Practical Work

Detection of Some Common Gases

Test for hydrogen (H_2):

Hydrogen gas is liberated when active metals such as Na, K, Mg react with dilute acids.

$$M + H_2SO_4 \longrightarrow MSO_4 + H_2$$
$$M + HCl \longrightarrow MCl + H_2$$
$$[M = Ca,\ Mg,\ Zn,\ etc.]$$

Few characteristics of this gas are as follows.

i. It is a colourless and odourless gas.

ii. When this gas is allowed to pass through a moist red or blue litmus paper, the colour of the paper does not change. This shows that hydrogen gas is neutral to litmus.

iii. A burning wooden splint, when brought near this gas, gets off and burns with a pale blue flame producing a pop sound.

$2\ H_2 + O_2 \rightarrow \quad 2\ H_2O$

Test for oxygen (O_2):

Oxygen gas is liberated on heating metal nitrates, potassium chlorate, potassium dichromate, potassium permanganate, hydrogen peroxide, barium peroxide and oxides such as HgO, PbO_2, Pb_3O_4.

$$2\ PbO_2 \xrightarrow{\Delta} 2\ PbO + O_2$$
$$2\ HgO \xrightarrow{\Delta} 2\ Hg + O_2$$

Few characteristics of this gas are as follows.

i. It is a colourless and odourless gas.

ii. When this gas is allowed to pass through a moist red or blue litmus paper, the colour of the paper does not change. This shows that oxygen gas is neutral to litmus.

iii. A burning wooden splint when brought near this gas re-lights brightly which shows that it is a supporter of combustion.

Test for water vapour (H_2O):

Water vapour is liberated on heating salts containing water of crystallisation, metallic hydroxides and metallic hydrogen carbonates.

$$Na_2CO_3.10H_2O \xrightarrow{\Delta} Na_2CO_3 + 10\,H_2O$$

$$CuSO_4.5H_2O \xrightarrow{\Delta} CuSO_4 + 5\,H_2O$$

Few characteristics of this gas are as follows.

i. It is a colourless and odourless gas.

ii. When this gas is allowed to pass through a moist red or blue litmus paper, the colour of the paper does not change. This shows that water vapour is neutral to litmus.

iii. It turns anhydrous copper sulphate to blue.

$$CuSO_4 + 5\,H_2O \longrightarrow CuSO_4.5H_2O$$

iv. It turns blue copper chloride to pink.

$$CoCl_2 + 2\,H_2O \longrightarrow CoCl_2.2H_2O$$

Test for ammonia (NH_3):

Ammonia is liberated by heating ammonium salts with alkalies and treating metallic nitrides with warm water.

$$2\,NH_4Cl + Ca(OH)_2 \longrightarrow CaCl_2 + 2\,H_2O + 2\,NH_3$$

Few characteristics of this gas are as follows.

i. It is a colourless gas with a strong biting odour that brings tears to eyes.

ii. When this gas is allowed to pass through a moist red litmus paper, the colour of the paper changes to blue. This shows that ammonia is basic in nature.

iii. Dense white fumes are formed when a rod dipped in HCl is brought near this gas.

$NH_3 + HCl \rightarrow NH_4Cl$

iv. It turns Nessler's reagent (K_2HgI_4) brown.

v. It forms a pale blue precipitate when passed through copper sulphate solution. This precipitate is soluble in excess of the gas and the solution turns dark blue in colour.

Test for carbon dioxide (CO_2):

Carbon dioxide is liberated by strong heating of metallic carbonates and hydrogen carbonates. It is also liberated when dilute mineral acids are treated with carbonates and hydrogen carbonates of metals.

$$\mathrm{ZnCO_3} \xrightarrow{\Delta} \mathrm{ZnO} + \mathrm{CO_2}$$
$$\mathrm{CaCO_3} + 2\ \mathrm{HCl} \longrightarrow \mathrm{CaCl_2} + \mathrm{H_2O} + \mathrm{CO_2}$$
$$\mathrm{NaHCO_3} + \mathrm{HCl} \longrightarrow \mathrm{NaCl} + \mathrm{H_2O} + \mathrm{CO_2}$$

Few characteristics of this gas are as follows.

i. It is a colourless and odourless gas.

ii. It turns lime water milky.

$$\mathrm{Ca(OH)_2} + \mathrm{CO_2} \longrightarrow \mathrm{CaCO_3} + \mathrm{H_2O}$$

ii. When this gas is allowed to pass through a moist blue litmus paper, the colour of the paper changes to light red. This shows that carbon dioxide is acidic in nature.

iii. A burning wooden splint when brought near this gas goes off which shows that it is not a supporter of combustion.

iv. It has no effect on filter paper dipped in acidified potassium dichromate ($K_2Cr_2O_7$) or potassium permanganate ($KMnO_4$) solution.

Test for sulphur dioxide (SO_2):

Sulphur dioxide is liberated by strong heating of metallic sulphites and hydrogen sulphites. It is also liberated when dilute mineral acids are treated with sulphites and hydrogen sulphites of metals.

$$CaSO_3 \xrightarrow{\Delta} CaO + SO_2$$
$$Na_2SO_3 + 2\,HCl \longrightarrow 2\,NaCl + H_2O + SO_2$$
$$2\,NaHSO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + 2\,H_2O + 2\,SO_2$$

Few characteristics of this gas are as follows.

i. It is a colourless gas having suffocating odour.

ii. It turns lime water milky.

$$Ca(OH)_2 + SO_2 \longrightarrow CaSO_3 + H_2O$$

iii. When this gas is allowed to pass through a moist blue litmus paper, the colour of the paper changes to red. This shows that sulphur dioxide is acidic in nature.

iv. It turns potassium permanganate solution colourless.

$$2\,KMnO_4 + 2\,H_2O + 5\,SO_2 \longrightarrow K_2SO_4 + 2\,MnSO_4 + 2\,H_2SO_4$$

v. It changes the colour of acidified potassium dichromate from orange to green.

$$K_2Cr_2O_7 + H_2SO_4 + 3\,SO_2 \longrightarrow Cr_2(SO_4)_3 + K_2SO_4 + H_2O$$

Test for hydrogen sulphide (H_2S):

Hydrogen sulphide is liberated by the action of dil. HCl or dil. H_2SO_4 on metallic sulphides.

$FeS + H_2SO_4 \rightarrow FeSO_4 + H_2S$

Few characteristics of this gas are as follows.

i. It is a colourless gas having rotten egg like smell.

ii. It turns lead acetate solution silvery black.

$$(CH_3COO)_2Pb + H_2S \longrightarrow PbS + 2\,CH_3COOH$$

iii. It turns moist blue litmus paper red. This shows that it is acidic in nature.

iv. It turns lead nitrate solution black in colour.

$Pb(NO_3)_2 + H_2S \rightarrow PbS + 2\ HNO_3$

Test for nitrogen dioxide (NO_2):

Nitrogen dioxide is liberated by heating metal nitrates.

$$2\ Cu(NO_3)_2 \xrightarrow{\Delta} 2\ CuO + 4\ NO_2 + O_2$$

Few characteristics of this gas are as follows.

i. It is a reddish-brown in colour.

ii. It has pungent and irritating odour.

iii. It turns moist blue litmus paper red. This shows that it is acidic in nature.

iv. It turns moist potassium iodide paper brown.

$2\ KI + 2\ NO_2 \rightarrow 2\ KNO_2 + I_2$

v. It turns acidified ferrous sulphate solution from green to brown.

Test for chlorine (Cl_2):

Chlorine is liberated by the action of conc. HCl on oxidising agents like Pb_3O_4, PbO_2, MnO_2, etc.

$MnO_2 + 4\ HCl \rightarrow MnCl_2 + 2\ H_2O + Cl_2$

Few characteristics of this gas are as follows:

i. It is a greenish-yellow in colour.

ii. It has sharp pungent choking odour.

iii. It turns moist blue litmus paper red followed by bleaching it. This shows that it is acidic in nature.

iv. It turns moist starch iodide paper blue black.

$$Cl_2 + 2\ KI \longrightarrow 2\ KCl + I_2$$
$$I_2 + \text{Starch} \longrightarrow \text{Blue} - \text{Black colour}$$

v. It forms a white precipitate when passed through silver nitrate solution.

$$3\ Cl_2 + 5\ AgNO_3 + 3\ H_2O \longrightarrow 5\ AgCl + HClO_3 + 5\ HNO_3$$

Test for hydrogen chloride (HCl):

Hydrogen chloride is liberated by the action of conc. H_2SO_4 on metal chloride like NaCl, KCl, etc.

$$NaCl + H_2SO_4 \longrightarrow NaHSO_4 + HCl$$

Few characteristics of this gas are as follows:

i. It is colourless.

ii. It has pungent choking odour.

iii. It turns moist blue litmus paper red.

iv. It produced dense white fumes when a rod dipped in ammonia solution is brought near the gas.

$NH_3 + HCl \rightarrow NH_4Cl$

v. It forms a white precipitate when passed through silver nitrate solution. This precipitate is soluble in excess of ammonium hydroxide solution.

$HCl + AgNO_3 \rightarrow AgCl + HNO_3$

Dry Tests for Salts

The Preliminary tests for the qualitative analysis of an inorganic salt involve the observation of the following physical properties:

1. Colour and Odour:

Physical property	Experiment	Observation	Inference

Colour	Observe colour of the salt	Pink Blue Light green Dark brown Flesh colour White	Co^{2+} Cu^{2+} Fe^{2+} Fe^{3+} Mn^{2+} Pb^{2+}, Zn^{2+}, Ca^{2+}, Na^{+}, K^{+}, NH_4^+
Odour	Rub a pinch of salt between the fingers with a drop of water	Ammoniacal smell Vinegar like smell Rotten egg-like smell Smell of sulphur dioxide gas	NH_4^+ CH_3COO^- S^{2-} SO_3^{2-}

2. Dry heating test

In order to perform this test, a small amount of salt is heated in a dry test tube and observations are recorded.

	Observation/ Gas evolved	**Inference**
1	*CO_2 gas*:- A colourless and odourless gas which turns lime water milky.	CO_3^{2-} or $C_2O_4^{2-}$
2	*H_2S gas*:- Colourless gas with smell like a rotten egg turns lead acetate paper black.	S^{2-}

3	*SO_2 gas*:- Colourless gas with smell like burning sulphur, turns acidified potassium dichromate paper green.	SO_3^{2-}
4	*HCl gas*:- Colourless gas with a pungent smell forms white fumes with ammonia and white ppt. with silver nitrate.	Cl^-
5	Colourless gas with vinegar like smell	CH_3COO^-
6	*NH_3 gas*: Colourless gas with characteristic smell turns Nessler's reagent brown.	NH_4^+
7	*NO_2 gas*:- Reddish brown gas turns ferrous sulphate solution black.	NO_2^- or NO_3^-
8	*Br_2 gas*:- Reddish brown vapours.	Br^-
9	*I_2 gas*:- Dark violet vapours.	I^-
10	*O_2 gas*:- Supports combustion, glowing wooden splinter burns.	O^{2-}

11	H_2O vapours:- Droplets of water on the cooler part of the test tube	Hydrated salt

3 Flame test.

In order to perform the flame test, the paste of salt with conc.HCl is introduced into the flame with the help of platinum wire and the colour of the flame is observed.

	Colour of flame	**Inference**
1	Brick red	Calcium
2	Crimson red	Strontium
3	Grassy-green	Barium
4	Bright-bluish green	Copper
5	Green flashes	Zn or Mn
6	Bull bluish	Lead

4. Solubility test

The following table represents solubility of various salts in water.

Anion→ Cation ↓	**NO_3^-**	**CH_3COO^-**	**Cl^-**	**SO_4^{2-}**	**OH^-**	**S^{2-}**	**CO_3^{2-}**	**SO_3^{2-}**	**PO_4^{3-}**
Al^{3+}	√	√	√	√	×	Not exist	Not exist	Not exist	×
Na^+	√	√	√	√	√	√	√	√	√
Ba^{2+}	√	√	√		√	√	×	×	×
Ca^{2+}	√	√	√	√	√	√	×	×	×
Mg^{2+}	√	√	√	√	√	√	×	×	×
K^+	√	√	√	√	√	√	√	√	√
Zn^{2+}	√	√	√	√	×	×	×	×	×
Hg^{2+}	√	√	√	√	Not exist	×	×	×	×
Fe^{3+}	√	√	√	√	×	Not exist	×	×	×
Mn^{2+}	√	√	√	√	×	×	×	×	×
Pb^{2+}	√	√	×	×	×	×	×	×	×
Cu^{2+}	√	√	√	√	×	×	×	×	×
Ag^{2+}	√	√	×	√	×	×	×	×	×
Fe^{2+}	√	√	√	√	×	×	×	Not exist	×

Identification of Ions

Salts are composed of cations and anions. They are dissolved in the following solvents to make solutions:

- Water
- Nitric acid (if the salt does not dissolve in water)

Identification of cations:

- by using of sodium hydroxide solution
- by using of potassium hydroxide solution
- by using of ammonia solution

Metal	Sodium Hydroxide Solution		Ammonium Solution	
	Colour of ppt	With Excess Sodium Hydroxide Solution	Colour of ppt	With Excess Ammonium Hydroxide Solution
Ca	White curdy	Insoluble	No ppt.	No change
Pb	White chalky	Soluble	White chalky	Insoluble
Zn	White gelatinous	Soluble	White gelatinous	Soluble
Cu	Pale blue	Insoluble	Pale blue	Soluble
Fe (II)	Pale green turning brown	Insoluble	Pale green turning brown	Insoluble
Fe(III)	Reddish brown	Insoluble	Reddish brown	Insoluble

Identification of anions:

- by using dilute sulphuric acid
- by using concentrated sulphuric acid
- by using nitric acid and barium chloride

- CO_3^{2-}, S^{2-}, NO_2^- and SO_3^{2-} react with dil. H_2SO_4 to give out CO_2, H_2S, NO_2 and SO_2 gases respectively.
- Cl^-, Br^-, I^-, NO_3^-, $C_2O_4^{2-}$ and CH_3COO^- react with conc. H_2SO_4 but not with dil. H_2SO_4 to produce characteristic gases.
- SO_4^{2-} and PO_4^{3-} react neither with dil H_2SO_4 nor with conc. H_2SO_4. These are, therefore, identified by individual tests.

Dil. H_2SO_4 Tests

	Experiment	Observation	Inference

1	Salt + dil. H_2SO_4	Brisk effervescence Colourless gas Odourless gas Does not support combustion Turns moist litmus red Turns lime water milky	The gas evolved is carbon dioxide Salt contains **carbonate** (CO_3^{2-})
2	Salt + dil. H_2SO_4	Rotten egg smelling gas Turns moist blue litmus paper red Turns moist lead acetate paper black	The gas evolved is hydrogen sulphide Salt contains **sulphide** ($S2^-$)
3.	Salt + dil. H_2SO_4	Suffocating gas Turns golden yellow or orange coloured filter paper moist with acidified potassium dichromate green	The gas evolved is sulphur dioxide Salt contains **sulphite** (SO_3^{2-})

Conc. H_2SO_4 Tests

	Experiment	Observation	Inference
1	Salt + conc. H_2SO_4 + Heat	Colourless pungent gas (HCl) Produces dense white fumes when a glass rod dipped in ammonia solution is brought near it Greenish yellow gas evolves that turns moist starch iodine paper blue-black when pinch of manganese is added to solution	**Chloride** ion confirmed (Cl^-)
2	Salt + conc. H_2SO_4 + Heat	Reddish brown fumes that turn thick on adding copper turnings A brown ring form at the junction of two liquids when iron (II) sulphate solution followed by conc. sulphuric acid is added to salt (**Brown ring test**)	The gas evolved is nitrogen dioxide Salt contains **nitrate** (NO_3^-)

Test for Sulphate Ion

	Experiment	Observation	Inference

1	Salt + Nitric acid + Barium chloride solution	White ppt insoluble in mineral acid When solution is treated with acetic acid and lead acetate solution, white ppt is obtained which is soluble in excess of ammonium acetate solution	**Sulphate** ion confirmed SO_4^{2-}

Test to Differentiate Black Copper Oxide from Black Manganese Dioxide

Experiment	Copper Oxide	Mangnanese Dioxide
Sample (black powder) + conc. HCl + Heat	No evolution of chlorine gas	Evolution of greenish yellow coloured chlorine gas
Filter	Blue coloured filtrate	Brown coloured filtrate
Filtrate + Ammonium hydroxide	Formation of blue ppt. which is soluble in excess of ammonium hydroxide	No ppt.