Practical Chemistry

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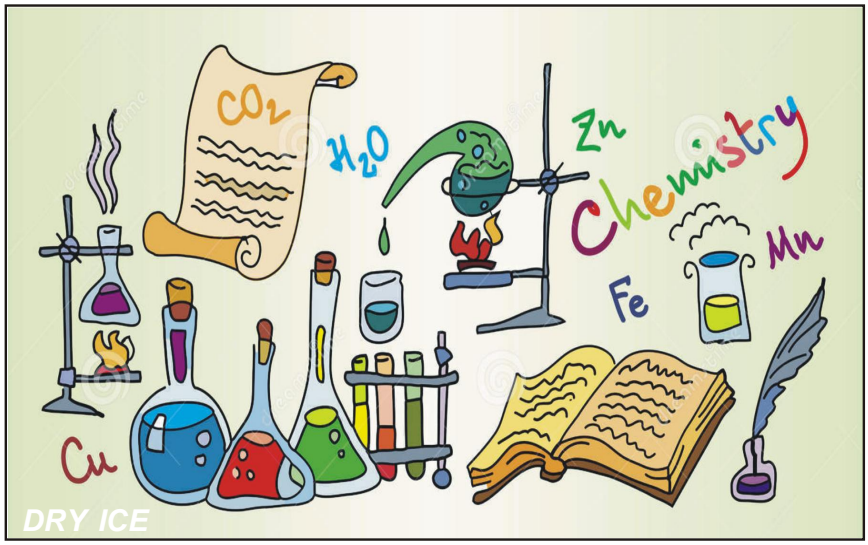


"Hypothesis become theories and theories attain rank of laws after withstanding rigorous experimental tests. Feasibility of a process is confirmed in the laboratory. Qualitative and quantitative analyses give complete chemical picture of the substance. it is with these considerations in mind we proceed to learn what is there in a chemistry laboratory."

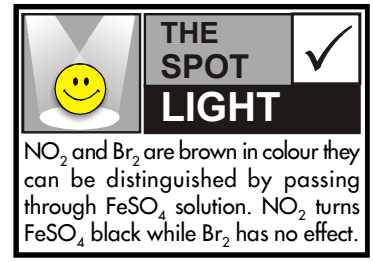
Introduction

Analytical chemistry deals with qualitative and quantitative analysis of the substances. The physical examation of the unknowin salt involves the study of colour, smell and density.

Preliminary tests give authentic informaton about an ion in the salt. For example, golden yellow colour in flame test shows the presence of sodium. In a charcoal cavity test, brown residue shows the presence of cadmium in a salt and so on.

Recognition and identification of gases

	Preparation of gas	Observations	Inference
1.	**Hydrogen (H_2) :** It is liberated by the action of active metals like magnesium, zinc with dilute hydrochloric acid or dilute sulphuric acid. e.g. $Zn + \underset{(dil.)}{H_2SO_4} \rightarrow ZnSO_4 + H_2$ ($\underset{Zinc}{Zn}$) $Zn + 2HCl \rightarrow ZnCl_2 + H_2$	(i) It is a colourless, odourless gas. (ii) It is netural towards litmus. (iii) When a burning wooden splinter is brought near it, it goes off and the gas burns with a pale blue flame producing a pop sound.	H_2 gas
2.	**Oxygen (O_2) :** It is liberated on heating (a) metal nitrates (b) metal oxides like HgO, PbO_2, Pb_3O_4 etc. (c) oxysalts like potassium chlorate, potassium dichromate, potassium permanganate etc. e.g. $2Pb_3O_4 \xrightarrow{\Delta} 6PbO + O_2\uparrow$ Red lead	(i) It is a colourless, odourless gas. (ii) It is neutral towards litmus. (iii) It rekindles a glowing wooden splinter.	O_2 gas



NO_2 and Br_2 are brown in colour they can be distinguished by passing through $FeSO_4$ solution. NO_2 turns $FeSO_4$ black while Br_2 has no effect.

3.	**Carbon dioxide (CO_2) :** It is liberated (a) by heating strongly metal carbonates except Na_2CO_3 and K_2CO_3. (b) by heating strongly metal bicarbonates. (c) by the action of dil. HCl or dil. H_2SO_4 with metal carbonates or bicarbonates. e.g. $Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2\uparrow$ Sodium carbonate (Dil)	(i) It is a colourless, odourless gas. (ii) It turns moist blue litmus paper red. (iii) It extinguishes a glowing wooden splinter. (iv) It turns freshly prepared lime water milky.	CO_2 gas
4.	**Chlorine (Cl_2) :** It is liberated by (a) heating MnO_2, PbO_2, Pb_3O_4, $KMnO_4$ or $K_2Cr_2O_7$ with conc. HCl e.g. $MnO_2 + 4HCl \rightarrow MnCl_2 + 2H_2O + Cl_2\uparrow$ Manganese dioxide (Conc.) (b) the action of bleaching powder with dil. HCl or dil H_2SO_4.	(i) It is a greenish yellow gas having pungent irritating smell. (ii) It turns moist blue litmus paper red and then bleaches it. (iii) It turns moist starch iodide paper blue-black.	Cl_2 gas
5.	**Hydrogen chloride (HCl)** It is liberated when a metal chloride or ammonium chloride is boiled with conc. H_2SO_4. e.g. $NaCl + H_2SO_4 \xrightarrow{\Delta} NaHSO_4 + HCl\uparrow$ Sodium chloride (Conc.)	(i) It is a colourless gas having pungent irritating smell. (ii) It turns moist blue litmus paper red. (iii) It gives dense white fumes when a glass rod dipped in NH_4OH is brought near it.	HCl gas
6.	**Sulphur dioxide (SO_2) :** It is liberated (a) by heating metal sulphites except Na_2SO_3 and K_2SO_3. (b) by heating metal hydrogen sulphites. (c) by the action of metal sulphites or metal hydrogen sulphites with dil. HCl or dil. H_2SO_4. e.g. $Na_2SO_3 + 2HCl \rightarrow 2NaCl + H_2O + SO_2\uparrow$ Sodium sulphite (Dil)	(i) It is a colourless gas having pungent suffocating smell like that of burning sulphur. (ii) It turns moist blue litmus paper red. (iii) It extinguishes a glowing wooden splinter. (iv) It decolorises acidified $KMnO_4$ solution. (v) It turns acidified potassium dichromate solution from orange to green	SO_2 gas
7.	**Hydrogen sulphide (H_2S)** It is liberated by the action of dil. HCl or dil. H_2SO_4 with metal sulphides. e.g. $Na_2S + H_2SO_4 \rightarrow Na_2SO_4 + H_2S\uparrow$ Sodium sulphide (dil.)	(i) It is a colourless gas having smell like that of rotten eggs. (ii) It turns moist blue litmus paper red. (iii) It turns lead acetate paper black.	H_2S gas

THE SPOT LIGHT

CO_2 and SO_2 both turn lime water milky so they can be distinguished by passing through acidified $K_2Cr_2O_7$ solution. SO_2 turns K_2Cr_2O7 green while CO_2 has no effect.

THE SPOT LIGHT

In order to avoid spurting, due to which H_2SO_4 may fly and spoil clothes and may result into serious injuries, the hot reaction mixture in case of conc. H_2SO_4 test is not thrown into the sink.

8.	**Ammonia (NH_3)** It is liberated (a) by heating ammonium salts with alkalies (b) by treating metal nitrides with hot water. e.g. $(NH_4)_2SO_4 + 2NaOH \rightarrow$ Ammonium sulphate $Na_2SO_4 + 2NH_3 \uparrow + 2H_2O$	(i) It is colourless gas having typical pungent smell. (ii) It turns moist red litmus blue. (iii) It gives dense white fumes when a glass rod dipped in conc. HCl is brought near it.	NH_3 gas
9.	**Water (H_2O) vapour** It is liberated on heating (a) hydrated salts like $CuSO_4 \cdot 5H_2O$ (b) metal hydroxide except NaOH and KOH (c) metal hydrogen carbonate or metal hydrogen sulphites. e.g. $CuSO_4.H_2O \xrightarrow{\Delta} CuSO_4 +$ Blue vitriol crystals $5H_2O$	(i) It is a colourless, odourless gas or vapour. (ii) It is neutral towards litmus, turns white anhydrous copper sulphate blue and blue cobalt chloride paper pink. (iii) Colourless liquid condenses on cooler sides of a test tube.	H_2O Vapour
10.	**Nitrogen dioxide (NO_2)** It is liberated by (a) heating metal nitrates (except $NaNO_3$ and KNO_3) (b) heating metal nitrates with conc. H_2SO_4. e.g. $2Pb(NO_3)_2 \xrightarrow{\Delta} 2PbO +$ Lead nitrate $4NO_2 + O_2 \uparrow$	(i) It is a reddish brown gas having pungent irritating smell. (ii) It turns moist blue litmus paper red. (iii) It turns moist potassium iodide paper brown	NO_2 gas

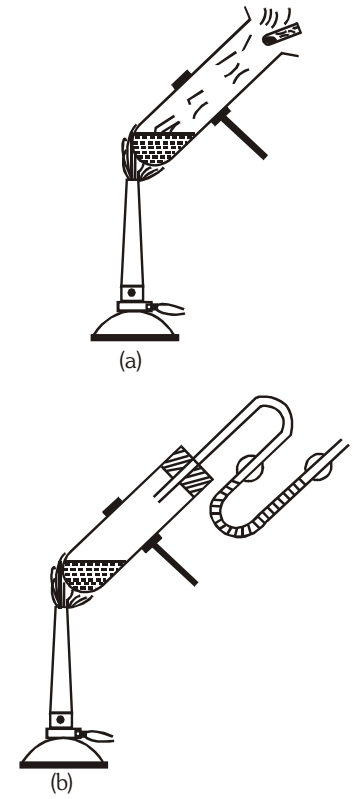


Fig. 1 (a) For testing a gas, a filter paper strip dipped in the reagent is brought near the mouth of the test tube. (b) For testing a gas the reagent is taken in the gas detector and the gas is pass throught it.

BUILDING CONCEPTS

Why a salt containing lead turn black in colour, when placed for a long time in laboratory ?

Explanation

Due to the formation of black lead-sulphide by the action of H_2S in atmosphere.

(I) Action of heat on the given (unknown) substance

Take a pinch of the given (unknown) substance in dry test tube. Heat it strongly and observe the following:

(a) Gas or vapour evolved

(b) Sublimate formed

(c) Colour of residue

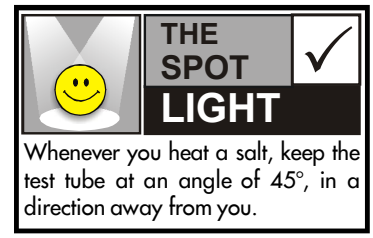
(d) Any other observation such as water drops, swelling, decripitation (crackling noise) etc.

1. Mercury (II) oxide (HgO)

Observations

(i) Orange red amorphous powder changes to deep red and appears black in colour.

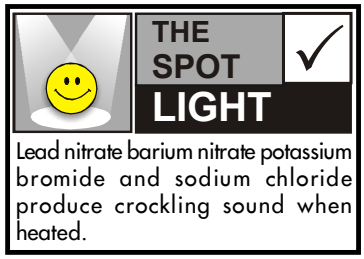
(ii) It gives off a colourless, odourless gas which rekindles a glowing wooden splinter (O_2 gas).



(iii) A silver mirror is produced near the mouth of the test tube and on scratching the surface tiny droplets of mercury are produced. (Residue is Hg).

(iv) The reaction taking place is

$$\underset{\text{Mercury (II) oxide (Orange)}}{2HgO} \xrightarrow{\text{Heat}} \underset{\text{Mercury (Silver grey)}}{2Hg} + O_2(g)\uparrow$$



Red lead (Pb_3O_4)

Observations

(i) The red or orange red amorphous powder changes to reddish brown on strong heating.

(ii) Colourless, odourless gas is given off which rekindles a glowing wooden splinter. (O_2 gas)

(iii) On cooling the residue becomes yellow which fuses partially and stains test tube yellow. (Residue is PbO)

(iv) The reaction taking place is

$$\underset{\text{Orange red}}{2Pb_3O_4} \xrightarrow{\text{Heat}} \underset{\text{Yellow}}{6PbO} + O_2\uparrow$$

Lead dioxide (PbO_2)

Observations

(i) Chocolate brown amorphous powder, changes to reddish brown colour on strong heating.

(ii) Colourless, odourless gas is given off which rekindles a glowing wooden splinter (O_2 gas).

(iii) On cooling the residue becomes yellow which partly fuses and stains yellow (PbO).

(iv) The reaction taking place is

$$\underset{\text{Brown}}{2PbO_2} \xrightarrow{\Delta} \underset{\text{Yellow}}{2PbO} + O_2\uparrow$$

Copper(II) carbonate ($CuCO_3$)

Observations

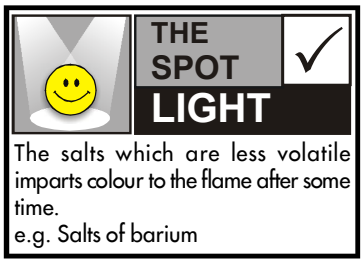
(i) Light green amorphous powder changes to black on strong heating.

(ii) It gives colourless, odourless gas which turns freshly prepared lime water milky.

(iii) The residue is copper (II) oxide (CuO).

(iv) The reaction taking place is

$$\underset{\text{Green}}{CuCO_3} \xrightarrow{\Delta} \underset{\text{Black}}{CuO} + CO_2\uparrow$$



Zinc carbonate ($ZnCO_3$)

Observations

(i) The light white amorphous powder becomes pale yellow on strong heating and become white on cooling.

(ii) Colourless, odourless gas is given off which extinguishes a glowing wooden splinter and turns freshly prepared lime water milky.

(iii) On cooling the residue becomes white.

(iv) The reaction taking place is

$$\underset{\text{White}}{ZnCO_3} \xrightarrow{\Delta} \underset{\text{White (on cooling)}}{ZnO} + CO_2\uparrow$$

Washing soda or sodium carbonate decahydrate ($Na_2CO_3.10H_2O$)

Observations

(i) White crystalline solid which on strong heating swells, melts and then gives steamy vapour (H_2O vapour).

(ii) Colourless, odourless vapour evolved on heating which condense on the cooler parts of the test tube forming tiny droplets of colourless liquid which turns anhydrous copper sulphate (white) to hydrated copper sulphate (Blue).

(iii) On cooling, a white amorphous residue is left i.e., Na_2CO_3.

(iv) The reaction taking place is

$$\underset{\text{White}}{Na_2CO_3.10H_2O} \xrightarrow{\Delta} \underset{\text{White}}{Na_2CO_3} + 10H_2O\uparrow$$

Efflorescence :
Certain hydrated crystalline salts when exposed to atmosphere lose their water of crystallisation spontaneously and change into amorphous powder.
This process is called efflorescence and the substances exhibiting efflorescence are called efflorescent substances.
For example : Washing soda ($Na_2CO_3.10H_2O$), Glauber's salt ($Na_2SO_4.10H_2O$), Blue vitriol ($CuSO_4.5H_2O$).

Copper (II) sulphate crystals [$CuSO_4.5H_2O$]

Observations

(i) The blue crystalline solid on strong heating gives white amorphous powder.

(ii) Steamy vapour are given off which condense on the cooler parts of the test tube to form colourless liquid (water vapour).

(iii) The residue is anhydrous copper sulphate.

(iv) The reaction taking place is

$$\underset{\substack{\text{(Blue vitriol}\\ \text{crystals)}\\ \text{Blue}}}{CuSO_4.5H_2O} \xrightarrow{\Delta} \underset{\substack{\text{(Anhydrous}\\ \text{copper sulphate)}\\ \text{white}}}{CuSO_4} + 5H_2O\uparrow$$

Zinc nitrate hexahydrate [$Zn(NO_3)_2.6H_2O$]

Observations

(i) White crystalline deliquescent solid on strong heating melts to form a white sticky mass which gives off steam vapour.

(ii) These steamy vapour condense on the cooler parts of the test tube to form tiny droplets of colourless liquid (water) which turn anhydrous copper sulphate to blue.

(iii) On strong heating the residue gives off reddish brown fumes which turn freshly prepared ferrous sulphate solution black (NO_2 gas) and rekindles a glowing wooden splinter (O_2 gas).

(iv) The residue is pale yellow when hot and cooling it becomes white.

(v) The reaction taking place is

$$\underset{\text{White}}{2Zn(NO_3)_2.6H_2O} \xrightarrow{\Delta} \underset{\substack{\text{Yellow when}\\ \text{hot white when cold}}}{2ZnO} + 4NO_2\uparrow + O_2\uparrow + \underset{\text{(Steam)}}{12H_2O}$$

Hygroscopic Substances :
Certain substance absorb water from the atmosphere without undergoing change in physical state. Such substances are known as hygroscopic substance.
Anhydrous sodium carbonate, anhydrous copper sulphate, concentrated sulphuric acid are examples of hygroscopic substances.

Copper(II) nitrate hexahydrate [$Cu(NO_3)_2.6H_2O$]

Observations

(i) Bluish green crystalline solid, on strong heating melts to form bluish green mass and gives off steamy vapour.

(ii) The steam vapour condense on the cooler parts of the test tube to form colourless liquid (H_2O) which turns anhydrous copper sulphate (white) into hydrated copper sulphate (blue).

(iii) On further heating, the bluish green mass changes to a black residue [Copper (II) oxide].

(iv) Reddish brown gas having pungent smell is given off which turns freshly prepared ferrous sulphate solution black (NO_2 gas) and rekindles a glowing wooden splinter (O_2 gas).

(v) The reaction taking place is

$$\underset{\substack{\text{[Copper (II) nitrate}\\ \text{hexahydrate] Blue}}}{2Cu(NO_3)_2.6H_2O} \xrightarrow{\Delta} \underset{\substack{\text{(Copper (II)}\\ \text{Oxide) Black)}}}{2CuO} + 4NO_2\uparrow + O_2\uparrow + 12H_2O$$

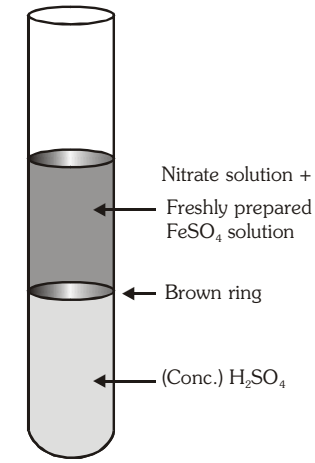


Fig. 2 Brown ring test

Lead(II) nitrate [$Pb(NO_3)_2$]

Observations

(i) Heavy, white crystalline solid, on strong heating it crumbles and produces a crackling noise.

(ii) Reddish brown gas having pungent smell is given off which turns freshly prepared ferrous sulphate solution black (NO_2 gas)

(iii) The gas rekindles a glowing wooden splinter (O_2 gas).

(iv) The residue is reddish brown when hot and becomes yellow on cooling. The residue is lead (II) oxide PbO.

(v) The reaction taking place is

$$\underset{\substack{\text{[Lead(II)}\\\text{nitrate}\\\text{White]}}}{2Pb(NO_3)_2} \xrightarrow{\Delta} \underset{\substack{\text{[Lead(II)}\\\text{oxide}\\\text{Reddish brown}}}{2PbO} + 4NO_2\uparrow + O_2\uparrow$$

Ammonium chloride (NH_4Cl)]

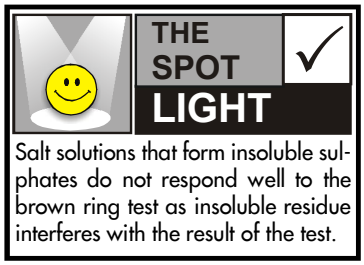
Observations

(i) White crystalline solid on heating sublimes to give dense white fumes.

(ii) The dense white fumes form white powdery mass on the cooler parts of a test tube.

(iii) The reaction taking place is

$$\underset{\text{White}}{NH_4Cl} \xrightarrow{\Delta} NH_3\uparrow + HCl\uparrow$$



Salt solutions that form insoluble sulphates do not respond well to the brown ring test as insoluble residue interferes with the result of the test.

Iodine (I_2)

Observations

(i) Greyish brown crystalline solid sublimes on heating to form violet vapour which condense on the cooler parts of tube to give greyish brown solid. (Iodine)

(ii) The chemical equation is

$$\underset{\text{Greyish brown}}{I_2(s)} \underset{}{\overset{\Delta}{\rightleftharpoons}} \underset{\text{Violet vapour}}{I_2(g)}$$

Ammonium dichromate [$(NH_4)_2Cr_2O_7$]

Observations

(i) Orange red crystalline solid which on strong heating swells and gives off steamy fumes which condense on the cooler parts of a test tube to form droplets of colourless liquid (H_2O).

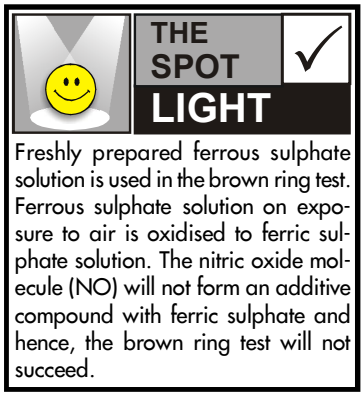
(ii) This liquid turns anhydrous cooper sulphate to hydrated copper sulphate (blue).

(iii) Colourless, odourless gas is given off which is neither combustible nor a supporter of combusion and does not turn lime water milky (N_2 gas)

(iv) Greenish grey residue is left behind (Cr_2O_3).

(v) The reaction taking place is

$$\underset{\substack{\text{Ammonium}\\\text{dichromate}\\\text{(Orange red)}}}{(NH_4)_2Cr_2O_7} \xrightarrow{\Delta} \underset{\substack{\text{Greenish}\\\text{(Grey)}}}{C_2O_3} + N_2\uparrow + 4H_2O\uparrow$$



Freshly prepared ferrous sulphate solution is used in the brown ring test. Ferrous sulphate solution on exposure to air is oxidised to ferric sulphate solution. The nitric oxide molecule (NO) will not form an additive compound with ferric sulphate and hence, the brown ring test will not succeed.

(II) Action of dilute sulphuric acid on a given substance.

Metal sulphides

Observations

Colourless gas with a foul smell, as of rotten eggs, is evolved, and it turns lead acetate paper black.

e.g. $FeS + H_2SO_4 \rightarrow FeSO_4 + H_2S$

$ZnS + H_2SO_4 \rightarrow ZnSO_4 + H_2S$

Inference

Gas evolved is hydrogen sulphide. Substance may be a sulphide.

Metal carbonates or bicarbonates

Observations

Colourless gas is evolved with brisk effervesence, and it turns lime water milky.

e.g. $Na_2CO_3 + H_2SO_4 \rightarrow Na_2SO_4 + H_2O + CO_2$

$2NaHCO_3 + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O + CO_2$

Inference

Gas evolved is carbon dioxide. Substance may be a carbonate or hydrogen carbonate.

Metals which are more reactive than hydrogen

Observations

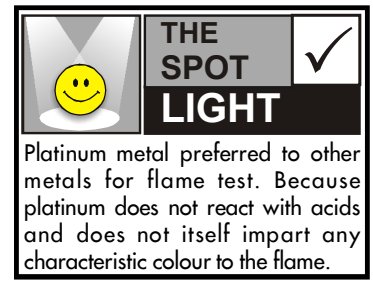
There is vigorous effervesence, and a colourless, odourless gas evolves. It burns with a pop sound when a burning splint is brought near it.

e.g. $Mg + H_2SO_4 \rightarrow MgSO_4 + H_2$

$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$

Inference

Gas evolved is hydrogen. Given substance may be a reactive metal like zinc, iron magnesium, etc.



Metal sulphites

Observations

Colourless gas smelling like burnt sulphur is evolved with effervescence. It decolourizes the purple solution of potassium permanganate but has no effect on lead acetate paper.

e.g. $Na_2SO_3 + H_2SO_4 \rightarrow Na_2SO_4 + H_2O + SO_2$

$K_2SO_3 + H_2SO_4 \rightarrow K_2SO_4 + H_2O + SO_2$

Inference

Gas evolved is sulphur dioxide. Substance may be a sulphite.

CHECK YOUR CONCEPTS

Name the gas released :

Zinc + Sulphuric acid

Red lead is heated

Give two observations for the following :

When washing soda is heated

When ammonium dichromate is heated

Identification of Ions

Identifcation of ions is usually done in solution state. Salt is dissolved in water to make solution. If the salts do not dissolve in water then Nitric acid is added to form nitrate. All nitrates are soluble in water.

Cations are tested by the action of alkalies as they give characteristic coloured metallic hydroxide precipitates. When adding the alkali, add it slowly at first (one drop at a time). If it is added too quickly, it is easy to a precipitate that redissolves in excess.

Anions are tested by the reaction of acids or by specific reagents.

(A) By adding dilute sulphuric acid

		Experiment	Observation	Inference
1.	(a)	Take a small quantity of salt in a test tube and add dilute H_2SO_4. Warm, if no action in cold.	Brisk effervescence and a colourless gas evolved. It does not support combustion i.e. burning splinter get extinguished. It turns moist blue litmus faint red.	The gas evolved is carbon dioxide. The salt contains Carbonate (CO_3^{2-}).
	(b)	Pass the gas through lime water.	Lime water turns milky.	
	(c)	To the above precipitate, pass the gas in excess or add dilute nitric acid in excess.	The white precipitate dissolves to form colourless solution.	
2.	(a)	Take a small quantity of salt in a test tube and add dil. H_2SO_4 acid.	Rotten egg smelling gas evolved. It turns moist blue litmus paper red.	The gas evolved is hydrogen Sulphide.
	(b)	Bring a moist lead acetate paper near the gas.	Moist lead acetate paper turns black.	The salt contains Sulphide ion (S^{2-}).
3.	(a)	Take a small quantity of salt in a testtube and add dilute H_2SO_4 acid (warm if necessary).	Gas evolved the suffocating odour of burning sulphur.	The gas evolved is Sulphur dioxide.
	(b)	Bring a filter paper moistened with acidified $K_2Cr_2O_7$ (Potassium dichromate) near the gas.	Golden yellow or orange colour paper turns green.	The salt contains Sulphite ion (SO_3^{2-}).

THE SPOT LIGHT

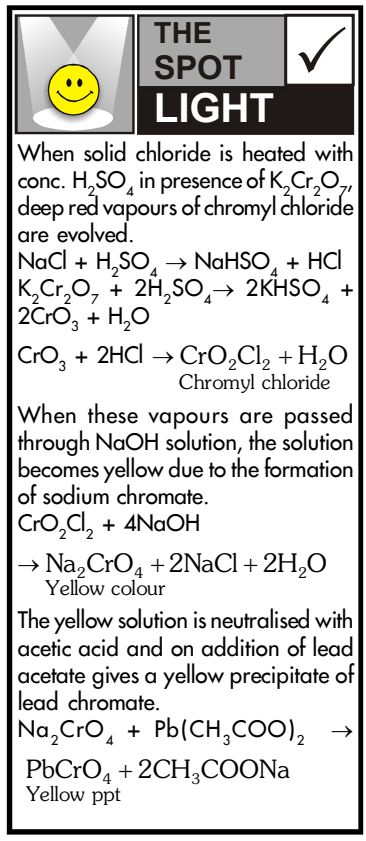
All acetates are soluble in water. On addition of neutral $FeCl_3$ solution to the solution of an acetate, blood red colouration develops due to the formation of ferric acetate.

$FeCl_3 + 3CH_3COONa \longrightarrow (CH_3COO)_3Fe + 3NaCl$

Blood red colour

(B) By adding concentrated sulphuric acid

	Experiment	Observation	Inference
1. (a)	Take a small amount of salt in a test-tube and add conc. H_2SO_4. Warm it gently.	Colourless gas (HCl) evolves with pungent colour.	Chloride ion (Cl^-) may be present.
(b)	Bring a glass rod carrying a drop of ammonia solution near the gas evolved.	Dense white fumes are produced.	Chloride ion (Cl^-) confirmed.
(c)	Add a pinch of manganese dioxide to the salt followed by conc. H_2SO_4 and heat.	Greenish yellow gas evolves with a pungent odour and turns moist starch iodide paper blue black.	Chloride ion (Cl^-) confirmed.
(d)	Add silver nitrate ($AgNO_3$) solution	White preciptrate of AgCl is formed which dissolves in excess of NH_4OH	Chloride ion (Cl^-) confirmed.
2. (a)	Take a small amount of salt in a test-tube and add conc. H_2SO_4. Warm it gently.	Reddish brown fumes evolve. The fumes become thick on adding copper turnings.	The gas evolved is nitrogen dioxide and salt contains Nitrate (NO_3^-)
(b)	To the salt solution, add freshly prepared ferrous sulphate solution, then cautiously pour a few drops of conc. H_2SO_4 along the side of the test tube. This test is known as brown ring-test.	A brown ring appears at the junction of the two liquid layers. The brown ring disapperas on shaking.	Nitrate ion (NO_3^-) confirmed.



When solid chloride is heated with conc. H_2SO_4 in presence of $K_2Cr_2O_7$, deep red vapours of chromyl chloride are evolved.

$NaCl + H_2SO_4 \rightarrow NaHSO_4 + HCl$

$K_2Cr_2O_7 + 2H_2SO_4 \rightarrow 2KHSO_4 + 2CrO_3 + H_2O$

$CrO_3 + 2HCl \rightarrow CrO_2Cl_2 + H_2O$

Chromyl chloride

When these vapours are passed through NaOH solution, the solution becomes yellow due to the formation of sodium chromate.

$CrO_2Cl_2 + 4NaOH$

$\rightarrow Na_2CrO_4 + 2NaCl + 2H_2O$

Yellow colour

The yellow solution is neutralised with acetic acid and on addition of lead acetate gives a yellow precipitate of lead chromate.

$Na_2CrO_4 + Pb(CH_3COO)_2 \rightarrow$

$PbCrO_4 + 2CH_3COONa$

Yellow ppt

(C) Test for sulphate ion.

	Experiment	Observation	Inference
1.	To the salt solution, add littile nitric acid and then add barium chloride solution.	White precipitate is obtained, which is insoluble in mineral acid.	Sulphate ion (SO_4^{2-}) is confirmed
2.	To the solution, add acetic acid and lead acetate solution.	White precipitate is obtained, which is soluble in excess of ammonium acetate solution.	Sulphate ion (SO_4^{2-}) is confirmed

General Identification of Anions

	Add to the salt or salt solution	Observation	Anion Present
1.	dil HCl or dil H_2SO_4 and heat	(i) Carbon dioxide gas is evolved. (ii) Sulphur dioxide gas is evolved. (iii) Hydrogen Sulphide gas is evolved.	(CO_3^{2-}) SO_3^{2-} S^{2-}
2.	Conc. H_2SO_4 and heat	(i) Hydrogen chloride gas is evolved. (ii) Nitrogen dioxide gas is evolved.	Cl^- NO_3^-
3.	Silver Nitrate solution	Curdy white ppt., is insoluble in dil. HNO_3 but dissolves in NH_4OH	Cl^-
4.	Lead acetate solution	White ppt insoluble in dil. HCl & HNO_3	SO_4^{2-}
5.	Barium nitrate solution or Barium chloride solution	(i) White precipitate soluble in dil. HCl or dil. HNO_3.	CO_3^{2-} or SO_3^{2-}
		(ii) White precipitate insoluble in dil. HCl or dil. HNO_3.	SO_4^{2-}

THE SPOT LIGHT

When borate is heated with ethyl alcohol and H_2SO_4, ethyl borate vapours come out which burn with green edged flame.

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

$H_3BO_3 + 3C_2H_5OH \rightarrow (C_2H_5)_3BO_3$ (Ethyl borate) $+ 3H_2O$

General Identification of Anions

	Test	Acids	Alkalis
1. (a)	Moist litmus paper	Blue turns red	Red turns blue
(b)	Methyl orange	Orange turns pink	Orange turns yellow
(c)	Phenolphthalein	Remains colourless	Colourless turns pink
2.	**Chemical test**		
(a)	On adding sodium carbonate	Carbon dioxide is evolved [test with lime water]	Carbon dioxide is not evolved
(b)	On adding ammonium carbonate	No ammonia gas evolved	Ammonia gas evolved [test with red litmus and bring glass rod dipped in HCl in contact with the gas]

Distinguish Between Black Copper Oxide and Black Manganese Dioxide

	Experiment	Manganese dioxide	Copper oxide
(a)	Add conc. HCl to black powder and heat.	Greenish yellow gas chlorine is evolved.	Chlorine gas is not evolved.
(b)	Filter the above solution.	Filtrate is brownish in colour.	FIltrate is bluish in colour.
(b)	On adding ammonium hydroxide to the above filtrate.	No precipitate is formed.	The pale blue precipitate is formed which is soluble in excess of ammonium hydroxide, giving an azure blue colour (deep blue) to the solution.

Flame test

Flame test is used for the identification of metal ions (Basic radicals) in the given salt. This test is carrried out as given below.

Take a thin platinum wire of loop. Clean it thoroughly by repeatedly dipping it in conc. HCl and heating it in a non-luminous flame of the burner. This process is repeated till the wire or loop imparts no colour to the flame. Make a thin paste of the salt in conc. HCl and take this paste on the cleaned platinum wire or loop and heat it in a non-luminous flame of burner. Note the colour imparted to the flame with naked eye and then through blue glass.

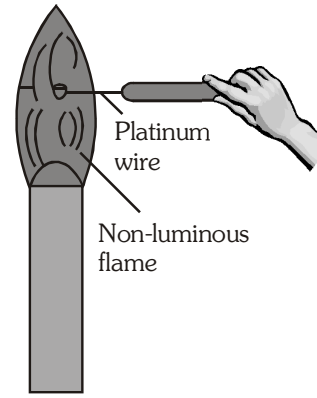


Fig. 3 Flame test

S.No	Colour of the flame with naked eye	Colour of the flame through blue gas	Metallic ion or Basic radical
1.	Golden yellow	Presistent pale yellow flame	Na^+ may be present
2.	Lilac	Lilac flame	K^+ may be present
3.	Brick red	Pale green	Ca^{2+} may be present
4.	Peacock bluish green	Bluish green.	Cu^{2+} may be present

BUILDING CONCEPTS

In the flame test, sodium imparts yellow colour to the flame while magnesium does not impart any colour. Why ?

Explanation

In case of magnesium, when the excited electron jumps back to the ground state, the frequency of radiation emitted does not fall in the visible region.

THE SPOT LIGHT

The blue glass can absorb a part or whole of the coloured light in certain cases. Therefore, the flame appears to be of different colour when viewed through blue glass. This helps in identification of some basic radicals.

Determination of percentage composition of a mixture of powdered salt and water washed sand

ACTIVE CHEMISTRY

Aim

Determination of percentage composition of a mixture

Requirements

Beaker, funnel, filter paper, tripod stand, glass rod, evaporating dish, wire gauze etc.

Procedure

The method involves the following steps :

1. Take a clean and dry beaker and weigh it.
2. Pour some mixture of sand and salt (about 10 g) in the beaker and again weigh it.
3. Add 100 cc of distilled water into the mixture. Stir it to dissolve the salt.
4. Filter the solution. Collect the filtrate (salt solution in another beaker and residue (sand) in an evaporating dish.
5. Dry the residue (sand) in hot air and again weigh it. From this data, we can calculate the percentage composition of the mixture.

Observations

Let mass of the empty beaker = a g

Mass of beaker + mixture = b g

Mass of dry sand = c g

Mass of mixture = (b – a) g

$\therefore$ (b–a) g of mixture contains sand = c g

$$1 \text{ g of mixture contains sand} = \frac{c}{(b-a)} \text{g}$$

$$100 \text{ g of mixture contains sand} = \frac{c}{(b-a)} \times 100 \text{g}$$

$\therefore$ Percentage of sand in mixture = x

and Percentage of salt in the mixture = 100 – x.

THE SPOT LIGHT

Hardness of water is caused due to presence of calcium and magnesium ions.

THE SPOT LIGHT

Hard water is also unfit for use in industries as it forms scales or furs that damage appliances and also causes wastage of fuel. Hard water cannot be used for cooking pulses.

Simple experiments based on hard water and soft water.

Hard Water : Water that contains dissolved bicarbonates, sulphates and chlorides of calcium and magnesium is called hard water. This water does not form lather with ordinary soap. Examples : Sea water, river water, lake water etc.

Soft water : Water that does not contain dissolved calcium and magnesium salts. This water froms lather with ordinary soap. Examples : distilled water and rain water.

Types of Hardness

Temporary Hardness
Contains Ca and Mg bicarbonates
Removal : by boiling followed by filtration.

Permanent Hardness
Contains Ca and Mg chlorides and sulphates
Removal : by addition of
(i) washing soda
(ii) caustic soda.

BUILDING CONCEPTS

What are the cause of hardness of water ?

Explanation

The hardness of water is due to the presence of certain dissolved salts in it. These are

$Ca(HCO_3)_2$	–	Calcium bicarbonate
$Mg(HCO_3)_2$	–	Magnesium bicarbonate
$CaCl_2$	–	Calcium chloride
$MgCl_2$	–	Magnesium chloride
$CaSO_4$	–	Calcium sulphate
$MgSO_4$	–	Magnesium sulphate

ACTIVE CHEMISTRY

Aim

Differentiating hard water from soft water

Procedure

Two unknown sample A and B, one containing hard water and the other containing soft water, are taken separately in beakers, Ordinary soap is rubbed by the hands into the two samples.

Observation

One sample forms lather easily, while the other sample does not form lather.

Conclusion

The sample that lathers easily with ordinary soap is soft water.

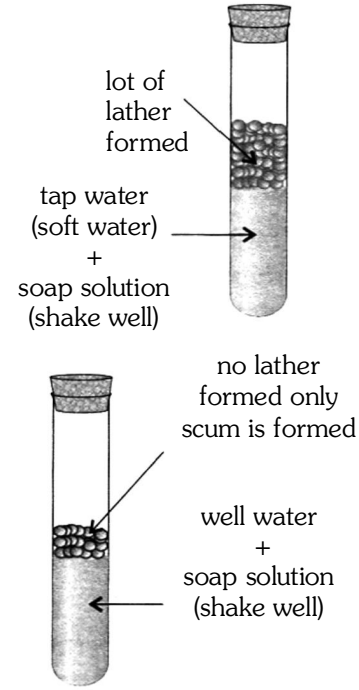


Fig. 4 Hardness or softness of water

ACTIVE CHEMISTRY

Aim

Differentiating between temporary and permanent hard water

Procedure

Provide two unknown samples to the students, one containing temporary and the other containing permanent hard water, in separate beakers. The water is boiled slowly, and then filtered. Ordinary soap is rubbed by the hands into each filtered sample.

Observation

One sample lathers with soap, but the other one does not.

Conclusion

The boiled and filtered sample that lathers with soap is temporary hard water.

$Ca(HCO_3)_2 \longrightarrow CaCO_3 + CO_2 + H_2O$

Calcium bicarbonate

THE SPOT LIGHT

The process of formation of soft water from hard water by use of suitable methods is known as softening of water.

The other sample is permanent hard water.

ACTIVE CHEMISTRY

Aim

Softening temporary and permanent hard water by addition of washing soda.

Procedure

Take samples of temporary and permanent hard water in separate beakers and add washing soda to both samples. The two solutions are filtered to remove any precipitate formed.

Ordinary soap is rubbed into the filtered solutions.

Observation

Both samples lather easily.

Conclusion

(i) Temporary hard water is softened by using washing soda.

$Ca(HCO_3)_2$ + Na_2CO_3 $\longrightarrow$ $CaCO_3$ + $2NaHCO_3$

Bicarbonate present is temporary — Washing Soda

(ii) Permanent hard water is softened by using washing soda since permanent hardness is due to the presence of sulphate and chlorides of calcium and magnesium.

$CaSO_4$ + Na_2CO_3 $\longrightarrow$ $CaCO_3$ + Na_2SO_4

Sulphate present in hard water — Precipitate

Soap and detergents

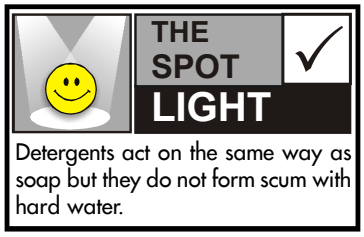
Soap : It is the sodium or potassium salt of an organic fatty acid. It reacts with hard water forming scum, which is why ordinary soap is wasted.

$CaSO_4 + 2NaSt$ (soap) $\longrightarrow$ $CaSt_2 + Na_2SO_4$

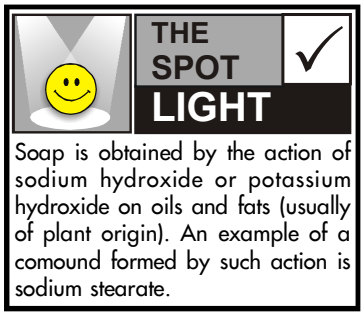
scum

Detergents : They are the sodium salts of alkyl sulphonic acids. Detergents contain a sulphonic acid group (SO_3H) instead of a carboxylic group (–COOH).

They can lather even with hard water, since due to the solubility of their calcium and magnesium salts in water they do not form scum.



Detergents act on the same way as soap but they do not form scum with hard water.



Soap is obtained by the action of sodium hydroxide or potassium hydroxide on oils and fats (usually of plant origin). An example of a comound formed by such action is sodium stearate.

ACTIVE CHEMISTRY

Aim

Comparing the effects of soaps and detergents on hard water

Procedure

Take two beakers containing samples of hard water. In one beaker, ordinary soap is rubbed into the water, while in the other beaker, a detergent is rubbed into the water.

Observation

Lather is formed in the beaker in which detergent is used, but lather does not form when ordinary soap is rubbed.

Conclusion

Detergents form lather even with hard water, while ordinary soap is wasted due to formation of scum.

CHECK YOUR ANSWERS

1. H_2 gas

2. O_2 gas

3. (i) Colourless, odourless vapour of H_2O evolved. (ii) White amorphous residue of Na_2CO_3 left behind

4. (i) Colourless, odourless N_2 gas evolved. (ii) Greenish grey residue of Cr_2O_3 left behind.

EXERCISE # 1

Multiple choice questions

1. Name the gas evolved when dilute hydrochloric acid is added to metallic carbonate.

(1) Oxygen

(2) Carbon dioxide

(3) Carbon monoxide

(4) Nitrogen

2. Name the residue left behind when zinc nitrate is heated.

(1) Zinc carbonate

(2) Zinc nitrite

(3) Zinc

(4) Zinc oxide

3. Name a green coloured salt which on heating changes to black.

(1) Copper carbonate

(2) Copper oxide

(3) Copper sulphate

(4) Zinc oxide

4. Name a crystalline salt which on heating changes to white.

(1) Hydrated copper sulphate : $CuSO_4.5H_2O$

(2) Copper carbonate : $CuCO_3$

(3) Copper oxide : CuO

(4) Magnesium oxide : MgO

5. Name a salt which on heating does not leave behind any residue.

(1) Lead nitrate

(2) Ferric hydroxide

(3) Lead oxide

(4) Ammonium chloride

6. What is the colour of lead oxide when hot and when cold ?

(1) Hot-yellow : Cold-brown

(2) Hot-red : Cold-green

(3) Hot-reddish brown : Cold-light yellow

(4) Hot-blue : Cold-yellow

7. Name the green coloured compound formed when acidified $K_2Cr_2O_7$ comes in contact with SO_2.

(1) Manganese oxide

(2) Chromium sulphate

(3) Potassium chloride

(4) Ammonium chloride

8. What is the odour of hydrogen sulphide ?

(1) Rotten egg smell

(2) Burning carbon

(3) Burning fuel

(4) Burning of coal

9. What is the colour of chromium oxide ?

(1) Yellow

(2) Red

(3) Green

(4) Black

10. Name the gases obtained when ammonium dichromate is heated.

(1) Nitrogen and water vapours

(2) Nitrogen and carbon dioxide

(3) Ammonia and water vapour

(4) Ammonia and nitric oxide

Fill in blanks

1. Temporary hardness is due to the presence of dissolved .....of calcium and magnesium.

2. Permanent hardness is due to the presence of dissolved.....and.....of calcium and magnesium.

3. .....water readily forms lather with soap.

4. Soaps are sodium or potassium salts of higher.....

5. Soluble bicarbonates on heating gives insoluble.....

One word

1. It is a reddish brown gas which turns KI paper brown.

2. It turns anhydrous copper sulphate blue.

3. It gives dense white fumes with rod dipped in HCl.

4. It has rotten egg smell and turns lead acetate paper black.

5. It turns potassium dichromate solution from orange to green.

6. Water which does not readily give lather with soap.

7. Hardness present due to dissolved bicarbonates of Ca and Mg.

8. Water which readily gives lather with soap.

9. A white substance added to remove temporary hardness.

10. Sodium salts of long chain fatty acids.

Match the column

	Column I		**Column II**
(1)	Hydrogen sulphide	(a)	Burning sulphur smell
(2)	Sulphur dioxide	(b)	Burns with a pop sound
(3)	Carbon dioxide	(c)	Rotten egg smell
(4)	Hydrogen	(d)	Turns lime water milky
(5)	Oxygen	(e)	Decrepitates
(6)	Nitrogen dioxide	(f)	Erupts in the form of volcanoes
(7)	Hydrogen chloride gas	(g)	Sublimes
(8)	Ammonium dichromate	(h)	Fumes in moist air
(9)	Iodine	(i)	Reddish brown
(10)	Lead nitrate	(j)	Supporter of combustion

EXERCISE # 1 ANSWER KEY

Multiple choice questions

Que.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Ans.	2	4	1	1	4	3	2	1	3	1

Fill in the blanks

1. Bicarbonates **2.** Chlorides, Sulphates **3.** Soft **4.** Fatty acids **5.** Carbonates

One Word

1. NO_2 gas **2.** Water **3.** NH_3 gas **4.** H_2S gas **5.** SO_2 gas

6. Hard water **7.** Temporary hardness **8.** Soft water **9.** Lime water **10.** Soap

Match the column

(1) → c ; (2) → a ; (3) → d ; (4) → b ; (5) → j ; (6) → i ; (7) → h ; (8) → f ; (9) → g ; (10) → e

EXERCISE # 2

Short answer type questions

1. What is the confirmatory test for nitrogen dioxide gas ?

2. Give the chemical name and the chemical formula of the brown-black solution formed during ring test of NO_2 gas.

3. Give balanced chemical equation when hydrated copper sulphate is heated.

4. Give two tests for water.

5. How will you distinguish between lead carbonate and zinc carbonate by heating alone ?

6. How will you distinguish between the following by flame test ?

(a) Sodium chloride and zinc sulphate.

(b) Sodium carbonate and calcium carbonate.

7. A mixture consists of sand and common salt. Briefly describe the experimental procedure for calculating the percentage of sand.

8. Using dilute acid how would you differentiate between :

(a) Sodium sulphide and sodium carbonate.

(b) Copper and magnesium.

9. What are soaps and detergents ?

10. What do you understand by

(i) temporary hardness

(ii) permanent hardness

11. (a) Name the gas evolved when dilute sulphuric acid is added to

(i) Zinc (ii) Zinc carbonate

(iii) Zinc sulphide

(b) Name the gas evolved when conc. Sulphuric acid is added to

(i) Zinc (ii) Sodium chloride

(iii) Potassium nitrate

12. State what would you observe when the following are heated :

(i) Copper carbonate

(ii) Copper sulphate crystals

(iii) Lead nitrate

Give a balanced equation for the above reactions.

13. Name the two types of hardness of water.

14. Name the compound that must be added to water to remove hardness.

15. Name the salt that decrepitates on heating.

Long answer type questions

1. A chocolate brown coloured substance A on heating gives a colourless gas 'B' which rekindles a glowing splinter and a residue 'C' which is rust when hot and yellow when cold.

(i) Give another test to identify gas B.

(ii) Give the common name of residue C.

(iii) Give a balanced equation for

(a) Action of heat on substance A.

(b) Residue + caustic potash solution.

(c) Name the type of reaction taking place in (a) and (b)

2. Salts A, B, C, D and E undergo reactions (i) to (v) respectively. Identify the anion present in these salts on basis of these reactions.

(i) When silver nitrate solution is added to a solution of A, a white precipitate, insoluble in dilute nitric acid, is formed.

(ii) Addition of dilute hydrochloric acid to B produces a gas which turns lead acetate paper black.

(iii) When a freshly prepared solution of ferrous sulphate is added to a solution of C and concentrated sulphuric acid is gently poured from the side of the test-tube, brown ring is formed.

(iv) When dilute sulphric acid is added to D, a gas is produced which turn acidified potassium dichromate solution from orange to green.

(v) Addition of dilute hydrochloric acid to E produces an effervescence. the gas produced turns limewater milky but does not affect acidified potassium dichromate solution.

3. Write balaned equation when the following substances are heated strongly:

(a) Washing soda crystals

(b) Copper (II) sulphate pentahydrate

(c) Copper (II) nitrate hexahydrate

(d) Lead nitrate

(e) Zinc nitrate hexahydrate

(f) Ammonium chloride

(g) Ammonium dichromate

4. Select the correct gas which matches with the descriptions a to e.

CO_2, SO_2, NH_3, water vapour Cl_2, H_2S

(a) Turns moist red litmus paper blue.

(b) Turns lime water milky and blue litmus paper slightly pink.

(c) Turns cobalt chloride paper from blue to pink.

(d) Turns lead acetate paper from white to silvery black.

(e) Turns moist blue litmus red and then bleaches it.

5. Using a platinum wire, conc. hydrochloric acid and a bunsen burner how would you distinguish between the three salts i.e. sodium chloride, potassium chloride and calcium chloride. Explain in brief the method used for the same.

6. Using litmus paper how would you distinguish between chlorine gas and sulphur dioxide gas ?

7. Red lead, red mercuric oxide and ammonium dichromate are all orange red compounds. If finely ground samples of these compounds were provided for identification, how would it be possible to distinguish between the three ?

8. How would you distinguish between

(a) lead nitrate and zinc nitrate ?

(b) ammonium chloride and sodium chloride ?

(c) ammonia and hydrogen chloride gas ?

(d) zinc sulphate and zinc sulphide ?

(e) copper carbonate and copper sulphite ?

9. How is copper different from zinc with respect to its reactivity with dilute hydrochloric acid ?

10. How flame test performed ?

Important Notes