.
(i) $4Cl^- + Cr_2O_7^{2-} + 6H^+ \longrightarrow 2CrO_2Cl_2 \uparrow$ (deep red) $+ 3H_2O$
(ii) $NO_2^- + H^+ \longrightarrow HNO_2$; $3HNO_2 \longrightarrow HNO_3 + NO \uparrow + H_2O$
$2NO \uparrow + O_2 \uparrow \longrightarrow NO_2 \uparrow$ (brown)
(iii) $3I^- + 2H_2SO_4 \longrightarrow I_3^- \uparrow$ (violet) $+ SO_4^{2-} + 2H_2O + SO_2$
(iv) $2KBr + 2H_2SO_4 \longrightarrow Br_2 \uparrow$ (reddish brown) $+ SO_2 \uparrow + NO_4^{2-} + 2K^+ + 2H_2O$
(v) $Cl^- + H_2SO_4 \longrightarrow HCl \uparrow$ (colourless) $+ HSO_4^-$
(vi) $2KBr + MnO_2 + 2H_2SO_4 \longrightarrow Br_2 \uparrow$(reddish-brown) $+ 2K^+ + Mn^{2+} + 2SO_4^{2-} + 2H_2O$
(vii) $4NO_3^- + 2H_2SO_4 \longrightarrow NO_2 \uparrow$ (brown)
(viii) $KCl + MnO(OH)_2 + 2H_2SO_4 \longrightarrow Mn^{2+} + Cl_2 \uparrow$(yellowish green) $+ 2SO_4^{2-} + 3H_2O$
(ix) $SO_3^{2-} + 2H^+ \longrightarrow SO_2 \uparrow$ (colourless) $+ H_2O$

16.
(I) $Pb^{+2} + H_2S \longrightarrow \underset{\text{black}}{PbS\downarrow}$
$Cd^{+2} + H_2S \longrightarrow \underset{\text{yellow}}{CdS\downarrow}$
(II) $Zn + H_2SO_4 + SO_3^- \longrightarrow H_2S\uparrow + Zn^{2+}$
(III) Stability of carbonate $\propto$ metallic character
(IV) Borax bead test is responded by d-block metal salt.
(V) $NaCl + K_2Cr_2O_7 + H_2SO_4 \longrightarrow CrO_2Cl_2\uparrow + Cr^{3+} + SO_4^{2-}$

17. $Na_2B_4O_7.10H_2O$ contains 5 B–O–B bonds
Borax

18. a = 0 H_2O, NO^+ are not ambidentate ligand
b = 1 Fe^{+1}
a + b = 1

(19 - 21)



22.
1 → $IO_3^- + SO_2 \longrightarrow I_2 + SO_4^{2-}$
I_2 + Starch $\longrightarrow$ deep blue colour
2 → $SO_2 + MnO_4^- \longrightarrow \underset{\text{colourless}}{MnSO_4} + SO_4^{2-}$
3 → $Zn + NaOH + SO_2 \longrightarrow \underset{\text{rotten egge smell}}{H_2S\uparrow} + Zn^{2+}$
4 → $CO_2 + Ca(OH)_2 \longrightarrow CaCO_3\downarrow$ (milky)