



QUALITATIVE ANALYSIS

Student Learning Outcomes (SLOs)

After completing this lesson, the student will be able to:

- Describe tests to identify important gases (Some examples include: a) ammonia, NH_3 , using damp red litmus paper b) carbon dioxide, CO_2 , using lime water c) chlorine, Cl_2 , damp litmus paper d) hydrogen, H_2 , using a lighted splint) oxygen, O_2 , using a glowing splint e) sulphur dioxide, SO_2 , using acidified aqueous potassium manganate(VII)
- Explain the use of a flame test to identify important cations: (Some examples include; a) lithium, Li^+ b) sodium, Na^+ , c) potassium, K^+ , d) calcium, Ca^{2+} , e) copper, Cu^{2+} , f) barium, Ba^{2+}

INTRODUCTION

Qualitative analysis is those in which one only tells about the nature of a substance and not its quantity. These analysis methods have different reliability. Some of them are very reliable and reach up to confirmatory tests.

18.1 DETECTION OF GASES

18.1.1 Detection of ammonia

Ammonia is a basic gas whose pH is more than 7. It is used for making urea fertilizer. It can be manufactured by Haber's process using hydrogen and nitrogen gases.

Procedure for detection

1. Take a red litmus paper.
2. Moist the filter paper with water spray
3. Place the litmus paper at the mouth of test tube or flask containing ammonia gas.
4. The red litmus paper will turn blue.

Turning the litmus paper blue confirm the presence of any basic gas like ammonia.

18.1.2 Detection of carbon dioxide (CO_2)

Procedure of production and detection

1. Take some marble pieces in a conical flask.
2. Cork it with the help of the cork with two holes.
3. From one hole insert a thistle funnel, and from the other whole a glass tube of u shape.
4. Insert the other end of tube in a test tube containing lime water ($\text{Ca}(\text{OH})_2$) aq.
5. Hydrochloric acid in the thistle funnel.

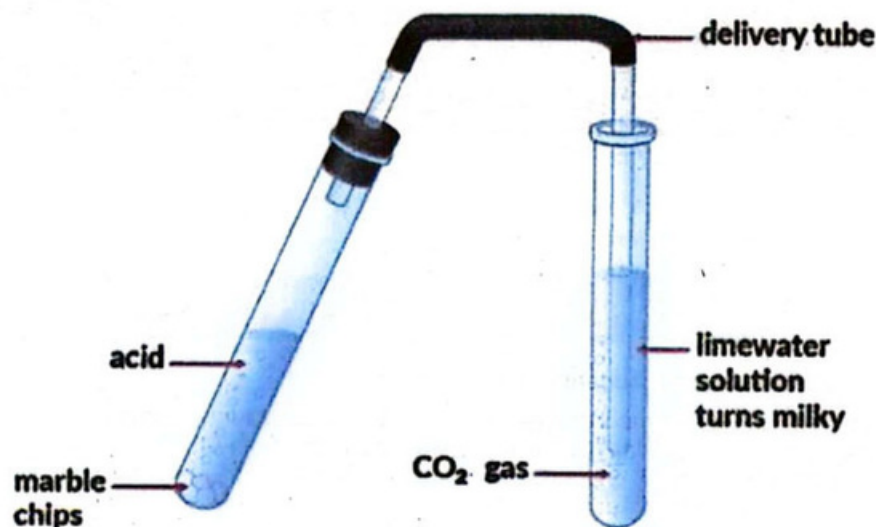


Figure 18.1: Detection of carbon dioxide.

- Carbon dioxide gas formed will travel through the tube into lime water.
- $\text{CaCO}_3 + \text{HCl} \rightarrow \text{CaCl}_2 + \text{CO}_2 + \text{H}_2\text{O}$
- The lime water will turn milky due to the production of calcium carbonate which is insoluble.
- $\text{CO}_2 + \text{Ca(OH)}_2 \rightarrow \text{CaCO}_3 + \text{H}_2\text{O}$

This method is a confirmatory test for Carbon dioxide.

18.1.3 Detection of chlorine gas

Detection procedure

- Prepare Damp Litmus Paper:**
Take a piece of blue litmus paper and dampen it with distilled water. Blue litmus paper is typically used for acidic gases like chlorine.
- Expose to the Gas:**
Place the damp blue litmus paper in the test tube of chlorine gas.
- Observe Colour Change:**
If chlorine gas is present, the blue litmus paper will turn red. This colour change occurs because chlorine gas is acidic and reacts with the red litmus paper, causing it to change from blue to red and then bleaches it to white.

Interestingly blue litmus after turning red turns white as it bleaches the paper, chlorine gas is a bleaching agent.

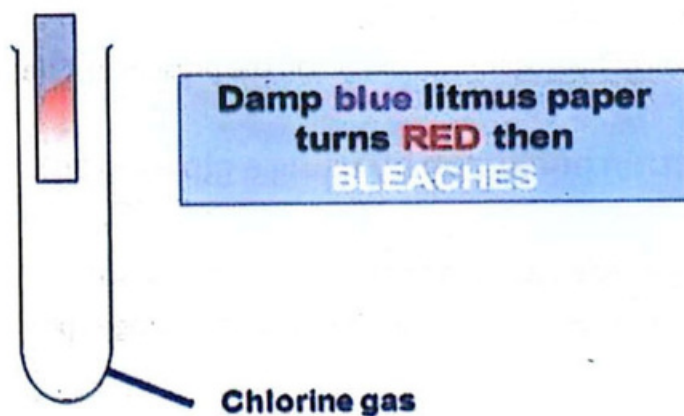


Figure 18.2: Detection of chlorine.

18.1.1 Detection of hydrogen gas using lighted splint (pop reaction)

hydrogen gas can be prepared by the reaction of zinc metal with sulphuric acid. It can be stored in an open inverted test tube. Because of its light weight it does not go out in a vertically inverted test tube.

Procedure:

- Put some zinc metal pieces in a wolf bottle.
- Wolf bottle has two openings, from one opening using a cork pass a thistle

- funnel, from the other opening pass a U-shaped tubing.
- Make the apparatus air tight by using wax.
- Take a test tube to collect hydrogen gas coming from the tubing. And place it vertically inverted over the tubing
- Pour sulphuric acid from the thistle funnel.
- $$\text{Zn}_{(s)} + \text{H}_2\text{SO}_{4(aq)} \rightarrow \text{ZnSO}_{4(aq)} + \text{H}_{2(g)}$$

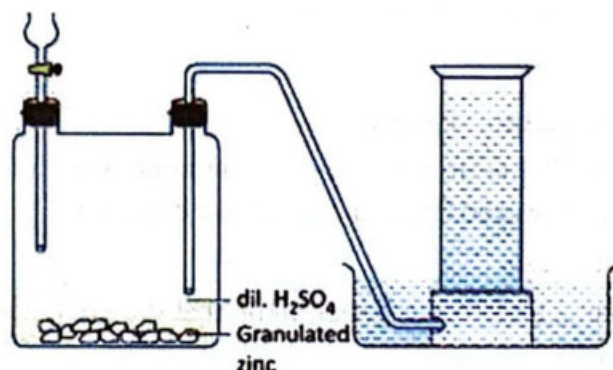


Figure 18.3: Formation of hydrogen.

- The test tube will be filled with the hydrogen gas.
- Bring a burning splint after the test tube is filled with hydrogen,
- A popping voice with a flame is observed which will confirm the presence of hydrogen gas.
$$2\text{H}_{2(g)} + \text{O}_{2(g)} \rightarrow 2\text{H}_2\text{O}_{(l)}$$

This happens as a reaction of hydrogen with oxygen in the presence of flame and the formation of water vapours.

18.1.2 Detection of oxygen by using a glowing splint

Materials required

- A glowing wooden splint (a small stick or piece of wood)
- A source of oxygen (e.g., oxygen gas tank or hydrogen peroxide solution)
- A test tube
- A match stick

Procedure:

Ensure you are in a well-ventilated area and follow safety precautions when handling flammable materials.

Prepare your source of oxygen:

use hydrogen peroxide, pour a small amount into the test tube, it generates oxygen gas automatically.

Ignite the wooden splint using a matchstick or lighter until it's glowing at the tip. Carefully insert the glowing splint into the test tube containing the oxygen gas.

Observe what happens to the splint inside the test tube, if oxygen is present, the splint will burst into flames, burning brightly.

Oxygen gas helps in combustion, thus it will suddenly enflame the vanishing splint.

18.1.6 Detection of Sulphur dioxide

SO₂ is a very good reducing agent, it can be detected by using an oxidizing agent like Potassium permanganate.

Procedure

1. Prepare a solution of potassium permanganate (KMnO₄) in water it will be of bright purple colour.
2. Pass the gas sample containing SO₂ through the KMnO₄ solution.
3. The following reaction occurs in which purple colour of KMnO₄ will be discharged. It shall indicate the presence of SO₂ gas.
4. $2\text{KMnO}_4 + 3\text{SO}_2 + \text{H}_2\text{O} \rightarrow 2\text{MnO}_2 + 2\text{K}_2\text{SO}_4 + 2\text{H}_2\text{SO}_4$

This method is often used in analytical chemistry and environmental monitoring to detect and measure SO₂ levels in gases.

18.2 DETECTION OF METAL CATIONS BY FLAME TEST

A Bunsen burner flame has two parts the upper part is called oxidizing flame and the lower part is called reducing flame.

Bunsen flame has enough energy to excite the electrons of alkali and alkaline earth metal atoms.

Alkali metals have low ionization potentials that's why their atoms get their electrons excited by the energy of visible wavelength of light. The same energy is released when the electron comes to the ground state showing the colour of flame, as this flame contains the energy of visible wavelength of light it possesses a characteristic flame colour.

How is flame test performed?

1. **Sample Preparation:** A small amount of the sample e.g. salt, oxide or any other compound containing the metal ions is usually dissolved in water to create a solution or paste.
2. **Clean Wire Loop:** A clean, non-reactive wire loop of platinum or even a clean glass rod is used to hold a small amount of the sample solution.
3. **Heating:** The wire loop with the sample is then introduced into the flame of a Bunsen burner. The heat causes the metal ions in the sample to become excited.
4. **Observation:** As the metal ions return to their ground state from the excited state, they emit light in the form of characteristic coloured flames. The colour of the flame is then observed and compared to a reference chart to identify the metal ion present.

Sodium gives golden yellow, lithium and strontium give crimson red, Potassium gives purple, Cesium gives blue, barium gives green and copper gives bluish green flame colours.



Figure 18.4: Flame of different metallic cations.

KEY POINTS

- Qualitative analysis is those in which one only tells about the nature of a substance and not its quantity
- Ammonia gas turns red litmus paper blue
- Carbon dioxide turns lime water milky
- Chlorine changes blue litmus paper red and then bleaches to colourless
- Hydrogen burns with pop sound
- Oxygen helps in combustion
- Sulphur dioxide discharges the purple colour of KMnO_4
- Sodium gives golden yellow flame, lithium and strontium give crimson red, Potassium gives purple, Cesium gives blue, barium gives green and copper gives bluish green flame

REVIEW QUESTIONS**1. Encircle the correct answer.**

- (i) Ammonia is a gas
(a) Acidic (b) Basic
(c) Neutral (d) Amphoteric
- (ii) Which gas helps in combustion process?
(a) Oxygen (b) Nitrogen
(c) Sulphur dioxide (d) Carbon dioxide
- (iii) Which gas turns the lime water, milky?
(a) Carbon monoxide (b) Carbon dioxide
(c) Sulphur dioxide (d) Oxygen
- (iv) Electrons of alkali metals excite by absorbing the light in:
(a) Visible wavelength (b) UV wavelength
(c) IR wavelength (d) Radio wavelength
- (v) The colour imparted by the flame of sodium metal is:
(a) Blue (b) Green
(c) Golden yellow (d) Purple

2. Give short answer.

- (i) How is ammonia detected by a litmus paper?
- (ii) How can you identify carbon dioxide?
- (iii) How can you detect hydrogen gas?
- (iv) How can you detect sulphur dioxide?
- (v) Differentiate between oxidizing and reducing flame?
3. What is the difference between qualitative and quantitative analysis?
4. What is the origin of flame colour?
5. Why does hydrogen gas produce a popping voice when it is exposed to the flame?
6. Why the litmus paper turns white at the end after converting red.

