# 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-I

## Introduction :

Qualitative analysis of inorganic salts means the identification of cations and anions present in the salt or a mixture of salts. Inorganic salts may be obtained by complete or partial neutralisation of acid with base or vice-versa. In the formation of a salt, the part contributed by the ***acid*** is called ***anion*** and the part contributed by the ***base*** is called ***cation***. For example, in the salt $CuSO_4$ , $Cu^{2+}$ ion is cation and $SO_4^{2-}$ ion is anion. The systematic procedure for qualitative analysis of an inorganic salt involves the following steps :

**(a) Preliminary tests**

- Physical appearance (smell, colour)
- Dry heating test.
- Flame test.
- Borax bead test.
- Charcoal cavity test.
- Cobalt nitrate test.
- Solubility in water

**(b) Wet tests for acid radicals.**

**(c) Wet tests for basic radicals.**

## 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 | $NH_4^+$ |
| Smell like that of rotten eggs | $S^{2-}$ |
| Vinegar like smell | $CH_3COO^-$ |

## 2. Dry Heating Test :

On heating small amount of salt in dry test tube, evolution of the gas(es) or changes in the colour take place. These observations are tabulated below.

**Table 2 : Gases evolved on heating salt**

| **Observations** | **Inference** | |
|---|---|---|
| | **Gas Evolved** | **Possible Anion** |
| A colourless, odourless gas is evolved with brisk effervescence. | $CO_2$ | Carbonate ($CO_3^{2-}$) |
| Brown gas with pungen smell. | $NO_2$ | Nitrite ($NO_2^-$) |

**Table 2 : Inferences from the colour change on heating the salt**

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

**Table 1: Preliminary test with dilute sulphuric acid**

| Swelling | Inference |
|---|---|
| The salt swells up on heating | $PO_4^{3-}$ , $BO_3^{3-}$ indicated |

**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.

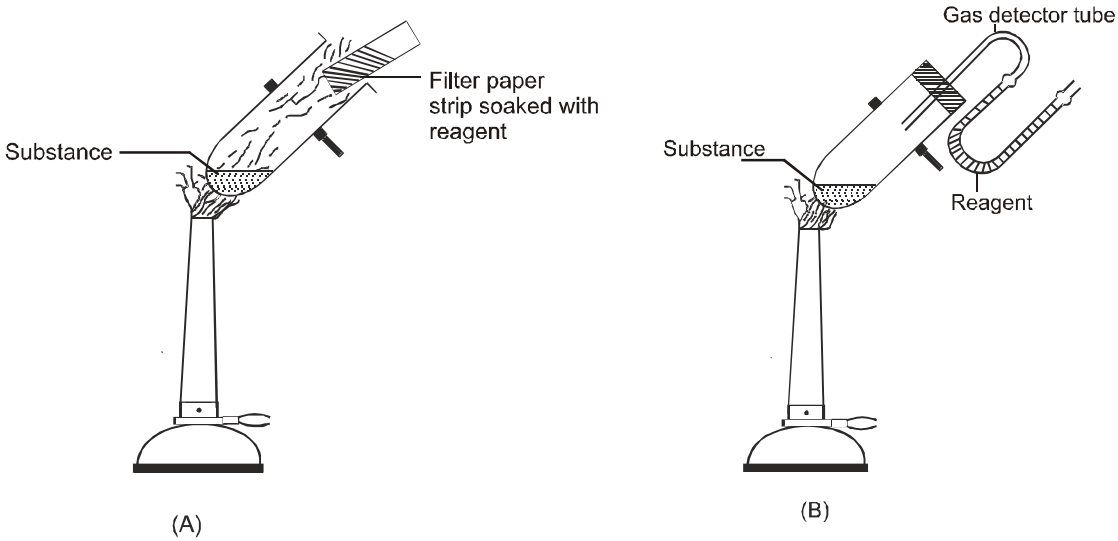



**Figure : Detection of gas evolved.**

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

**(A) Parts of Bunsen Burner**

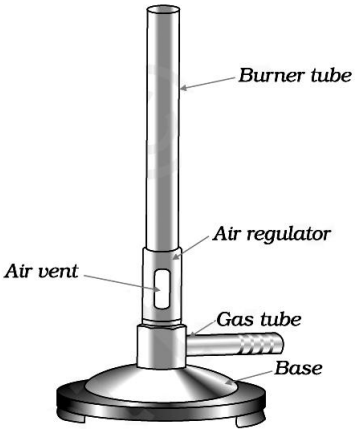



**Fig. Bunsen burner**

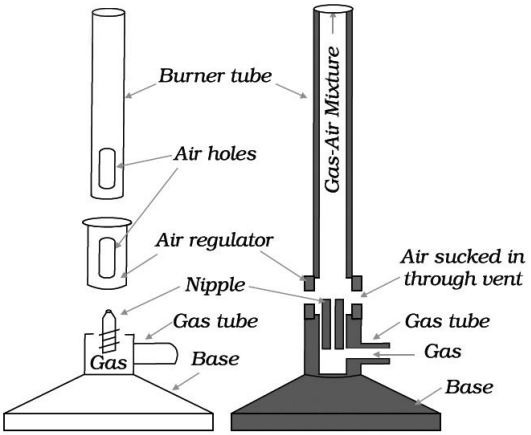
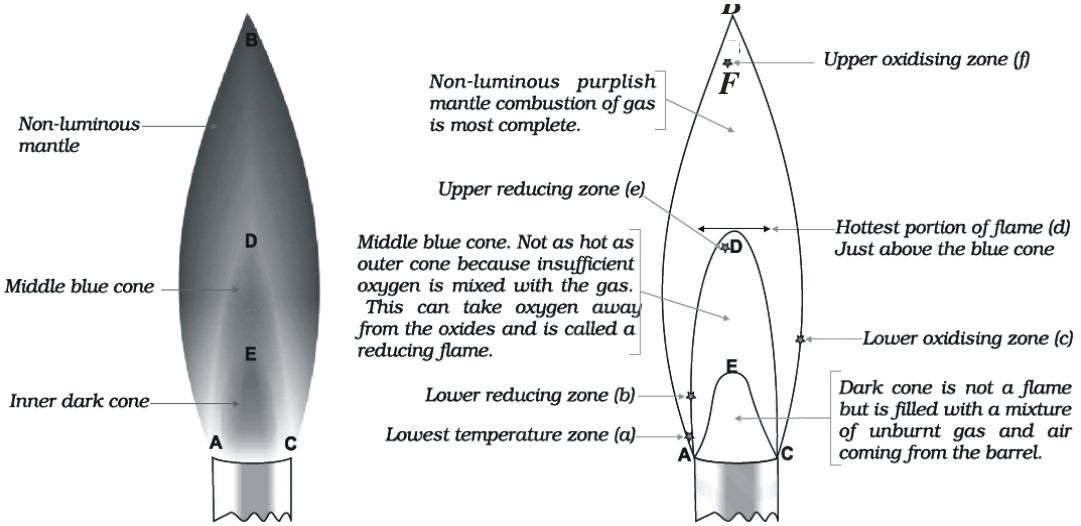



**Fig. Parts of Bunsen barner**




*Zones of flame of Bunsen burner*

**(B) PRINCIPAL PARTS OF BUNSEN FLAME**

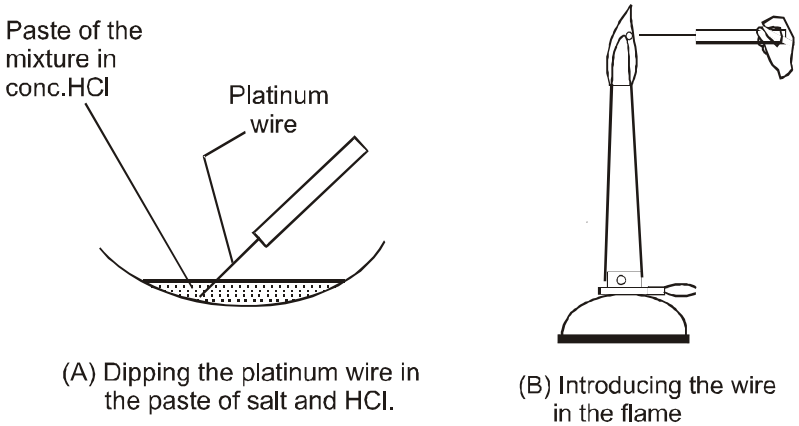
- **The Inner Dark Cone, A E C**
- **The Middle Blue Cone, A D C E A**
- **The Outer Non-luminous Mantle, A B C D A**

**3. Flame test :**

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

**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 :**

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

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

$$Na_2B_4O_7 .10H_2O \longrightarrow Na_2B_4O_7 + 10H_2O$$

Borax

$$Na_2B_4O_7 \longrightarrow \underset{\text{Sodium metaborate}}{2NaBO_2} + \underset{\text{Boric anhydride}}{B_2O_3}$$

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

$$CuSO_4 + B_2O_3 \xrightarrow{\text{Non-luminous flame}} \underset{\substack{\text{Cupric metaborate}\\ \text{Blue-green}}}{Cu(BO_2)_2} + SO_3$$

Two reactions may take place in the reducing flame:

(i) The blue $Cu(BO_2)_2$ is reduced to colourless cuprous metaborate as follows:

$$2Cu(BO_2)_2 + 2NaBO_2 + C \xrightarrow{\text{Luminous flame}} 2CuBO_2 + Na_2B_4O_7 + CO$$

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

$$2Cu(BO_2)_2 + 4NaBO_2 + 2C \xrightarrow{\text{Luminous flame}} 2Cu + 2Na_2B_4O_7 + 2CO$$

**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.

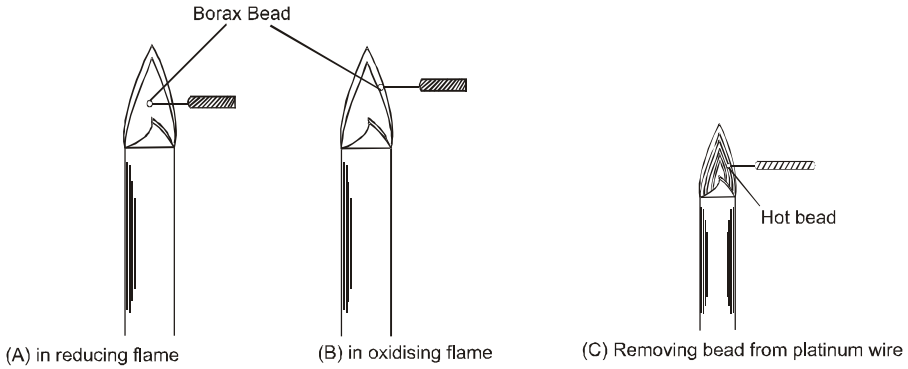



**Figure : Borax bead test**

☞ 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 :**

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

The test may be performed as follows:

(i) Make a small cavity in a charcoal block with the help of a charcoal borer [Fig.1.6 (a)].

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

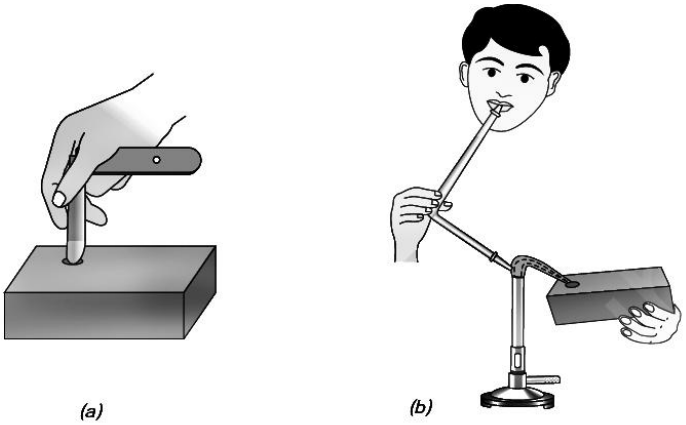



***Fig. 1.6** : (a) Making charcoal cavity (b) Heating salt in the cavity*

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

$$CuSO_4 + Na_2CO_3 \xrightarrow{Heat} CuCO_3 + Na_2SO_4$$

$$CuCO_3 \xrightarrow{Heat} CuO + CO_2$$

$$CuO + C \xrightarrow{Heat} Cu + CO$$

Red colour

In case of $ZnSO_4$ :

$$ZnSO_4 + Na_2CO_3 \xrightarrow{Heat} ZnCO_3 + Na_2SO_4$$

$$ZnCO_3 \xrightarrow{Heat} ZnO + CO_2$$

Yellow when hot,
White when cold

**Table : Inference from the charcoal cavity test**

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

**6. Cobalt Nitrate Test :**

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

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

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

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

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

$$2Co(NO_3)_2 \xrightarrow{\text{Heat}} 2CoO + 4NO_2 + O_2$$

$$CoO + ZnO \longrightarrow \underset{\text{Green}}{CoO.ZnO}$$

$$CoO + MgO \longrightarrow \underset{\text{Pink}}{CoO.MgO}$$

$$CoO + Al_2O_3 \longrightarrow \underset{\text{Blue}}{CoO.Al_2O_3}$$

**7. SOLUBILITY CHART (IN WATER)**

| 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. |

## 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.

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

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

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 $CO^{2-}_3$ or $HCO^-_3$ ions.

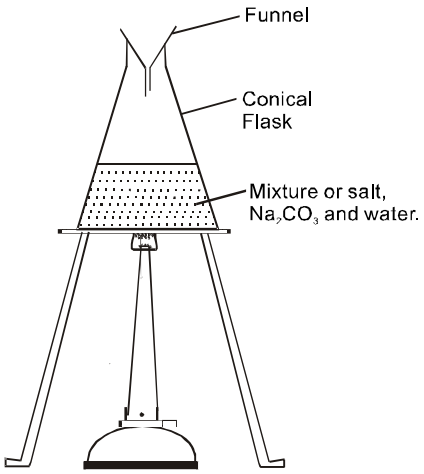



**Figure : Preparation of sodium carbonate extract**

## 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 vapours with dilute sulphuric acid/hydrochloric acid.

| Observation | Gas evolved | Acidic 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 wet starch –iodide paper blue. | $NO_2$ | $NO_2^-$ |
| 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 vapours or gases with conc. $H_2SO_4$.

**Table : 6**

| Observation | Gas evolved | Radical |
|---|---|---|
| Colourless gas with pungent smell which gives dense white fumes with a glass rod dipped in $NH_4OH$.(aq.) | HCl | $Cl^-$ |
| Reddish brown gas with pungent smell, intensity of reddish brown fumes increases on addition 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. Also it turns wet starch iodide paper blue. | $NO_2$ | $NO_3^-$ |

**(B) GROUP 'B' RADICALS :** Anions of this group do not give 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) Precipitation reactions :** $SO_4^{2-}$, $PO_4^{3-}$ etc.

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

## Individual tests :

### (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 $CO_2$, 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

  $CO_3^{2-} + Ag^+ \longrightarrow Ag_2CO_3\downarrow$ (soluble in $HNO_3$ and ammonia)

☞ 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.

$CO_3^{2-} + 4Hg^{2+} + 3H_2O \longrightarrow Hg_4O_3CO_3\downarrow + 6H^+$

☞ 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 :** $2NaHCO_3 \xrightarrow{\Delta} Na_2CO_3 + H_2O + CO_2$

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

$$Li_2CO_3 \xrightarrow{\Delta} Li_2O + CO_2 \uparrow ;\ MgCO_3 \xrightarrow{\Delta} MgO + CO_2 \uparrow ;\ Ag_2CO_3 \xrightarrow{\Delta} 2Ag + CO_2 \uparrow$$

**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.
  $$CaSO_3 + H_2SO_4 \longrightarrow CaSO_4 + H_2O + SO_2 \uparrow$$
  $SO_2$ has odour of burning sulphur.
- **Acidified potassium dichromate test :** The filter paper dipped in acidified $K_2Cr_2O_7$ turns green.
  $$Cr_2O_7^{2-} + 2H^+ + 3SO_2 \longrightarrow 2Cr^{3+}\ (\text{green}) + 3SO_4^{2-} + H_2O.$$
- **Barium chloride/Strontium chloride solution :** White precipitate of barium (or strontium) sulphite is obtained.
  $$SO_3^{2-} + Ba^{2+}/Sr^{2+} \longrightarrow BaSO_3/SrSO_3 \downarrow (\text{white}).$$
  (Soluble in dilute)

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.

$$2\,BaSO_3 \downarrow + O_2 \longrightarrow 2\,BaSO_4 \downarrow$$
$$BaSO_3 \downarrow + Br_2 + H_2O \longrightarrow 2\,BaSO_4 \downarrow + 2\,HBr$$

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

- **Zinc and sulphuric acid test :** Hydrogen sulphide gas is evolved.
  $$SO_3^{2-} + 3Zn^{2+} + 8H^+ \longrightarrow H_2S \uparrow + 3Zn^{2+} + 3H_2O$$
- **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.
  $$Ca(OH)_2 + SO_2 \longrightarrow CaSO_3 \downarrow (\text{milkiness}) + H_2O$$
  $$CaSO_3 \downarrow + SO_2 + H_2O \longrightarrow Ca(HSO_3)_2\ (\text{soluble})$$
- **Lead acetate or lead nitrate solution :** White precipitate of $PbSO_3$ is obtained.
  $$SO_3^{2-} + Pb^{2+} \longrightarrow PbSO_3 \downarrow (\text{soluble in dil. } HNO_3 \text{ on boiling})$$

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

- **Dilute $H_2SO_4$ test :** Rotten egg smelling gas is obtained.
  $$S^{2-} + 2H^+ \longrightarrow H_2S \uparrow$$
- **Lead acetate test :** Filter paper moistened with lead acetate solution turns black.
  $$(CH_3COO)_2Pb + H_2S \longrightarrow PbS \downarrow (\text{black}) + 2CH_3COOH.$$
- **Sodium nitroprusside test :** Purple coloration is obtained.
  $$S^{2-} + [Fe(CN)_5(NO)]^{2-} \longrightarrow [Fe(CN)_5NOS]^{4-}\ (\text{violet/purple}).$$
  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.

☞ $H_2S$ does not provide sufficient concentration of $S^{2-}$ ions so that it does not give sodium nitroprusside test.

- **Cadmium carbonate suspension/ Cadmium acetate solution :** Yellow precipitate is formed.
  $$Na_2S + CdCO_3 \longrightarrow CdS \downarrow + Na_2CO_3$$
- **Silver nitrate solution :** Black precipitate is formed which is insoluble in cold, but soluble in hot, dilute nitric acid.
  $$Ag^+ + S^{2-} \longrightarrow Ag_2S \downarrow$$

- **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.

$$NO_2^- + H^+ \longrightarrow HNO_2 \; ; \; (2HNO_2 \longrightarrow H_2O + N_2O_3);$$
$$3HNO_2 \longrightarrow HNO_3 + 2NO + H_2O \; ; 2NO + O_2 \longrightarrow 2NO_2 \uparrow$$

- **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.

$$2NO_2^- + 3I^- + 4CH_3COOH \longrightarrow I_3^- + 2NO \uparrow + 4CH_3COO^- + 2H_2O$$
$$\text{Starch} + I_3^- \longrightarrow \text{Blue (starch iodine adsorption complex)}$$

- **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.

$$NO_2^- + CH_3COOH \longrightarrow HNO_2 + CH_3COO^-$$
$$3HNO_2 \longrightarrow H_2O + HNO_3 + 2NO \uparrow$$
$$Fe^{2+} + SO_4^{2-} + NO \uparrow \longrightarrow [Fe, NO]SO_4$$

- **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.

$$NaNO_2 + CH_3COOH \longrightarrow HNO_2 + CH_3COONa$$
$$HNO_2 + H_2NCSNH_2(s) \text{ (thiourea)} \longrightarrow N_2 + HSCN + 2H_2O$$
$$FeCl_3 + 3HSCN \xrightarrow{\text{dil HCl}} Fe(SCN)_3 \text{ (blood red colouration)} + 3HCl$$

- **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 :**

$$NO_2^- + AgNO_3\,(aq.) \longrightarrow AgNO_2 \downarrow (\text{white}) + NO_3^-$$

(Water soluble metal nitrite)

**5. ACETATE ION ($CH_3COO^-$)**

- **Dil. $H_2SO_4$ test :** colourless gas with vinegar 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** :

$$CH_3COO^- + Ag^+ \rightleftharpoons CH_3COOAg \downarrow$$

(Water soluble metal acetate) (soluble in boiling water as well as in ammonia solution)

## (b) CONC. $H_2SO_4$ GROUP :

### 1. CHLORIDE ION ($Cl^-$) :

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

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

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

☞ $2NaCl + MnO_2 + 2H_2SO_4$ (conc.) $\xrightarrow{\Delta} Na_2SO_4 + MnSO_4 + 2H_2O + Cl_2$

- **Silver nitrate test :**

$$Cl^- + Ag^+ \longrightarrow AgCl \downarrow \text{(white)}$$

$$3AgCl\downarrow + AsO_3^{3-} \longrightarrow Ag_3AsO_3\downarrow + 3Cl^-.$$

(yellow)

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

$$AgCl + 2NH_4OH \underset{+H^+}{\rightleftharpoons} [Ag(NH_3)_2]Cl \text{ (Soluble)} + 2H_2O$$

- **Chromyl chloride test :**

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

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.

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

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

☞ Heavy metal chlorides such as $Hg_2Cl_2$, $HgCl_2$, $SnCl_4$, AgCl, $PbCl_2$ and $SbCl_3$, CuCl do not respond to this test as they are partially dissociated. This test is given generally by ionic chlorides.

☞ Test should be carried out in a dry test tube otherwise chromic acid will be formed.

$$CrO_2Cl_2 + 2H_2O \longrightarrow H_2CrO_4 + 2HCl$$

### 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.

$$2Br^- + Pb^{+2} \longrightarrow PbBr_2 \downarrow$$

- **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.

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

$$Br_2 + CHCl_3 / CCl_4 \longrightarrow Br_2 \text{ (dissolve to give reddish brown colour in organic solvent).}$$

With excess of chlorine water, the bromine is converted into yellow bromine monochloride

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

(yellow)

- **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 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 solvent forming a violet solution.

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

  $I_2 + CHCl_3 \longrightarrow I_2$ (dissolves in organic solvent to give violet layer)

- **Lead acetate solution :** A yellow precipitate is formed.

  $2I^- + Pb^{+2} \longrightarrow PbI_2\downarrow$

- **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

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

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

$2CuI_2 \longrightarrow Cu_2I_2 + I_2$ (without heating)

**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.

  $NaNO_3 + H_2SO_4 \longrightarrow NaHSO_4 + HNO_3$

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

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).

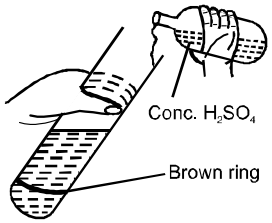



**Figure : Brown ring test**

☞ On shaking and warming the mixture, NO escapes and a yellow solution of iron(III) ions is obtained.

☞ 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.

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

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

$CO(NH_2)_2 + 2HNO_2 \longrightarrow 2N_2 \uparrow + CO_2 \uparrow + 3H_2O$

- **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.

**(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. + Barium chloride (aq) $\longrightarrow$ 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.+ Lead acetate $\longrightarrow$ 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. $+ (NH_4)_2SO_4$

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

● **Match stick test :**

(a) W.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.

$SO_4^{2-} + 2Ag^+ \longrightarrow Ag_2SO_4 \downarrow$

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

● **Ammonium molybdate test :**

$Na_2HPO_4$ (aq) + $12(NH_4)_2MoO_4 + 23HNO_3 \rightarrow (NH_4)_3PMo_{12}O_{40} \downarrow$ (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. + Magnesium nitrate reagent 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 $NH_3$.

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

$PO_4^{3-} + 3Ag^+ \longrightarrow Ag_3PO_4 \downarrow$

**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 $(C_2H_5O)_3B \uparrow + 3H_2O$

## MISCELLANEOUS SOLVED PROBLEMS (MSPs)

**1.** $BaCl_2$ 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:
(A) sulphite (B) sulphide (C) acetate (D) carbonate

**Ans.** **(A)**

**Sol.** $Ba^{2+} + SO_3^{2-} \longrightarrow BaSO_3 \downarrow$ (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.

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

**3.** 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)**

**Ans.** (A) $Pb^{2+} + 2Cl^- \longrightarrow PbCl_2\downarrow$ (white) ; $Ba^{2+} + 2Cl^- \longrightarrow BaCl_2$ (water soluble)

(B) $(CH_3COO)_2Pb$ 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)

**4.** 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) $+ 2H^+$

**5.** 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)**

**6.** 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)

**7._** 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 $F^-$, $Cl^-$, $Br^-$

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

**9.** 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)**

**10._** 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.

**11._** 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) $\xrightarrow{NaOH} \underset{\text{Yellow (sodium chromate)}}{Na_2CrO_4} \xrightarrow{(CH_3COO)_2Pb} \underset{\text{Lead chromate (Yellow)}}{PbCrO_4}$

**12._** 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.

**13._** 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.

**14._** 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.

**15.** 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 may have for Revision Questions.**

## PART - I : SUBJECTIVE QUESTIONS

### Section (A) : Heating in dry test tube

**A-1.** How many of the following does not give metal oxide on heating
$Na_2CO_3$, $K_2CO_3$ ,$Rb_2CO_3$, $MgCO_3$, $CaCO_3$

**A-2.** What is importance of dry tests and it is applicable to which kind of substances ?

**A-3.** 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.** Which of the following cations can not detected by the flame test?

$NH_4^+$ , $K^+$ , $Mg^{2+}$, $Al^{3+}$

**B-2.** Why compounds shows colours in flame test ?

**B-3.** Is intensity of colour in flame test, depends upon the concentration of metal present ?

**B-4.** Why is a green flame not obtained in the case of barium sulphate or barium phosphate ?

**B-5.** $Cu^{2+}$ and $Ba^{2+}$ interfere in the flame test for borate, why ?

**B-6.** 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.** When $H_2S$ gas passed through sodium nitroprusside solution, no colour change is observed. However when solution is made alkaline, purple colouration is obtained, explain why

**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.** $A + Zn + OH^- \longrightarrow B + [Zn(OH)_4]^{2-}$
$B + C \longrightarrow$ (D) White fumes
Identify A, B, C and D

**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) : Concentrated HCl / Conc. $H_2SO_4$ group

**D-1.** Why $Ca(NO_3)_2$, $Ba(NO_3)_2$ and $Pb(NO_3)_2$ don't respond to brown ring test

**D-2.** Why is it necessary to test for the acid radicals first with dil. $H_2SO_4$ and then with conc. $H_2SO_4$?

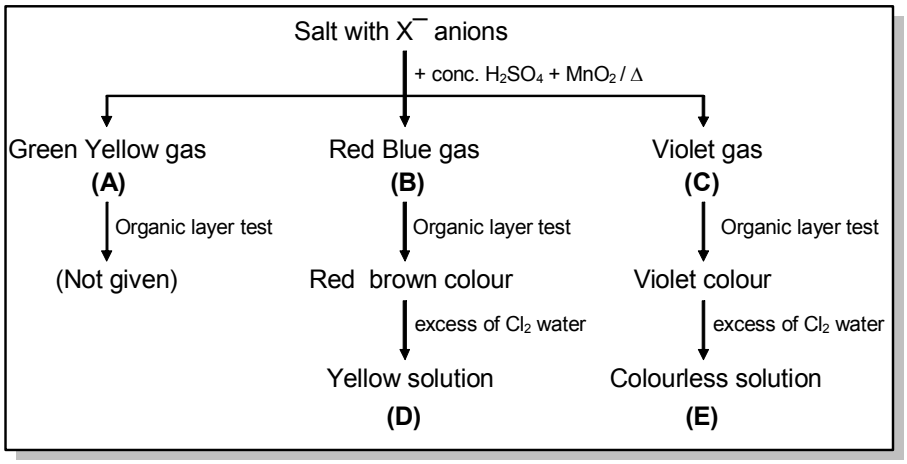
**D-3.** Why chromyl chloride test is carried out in a dry test tube ?

**D-4.** Why bromides and iodides do not respond to chromyl chloride test ?

**D-5.** NaCl on heating with conc. $H_2SO_4$ gives HCl where as NaBr and NaI give $Br_2$ and $I_2$ respetively, why?

**D-6.** Dilute Hydrochloric acid contains chloride ions but it doesnot give positive chromyl chloride test, why ?

**D-7.**




Identify the gas A, B and C.

**D-9.** Why is a freshly prepared solution of $FeSO_4$ used for the detection of nitrate and nitrite ?

## Section (E) : Precipitation Reactions

**E-1.** $BO_3^{3-} + \underset{\text{Conc.}}{H_2SO_4} \xrightarrow{\Delta} \underset{\text{White fumes}}{(P)}$

$BO_3^{3-} + \underset{\text{Conc.}}{H_2SO_4} + C_2H_5OH \xrightarrow{\Delta} \underset{\text{Vapours}}{(Q)}$

P & Q are respectively -

**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.** Mercuric nitrate solution reacts with a soluble sulphate forming a yellow precipitate. If the statement is true then explain giving the complete balanced equation.

**E-4.** How will you distinguish between sulphite and sulphate ions ?

# PART - II : OBJECTIVE QUESTIONS

## Section (A) : Dry test

**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) $NaNO_3 \xrightarrow[800°C]{\Delta}$ (D) $AgNO_3(s) + conc.\ H_2SO_4 \longrightarrow$

**A-6.** 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) $MgCO_3 + Al_2O_3$

## Section (B) : Flame and borax bead test

**B-1.** Which metal gives violet colour in oxidising flame when heated with borax ?
(A) Fe (B) Pb (C) Co (D) Mn

**B-2.** 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-3.** 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-4.** 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-5.** 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-6.** 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-7.** 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-8.** 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) $CH_3COO^-$, $I^-$, $CO_3^{2-}$

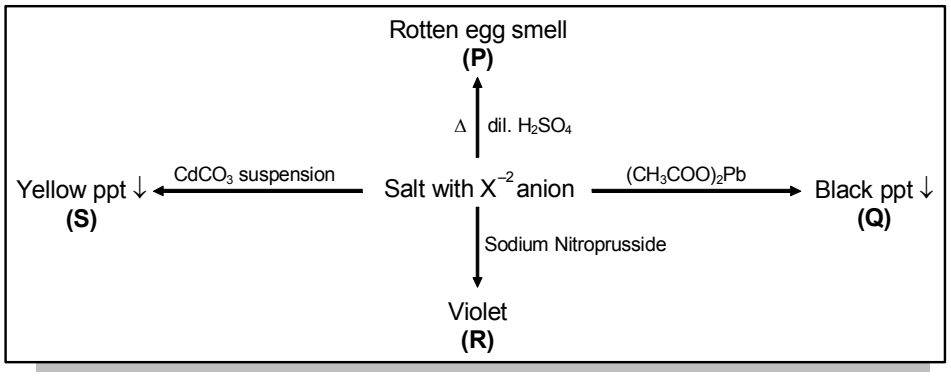
**C-2.** Two inorganic compounds **A** and **B** were heated in a dry test tube. **A** evolved a colourless gas which turned lead acetate paper black and **B** evolved a gas which turned lime water milky. The anions in **A** and **B** respectively are :
(A) $SO_3^{2-}$ , $CO_3^{2-}$ (B) $S^{2-}$, $CO_3^{2-}$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

**C-9.**

| | **List–I (Molecule)** | **List–II (Characteristic Odour)** |
|---|---|---|
| (P) | $CO_2$ | (1) Rotten egg smell |
| (Q) | $SO_2$ | (2) Suffocating smell of burning sulphur |
| (R) | $H_2S$ | (3) Vineger like smell |
| (S) | $CH_3COOH$ | (4) Odour less |

**Code :**

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

## Section (D) : Concentrated HCl / Conc. $H_2SO_4$ group

**D-1.** 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 :
(A) KI (B) NaI (C) $MgI_2$ (D) $CaBr_2$

**D-2.** 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 $C_6H_5NH_3Cl$

**D-3.** 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

**D-4.** 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-5.** 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-6.** 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-7.** 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-8.** 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-9.** 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-10.** 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-11.** 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-12.** 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) $NO_2^-$

**D-13.** Which of the following gases turn starch iodide paper blue?
(A) $CO_2$ (B) $SO_2$ (C) $NO_2$ (D) $H_2S$

**D-14.** 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.** Precipitate of $PbSO_4$ is soluble in :
(A) ammonium acetate (6M) (B) dilute HCl
(C) dilute $H_2SO_4$ (D) none of these

**E-2.** 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-3.** 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) Yellow ppt. with $Hg(NO_3)_2$ 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) $PbNO_3$ solution | (r) $S^{2-}$ |
| (D) Acidified $KMnO_4$ solution | (s) $NO_2^-$ |

# Exercise-2

**Marked Questions may have for Revision Questions.**

## PART - I : ONLY ONE OPTION CORRECT TYPE

**1.** An aqueous solution of gas (X) gives the white turbidity on passing $H_2S$ in the solution. Identify (X)
(A) $NH_3$ (B) $SO_2$ (C) $CO_2$ (D) None of these

**2.** $NO_2^-$ and $NO_3^-$ can be distinguished by which of the following reagent.
(A) dil. $H_2SO_4$ (B) conc. $H_2SO_4$
(C) Devarda's alloy (Cu + Zn + Al) + conc.NaOH (D) None of these

**3.**

| | List–I (Reaction) | | List–II (Product) |
|---|---|---|---|
| (P) | $KI + NO_2^- \longrightarrow$ | (1) | $NH_3$ |
| (Q) | $NH_4NO_3 \xrightarrow{\Delta}$ | (2) | NO |
| (R) | $NO_2^- \xrightarrow{Zn+NaOH}$ | (3) | $N_2$ |
| (S) | $(NH_4)_2Cr_2O_7 \xrightarrow{\Delta}$ | (4) | $N_2O$ |

**Code :**

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

**4.** Which of the following halide is soluble in water ?
(A) AgF (B) AgCl (C) AgBr (D) AgI

**5.** Which of the following pair of acidic radical can be distinguished by using dil $H_2SO_4$?
(I) $SO_3^{2-}$ and $HSO_3^-$ (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

**6.** Which of the following salt liberates a colourless gas when acidification with dil. $H_2SO_4$ ?
(A) $KNO_2$ (B) $Na_2CO_2$ (C) $NaNO_2$ (D) $NaHCO_3$

**7.** 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

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

**9.** A sodium salt of unknown anion when treated with $MgCl_2$ gives white precipiate only on boiling. The anion of unknown salt is :
(A) $SO_4^{2-}$ (B) $HCO_3^-$ (C) $CO_3^-$ (D) $NO_3^-$

**10.** 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

**11.** 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.

**12.** 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) $S^{2-}$

**13.** 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) $SO_3^{2-}$ (D) $S^{2-}$

**14.** $Na_2SO_4 + BaCl_2 \longrightarrow$ 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

**15.** 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) $(C_2H_5)_3BO_3$

**16.** When a acidic solution of salt **(X)** is treated with thiourea, $N_2$ is evolved and thiocyanic acid is produced. This thiocyanic acid give blood red colour with $FeCl_3$ solution. Salt **(X)** contains the anion :

(A) $S^{2-}$ (B) $NO_3^-$ (C) $NO_2^-$ (D) $CO_3^{2-}$

## PART - II : SINGLE AND DOUBLE VALUE INTEGER TYPE

**1.** How many compounds liberate $NH_3$ on heating from the following?

$(NH_4)_2SO_4$, $(NH_4)_2CO_3$, $NH_4Cl$, $NH_4NO_3$, $(NH_4)_2Cr_2O_7$

**2.** Number of ions which are identified by dil. HCl from the following.

$SO_4^{2-}$, $CO_3^{2-}$, $SO_3^{2-}$, $HCO_3^-$, $NO_2^-$, $NO_3^-$, $CH_3COO^-$, $PO_4^{3-}$

**3.** $Na_2S + Na_2[Fe(CN)_5NO] \longrightarrow$ "X" (Violet colour)

The total number of possible isomers for complex "X" is, provided the ambident behaviour of $CN^-$ is not considered.

**4.**

$$B(g) \xleftarrow[H_2SO_4]{\text{Conc.}} \underset{\text{(Mixture of two anions)}}{(A)} \xrightarrow{\text{(Sulphamic acid)}} \underset{\text{(Only one is present)}}{(C)} \xrightarrow[+\text{ conc. } H_2SO_4]{FeSO_4} (D)\ \text{(Unstable brown coloured compound)}$$

Calculate difference in oxidation state of element (other than oxygen) in two anions.

**5.** $Fe^{2+} + NO_3^- + H_2SO_4(\text{conc.}) \rightarrow$ 'X' (Brown ring complex)

The magnetic moment of complex 'X' to its nearest integer is :

**6.** How many anions evolve brownish gas when treated with dil./conc. HCl. ?

$CO_3^{2-}$, $SO_3^{2-}$, $NO_2^-$, $Cl^-$, $Br^-$, $NO_3^-$, $CH_3COO^-$

**7.** $Na_2CO_3$, 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.

**8.** $BO_3^{3-} + \text{conc. } H_2SO_4 + CH_3CH_2{-}OH \xrightarrow{\text{ignite}}$ 'A' (green flame)

What is the oxidation number of central atom in Compound 'A' that is responsible for green flame ?

**9.**

$$NaCl(s) \begin{cases} \xrightarrow{MnO_2 \,/\, \text{Conc.}H_2SO_4} X(g) \\ \xrightarrow{K_2Cr_2O_7 \,/\, \text{Conc. } H_2SO_4} Y(g) \end{cases}$$

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.** When $Ag_2CO_3$ is strongly heated then product will be -
(A) $Ag_2O$ (B) Ag (C) $O_2$ (D) $CO_2$

**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) $BaCO_3$

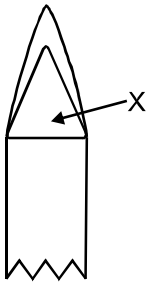
**4.** Salt of Anion A
- dil. $H_2SO_4$ → Colourless gas with brick effervescence
- $AgNO_3$ → White ppt —boil→ Turns black
- Acidic $K_2Cr_2O_7$ → Green colour

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

**5.** 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 $NO_3^{2-}$

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

**7.** In the following diagram bunsen flame the (X) represent




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

**8.** A (mixture of two anions)
- $AgNO_3$ solutions → "B" (White crystalline precipitate)
- $Zn+dil/H_2SO_4$ → C (g) —$(CH_3COO)_2Pb$→ "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.** 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.

**10.** 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 ligand is +1.

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

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

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

**14.** 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

**15.** $\underset{\text{(mixture of two anions)}}{\mathbf{A}} \xrightarrow[\text{excess of } BaCl_2]{\text{Cold}}$ 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

**Comprehension # 1**

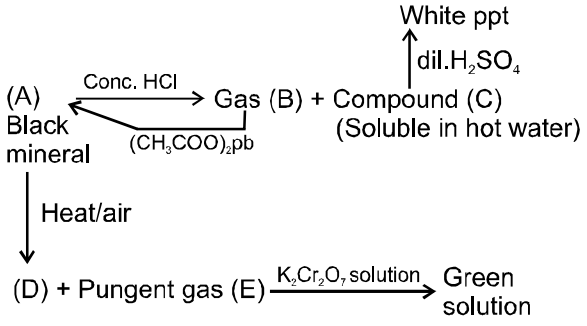
**Step-I** **Step-II** **Step-III**

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

**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) $H_2S$, $CO_2$

# Exercise-3

## JEE (ADVANCED) / IIT-JEE PROBLEMS (PREVIOUS YEARS)

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

**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]**

$[Fe(H_2O)_6]^{2+} + NO_3^- + H^+ \longrightarrow$ ..... + $[Fe(H_2O)_6]^{3+} + H_2O$

$[Fe(H_2O)_6]^{2+}$ + ..... $\longrightarrow$ ..... + $H_2O$

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, 3/150]**

(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, 3/144]**

(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, 3/144]**

(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) $HCO_3^{2-}$, $CO_3^{2-}$
(C) $CO_3^{2-}$, $HCO_3^-$ (D) $CO_2$, $H_2CO_3$

**8.** Consider the following list of reagents : **[JEE Adv. 2014]**
Acidified $K_2Cr_2O_7$, alkaline $KMnO_4$, $CuSO_4$, $H_2O_2$ , $Cl_2$, $O_3$, $FeCl_3$, $HNO_3$ and $Na_2S_2O_3$.
The total number of reagents that can oxidise aqueous iodide to iodine is

**9.** The reagent(s) that can selectively precipiate $S^{2-}$ from a mixture of $S^{2-}$ and $SO_4^{2-}$ in aqueous soltuion is(are) **[JEE(Adv.)-2016]**

(A) $CuCl_2$ (B) $BaCl_2$ (C) $Pb(OOCCH_3)_2$ (D) $Na_2[Fe(CN)_5NO]$

**10.** The green colour produced in the borax bead test of a chromium(III) salt is due to- **JEE(Adv.)-2019]**

(A) $Cr(BO_2)_3$ (B) CrB (C) $Cr_2(B_4O_7)_3$ (D) $Cr_2O_3$

# ANSWER KEY

## EXERCISE - 1

### PART - I

**A-1.** 3

**A-2.** 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-3.** (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.** 3

**B-2.** 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-3.** Yes, because intensity of the absorbed light is proportional to the concentration of element in the flame.

**B-4.** 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-5.** Because they also impart green colour to flame.

**B-6.** $Na_2B_4O_7.10H_2O \xrightarrow[740°C]{\Delta} \underset{(A)}{2NaBO_2} + \underset{(B+C)}{B_2O_3} \xrightarrow{Cu^{2+},\Delta} \underset{(D)}{Cu(BO_2)_2}$ (Blue bead)

**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.** Bacause $H_2S$ is a weak acid and don't provide sufficient $S^{2-}$ ions to change the colour but on addition of alkali, concentration of $S^{2-}$ ions increases and give this test

**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.** $A = NO_2^-$ Or $NO_3^-$ $B = NH_3$ ,$C = HCl$, $D = NH_4Cl$

**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.** Due to the precipitation of corresponding metal sulphate

**D-2.** 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-3.** Because in presence of water, chromyl chloride forms the chromic acid.
$CrO_2Cl_2 + 2H_2O \longrightarrow H_2CrO_4 + 2HCl$

**D-4.** 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-5.** 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-6.** Because in presence of water chromic acid is obtained in place of chromyl chloride.

**D-7.** $A = Cl_2$
$B = Br_2$
$C = I_2$

**D-8.** Because heavy metal chlorides are partially dissociated, This test is given generally by Ionic chloride.

**D-9.** 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.** $H_3BO_3$ & $(C_2H_5)_3BO_3$

**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.** $SO_4^{2-} + 3\,Hg^{2+} + 2\,H_2O \longrightarrow HgSO_4.\,2\,HgO\downarrow + 4\,H^+$
Yellow precipitate is owing to the formation of basic Hg(II) sulphate.

**E-4.** $BaCl_2$ 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.
$FeCl_3$ solution gives a red colour with sulphite and no colour is obtained with sulphate.

## PART - II

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **A-1.** | (B) | **A-2.** | (B) | **A-3.** | (C) | **A-4.** | (D) | **A-5.** | (D) |
| **A-6.** | (C) | **B-1.** | (D) | **B-2.** | (C) | **B-3.** | (B) | **B-4.** | (A) |
| **B-5.** | (B) | **B-6.** | (D) | **B-7.** | (C) | **B-8.** | (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) | **C-9.** | (A) | **D-1.** | (A) | **D-2.** | (B) |
| **D-3.** | (A) | **D-4.** | (B) | **D-5.** | (A) | **D-6.** | (B) | **D-7.** | (B) |
| **D-8.** | (B) | **D-9.** | (D) | **D-10.** | (D) | **D-11.** | (D) | **D-12.** | (C) |
| **D-13.** | (C) | **D-14.** | (B) | **E-1.** | (A) | **E-2.** | (C) | **E-3.** | (C) |

## PART - III

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

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

## EXERCISE - 2

### PART - I

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **1.** | (B) | **2.** | (A) | **3.** | (D) | **4.** | (A) | **5.** | (B) |
| **6.** | (C) | **7.** | (C) | **8.** | (C) | **9.** | (B) | **10.** | (B) |
| **11.** | (A) | **12.** | (B) | **13.** | (A) | **14.** | (D) | **15.** | (D) |
| **16.** | (C) | | | | | | | | |

### PART - II

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **1.** | 3 | **2.** | 5 | **3.** | 3 | **4.** | 2 | **5.** | 4 |
| **6.** | 1 | **7.** | 5 | **8.** | 3 | **9.** | 14 | | |

### PART - III

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **1.** | (BCD) | **2.** | (ACD) | **3.** | (ACD) | **4.** | (AC) |
| **5.** | (ABCD) | **6.** | (AC) | **7.** | (BC) | **8.** | (CD) |
| **9.** | (AD) | **10.** | (ABD) | **11.** | (AB) | **12.** | (AB) |
| **13.** | (ABC) | **14.** | (CD) | **15.** | (AC) | | |

### PART - IV

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **1.** | (D) | **2.** | (AD) | **3.** | (B) | **4.** | (B) |

## EXERCISE - 3

**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.** $\because$ $Fe^{II}$ and $Fe^{III}$ have different magnetic moment due to different number of unpair electrons.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **3.** | (B) | **4.** | (C) | **5.** | (A) | **6.** | (A) | **7.** | (A) |
| **8.** | 7 | **9.** | (AC) | **10.** | (A) | | | | |

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

# Self Assessment Test

## PART- 1 : PAPER JEE (MAIN) PATTERN

**SECTION–I : (Maximum Marks : 80)**

- This section contains **TWENTY** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is correct.
- For each question, darken the bubble corresponding to the correct option in the ORS.
- For each question, marks will be awarded in one of the following categories :
  *Full Marks* : +4If only the bubble corresponding to the correct option is darkened.
  *Zero Marks* : 0 If none of the bubbles is darkened.
  *Negative Marks* : –1 In all other cases

**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 :
(A) a sulphite (B) a carbonate (C) a nitrate (D) 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 :
(A) $Br^-$ (B) $I^-$ (C) $NO_3^-$ (D) $NO_2^-$

**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 :
(A) the nitrate (B) the bromide (C) both (D) none of the two

**4.** Which of the following combines with Fe(II) ions to form a brown complex?
(A) $N_2O$ (B) NO (C) $N_2O_3$ (D) $N_2O_4$

**5.** Colourless salt (A) + dil. $H_2SO_4$ or $CH_3COOH$ + KI $\longrightarrow$ blue colour with starch. (A) can be
(A) $K_2SO_3$ (B) $Na_2CO_3$ (C) $NH_4NO_2$ (D) $NH_4Cl$

**6.** There are four test tubes containing dilute HCl, $BaCl_2$, $CdCl_2$ and $KNO_3$ solutions. Which of the following reagents will help in the identification of $BaCl_2$ ?
(A) NaOH (B) $K_2CrO_4$ (C) $AgNO_3$ (D) both (B) and (C)

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

**8.** A brick red colour is imparted to Bunsen flame by a :
(A) Ca salt (B) Sr salt (C) Na salt (D) Co salt

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

**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:
(A) sulphite (B) sulphide (C) acetate (D) 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.
(A) $SO_3^{2-}$ (B) $NO_2^-$ (C) $S^{2-}$ (D) All of these

**12.** When KI is added to acidified solution of sodium nitrite :
(A) NO gas is liberated and $I_2$ is set free (B) $N_2$ gas is liberated and HI is produced
(C) $N_2O$ gas is liberated and $I_2$ is set free (D) $N_2$ gas is liberated and HOI is produced

**13.** Zinc pieces are added to acidified solution of $SO_3^{2-}$. Gas liberated can :
(A) turn lead acetate paper black (B) turn lime water milky
(C) give white precipitate with $AgNO_3$ solution (D) 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 :
(A) $CO_3^{2-}$ (B) $S^{2-}$ (C) $SO_3^{2-}$ (D) $NO_2^-$

**15.** Ammonium molybdate test is used for the estimation of :
(A) $PO_4^{3-}$ (B) $NO_3^-$ (C) $SO_3^{2-}$ (D) $SO_4^{2-}$

**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 ?
(A) HCl (B) $H_2S$ (C) $SO_2$ (D) $NH_3$

**17.** When Ag reacts with conc. HCl, then products will be :
(A) AgCl, $Cl_2$ (B) AgCl, $H_2$ (C) AgCl, $H_2$, $Cl_2$ (D) None of these

**18.** Which of the following salt will evolve sulphur dioxide gas along with formation of yellowish turbidity when treated with dilute $H_2SO_4$ ?
(A) Sodium sulphide (B) Sodium sulphite (C) Sodium thiosulphate (D) 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 :
(A) $CO_3^{2-}$ (B) $HCO_3^-$ (C) $SO_3^{2-}$ (D) $C_2O_4^{2-}$

**20.** In the test for iodine, $I_2$ is treated with sodium thiosulphate ($Na_2S_2O_3$) :
$Na_2S_2O_3 + I_2 \longrightarrow NaI + .....$
(A) $Na_2S_4O_6$ (B) $Na_2SO_4$ (C) $Na_2S$ (D) $Na_3ISO_4$

**SECTION-II : (Maximum Marks: 20)**

- This section contains **FIVE** questions.
- The answer to each question is a **NUMERICAL VALUE**.
- For each question, enter the correct numerical value (If the numerical value has more than two decimal places, **truncate/round-off** the value to **TWO** decimal places; e.g. 6.25, 7.00, –0.33, –.30, 30.27, –127.30, if answer is 11.36777..... then both 11.36 and 11.37 will be correct) by darken the corresponding bubbles in the ORS.
  **For Example :** If answer is –77.25, 5.2 then fill the bubbles as follows.
- Answer to each question will be evaluated according to the following marking scheme:
  *Full Marks* : +4 If ONLY the correct numerical value is entered as answer.

**21.** When calamine is heated then a product (A) is formed then find the total number of following options are correct for compound (A) -
(i) Compound (A) is white in cold conditions
(ii) Compound (A) is yellow in hot conditions
(iii) Compound (A) is called phillosopher's wool
(iv) Compound (A) when combined with CoO, then compound (B) is formed & colour of new compound (B) is green
(v) Compound (B) is called Rinmann's green

**22.** $NaNO_3 \xrightarrow{500°C}$ (A) + (B) ; (A) $\xrightarrow{800°C}$ (C) + (D) + (E)
Find the number of correct statements
(1) Compound (B) is paramagnetic in nature
(2) Compound (B) when undergoes dimerisation then dimer product is diamagnetic in nature
(3) Bond order of compound (B) is two
(4) D is $N_2$ gas
(5) Compound B and E are same gas

**23.** 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).

**24.** How many of the following will volatilize on heating leaving no solid residue ?
$NaNO_3$, $NH_4NO_3$, $Ca(H_2PO_2)$, $NH_4HCO_3$, $N_2H_5HSO_3$, $AlCl_3$, $[Cu(NH_3)_4]SO_4$, $FeSO_4.7H_2O$

**25.** $Na_2S + Na_2[Fe(CN)_5NO] \rightarrow$ "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 :

## PART 2 : PAPER JEE (ADVANCED) PATTERN

**SECTION-I : (Maximum Marks : 12)**

- This section contains **FOUR** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is correct.
- For each question, darken the bubble corresponding to the correct option in the ORS.
- For each question, marks will be awarded in one of the following categories :

| | | | |
|---|---|---|---|
| *Full Marks* | : | +3 | If only the bubble corresponding to the correct option is darkened. |
| *Zero Marks* | : | 0 | If none of the bubbles is darkened. |
| *Negative Marks* | : | –1 | In all other cases |

**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

**SECTION-II : (Maximum Marks: 32)**

- This section contains **EIGHT** questions.
- Each question has **FOUR** options for correct answer(s). **ONE OR MORE THAN ONE** of these four option(s) is (are) correct option(s).
- For each question, choose the correct option(s) to answer the question.
- Answer to each question will be evaluated according to the following marking scheme:

| | | | |
|---|---|---|---|
| *Full Marks* | : | +4 | If only (all) the correct option(s) is (are) chosen. |
| *Partial Marks* | : | +3 | If all the four options are correct but ONLY three options are chosen. |
| *Partial Marks* | : | +2 | If three or more options are correct but ONLY two options are chosen, both of which are correct options. |
| *Partial Marks* | : | +1 | If two or more options are correct but ONLY one option is chosen and it is a correct option. |
| *Zero Marks* | : | 0 | If none of the options is chosen (i.e. the question is unanswered). |
| *Negative Marks* | : | –1 | In all other cases. |

- **For Example :** If first, third and fourth are the **ONLY** three correct options for a question with second option being an incorrect option; selecting only all the three correct options will result in +4 marks. Selecting only two of the three correct options (e.g. the first and fourth options), without selecting any incorrect option (second option in this case), will result in +2 marks. Selecting only one of the three correct options (either first or third or fourth option), without selecting any incorrect option (second option in this case), will result in +1 marks. Selecting any incorrect option(s) (second option in this case), with or without selection of any correct option(s) will result in –1 marks.

**5.** 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.

**6.** 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 $HNO_3$.

**7.** 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).

**8.** 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

**9.** 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) $AgBO_2$

**10.** 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)

**11.** 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) $AgNO_3 + NaNO_2$

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

**SECTION-III : (Maximum Marks: 18)**

- This section contains **SIX** questions.
- The answer to each question is a **NUMERICAL VALUE**.
- For each question, enter the correct numerical value (in decimal notation, truncated/rounded-off to the **second decimal place**; e.g. 6.25, 7.00, –0.33, –.30, 30.27, –127.30, if answer is 11.36777..... then both 11.36 and 11.37 will be correct) by darken the corresponding bubbles in the ORS.
**For Example :** If answer is –77.25, 5.2 then fill the bubbles as follows.
- Answer to each question will be evaluated according to the following marking scheme:
*Full Marks* : +3 If ONLY the correct numerical value is entered as answer.
*Zero Marks* : 0 In all other cases.

**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), $KNO_3$, KCl(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 =?

## PART - 3 : OLYMPIAD (PREVIOUS YEARS)

**1.** Which of the following metal carbonate will decompose on heating ? **[NSEC-2000]**
(A) $K_2CO_3$ (B) $Na_2CO_3$ (C) $MgCO_3$ (D) None of these

**2.** For which element crimson colour is obtained in flame test ? **[NSEC-2002]**
(A) sodium (B) barium (C) strontium (D) calcium

**3.** The precipitate of AgCl dissolves in **[NSEC-2004]**
(A) conc. $HNO_3$ (B) excess of HCl (C) dilute $H_2SO_4$ (D) aq. ammonia.

**4.** Colour of the bead in borax bead test mainly due to the formation of **[NSEC-2005]**
(A) metal oxides (B) boron oxide (C) metal metaborates (D) elemental boron

**5.** 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) $[Fe(H_2O)_5NO]^{+}$.

**6.** 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) $[Fe(H_2O)(NO)_5]^{2+}$

**7.** $MgSO_4$ on reaction with $NH_4OH$ and $Na_2HPO_4$ forms a white crystalline precipitate. The formula of the precipitate is : **[NSEC-2009]**
(A) $Mg(NH_4)PO_4$ (B) $Mg_3(PO_4)_2$ (C) $MgCl_2.MgSO_4$ (D) $MgSO_4$

**8.** The gas which liberates bromine from a solution of KBr is **[NSEC-2013]**
(A) $Cl_2$ (B) $I_2$ (C) $SO_2$ (D) HI

**9.** Silver nitrate solution when added to a colorless aqueous solution E forms a white precipitate which disolves 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) $Na_2SO_4$

**10.** 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) $NH_4OH + S$

**11.** 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 - 4 : ADDITIONAL PROBLEMS

**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.** 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) $Na_2B_4O_7$

**6.** 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) $CO_3^{2-}$

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

**8.** $CuCO_3$ 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) | $Cr(BO_2)_2$ |

**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).

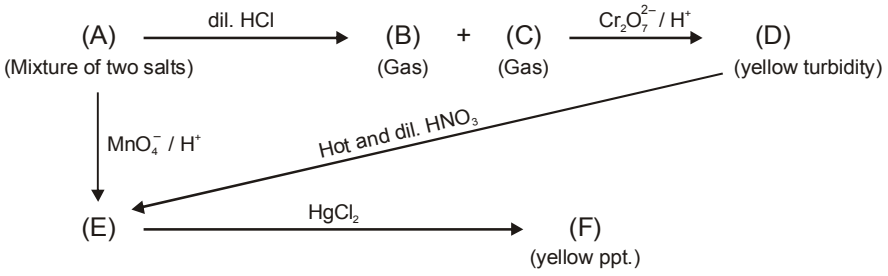
**9.** Gas (B) may be :
(A) $Cl_2$ (B) $Br_2$ (C) $I_2$ (D) $NO_2$

**10.** 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) $C_6H_5 – NH – \underset{\underset{O}{\downarrow}}{N} – C_6H_5$

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

**12.** 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) $S^{2-}$

**Paragraph For Questions 13 to 15**



**13.** Find the anion(s) :

(A) $SO_3^{2-}$ (B) $SO_3^{2-}$ , $S^{2-}$ (C) $SO_3^{2-}$ , $CO_3^{2-}$ (D) $S_2O_3^{2-}$

**14.** Find out (E) :

(A) $S^{2-}$ (B) $CO_3^{2-}$ (C) $S_2O_3^{2-}$ (D) $SO_4^{2-}$

**15.** Find out (F) :

(A) $HgSO_4.2HgO$ (B) $HgSO_4.3HgO$ (C) $HgSO_4$ (D) $Hg_2SO_4.3HgO$

**16.** 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 |

# RRP ANSWER KEY

## PART - 1

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1.** | (A) | **2.** | (D) | **3.** | (B) | **4.** | (B) | **5.** | (C) | **6.** | (B) | **7.** | (D) |
| **8.** | (A) | **9.** | (D) | **10.** | (A) | **11.** | (D) | **12.** | (A) | **13.** | (A) | **14.** | (C) |
| **15.** | (A) | **16.** | (D) | **17.** | (D) | **18.** | (C) | **19.** | (B) | **20.** | (A) | **21.** | 5 |
| **22.** | 4 | **23.** | 3 | **24.** | 4 | **25.** | 30 | | | | | | |

## PART - 2

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **1.** | (B) | **2.** | (D) | **3.** | (C) | **4.** | (C) | **5.** | (BC) |
| **6.** | (AB) | **7.** | (BCD) | **8.** | (BCD) | **9.** | (BC) | **10.** | (ABCD) |
| **11.** | (AB) | **12.** | (ABC) | **13.** | 5 | **14.** | 6 | **15.** | 7 |
| **16.** | 4 (I), (III), (IV) & (V) | | | **17.** | 5 | **18.** | 1 | | |

## PART - 3

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

## PART - 4

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **1.** | (A) | **2.** | (C) | **3.** | (B) | **4.** | (C) | **5.** | (BC) |
| **6.** | (ABD) | **7.** | (ABC) | **8.** | A→R, B→U, C→P, D→V | | | | |
| **9.** | (D) | **10.** | (B) | **11.** | (C) | **12.** | (B) | **13.** | (B) |
| **14.** | (D) | **15.** | (A) | **16.** | (C) | | | | |

# RRP SOLUTIONS

## PART- 1

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

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

**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.** $E^0_{SRP}$ of Ag = 0.80 V , $E^0_{SRP}$ of $Cl^-$ = 1.36 V , $E^0_{SRP}$ of $H^+$ = 0.00 V , So Ag can not oxidize $Cl^-$ and can not reduce $H^+$.

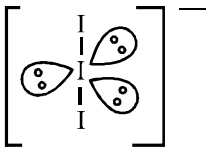
**18.** $S_2O_3^{2-}$ + dil.$H_2SO_4 \xrightarrow{\Delta} SO_2\uparrow$ (Suffocating gas) $2Cl^- + S\downarrow$ (yellow turbidity or white turbidity) + $H_2O$

**19.** $HCO_3^- + Mg^{2+} \rightarrow Mg(HCO_3)_2$ (No PPt) $\xrightarrow{\Delta}$ $MgCO_3\downarrow$

## SECTION–II

**23.** $3I^- + MnO_2 + H_2SO_4 \longrightarrow I_3^- \uparrow + Mn^{2+} + SO_4^{2-} + H_2S$

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



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

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

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

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

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

ambidentate ligand [a] = $CN^-, NOS^-$

a = 2

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

$7a + 8b = 30$

# PART- 2

## SECTION–I

**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.

## SECTION–II

**5.** (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) $5SO_2 + 2IO_3^- + 4H_2O \longrightarrow I_2 + 5SO_4^{2-} + 8H^+$

**6.** (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 $HNO_3$.

**7.** (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) $6KBr + K_2Cr_2O_7 + 7H_2SO_4 \longrightarrow 3Br_2 + 2Cr^{3+} + 2K^+ + 7SO_4^{2-} + 7H_2O$

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

**9.** $B_4O_7^{2-} + 4Ag^+ + H_2O \longrightarrow 4AgBO_2\downarrow$ (white) $+ 2H^+$

$$2AgBO_2\downarrow + 3H_2O \xrightarrow[\Delta/H_2O]{\text{Hydrolysis}} Ag_2O\downarrow \text{ (brown)} + 2H_3BO_3$$

**10.** $ZnCO_3 \xrightarrow{\Delta} ZnO + CO_2\uparrow$. ZnO is yellow when hot.
(white)

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

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

$$\underset{\text{(faint pink)}}{3MnSO_4} \xrightarrow{\Delta} \underset{\text{(black)}}{Mn_3O_4} + 2SO_2\uparrow + SO_3\uparrow$$

**11.** $AgNO_3 + NaBr \longrightarrow AgBr \downarrow$ (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. )

## SECTION–III

**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) $4NO_3^- + 2H_2SO_4 \longrightarrow Br_2\uparrow$ (reddish-brown) $+ 2K^+ + Mn^{2+} + 2SO_4^{2-} + 2H_2O$

(viii) $KCl + MnO(OH)_2 + 2H_2SO_4 + 2Cl^-$ (brown) $\longrightarrow Mn^{2+} + Cl_2\uparrow$ (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.** $\because$ a = 0 $H_2O$, $NO^+$ are not ambidentate ligand

b = 1 $Fe^{+1}$

a + b = 1

## PART - 3

**1.** $MgCO_3 \rightarrow MgO + CO_2$ because $Mg^{2+}$ have polarizing power.

**2.** Na $\rightarrow$ Golden yellow , Ba $\rightarrow$ apple red , Sr $\rightarrow$ Crimson , Ca $\rightarrow$ Brick red

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

**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) $+ 2B_2O_3 + 2CO$.

| 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 |

**5.** $NO_3^- + con.HCl \rightarrow NO\uparrow$

$\Rightarrow$ $Fe^{2+} NO + 5H_2O \rightarrow [Fe(H_2O)_5NO]^{2+}$

**6.** $NO_2^- / NO_3^- + dil.\ HCl/con.HCl \rightarrow NO\uparrow$

$\Rightarrow$ $Fe^{2+} NO + 5H_2O \rightarrow [Fe(H_2O)_5NO]^{2+}$

**7.** $MgSO_4 + NH_4OH + Na_2HPO_4 \longrightarrow \underset{\text{white crystalline ppt.}}{Mg(NH_4)PO_4} + Na_2SO_4 + \text{- - - - - - -}$

**8.** $Cl_2$ is oxidising agent.

## PART - 4

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

**2.** $\underset{(NaX)}{NaHCO_3} + HCl \longrightarrow NaCl + H_2O + \underset{(Y)}{CO_2\uparrow}$

$2NaHCO_3 \xrightarrow{\Delta} Na_2CO_3 + H_2O + CO_2\uparrow$

$CO_2 + 2KOH \longrightarrow K_2CO_3 + H_2O$

$CO_2$ 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.** $Na_2B_4O_7.10H_2O \xrightarrow{\Delta} Na_2B_4O_7 \xrightarrow{\Delta} \underset{\text{glassy bead}}{2NaBO_2 + B_2O_3}$

**6.** All nitrate are water soluble.

**7.** $H_2S$, $SO_2$ 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

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

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

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

**8.** $CuCO_3 \xrightarrow{\Delta} \underset{(A)}{CuO}\downarrow + \underset{(B)}{CO_2}\uparrow$

$$CuO + \underbrace{\overset{(X)}{NaBO_2 + B_2O_3}}_{\text{Borax bead}} \longrightarrow \underbrace{Cu(BO_2)_2}_{\text{(C) Blue bead}} + NaBO_2$$

$Cr_2(SO_4)_3 \xrightarrow[\text{Bead test}]{\text{Borax}}$ Green colored metaborate

**9-11)** $NaNO_3 + H_2SO_4 \longrightarrow \underset{(A)}{NaHSO_4} + HNO_3$

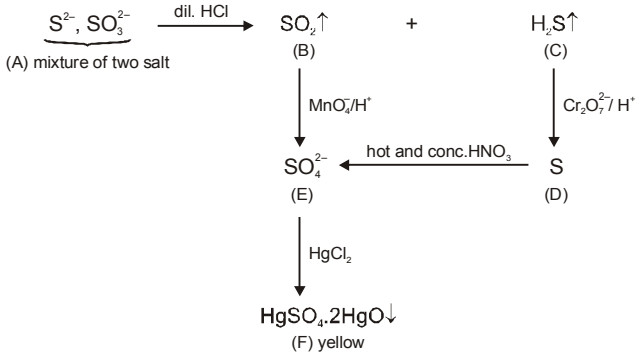
$2HNO_3 \longrightarrow H_2O + \underset{(B)}{2NO_2}\uparrow + [O]$

$2C_6H_5NHC_6H_5 + [O] \longrightarrow \underset{\text{blue ring (D)}}{(C_6H_5)_2N\text{–}N(C_6H_5)_5} + H_2O$

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

**12.** $NaCl + AgNO_3 \longrightarrow AgCl\downarrow$ (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.

**Sol.(13 - 15)**




**16.** $1 \rightarrow$ $IO_3^- + SO_2 \longrightarrow I_2 + SO_4^{2-}$ ; $I_2$ + Starch $\longrightarrow$ deep blue colour

$2 \rightarrow$ $SO_2 + MnO_4^- \longrightarrow \underset{\text{colourless}}{MnSO_4} + SO_4^{2-}$

$3 \rightarrow$ $Zn + NaOH + SO_2 \longrightarrow \underset{\text{rotten egge smell}}{H_2S\uparrow} + Zn^{2+}$

$4 \rightarrow$ $CO_2 + Ca(OH)_2 \longrightarrow CaCO_3\downarrow$ (milky)