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TOPIC 1.3: QUALITATIVE ANALYSIS

THE ABOUT

CHAPTER ANALYSIS



TIME

- Heavy memorising
- 3 **key** concepts



EXAM

- Always tested
- Typical format is a flowchart question which involves backtracking to identify ions



WEIGHTAGE

- Medium overall weightage
- Constitute to **3.5%** of marks for past 5 year papers

KEY CONCEPT

QUALITATIVE ANALYSIS

TEST FOR CATIONS

TEST FOR ANIONS

TEST FOR GASES



KEY CONCEPT

TEST FOR CATIONS

BLUE

GREEN

REDDISH
BROWN

Cation	Reaction with NaOH (aq) (strong alkaline)	Reaction with NH ₃ (aq) (weak alkaline)
Copper(II) Cu ²⁺	Forming blue precipitate of Cu(OH) ₂ Precipitate is insoluble in excess NaOH	Forming blue precipitate of Cu(OH) ₂ Precipitate dissolves in excess NH ₃ to give dark blue complex ion
Iron(II) Fe ²⁺	Forming green precipitate of Fe(OH) ₂ Precipitate is insoluble in excess NaOH	Forming green precipitate of Fe(OH) ₂ Precipitate is insoluble in excess NH ₃
Iron(III) Fe ³⁺	Forming reddish-brown precipitate of Fe(OH) ₃ Precipitate is insoluble in excess NaOH	Forming reddish-brown precipitate of Fe(OH) ₃ Precipitate is insoluble in excess NH ₃
Calcium Ca ²⁺	Forming white precipitate of Ca(OH) ₂ Precipitate is insoluble in excess NaOH	No observable reaction
Aluminium Al ³⁺	Forming white precipitate of Al(OH) ₃ Precipitate dissolves in excess NaOH to give colourless solution	Forming white precipitate of Al(OH) ₃ Precipitate is insoluble in excess NH ₃
Lead(II) Pb ²⁺	Forming white precipitate of Pb(OH) ₂ Precipitate dissolves in excess NaOH to give colourless solution	Forming white precipitate of Pb(OH) ₂ Precipitate is insoluble in excess NH ₃
Zinc Zn ²⁺	Forming white precipitate of Zn(OH) ₂ Precipitate dissolves in excess NaOH to give colourless solution	Forming white precipitate of Zn(OH) ₂ Precipitate dissolves in excess NH ₃ to give colourless solution
Ammonium NH ₄ ⁺	No precipitate formed Warming the solution produces pungent ammonia gas which turns moist red litmus blue	No observable reaction

PPT formed is **amphoteric oxide** and is able to react with alkaline to produce soluble salt.

Gives exactly same result for both reaction.

Add potassium iodide, lead (II) ions will give a yellow ppt (insoluble lead iodide).

KEY CONCEPT

TEST FOR ANIONS

Anions	Test	Observation
Carbonate CO_3^{2-}	Add dilute H_2SO_4 and bubble gas produced through limewater. (Any other suitable dilute acid can be used.) $2\text{H}^+(\text{aq}) + \text{CO}_3^{2-}(\text{aq}) \rightarrow \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$	Bubbles of CO_2 gas produced which gives a white precipitate of CaCO_3 in limewater.
Sulfate SO_4^{2-}	Add dilute HNO_3 , followed by adding $\text{Ba}(\text{NO}_3)_2$ solution. $\text{Ba}^{2+}(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) \rightarrow \text{BaSO}_4(\text{s})$	A white precipitate of BaSO_4 is formed.
Chloride Cl^-	Add dilute HNO_3 , followed by adding AgNO_3 solution. $\text{Ag}^+(\text{aq}) + \text{Cl}^-(\text{aq}) \rightarrow \text{AgCl}(\text{s})$ Alternative test: Add dilute HNO_3 , followed by adding $\text{Pb}(\text{NO}_3)_2$ solution. $\text{Pb}^{2+}(\text{aq}) + 2\text{Cl}^-(\text{aq}) \rightarrow \text{PbCl}_2(\text{s})$	A white precipitate of AgCl is formed. For alternative test: A white precipitate of PbCl_2 is formed.
Iodide I^-	Add dilute HNO_3 , followed by adding $\text{Pb}(\text{NO}_3)_2$ solution. $\text{Pb}^{2+}(\text{aq}) + 2\text{I}^-(\text{aq}) \rightarrow \text{PbI}_2(\text{s})$ Alternative test: Add dilute HNO_3 , then add AgNO_3 solution. $\text{Ag}^+(\text{aq}) + \text{I}^-(\text{aq}) \rightarrow \text{AgI}(\text{s})$	A yellow precipitate of PbI_2 is formed. For alternative test: A yellow precipitate of AgI is formed.
Nitrate NO_3^-	Add dilute NaOH , followed by adding a little aluminium powder . Warm the mixture. Aluminium reduces NO_3^- to NH_4^+ ions: $\text{NH}_4^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{NH}_3(\text{aq}) + \text{H}_2\text{O}(\text{l})$	Pungent NH_3 gas is produced which turns moist red litmus blue .

We are adding reagents with cations that can form an insoluble salt with the anion.

The **insoluble salt** is the coloured ppt we observe.

Dilute HNO_3 is first added to **remove other possible anions present** such as **carbonates** and **hydroxides**.

As presence of these anions might also produce precipitates with silver or lead.

Nitric acid is not needed if there is only one anion.

KEY CONCEPT

TEST FOR GASES

Gas	Smell	Test	Observation
Ammonia, NH₃	colourless, pungent	Test with a moist piece of red litmus paper	Moist red litmus paper turns blue
Carbon dioxide, CO₂	colourless, odourless	Bubble the gas through limewater , Ca(OH) ₂	A white precipitate (CaCO₃) is formed
Chlorine, Cl₂	greenish-yellow, pungent	Test with a moist piece of blue litmus paper	Blue litmus paper first turns red and then bleached
Hydrogen, H₂	colourless, odourless	Place a lighted splint near the gas	Gas extinguishes lighted splint with a " pop " sound
Oxygen, O₂	colourless, odourless	Place a glowing splint near the gas	Gas reignites glowing splint
Sulfur dioxide, SO₂	colourless, pungent	Bubble the gas through a solution of acidified potassium dichromate(VI), K₂Cr₂O₇ . Alternative: Bubble the gas through a solution of acidified potassium manganate(VII), KMnO₄ . <i>Recall:</i> <i>SO₂ is a reducing agent! Redox reaction occurs.</i>	Acidified potassium dichromate (VI) turns from orange to green Acidified potassium manganate (VII) turns from purple to colourless

Try it yourself! (TYS Question)

13. Three different experiments with colour changes are carried out.

- 1 Sulfur dioxide is tested with acidified potassium manganate(VII) solution.
- 2 Universal Indicator solution is added to a solution of a weak acid.
- 3 Aqueous potassium iodide and dilute nitric acid are mixed. Then aqueous silver nitrate is added.

Which row correctly identifies the experiments that correspond to the colour changes?

(N2019/P1/Q4)

	colourless solution to a yellow precipitate	purple to colourless	green to orange
A	1	2	3
B	2	1	3
C	3	2	1
D	3	1	2

()

Answer:

13. **D**
- 1: Sulfur dioxide will cause purple KMnO_4 to turn colourless/decolourise.
 - 2: Weak acid will cause the Universal Indicator solution to turn orange.
 - 3: This is a test for halides. In this case, a yellow precipitate of AgI will be produced.

Try it yourself! (TYS Question)

14. The following substances are used in the laboratory to test for various ions and gases.

acidified potassium manganate(VII)	aqueous ammonia	aqueous barium nitrate
aqueous silver nitrate	aqueous sodium hydroxide	limewater
red litmus paper	wooden splint	blue litmus paper

When testing for ammonia, chlorine, hydrogen and oxygen, what is the **minimum** number of items from the table above needed to identify these four gases? (N2020/P1/Q3)

A 2
C 4

B 3
D 5

()

Answer:

14. A
The red litmus paper is necessary as ammonia will turn moist red litmus paper blue and chlorine will bleach the red litmus paper. Hydrogen will extinguish a lighted splint with a 'pop' sound while oxygen will rekindle a glowing splint.

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