Experiment 11

AIM

To study the interaction of metals such as magnesium, zinc, iron, tin, lead, copper, aluminum (any four) with their salt solutions and to arrange them according to their reactivity.

THEORY

Different metals have different reactivities towards chemical reagents. Some metals are more reactive than others. The metals, which can lose electrons more readily to form positive ions are more reactive. Displacement reactions can be used to find out the relative reactivities of metals. A more reactive metal displaces a less reactive metal from its salt solution. For example, if a piece of zinc metal is dipped in a solution of copper sulphate, zinc will displace copper from copper sulphate. The blue colour of copper sulphate solution will gradually fade and finally, a colourless solution of zinc sulphate will be obtained.

$$\underset{}{Zn\ (s)} + \underset{\text{Blue}}{CuSO_4\ (aq)} \longrightarrow \underset{\text{Colourless}}{ZnSO_4\ (aq)} + \underset{\text{Reddish brown}}{Cu\ (s)}$$

MATERIALS REQUIRED

Pieces of metals such as zinc, copper, iron, and lead or other suitable metals (at least four strips of each metal), solutions like zinc sulphate; copper (II) sulphate; iron (II) sulphate; and lead nitrate, distilled water, four beakers (100 mL), four test tubes, a measuring cylinder (50 mL), sa test tube stand, and a piece of sand paper.

PROCEDURE

1. Take zinc, copper, iron, and lead metal pieces and clean their surfaces with a sand paper.
2. Prepare 50 mL solutions of 5% concentration (by volume) of zinc sulphate, copper (II) sulphate, iron (II) sulphate and lead nitrate in distilled in four different beakers. Label these beakers as W, X, Y, and Z. Note that these are the salt solutions of the four metals taken for studying the interaction.
3. Take 10 mL of each solution in four different test tubes and label them as tubes A, B, C, and D.
4. Put zinc metal strip in all the four test tubes, that is in tubes A, B, C, and D and observe the change that follows.
5. Repeat the above experiment with other metal strips by dipping them in fresh salt solutions of metals and observe for displacement reactions.

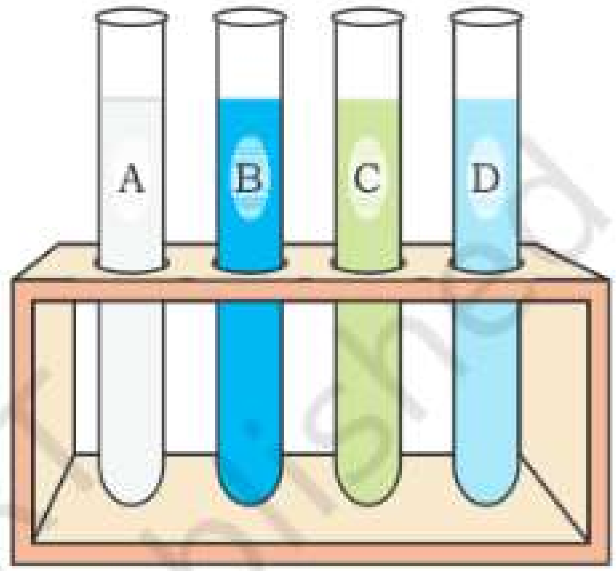

Fig 11.1 : *Zinc metal dipped in Zinc sulphate (A), copper sulphate (B), iron sulphate (C) and lead nitrate (D) solutions*

OBSERVATIONS

Sl.No.	Metal	Metal displacement and colour change of solution (Solution to which metal is added)			
		Zinc sulphate solution, A	Copper (II) sulphate solution, B	Iron (II) sulphate solution, C	Lead nitrate solution, D
1.	Zinc				
2.	Copper				
3.	Iron				
4.	Lead				

Results and Discussion

Infer from the observations and arrange the metals in the order of their decreasing reactivities.

Precautions

- Clean the metals by rubbing them with a piece of sand paper before dipping them in the salt solutions.
- Wash the test tubes after every set of observations of interaction of a particular metal with the four salt solutions.

Note for the Teacher

- One or two drops of conc. H_2SO_4 may be added during the preparation of salt solutions to avoid the hydrolysis of sulphate salts.
- For obtaining granuels of different metals, sheets of metals may be cut into smaller pieces.

Questions

- In the following reaction, A and B are metals. BX is a salt of metal B.

$$A + BX \longrightarrow AX + B$$

  Which one of the two metals is more reactive? Give reason.
- Name any two metals that are more reactive than iron?
- Why did the colour of copper (II) sulphate solution, change, when zinc metal was dipped in it?
- What is your observation when copper is added in iron (II) sulphate solution?
- Which is the most and the least reactive metal in the above experiment?
- Why can we safely preserve iron (II) sulphate in a copper vessel whereas the same can't be safely preserved in zinc vessel?

Experiment 12

AIM

To study the reaction of metals with water under different temperature conditions.

THEORY

Some metals react with water and produce metal hydroxides or oxides and liberate hydrogen gas. Metals like potassium and sodium react violently with cold water. The reaction is so violent that the liberated hydrogen immediately ignites. But all metals donot react with water.

$$2K\ (s) + 2H_2O\ (l) \longrightarrow 2\ KOH\ (aq) + H_2\ (g)$$

$$2Na\ (s) + 2H_2O\ (l) \longrightarrow 2\ NaOH\ (aq) + H_2\ (g)$$

However calcium reacts less violently with cold water. That is

$$Ca\ (s) + 2H_2O\ (l) \longrightarrow Ca(OH)_2\ (aq) + H_2\ (g)$$

Magnesium does not react with cold water. It reacts with hot water to form magnesium hydroxide and hydrogen. Metals like aluminium, zinc and iron donot react either with cold or hot water, but they react with steam to form a metal oxide and hydrogen.

$$2Al\ (s) + 3H_2O\ (g) \longrightarrow Al_2O_3\ (s) + 3H_2\ (g)$$

$$3Fe\ (s) + 4H_2O\ (g) \longrightarrow Fe_3O_4\ (s) + 4H_2\ (g).$$

Metals like lead, copper, silver and gold donot react even with steam.

In this experiment we shall study reactions of some metals with water under different conditions.

Materials Required

Small pieces of same sizes of seven samples of metallic substances (sodium, magnesium, zinc, lead, iron, aluminium, and copper), distilled water, fourteen test tubes, two test tube stands, burner, a beaker (250 mL), a gas jar, a boiling tube, a laboratory stand, a delivery tube, a trough, a single bored cork, glass wool, and a piece of sand paper.

Procedure

1. Take seven test tubes each half filled with cold water. Place them in a test tube stand.
2. Put small samples of clean metallic substances in these seven test tubes.
3. Observe the test tubes to identify the metals that react with cold water. How fast these metals react with cold water? Do all metals react at the same rate? The order of reactivity in different test tubes can be compared by carefully observing the rate of formation of bubbles of liberated hydrogen gas in the test tubes.
4. Boil about 100 mL water in a beaker.

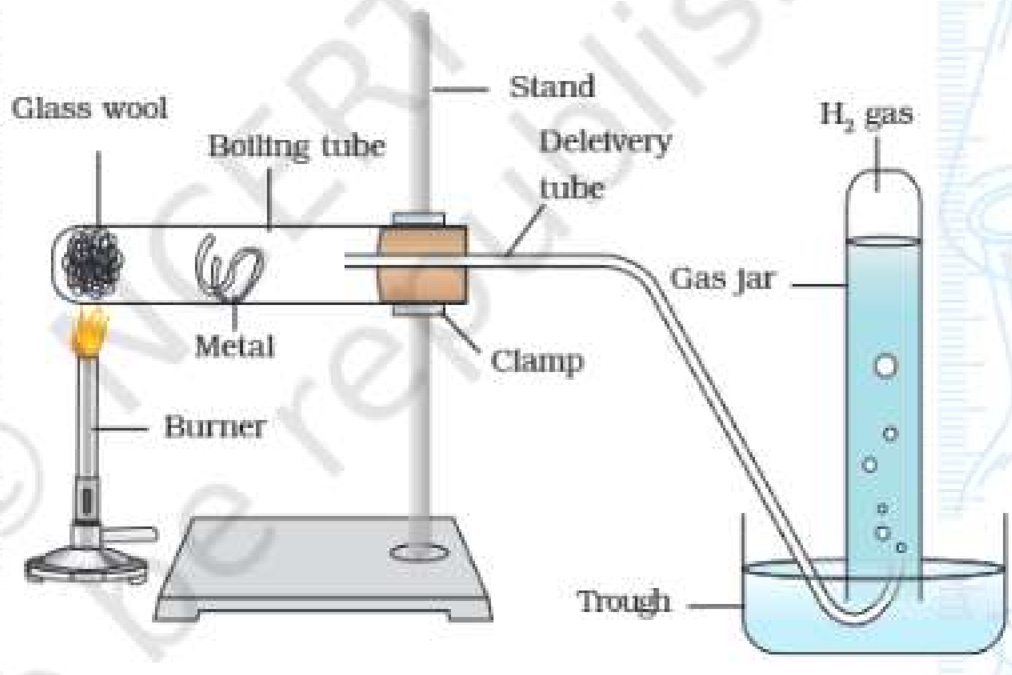

Fig. 12.1 : *Action of steam on a metal*

5. Take out the metallic pieces from the test tubes that did not react with cold water in steps 2 and 3.
6. Put these metallic pieces in test tubes half filled with hot water.
7. Observe the test tubes to identify the metals that react with hot water. Also observe that which metal reacts fast with hot water? Also compare their order of reactivity by observing the bubbles of liberated hydrogen gas in the test tubes.
8. Did you find any metallic substance reacting neither with cold water nor hot water? These may or may not react with steam. Take such samples out from the test tubes.

9. To see the reaction of metallic substances (as identified in step 8) with steam, arrange the apparatus as shown in Fig 12.1, and observe their reaction with steam.
10. Arrange the metals in the decreasing order of reactivity with water under different conditions.

Observations

Record your observation as vigrous, slow or no reaction with cold water or with hot water or with steam in the following table.

Sl.No.	Metals	Reaction conditions		
		cold water	hot water	steam
1.	Sodium			
2.	Magnesium			
3.	Zinc			
4.	Lead			
5.	Iron			
6.	Aluminium			
7.	Copper			

Results and Discussion

List the metals that react with cold water, with hot water, with steam separately. Also arrange the metals in the order of decreasing reactivity in each list. Also list the metals that do not react with water.

Precautions

- Always handle sodium metal carefully as it even react with moisture of skin.
- All metals except sodium should be cleaned by rubbing with a sand paper.
- The exposed surface area of all samples of metallic substances under observations should be same.

QUESTIONS

- Which gas is produced when an active metal reacts with water?
- Did any metal produce fire in water?
- Which metals did not react with cold water at all?
- Why should we use glass-wool soaked in water for action of sodium on cold water?
- Which metal did not react with water even in the form of steam?

Experiment 13

Aim

To study reaction of metals with dilute acids.

Theory

Many metals react with dil. hydrochloric and dil. sulphuric acid to form a salt. In this reaction hydrogen gas is evolved. The metal replaces the hydrogen atoms from the acid to form a salt. That is

$$\text{Metal + dilute acid} \longrightarrow \text{Metal salt + Hydrogen}$$

$$Mg\ (s) + 2HCl\ (aq) \longrightarrow MgCl_2\ (aq) + H_2\ (g)$$

$$2Al\ (s) + 6HCl\ (aq) \longrightarrow 2AlCl_3\ (aq) + 3H_2\ (g)$$

$$Zn\ (s) + 2HCl\ (aq) \longrightarrow ZnCl_2\ (aq) + H_2\ (g)$$

$$2Fe\ (s) + 6HCl\ (aq) \longrightarrow 2FeCl_3\ (aq) + 3H_2\ (g)$$

However all metals do not react with dil. HCl or dil. H_2SO_4. Hydrogen gas is rarely evolved when metal reacts with nitric acid. It is because HNO_3 is a strong oxidising agent. It oxidises the hydrogen produced to water and reduces to any of oxides of nitrogen (such as N_2O, NO_2, NO). However, magnesium and manganese metals react with dil. HNO_3 to liberate hydrogen gas.

Materials Required

Five samples of metallic substances (such as magnesium, aluminium, zinc, iron, and copper), dil. hydrochloric acid, dil. sulphuric acid, dil. nitric acid, five test tubes, a test tube stand, a measuring cylinder (50 mL), and a piece of sand paper.

Procedure

1. Take five test tubes in the test tube stand and label them as A, B, C, D, and E.
2. Take small pieces of sample metallic substances (magnesium, zinc, aluminium, iron, and copper metals). Clean their surfaces by rubbing with a sand paper.
3. Place these metals in test tubes A, B, C, D and E respectively.
4. Add about 10 mL dil. hydrochloric acid to each of these test tubes.
5. Observe carefully the rate of formation of bubbles in the test tubes. These bubbles are of the hydrogen gas, liberated in the reaction.
6. Arrange the metals in the decreasing order of reactivity with dil. hydrochloric acid.
7. Take out the metallic samples from the test tubes. Wash the test tubes with water. Put them in a test tube stand.
8. Repeat the experiment (steps 1 to 6) with dil. sulphuric acid and dil. nitric acid.
9. Record your observations as vigrous, slow or no reaction in the following table.

Observations

Sl.No.	Metal	Intensity of reaction with		
		dil. HCl	dil. H_2SO_4	dil. HNO_3
A	Magnesium			
B	Zinc			
C	Aluminium			
D	Iron			
E	Copper			

Results and Discussion

List the metals that react with dil. HCl, dil. H_2SO_4 and dil. HNO_3 separately. Also arrange the metals A, B, C, D, and E in the order of decreasing reactivity in each case.

PRECAUTIONS

- The exposed surface area of the metals should be approximately same.
- Clean the metal surface with sand paper, specially for Mg and Al.

NOTE FOR THE TEACHER

- The intensity of reaction depends on concentration of acid used and surface area of the metal exposed besides the nature of metal and the experimental temperature.

APPLICATIONS

Such studies can help us to construct metal activity series.

QUESTIONS

- What was your observation when zinc was dipped in dil. hydrochloric acid?
- Which metals reacted vigorously with dil. hydrochloric acid?
- Which metal did not react with dil. hydrochloric acid?
- Metal reacts with dil. hydrochloric acid to give metal salt and hydrogen gas. Can you suggest any test to verify that evolved gas, if any, is hydrogen?
- Can we use dil. nitric acid in place of dil. HCl in this experiment?
- Why would iron dust reacts vigorously as compared to iron filings with dil. HCl?

Experiment 14

AIM

To prepare sulphur dioxide gas and study its physical and chemical properties.

THEORY

Sulphur dioxide is prepared by the action of hot concentrated sulphuric acid on copper turnings.

$$Cu\,(s) + 2H_2SO_4\,(l) \xrightarrow{Heat} CuSO_4\,(aq) + SO_2\,(g) + 2H_2O$$

Sulphur dioxide is acidic in nature. It decolourises acidified potassium permanganate ($KMnO_4$) solution. Acidified potassium dichromate solution ($K_2Cr_2O_7$) is also turned green by SO_2. The reactions with $KMnO_4$ and $K_2Cr_2O_7$ are due to the reducing property of SO_2 and oxidising nature of acidified $KMnO_4$ and $K_2Cr_2O_7$.

Or $\quad 2KMnO_4 + 5SO_2 + 2H_2O \longrightarrow K_2SO_4 + 2MnSO_4 + 2H_2SO_4$.

Similarly,

$$K_2Cr_2O_7 + 4\,H_2SO_4 \longrightarrow K_2SO_4 + Cr_2(SO_4)_3 + 4H_2O + 3[O]$$

$$[SO_2 + H_2O + [O] \longrightarrow H_2SO_4] \times 3$$

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

MATERIALS REQUIRED

Copper turnings, conc. sulphuric acid, dil. sulphuric acid, potassium permanganate solution, potassium dichromate solution, red and blue litmus papers, a round bottom flask, a thistle funnel, a delivery tube, a double bored cork, a piece of card board as a lid, a laboratory stand, a burner, a wire gauze, a tripod stand, two test tubes, a trough, a measuring cylinder (50 mL), and a gas jar.

PROCEDURE

1. Place few pieces of copper turnings (about 5 g) in a round bottom flask and arrange the apparatus as shown in Fig. 14.1.
2. Add 15 - 20 mL of conc. sulphuric acid to it through a thistle funnel.
3. Place the cork in its position on the flask again and heat the contents gently. The gas formation starts after sometime.
4. Collect the gas in the gas jar and study its properties as per the steps given in the observation table.

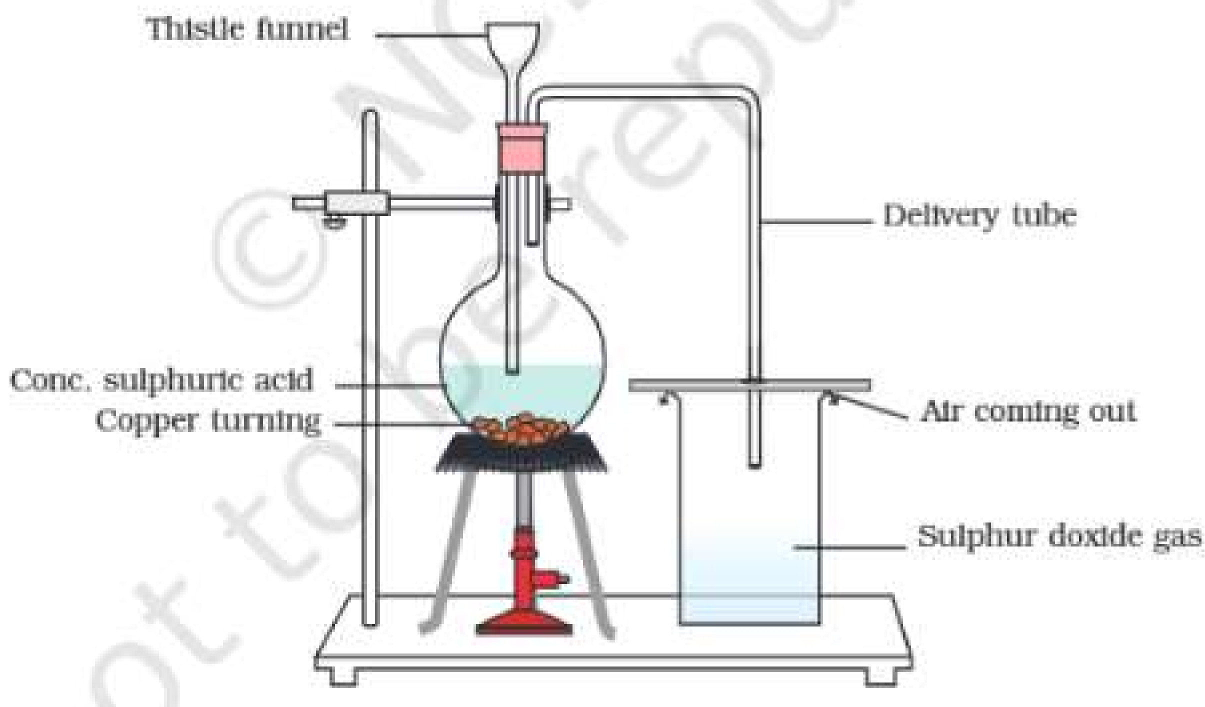

Fig. 14.1 : *Preparation of sulphur dioxide gas*

Observations

Sl.No.	Test	Experiment	Observation	Inference
1.	**Physical Properties**			
(a)	Colour	Look at the sulphur dioxide filled gas jar.		
(b)	Solublity in water	Take a gas jar filled with sulphur dioxide with its mouth closed with a lid. Invert it in water contained in a trough. Remove the lid carefully.		
2.	**Chemical Properties**			
(a)	Acidic or basic nature	Insert damp or wet litmus paper in the jar filled with sulphur dioxide.		
(b) (i)	Reaction with potassium permanganate ($KMnO_4$) solution	Take about 2 mL of potassium permaganate solution in a test tube, add about 1 mL of dilute H_2SO_4 and pass sulphur dioxide gas in this solution.		
(ii)	potassium dichromate ($K_2Cr_2O_7$) solution	Pass sulphur dioxide through another test tube containing acidified potassium dichromate solution		

Results and Discussion

Infer the observations and note your inferences in observation table. On the basis of observations mention the physical and chemical properties of the liberated sulphur dioxide gas. Solubility of SO_2 in water is a chemical property on account of the following reaction.

$$SO_2\ (g) + H_2O\ (l) \longrightarrow H_2SO_3\ (l)$$

SO_2 is both oxidising and reducing in its behaviour as, it can take as well as supply oxygen.

Precautions

- Keep the apparatus for preparation of gas airtight.
- Concentrated sulphuric acid should be handled carefully. It should not touch your skin.
- Avoid adding large quantity of acid at a time, otherwise a vigorous reaction may occur. Care should be taken while handling hydrochloric acid. It should not touch the skin.
- Do not inhale sulphur dioxide.

Note for the Teacher

- Sulphur dioxide can also be prepared by
  Na_2SO_3 (aq)+ dil. H_2SO_4 (aq) $\longrightarrow$ Na_2SO_4 (aq) + H_2O (l) + SO_2 (g)

Questions

- What type of reaction (oxidation or reduction) does sulphuric acid undergo during the laboratory preparation of sulphur dioxide?
- What happens when sulphur dioxide is passed through acidified potassium permanganate solution?
- How will you prove that sulphur dioxide is acidic in nature?
- Why is sulphur dioxide collected by upward displacement of air?
- What are the different roles of H_2SO_4 in chemical reactions? Justify your answer with an example of each?
- Identify the role (oxidant or reductant) of each gas in the following reaction:

  $2H_2S$ (g) + SO_2 (g) $\longrightarrow$ 3S (s) + $2H_2O$ (l)
- Compare the reactions:

  (i) Cu(s) + $2H_2SO_4$ (l) $\longrightarrow$ $CuSO_4$ (aq) + SO_2 (g) + $2H_2O$ (l)

  (ii) 4Zn (s) + $5H_2SO_4$ (l) $\longrightarrow$ $4ZnSO_4$ (aq) + H_2S + $4H_2O$ (l)

  What conclusion do you draw about the two metals here?

Experiment 15

AIM

To prepare carbon dioxide gas and study its physical and chemical properties.

THEORY

In a laboratory, carbon dioxide gas (CO_2) may be prepared by the action of dilute acids on calcium carbonate. Calcium carbonate is usually taken in the form of marble chips.

$$CaCO_3\ (s) + 2HCl\ (aq) \longrightarrow CaCl_2\ (aq) + H_2O + CO_2\ (g)$$

Carbon dioxide gas is acidic in nature. It is also an oxidising agent. It turns a red litmus paper blue and turns lime water [$Ca(OH)_2$ (aq)] milky.

$$Ca(OH)_2\ (aq) + CO_2\ (g) \longrightarrow CaCO_3\ (s) + H_2O\ (l)$$

On passing excess of CO_2 through lime water, calcium hydrogencarbonate is formed. It is soluble in water and forms a colourless solution.

$$CaCO_3\ (s) + H_2O\ (l) + CO_2\ (g) \longrightarrow Ca(HCO_3)_2\ (aq).$$

MATERIALS REQUIRED

Marble chips (10 g), dil. hydrochloric acid, red and blue litmus paper strips, freshly prepared lime water, a small piece of magnesium ribbon, Woulfe's bottle or a round bottom flask, a gas jar, a measuring cylinder (50 mL), a thistle funnel, a delivery tube, two single bored corks, a trough, a candle, and a piece of cardboard.

PROCEDURE

1. Take about 10 g of small pieces of marble chips in a woulfe's bottle and set up the apparatus as shown in Fig. 15.1.
2. Add, dropwise, 10 mL of dil. hydrochloric acid to the woulfe's bottle through the thistle funnel.
3. Do you see any reaction taking place in the woulfe's bottle? Do you see any gas formation?
4. Collect the liberated gas in gas jar to perform the colour, odour, solubility in water, combustibility and acidic tests. Record your observations in the observation table.
5. Pass the liberated gas through freshly prepared lime water in a test tube. Do you see any gas bubbles in the lime water? Does the colour of lime water turns milky?

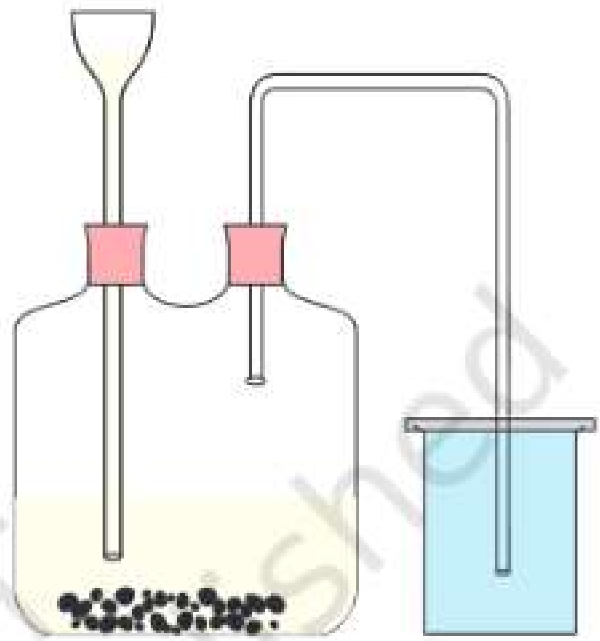

Fig. 15.1 : *Preparation of CO_2 gas in Woulfe's bottle*

OBSERVATIONS

Sl.No.	Test	Experiment	Observation	Inference
1.	Colour	Look at a gas jar filled with carbon dioxide gas.		
2.	Odour	With the help of your hand, fan the gas gently towards your nose and smell.		
3.	Solubility in water	Introduce a gas filled jar over a trough of water.		
4.	Combustibility	Introduce a lighted candle in the gas filled jar		
5.	Acidic nature	Insert a moist or wet red litmus paper in the gas filled jar.		
6.	Reaction with lime water	Take abour 5 mL of freshly prepared lime water in a test tube and pass the liberated gas from the Woulfe's bottle through lime water using a delivery tube. Excessively pass the liberated gas through the lime water.		

Results and Discussion

Infer the observations and note your inferences in observation table. On the basis of observations mention the properties of liberated gas.

Precautions

- The apparatus should be airtight.
- The lower end of the thistle funnel should be dipped in the acid taken in Woulfe's bottle otherwise carbon dioxide will escape through the thistle funnel.
- Avoid adding large quantity of acid at a time, otherwise a vigorous reaction may occur. Care should be taken while handling hydrochloric acid. It should not touch the skin.
- While collecting the gas in the jar, a piece of cardboard should be placed over the mouth of the gas jar.

Note for the Teacher

- *Preparation of lime water:* Shake about 5 g of calcium oxide, CaO, with 100 mL water. Allow it to stand for 24 hours. Decant the supernatant liquid and use it for the tests. Always use freshly prepared limewater.
- It is not necessary to set up the Woulfe's apparatus for preparing the carbon dioxide gas. This set up is needed for collecting the gas in a jar. The reaction may also be carried out in a test tube.
- In this experiment dil. H_2SO_4 may also be used in place of dil. HCl. It forms $CaSO_4$ on reacting with marble chips. In this reaction, initially CO_2 is liberated but with time a layer of $CaSO_4$ deposits on $CaCO_3$ and this will stop the reaction and no CO_2 will form.

Questions

- Why is carbon dioxide collected by upward displacement of air?
- Sulphuric acid is not used for preparing the carbon dioxide gas in the laboratory. Why?
- What happens to the burning magnesium strip when introduced in the jar filled with carbon dioxide?
- Why is lighted candle put off when inserted in the jar of carbon dioxide?

- What is the chemical name of the compound formed when carbon dioxide gas is passed through limewater?
- What is the effect of carbon dioxide gas on moist blue litmus paper?
- How can you prove that we exhale (breathe out) carbon dioxide?
- Can the reaction

  $$Ca(OH)_2\ (aq) + CO_2\ (g) \longrightarrow CaCO_3\ (s) + H_2O\ (l)$$

  be called acid-base reaction?
- What happens when excess of CO_2 is passed through lime water? Write the chemical equation for the reaction involved.
- Why can't you introduce the dil. HCl in Woulfe's bottle at a faster rate?

Experiment 16

AIM

To study the process of electrolysis.

THEORY

An electrolyte is a compound that, in solution or in the molten state, dissociate into ions and conduct an electric current. On passing an electric current from an external source, these ions migrate towards the oppositely charged electrodes. Positive ions migrate to the negative electrode and negative ions to the positive electrode and they discharge at respective electrodes. This phenomenon is called electrolysis and the container in which electrolysis occur is called electrolytic cell.

In this experiment, we take an aqueous solution of copper sulphate as an electrolyte; a strip of pure copper metal as cathode; and a strip of impure copper as an anode. When an electric current is passed through the aqueous solution of copper sulphate, copper ions (Cu^{2+}) migrate towards the pure copper strip cathode, get discharge and deposit over it. Sulphate (SO_4^{2-}) ions move towards the impure copper anode, dissolve its copper into the solution as copper ions and thus keep their concentration constant in the solution.

Materials Required

An impure thick copper metal strip, a thin pure copper metal strip, copper sulphate crystals, distilled water, dil. sulphuric acid, two dry cells with a cell holder (or a battery of 3 V or a battery eliminator), a plug key, a beaker (250 mL), a measuring cylinder (50 mL), physical balance with weight box, a small cardboard with two holes, connecting wires, and a piece of sand paper.

Procedure

1. Take a beaker to use it as an electrolyic cell.
2. Dissolve about 3 g of copper sulphate crystals in 100 mL distilled water and pour this solution in the electrolytic cell. Add to it about 1 mL of dil. sulphuric acid to make the solution acidified.
3. Clean the ends of the connecting wires using a sand paper.
4. Connect two wires with the two copper strips to be considered as positive electrode (impure copper strip) and negative electrode (pure copper strip). Pass these strips through the two holes of the cardboard(Fig. 16.1).
5. Connect the two copper strips with a combination of two dry cells (in a cell holder) through a plug key as shown in Fig. 16.1.

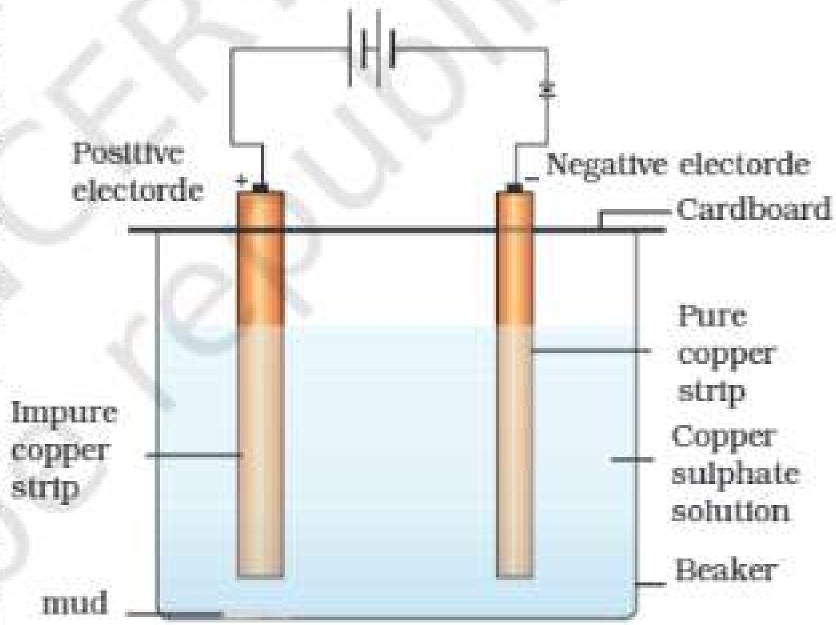

Fig. 16.1 : *An electrolysis process*

   [In place of cells a battery of 3 V or a battery eliminator may also be used.] Do not plug the key.
6. Immerse the two copper strips into the solution and cover the beaker with the cardboard.
7. Insert the key into the plug to allow the electric current to pass through the electrolytic solution.
8. Observe the electrolytic solution after sometime. Do you find any change in the thickness(es) of the two copper strips? Note your observations. If not, allow the current to flow through the electrolyte

for more time till you observe a change in the thickness of the two copper strips.

Observations

The thickeness of impure copper strip (positive electrode) decreases whereas the thickness of pure copper strip (negative electrode) increases on passing an electric current through the acidified copper sulphate for some time.

Results and Discussion

In this electrolysis process, copper ions are released from the impure copper strip (positive electrode). These ions move through the solution in the electrolytic cell towards the pure copper strip (negative electrode). Here they get discharged and deposited. That is how the thickness of impure copper strip keeps on decreasing and the thickness of pure copper strip keeps on increasing on passing the current through the electrolyte.

Discuss the role and movement of sulphate ions in the solution.

Precautions

- Copper sulphate is poisnous in nature. Handle it carefully.
- Thin strip of copper (negative electrode) should be of pure metal (why?).
- Never keep the two electrodes close to each other in the electrolytic cell. Similarly, the two electrodes should not touch the sides of the cell.

Note for the Teacher

- Instead of impure and pure copper strips, loops of copper wire can also used as two electrodes. The purpose of electrolysis is electroplating. In fact any conducting material can be used as cathode over which the copper can be deposited.
- Oxidation is also described as loss of electrons and takes place at anode for example in the reaction under discussion.

  $Cu\ (s) + SO_4^{2-}\ (aq) \longrightarrow CuSO_4\ (aq) + 2e^-$
- Reduction is gain of electrons and takes place at cathode and here it occurs in the following manner.

  $Cu^{2+} + 2e^- \longrightarrow Cu(s)$
- A little quantity of dil. sulphuric acid is added to acidify the copper sulphate solution to avoid its hydrolysis, failing which the precipitation of copper hydroxide will take place.

QUESTIONS

- What is electrolysis?
- How will you come to know that copper is deposited on cathode at the end of the experiment?
- What will happen to the impurities present in the impure copper strip (positive electrode)?
- How gold plated or silver plated articles are prepared?
- These days aluminium vessels by the name of 'anodised aluminium' are available in the market. How are these prepared?
- What is the role of electricity in the process of electrolysis.

Experiment 17

AIM

To study physical and chemical properties of acetic acid (ethanoic acid).

THEORY

Ethanoic acid (CH_3COOH) is an organic acid containing (-COOH) functional group. It has an odour of vinegar. It turns blue litmus paper red and reacts with

(a) sodium hydrogencarbonate and sodium carbonate to evolve carbon dioxide gas.

$$CH_3COOH\ (l) + NaHCO_3\ (s) \longrightarrow CH_3COONa\ (aq) + CO_2\ (g) + H_2O\ (l)$$
$$2CH_3COOH\ (l) + Na_2CO_3\ (s) \longrightarrow 2CH_3COONa\ (aq) + CO_2\ (g) + H_2O\ (l)$$

(b) sodium hydroxide to produce sodium ethanoate and water.

$$CH_3COOH + NaOH\ (aq) \longrightarrow CH_3COONa\ (aq) + H_2O.$$

MATERIALS REQUIRED

Sodium hydrogencarbonate, sodium carbonate, sodium hydroxide, phenolphthalein solution, conc. sulphuric acid, 5% ethanoic acid, blue litmus paper strips, two beakers (100 ml), four test tubes, measuring cylinder (10 mL), tripod stand, a burner, and wire gauge.

PROCEDURE

1. Study the physical and chemical properties of ethanoic acid according to the following table and record your observations.

OBSERVATIONS

Sl.No.	Test	Experiment	Observations	Inference
1.	**Physical Property**			
	Smell	Smell the sample of ethanoic acid		
(b)	Solubility test	Add 1 mL of the given sample of acid in 2 mL water.		
2.	**Chemical Porperty**			
(a)	Litmus test	Put a drop of ethanoic acid over a (i) blue litmus paper and (ii) red litmus paper		
(b)	Reaction with sodium hydrogen-carbonate	Take 1 mL of the ethanoic acid and add to it a pinch of sodium hydrogen-carbonate.		
(c)	Reaction with sodium carbonate	Take 1 mL of the ethanoic acid and add to it a pinch of sodium carbonate.		
(d)	Reaction with aqueous sodium hydroxide solution.	Take 5 mL of the ethanoic acid and add 2-3 drops of phenolph-thalein solution to it. Then add sodium hydroxide solution to the mixture drop by drop. Shake the mixture gently. Count the number of drops of sodium hydroxide needed for appearance of pink colour in the reaction mixture.		

Results and Discussion

Infer the physical properties and chemical properties on the basis of observations.

Precautions

- Handle ethanoic acid carefully.
- Add only small amount (0.01 g) of $NaHCO_3$ or Na_2CO_3 to ethanoic acid to control the intensity of CO_2 evolved.

Questions

- Which gas is evolved when ethanoic acid reacts with sodium hydrogencarbonate?
- How will you test that the liberated gas is carbon dioxide?
- How will you show that ethanoic acid is acidic in nature?
- Where do you find the use of ethanoic acid in day-to-day food products?
- What is the common name of ethanoic acid as sold in the market in the form of its dilute solution?
- What type of reaction takes place between ethanoic acid and sodium hydroxide solution?

Experiment 18

AIM

To study esterification reaction between alcohol and carboxylic acid.

THEORY

Carboxylic acid react with alcohols in presence of conc. H_2SO_4 to form esters with a loss of water molecule. For example when ethanoic acid reacts with ethanol, the ethyl ethaonate ester is formed.

$$\underset{\text{Ethanoic acid}}{CH_3COOH} + \underset{\text{Ethanol}}{CH_3CH_2OH} \xrightarrow{\text{Conc. } H_2SO_4} \underset{\text{Ethyl ethnoate}}{CH_3COOCH_2CH_3} + H_2O$$

Ester has a fruity odour which is distinct from those of carboxylic acid and alcohol.

MATERIALS REQUIRED

Ethanoic acid (3 mL), ethanol (3 mL), few drops of conc. H_2SO_4, distilled water, sodium hydrogencarbonate (1 g), thermometer (– 10°C to 110 °C), a test tube, a cork, measuring cylinder (10 mL), a beaker (250 mL), burner, tripod stand, and a wire gauge.

PROCEDURE

1. In a clean test tube take 3 mL ethanoic acid.

2. Add about 3 mL ethanol to it. Also add four to five drops of conc. H_2SO_4 to the reaction mixture. Put a cork loosely over the mouth of the test tube.
3. Take about 150 mL water in the beaker. Heat it to about 60 °C.
4. Put the test tube in the warm water. (The reaction mixture would also get heated. This is the warming of reaction mixture on a water bath.)
5. Shake the reaction mixture occassionaly.
6. Pour the reaction mixture into a beaker containing aqueous solution of sodium hydrogencarbonate. This will remove the unreacted ethanoic acid from the reaction mixture. Do you see any effervesence coming out?
7. Fan the liberated vapours of ester formed with your hand gently towards your nose and smell.
8. Feel the difference in the odours of ethanoic acid, ethanol and ester.

Results and Discussion

Comment on the difference in odours of ethanoic acid, ethanol and ester. Esters are formed when -OH of carboxylic acid are replaced by -OR (here R represent an alkyl group). In this reaction conc. H_2SO_4 is used as a catalyst.

Precautions

- Be careful while using conc. H_2SO_4.
- The organic compounds are extremely volatile and alcohol is combustible so never heat it directly on a flame. Always use water bath for heating the reaction mixture.

Note for the Teacher

- Ethanoic acid is often available as glacial acetic acid, which is 98% pure. The vinegar used at home is only approximately 2% ethanoic acid solution in water.
- The reaction mixture is poured into aqueous solution of sodium hydrogencarbonate to neutralise the unreacted acid. And Ethanol gets diluted in water. This is needed so that the smell of ester is not masked by smell of unreacted acid and alcohol.

QUESTIONS

- What will be the ester formed when propanoic acid reacts with propanol?
- What is the function of conc. sulphuric acid in this experiment?
- Will the ester formed, turn blue litmus to red?
- Name any subsatnce other than conc. H_2SO_4 that can be used as a catalyst.
- Why do you use a water bath in this experiment?

Experiment 19

AIM

To study some oxidation reactions of alcohol.

THEORY

An oxidation process involves gain of oxygen by the elements or compounds. Alcohol can be oxidised to form various products under different conditions.

1. Complete combustion: On burning alcohol (ethanol)in an excess supply of oxygen (present in air) with a flame, gives carbon dioxide and water.

   $$CH_3CH_2OH + 3O_2 \longrightarrow 2CO_2 + 3H_2O$$

2. Oxidation using an oxidising agent: alcohol on oxidation with an oxidising agent (such as alkaline potassium permanganate solution) get oxidised to a carboxylic acid.

   $$CH_3CH_2OH \xrightarrow{\text{Heat with alkaline } KMnO_4} CH_3COOH + H_2O.$$

   The completion of reaction is characterised by the decolourisation of potassium permanganate solution.

MATERIALS REQUIRED

Ethanol, 1% solution of alkaline $KMnO_4$, $NaHCO_3$, freshly prepared lime water, spirit lamp, two boiling tubes, a measuring cylinder (10 mL), a beaker (250 mL), rubber tubing, jet, a funnel, and filter paper.

PROCEDURE

1. Perform the reactions as mentioned in the Observation Table.

   For warming ethanol in a test tube (step 2), adopt the following:

   (i) Take about 150 mL water in a beaker. Heat it to about 60 °C.

   (ii) Put the test tube in the warm water. (The reaction mixture would also get heated. This is the warming of mixture on a water bath.)

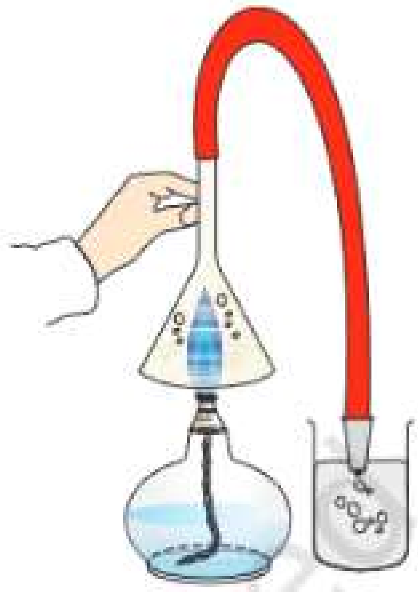

Fig. 19.1 : *Complete combustion of ethanol*

OBSERVATIONS

Sl. No.	Experiment	Observation	Inference
1.	*Complete combustion:* Take ethanol as fuel in a spirit lamp. Burn it as usual and cover the lamp with an inverted funnel (Fig. 19.1). Fix the stem of the inverted funnel with a rubber tubing which is attached to a jet on another end. Pass the evolved vapours through freshly prepared lime water. Do you observe any condensation of water vapours on the inner surface of the inverted funnel?		
2.	*Oxidation using an oxidising agent:* Take 3 mL of ethanol in a boiling tube confined to a water bath. To this add two or three drops of 1% alkaline $KMnO_4$ solution. Warm the tube till the reaction mixture decolourises. Filter it and then add a pinch of sodium hydrogen-carbonate ($NaHCO_3$).		

Results and Discussion

Infer the two oxidation reactions. Oxidation product of alcohol depends on conditions and nature of the process carried out.

Precautions

- Alcohols are extermely volatile and inflammable.
- The alkaline potassium permaganate solution should be very dilute and added dropwise only.
- Do not add potassium permangnate solution in the reaction excessively.

Note for the Teacher

- The alkaline potassium permanganate solution can be prepared by dissolving 1 pellet of KOH and 2-3 small crystals of $KMnO_4$ in 20 mL distilled water.
- If $KMnO_4$ solution is concentrated or is added in excess, the occurrence of reaction may not be observed, as it will not be decolourised.

Questions

- On adding diluted potassium permanganate solution to an alcohol, it decolourises initially and then on its excess addition, the colour of $KMnO_4$ persists. How?
- What are the species oxidised, reduced acting as an oxidising agent or as a reducing agent in the reaction.
- Why should the reaction of alcohol with potassium permaganate be considered as an oxidation reaction for an alcohol?

Experiment 20

AIM

To study saponification reaction for preparation of soap.

THEORY

Oil or fat when treated with sodium hydroxide solution, gets converted into sodium salt of fatty acid (soap) and glycerol. This reaction is known as saponification.

$$
\begin{array}{llll}
CH_2OCOC_{17}H_{35} & & CH_2OH & \\
| & & | & \\
CH\text{-}OCOC_{17}H_{35} & + \ 3NaOH\ (aq) \longrightarrow & CHOH & + \ 3\ C_{17}H_{35}COONa \\
| & \quad \text{Sodium hydroxide} & | & \quad \text{Soap} \\
CH_2OCOC_{17}H_{35} & & CH_2OH & \\
\text{Triester or Triglyceride} & & \text{Glycerol} & \\
\text{(oil or fat)} & & &
\end{array}
$$

It is an exothermic reaction, that is heat is liberated during saponification.

MATERIALS REQUIRED

Sodium hydroxide, a sample of vegetable oil such as castor oil (25 mL), common salt (about 10 g), distilled water, red and blue litmus paper strips, two beakers (250 mL), two test tubes, a glass rod, a measuring cylinder (50 mL), and a knife.

PROCEDURE

1. Take about 20 mL of castor oil (triglyceride) in a beaker (250 mL).
2. Prepare about 50 mL 20% solution of sodium hydroxide in distilled water and add 30 mL of this solution in 25 mL castor oil.
3. Successively dip the red and blue litmus paper strips into this reaction mixture. Do you find any change in colour of any litmus paper strip. Note and record your observation.
4. Touch the beaker from outside. Is it hot or cold?
5. Add 5 g to 10 g of common salt to this mixture and using a glass rod to stir the mixture continuosly till the soap begins to set.
6. Leave it for a day till the mixture cools and becomes solid.
7. Remove the soap cake and cut it into desired shapes and sizes.

OBSERVATIONS

(i) The colour of red litmus paper (when dipped into mixture) turns __________, while the colour of blue litmus paper becomes _________

(ii) The temperature of reaction mixture on adding sodium hydroxide with oil ____________ (increases/decreases).

RESULTS AND DISCUSSION

On the basis of your observations with litmus paper, ascertain the medium of soap solution is (acidic/basic). Also comment whether the saponification reaction is exothermic or endothermic.

The saponification reaction suggests the formation of glycerol alongwith the soap which is present as a separate product.

Soap is salt of fatty acid and its precipitation is governed just like the precipitation of any other salt.

PRECAUTIONS

- Stir the soap solution carefully so that it does not spill out.

NOTE FOR THE TEACHER

- If castor oil is not available, any other edible oil may be taken.
- For commercial preparation of soap certain additives like colour, perfume, fillers are added. Fillers harden the soap and make the cutting of the soap easy.
- Common salt is used to favour precipitation of soap.

- Notice that in a saponification reaction, glycerol (commonly known gas glycerine) may be obtained as a by product.

Questions

- Why does a red litmus paper changes its colour when dipped in soap solution? Explain your observation.
- Why is it advised to add common salt while preparing the soap?
- Can we use Na_2CO_3 instead of NaOH? Explain.
- Was heat evolved or absorbed when sodium hydroxide was added to oil?
- What is the chemical reaction involved in the manufacture of soap?
- Can you devise a method to separate glycerine from the reaction mixture?