DEPARTMENT OF CHEMISTRY

Advanced level practical workbook

Student's Name……...……

Combination……..…….

A' level chemistry examinations consist of three papers i.e. P525/**1**, P525/**2** and P525/**3**.

Paper 3 (P525/3) is usually practical paper which is done in 3 hours. This paper consists of three questions which are set from the three branches of chemistry as below;

Question 1**: Physical chemistry**

Question 2: **Inorganic chemistry**

Question 3: **Organic chemistry**

This simplified workbook consists of two parts i.e. **inorganic** and **organic** qualitative analysis with worked examples and exercise questions. It also contains short explained and guiding notes which a student should read and understand.

For equations, refer to notes of theory and construct them in the spaces provided.

A good student does research and reads beyond what has been given in class; so be one but not a master of complaints always.

Part 1. INORGANIC QUALITATIVE ANALYSIS

Introduction

Qualitative analysis is branch of practical chemistry which deals with the identification of ions that are present in a substance by carrying out several chemical tests on it. There are two types of ions in ionic or electrovalent compound i.e. cations and anions.

Cations

These are positively charged ions. They are categorised into two major groups i.e. non-transition metal ions (non- coloured cations) and transitional metal ions (coloured cations).

a) Non-transition metal ions (non- coloured cations)

These form white compounds and colourless solutions when dissolved. They include;

Lead(II) ions, Pb^{2+}

Magnesium ions, Mg^{2+}

Aluminium ions, Al^{3+}

Ammonium ions, NH_4^+

Calcium ions, Ca^{2+}

Zinc ions, Zn^{2+}

Barium ions, Ba^{2+}

Others may include; tin(II) (Sn^{2+}), tin(IV) (Sn^{4+}) and silver ions (Ag^+).

b) Transitional metal ions (coloured cations)

These form coloured compounds and coloured solutions when dissolved. They include;

Iron(III) ions, Fe^{3+}

Iron(II) ions, Fe^{2+}

Copper(II) ions, Cu^{2+}

Manganese(II) ions, Mn^{2+}

Nickel(II) ions, Ni^{2+}

Other may include: Chromium(III) ions, Cr^{3+}

Anions

These are negatively charged ions. They include;

Sulphate ions, SO_4^{2-}

Carbonate ions, CO_3^{2-}

Chloride ions, Cl^-

Nitrate ions, NO_3^-

Hydrogencarbonate ions, HCO_3^-

Iodide ions, I^-

Bromide ions, Br^-

Ethanoate ions or acetate ions, CH_3COO^-

Oxalate ions, $C_2O_4^{2-}$

Others include; Nitrite ions (NO_2^-), Sulphite ions (SO_3^{2-})

- **Important to note**

In qualitative analysis experiments, there is always a table which consists of three columns. Test/procedure being the first column followed by observation and then conclusion/deduction/ inference as illustrated below.

Tests/procedure	Observations	Deductions/conclusion/inferences

- ✓ **Tests:** These are instructions given to the students stating what to do on the unknown substances or its solution in order to identify the ions present in it.

  NB; **In case the student is asked to carry out a test of his/her own choice to identify or confirm an anion or a cation present in the unknown compound, the student has to write the test he or she has performed to identify or confirm the ion asked.**
- ✓ **Observation:** This is what is seen or identified by a student during and after carrying out a test. Observations should be short statements that are well summarized.

- ✓ **Deduction/conclusion/inference:** These are facts derived from observations and can lead to the correct identification of the ions present in the unknown substance. The deductions should correspond to the stated observations that is should follow the order in which observations are written.

  NB: **No correct deduction(s) is/are awarded any mark(s) if the corresponding observation(s) is/are wrong**.

PRELIMINARY TESTS

These are tests that give us a clue/hint or general guidelines on the nature of the substance being analysed. Preliminary tests are majorly based on the following aspects i.e.

- ❖ Physical appearance of the substance
- ❖ Solubility of the substance
- ❖ Action of heat on the substance
- ❖ Use of common reagents such as NaOH(aq), NH_3(aq), Na_2CO_3(aq), $Pb(NO_3)_2$(aq) etc.

a) Appearance of the substance

The appearance of a substance based on the colour and texture of the substance given. The texture of the solid depends whether the solid is crystalline or powdery.

In terms of colour, the solid may be white, green, blue, pick/red, brown, yellow or orange, purple, violet, etc. If the solid is white, then it consists of non-transition metal ions. However, if the solid is coloured, then it consists of transition metal ions with its specific colour

Summary of the colours of given substance.

Colour	**Deductions**
White	Non-transitional metal ions
Green	Fe^{2+}, Cu^{2+}, Ni^{2+}, Cr^{3+}.
Blue	Hydrated Cu^{2+} salt.
Brown	Fe^{2+} or Fe^{3+}
Black	Cu^{2+} or Ni^{2+} or Fe^{2+} or Mn^{2+}
Pink (not visible in solution)	Mn^{2+}

Violet	Cr^{3+}

Note;

1. In case the solid is crystalline, it has got water of crystallisation and this should be reflected in that part of heating because water is given off.
2. In case of making deductions about the colour of any unknown solid given, **ALWAYS** write cations because they (cations) are the ones that influence the colour of the solid.

b) Solubility of the substance given

Since qualitative analysis is mainly carried out in aqueous solutions, there is need to know which salts are soluble in water and those that are insoluble.

A student may be asked to dissolve a sample of the solid given in water and he or she is expected to make some observations and deductions. The sample may not dissolve in water but dissolves in acid. Soluble and insoluble salts are given below.

- All **nitrates** are **soluble** in water.
- All **sulphates** are **soluble** in water except those of barium and lead; Calcium and silver sulphates are sparing soluble.
- All **carbonates** are **insoluble** in water except those of sodium, potassium and ammonium.
- All **hydrogen carbonates** are **soluble** in water
- All **ethanoates or acetates** are **soluble** in water
- All **halides** (Chlorides, Iodides and Bromides) are **soluble** in water except those of silver and lead. Halides of lead are sparing soluble in warm or hot water but insoluble in cold water.
- All **chromates** are **soluble** in water except those of lead, barium and silver. Calcium chromate is sparing soluble.
- All **oxalates** are **insoluble** in water except those of sodium, potassium and ammonium.
- All **nitrites** are **soluble** in water except silver nitrite which is sparing soluble
- All **sulphites** are **soluble** in water except those of lead, barium and silver.

Making a test solution

Procedure

Dissolve a little of the substance provided e.g. a spatula endful in about 5 or 10 cm^3 of water. Shake the test tube well until the substance dissolves. The solution obtained is now your test solution.

Summary of the colour of solutions formed by different compounds

Observations (colour of solution)	**Deductions**
Colourless	Non-transitional metal ions
Green	Fe^{2+}, Cu^{2+}, Ni^{2+}, Cr^{3+}.
Blue	Cu^{2+}
Brown	Fe^{3+}
Pink (not visible in solution)	Mn^{2+}

Note;

1. All soluble white compounds dissolve in water to form colourless solutions whereas soluble coloured (transition) compounds form solutions corresponding to their colours when dissolved in water.
2. Dilute nitric acid, sulphuric acid or hydrochloric acid can be used to dissolve insoluble salts and they also form solutions depending on the colour of the solid given.
3. If the substance is insoluble or partially soluble then filtering may be done. When filtering is performed, the colour of residue and filtrate must be stated with respective deduction(s).

c) Action of heat on substances

Here, candidates are instructed to heat a small quantity (usually spatula end-ful) of a solid substance in a dry clean glass tube strongly until there is no further change. A candidate is supposed to note the following while heating:

i) Evolution of a gas;

Gases may be evolved and can be identified using their smell, action on a glowing splint, effect on litmus paper or any specific reagent for that particular gas given off.

Identification of gases

Gases are normally given off when substances are heated or when acids are added to substances. A learner can know that a gas is given off through;

- Effervescence (rapid emission of bubbles) occurs. This is only seen when an acid is added to a solid.
- Colour. A few gases possess noticeable colours e.g. brown fumes for nitrogen dioxide.
- Smell. Some gases have got distinctive smells and they are usually unpleasant. E.g. ammonia (choking smell) and hydrogen sulphide (smell of rotten eggs).

After knowing that a gas is given off, it can then be identified using a chemical test.

Observation	**Deduction**
Colourless vapour condenses on the cooler parts of the test tube to form a colourless liquid that turns white anhydrous copper(II) sulphate blue or blue cobalt(II) chloride paper pink.	water of crystallization :. Hydrated compound
A colourless gas is given off that turns moist/damp blue litmus paper red/pink and lime water milky.	CO_2 gas evolved .: HCO_3^- or CO_3^{2-} or CH_3COO^- or $C_2O_4^{2-}$
A colourless gas with a chocking/irritating smell is given off that turns moist red litmus paper blue and forms dense white fumes with concentrated hydrochloric acid/hydrogen chloride gas.	NH_3 gas produced :. NH_4^+
A colourless gas with an irritating smell is given off that turns damp blue litmus paper red and orange potassium dichromate(VI) solution green.	SO_2 gas evolved :. SO_4^{2-} or SO_3^{2-}
Reddish brown or brown gas with an irritating smell is given off that turns moist blue litmus paper red and a colourless gas that relights a glowing splint.	NO_2 and O_2 gases evolved :. NO_3^-

Brown vapour that turns moist blue litmus paper red and bleaches it.	Br_2 gas evolved :. Br^-
Purple vapour that turns moist blue litmus paper red and sublimes to form a black or purple or purplish-black solid	I_2 gas evolved :. I^-
A greenish yellow gas with an irritating smell, turns damp blue litmus paper red and then bleaches it.	Cl_2 gas produced :. Cl^-
A colourless gas with an irritating smell, fumes in moist air, turns moist blue litmus paper red and forms dense white fumes with concentrated ammonia.	HCl gas evolved :. Cl^-
White fumes with sweet odour that forms white precipitate with Brady's reagent	CH_3COCH_3 gas evolved :. CH_3COO^-
White fumes that that moist blue litmus paper red and forms white precipitate with barium nitrate solution	SO_3 gas evolved :. SO_4^{2-}

Note: Students are advised to test for gases whenever they

- heat the solid
- add sodium hydroxide solution to sample and heat
- add acid to the sample

ii) Colour of residue after heating a substance

Residue is a solid that remains in a glass tube after heating or on the filter paper after filtering a mixture of a solid and a liquid. The colour of the residue helps to identify the Cation in the unknown substance and therefore needs to be carefully observed.

Summary of the colour of residue after heating.

Observation	**Deduction**
Residue is black	CuO or FeO or Fe_3O_4 or NiO or MnO_2 :. Cu^{2+} or Fe^{2+} or Fe^{3+} orNi^{2+} or Mn^{2+}
Residue is white.	MgO or CaO or Al_2O_3 or BaO :. Mg^{2+} or Ca^{2+} or Al^{3+} or Ba^{2+}
White sublimate.	NH_4^+

Residue is yellow when hot, white when cold.	ZnO :. Zn^{2+}
Residue is reddish brown when hot, yellow when cold.	PbO :. Pb^{2+}
Residue is brown or yellow	Fe_2O_3 :. Fe^{3+}

d) Use of common reagents

Identification of cations

i) Identification using sodium hydroxide and aqueous ammonia

The main reaction between these two reagents and the cations is the precipitation of insoluble metal hydroxides. Some of these metal hydroxides dissolve in excess of these reagents forming solutions of complex ions and some do not dissolve.

Procedure

- To a small portion of the test solution, add a few drops of NaOH(aq) or NH_3(aq) and shake the mixture. Check if precipitate is formed and note its colour.

- Add more sodium hydroxide solution or NH_3(aq) until in excess and then shake the solution. Note whether the precipitate formed is soluble in excess alkali or insoluble in excess alkali.

NB. In case no precipitate appears after adding sodium hydroxide solution, warm the mixture gently and test for ammonium ions if present or not.

Below is a summary of observations and deductions for reactions between the common cations and sodium hydroxide solution or aqueous ammonia

Expected observation(s)	**Deduction(s) with;**	
	NaOH(aq)	**NH_3(aq)**
White precipitate insoluble in excess.	Ca^{2+} or Ba^{2+} or Mg^{2+}	Al^{3+} or Pb^{2+} or Sn^{2+} or Mg^{2+}or Ba^{2+}
White precipitate soluble in excess forming a colourless solution.	Zn^{2+} or Al^{3+}or Pb^{2+}or Sn^{2+}	Zn^{2+}

White precipitate insoluble in excess turns brown on standing.	Mn^{2+}	Mn^{2+}
No observable change, a colourless gas with a choking smell turns moist red litmus paper blue and forms dense white fumes with concentrated hydrochloric acid is given off on warming.	NH_3 gas evolved NH_4^+ confirmed	-
Pale blue precipitate insoluble in excess.	Cu^{2+} present	
Green precipitate soluble in excess to form a blue solution	-	Ni^{2+}
Green precipitate insoluble in excess	Ni^{2+}	-
Green precipitate insoluble in excess, turns brown on standing.	Fe^{2+}	Fe^{2+}
Brown precipitate insoluble in excess.	Fe^{3+}	Fe^{3+}
No observable change/colourless solution	-	Ca^{2+} or NH_4^+
Pale blue precipitate soluble in excess forming a deep blue solution.	-	Cu^{2+}
Green precipitate insoluble in excess	-	Cr^{3+}
Green precipitate soluble in excess to form a green solution.	Cr^{3+}	-

Assignment 1

Write ionic equation(s) (if any) for the reaction(s) between the metal ions and sodium hydroxide solution and aqueous ammonia.

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ii) Identification using sodium carbonate solution

The procedure is the same as that of addition of sodium hydroxide solution or aqueous ammonia.

Observations	**Deductions**
White precipitate insoluble in excess	Zn^{2+} or Pb^{2+} or Sn^{2+} or Mg^{2+}or Ba^{2+}
White precipitate insoluble in excess with effervescence of a colourless gas that turns lime water milky	Al^{3+}
White precipitate insoluble in excess but turns brown on standing	Mn^{2+}
A green or blue precipitate insoluble in excess	Cu^{2+}
A dirty green precipitate insoluble in excess	Fe^{2+}
A brown precipitate insoluble in excess with effervescence of a colourless gas that turns lime water milky	Fe^{3+}
Pale green precipitate insoluble in excess	Ni^{2+}
No observable change	NH_4^+

Assignment 2

Use ionic equations to illustrate the above observations.

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CONFIRMATORY TESTS FOR CATIONS

These are tests that prove beyond doubt that indeed a particular ion is present in the given sample. The table below summarizes the confirmatory tests for cations.

Cation	Test procedure	Observations
Zn^{2+}	To the test solution, add solid ammonium chloride followed by 4-5 drops of disodium hyrogenphosphate solution followed by dilute ammonia drop wise until in excess.	White precipitate soluble in excess forming a colourless solution
	To the test solution, add potassium ferrocyanide or hexacyanoferrate(II) solution	White precipitate is formed
Pb^{2+}	To the test solution, add potassium iodide solution.	Yellow precipitate
	To the test solution, add dilute hydrochloric acid	White precipitate
	To the test solution, add dilute sulphuric acid	White precipitate
	To the test solution, add potassium chromate solution followed by dilute sodium hydroxide solution until is excess	Yellow precipitate soluble in excess sodium hydroxide solution
Ba^{2+}	To the test solution, add dilute sulphuric acid	White precipitate
	To the test solution, add ammonium oxalate followed by dilute ethanoic acid.	White precipitate soluble in dilute acid
	To the test solution, add potassium chromate solution followed by dilute sodium hydroxide solution until is excess	Yellow precipitate insoluble in excess sodium hydroxide solution
	To the test solution, add potassium chromate solution followed by dilute ethanoic acid	Yellow precipitate insoluble in dilute acid
Cu^{2+}	To the test solution, add dilute ammonium dropwise until in excess	Pale blue precipitate soluble in excess to form a deep blue solution
	To the test solution, add 3-4 drops of potassium iodide solution	White precipitate in a brown solution

	To the test solution, add potassium ferrocyanide or hexacyanoferrate(II) solution.	A brown precipitate is formed
	To the test solution, add excess concentrated hydrochloric acid.	A yellow solution is formed
Al^{3+}	To the test solution, add 2-3 drops of dilute nitric acid followed by 3-4 drops of litmus solution and then dilute ammonia solution drop wise until is excess.	A blue lake solution is formed
	To the test solution, add 2drops of litmus solution, followed by about $1cm^3$ of dilute hydrochloric acid and then dilute ammonia solution until the solution is alkaline, then add Alizarin reagent	Purple colouration is formed
Mg^{2+}	To the test solution, add solid ammonium chloride followed by 4-5 drops of disodium hyrogenphosphate solution followed by dilute ammonia dropwise until in excess.	White precipitate insoluble in excess ammonia
Ca^{2+}	To the test solution, add ammonium oxalate followed by dilute ethanoic acid.	White precipitate insoluble in dilute acid
	To the test solution, add potassium chromate solution followed by dilute sodium hydroxide solution until is excess	Yellow precipitate soluble in excess sodium hydroxide solution
Ni^{2+}	To the test solution, add little ammonia solution followed by dimethyl glyoxime solution	A red or pink precipitate is formed
	To the test solution, add few drops of potassium hexacyanoferrate(III) solution.	A brown precipitate is formed
Mn^{2+}	To the test solution, add a few drops of concentrated nitric acid followed by a little sodium bismuthate and warm gently	A purple solution is formed
	To the test solution, add a few drops of concentrated nitric acid followed by lead(IV) oxide and warm gently.	A purple solution is formed

	To the test solution, add a few drops of hydrogen peroxide solution followed by dilute sodium hydroxide drop wise until in excess.	A dark brown ppt with rapid effervescence of a colourless gas that relights a glowing splint
Fe^{2+}	To the test solution, add 3-4 drops of potassium hexacyanoferrate(III) solution.	A dark blue precipitate is formed
	To the test solution, add hydrogen peroxide solution and warm	Pale green solution turns to brown
	To the test solution, add concentrated nitric acid and warm	Green solution turns to brown
Fe^{3+}	To the test solution, add 3-4 drops of potassium hexacyanoferrate(II) solution.	A dark blue precipitate is formed
	To the test solution, add ammonium or potassium thiocyanate solution	A deep red solution is formed
Cr^{3+}	To the test solution, add dilute sodium hydroxide solution drop wise until in excess followed by hydrogen peroxide and warm	A green precipitate soluble in excess NaOH forming a green solution and turns to yellow on addition of hydrogen peroxide
	To the test solution, add lead(II) nitrate or ethanoate solution followed by dilute sodium hydroxide	A yellow precipitate

Making the solution "Just Acidic"

This is done by adding dilute mineral acid such as dilute nitric acid to the filtrate obtained after adding sodium hydroxide solution or ammonia solution and filtering. This differentiates amphoteric cations and non-amphoteric cations.

During addition of an acid, a precipitate is formed and when it dissolves, the addition is stopped and the solution is said to be '**just acidic**'.

Explanation

During the reaction the amphoteric cation with sodium hydroxide, a precipitate is formed which dissolves in excess to form a complex solution e.g.

In little sodium hydroxide solution

Al^{3+} (aq) + $3OH^-$ (aq) → $Al(OH)_3$ (s) (white precipitate)

In excess sodium hydroxide solution

$Al(OH)_3$ (s) + OH^- (aq) → $[Al(OH)_4]^-$ (aq) (colourless solution)

During filtration the colourless solution (tetrahydroxoaluminate(III) ions) remain in the filtrate and to make them free, an acid has to be add to the filtrate until it is just acidic. Then the aluminium ions are free in solution. The reactions which occur are;

$[Al(OH)_4]^-$ (aq) + H^+ (aq) → $Al(OH)_3$ (s) + H_2O (l)

$Al(OH)_3$ (s) + $3H^+$ (aq) → Al^{3+} (aq) + $3H_2O$ (l)

Washing the residue with distilled water and then dissolving in acid

This is done by pouring water on the residue through the filter paper in a funnel times. This removes any traces of the soluble cations which might be trapped in the residue. The wash residue is the dried between filter papers and carefully transferred to the test tube.

A dilute acid normally hydrochloric acid or nitric acid is then added to the residue until there is no further change. Watch what happens and the write your observations and deductions as illustrated below

Observations	**Deductions**
The white residue dissolves with effervescence of a colourless gas that turns moist blue litmus paper red and lime water milky.	CO_2 evolved CO_3^{2-} confirmed
The resultant solution is colourless	Non transition metal ions present

Identification of anions

The anions identified at A' level include;

Sulphate ions, SO_4^{2-}

Carbonate ions, CO_3^{2-}

Chloride ions, Cl^-

Nitrate ions, NO_3^-

Hydrogencarbonate ions, HCO_3^-

Iodide ions, I^-

Bromide ions, Br^-

Ethanoate ions or acetate ions, CH_3COO^-

Oxalate ions, $C_2O_4^{2-}$

Sulphite ions (SO_3^{2-})

a) Action of lead(II) nitrate

Test	**Observation**	**Deduction**
To the test solution, add lead(II) nitrate solution	White precipitate	SO_4^{2-}, $C_2O_4^{2-}$, CO_3^{2-}, SO_3^{2-}
To the test solution, add lead(II) nitrate solution	A yellow precipitate	I^-
To the test solution, add lead(II) nitrate solution and warm	White precipitate insoluble on warming	SO_4^{2-}
	White precipitate soluble on warming and reappears on cooling.	Cl^-
To the test solution, add lead(II) nitrate solution followed by dilute nitric acid	A white precipitate soluble in the acid	Cl^-, SO_4^{2-}

To the test solution, add lead(II) nitrate solution followed by dilute nitric acid	A white precipitate soluble in the acid with effervescence of a colourless gas that turns moist blue litmus paper red and lime water milky	CO_2 evolved $C_2O_4^{2-}$, CO_3^{2-}

b) Action of barium nitrate and dilute nitric acid

Test	**Observations**	**Deductions**
To the test solution add barium nitrate solution followed by dilute nitric acid	A white precipitate insoluble in the acid	SO_4^{2-} confirmed
	A white precipitate soluble in the acid	SO_3^{2-}
	A white precipitate soluble in the acid with effervescence of a colourless gas that turns moist blue litmus paper red and lime water milky	CO_2 evolved $C_2O_4^{2-}$, CO_3^{2-}
To the test solution, add dilute nitric acid followed by barium nitrate solution	White precipitate	SO_4^{2-} confirmed

Note: A combination of barium chloride and dilute hydrochloric acid gives similar observations as noted in the table above.

c) Action of silver nitrate and dilute nitric acid

Test	**Observation**	**Deductions**
To the test solution, add dilute nitric acid followed by few drops of silver nitrate solution	White precipitate	Cl^- confirmed
	A pale yellow precipitate	I^-
	No observable change	SO_4^{2-}

To the test solution, add few drops of silver nitrate followed by dilute nitric acid	White precipitate insoluble in acid	Cl^- confirmed
	A pale yellow precipitate	I^-
	A white precipitate soluble in the acid with effervescence of a colourless gas that turns moist blue litmus paper red and lime water milky	CO_2 evolved $C_2O_4^{2-}$, CO_3^{2-}

d) Action of silver nitrate and aqueous ammonia

Tests	**Observations**	**Deductions**
To the test solution, add few drops of silver nitrate followed by ammonia solution dropwise until in excess	A white precipitate soluble in excess ammonia solution forming a colourless solution	Cl^- confirmed
	Pale yellow precipitate insoluble in excess ammonia solution	I^-
	No observable change	SO_4^{2-}
	White precipitate insoluble in excess ammonia	SO_3^{2-}
	White precipitate soluble in excess ammonia	$C_2O_4^{2-}$, CO_3^{2-}

Confirmatory tests for anions

Anion	**Test(s)**	**Observation(s)**
CO_3^{2-}	To the solid sample, add dilute nitric or hydrochloric acid	Effervescence of a colourless gas that turns moist blue litmus red and forms a white precipitate with calcium hydroxide solution

	To the test solution, add magnesium sulphate or chloride solution	White precipitate
HCO_3^-	To the test solution, add magnesium sulphate or chloride solution	No observable change
$C_2O_4^{2-}$	To the test solution, add acidified potassium permanganate and heat	Purple solution turns to colourless
	To the test solution, add iodine solution and heat	Brown solution turns to colourless
SO_4^{2-}	To the test solution, add barium nitrate solution followed by dilute nitric acid	White precipitate insoluble in acid
	To the test solution, add barium chloride solution followed by dilute hydrochloric acid	White precipitate insoluble in acid
SO_3^{2-}	To the test solution, add acidified potassium permanganate	Purple solution turns to colourless
	To the test solution, add iodine solution	Brown solution turns to colourless
Cl^-	To the test solution, add lead(II) nitrate solution and warm	White precipitate soluble on warming and reappears on cooling
	To the test solution, add few drops of silver nitrate solution followed by aqueous ammonia	White precipitate soluble in excess ammonia solution to form a colourless solution
	To the test solution, add few drops of silver nitrate solution followed by dilute nitric acid	White precipitate insoluble in acid
CH_3COO^-	To the test solution, add ethanol followed by 3-4 drops of concentrated sulphuric acid and warm. Pour the mixture into cold water in a beaker	A sweet fruity smell

	To the test solution, add neutral iron(III) chloride solution	A red colouration/solution is formed
NO_3^-	To the test solution, add freshly prepared iron(II) sulphate solution. Then hold the test in a slanting position and add concentrated sulphuric acid down the sides of the test tube	A brown ring is formed
	Heat the solid sample in a dry hard test tube gently then strong	-Brown fumes of a gas that turns moist blue litmus paper red -Another colourless gas that relights a glowing splint and neutral to litmus paper
Br^-	To the test solution, add little bleaching powder (or 1 cm^3 of sodium hypochlorite solution), followed by1cm^3 of dilute and then 1cm^3 of chloroform (or 1cm^3 of tetrachloromethane) and shake gently.	An orange solution in the lower organic layer
I^-	To the test solution, add 3-5 drops of concentrated nitric acid and warm. Cool and the add starch solution	Colourless solution turns to brown and then to a blue-black solution
	To the test solution, add little bleaching powder (or 1 cm^3 of sodium hypochlorite solution), followed by1cm^3 of dilute and then 1cm^3 of chloroform (or 1cm^3 of tetrachloromethane) and shake gently	A purple solution in the organic or lower layer
	To the test solution, add 5-6 drops of concentrated sulphuric acid and	Colourless solution turns to brown then to colourless.

	warm. To the mixture, add sodium thiosulphate solution	

Rules followed while doing an inorganic qualitative analysis examination

- ✓ Observations and deductions should be written precisely
- ✓ Deductions should relate to observations
- ✓ In deduction column, a wrong answer cancels out a correct one
- ✓ The use of words inappropriately will lead to loss of marks and therefore should be avoid
- ✓ Technical words such as precipitate, effervescence, ion should be correctly spelt
- ✓ In case of a confirmatory test, the word confirmed should accompany the ion
- ✓ The symbol or formula of ion should be correctly written. Refer to our notes, text books and discussions for details
- ✓ Whenever asked to carry out a test of your own choice, the test **MUST** be written and corresponding observations. The order of reagents is very paramount and once altered, wrong observations are got.

Take note of the following.

Ion or compound	Correct presentation of symbol or formula	Wrong presentation of symbol or formula
Zinc ion	Zn^{2+}	$2n^{2+}$, ZN^{2+}, Zn^{2+}, Zn^{2+}, Zn^{+2}
Lead(II) ion	Pb^{2+}	P_b^{2+}, Pb^{2+}, Pb^{2+}, Pb^{2+}, Pb^{+2}
Aluminium ion	Al^{3+}	Al^{3+}, Al^{3+}, Al^{3+}, Al^{3+}, Al^{+3}
Calcium ion	Ca^{2+}	Ca^{2+}, Ca^{2+}, Ca^{2+}, Ca^{+2}
Magnesium ion	Mg^{2+}	Mg^{2+}, mg^{2+}, Mg^{2+}, Mg^{2+}, Mg^{+2}
Barium ion	Ba^{2+}	Ba^{2+}, Ba^{2+}, Ba^{2+}, Ba^{2+}, Ba^{+2}
Copper(II) ion	Cu^{2+}	Cu^{2+}, CU^{2+}, Cu^{2+}, Cu^{+2}
Iron(II) ion	Fe^{2+}	Fe^{2+}, Fe^{2+}, Fe^{2+}, Fe^{2+}, fe^{2+}, fe^{2+}
Nickel(II) ion	Ni^{2+}	N_i^{2+}, Ni^{2+}, Ni^{2+}, Ni^{2+}, Ni^{+2}
Ammonium ion	NH_4^+	NH_4^+, NH_4^+, NH_3^+
Carbonate ion	CO_3^{2-}	Co_3^{2-}, CO_3^{2-}, CO_3^{2-}, CO_3^{-2}
Sulphate ion	SO_4^{2-}	So_4^{2-}, SO_4^{2-}, SO_4^{2-}, SO_4^{-2}
Chloride ion	Cl^-	Ci^-, Cl^-, CL^-, Cl^-, cl^-
Iodide ion	I^-	I^-, I^-, i^-
Carbon dioxide	CO_2	Co_2, CO_2, CO_2, cO_2
Zinc oxide	ZnO	Zno, ZNO, $2nO$, ZnO
Magnesium oxide	MgO	Mgo, MgO, MgO, MgO
Lead(II) oxide	PbO	Pbo, PbO, PbO, Pb^{2+}

Sample question

You are provided with substance K which contains two cations and two anions. You are required to carry out the following tests on K to identify the cations and anions in K. Identify any gas(es) evolved. Record your observations and deductions in the table below.

Tests	**Observations**	**Deductions**
a) Heat a spatula endful of ***K*** in a dry test tube strongly until there is no further change.	-White crystalline solid -A colourless condensate which turns white anhydrous copper(II) sulphate to blue -A colourless vapour with a sweet fruity smell and forms a yellow precipitate with Brady's reagent -A colorless gas that turns lime water milky and moist blue litmus paper red -Brown fumes of a gas which turns moist blue litmus paper red -A brown residue when hot and yellow on cooling	Non-transition metal ions Water of crystallization Hydrated salt Propanone vapour evolved CH_3COO^- CO_2 evolved $C_2O_4^{2-}$ or CO_3^{2-} NO_2 evolved NO_3^- PbO Pb^{2+}
b) To a spatula endful of ***K***, add 3-5 drops of concentrated sulphuric acid and warm gently.	- White fumes with a vinegar smell and turns moist blue litmus paper red. - Brown fumes which turn moist blue litmus paper red.	Ethanoic acid fumes evolved $\therefore CH_3COO^-$ $NO_2(g)$ evolved $\therefore NO_3^-$
c) To two spatula endfuls of K, add distilled water and shake to dissolve. To the resultant solution, add dilute ammonia solution drop wise until in excess and filter.	- White crystalline solid dissolves to form a colourless solution - White precipitate insoluble in excess. - Colourless filtrate. - White solid residue.	Ba^{2+}, Ca^{2+} or Mg^{2+} Pb^{2+} or Al^{3+} or Mg^{2+} Zn^{2+} or Ca^{2+} Pb^{2+}or Al^{3+}

Keep both filtrate and residue.		
d) To the filtrate, add dilute nitric acid drop wise until the solution is just acidic.	White precipitate which dissolves in acid to form a colourless solution	Zn^{2+}
e) Divide the acidified filtrate into six portions. i) To the first portion, add dilute sodium hydroxide solution drop wise until in excess.	White precipitate soluble in excess to form a colourless solution.	Zn^{2+}
ii) To the second portion, add sodium carbonate solution, drop wise until in excess.	White precipitate insoluble in excess	Zn^{2+}
iii) To the third portion, add dilute ammonia solution, drop wise until in excess.	White precipitate soluble in excess to form a colourless solution.	Zn^{2+}
iv) To the fourth portion, carry out a test of your own choice to confirm one of the cations in K. **Test** ***Add solid ammonium chloride followed by 4 drops of disodium hydrogen phosphate solution and then aqueous ammonia drop wise until in excess.***	White precipitate soluble in excess to form a colourless solution.	Zn^{2+} confirmed
v) To the fifth portion, add ethanol followed by 3-5	A colourless sweety fruity smelling compound.	Ester formed $\therefore CH_3COO^-$ confirmed

drops of concentrated sulphuric acid and warm. Pour the mixture into a beaker of cold water.		
vi) To the sixth portion, add zinc metal powder followed by excess sodium hydroxide solution and warm.	A colourless gas which turns moist red litmus paper blue and forms dense white fumes with hydrogen chloride gas.	NH_3(g) evolved. $\therefore NO_3^-$ confirmed
f) Wash the residue obtained in (c) with water and dissolve it in dilute nitric acid. Divide the resultant solution into four portions.	White solid residue dissolves to form a colourless solution	Pb^{2+} or Al^{3+}or Mg^{2+}
i) To the first part, add dilute sodium hydroxide solution drop wise until in excess.	White precipitate soluble in excess to form a colourless solution.	Pb^{2+} or Al^{3+}
ii) To the second portion, add dilute ammonia solution drop wise until in excess.	White precipitate insoluble in excess	Pb^{2+} or Al^{3+}
iii) To the third portion, add dilute sulphuric acid.	White precipitate	Pb^{2+}
iv) To the fourth portion, add potassium chromate solution followed by sodium hydroxide solution drop wise until in excess.	Yellow precipitate soluble in excess to form a yellow solution	Pb^{2+}

(g) (i) The cations in ***K*** are Zn^{2+} and Pb^{2+}

(ii) The anions in ***K*** are CH_3COO^- and NO_3^-

BRAIN CHECK.

1. You are provided with substance Q which contains two cations and two anions. You are required to carry out the following tests on Q to identify the cations and anions present. Identify any gas(es) evolved. Record your observations and deductions in the table below.

Q [$FeSO_4.7H_2O + ZnCO_3$]

Tests	**Observations**	**Deductions**
a) Heat a spatula endful of Q in a dry test tube strongly until there is no further change.		
b) To two spatula endfuls of Q, add distilled water, shake and filter. Keep both filtrate and residue.		
c) Divide the filtrate into five portions. i) To the first portion, add dilute sodium hydroxide solution drop wise until in excess.		

ii) To the second portion, add ammonia solution, drop wise until in excess.		
iii) To the third portion, add 3-4 drops of concentrated sulphuric acid followed by 2-3 drops of potassium thiocyanate.		
iv) To the fourth portion, add lead(II) nitrate solution and heat. Allow it to cool		
v) Use the fifth portion to carry out a test of your own choice to identify one of the anions in Q. **Test**		
c) Wash the residue with water and dissolve it in dilute hydrochloric acid. Divide the resultant solution into three portions.		
i) To the first part, add dilute sodium hydroxide solution drop wise until in excess.		

ii) To the second portion, add dilute ammonia solution drop wise until in excess.		
iii) Use the third portion to carry out a test of your own choice to confirm one of the cations in Q **Test**		

d) Identify the

i) Cations in Q……

ii) Anions in Q……

3. You are provided with substance W which contains two cations and two anions. You are required to carry out the following tests on W to identify the cations and anions present. Identify any gas(es) evolved. Record your observations and deductions in the table below.

W [$(CH_3COO)_2Pb + ZnCl_2.6\ H_2O$]

Tests	**Observations**	**Deductions**
a) Heat a spatula endful of W in a dry test tube strongly until there is no further change.		

b) To two spatula endfuls of W, add 2-3 drops of concentrated sulphuric acid and warm.		
c) To two spatula endfuls of W, add dilute nitric acid until there is no further change Add sodium hydroxide solution drop wise until in excess. Filter and keep both filtrate and residue.		
d) to the filtrate, add dilute nitric acid until it is just acidic Divide the resultant solution into four parts.		
i) To the first part of the filtrate, add dilute sodium hydroxide solution drop wise until in excess.		
ii) To the second part of the filtrate, add ammonia solution, drop wise until in excess.		
iii) To the third part of the acidic solution, add dilute sulphuric acid		
iv) Use the fourth portion to carry out a test of your own choice to confirm one of the cations in W. Test		

e) To 2 spatula endfuls of W, add about 5cm3 of water, shake and filter. Divide the filtrate into five parts		
i) To the first part, add dilute sodium hydroxide solution drop wise until in excess.		
ii) To the second portion, add dilute ammonia solution drop wise until in excess.		
iii) Use the third portion to carry out a test of your own choice to confirm one of the cations in W **Test**		
iv) to the fourth part, add lead(II) nitrate solution and heat		
v) Use the fifth part to carry out a test of your own choice to confirm one of the anions in W **Test**		

d) Identify the

i) Cations in W……

ii) Anions in W……...……

4. You are provided with substance X which contains two cations and two anions. You are required to carry out the following tests on X to identify the cations and anions present. Identify any gas(es) evolved. Record your observations and deductions in the table below.

[$NiCl_2.6H_2O$ + $ZnCO_3$]

TESTS	**OBSERVATIONS**	**DEDUCTIONS**
a) Heat a spatula endful of X in a dry test tube first gently, then strongly until there is no further change. Allow it to cool		
b) To two spatula endfuls of X, add about 10cm^3 of water. Shake well and filter Keep both the filtrate and residue divide the filtrate into four parts		
i) To the first part of the filtrate, add dilute sodium hydroxide solution drop wise until in excess.		
ii) To the second part of the filtrate, add ammonia solution,		

drop wise until in excess. Add 2-3 drops of dimethyl glyoxime to the mixture		
iii) To the third part of solution, add dilute nitric acid followed by a few drops of lead(II) nitrate solution and warm		
iv) Use the fourth portion to carry out a test of your own choice to confirm one of the anions in X. Test		
c) Dissolve the residue in $5cm^3$ of dilute nitric acid and divide the resultant solution into two parts;		
i) To the first part, add dilute sodium hydroxide solution drop wise until in excess.		
ii) To the second part, add solid ammonium chloride followed by 2-3 drops of disodium hydrogen phosphate. Add ammonia solution to the mixture drop wise until in excess		

d) Identify the;

i) Cations in X……

ii) Anions in X……...……

4. You are provided with substance T which contains two cations and two anions. You are required to carry out the following tests on T to identify the cations and anions present. Identify any gas(es) evolved. Record your observations and deductions in the table below.

TESTS	**OBSERVATIONS**	**DEDUCTIONS**
a) Heat a spatula endful of T in a dry test tube first gently, then strongly until there is no further change.		
b) To two spatula endfuls of T in a boiling tube, add dilute nitric acid drop wise there is no. To the resultant solution, add dilute sodium hydroxide drop wise until in excess. Shake and filter. Keep both the filtrate and residue		

c) To the filtrate, add dilute nitric acid little at a time until the solution is just acidic. Divide the filtrate into four parts		
i) To the first part of the acidified filtrate, add 2cm3 of ethanol followed by 2-3 drops of concentrated sulphuric acid and warm the mixture.		
ii) To the second part of the filtrate, add dilute sodium hydroxide solution drop wise until in excess.		
iii) To the third part of the acidified filtrate, add dilute ammonia solution drop wise until in excess.		
iv) Use the fourth portion to carry out a test of your own choice to confirm one of the cations in T. **Test**		

d) Dissolve the residue in (b) above in dilute hydrochloric acid and divide the resultant solution into four parts parts		
i) To the first part of the resultant solution, add dilute sodium hydroxide solution drop wise until in excess.		
ii) To the second part of the resultant solution, add dilute ammonia solution drop wise until in excess		
iv) To the second part of the resultant solution, add potassium iodide solution		
iv) Use the fourth part of the resultant solution to carry out a test of your own choice to confirm the second cation in T. **Test**		

d) Identify the;

i) Cations in T……

ii) Anions in T……...……

5. You are provided with substance H which contains two cations and two anions. You are required to determine the ions in H.
   Carry out the following tests and identify any gas(es) evolved. Record your observations and deductions in table III below.

Tests	**Observations**	**Deductions**
a) Heat two spatula endfuls of H in a dry test tube, first gently then strongly until there is no further change. Allow it to cool		
b) To 2 spatula endfuls of H, add 10 cm^3 of water. Shake well and filter. Keep both the filtrate and residue. Divide the filtrate into four parts		

i) To the first part of the solution, add sodium hydroxide solution dropwise until in excess		
ii) To the second part of the solution, add aqueous ammonia drop wise until in excess		
iii) To the third part of the solution, add dilute nitric acid followed by few drops of lead(II) nitrate solution and warm		
iv) Use the fourth part of the solution to carry out a test of your own choice to confirm one of the anions in H **Test**		
c) Dissolve the residue in about $5cm^3$ of dilute nitric acid. Divide the resultant solution into two equal parts.		
i) To the first part of the solution, add sodium hydroxide solution drop wise until in excess		

ii) To the second part of the solution, add aqueous ammonia drop wise until in excess.		
iii) To the third part of the solution, add solid ammonium chloride followed by 3 or 4 drops of disodium hydrogen phosphate solution. Add ammonia solution to the mixture drop wise until in excess.		

a) Identify the

i) Cations in H …… and ……

ii) Anions in H …… and ……

6. You are provided with substance **X**, which contains **two** cations and **two** anions. You are required to carry out the following tests on **X** to identify the cations and anions in **X.** Identify any gases evolved.

TESTS	**OBSERVATIONS**	**DEDUCTIONS**
(a) Heat a spatula endful of **X** strongly in a dry test tube.		
(b) To ½ spatula endful of **X** add 2-3 drops of concentrated sulphuric acid. Heat the mixture.		

(c)To **three** spatula endfuls of **X** in a boiling tube, add about 8cm^3 of water and shake vigorously until **X** dissolves completely. Use the resultant solution as instructed below.		
(i) To 1cm^3 of the resultant solution, add an equal volume of iron(III) chloride solution. Boil the mixture.		
(ii) To another 1 cm^3 of the resultant solution add lead(II) nitrate solution.		
(iii) To another 1cm^3 of the resultant solution add barium nitrate solution followed by dilute nitric acid.		
(d) To the remaining portion of the resultant solution add sodium hydroxide solution drop-wise until in excess. Filter. Keep both the filtrate and residue.		
(e) To the filtrate in (d) add dilute nitric acid drop-wise until the solution is **just acidic.** Divide the acidified solution into **three** portions.		
(i) To the first portion add sodium hydroxide solution drop-wise until in excess.		
(ii)To the second portion add ammonia solution drop-wise until in excess.		

(iii) Use the third portion to carry out a test of your own choice to confirm one of the cations in **X**. **TEST**		
(e) Wash the residue with sodium hydroxide solution and then with water and dissolve it in dilute nitric acid. Divide the resultant solution into three parts.		
(i) To the first part of the resultant solution add sodium hydroxide drop-wise until in excess.		
(ii) To the second part of the resultant solution add ammonia solution drop-wise until in excess.		
(iii) Use the third part of the of the resultant solution to carry out a test of your choice to confirm the remaining cations in **X**. **TEST:**		

(e) Identify the

(i) Cations in **X** ……and …….

(ii) Anions in **X** …… and ……

PART 2: ORGANIC QUALITATIVE ANALYSIS

Introduction

Simple organic compounds are classified according to their functional groups. These functional groups are the reaction sites where specific reactions particular to a certain group of compounds take place.

Objectives/Aims of analyzing organic compounds

- ✓ Categorizing organic compounds as either **aliphatic or aromatic**
- ✓ Determining **carbon to hydrogen ratio** or **carbon content** in organic compounds
- ✓ Identification of **functional groups** in organic compounds e.g. hydroxyl group, carbonyl group, carboxyl group, amino group etc.
- ✓ Categorizing organic compounds as either **acidic, basic or neutral.**
- ✓ Categorizing organic compounds as either **polar or non-polar**.
- ✓ Differentiating between classes of organic compounds that is **primary, secondary and tertiary**
- ✓ Categorizing organic compounds as either **saturated or unsaturated**.

Note: It's from the above objectives that should derive the required comment on the nature of the organic compound given.

Nature of organic question

You are provided with an **organic compound M**. You are required to carry out the following tests on M. Record your **observations** and **deductions** in the table below and describe the /comment on the **nature of M**.

Organic questions are usually organized in a table format (as below) requiring candidates to write observations and deductions after performing the given tests. However, examiners can ask learners to carry out tests of their own choice to identify the organic compound given.

Test	Observation	Deduction

The objectives are above are achieved by carrying out preliminary and confirmatory tests on the given organic substance

a) Preliminary tests

1. Physical appearance

This gives an over view of the nature of the organic compound

Observation	**Deduction**
A colourless liquid	Lower aliphatic compound e.g. alcohol, aldehydes, ketones, carboxylic acids, esters
Solid compound	Aromatic compound or higher aliphatic compound e.g. salts of carboxylic acids, phenol, dicarboxylic acids and carbohydrates.

2. The flame test

Unlike inorganic compounds, flame test is vital in analyzing organic compounds.

This is important in

- Categorizing organic compounds as either **aliphatic or aromatic**.
- Determining carbon to hydrogen ratio **(carbon content)** in organic compounds
- Categorizing organic compounds as either **saturated or unsaturated**.

Test	**Observation**	**Deduction**
Burn a small amount of the organic compound on a spatula end or crucible	Burns with a yellow non-sooty flame	Aliphatic, saturated compound with a low carbon content
	Burns with a yellow sooty flame	Aromatic or unsaturated aliphatic compound with a high carbon content
	Does not burn	Alkyl halide or nitrogen containing compound or salt of carboxylic acid.

3. Smell. The smell of the compound can be a guide but not a sure test

4. Solubility in Water

The solubility of organic compounds decreases with increasing molecular mass of the compounds in a given series.

Therefore, if the substance readily dissolves in water, then the sample is likely to be a low molecular compound.

Aromatic compounds are less soluble compared to their corresponding aliphatic compounds.

If the organic compound is in liquid state the word '**miscible' or 'immiscible'** is used and if in solid state the word "**soluble**" or "**dissolve"** is commonly used.

Test	**Observation**	**Deduction**
To $1cm^3$ of organic compound, add $2cm^3$ of water	Miscible with water forming a colourless solution	Polar aliphatic compound with low carbon content e.g. alcohol, carboxylic acid carbonyl or ester
To $1cm^3$ of organic compound, add $2cm^3$ of water	Immiscible with water	Non-polar aliphatic compound
Shake a spatula endful of organic compound with about $4cm^3$ of water and warm	Sparingly soluble in cold water but dissolves on warming to form a colourless solution	Polar aromatic compound; Phenol
Shake a spatula endful of organic compound with about $4cm^3$ of water	Insoluble in water	Polar aromatic compound

Note:

- Usually the solution formed with water is tested with litmus (blue and red) or universal indicator to ascertain whether it is neutral, basic or acidic.
- Phenol and aromatic carboxylic acids do not easily dissolve in cold water, but soluble in hot water, and their solutions turn blue litmus paper red.

5. Use of indicator

Litmus paper	**Litmus solution**	**Universal indicator solution**	**Deduction**

Has no effect on both blue and red litmus paper	Has no effect on litmus solution	Solution remains green	Neutral compound; Alcohols or carbonyl or ester present
Blue litmus paper turns to red or pink	Blue litmus solution turns to red	Solutions turn to red or pink or orange	Acidic compound; Carboxylic acid or phenol present
Red litmus paper turns blue	Red litmus solution turns blue	Solution turns blue	Basic compound Amines or salt of carboxylic acid present

6. Action of dilute sodium hydroxide

Sodium hydroxide solution is used to test for the presence of carboxylic acids and phenols in a neutralization reaction

Tests	**Observations**	**Deductions**
To 1cm^3 of the organic compound, add 4cm^3 of sodium hydroxide solution	Miscible to form a colourless solution with no evolution of a gas	Neutralization reaction Aliphatic carboxylic acid or phenol present
To a spatula endful of the organic compound, add 4cm^3 of sodium hydroxide solution	Dissolves to form a colourless solution with no evolution of a gas	Neutralization reaction Aromatic carboxylic acid or phenol present
To 1cm^3 of the organic compound, add 4cm^3 of sodium hydroxide solution and boil or heat	Miscible to form a colourless solution with evolution of a gas and on boiling or heating the sweet fruity smell is lost	Ester hydrolysis to alcohol and a sodium salt of carboxylic acid Ester present
To 1cm^3 of the organic compound, add 4cm^3 of sodium hydroxide solution	Miscible to form a colourless solution with	Aliphatic amine present

	evolution of a gas that turns moist red litmus paper blue	
To the organic compound, add sodium hydroxide solution	Solid insoluble in sodium hydroxide solution	Aromatic amine

7. Use of bromine water

Test	**Observation**	**Deduction**
Add bromine water to the unknown organic compound	Brown water turns from brown to colourless	Saturated compound present; (Phenol or aniline present)
	Brown colour of bromine water persists	Unsaturated compound present; (Phenol or aniline absent)
	White precipitate	Phenol present

b) Confirmatory tests

Test	**Observation**	**Deduction**
Add a few drops of **Brady's reagent** or 2-3 drops of 2,4-dinitrophenylhydrazine Note: Conc. HCl can be added followed by warming	Yellow precipitate	Carbonyl Compound; (ketone or aldehyde)
	No observable change	Carbonyl compound absent
Add acidified potassium dichromate solution and heat	Orange solution turns to green	Primary or secondary alcohol, Aldehyde present
	No observable change	Tertiary alcohol or ketone present
Add acidified potassium permanganate solution and heat	Purple solution turns to colourless	Primary or secondary alcohol, Aldehyde present

	No observable change	Tertiary alcohol or ketone present
Add **Tollen's reagent** (silver nitrate in ammonia solution or ammoniacal silver nitrate)	Silver mirror is formed	Ketone absent; Aldehyde confirmed Or HCOOH present
	No observable change	Aldehyde absent; Ketone confirmed
Add **Fehling's s**olution (copper(II) sulphate solution	Red precipitate	Ketone absent; Aldehyde confirmed
	No observable change	Aldehyde absent; Ketone confirmed HCOOH present
Add **Lucas' reagent** (anhydrous zinc chloride and concentrated hydrochloric acid). Shake well and allow to stand	No observable change	Primary (1^o) alcohol is present
	Cloudiness formed within 5-10 minutes	Secondary (2^o) alcohol
	Immediate cloudiness is formed	Tertiary (3^o) alcohol present
Add sodium carbonate or sodium hydrogencarbonate solution or solid	Effervescence of a colourless gas that turns lime water milky and moist blue litmus paper red.	Carbon dioxide gas evolved; Carboxylic acid present
Add $1cm^3$ of **ethanoic acid** followed by a few drops of **concentrated sulphuric acid** and boil for 2 minutes. Pour this mixture in a small beaker of cold water	Colourless sweet fruity smelling compound	Esterification reaction Ester formed Alcohol present
	Purple/Violet colouration	Phenol confirmed

Add neutral **Iron(III) chloride** solution.	No observable change	Phenol absent
Add 2 drops of **Iron(III) chloride** solution followed by heating	A reddish brown or brown precipitate	Salt of carboxylic acid present
Add sodium hydrogen sulphate solution	White precipitate	Carbonyl compound present
Add two spatula endfuls of **soda lime**	A colourless gas that turns lime water milky and moist blue litmus paper red	Carbon dioxide gas evolved Carboxylic acid
Add a little PCl_5 or PCl_3 solution. ***(Read more in theory here for observations with $SOCl_2$ solution in pyridine)***	Mist fumes which form dense white fumes with concentrated ammonia solution	Compound with –OH group Phenol or alcohol or carboxylic acid
Add excess **iodine solution** followed **sodium hydroxide solution** dropwise until the solution is pale yellow or brown. Warm gently and cool under running tap water	A yellow precipitate	Alcohol, carbonyl compounds, carboxylic acid; with a methyl group ($-CH_3$) directly attached to the carbon atom with the functional group present. CHI_3 formed
	No observable change	Alcohol, carbonyl compounds, carboxylic acid; with a methyl group ($-CH_3$) directly attached to the carbon atom with the functional group absent
Add **sodium metal**	Effervescence of a colourless gas that burns with a pop sound	Hydrogen gas produced Phenol, alcohol or carboxylic acid present

Add concentrated hydrochloric acid; cool the mixture and then add sodium nitrite solution dropwise and keep the solution mixture in an ice- bath for 5-10 minutes.	Effervescence of a colourless gas neutral to litmus paper	Primary aliphatic amine
	A yellow oily liquid	Secondary aliphatic amine
	No observable change	Tertiary aliphatic amine
	No observable change but on warming effervescence of a colourless gas neutral to litmus paper	Primary aromatic amine
Add sodium hydroxide solution and heat followed by silver nitrate solution followed by dilute nitrate acid	White precipitate is formed	RCH_2-Cl present
	Pale yellow precipitate	RCH_2-Br present
	Yellow precipitate is formed	RCH_2-I present

Sample questions

1. You are provided with an organic substance Y. Carry out the following tests on Y and record your observations and deductions in the table below.

Tests	**Observations**	**Deductions**
a) Burn a little of **Y** on a spatula.	Colourless liquid burns with a yellow non- sooty flame	Saturated aliphatic compound; alcohol or carbonyl or carboxylic acid.
b) Add $1cm^3$ of **Y** to $1cm^3$ of water in a test tube and shake. Test the mixture with litmus. Divide the resultant solution into three parts.	Miscible with water forming a colourless solution; Resultant solution has no effect on litmus	Polar aliphatic compound of lower molecular. Neutral compound; Alcohol or carbonyl compound.

i) To the first part, add 2-3 drops of sodium carbonate solution	No observable change	Carboxylic acid absent
ii) To the second part, add $2cm^3$ of Brady's reagent	No observable change	Carbonyl compound absent; alcohol present.
iii) To the third part, add $2cm^3$ of iodine solution followed by sodium hydroxide solution dropwise until the colour of iodine is discharged.	Yellow precipitate	CHI_3 formed Alcohol with a methyl group directly attached to the carbon atom with the functional group present.
c) Add $2cm^3$ of acidified potassium permanganate solution to $3cm^3$ of **Y** in a boiling tube heat the mixture. Divide the solution into two parts	The purple solution turns to colourless	Primary or secondary alcohol oxidised
i) To the first part, add 3 drops of Brady's reagent	No observable change	Carbonyl compound absent Primary alcohol present
ii) To the second part, add sodium carbonate solution	Effervescence of a colourless gas that turns lime water milky and moist blue litmus paper red	Carbon dioxide evolved Carboxylic acid from oxidation of primary alcohol

d) Deduce the nature of **Y**.

Y is a **polar aliphatic saturated primary alcohol** with a **methyl group** directly attached to the carbon atom with the functional group.

2. You are provided with solid **T**. you are required to carry out the following tests to determine the nature of **T**

Tests	**Observations**	**Deductions**
a) Burn a little of T on a spatula end	T burns with a yellow sooty flame	Aromatic compound

b) Add sodium hydroxide solution to a little of T in a test and shake well	T dissolves forming a colourless solution	Phenol or carboxylic acid
c) To a little of T in a test tube, add about 5cm3 of water and heat. Test the mixture with litmus paper. Divide the mixture into 5 parts	T is sparing soluble in water. T dissolves on heating to form a colourless solution Solution turns blue litmus paper to red	Polar organic compound of high molecular mass Acidic compound; carboxylic acid or phenol present
i) To the first part add sodium carbonate solution	Effervescence of a colourless gas that turns lime water milky and moist blue litmus paper	Carbon dioxide evolved Carboxylic acid
ii) To the second part, add neutral iron(III) chloride solution	Purple or violet solution is formed	Phenol present
iii) To the third part, add Brady's reagent	No observable change	Carbonyl compound absent
iv) To the fourth part add sodium hydroxide solution followed by few drops of concentrated sulphuric acid followed by ethanoic acid	Colourless sweet fruity smelling compound	Esterification reaction Ester formed Phenol present
v) To the fifth part, add equal volume of ethanol followed by three drops of concentrated sulphuric acid and warm.	Colourless sweet fruity smelling compound	Ester formed T is Carboxylic acid

d) Comment on the nature of T

T is an **aromatic carboxylic acid** with a **hydroxyl group** attached to the **benzene ring**

Practical Exercises

1. You are provided with an organic compound N. carry out the following tests on N to identify its nature

Tests	Observations	Deductions
a) Burn a small amount of N on a spatula end		
b) To 1cm^3 of N. add equal volume of sodium hydroxide solution		
c) Shake 2cm^3 of N with about 2cm^3 of water. Test the resultant solution with litmus paper. Divide the resultant solution into three parts		
i) To the first part, add 2-3 drops of neutral iron(III) chloride solution and heat		
ii) To the second part, add little sodium carbonate powder		
iii) To the third part, add acidified potassium dichromate solution and warm		
d) To 1cm^3 of N, add ammoniacal silver nitrate solution and warm; then allow the mixture to stand		

e) State the identity of N

……

……

3. You are provided with an organic compound R. carry out the following tests on R to identify its nature. Record your observations and deductions in the table below

Tests	**Observations**	**Deductions**
a) Burn a spatula endful of R on a spatula end		
b) Two spatula endfuls of R in a clean test tube, add about $5cm^3$ of distilled water. Shake vigorously and warm. Test the solution with litmus paper. Divide the result solution in 6 portions		
i) To the first portion, add few drops of sodium hydroxide solution		
ii) To the second portion add $1cm^3$ of Brady's reagent		
iii) To the third portion, add 2-3 drops of neutral iron(III) chloride solution		
iv) To the fourth portion, add $2cm^3$ of ethanol followed by 3 drops of concentrated sulphuric and warm		
(v) To the fifth portion, add $1cm^3$ of sodium carbonate solution		
(vi) To the sixth portion, add excess soda lime and heat the mixture, place a burning splint on the mouth of the test		

e) Deduce the nature of R

……

……

3. You are provided with an organic compound Q. carry out the following tests on Q to identify nature.

Tests	Observations	Deductions
a) Burn a spatula endful of Q on a spatula end		
b) Shake $1cm^3$ of Q with about $5cm^3$ of water. Test the resultant solution with litmus paper. Divide it into 2 parts		
i) To the first portion, add 2-3 drops of neutral iron(III) chloride solution		
ii) To the second portion, add acidified potassium permanganate and heat.		
c) To about $1cm^3$ of Q, add 4-5 drops of 2,4-dinitrophenylhydrazine		
d) To about $1cm^3$ of Q, add $1cm^3$ of methanol and shake well. To the resultant solution, add $4cm^3$ of iodine solution followed by sodium hydroxide drop wise until the solution turns pale yellow. Warm the mixture and allow it to cool		

e) To 1cm3 of Q, add equal volume of Fehling's solution and heat the mixture		

f) From your results above, comment on the nature of Q.

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4. You are provided with substance Y which is an organic compound. Carry out the following tests to identify its nature

Tests	**Observations**	**Deductions**
a) Burn a spatula endful of Y on a spatula end		
b) Shake two spatula endfuls of Y with about 6cm3 of water. Test the resultant solution with litmus paper. Divide the resultant solution into four parts		
i) To the first portion, add sodium hydroxide solution		
ii) To the second portion, add little sodium hydrogencarbonate solution		
iii) To the third portion, add $1cm^3$ of bromine water		

iv) To the fourth portion, add neutral iron(III) chloride solution drop wise as you shake.		

c) Comment on the nature of Y

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5. You are provided with substance K which is an organic compound. Carry out the following tests on K to identify its functional group.

Tests	**Observations**	**Deductions**
a) Burn a spatula endful of K on a spatula end		
b) Shake half spatula endful of K with about 6cm3 of water. Test the resultant solution with litmus paper.		
c) Divide the resultant solution into five portions; i) To the first portion, add neutral iron(III) chloride solution		
ii) To the second portion, add little sodium hydrogencarbonate solution		
iii) To the third portion, add 4-5 drops of Brady's reagent		

iv) To the fourth portion, add acidified potassium permanganate solution and heat.		
v) To the fifth portion, add 2cm^3 of Tollen's reagent and warm; then allow the mixture to stand.		

d) Comment on the nature of K

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6. You are provided with an organic compound **W**. You are required to carry out the tests below on **W** to identify its nature. Identify any gas(es) evolved. Record your observations and deductions in the table below

Tests	**Observations**	**Deductions**
a) Burn a small amount of W on a spatula end or in a dry porcelain dish		
b) To about 0.5cm^3 of W, add 1cm^3 of water, shake and test the resultant solution with litmus paper.		
c) To about 1cm^3 of W, add 3-4 drops of neutral iron(III) chloride solution		
d) To about 1cm^3 of W, add 3-4 drops of Brady's reagent		
e) To about 2cm^3 of W, add 4-5 drops of acidified potassium dichromate		

solution, heat, allow it to cool and use in part (f).		
f) To the mixture from (e), add 3-4 drops of Brady's reagent.		
g) To about $2cm^3$ of Lucas reagent, add $1cm^3$ of W.		

Describe the nature of W.

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7. You are provided substance M which is an organic compound. You are required to determine the nature of M. carry out the following tests and identify any gas(es) evolved Record your observations and deductions in the table below

Tests	Observations	Deductions
a) Burn a small amount of M on a spatula		
b) To $1cm^3$ of M, add $3cm^3$ of water and shake. Divide the mixture into three parts		
i) To the first part of the solution, add 2-3 drops of iron(III) chloride solution.		
ii) To the second part of the solution, and 3-4 drops of neutral iron(III) chloride solution		

iii) To the third part of the solution, add 2-3 drops of acidified potassium dichromate solution and warm		
c) to 0.5cm3 of M in a test tube, add 2-3 drops of 2,4-dinitrophenyl hydrazine solution. (Brady's reagent)		
d) To about 1cm3 of M, add 2cm^3 of ethanoic acid followed by 3 drops of concentrated sulphuric acid and heat, pour the products in beaker of cold water.		
e) To 0.5cm^3 of M, add 2cm^3 of sodium hydroxide solution followed by aqueous iodine drop wise until in excess. Warm the mixture and leave to stand.		
f) To 1cm^3 of M, add 3$cm^3$of Lucas' reagent and shake, and leave it to stand.		

g) Describe the nature of M

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8. You are provided substance L which is an organic compound. You are required to determine the nature of L. carry out the following tests and identify any gas(es) evolved. Record your observations and deductions in the table below

Tests	**Observations**	**Deductions**

a) Burn a small amount of L on a dry spatula or dry porcelain		
b) (i) Shake about half spatula endful of L with 2cm^3 of sodium hydroxide solution.		
ii) Shake about half spatula endful of L with 2cm^3 of sodium hydroxide solution and add 2-3 drops of litmus solution.		
c) Shake about half spatula endful of L with 2cm^3 of water and divide the solution into three parts.		
i) To the first part of the solution, add 2-3 drops of sodium hydrogen carbonate solution		
ii) To the second part, add 2-3 drops of 2,4-dinitrophenyl hydrazine solution (Brady's reagent).		
iii) To the third part of the solution, add 2-3 drops of iron(III) chloride solution and warm		
d) Dissolve a spatula endful of L in about 5cm^3 of water. To the		

solution, add 1-2cm^3 of sodium hydroxide solution. Heat the mixture, cool and add 2-3 drops of silver nitrate solution and filter Keep both the filtrate and residue.		
e) To the residue, add dilute ammonia solution drop wise until in excess.		
f) To the filtrate, add equal volume of ethanol followed by 3-4 drops of concentrated sulphuric acid. Heat the mixture and allow it to cool.		

g) State the nature of L

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9. You are provided with an organic compound H. You are required to determine the nature of H. carry out the following tests and identify any gas(es) evolved

Record your observations and deductions in the table below

Tests	**Observations**	**Deductions**
a) Burn a small amount of H on a spatula end		

b) Add a spatula endful of H to about 5cm^3 of sodium hydroxide solution		
c) To a spatula endful of H in a test tube, add 5cm^3 of water. Shake vigorously and test the resultant solution with litmus paper. Divide the resultant solution into three parts		
i) To the first part, add 2-3 drops of Brady's reagent		
ii) To the second part, add Iron(III) chloride solution		
iii) To the third part, add 2-3 drops of sodium hydrogen carbonate solution		
d) To 2cm^3 of ethanol, add spatula endful of H followed by 3-4 drops of concentrated sulphuric acid and warm the mixture.		

e) From your results above, comment on the nature of H.

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THE END

Those at the top didn't just fall there, work hard…