UNIT I
Materials

Experiment 1

AIM

To study the chemical reaction of an iron nail with aqueous copper sulphate solution; and to study the burning of magnesium ribbon in air.

(a) Chemical reaction of iron nail with copper sulphate solution in water.

THEORY

Iron displaces copper ions from an aqueous solution of copper sulphate. It is a single displacement reaction of one metal by another metal. Iron is placed above copper in the activity series. Elements placed above in this series are more reactive than those placed below them. Thus iron is more reactive than copper. In this reaction, metallic iron is converted into ferrous ion (Fe^{2+}) and cupric ion (Cu^{2+}) is converted into metallic copper.

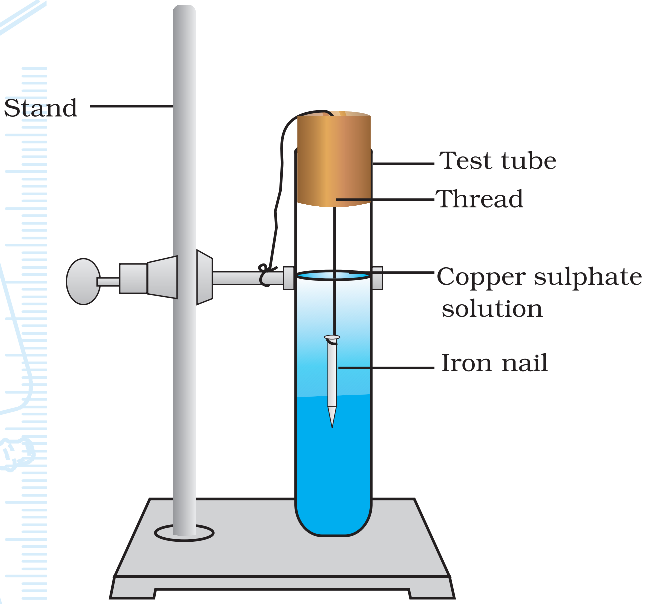
$$Fe\ (s) + Cu^{2+}\ (aq) \longrightarrow Fe^{2+}\ (aq) + Cu\ (s).$$

MATERIALS REQUIRED

Two test tubes, two iron nails, measuring cylinder (50 mL), laboratory stand with clamp, test tube stand, thread, a piece of sand paper, single bored cork, copper sulphate, distilled water, and dil. sulphuric acid,

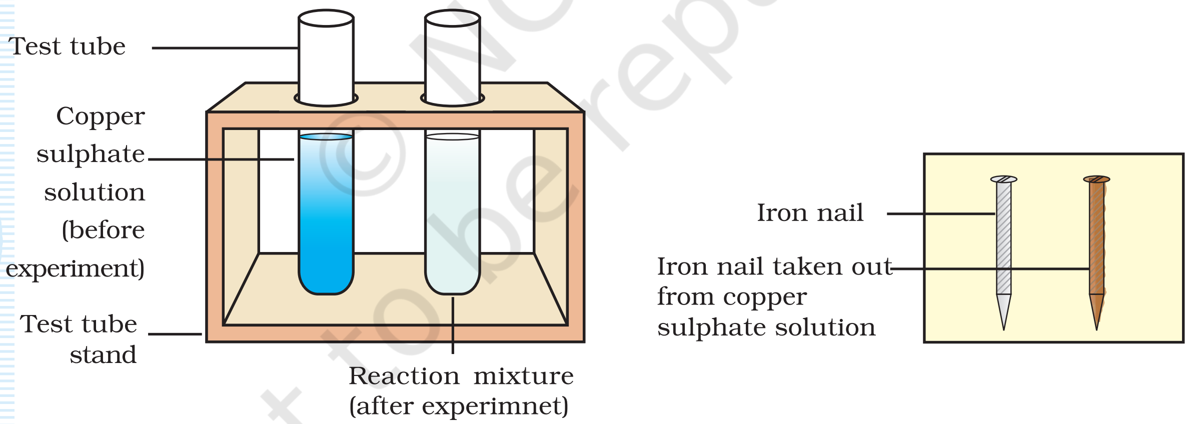
PROCEDURE

1. Take two iron nails and clean them with a sand paper.



(a)

2. Take 20 mL of distilled water in a clean test tube and dissolve 1.0 g of copper sulphate in it. Add 2 or 3 drops of dil. sulphuric acid to it to check hydrolysis of $CuSO_4$ in water. Label this test tube as A.
3. Transfer about 10 mL of copper sulphate solution from tube A to another clean test tube. Label this test tube as B.
4. Tie one iron nail with a thread and immerse it carefully in copper sulphate solution in test tube B through a bored cork [as shown in the Fig 1.1(a)] for about 15 minutes [Fig. 1.1(a)]. Keep the another iron nail separately for comparison afterwards.
5. After 15 minutes take out the iron nail from the copper sulphate solution.



(b) *(c)*

Fig. 1.1 : *(a) Iron nail dipped in copper sulphate solution; and (b) Iron nails and copper sulphate solutions are compared*

6. Compare the intensity of blue colour of copper sulphate solution before and after the experiment in tubes A and B, and also compare the colour of iron nail dipped in copper sulphate solution with the one kept separately [Fig. 1.1(b) and (c)]. Record your observations.

Observations

Sl.No.	Property	Before experiment	After experiment
1.	Colour of copper sulphate solution		
2.	Colour of iron nail		

Results and Discussion

Infer from your observations about the changes in colours of copper sulphate solution and iron nail. Discuss the reason(s).

Precautions

- The iron nails must be cleaned properly by using sand paper before dipping them in copper sulphate solution.

Questions

- Why does the colour of copper sulphate solution change, when an iron nail is dipped in it?
- How would you devise the procedure to show that Mg > Fe > Cu in reactivity series?
- What is the basic principle involved in this experiment?
- Why does the following reaction takes place?

$$2I^- (aq) + Cl_2 (aq) \xrightarrow{CCl_4} 2Cl^- (aq) + I_2 \text{ (solvated)}$$

(b) Chemical reaction of burning of magnesium ribbon in air.

Theory

Magnesium forms magnesium oxide on burning in presence of air. It is a combination reaction between two elements. Magnesium oxide is basic in nature and thus its aqueous solution turns red litmus blue.

$$2Mg (s) + O_2 (g) \longrightarrow 2MgO (s)$$

MATERIALS REQUIRED

Magnesium ribbon (2 to 3 cm long), a pair of tongs, burner, a pair of dark coloured goggles, watch glass, red and blue litmus papers, distilled water, beaker, and a piece of sand paper.

PROCEDURE

1. Take a magnesium ribbon (2 to 3 cm long) and clean it with a sand paper. This will remove the oxide layer deposited over the magnesium ribbon, which makes it passive.
2. Hold the magnesium ribbon with a pair of tongs over a watch glass and burn it in air with a burner (Fig. 1.2). Watch the burning of magnesium ribbon using a pair of dark coloured goggles.

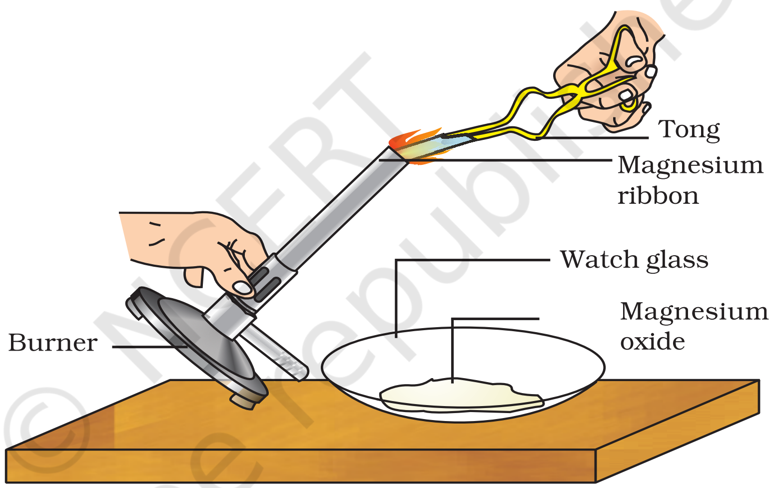


Fig. 1.2 : *Burning of magnesium ribbon and collection of magnesium oxide on a watch glass*

3. Collect the white powder obtained on a watch glass.
4. Transfer and mix the white powder in a beaker containing a little amount of distilled water.
5. Put drops of this mixture over the red and blue litmus papers and record your observations.

OBSERVATIONS

On putting a drop of mixture over the red litmus paper, colour of red litmus paper changes into _____ .

On putting a drop of mixture over the blue litmus paper, colour of blue litmus paper changes into _____ .

Results and Discussion

The change in the colour of ____ litmus paper into _____ suggests that the aqueous solution of magnesium oxide is ________ in nature.

Preacautions

- Clean the magnesium ribbon carefully to remove the deposited oxide layer on it.
- Burn the magnesium ribbon keeping it away from your eyes as far as possible and use dark coloured goggles to see dazzling light emitted during burning of magnesium. (Why?)
- Collect magnesium oxide powder carefully so that it does not touch your skin.

Note for the Teacher

- Oxides on account of their interacting capability with water are classified as acidic, basic and neutral oxides.
- Magnesium oxide (MgO) dissolves in water to form magnesium hydroxide $Mg(OH)_2$ (aq) which is a strong base.

  $MgO\ (s) + H_2O\ (l) \longrightarrow Mg\ (OH)_2\ (aq)$

  Here the reaction is:

  $O^{2-}\ (s) + H_2O\ (l) \longrightarrow 2OH^-\ (aq).$
- It is advised to tilt the burner in order to collect the magnesium oxide (product).

Questions

- Why should magnesium ribbon be cleaned before burning it in air?
- Which reaction that takes place when magnesium burns in air? Why is it called a combination reaction?
- Why does the red litmus paper turn blue when touched with aqueous solution of magnesium oxide?
- What is the total electron content of the species Mg^{2+} and O^{2-}? Name 5 more such species?
- Is there a possibility of a compound other than MgO formed in the above reaction?
- Is there any similarity between compounds LiH, MgO, and K_2S?
- Why is it suggested to wear dark coloured goggles while watching the burning of magnesium ribbon in air?

Experiment 2

AIM

To study the following chemical reactions: (a) zinc with sulphuric acid; (b) precipitation reaction between aqueous solution of barium chloride and aqueous solution of sodium sulphate; and (c) thermal decomposition of ammonium chloride in an open container.

(a) Chemical reaction of zinc with sulphuric acid.

THEORY

Zinc metal reacts with dil. sulphuric acid and produces hydrogen gas.

$$Zn\ (s) + H_2SO_4\ (aq) \longrightarrow ZnSO_4\ (aq) + H_2\ (g)$$

This is an example of a single displacement reaction of a non-metal by a metal.

MATERIALS REQUIRED

Zinc metal granules, dil. sulphuric acid, red and blue litmus papers, test tube, and candle.

PROCEDURE

1. Take few zinc granules in a test tube.
2. Add about 10 mL of dil. sulphuric acid to zinc granule. Effervescence

comes out from the reaction mixture, as shown in Fig. 2.1.

3. Perform the tests as given in the observation table and record your observations.

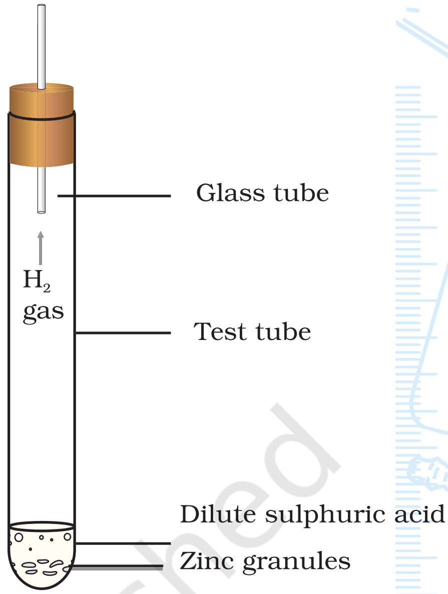


Fig. 2.1 : *Reaction of zinc granules with dil. sulphuric acid*

Observations

Sl. No.	Test	Activity	Observations
1.	Colour	Look at the colour of the gas liberated	
2.	Smell	Fan the gas gently towards your nose with your hand	
3.	Litmus test	Bring moist blue and red litmus papers near to the mouth of the test tube	
4.	Combustion test	Bring a lighted candle near to the mouth of the test tube	

Results and Discussion

Infer from the observations about the nature of the gas liberated. Is it acidic or basic or neutral? Does it burn in air (or ignites exothermically) to produce water?

Precautions

- Clean zinc granules should be used.
- Care should be taken while pouring the dil. sulphuric acid in the test tube and performing combustion test.

Note for the Teacher

- The combustion test must be performed very carefully. It is advised that this test may first be demonstrated in the laboratory.

Questions

- Write the chemical reaction of zinc with dil. sulphuric acid.
- How does the combustion of hydrogen gas produce water?
- How will you show that the hydrogen gas is neutral in behaviour?
- What are the others metals among the species Mg, Al, Fe, Sn, Pb, Cu, Ag metals which react with dil. sulphuric acid to produce hydrogen gas?
- Which of the above metal(s) would not evolve hydrogen gas from dilute hydrochloric acid?

(b) Precipitation reation between aqueous solution of barium chloride with aqueous solution of sodium sulphate.

Theory

When a solution of sodium sulphate is mixed with a solution of barium chloride, the following double displacement reaction takes place:

$$Na_2SO_4\ (aq) + BaCl_2\ (aq) \longrightarrow BaSO_4\ (s) + 2NaCl\ (aq)$$

In this reaction, sulphate ions (SO_4^{2-}) from sodium sulphate are displaced by chloride ions (Cl-) and chloride ions in barium chloride are displaced by sulphate ions. As a result, a white precipitate of barium sulphate is formed and sodium chloride remains in the solution.

Materials Required

Two test tubes, a small measuring cylinder (50 mL), aqueous solution of sodium sulphate, aqueous solution of barium chloride.

Procedure

1. Take 3 mL of sodium sulphate solution in a test tube and label it as A.
2. In another test tube, take 3 mL of barium chloride and label it as B.

3. Transfer the solution from test tube A to the test tube B.
4. Mix the two solutions with gentle shaking.
5. Observe the changes in colours of the solutions as per the steps given in observation table below.

Observations

Sl.No.	Experiment	Observations
1.	Observe the colour of the two solutions in test tubes A and B before mixing them,	
2.	Mix the two solutions and leave the mixture undisturbed for some time. Does anything precipitates in the test tube? If so, what is the colour of it?	

Results and Discussion

Confirm whether you have obtained a white precipitate of barium sulphate in the test tube. Does it suggests that the substances which produce ions in water result into precipitation reaction under favourable condition?

Note for the Teacher

- The aqueous solutions of barium chloride and sodium sulphate can be prepared by dissolving 6.1 g $BaCl_2.2H_2O$ and 3.2 g of $Na_2SO_4.10H_2O$ in water and then diluting them to 100 mL separately.

Questions

- Fill in the blanks:

  (a) Sodium sulphate and barium chloride are _______ (ionic/ covalent) compounds.

(b) As the white precipitate of barium sulphate is formed __________ (immediately/sometime after mixing the two solutions), the reaction between __________ (ionic/ covalent) compounds is _____________ (instantaneous/ slow).

- What may happen on mixing $Pb(NO_3)_2$ and KCl solutions? Predict (you may try to experimentally verify).
- What are the industrial applications of the type of the reaction being studied?
- Why do the persons suffering from the ailment of stone formation advised not to take too much milk and tomato juice?

(c) Thermal decomposition of ammonium chloride in an open container.

Theory

Ammonium chloride on heating in an open container is decomposedinto hydrogen chloride and produces ammonia gas. This is an example of decomposition reaction.

$$NH_4Cl\,(s) \xrightarrow{\text{Heat}} NH_3\,(g) + HCl\,(g)$$

Materials Required

Ammonium chloride, Nessler's reagent $K_2[HgI_4]$, blue litmus paper, laboratory stand with clamp, tripod stand, burner, china dish, wire gauge, and a funnel.

Procedure

1. Take about 5 g of ammonium chloride in a clean and dry china dish.
2. Place the china dish on a wire gauge and keep it on a tripod stand.
3. Place an inverted clean and dry funnel over the china dish containing the sample.
4. Heat the china dish containing the sample of ammonium chloride (Fig. 2.2).
5. Vapours are formed that come out from the stem of the funnel. Check whether any liquid is produced in the china dish?

6. Bring a strip of filter paper dipped in Nessler's reagent $K_2[HgI_4]$ near the tip of funnel. Observe the change in the colour of the filter paper.
7. Bring a wet blue litmus paper near the tip of the funnel. Observe the change in its colour.

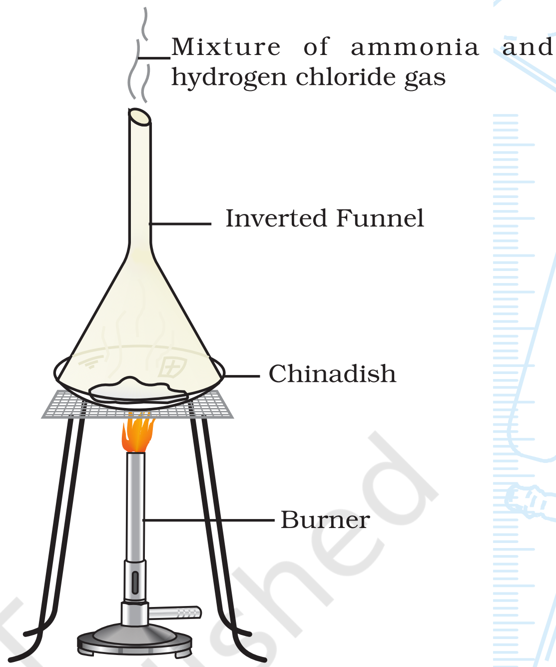


Fig. 2.2 : *Heating of ammonium chloride in an open container*

OBSERVATIONS

Sl. No.	Experiment	Observations	Inference
1.	Nessler's reagent test		
2.	Litmus paper test		

RESULTS AND DISCUSSION

Infer from the observations from the Nessler's reagent test and litmus paper test on the vapours evolving from the funnel for the presence of ammonia and hydrogen chloride gases respectively. Now conclude that ammonium chloride when heated in open system, decomposes to give ammonia and hydrogen chloride gases.

PRECAUTIONS

- The heating must be stopped when most of the ammonium chloride is decomposed.

Note for the Teacher

- If this reaction takes place in a closed container, the hydrogen chloride and ammonia gases cannot escape. (This reaction can be performed by tightly plugging the top of the stem of the funnel by cotton.) These gases then recombine to form ammonium chloride (NH_4Cl).

  $$NH_3\ (g) + HCl\ (g) \xrightarrow{\text{Cool}} NH_4Cl\ (s)$$

  Thus, an equilibrium exists between ammonium chloride, ammonia and hydrogen chloride in a closed container.

  In this reaction, solid ammonium chloride is converted directly into gaseous state without changing into liquid. It is thus sublimation reaction.

- *Preparation of Nessler's Reagent* : Dissolve 10 g of potassium iodide in 10 mL water (solution A). Dissolve 6 g mercury(II) chloride in 100 mL water (solution B). Dissolve 45 g potassium hydroxide in water and dilute to 80 mL (solution C). Add solution B to solution A dropwise, until a slight permanent precipitate is formed. Add solution C to it, mix and dilute with water to 200 mL. Allow it to stand overnight and decant the clear solution.

Questions

- What gases are liberated on heating ammonium chloride?
- How will you distinguish between hydrogen chloride and ammonia gases in a laboratory?
- Can you think of decomposing water into its elemental components H_2 and O_2, using this method?
- How does the decomposition reaction

  $$2Pb(NO_3)_2 \xrightarrow{\text{Heat}} 2PbO\ (s) + 4\ NO_2\ (g) + O_2\ (g)$$

  differ from the one being discussed in this experiment?
- Limestone decomposes thermally into quick lime. What is the industrial importance of this chemical reaction?
- On thermal decomposition, ammonium chloride produces a mixture of ammonia gas (basic) and hydrogen chloride gas (acidic). This gas mixture does not show neutral behaviour in litmus test. Why?

Experiment 3

AIM

To measure the change in temperature during chemical reactions and to conclude whether the reaction is exothermic or endothermic.

THEORY

Most of the chemical reactions are accompanied by energy changes. In some reactions, energy is absorbed while in some energy is released in the form of heat. The chemical reactions in which energy is absorbed are called endothermic reactions and those in which energy is released are known as exothermic reactions. The reaction can be identified as exothermic or endothermic by measuring the change in temperature of the reaction mixture.

In this experiment the following chemical reactions can be carried out:

(i) $NaOH\ (aq) + HCl\ (g) \longrightarrow NaCl\ (g) + H_2O\ (l)$; and

(ii) $Ba(OH)_2.8H_2O\ (s) + 2NH_4Cl\ (s) \longrightarrow BaCl_2\ (aq) + 10H_2O\ (l) + 2NH_3\ (aq)$

MATERIALS REQUIRED

Sodium hydroxide solution, hydrochloric acid, ammonium chloride (solid) and barium hydroxide (solid), weighing balance, watch glass, four beakers (100 mL), a thermometer (–10 ºC to 110 ºC), and a glass rod.

PROCEDURE

1. Mark all the four clean beakers as 1, 2, 3, and 4.
2. Take 20 mL of sodium hydroxide solution in beaker no. 1; 20 mL of hydrochloric acid in beaker no. 2; 15.75 g of barium hydroxide in beaker no. 3, and 5.35 g of ammonium chloride in beaker no. 4.
3. Successively insert a thermometer in each beaker for some time and record their temperatures. Also record the room temperature.
4. To see the reaction of sodium hydroxide solution with hydrochloric acid, pour the contents of beaker no. 1 in beaker no. 2. Quickly insert the thermometer in the reaction mixture. Note and record its initial temperature reading. Stir well the reaction mixture gently using a glass rod. Note and record the final temperature reading of the thermometer. Wash the thermometer and glass rod after noting the readings.
5. Similarly, to see the reaction of barium hydroxide solution with ammonium chloride, pour the contents of beaker no. 3 in beaker no. 4. Quickly insert the thermometer in this reaction mixture. Note and record the initial temperature. Stir well the reaction mixture gently using the glass rod. Note and record the final temperature readings of the thermometer.

OBSERVATIONS AND CALCULATIONS

(i) Temperature of the sodium hydroxide solution = ___ °C =___ K
(ii) Temperature of the hydrochloric acid = ___ °C =___ K
(iii) Temperature of the barium hydroxide solution = ___ °C =___ K
(iv) Temperature of the ammonium chloride = ___ °C =___ K
(v) Room temperature = ___ °C =___ K

Sl. No.	Reactants of the reaction	Inital temperature of the reaction mixture	Final temperature of the reaction mixture	Change in temperature
		‾N= (°C)	‾O= (°C)	‾O=~ ‾N= (°C)
1.	NaOH + HCl			
2.	$Ba(OH)_2.8H_2O + 2NH_4Cl$			

Results and Discussion

Based on your observations for the change in tempearture in two reactions, infer about the nature of the two chemical reactions (exothermic or endothermic).

The reaction between sodium hydroxide solution and hydrochloride acid is ____________________ ; and the reaction between barium hydroxide solution and ammonium chloride is ____________________ (exothermic or endothermic).

Precautions

- Stir the reaction mixture very gently so that there is no heat loss during stirring.
- Wash the thermometer and glass rod with water before inserting it in another reactant or reaction mixture.

Questions

- The reaction between HCl and NaOH in its simplified version is

  H^+ (aq) + OH^- (aq) $\longrightarrow$ H_2O (l)

  (from acid) (from base)

  Can you assign a plausible explanation as to why the reaction should be exothermic?
- Consider the changes;

  $2HCl\ (g) \longrightarrow H_2\ (g) + Cl_2\ (g)$;

  $2Mg\ (s) + O_2\ (g) \longrightarrow 2MgO\ (s)$.

  Which according to you is exothermic change?
- What precautions did you take while measuring the temperature of a reaction mixture?

Experiment 4

Aim

To study the reactions of hydrochloric acid with zinc metal, sodium carbonate, and sodium hydroxide.

Theory

An acid (HCl) reacts (i) with zinc metal to produce hydrogen gas, (ii) with carbonates and hydrogen carbonates to form carbon dioxide gas, and (iii) with sodium hydroxide (base) to neutralise and to produce sodium chloride (salt) and water.

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

$$Na_2CO_3\ (s) + 2HCl\ (aq) \longrightarrow 2NaCl\ (aq) + H_2O\ (l) + CO_2\ (g)$$

$$NaOH\ (aq) + HCl\ (aq) \longrightarrow NaCl\ (aq) + H_2O\ (l)$$

Materials Required

Zinc metal granules, dil. hydrochloric acid, sodium carbonate, sodium hydroxide solution, freshly prepared lime water, red and blue litmus papers, distilled water, four test tubes, a delivery tube, single bore cork to be fixed on a test tube, and a piece of sand paper.

Procedure

(i) *Reaction with Zinc Metal*

1. Take a clean zinc granule in a clean and dry test tube.

2. Put about 5 mL of dil. hydrochloric acid into it.
3. Effervescence will come out from the reaction mixture.
4. Successively bring wet blue and red litmus papers to the mouth of the test tube. Note and record the observation.

Observations

Sl.No.	Experiment	Observations	Inference
1.	Litmus test: Action on red litmus Action on blue litmus		

(ii) *Reaction with Sodium Carbonate*

1. Take about 1 g of sodium carbonate in a clean and dry test tube.
2. Add about 2 mL of dil. hydrochloric acid to it.
3, Effervescence will start coming from the reaction mixture.
4. Fix a delivery tube through a cork to the mouth of the test tube and pass the liberated gas through the freshly prepared lime water (Fig. 4.1). Observe what happens? Do you see bubbles of it in lime water? Does it turn milky? If yes, it shows the presence of carbon dioxide.

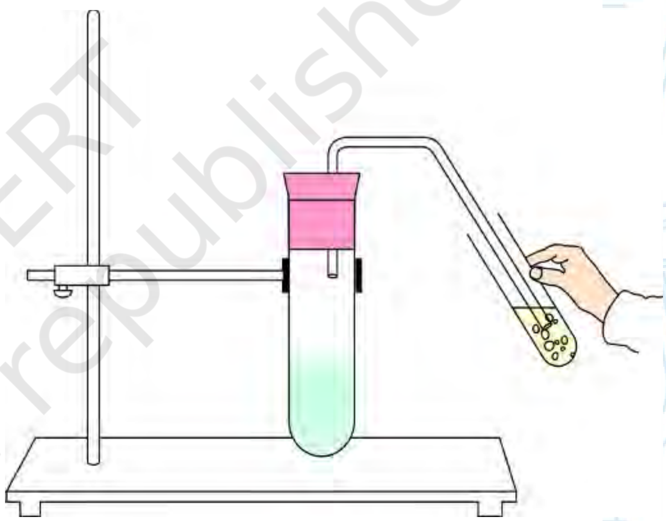


Fig. 4.1 : *Passing of liberated gas through the freshly prepared lime water*

Observations

Sl. No.	Experiment	Observations	Inference
1.	Lime water test		

(iii) *Reaction with Sodium Hydroxide*

1. Take about 5 mL dil. hydrochloric acid in a test tube and label it as A.
2. Similarly, take 5 mL of 10% sodium hydroxide solution in another test tube and label it as B.

3. Dip a blue litmus paper in test tube A containing dil. HCl. What do you see? Do you find the the blue litmus paper turns red.
4. Similarly, dip a red litmus paper in test tube B. Does it turn blue now?
5. Add dil. HCl from test tube A dropwise to dil. NaOH contained in test tube B.
6. Shake the mixture slowly but continously and observe the change by dipping litmus paper in the test tube B. (Which litmus paper will you use for this purpose?)
7. Keep on adding the dil. HCl from test tube A to 10% NaOH in test tube B dropwise till the reaction mixture in test tube B becomes neutral to litmus paper. Ascertain the neutrality of this mixture by successive dipping red and blue litmus papers.
8. Touch the test tube and feel the temperature. Do you find it warm or cold? What does that mean?

OBSERVATIONS

Sl. No.	Activity	Observations	Inference
1.	**Litmus Paper Test** *In the beginning of experiment:* Dip blue litmus paper in test tube A Dip red litmus paper in test tube B After adding n drops of dil. HCl from test tube A in dil. NaOH in test tube B *(i) n = ___ ; action on red litmus paper* *action on blue litmus paper* *(ii) n = ___ ; action on red litmus paper* *action on blue litmus paper* *(iii) n = ___ ; action on red litmus paper* *action on blue litmus paper* *(iv) n = ___ ; action on red litmus paper* *action on blue litmus paper* *...__ n = ___ ; action on red litmus paper* *action on blue litmus paper*	 *No change* *No change*	 *The solution in test tube B is neutralised*
2.	**Thermal Change** After the completion of litmus test, touch the test tube B from outside Heat absorbed/evolved during the reaction	Cold/Warm	Reaction is endothermic/ exothermic

Results and Discussion

State and discuss the performance of each test in all reactions performed in this experiment.

Precautions

- Always carry out the test for hydrogen with a very small volume of gas.
- Handle hydrochloric acid and sodium hydroxide solutions very carefully.
- Shake the solutions and reaction mixtures carefully without spilling.
- Care must be taken while performing the combustion test.

Note for the Teacher

- *Preparation of lime water*: Shake 5 g calcium hydroxide $Ca(OH)_2$, with 100 mL water. Allow it to stand for about 24 hours. Decant the supernatant liquid and use it for the tests. It is suggested to always use freshly prepared limewater.

Questions

- What will be the colour of a blue litmus paper on bringing it in contact with a drop of dil. hydrochloric acid?
- Explain why hydrogen gas is not collected by the downward displacement of air?
- What will happen to a lighted candle if it is brought near the mouth of a gas jar containing hydrogen gas?
- Which gas is produced when zinc metal reacts with hydrochloric acid?
- Which gas is liberated when sodium carbonate reacts with hydrochloric acid?
- Hydrogen gas is neutral to litmus paper. Explain how?
- What is the utility of the reaction between $NaHCO_3$ and HCl in daily life situation?
- How can the deposits of carbonates and hydrogencarbonates on the metal surface be cleaned?

Experiment 5

Aim

To study the reactions of sodium hydroxide with aluminum metal and hydrochloric acid.

Theory

Sodium hydroxide is a base. It reacts with aluminium metal to produce hydrogen gas. It also neutalises the hydrochloric acid to produce sodium chloride salt and water.

$$2NaOH\ (aq) + 2Al\ (s) + 2H_2O\ (l) \longrightarrow 2NaAlO_2\ (aq) + H_2\ (g)$$

$$NaOH\ (aq) + HCl\ (aq) \longrightarrow NaCl\ (aq) + H_2O\ (l)$$

Materials Required

Dil. hydrochloric acid, sodium hydroxide solution, some pieces of aluminium metal, red and blue litmus papers, a small measuring cylinder (100 mL), three test tube, and a candle.

Procedure

(i) *Reaction with Aluminium Metal*

1. Take a small piece of aluminium metal and place it in a clean and dry test tube.

2. Add about 5 mL sodium hydroxide solution in it.
3. Observe the effervescence coming out from the reaction mixture. Look at the colour of the gas liberated.
4. Perform the smell test on the gas liberated by fanning the gas gently towards your nose.
5. Bring moist blue and red litmus papers to the mouth of the test tube.
6. Perform combustion test by bringing a lighted candle near to the mouth of the test tube. Does the liberated gas ignites exothermically to produce water?

OBSERVATIONS

(i) *Reaction with Aluminium Metal*

Sl. No.	Test	Experiment	Observations	Inference
1.	Colour	Look at the colour of the gas liberated		
2.	Smell	Fan the gas gently towards your nose with your hand		
3.	Litmus test	Bring moist blue and red litmus papers near to the mouth of the test tube		
4.	Combustion test	Bring a lighted candle near to the mouth of the test tube		

(ii) *Reaction with hydrochloric acid*

The experiment should be carried out as done in Experiment 4.

RESULTS AND DISCUSSION

State and discuss the performance of each test in all reactions performed in this experiment.

PRECAUTIONS

- Always carry out the test for hydrogen with a very small volume of gas.
- Handle hydrochloric acid and sodium hydroxide solutions very carefully.
- Shake the solutions and reaction mixtures carefully without spilling.
- Care must be taken while performing the combustion test.

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QUESTIONS

- What will be the colour of a blue litmus paper on bringing it in contact with a drop of dil. NaOH?
- Explain why hydrogen gas is not collected by the downward displacement of air?
- What will happen to a lighted candle if it is brought near the mouth of a gas jar containing hydrogen gas?
- Which gas is produced when aluminium metal reacts with sodium hydroxide?
- Hydrogen gas is neutral to litmus paper. Explain how?
- What are the metals (other than Al) which react with alkalies to produce hydrogen gas? What are these metals called?

Experiment 6

AIM

To show that acids, bases, and salts are electrolytes.

THEORY

An electrolyte is a compound that, in solution or in the molten state, conducts an electric current and is simultaneously decomposed by it. The current in electrolytes is carried by the ions and not by the electrons as in metals. Electrolytes may be acid, bases, or salts. In this experiment we shall observe it by means of continuity test in an electric circuit that contains either an acid or a base or a salt solution as a part of it.

MATERIALS REQUIRED

Hydrochloric acid (about 5 mL), sodium hydroxide flakes (about 100 mg), sodium chloride (about 5 g), distilled water, four beakers (250 mL), four dry cells of 1.5 V each with a cell holder (or a battery of 6 V or a battery eliminator), a torch bulb of 6 V with a torch bulb holder, a rubber cork, two iron nails, a plug key, connecting wires, and a piece of sand paper.

PROCEDURE

1. Using a sand paper, clean the insulation layers from the ends of connecting wires.

2. Take a dry rubber cork and fix two iron nails in it at a distance. The two nails will work as two electrodes. Also connect these two nails, separately, with connecting wires.
3. Draw a circuit diagram for performing a continuity test in an clectric circuit that contains either an acid or a base or a salt solution as a part of it (see Fig. 6.1). Observe how different components like the dry cells (or battery or battery eliminator), torch bulb, a plug key, and the solution are connected in the circuit.
4. Take nearly 100 mL distilled water in each of the four beakers (250 mL). Label them as beakers A, B, C, and D respectively.
5. Add about five drops of hydrochloric acid in distilled water in beaker A to get an acidic solution; add about 100 mg flakes of sodium hydroxide in beaker B to get a basic solution; and add about 2 - 3 g of sodium chloride salt (about half a teaspoon) in water in beaker C to get a sodium chloride salt solution. Do not add anything in the distilled water in beaker D.

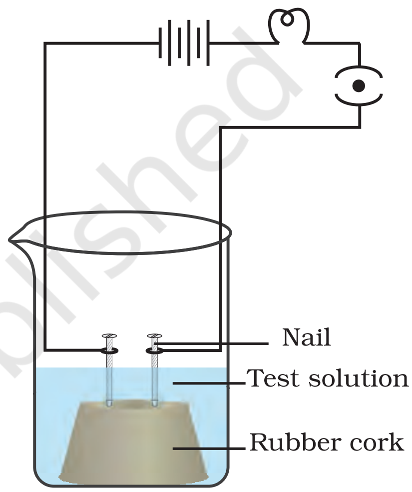


Fig. 6.1 : *Continuity test through an electrolyte*

6. Set up the electric circuit by connecting different components with the help of connecting wires. Do not dip the rubber cork (in which two iron nails are fixed and connected in the circuit) in any beaker. Insert the key into the plug. Check whether the torch bulb glows. It does not. Does it mean that the electric circuit is yet not complete or the dry rubber cork does not conduct electricity? Remove the key from the plug.
7. For observing the continuity test through the dil. hydrochloric acid (say), place the rubber cork in the beaker A such that the two iron nails are partially dipped in the solution.
8. Insert the key in the plug and allow the current to flow in the circuit containing dil. hydrochloric acid solution as a component. Does the bulb glow now? Yes, it glows. It means that the electric circuit is now complete and that the hydrochloric acid conducts electricity. Thus it is an electrolyte. Record your observation.

9. Remove the key and take out the rubber cork from the beaker A. Wash the rubber cork and make it dry using a clean cloth.
10. Repeat the experiment for the continuity test through the dil. sodium hydroxide solution, sodium chloride solution, and distilled water by successively dipping the rubber cork in beakers B, C, and D respectively.

OBSERVATIONS

Sl.No.	Experiment	Observations	Inference
	Electric continuity test through		
1.	Beaker A: dil. hydrochloric acid solution	Bulb glows or not?	
2.	Beaker B: dil. sodium hydroxide solution	Bulb glows or not?	
3.	Beaker C: sodium chloride solution	Bulb glows or not?	
4.	Beaker D: distilled water	Bulb glows or not?	

RESULTS AND DISCUSSION

Infer from the observations that acids, bases and salts are electrolytes. Discuss the following dissociation reactions:

$$HCl\ (aq) \longrightarrow H^{+}\ (aq) + Cl^{-}\ (aq)$$
$$NaOH\ (aq) \longrightarrow Na^{+}\ (aq) + OH^{-}\ (aq)$$
$$NaCl\ (aq) \longrightarrow Na^{+}\ (aq) + Cl^{-}\ (aq).$$

PRECAUTIONS

- The ends of the connecting wires must be cleaned and connected tightly with the other components of the circuit.
- The acidic concentration in the distilled water must be highly dilute otherwise the nails will start reacting with the acid.
- The nails must be partially dipped inside the liquid while performing electric continuity test.
- The rubber cork must be washed and dried after every test and before dipping it in another liquid solution.

Note for the Teacher

- In place of four cells of 1.5 V each, a 6 V battery or a battery eliminator may also be used. Please make sure that if a 6 V source is used in the circuit, a torch bulb of 6 V must be used. This experiment can also be performed with 3 V source preferably with a 3 V torch bulb.
- In place of a torch bulb, a galvanometer or an ammeter (0 - 3 A) may also be used to perform the continuity test. Please also connect a resistor of about 1 or 2 W resistance in series with the galvanometer or ammeter.
- Experiment Nos. 48 to 51, involve observations with electric circuits. It is advised that students may be suggested to perform any of these experiments before performing this experiment.
- In place of hydrochloric acid solution, sulphuric acid solution may also be used.

Questions

- Though sodium chloride and potassium chloride crystals are composed of ions. Why do they not conduct electricity?
- How does an alcoholic solution of potassium hydroxide conduct electricity?
- How does the hydrochloric acid solution proves to be a better conductor of electricity than acetic acid solution (CH_3COOH)?
- Which substance is used as an electrolyte in lead storage battery and which one in dry cells.
- What are the current carriers in electrolytes?

Experiment 7

AIM

To find the pH of the given samples of solutions of solids or fruit juices using pH paper.

THEORY

The pH is the measure of the acidic (or basic) power of a solution. It is a scale for measuring hydrogen ion concertration in a solution. The pH scale varies from 0 to 14. At 25 °C (298 K), a neutral solution has pH equal to 7. A value less than 7 on the pH scale represents an acidic solution. Where as pH value more than 7 represents basic solution. Generally a paper impregnated with the universal indicator is used for finding the approximate pH value. It shows different colour at different pH [Fig. 7.1(b)].

MATERIALS REQUIRED

Test solutions of samples (a) a dilute acid (HCl or H_2SO_4 or CH_3COOH etc.); (b) a dilute base (NaOH or KOH); (c) a salt (such as NaCl, Na_2CO_3, NH_4Cl etc.;1 g salt in 10 mL distilled water); (d) soil water extract (dissolve 1 g of soil sample in 10 mL distilled water and filter to get a soil water extract); and (e) a fruit juice, five test tubes and a test tube stand, a measuring cylinder (10 mL), pH papers, and a glass rod.

PROCEDURE

1. Place five clean test tubes in a test tube stand.
2. Take the solutions of a dilute acid (say HCl), dilute base (say NaOH), salt (say NaCl), soil, and a fruit juice separately in five test tubes and label them.
3. Put one or two drops of each test solution on different strips of pH papers, using a glass rod [Fig. 7.1(a)]. Glass rod used for one sample must be washed with water before used for the other sample.

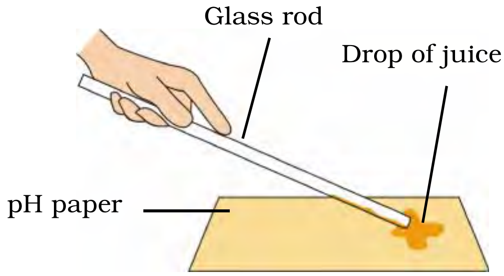


Fig. 7.1 : *(a) Testing the pH of a sample by putting a drop on pH paper by glass rod*

4. Note the pH by comparing the colour appeared on the pH paper with those on colour chart for pH paper [Fig. 7.1(b)].
5. For determining the pH of a fruit juice, squeeze the fruit and place 1 or 2 drop of the juice on the pH paper.

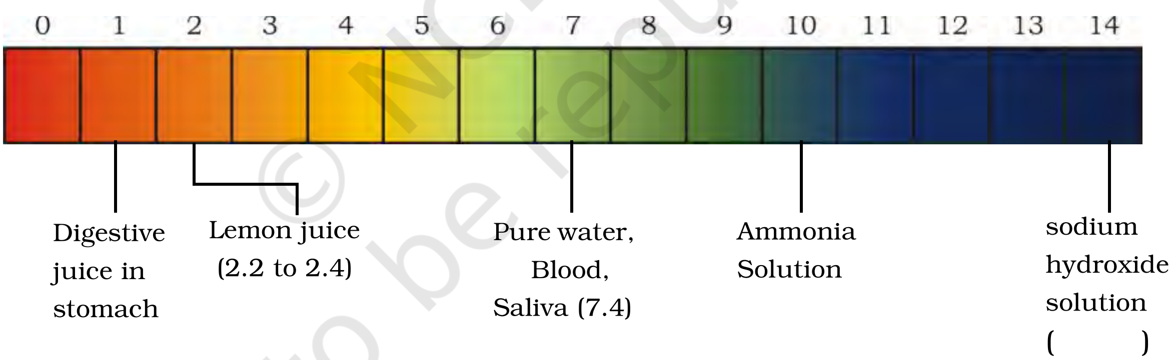


Fig. 7.1 : *(b) Colour of universal indicator at different pH*

OBSERVATIONS

Sl. No.	Sample	Approximate pH
1.	Dilute acid (HCl)	
2.	Dilute base (NaOH)	
3.	Salt solution (NaCl)	
4.	Soil water extract	
5.	A fruit (__________) juice	

Results and Discussion

As pH depends upon H^+ concentration and in an aqueous solution H^+ and OH^- ion concentrations are correlated, therefore, every acidic and basic solution shows different colour at different pH.

Precautions

- The test sample solutions should be freshly prepared and the fruit juice samples should also be fresh.
- Glass rod used for one sample should be used for the other sample only after washing it with water.

Note for the Teacher

- It is advised to explain the pH value of salt solutions and differentiate between acid and acidic compounds, bases and basic compounds.
- Teachers may take a solid chemical like oxalic acid and juices of citrus fruits, carrot, grapes etc., for making solutions for determining their pH values. Students may be suggested to compare the pH values of juices of unripe and ripe fruits and note the change in pH during ripening.

Questions

- What do you mean by pH?
- What is the pH of pure water at 25 °C (298 K)?
- What according to you should be the pH of dil. HCl and dil. NaOH solutions? Observe and explain your findings.
- On opening the soda water bottle the dissolved CO_2 comes out, would the pH of the solution increase or decrease as the gas comes out? Explain your answer either way.

Experiment 8

AIM

To identify bleaching powder among given samples of chemicals.

THEORY

Bleaching powder is calcium oxochloride ($CaOCl_2$). On treatment with small quantity of dilute acid, it liberates hypochlorous acid which can easily furnish oxygen (called nascent oxygen) and thus acts as an oxidising and bleaching agent.

$$2CaOCl_2\,(s) + H_2SO_4\,(aq) \longrightarrow CaSO_4\,(aq) + CaCl_2\,(aq) + 2HClO\,(aq)$$

$$HClO \rightarrow HCl + [O]$$

(Nasent oxygen)

In this experiment, we shall make use of this bleaching reaction to identify the bleaching powder from the given samples of chemicals (four, say).

MATERIALS REQUIRED

Given four samples: bleaching powder; sodium chloride; calcium chloride; and ammonium chloride (or alternate salts), dil. sulphuric acid, flowers petals or small pieces of coloured cotton cloth, eight beakers (100 mL), a measuring cylinder (100 mL), and a glass rod.

PROCEDURE

1. Prepare about 50 mL, 5% solution (by volume) of each of the four given samples of chemicals in four beakers. Label these beakers as A, B, C, and D.
2. Take about 20 mL of dilute sulphuric acid in each of remaining four beakers. Label them as E, F, G, and H.
3. Dip a small piece of coloured cloth or flower petal in beaker A.
4. Take out the cloth or flower petal from the beaker A and dip it in dil. sulphuric acid in beaker E and stir it gently with the help of a glass rod. Does the cotton cloth or flower petal decolourise? Record your observation.
5. Repeat steps 3 and 4 with other three samples of given chemicals and dil. sulphuric acid and record your observations.

OBSERVATIONS

Sl. No.	Sample	Colour of the cloth or flower petal dipped in the solution of sample chemical	Colour of cloth or flower petal (dipped in sample solution and then in dil. sulphuric acid)
1.	A		
2.	B		
3.	C		
4.	D		

RESULTS AND DISCUSSION

Infer from the observations that which chemical solution decolourises the cotton cloth or flower petal. The chemical which decolourises, exhibits bleaching action. Thus the bleaching powder can be identified.

In this case, the solution in beaker ___ shows bleaching reaction and therefore the chemical in solution in that beaker is bleaching powder. The nascent oxygen produced by the decomposition of hypochlorous acid (HClO) is the cause for bleaching action.

PRECAUTIONS

- Handle the sample solutions and sulphuric acid carefully. These must not touch your skin.
- Glass rod used for one sample solution should be used for the other sample solution only after washing it with water.

NOTE FOR THE TEACHER

- In the samples of chemicals, sulphites (SO_3^{2-}) and hydrogen sulphites (HSO_3^-) should not be given because these chemicals react with dil. sulphuric acid and produce sulphur dioxide gas which also acts as a temporary bleaching agent.

QUESTIONS

- Name the substance which on treating with chlorine yields bleaching powder.
- Why does the bleaching powder known as a mixture?
- What happens when bleaching powder is exposed to air?
- How does the bleaching powder help in the purification of water?
- What is the chemical name of bleaching powder?

17-04-2018

Experiment 9

AIM

To identify washing soda or baking soda among given samples of chemicals.

THEORY

Washing soda ($Na_2CO_3.10H_2O$) and baking soda (mainly $NaHCO_3$) are white solids. Their aqueous solutions are alkaline and turn red litmus blue. Carbonates and hydrogencarbonates react with dilute acids and produce carbon dioxide gas which turns lime water milky.

$$CO_3^{2-}\,(aq) + H_2O\,(l) \rightarrow H_2CO_3\,(aq) + 2OH^-\,(aq)$$

$$HCO_3^-\,(aq) + H_2O\,(l) \longrightarrow H_2CO_3\,(aq) + OH^-\,(aq)$$

$$Na_2CO_3\,(s) + 2HCl\,(aq) \longrightarrow 2NaCl\,(aq) + H_2O\,(l) + CO_2\,(g)$$

$$NaHCO_3\,(s) + HCl\,(aq) \longrightarrow NaCl\,(aq) + H_2O\,(l) + CO_2\,(g)$$

$$\underset{\text{Lime water}}{Ca(OH)_2\,(aq)} + CO_2\,(g) \longrightarrow \underset{\text{Milky}}{CaCO_3\,(s)} + H_2O\,(l)$$

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

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

17-04-2018

Materials Required

Samples: sodium carbonate (washing soda), sodium hydrogencarbonate (baking soda), ammonium chloride, sodium chloride etc., red litmus paper strips, freshly prepared lime water, dil. hydrochloric acid, five test tubes, a test tube stand, a boiling tube, a thistle funnel, a double bored cork, a delivery tube, and a glass rod.

Procedure

1. Take about 1 g each of the four given samples separately in four boiling tubes and label them as A, B, C, and D.
2. Add about 5 mL distilled water in each boiling tube. Gently shake the contents of the tubes.
3. Put a drop of every salt's solution on separate red litmus paper strips, using a glass rod. (Wash the glass rod used for one sample before using it for other sample.) Note the change in colour of the litmus paper, if any in each case.
4. Add 1 mL of dil. hydrochloric acid in each test tube. Do you see any effervescence from any test tube? If yes, perform the lime water test as detailed below.
5. For performing lime water test, take the solution of test tube A in a boiling tube and set up the apparatus (delivery tube, thistle funnel etc.) as shown in Fig. 9.1.
6. Add dil. hydrochloric acid drop by drop to the solution through the thistle funnel.
7. Pass the liberated gas evolved through the lime water in a test tube. Does the lime water turns milky? If yes, then it shows the presence of CO_2 gas.
8. Continue passing the liberated gas through the lime water. Does it again become colourless? This reconfirms that the liberated gas is CO_2.
9. Repeat the lime water test on all samples that give effervescence in step 4. Do not forget to wash the boiling tube when you change the sample in it for performing the lime water test.

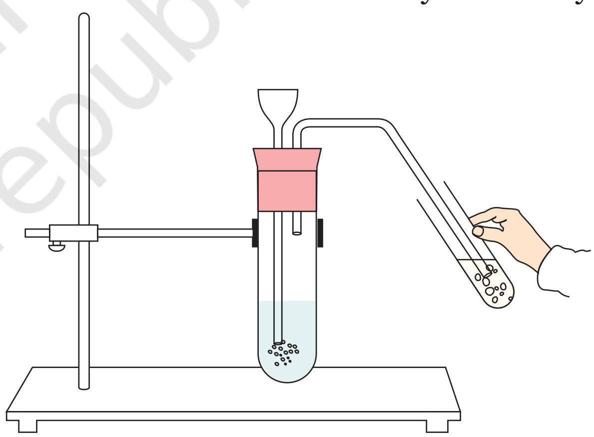


Fig. 9.1 : *Carbon dioxide gas formed by the reaction of dil/hydrochloric acid on washing soda or baking soda is being passed through lime water*

Observations

Sl. No.	Sample	Colour	Solubility in water	Action on red litmus paper	Action of dil. HCl acid	Lime water
			(Soluble/ insoulble)	(Changes to blue or not)	(Effervescence observed or not?)	Turns milky or not?
1.	A					
2.	B					
3.	C					
4.	D					

Results and Discussion

Infer from the observations about the identification of washing soda or baking soda out of the samples given for testing. Discuss about the litmus paper and lime water tests performed.

Sample in test tube ___ is washing soda/baking soda.

Precautions

- Add dil. hydrochloric acid to the salt solution drop by drop. If the addition of dil. hydrochloric acid is not slow, a vigorous reaction may occur and the reaction mixture may come out of the reaction tube and pass into lime water.
- Handle hydrochloric acid and washing soda carefully. These should not touch your skin.
- Freshly prepared lime water should be used for performing lime water test

Note for the Teacher

- Students may be given three or four samples of salts, of which one of the salts is washing soda or baking soda. The remaining samples of salts should not be carbonates, hydrogencarbonates, sulphites or hydrogensulphites. These salts liberate either CO_2 or SO_2. Sulphur dioxide also turn lime water milky.
- *Preparation of lime water*: Shake 5 g calcium oxide CaO, with 100 mL water. Allow it to stand for about 24 hours. Decant the supernatant liquid and use it for the tests. It is suggested to always use freshly prepared limewater.

QUESTIONS

- Explain why should dil. hydrochloric acid be added dropwise to the salt solution while performing lime water test?
- What will happen if crystalline washing soda is left open in air?
- CO_2 and SO_2 both turn lime water milky and their aqueous solutions turn blue litmus paper red. How can you then distinguish between these?
- Why should carbon dioxide be soluble in aqueous solution of potassium carbonate?

Experiment 10

Aim

To show that crystals of copper sulphate contain water of crystallisation.

Theory

Blue crystals of copper sulphate contains water of crystallisation. These crystals dehydrate on heating to lose water of crystallisation at a particular temperature and also change their colour.

$$\underset{\text{Blue}}{CuSO_4.5H_2O} \xrightarrow{100^\circ C} \underset{\text{Bluish white}}{CuSO_4.H_2O} \xrightarrow{250^\circ C} \underset{\text{White}}{CuSO_4}$$

If the dehydrated copper sulphate solid material is allowed to cool in air, then it regains blue colour after gaining water molecules from the atmosphere.

$$\underset{\text{White}}{CuSO_4} + \underset{\text{From atmosphere}}{5H_2O} \longrightarrow \underset{\text{Blue}}{CuSO_4.5H_2O}$$

Materials Required

Spatula, watch glass, copper sulphate, and a burner.

Procedure

1. Take some crystals of copper sulphate ($CuSO_4.5H_2O$) in a spatula.

2. Heat these crystals on a burner by keeping the spatula directly over the flame of the burner.
3. Note the change in colour of the copper sulphate crystals during the heating. Does it show a bluish white colour? If yes, keep on heating the crystals for some more time. After some time as temperature reaches around 250 °C, the copper sulphate crystals starts appearing white.
4. Stop heating when it becomes complete white .
5. Transfer the content (white powder) to a watch glass.
6. Keep the watch glass in open atmosphere for some time and allow it to cool. Do you find a change in the colour of copper sulphate crystals.

OBSERVATIONS

(i) On heating, the blue colour of copper sulphate crystals first changes into __________ and then to ________.

(ii) On cooling, the colour of copper sulphate again turns ________ .

RESULTS AND DISCUSSION

Infer from your observations that the hydrated sample of copper sulphate loses water of crystallisation on heating and becomes dehydrated whose colour is white. This dehydrated copper sulphate regains water of crystallisation on cooling and it again becomes blue. Thus the hydration and dehydration is the precise cause of colour change.

PRECAUTION

- Hold the spatula containing copper sulphate crystals very carefully. Do not bring your face near to hot spatula, as it may hurt.

QUESTIONS

- How can you test that a given sample contains water or not?
- What shall be the total action of heat on copper sulphate?
- It is regarded that each molecule of copper suphate crystals at room temperature contains five water molecules as water of crystallisation. Do you see any difference in them? (Hint: Look at the dehydration reaction of copper sulphate)

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.

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

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.

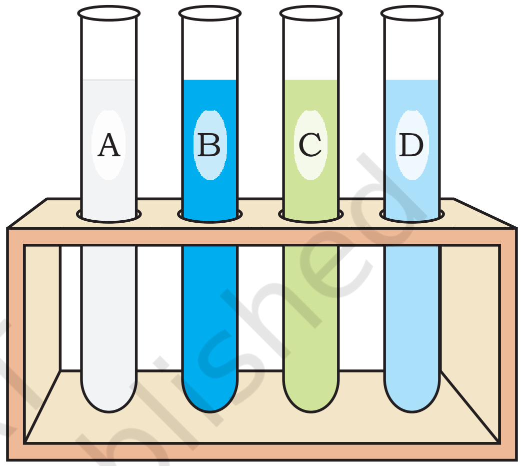


Fig 11.1 : *Zinc metal dipped in Zinc sulphate (A), copper sulphate (B), iron sulphate (C) and lead nitrate (D) solutions*

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.

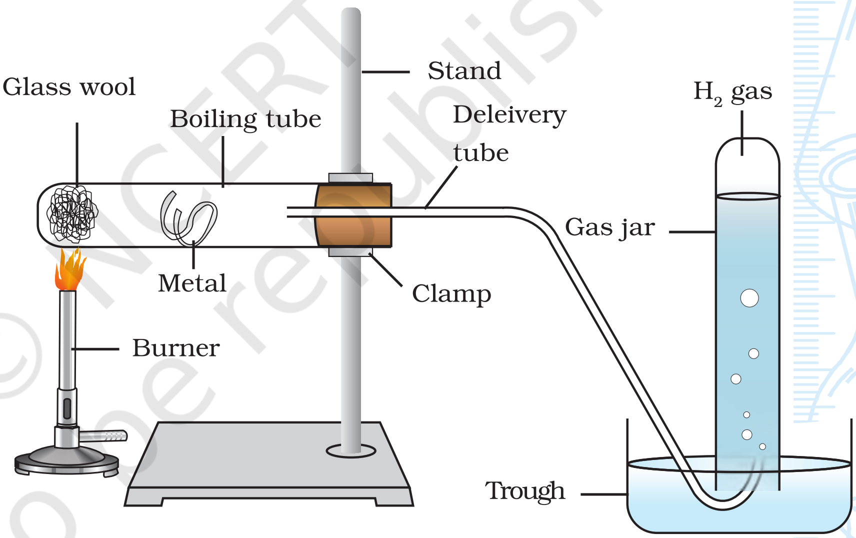


Fig. 12.1 : *Action of steam on a metal*

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

Metal + dilute acid $\longrightarrow$ 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 $2KMnO_4 + 5SO_2 + 2H_2O \longrightarrow K_2SO_4 + 2MnSO_4 + 2H_2SO_4$.

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.

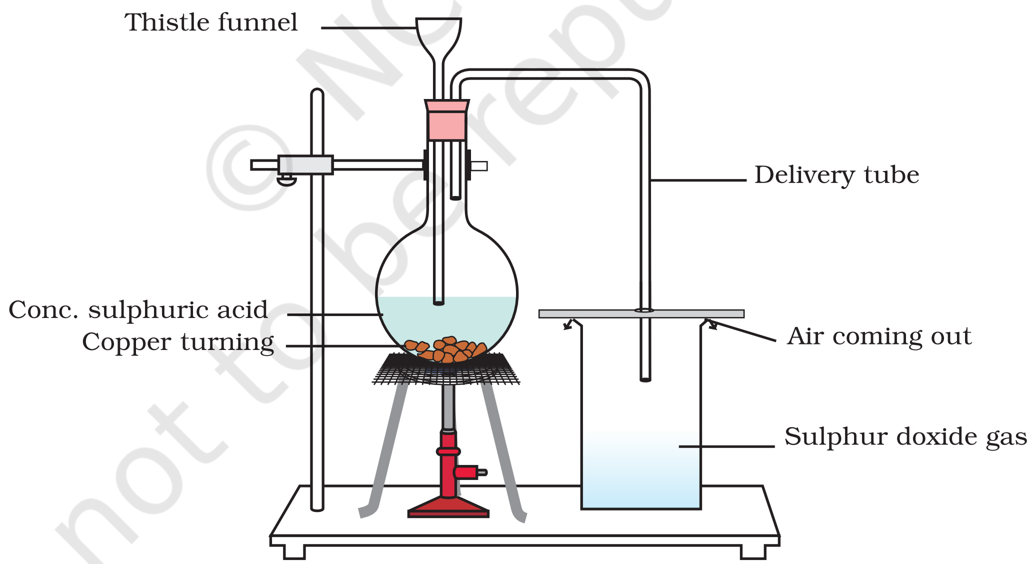


Fig. 14.1 : *Preparation of sulphur dioxide gas*

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.

17-04-2018

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?

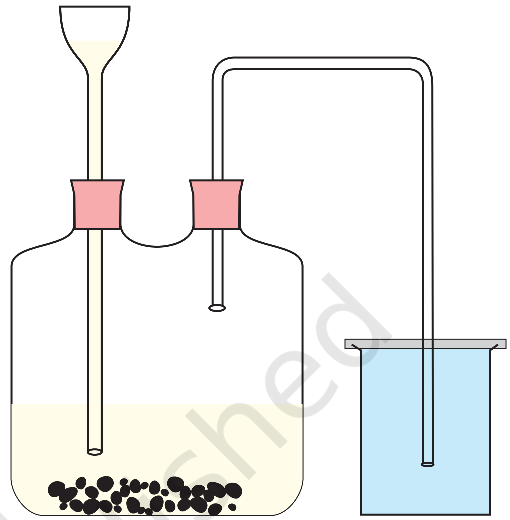


Fig. 15.1 : *Preparation of CO_2 gas in Woulfe's bottle*

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.

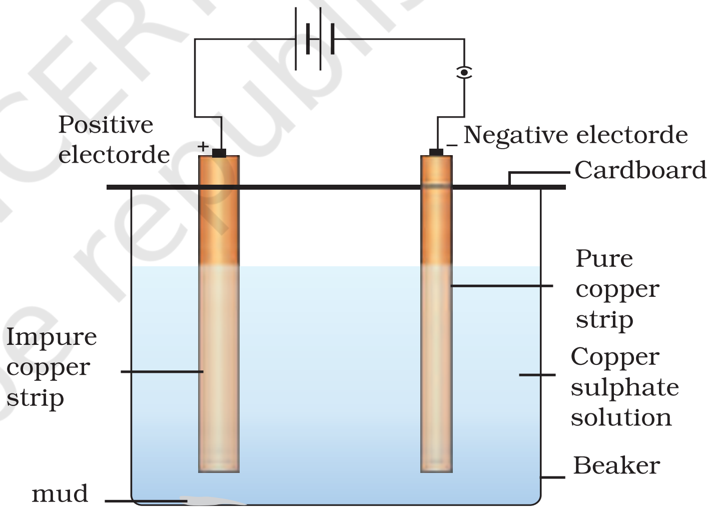


Fig. 16.1 : *An electrolysis process*

   [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.		

17-04-2018

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?

17-04-2018

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 (– 10ºC to 110 ºC), 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.)

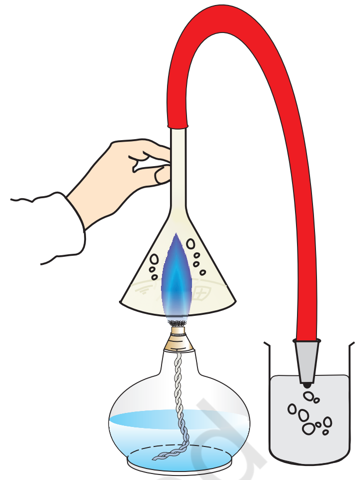


Fig. 19.1 : *Complete combustion of ethanol*

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.

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

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.

17-04-2018

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?

Experiment 21

AIM

To compare the foaming capacity of different samples of soap.

THEORY

Foam is produced when soap is shaken with water. Foaming of a soap is due to the presence of hydrophilic and hydrophobic portions in its molecule $RCOO^-Na^+$. (Refer Chapter 4, *Science Textbook for Class X*, published by the NCERT). Foaming capacity of different soap samples can be compared by measuring the quantity of the foam produced by equal amount of various soap samples.

MATERIALS REQUIRED

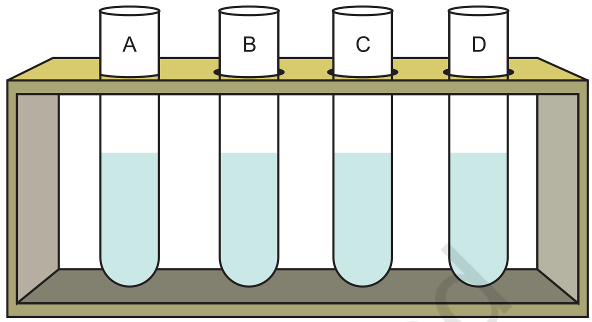
Four different samples of soaps, distilled water, physical balance and weight box, four test tubes, a test tube stand, four beakers (100 mL), a glass rod, burner, tripod stand, wire gauze, a measuring cylinder (50 mL) and a measuring scale.

PROCEDURE

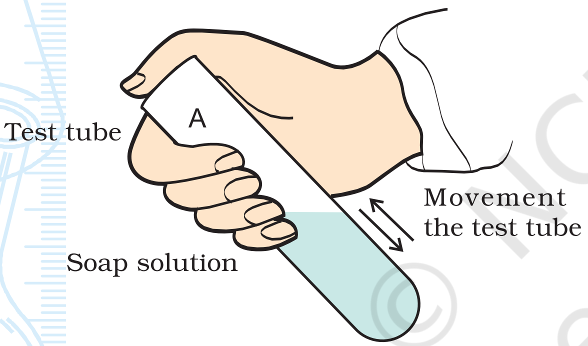
1. Take four 100 mL beakers and label them as beakers A, B, C, and D. Weigh 1 g each of the four different soap samples in a physical balance. Put them into four different beakers.
2. Add 20 mL of distilled water in all the beakers containing the soap

samples. Dissolve the soap in water by stirring the mixture with a glass rod. If a soap sample takes longer time to dissolve in distilled water, uniformly heat the contents of the beaker over a wire gauge.

3. Take a test tube stand and place the four test tubes in it and label them as tubes A, B, C, and D. Pour 1 mL each of the above-prepared soap solutions in corresponding test tubes. [Fig. 21.1(a)].
4. Add 5 mL of distilled water in each test tube.



(a)



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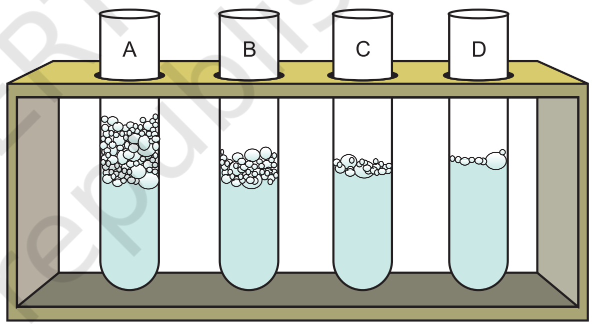


(c)

Fig. 21.1 : *(a) Test tubes containing different soap solutions*
(b) Showing the shaking of the test tube
(c) To compare the foaming capacity of different samples of soap

5. Take test tube labelled as tube A and shake it ten times by placing thumb on its mouth [see Fig. 21.1(b)].
6. By shaking the test tube, foam will be formed. Once the foam is formed, measure the length of the foam produced immediately with the help of a measuring scale [Fig. 21.1(c)].
7. Repeat steps 5 and 6 with the remaining three samples of soap solutions.

Observations and Calculations

(i) Mass of each soap sample taken in a beaker = ____ g

(ii) Volume of the distilled water added in each beaker = ____ mL

(iii) Volume of each soap sample taken in a test tube = ____ mL

(iv) Volume of distilled water added in each test tube = ____ mL

(v) Number of times each test tube shaken = _____

Soap solution	Initial length	Test tube readings Final length	Length of the foam produced
	(cm)	(cm)	(cm)
1.			
2.			
3.			
4.			

Results and Discussion

Infer from the observations that which soap sample produces the maximum length of foam (lather) in test tube.

Why does the different soap solutions have different foaming capacities? Is it due to the presence of different alkyl groups (R) in different soap solutions? An alkyl group in a soap is the hydrophobic part.

Precautions

- Use distilled water for each sample because foaming of a soap solution does not take place in hard water.
- Stir the mixture carefully while dissolving soap in water so as to avoid spilling of soap solution.
- The quantity of soap samples in all solutions must be same. The amount of distilled water added in every soap sample must be same. That is the concentration of all test solutions must be same.
- The mass of the soap samples must be determined very carefully using a physical balance. In case of any need, take help from your teacher.
- Shake every tube for equal number of times and in a similar manner.
- Measure the length of the foam produced immediately after its production.
- Use wire gauge to heat the beaker containing soap sample(s) uniformly.

NOTE FOR THE TEACHER

- Detergents should not be used in this experiment. However a similar experiment can separately be performed for comparing the foaming capacities of different detergents.
- Students may be guided to use a physical balance for weighing sample accurately.

QUESTIONS

- What is the name of the chemical reaction which takes place during the alkaline hydrolysis of oils and fats?
- Why is it necessary to shake every test tube for equal number of times and in a similar manner?
- Why does the concentration of every soap solutions be same?
- Was the length of foam formed same in each of the test tube containing soap solution?
- Which soap sample formed maximum foam?
- If distilled water had not been taken and salts of Mg^{2+} and Ca^{2+} were present in water sample. What would have been your observation?
- In hard water, which will form more foam - a soap or a detergent?
- In this experiment it is advised that the length of the foam produced should be measured immediately after its production. Why?

17-04-2018

Experiment 22

AIM

To study the comparative cleansing capacity of a sample of soap in soft and hard water.

THEORY

Hardness of water is caused by the presence of the salts of calcium and magnesium (hydrogencarbonates, chlorides and sulphates) in water. These salts are soluble in water. When soap is added to hard water, it reacts with the salts to form a scum, which is insoluble and floats on top of the water surface. The scum is formed due to the formation of insoluble calcium or magnesium salts of the fatty acid used in the soap formation. The soap in solution then becomes ineffective.

$$Ca(HCO_3)_2\ (aq) + 2Na^{+}\text{-stearate}\ (aq) \longrightarrow Ca(stearate)_2\ (s) + 2NaHCO_3\ (aq)$$

Sodium stearate (soap) — Scum

$$CaSO_4\ (aq) + 2Na^{+}\text{-stearate}\ (aq) \longrightarrow Ca(stearate)_2\ (s) + Na_2SO_4(aq)$$

Scum

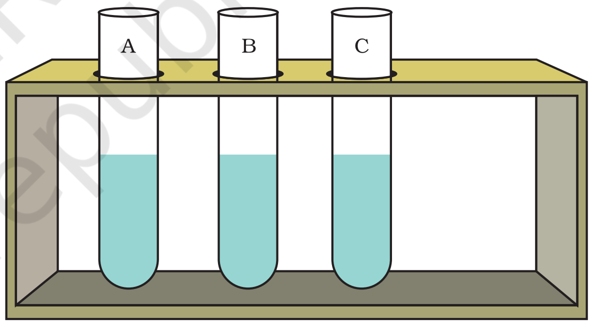
The salts of calcium and magnesium show similar reactions. Therefore, the presence of calcium and magnesium salts in water precipitates the soap thereby reducing its cleansing power and foaming capacity.

Materials Required

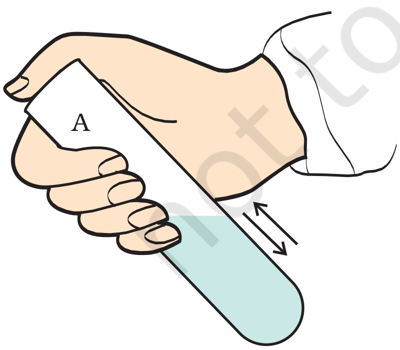
Underground water (well water), distilled water, calcium hydrogencarbonate or calcium sulphate, soap sample, a physical balance and weight box, three test tubes and a test tube stand, three beakers (100 mL), three glass rods, a measuring cylinder (50 mL), and a measuring scale,

Procedure

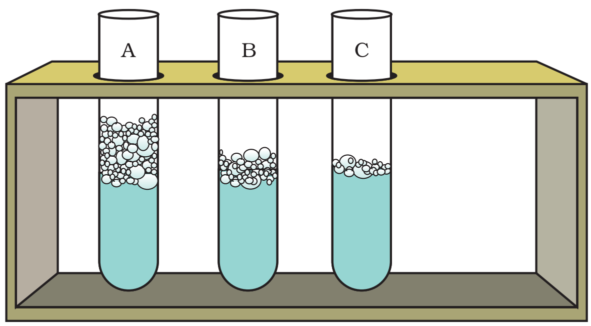
1. Take three beakers and label them as A, B and C.
2. Take 20 mL of distilled water in beaker A. In beaker B, put 20 mL of underground water, and in beaker C add 2 g of calcium hydrogencarbonate (or calcium sulphate) to 20 mL of distilled water.
3. Stir the contents of beaker C so that calcium hydrogen carbonate (or calcium sulphate) dissolves in water.
4. Put 1 g of soap in each beaker A, B, and C (after weighing it using a physical balance).
5. Stir the contents of these beakers with separate glass rods.
6. Place three test tubes in a test tube stand and label them as tube A, B and C [Fig. 22.1(a)].
7. Pour 3 mL of the above-prepared soap solution in the corresponding test tubes.



(a)



(b)



(c)

Fig. 22.1 : *(a) Test tubes containing different soap solutions*
(b) Showing the shaking of the test tube
(c) To compare the foaming capacity of different samples of soap

8. Take test tube A and shake it ten times by placing thumb on its mouth [Fig. 22.1(b)].
9. Foam or lather will be formed by shaking the test tube. Measure the length of the foam produced immediately with the help of a measuring scale [Fig. 22.1(c)].
10. Similarly, repeat steps 8 and 9 with the remaining two samples.

Observations and Calculations

(i) Mass of the soap sample taken in each beaker = _____ g

(ii) Volume of the distilled water and underground water added in each beaker = _____ mL

(iii) Volume of soap sample taken in each test tube = _____ mL

(iv) Number of times each test tube taken = _____

Sl. No.	Mixture (water + soap)	Test tube readings Initial length (cm)	Final length (cm)	Length of the foam produced (cm)
1.	Distilled water (soft water)			
2.	Well water or underground water (hard water)			
3.	Water containing $Ca(HCO_3)_2$ or $CaSO_4$ (hard water)			

Results and Discussion

Infer from the observations that which solution of the soap sample produces the maximum length of foam (lather).

For cleansing purpose, the foam needs to be produced which depends on free availability of hydrophobic portion of soaps (or alkyl groups). In hard water it is trapped due to scum or precipitation, this makes the hard water unsuitable for washing.

PRECAUTIONS

- Use same sample of soap for soft water and hard water.
- Stir the mixture carefully while dissolving soap in water so as to avoid spilling of soap solution.
- The quantity of soap sample in all solutions must be same. The amount of distilled water added in every soap sample must be same. That is the concentration of all test solutions must be same.
- The mass of the soap samples must be determined very carefully using a physical balance. In case of any need, take help from your teacher.
- Shake every tube for equal number of times and in a similar manner.
- Measure the length of the foam produced immediately after its production.

NOTE FOR THE TEACHER

- Students may be guided to use a physical balance for weighing sample accurately.

QUESTIONS

- Do both hard water and soft water produce foam with soap?
- Why is scum formed when hard water is treated with soap?
- Why did we add calcium hydrogencarbonate (or calcium sulphate) to beaker C?
- Was there any difference in the length of the foam formed in test tube C having water containing calcium hydrogencarbonate (or calcium sulphate) and test tube B containing well water or underground water?
- With their prolong use, white scales get deposited in the interior of boilers and electric kettles. What is the reason for this observation? How can these scales be removed?
- What do you understand by temporary and permanent hardness of water?
- What is the reaction between soap molecules and ions present in hard water?

UNIT II

The World of the Living

Experiment 23

AIM

To prepare temporary mounts of leaf peels to observe stomata and to differentiate between dicot and monocot stomata.

THEORY

In plants, physiological processes such as respiration and photosynthesis involve exchange of gases between plant tissues and the external atmosphere. This occurs through minute microscopic pores called stomata (singular; stoma) present in the leaf. Stoma is an elliptical pore with two kidney shaped guard cells on either side. The guard cells have thin outer and thick inner walls. When guard cells are turgid, the stoma opens and it closes when the guard cells are flaccid.

The number, distribution and type of stomata varies in different plants. Within a plant, the number and distribution may vary between the upper and lower surfaces of leaf. However, the type of stomata remains the same in a particular plant species. Stomata are either absent or non-functional in submerged aquatic plants. In this experiment we shall prepare the temporary mounts of leaf peels of dicot and monocot plants to observe their stomata.

MATERIALS REQUIRED

Fresh leaves of a dicot plant (such as *Petunia, Dianthus, Solanum)* and a monocot plant (such as lily, maize, grass), compound microscope, slide, cover slip, needle, brush, a piece of blotting paper, and a razor blade.

PROCEDURE

1. Remove a peel from the lower surface of a dicot leaf. This can be easily done by folding or tearing the leaf and pulling out the thin membranous transparent peel. Leaf peels can also be obtained by carefully scratching the leaf surface with a razor blade.
2. Mount the peel on a slide in a drop of water and place a cover slip on it. Avoid air bubbles. Blot the excess water from the slide.
3. Focus the peel under the low power of compound microscope and observe the stomata, guard cells and epidermal cells.
4. Count the number of stomata, and epidermal cells in the field of microscope without disturbing the slide.
5. Observe and identify the contents of guard cells under high power.
6. Move the slide and again count the number of stomata and epidermal cells. Record your observations.
7. Calculate the average number of stomata and epidermal cells in the field of the microscope.
8. Draw the diagram of a stoma and label its parts.
9. Repeat the process with peels removed from a monocot leaf. Record your observations.
10. Following the same procedure, study the stomata of other dicot and monocot plants.

OBSERVATIONS

Sl. No.	Observation	Dicot	Monocot
1.	Number of stomata in the microscopic field		
2.	Number of epidermal cells in the microscopic field		
3.	Shape of guard cells (bean seed shaped or dumbell shaped)		
4.	Number of chloroplasts in each guard cell		

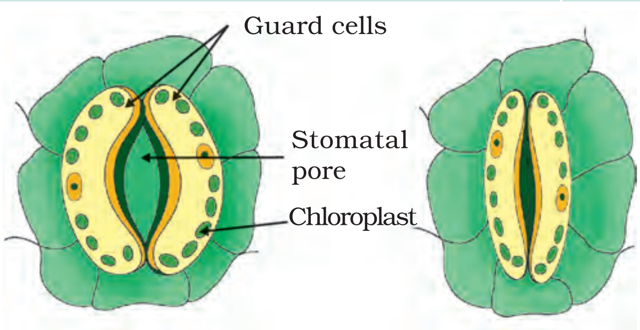


Fig. 23.1 : *(a) An open dicot stoma; and (b) closed dicot stoma*

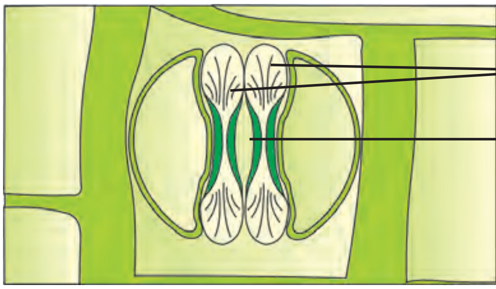


Fig. 23.2 : *An open monocot stoma (grass)*

RESULTS AND DISCUSSION

Based on the observation compare the characteristic of the dicot and monocot stomata and draw your own conclusion.

NOTE FOR THE TEACHER

- It is found that number, size, and distribution of stomata vary in different plants. In general, the stomata are lesser on the upper surface as compared to that on the lower surface of leaf.
- Fewer stomata on the upper surface prevent excessive loss of water due to transpiration as this surface is directly exposed to sunlight.
- In aquatic plants stomata are either absent or non-functional. Stomata are absent in roots also.
- This experiment can be extended as a project by taking leaves of different plants. This will help students to have a fair idea about the variations in shape, number, size and distribution of stomata on two surfaces of leaves of different plants. Stomatal index can be calculated by using the formula

$$\text{Stomatal index} = \frac{S}{E} \times 100\%$$

Here S and E are the numbers of stomata and epidermal cells respectively per microscopic field.

QUESTIONS

- What is the function of guard cells in stomata?
- Why is the number of stomata greater on the lower surface of a leaf?
- Why are stomata absent in roots?
- What is the shape of guard cells in stoma of grass leaf?
- Do guard cells have rigid or elastic walls? Justify your answer.

Experiment 24

AIM

To show that light is essential for photosynthesis.

THEORY

Photosynthesis is the process by which green plants synthesize carbohydrates by using carbon dioxide (CO_2), water, sunlight and chlorophylls present in the leaves. Light is one of the essential requirements for photosynthesis. The energy contained in solar radiation is absorbed by the photosynthetic pigments and is converted into utilizable chemical energy during photosynthesis.

MATERIALS REQUIRED

De-starched potted plant (balsam, *Amaranthus*, *Tecoma* or any plant with thin herbaceous broad leaves), thick black paper strips, paper clips, alcohol, iodine solution, a beaker (250 mL), a burner (or a spirit lamp), a tripod stand, a wire gauge, a boiling tube, forceps, and a petridish.

PROCEDURE

1. Take a de-starched plant (from the list given above). Using strips of thick black paper and paper clips, cover a part of an intact leaf of the plant as shown in Fig. 24.1(a). You may cover several leaves of the same plant with black strips and clips.

17-04-2018

2. Place the set-up in bright sunlight for about two hours.
3. Take about 150 mL water in a beaker and boil it.
4. Pluck the experimental leaves from the potted plant and remove the black paper strips from them. Keep these leaves in boiling water for some time till the leaves become soft. Stop heating the water. Remove the beaker from the tripod stand. Allow it to cool to about 60 °C.
5. Transfer the leaves to a boiling tube containing alcohol.
6. Place the boiling tube (containing experimental leaves in alcohol) in the beaker containing hot water at about 60 °C. Keep the boiling tube in the beaker till the leaves become colourless.
7. Take some iodine solution in a petri dish.
8. Wash the leaves in water and dip them in iodine solution in petri dish.
9. After about five minutes, remove the leaves from iodine solution, wash them with water and observe the colours of the exposed part and unexposed (covered with black paper) part of the leaf [Fig. 24.1(b)].

(a)

(b)

Fig 24.1 : *(a) A de-starched potted plant with part of a leaf covered with black paper strips on either side; (b) An experimental leaf after treatment with iodine*

OBSERVATIONS

After iodine treatment, colour of covered portion of leaf is ________ ; and the colour of the exposed portion of leaf is ________ .

RESULTS AND DISCUSSION

Based on the results obtained, give reasons for the appearance of blue colour in the exposed parts of leaf and non-appearance of blue colour in the parts of leaf covered by black paper.

PRECAUTIONS

- Alcohol is highly inflammable and hence it should not be heated directly on the flame.
- Satisfactory results will not be obtained if the plant is not completely de-starched.

Note for the Teacher

- It is advised to select a herbaceous plant with thin, broad leaves. Thick, mucilaginous and fleshy leaves should be avoided.
- Keep a potted plant in darkness for about forty eight hours for de-starching the leaves. A de-starched plant must be provided to students for performing this experiment.
- The boiling point of alcohol is about 78 °C. If the test tube containing the leaves in alcohol is either heated directly or dipped in the boiling water, the alcohol will immediately evaporate without being much in contact with the leaves. It is therefore important to heat the test tube containing alcohol and leaves in a water bath (a beaker containing hot water at about 60 °C, in this case).
- The exposed part (to the sunlight) of the leaf turns blue on treatment with iodine whereas the covered part does not turn blue. The standard test for starch is treatment with iodine. Appearance of blue-black colour confirms the presence of starch.

Questions

- What is meant by de-starching? Why do plants get de-starched when kept in continuous darkness for about forty eight hours?
- Will you get the same result if you perform the experiment without de-starching the plant? Give reason.
- Why do we warm the leaves in alcohol?
- Arrange the following steps in correct sequence:
  (i) de-starching the plant;
  (ii) treatment with iodine;
  (iii) attaching black paper strips to the leaf;
  (iv) keeping the set-up in sunlight;
- Why do we keep the experimental plant in bright sunlight?
- Can this experiment be performed with a de-starched leaf detached from the plant? Give reasons.

Experiment 25

AIM

To show that carbon dioxide is essential for photosynthesis.

THEORY

Plants are known as autotrophs as they synthesize or produce their own food (carbohydrate) by the process of photosynthesis. Besides light and water, carbon dioxide (CO_2) is essential for this process. Carbon dioxide is taken up from the atmosphere through the stomata present in the leaves. During photosynthesis, carbon dioxide is reduced to form carbohydrates (glucose). If any one of the raw materials is not available, photosynthesis will not occur.

MATERIALS REQUIRED

A de-starched herbaceous long leaved potted plant (such as *Tecoma*, balsam, *Amaranthus* or *Salvia*), two boiling tubes, a split cork, KOH solution (caustic potash), alcohol, iodine solution, petroleum jelly, beakers, a petridish, forceps, a burner (or a spirit lamp), a tripod stand, a wire gauge, and a laboratory stand with a clamp.

PROCEDURE

1. Take a de-starched potted plant (from the list given above).
2. Fill one-fifth of the boiling tube with KOH solution.

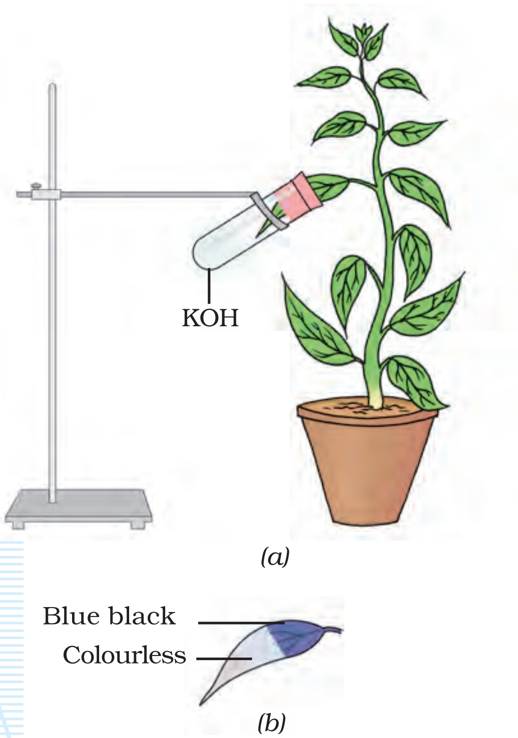


Fig. 25.1 : *A de-starched potted plant with part of a leaf in a boiling tube with KOH solution; (b) An experimental leaf after treatment with iodine*

3. Insert one half of an intact leaf of the de-starched plant into the boiling tube through a split cork as shown in Fig. 25.1. Ensure that the leaf does not touch the solution.
4. Fix the tube to the stand with a clamp. Make the boiling tube air tight by applying a thin smear of petroleum jelly.
5. Keep the set up in bright sunlight for about one and half hours.
6. Take about 150 mL water in a beaker and boil it.
7. Detach the experimental leaf from the parent potted plant and boil it in water in a beaker for some time. Stop heating the water. Remove the beaker from the tripod stand. Allow it to cool to about 60 °C.
7. Transfer the leaf to alcohol taken in another boiling tube.
8. Place the boiling tube (containing experimental leaf in alcohol) in the beaker containing hot water. The leaf will also become warm. Keep the boiling tube in the beaker till the leaf become colourless.
9. Take some iodine solution in a petri dish.
10. Wash the leaf in water and dip it in iodine solution in the petri dish.
11. After about five minutes, remove the leaf from the iodine solution, wash it with water and observe (Fig. 25.2).

Observations

After iodine treatment, colour of leaf portion that was inside the boiling tube (and not exposed to air) is ________ ; and the colour of leaf portion that was exposed to air is ________ .

Results and Discussion

Based on the results, reason out why only a part of the leaf turns blue or blue-black after treatment with iodine.

PRECAUTIONS

- Care must be taken while handling KOH and alcohol.
- While setting up the experiment, insert the leaf carefully through the split cork. Do not damage it.
- Experimental set-up must be air-tight.
- Alcohol is highly inflammable and hence it should not be heated directly on the flame.
- Leaf should not touch the KOH solution.
- Satisfactory results will not be obtained if the plant is not completely de-starched.

NOTE FOR THE TEACHER

- Keep a potted plant in darkness for about forty eight hours for de-starching the leaves. A de-starched plant must be provided to students for performing this experiment.
- The boiling point of alcohol is about 78 °C. If the test tube containing the leaves in alcohol is either heated directly or dipped in the boiling water, the alcohol will immediately evaporate without being much in contact with the leaves. It is therefore important to heat the test tube containing alcohol and leaves in a water bath (a beaker containing hot water at about 60 °C, in this case).

QUESTIONS

- Why do we de-starch the leaves before the experiment?
- What is the role of KOH in the experiment? Can you suggest any other substance that can be used in place of KOH?
- How does the carbon dioxide gas enter the leaves?
- If carbon dioxide gas is essential for photosynthesis, do you think that plants growing in places with high CO_2 concentration have an advantage over plants growing in less polluted areas?

Experiment 26

AIM

To study the liberation of carbon dioxide gas during aerobic respiration.

THEORY

Respiration is a catabolic process wherein food is oxidized to release energy for various life processes. It is of two types, namely (i) aerobic respiration that takes place in the presence of oxygen, and (ii) anaerobic respiration that takes place in the absence of oxygen. In aerobic respiration the breakdown of food (glucose) leads to the release of carbon dioxide gas, water and energy in the form of adenosine triphosphate (ATP). Most organisms that we see around us undergo aerobic respiration. Yeast and certain microorganisms and cells of skeletal muscles in our body undergo anaerobic respiration. In this experiment, we shall study the liberation of carbon dioxide gas during an aerobic respiration, using two different methods.

Note: Here, two methods are suggested to study the liberation of carbon dioxide gas. Teachers may suggest any one of these depending on the facilities available in the school laboratory.

METHOD 1

MATERIALS REQUIRED

Germinating gram seeds, KOH solution, petroleum jelly, a conical flask

(100 mL), a beaker (250 mL), a single-bore cork, a clean delivery (bent) tube, a small test tube, a piece of thread, and a measuring scale.

PROCEDURE

1. Take about fourty germinating seeds in a conical flask.
2. Fix the cork to the mouth of the conical flask and with the help of a thread, suspend the tube containing KOH solution (as shown in Fig. 26.1).
3. Insert one end of a clean delivery tube in the conical flask through the cork. Dip the other end of the delivery tube in a beaker filled with water as shown in Fig. 26.1. There will be a rise of water level inside the delivery tube at the end dipped in the water due to capillary action. Mark the position of water level in the tube. This is the initial reading (h_1)of water level in the delivery tube. (Mark the initial position of water level on the delivery tube with a sketch pen.)
4. Make the conical flask air-tight by applying a thin smear of petroleum jelly so that the gas evolved during the process of respiration by the germinating seeds does not leak out.
5. Keep this set-up undisturbed for about forty five minutes in the bright sunlight.
6. Do you find any change in the water level inside the delivery tube after forty five minutes? Does it increase? Note and record the final water level (h_2) in the delivery tube. (Mark the final level of water in the delivery tube with a sketch pen.)
7. You have drawn lines on the delivery tube for recording the initial and final water levels in it. As a matter of courtesy to those using this tube later, please clean the tube.

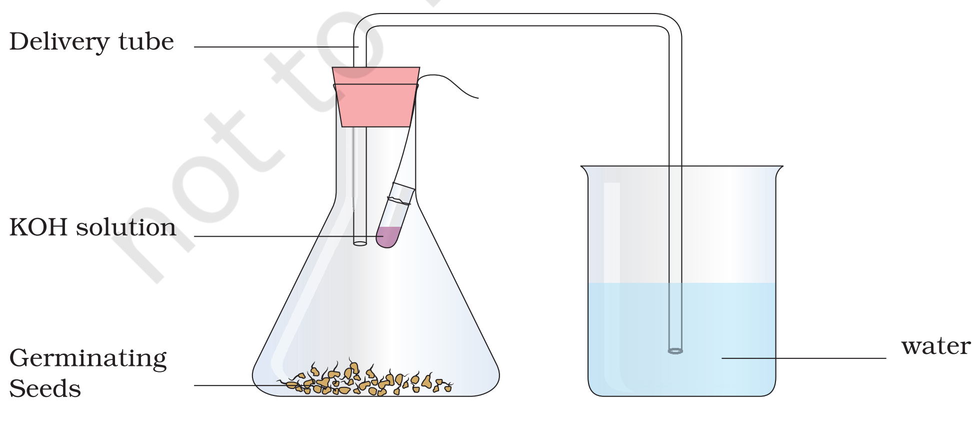


Fig. 26.1 : *Production of carbon dioxide gas during respiration in a conical flask*

Observations

- Observe the position of water level inside the delivery tube in the begining of the experiment and at the end of the experiment (The duration of experiment is the time during which the experimental set-up is placed in bright sunlight).
- Record the change in water level in the delivery tube.

Results and Discussion

Analyse the experimental results and give reasons for the results obtained.

Precautions

- Ensure that the experimental set-up is air-tight.
- KOH is corrosive. Handle it carefully.

Note for the Teacher

- KOH solution kept in the test tube inside the air-tight conical flask absorbs the evolved carbon dioxide released by germinating seeds thereby creating a partial vaccum in the conical flask. So an equal volume of water rises up in the tube. This indicates that the germinating seeds are actively respiring and evolving carbon dioxide gas during the process of respiration.
- This experiment can aslo be performed using flower buds.

Questions

- What is the role of KOH in this experiment?
- When we say that plants and animals respire, where exactly is the process occurring?
- Why do we use germinating seeds in this experiment?

Method 2

Materials Required

Germinating gram seeds, phenol red indicator, petroleum jelly, a thistle

17-04-2018

funnel, a delivery tube, rubber tubing, boiling tube, a test tube, a two-bore rubber cork, a pinch cock and a stand with clamp,

PROCEDURE

1. Place about twenty germinating seeds in a boiling tube containing some water in it.
2. Fit a two-bore rubber cork to the mouth of the boiling tube. Make the set up air-tight by applying a thin smear of petroleum jelly so that the gas evolved during the process of respiration by the germinating seeds does not leak out.
3. Fix a thistle funnel through one of the bores in the cork (Fig. 26.2). The lower end of thistle funnel must dip in water.

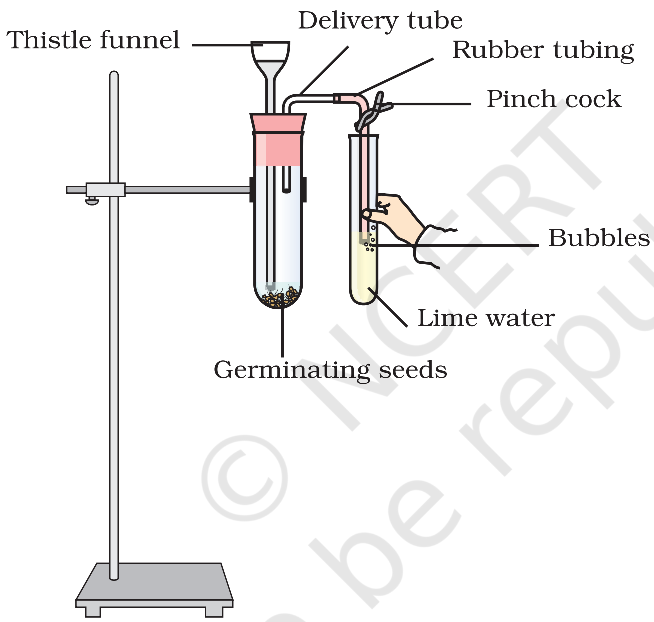


Fig. 26.2 : *Production of carbon dioxide gas during respiration*

4. Pass a delivery tube through the second bore of the cork. Attach a rubber tubing to the delivery tube, fold it backwards and fix a pinch cock. Using a clamp, fix the boiling tube to a stand, as shown in Fig. 26.2.
5. Place the set-up in bright sunlight for about one hour.
6. Take about 1 mL of water in a test tube (1 drop of water has a volume of nearly 0.1 mL). Add two drops of phenol red indicator to it and shake. Note the colour.
7. Dip the free end of rubber tubing into the test tube containing phenol red indicator solution and release the pinch cock.

8. Pour a few mL of water through the thistle funnel into the boiling tube containing germinating gram seeds.
9. Observe bubbles of a gas emerging from the rubber tube dipped in the phenol red indicator solution. Shake the test tube vigorously and note the change in the colour of indicator. Record your observations.

Observations

Colour of dilute phenol red indicator in the beginning of experiment is ______________ . After keeping the boiling tube in bright sunlight for about an hour and on passing the evolved gas from the boiling tube through the indicator, the colour of phenol red indicator changes to __________ .

Results and Discussion

With the knowledge of reaction of carbon dioxide gas with phenol red indicator solution interpret the observations.

Precautions

- Take sufficient number of germinating seeds.
- Keep the set up in bright sunlight.
- Apparatus must be air-tight. Check all joints and apply petroleum jelly so that the evolved gas does not escape from the boiling tube.

Note for the Teacher

- Phenol red is a very sensitive indicator. Initially when diluted with water it is pink in colour. After carbon dioxide gas is passed through it, its colour turns to pale yellow. Phenol red is pink in neutral and alkaline medium. However its colour is pale yellow in acidic medium.
- In place of phenol red indicator, lime water [$Ca(OH)_2$ (aq.)] can also be used. Lime water is a colourless solution. It becomes milky when carbon dioxide gas is passed through it (this is due to the formation of calcium carbonate), However on passing excess of carbon dioxide gas through the lime water, calcium hydrogencarbonate is formed. It is soluble in water and forms a colourless solution.

  Preparation of lime water: Shake about 5 g of calcium hydroxide, $Ca(OH)_2$ in 100 mL water. Allow it to stand for 24 hours. Decant the supernatant liquid and use it for the tests. Always use freshly prepared lime water.

QUESTIONS

- Why germinating seeds or flower buds are ideal materials for this experiment?
- Why is the experimental set-up kept in sun-light?
- Why do we pour water into the boiling tube containing germinating seeds through a thistle funnel?
- What is the gas that reacts with the phenol red indicator (or with the lime water)?
- How do germinating seeds respire - aerobically or anaerobically? Analyse.
- Drop a NaOH (or KOH) pellet into the pale yellow phenol red indicator and observe? Reason out the cause of the change.
- Arrange the following steps in correct sequence for this experiment:

  (i) the colour of phenol red indicator (or lime water) changes;

  (ii) remove the pinch-cock attached to the rubber tubing;

  (iii) take a few germinating seeds in the boiling tube;

  (iv) place the set-up in bright sunlight.

  (a) i, ii, iii, iv; (b) iii, iv, ii, i; (c) iv, ii, iii, i; and (d) iii, ii, iv, i.

Experiment 27

AIM

To study the liberation of carbon dioxide gas during fermentation.

THEORY

Living organisms obtain their energy from the food material by the process of cellular respiration. Most of the organisms are aerobic wherein, oxygen is used to break-down glucose completely into carbon dioxide and water, and simultaneously releasing energy in the process. Some organisms like yeast and certain bacteria can respire in the absence of oxygen by a process called anaerobic respiration. During this process, glucose is converted to ethanol and carbon dioxide, and energy is released. This process of respiration in some microorganisms under anaerobic conditions is called fermentation. In this experiment we shall study the process of fermentation and the liberation of carbon dioxide gas.

MATERIALS REQUIRED

Any fruit juice (or sugar solution), powdered grannules of baker's yeast, freshly prepared lime water, petroleum jelly, two test tubes, a single-bore cork, a delivery tube, a dropper, a beaker (250 mL), and a laboratory stand with a clamp,

PROCEDURE

1. Fill a test tube completely with a fruit juice (or sugar solution).
2. Dissolve the powdered grannules of baker's yeast in water in another test tube. Using a dropper, add about twenty drops (2 mL) of this suspension in the test tube filled with the fruit juice. Smell the liquid mixture and record its smell.
3. Fix a cork in the mouth of this completely filled test tube. While fitting cork, some fruit juice may spill over. Make the test tube air-tight by applying a thin smear of petroleum jelly.
4. Insert a delivery tube through the single-bore cork in this completely filled test tube through the cork (Fig. 27.1).
5. Clamp the test tube to a laboratory stand.
6. Dip the other end of the delivery tube in the freshly prepared lime water kept in a beaker, as shown in Fig. 27.1.

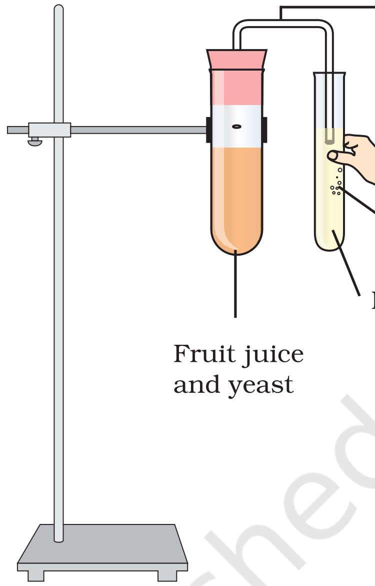


Fig. 27.1 **:** *Set-up to study liberation of carbon dioxide gas during fermentation*

7. Keep the set-up undisturbed in bright sunlight for about sixty minutes.
8. Do you see any gas bubbles passing through the lime water? Does it turn milky? Record your observations.
9. Note and record the smell of the fruit juice mixture in the test tube at the end of the experiment.

OBSERVATIONS

Smell of the fruit juice mixture at the begining of experiment is ____________, while at the end of experiment (that is after keeping the set-up in bright sunlight for about sixty minutes) is ____________ .

Gas bubbles passing through the lime water are observed during the experiment and the lime water turns _________ .

RESULTS AND DISCUSSION

Observe the change in smell of the fruit juice mixture after keeping it in bright sunlight. What does it show? Analyse the results and comment on the anaerobic nature of the set experiment and formation of ethanol and carbon dioxide.

PRECAUTIONS

- Apparatus must be airtight to provide anaerobic conditions.
- Use only freshly prepared lime water.

APPLICATIONS

- Fermentation has intense industrial applications. Breweries, baking industries and pharmaceutical industries make use of this process extensively.

NOTE FOR THE TEACHER

- During the experiment, fermentation has taken place under anaerobic conditions in which glucose in the fruit juice (or sugar solution) is broken down into ethanol and carbon dioxide. Lime water [$Ca(OH)_2$ (aq.)] is a colourless solution. It becomes milky when carbon dioxide gas is passed through it. This is due to the formation of calcium carbonate. However, on passing excess of carbon dioxide gas through the lime water, calcium hydrogencarbonate is formed. It is soluble in water and forms a colourless solution.
  Preaparation of lime water: Stir about 5 g of calcium hydroxide, $Ca(OH)_2$, with 100 mL water. Allow it to stand for 24 hours. Decant the supernatant liquid and use it for the tests. Always use freashly prepared limewater.
- The liberation of carbon dioxide may also be verified by dipping the delivery tube in freshly prepared KOH solution (in place of lime water). The carbon dioxide gas released in the fermentation process of fruit juice (or sugar solution) is absorbed by the KOH solution. A partial vacuum is produced inside the delivery tube and the level of KOH solution in the delivery tube rises.
- The liberation of carbon dioxide may also be verified by dipping the delivery tube in a test tube containing phenol red indicator solution. On passing the carbon dioxide gas through it, the pink indicator turns into pale yellow.
- Fermentation is not always limited to anaerobic organisms. For example, even in the presence of abundant oxygen, yeast cells prefer fermentation rather than oxidative phosphorylation, as long as sugars are readily available for consumption. Sugars are the common substrates for fermentation, and most common fermentation products are ethanol and lactic acid.

QUESTIONS

- Why do we take a fruit juice (or a sugar solution) for this experiment? Can we use any other food material in place of fruit juice or sugar solution?
- How does the lime water turn milky in this experiment?
- What are the industrial products that are manufactured by the process of fermentation?
- What are the end products of fermentation?
- Which by-product of the fermentation process is useful in baking industry?
- Which by-product of fermentation is useful in brewing industry?

Experiment 28

AIM

To study the action of salivary amylase on starch solution.

THEORY

The human digestive system consists of an alimentary canal and its associated glands, namely salivary glands, gastric glands, liver, pancreas and intestinal glands. These glands secrete various digestive enzymes which hydrolyze complex molecules of food into simpler molecules that are absorbed into the blood. Saliva is one of the digestive juices secreted by salivary glands present in the mouth cavity. It contains an enzyme called salivary amylase (ptyalin) that acts on starch and converts it into simpler sugars.

MATERIALS REQUIRED

1% starch solution, 1% iodine solution, saliva, distilled water, three test tubes, test tube stand, a measuring cylinder (10 mL), a dropper, a glass rod, a glazed tile (or two petri dishes), a spatula (or spoon), and surgical cotton,

PROCEDURE

1. Rinse your mouth with fresh water. Using a spatula or spoon, collect some saliva from the mouth cavity. Filter the saliva through a cotton swab and take 1 mL of it in a test tube. Add 10 mL distilled water to it.

Label this test tube as saliva solution. Keep it in the test tube stand.

2. Take 2 mL of 1% starch solution in each of two test tubes. Label the test tubes as A and B. Keep both test tubes in the test tube stand.
3. Add 1 mL diluted saliva to test tube B. Shake thoroughly. Do not add anything to test tube A.
4. After about five minutes using a dropper, take five drops of solution from test tube A on a glazed tile (or in a petri dish) and add two drops of 1% iodine solution. Mix the two with a glass rod. Observe the colour of the mixture and record your observation. Wash the glass rod after mixing.
5. At a distance away from the place where the above mixture (step 4) is kept on the glazed tile (or on a separate petri dish), place five drops from test tube B. Add two drops of 1% iodine solution to it. Mix the two with the glass rod and observe the colour of this mixture and record your observation. Wash the glass rod after mixing.
6. Repeat steps 4 and 5, after five, ten, fifteen and twenty minutes.

OBSERVATIONS

Solution	Colour after adding iodine solution			
	5 min	10 min	15 min	20 min
Test tube A solution				
Test tube B solution				

RESULTS AND DISCUSSION

Based on observations, reason out the results obtained for test tube A and test tube B solutions.

PRECAUTIONS

- Rinse your mouth with water before collecting saliva.
- Saliva should be filtered through moistened cotton swab before use.
- Wash the glass rod every time after use.

NOTE FOR THE TEACHER

- Iodine is an indicator that turns starch into blue-black colour. In test tube A starch was not hydrolysed since amylase was not present. In tube B amylase broke down starch into simpler carbohydrates.

Since no starch is available in tube B after some time, it does not turn blue-black with iodine solution.

- Iodine crystals are insoluble in water but soluble in potassium iodide solution.

QUESTIONS

- Name the enzyme present in saliva.
- What is the role of iodine solution in the experiment?
- What is an enzyme?
- What is the substance formed when iodine reacts with starch.
- Name the substrate and enzyme in this experiment.
- Why does chewing food thoroughly in our mouth helps the digestive process?
- Which one of the following is an indicator in the experiment?
  (i) starch solution; (ii) amylase; (iii) saliva; (iv) iodine solution.

Experiment 29

AIM

To determine the mass percentage of water imbibed by raisins.

THEORY

Imbibition is a special type of diffusion in which movement of water takes place due to difference in water molecule concentration between the adsorbant and the imbibant. For imbibition to occur an adsorbent is required. For example, the dry plant or dry seeds (adsorbent) when placed in water increase enormously in volume. Water molecule concentration difference between the adsorbent and the liquid imbibed is essential for imbibition. In addition, for any adsorbent to imbibe any liquid, affinity between the adsorbent and the imbibent is necessary. For example, the cellulose material of dry wood (adsorbent) has strong affinity for water (imbibent). This results in swelling of wood when kept in water. The rate of imbibition varies with the variations in temperature.

In this experiment we shall study the phenomenon of imbibition using dry raisins. Water molecules enter the dry raisins as a result of which they swell. The difference in mass between swollen and dry raisins gives the amount of water absorbed by the raisins. When expressed in terms of percentage, it is called mass percentage of water imbibed by raisins.

$$\text{Mass \% of water imbibed} = \frac{\text{mass of the water absorbed by the raisins}}{\text{initial mass of the raisins}} \times 100$$

MATERIALS REQUIRED

A handful of raisins, a beaker (50 mL), a thermometer, physical balance with weight box, a pair of forceps and a piece of blotting paper.

PROCEDURE

1. Select about twenty dry and clean raisins of approximately uniform size.
2. Weigh them using a physical balance and note their mass (m_1).
3. Keep the raisins for about an hour in sufficient water taken in a beaker. (It is expected that the raisins would be completely swollen within an hour.)
4. Note the temperature (θ)of water in the beaker.
5. Using forceps, remove the swollen raisins from the beaker; gently roll them on a blotting paper to remove the water sticking to their surface.
6. Weigh the swollen raisins to find their final mass (m_2).

OBSERVATIONS AND CALCULATIONS

Temperature of water, θ = ______ °C = ______ K

Initial mass of the twenty dry raisins, m_1 = ______ g

Final mass of the swollen raisins, m_2 = ______ g

Mass of the water absorbed by the raisins, (m_2 - m_1) = ______ g.

or

$$\text{Mass \% of water imbibed} = \frac{\text{mass of the water absorbed by the raisins}}{\text{initial mass of the raisins}} \times 100$$

$$\text{Mass \% of water imbibed} = \frac{m_2 - m_1}{m_1} \times 100$$

= _____ .

RESULTS AND DISCUSSION

The mass percent of water absorbed by the raisins at temperature ____ K is ____ %.

Analyse the reasons of water imbibed by the raisins.

PRECAUTIONS

- Ensure that the raisins are dipped in water completely.
- Remove the raisins from the beaker only after ensuring that the raisins are completely swollen. Care should be taken while taking the raisins out from the beaker while using forceps. The forceps must not pierce into the raisins.
- Before weighing the swollen raisins, they should be properly dried with the help of blotting paper.

NOTE FOR THE TEACHER

- In this study, adsorption is the process of formation of a layer of a liquid on a solid.
- In place of raisins, dry gram seeds may also be used. However, these may require more time for complete swelling.
- The mechanism by which the water enters the raisins or seeds is also called imbibition.

QUESTIONS

- Will a piece of iron also swell when it is kept in water? Justify your answer.
- Have you experienced difficulty in closing wooden doors or windows during rainy seasons? Give a suitable explanation.
- Suggest an experiment by which the swollen raisins can be shrunk again.
- In some plants seed coats are very hard and thick. How do they break before seeds germinate.
- What will happen to the shape of a grape when it is placed in a viscous sugar solution?
- What is the effect of temperature on rate of imbibition?

Experiment 30

AIM

To study the phenomenon of phototropism and geotropism in plants.

THEORY

Plant and its parts respond to various environmental stimuli like light, water, gravitational force, day-night changes, certain chemicals etc. All such responses are collectively called plant movements. Two of the most common responses are phototropism and geotropism. Phototropism refers to the response of plants to sunlight and geotropism refers to their response to gravitational force. Stems and aerial parts of plants grow towards the source of light; hence they are said to be positively (+ve) phototropic and concurrently also negatively (–ve) geotropic. Roots on the other hand grow away from light [negative (–ve) phototropism] and towards the gravitational force hence they exhibit positive (+ve) geotropism.

MATERIALS REQUIRED

Two tender undamaged and un-branched plants with roots and leaves (such as seedlings of green gram), two boiling tubes, two laboratory stands with clamps, cotton, and adhesive tape.

PROCEDURE

1. Take water in two test tubes to about two-third of their heights. Mark these test tubes as A and B.

2. Insert one plant into each test tube and introduce cotton swabs in such a way that roots dip in water and the stem with leaves project out of the test tube.
3. Seal the mouth of two test tubes using additional cotton and adhesive tape such that no water trickles out of the test tube even when they are inverted.
4. Fix tube A vertically upright in a laboratory stand as shown in Fig. 30.1(a). Fix the other test tube B upside down in another laboratory stand, as shown in Fig. 30.1(b). Ensure that the water in second tube does not trickle down.

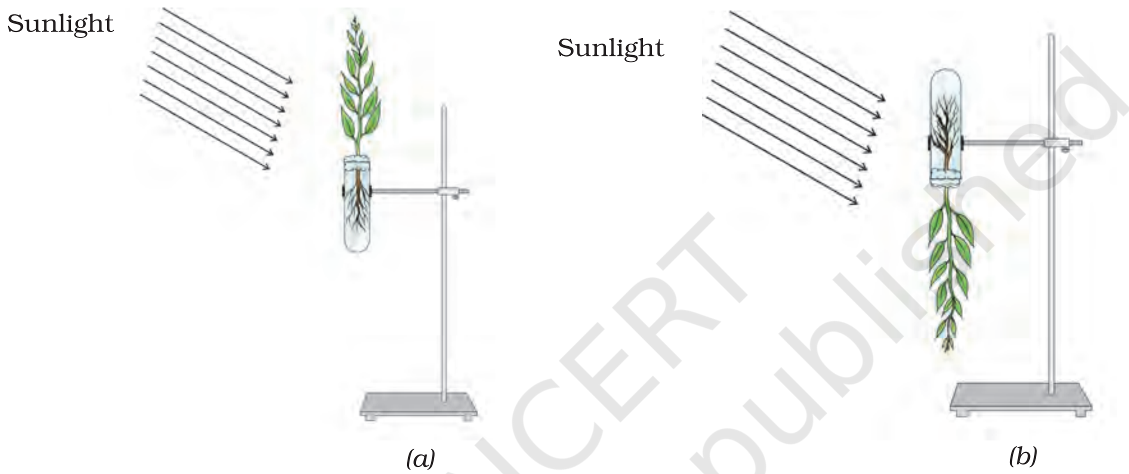


Fig. 30.1 : *The two plants in the begining of the experiment on day 1*

5. Place the two laboratory stands near a window such that direct sunlight falls on the two plants.

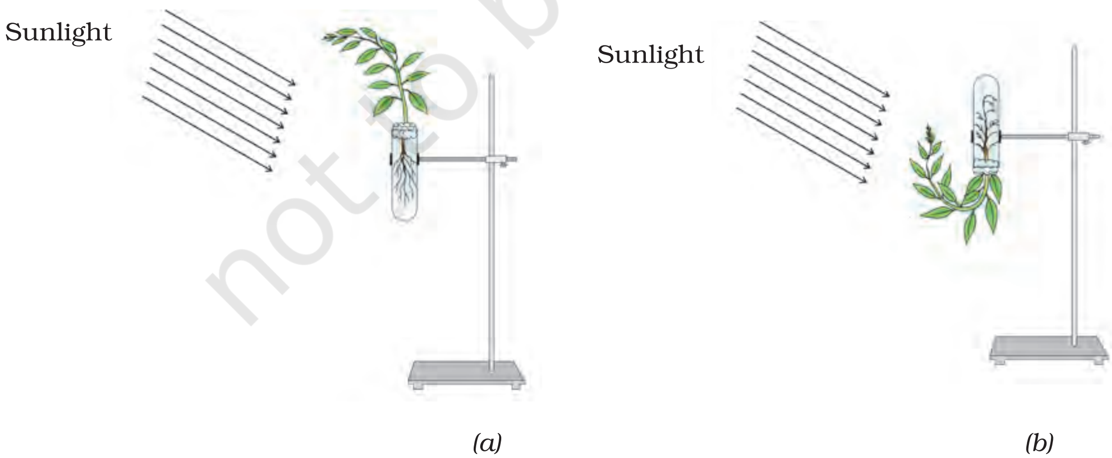


Fig. 30.2 : *The two plants at the end of the experiment on day 4 (say)*

6. Observe the plants in each test tube on day 2, day 3, and day 4. Record your observations. Note the direction of growth of stem and primary root. Indicate the features having +ve (or –ve) phototropism and +ve (or –ve) geotropism.

OBSERVATIONS

	Day 1	Day 2	Day3	Day 4
Plant in test tube A:				
Stem				
Root				
Plant in test tube B:				
Stem				
Root				

RESULTS AND DISCUSSION

- Based on the observations recorded for plants in test tubes A and B, reason out the responses of stem and root in the experiment.

PRECAUTIONS

- Select tender, un-branched herbs.
- Ensure that the roots of plants dip in water.

NOTE FOR THE TEACHER

- The stem in test tube A grows vertically upwards and bends towards the light. The stem in test tube B shows a curvature and bends upwards towards the light and away from the gravitational force, thus showing +ve phototropism and –ve geotropism. Roots in both the test tubes grow downwards thus exhibiting positive geotropism. Roots in test tube B curve and grow towards the gravitational force thus exhibiting +ve geotropism.
- Experiment can also be set up with germinating seedlings of grams. Gram seedlings (20 -30) can be grown in a pot or in a small vessel and placed near a window. The young seedlings curve towards the direction of light.
- While it is easy to observe the response of stems, it is rather difficult to observe the response of roots.

QUESTIONS

- Can a plant part be both +vely phototropic and +vely geotropic?
- What is the response of rhizome of ginger to light stimulus?
- Look at a banyan tree. Structures hang from aerial branches and grow towards the soil. Should we call these structures stem branches or roots? Explore.
- In what way does +ve geotropic response of roots help plants?

Experiment 31

AIM

To study binary fission in *Amoeba* or *Paramoecium* and budding in yeast or *Hydra*.

THEORY

Binary fission and budding are forms of asexual reproduction in lower organisms, like bacteria, unicellular protozoans, and a few other animals. In binary fission, the parent cell divides into two daughter cells by amitosis and each daughter cell grows into an adult. The division of nucleus is called amitosis because the stages of a typical mitotic divison are not observed in these cells. Budding is commonly seen in yeast and *Hydra*. *Hydra* is a tiny freshwater organism which produces young ones from its body laterally. Yeast is a unicellualr organism which produces a chain of cells attached to the parent cell.

MATERIALS REQUIRED

A compound microscope, permanent slides of binary fission in *Amoeba* or *Paramoecium*; budding in yeast or *Hydra*; charts of binary fission and budding.

PROCEDURE

1. Focus the slide under high power of compound microscope.
2. Observe the stages in binary fission and budding (Figs. 31.1 and 31.2).

3. Draw diagrams of the stages in binary fission and budding.

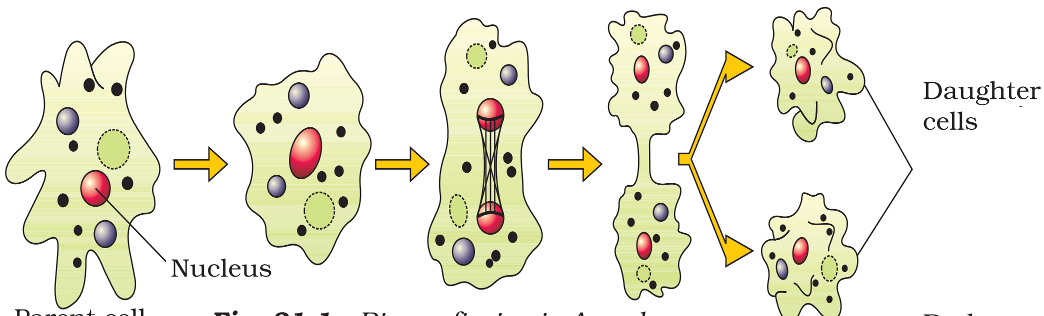


Fig. 31.1 **:** *Binary fission in Amoeba*

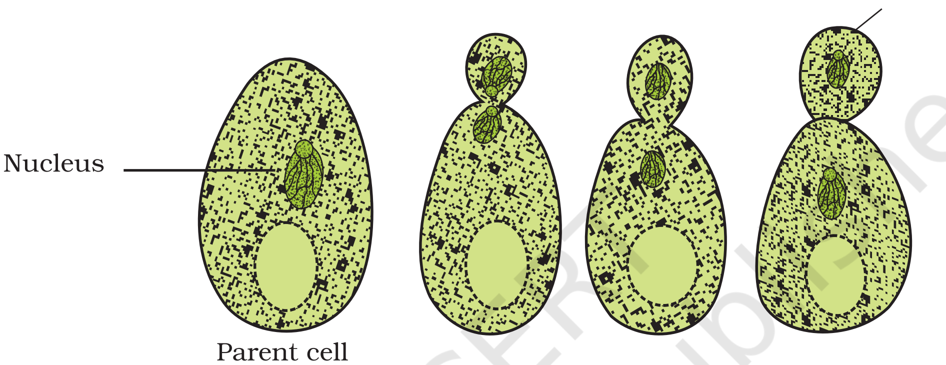


Fig. 31.2 **:** *Budding in yeast*

NOTE FOR THE TEACHER

- Charts may be used to reinforce the knowledge about different stages in binary fission and budding.
- A few points pertaining to binary fission and budding are given as follows:

  (a) Binary fission in *Amoeba* or *Paramoecium*

  (i) *Amoeba* is irregular in outline and possesses a nucleus.

  (ii) *Paramoecium* is also a unicellular organism but its shape is like a slipper.

  (iii) While viewing the permanent slide under high power, it is advised to locate and demonstrate the stages of binary fission.

  (b) Budding in yeast or *Hydra*

  (i) Yeast cells are spherical or oval in shape.

  (ii) While viewing the permanent slide under high power, it is advised to locate and demonstrate the stages of budding and chain of buds.

  (iii) In *Hydra*, buds appear laterally from the parent organism.

QUESTIONS

- Which type of cell division is involved in binary fission?
- How many daughter cells are formed in binary fission?
- Why binary fission and budding are included under asexual reproduction?
- Are binary fission and budding faster processes of reproduction when compared to sexual reproduction. Justify.

Experiment 32

AIM

To study vegetative propagation in potato, *Bryophyllum* and an aquatic plant.

THEORY

Although majority of flowering plants reproduce sexually by the production of flowers, some angiosperms reproduce by asexual methods also. Such plants produce offspring from the vegetative parts like roots, rhizome, stem and leaves. This method of reproduction is called vegetative propagation. Common examples of plants exhibiting vegetative propagation are potato, *Bryophyllum Chrysanthemum* etc. and aquatic plants like *Hydrilla*, *Eichhornia*, *Pistia* etc. Horticulturists use this method for propagation of ornamentals like *Hibiscus*, rose, *Chrysanthemum*, jasmine etc.

MATERIALS REQUIRED

Two old tubers of potato (one with shoots and another without shoots), a few mature leaves of *Bryophyllum* with young adventitious buds, aquatic plant like *Eichhornia* or *Pistia*, a hand lens (magnifying lens).

PROCEDURE

1. Examine a potato tuber carefully [Fig. 32.1(a)]. You will observe small pots or 'eyes' are actually the nodes of the stem.

2. With the help of hand lens (magnifying lens), observe each 'eye'. You will find a small adventitious bud in each eye.
3. Observe the origin of shoots from the surface of tuber. Draw sketches of a tuber without shoots and another with shoots.
4. Observe the lamina of Bryophyllum leaf, particularly the leaf margins [Fig. 32.1(b)].

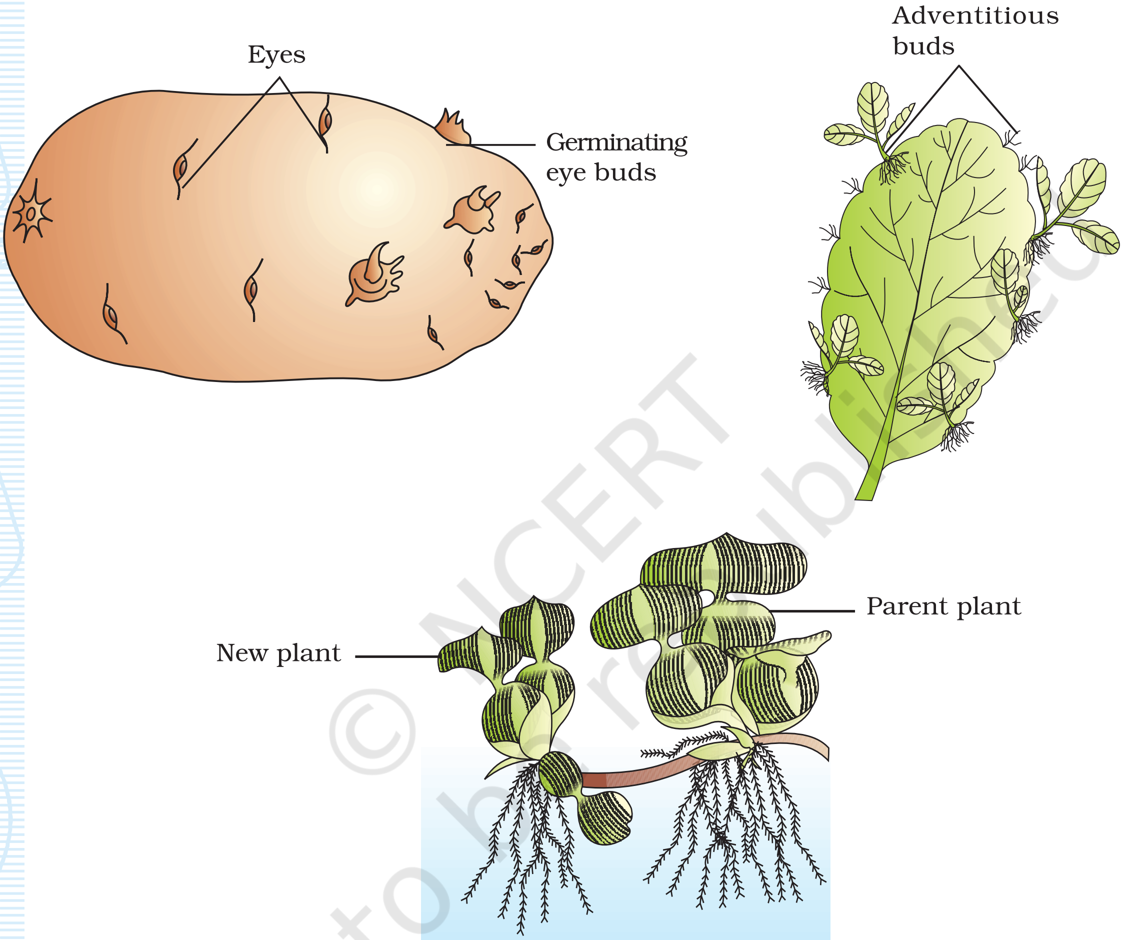


Fig. 32.1 **:** *Vegetative propagation in (a) potato; (b) Bryophyllum; and (c) an aquatic plant*

5. Tiny plants will be seen arising some notches in the margin.
6. Draw a diagram of Bryophyllum leaf with tiny plants attached to its margins.
7. Carefully observe the aquatic plant [Fig. 32.1(c)].
8. Note the formation of a new plant and the region of attachment of both plants.
9. Draw a diagram of the aquatic plant depicting the exact origin of the yound plants.

17-04-2018

OBSERVATIONS

The surface of potato tuber has several __________. New shoots arise from the __________. Potato tuber represents a modified.

The margins of Bryophyllum leaves are __________ and they bear __________. Leaf is the __________ part of a plant.

In aquatic plant, new plant arises from the portion of parent plan.

DISCUSSION

Analyse the origin of new plants in the three materials observed. Give reasons why this method of propagation is called vegetative propagation.

NOTE FOR THE TEACHER

- In the present exercise, three example are explained to understand vegetative propogation. The ability of certain plants like the ornamental plants, fruit bearing plants and plants used as vegetables to propagate vegetatively has been exploited by horticulturists, floriculturists and agriculturists.
- The most common method of reproduction in floating aquatic plants is the vegetative method. From the base of the condensed stem lateral shoots called offsets are formed. New plants arise from these offsets. This is how in a very short period of time aquatic plants multiply rapidly and cover the surface of the entire water body.
- This activity may also be considered as a project work.

QUESTIONS

- Both potato tuber and radish are underground organs. Why is the former called a stem but later called a root?
- Can a vegetatively produced plant be called a clone? Analyse.
- Find out the method of propagation in banana, sugarcane, and ginger.

Experiment 33

AIM

To study the parts of a flower and their role in sexual reproduction.

THEORY

Flower is a sexual reproductive part of angiosperms. A typical flower consists of four parts, namely sepals, petals, stamens and carpels. Collectively, sepals and petals constitute *Calyx* and *Corolla,* respectively. Likewise, stamens and carpels (or pistil) constitute *androecium* and *gynoecium,* respectively. Calyx and corolla are called accessory parts of the flower while andoecium and gynoecium are called the reproductive parts. Stamens are the male reproductive organs where pollen grains are formed and carpels are the female reproductive parts, which enclose the ovules.

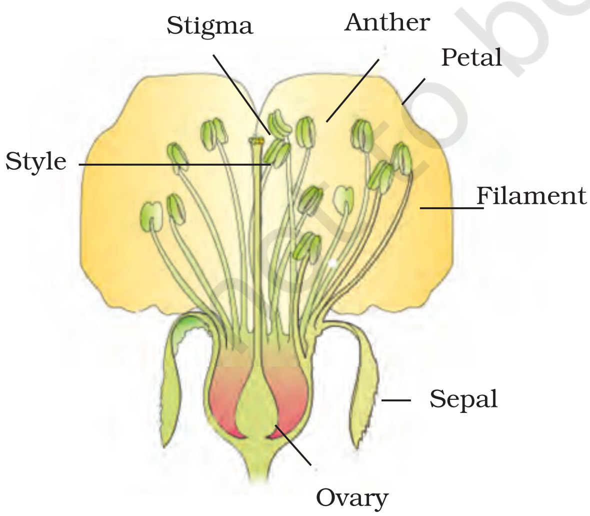


Fig. 33.1 : *Longitudinal section of a flower*

All floral parts are inserted on the thalamus which is a flattened or knob like structure of the stalk of flower (pedicel). Floral parts are present in successive whorls, sepals form the outer most whorl followed by petals, stamens and carpels.

Flowers show lot of variation in their shape, size, colour, number of sepals, petals,

17-04-2018

stamens and carpels. Various scientific terms are used to describe the stucture of a flower. A short list of terms is provided here. The students are required to understand the definition of these terms before describing a flower.

Materials Required

Flowers of china rose, *Datura*, mustard, *Petunia* or *Dianthus*, charts of transverse sections of anther and ovary, permanent slides of the flowers chosen, dissection microscope, beaker, forceps, needle, slides, razor blade, and cover slips.

Procedure

1. To prevent drying of flowers, keep the twigs in a beaker containing water.
2. Examine the position of flower on the twig. Determine whether it is axillary or terminal; solitary or an inflorescence.
3. Study the following characters of the flower and record the features:
   (a) Flower *pedicellate* (with stalk) or *sessile* (without stalk).
   (b) Complete – a flower with sepals, petals, stamens and carpels. Incomplete – a flower which lacks one or more floral whorls.
   (c) Unisexual – a flower with only stamens or carpels.
   bisexual – a flower with both stamens and carpels.
   (d) Sepals (calyx), Fig. 33.2(a): They form the outer whorl of the flower. They are small, green leaf like structures. In some flowers sepals may be coloured. Count the number of sepals; observe their colour; find out whether the sepals are free (polyseplous) or fused (gamoseplous).
   (e) Petals (*corolla*), Fig. 33.2(b): Count the number of petals; observe their colour and shape; find out whether petals are free (polypetalous) or fused (gamopetalous).
   (f) Stamens (*Androecium*), Fig. 33.2(c): Mount one stamen on the stage of the dissecting microscope and observe its various parts such as a stalk (short or long) called the filament, and a terminal bi-lobed anther.
   (g) Pistil (Gynoecium), Fig. 33.2(d): Mount the pistil on the stage of the dissecting microscope and observe its various parts such as the basal swollen portion (ovary), a *style* and a flattened tip, the *stigma*. Inside the ovary are one or more ovules attached to a flattenned cellular cushion known as *placenta*.
4. Cut a cross section of the anther. Mount the section in a drop of water taken on a slide. Observe it under the dissecting microscope.

Locate pollen grains in the slide and the cavities in anther called pollen sacs.

5. Cut a cross section of ovary, mount the section in a drop of water taken on a slide. Observe it under the dissection microscope. Count the number of chambers (locules) and locate ovules.
6. Draw diagrams of a flower showing sepal, petal, stamen and pistil.
7. Observe the permanent slides of transverse sections of anther and ovary. Identify diferent parts using the charts provided. Draw their diagrams in your notebook.

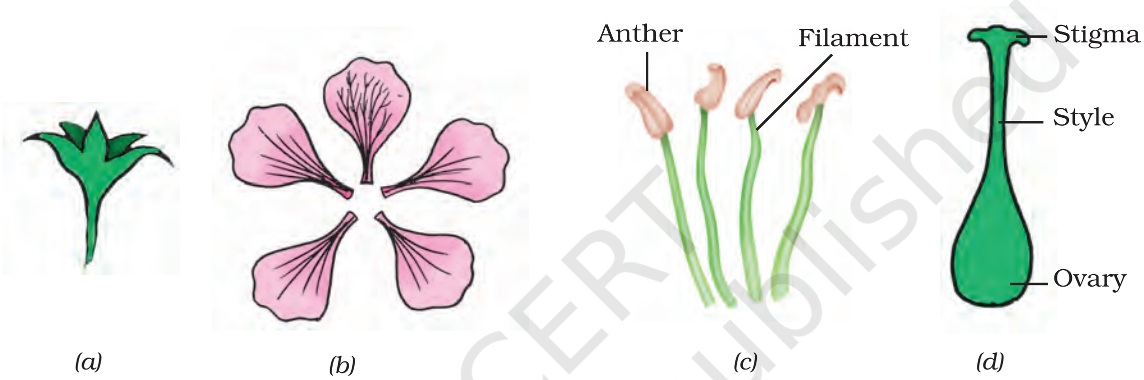


Fig. 33.2 : *(a) Sepals (calyx); (b) Petals (corolla); (c) Stamens (Androecium); and (d) Pistil (Gynoecium)*

OBSERVATIONS

Table 1

Flower	Observations
Solitary or inflorescence Axillary or terminal Pedicellate or sessile Complete or incomplete Unisexual or bisexual	

Table 2

	Number	Colour	Free/fused
Sepals			
Petals			
Stamens			
Pistil			

Note for the Teacher

- The purpose of this experiment is to observe the flower as a sexual reproductive part. Hence taxonomic description is kept minimum.
- Emphasis should be more on the stamen and pistil, their parts and the role in sexual reproduction.
- It is advised to show pollen grains and ovules to the students by making temporary mounts of these materials. Their role in sexual reproduction may also be discussed.
- If fruits and seeds are available, a seed can be cut open and its embryo may be mounted on a slide and demonstrated.

Questions

- Does a plant produce as many fruits as the number of flowers it produces?
- Why does a flower produce thousands of pollen grains but only a few ovules?
- What is the function of coloured petals in a flower?
- Why are stamens and pistil called the essential parts of a flower?

UNIT III

The Natural Phenomenon

Experiment 34

AIM

To verify the laws of reflection of light using a plane mirror.

THEORY

When light falls on a smooth polished surface, it gets reflected in a definite direction. Fig. 34.1 shows a ray of light PO, incident on a plane polished surface (plane mirror) SS'. Line OQ shows the changed path of the incident ray after reflection at the point O. The ray PO is called *incident ray* and ray OQ is called *reflected ray*. The point O where the incident ray strikes the polished surface is called *point of incidence*. If ON be the normal to the polished surface SS′ at point O, then the angle PON and the angle NOQ are called the *angle of incidence* (*i*) and the *angle of reflection* (*r*) respectively. The plane containing the incident ray and normal is called *plane of incidence*.

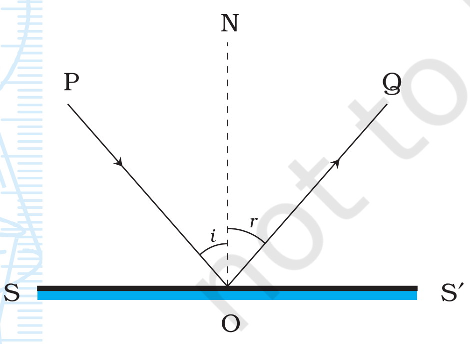


Fig. 34.1 : *Reflection of a ray of light*

The laws of reflection as deduced from the experiments states that the reflected ray lies in the plane of incidence along with the normal at the point of incidence, and $\angle i = \angle r$.

Materials Required

A plane mirror with a support to hold it vertical, a drawing board, sheet of white paper, protractor, measuring scale, pins, drawing pins or adhesive tape.

Procedure

1. Fix a white sheet of paper on the drawing board using either adhesive tape or drawing pins.
2. Draw a thin line SS′ in the middle of the paper. Also draw a normal ON to the line SS′ at point O as shown in Fig. 34.2.
3. Draw a thin line PO at any angle to the line SS′. Place the mirror vertically on line SS′ with the help of a support so that its polished surface faces line PO.
4. Vertically fix two pins P_1 and P_2 with their tips, separated by a suitable distance of about 5 to 6 cm at two points on line PO. Look at the images P'_1 and P'_2 of pins P_1 and P_2 respectively from the same side of the plane mirror.
5. Fix two pins P_3 and P_4, vertically such that their feet appear to be in the same straight line as that of images P'_1 and P'_2. Look through the feet of pins P_1 and P_2, whether the feet of images (not shown in the Fig. 34.2 of pins P_3 and P_4, as seen in the mirror appear to be on the same straight line. If it is so, you have correctly fixed the pins P_3 and P_4.
6. Remove all the pins and the mirror. Mark the positions of feet of pins P_3 and P_4. Draw a thin line OQ joining the points that mark the position of feet of pins P_3 and P_4. Also extend this line till it meets the line SS¢. This extended line should meet the surface SS¢ at the point O. The line OQ shows the path of the reflected ray corresponding to the incident ray along the line PO, at the point of incidence.

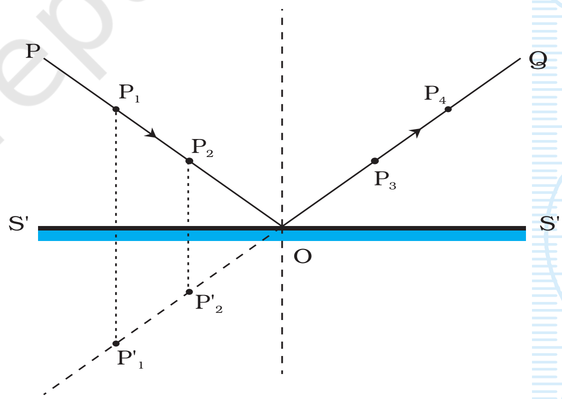


Fig. 34.2 : *Verification of laws of reflection*

7. Measure angles PON ($\angle i$) and NOQ ($\angle r$) and record the values in observation table.
8. Repeat the experiment for two more angles of incidence.

Observations and Calculations

Sl.No.	Angle of incidence	Angle of reflection	Difference
	$\angle i = \angle PON$	$\angle r = \angle NOQ$	$\angle i \sim \angle r$
1.			
2.			
3.			

Results and Discussion

1. Does the reflected ray meet the point of incidence for all angles of incidence? Does the reflected ray lie in the plane of incidence? Explain on the basis of your observations.
2. Is the angle of incidence equal to the angle of reflection in each case? If not, is the difference between the two very large?
3. As $\angle i = \angle r$, and the incident ray, normal and the reflected ray lie in the same plane, laws of reflection are verified.

Precautions

- Plane mirror must be placed vertically on the plane of paper.
- Mirror should be made of thin glass with a smooth surface (Why? Otherwise many images may be formed due to multiple reflections). It should be of good quality with good reflecting surface.
- The pins P_1, P_2, P_3. and P_4 fixed on the paper may not be exactly perpendicular (or vertical) to the plane of paper, Thus, if their feet are collinear, their heads may not appear to be collinear. Therefore while marking the position of the pins on paper, the positions of their feet should be considered for drawing the lines to show the path of incident and the reflected rays. It is done by marking the position of the holes made by the pins.
- While fixing the pins to mark the reflected ray by viewing the images of pins fixed on the path of the incident ray, the eye must be kept at a distance from the pins so that feet of all of them can be simultaneously seen clearly.
- The distance between P_1 and P_2; and P_3 and P_4 should not be less than about 5 to 6 cm so that the direction of incident ray and reflected ray can be located with a greater accuracy.

- The eye should be kept at such a postion that the distance between the image of the pins and eye is at least 25 cm. Also, while observing the image clearly, one eye should be closed.
- All lines drawn must be thin. A pencil with sharp tip must be used for this purpose.
- The angles should be measured accurately by keeping the eye normally above the marking on the protractor.

Note for the Teacher

- In case if the mirror strip being used in this experiment is thick, one may find that the incident ray and reflected ray do not meet at the same point O on line SS′. This is because of the formation of multiple images due to multiple reflection. It is therefore strongly adivsed that a thin glass sheet must be used in this experiment. However, it is ideal to use a front-coated mirror.
- The surface irregularities in glass may cause error. For example, the angles of incidence and reflections may not appear to be equal. It is necessary that the mirror strip must be made up of very good quality glass.

Questions

- Why do we prefer a thin mirror strip to verify the laws of reflection?
- Can you obtain the image of a lighted candle placed in front of a plane mirror on a screen? Justify your answer.
- If the incident ray is perpendicular to the plane mirror, what will be the angle of reflection?
- An incident ray is reflected backwards along the same path, from a plane mirror. What is the angle of incidence?
- A pin is fixed at a distance of 5 cm in front of a plane mirror. Where and at what distance will the image be formed?

Experiment 35

AIM

To draw the images of an object, formed by a concave mirror, when the object is placed at various positions.

THEORY

A concave mirror (a spherical mirror), like a plane mirror obeys the laws of reflection of light. The nature, position and relative size of the images, formed by a concave mirror, of an object placed at various positions depend on the position of the object with respect to the pole of the concave mirror. The formation of images by a concave mirror can also be studied by drawing ray diagrams, using the new cartesian sign convention (Fig. 35.1).

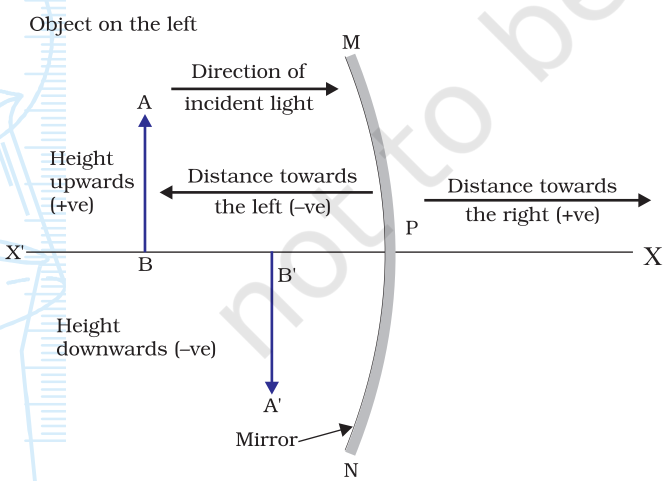


Fig. 35.1 : *The New Cartesian Sign Convention for spherical mirrors*

In this convention, the pole (P) of the mirror MN is taken as the origin and its principal axis as the x-axis (X'X) of the coordinate system. According to this convention: (i) The object is always placed to the left of the mirror. This implies that the light from the object falls on the mirror from the left-hand side; (ii) All distances parallel to the principal axis are measured from the pole of the mirror; (iii) All distances measured to the right of the origin (that is along the +x-axis) are taken as positive while those measured to the left of the origin (that is along the –x-axis) are taken as negative; (iv) Distances measured perpendicular to and above the principal axis (that is along the +y-axis) are taken as positive; and (v) Distances measured perpendicular to and below the principal axis (that is along the –y-axis) are taken as negative.

For an extended object AB of finite size, placed in front of a concave mirror, its each small portion is assumed to act like a point source. An infinite number of rays of light originate from each of these point sources which could be considered for drawing the ray diagrams in order to locate the image of object AB. For the sake of clarity of the ray diagram, only two rays are considered and so chosen as to know their directions easily after reflection from the concave mirror. Fig. 35.2 illustrates the ray diagrams for the path of incident rays after reflection from the concave mirror. The intersection of at least two reflected rays give the position of image of the point object. Any two of the following rays can be considered for locating the image by a concave mirror:

(i) A ray parallel to the principal axis, after reflection, will pass through the principal focus F [Fig. 35.2(a)].

(ii) A ray passing through the principal focus F of a concave mirror, after reflection, will emerge parallel to the principal axis [Fig. 35.2(b)].

(iii) A ray passing through the centre of curvature C of a concave mirror, after reflection, is reflected back along the same path [Fig. 35.2(c)]. The light rays come back along the same path because the incident rays fall on the mirror along the normal to the reflecting surface.

(iv) A ray incident obliquely to the principal axis, towards a point P (pole of the mirror), on the concave mirror [Fig. 35.2(d)], is reflected obliquely. The incident and reflected rays follow the laws of reflection at the point of incidence (point P), making equal angles with the principal axis.

Neat ray diagrams can be drawn for various positions of an object in front of a concave mirror, using the new cartesian sign convention (Fig. 35.1) and convenient rays for locating

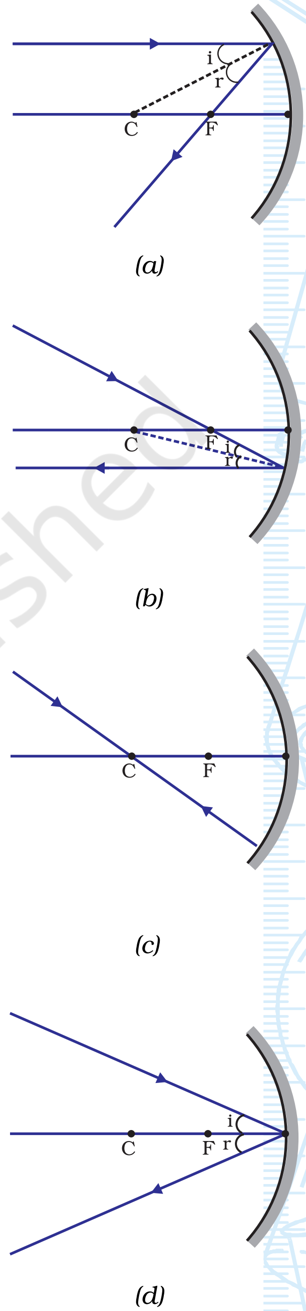


Fig. 35.2 : *Any two of the above rays can be considered for locating the image formed by a concave mirror*

the image (Fig. 35.2). It may be considered that the concave mirror is thin and that it has a small aperture (Is it necessary?). The nature, position and relative size of the image formed in each case may then be determined.

Normally the spherical mirrors used in school laboratories are polished at the back of a thin transparent glass strip.

MATERIALS REQUIRED

Drawing board, measuring scale, white paper, a pair of compassess, protractor, drawing pins or adhesive tape.

PROCEDURE

1. Fix a white sheet of paper on a drawing board with the help of adhesive tape or drawing pins. At the centre of the white sheet, draw a thin line CP of about 10 - 12 cm length.
2. Place the tip of the compass at point C and draw an arc to represent a concave mirror MM′ as shown in Fig. 35.3(a). Here, C represents the centre of curvature, point P the pole, and distance CP the radius of curvature *R* of the concave mirror.
3. Draw rays from a distant object AB assumed to be placed at infinity in Fig. 35.3(a). Draw two lines, representing incident rays with arrows

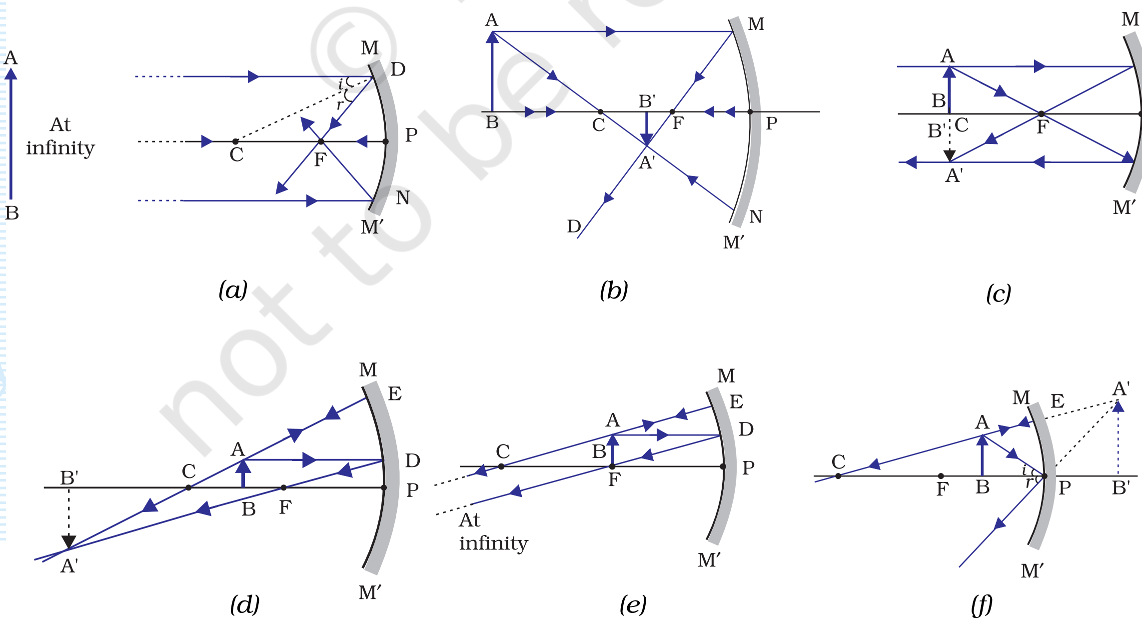


Fig. 35.3 : *Ray diagrams for the image formation by a concave mirror*

(to show the direction of the ray), on the surface of the concave mirror MM′ at points of incidence D and N respectively.

4. Join points D and N to point C by a dotted straight line. Then, lines CD and CN are normal to the curved surface MM′ at the points D and N respectively. Here ∠ADC = ∠BNC = ∠*i*, the angle of incidence at points D and N. Measure these angles of incidence in each case.
5. The incident light rays AD and BN will be reflected by the mirror MM′ at angles equal to angles of incidence (= ∠*i*) at points D and N. For this, draw a line DF with an arrow, meeting the principal axis at F, such that ∠CDF equals to ∠ADC. The ∠CDF is the angle of reflection at the point D (that is, ∠CDF = ∠*r*). Similarly, draw a line from the point N, meeting the principal axis at a point, such that the angle of reflection for the incident ray BN with the normal CN is equal to ∠BNC (= ∠*i*). Does this reflected ray from point N also meet the principal axis at point F? If so, draw the line NF (as the reflected ray) and mark ∠CNF = ∠*r*, the angle of reflection at the point of incidence N. Then, the point F is the principal focus of the concave mirror.
6. Measure the lengths CF and FP. Is CF = FP? (Ideally, the point F must lie mid-way between the points C and P.)
7. Draw a line CP with an arrow to represent the incident ray falling normally on the mirror MM′ at the pole of the mirror, P. This ray, after reflection, will pass through the principal focus F. Draw the line PC with an arrow at the point of incidence P. In this situation, the reflected ray PC retraces its path in opposite direction to the incident ray.
8. The reflected rays DF, NF, and PC meet at the principal focus F. Thus the image of the distant object AB (placed at infinity) is formed at the point F, as shown in Fig. 35.3(a).
9. Repeat the above steps, using the New Cartesian Sign Convention (Fig. 35.1) and considering relevant rays for locating the image. Draw neat ray diagrams for each position of the object placed beyond the centre of curvature C [Fig. 35.3(b)]; at the centre of curvature C [Fig. 35.3(c)]; between the centre of curvature C and principal focus F [Fig. 35.3(d)]; at the principal focus F [Fig. 35.3(e)]; and between the pole P and the principal focus F [Fig. 35.3(f)].
10. Measure the height h and h', using the scale, of the object AB and its image A′B′ respectively, formed by the concave mirror MM′ in the ray diagram drawn in each case of Figs. 35.3(b) to (f). Record them in the observation table.
11. Describe the nature, postion and relative size of the image, formed

by the concave mirror, of the object placed at various positions. Tabulate the results in the observation table.

Observations, Results and Conclusions

Formation of image of an object placed at different location/position in front of a concave mirror as illustrated in ray diagrams in Fig. 35.3:i.

Sl. No.	Ray diagram	Position of the object	Position of the image	Nature of the image	Size of the object h (cm)	Size of the image h' (cm)	Magnification (h'/h)
1.	(a)	At infinity	At the focus, F	Real and inverted			
2.	(b)	Beyond C	Between F and C	Real and inverted			
3.	(c)	At C	At C	Real and inverted			
4.	(d)	Between C and F	Beyond C	Real and inverted			
5.	(e)	At F	At infinity	Real and inverted			
6.	(f)	Between P and F	Behind the mirror	Virtual and erect			

Precautions

- Use a sharp tip pencil to draw the thin lines to represent incident and reflected rays, and also all other lines.
- Measure the angles of incidence and reflection, using protractor of very good quality with clear markings.
- The tip of a pair of compasses should be sharp for drawing the concave mirror.
- The concave mirror drawn should be thin and of small aperture and sufficiently large radius of curvature for locating a distinct image.

NOTE FOR THE TEACHER

- The position F of a concave mirror should not be marked mid-way between C and P in a ray diagrams illustrated in Fig. 35.3 (Why?). Its position on the principal axis should be found, using the laws of reflection of light.
- The ray diagrams for the formation of image of an object by a concave mirror can also be drawn on a graph paper. This might facilitate students in making all measurements.

QUESTIONS

- Sometimes the image formed by a concave mirror of an object placed at C is not of the same size and at location C. What could be the possible reason(s) for such a situation?
- In what way will the position and size of the image affected if the pencil used for drawing ray diagrams is not sharp and thin?
- What is the advantage of joining the point C with the point of incidence D, while drawing ray diagrams for the image formation by a concave mirror?

Experiment 36

AIM

To determine the focal length of a concave mirror by obtaining image of a distant object.

THEORY

A concave mirror, like a plane mirror, obeys the laws of reflection of light. The rays of light coming from a distant object such as the sun (or a distant

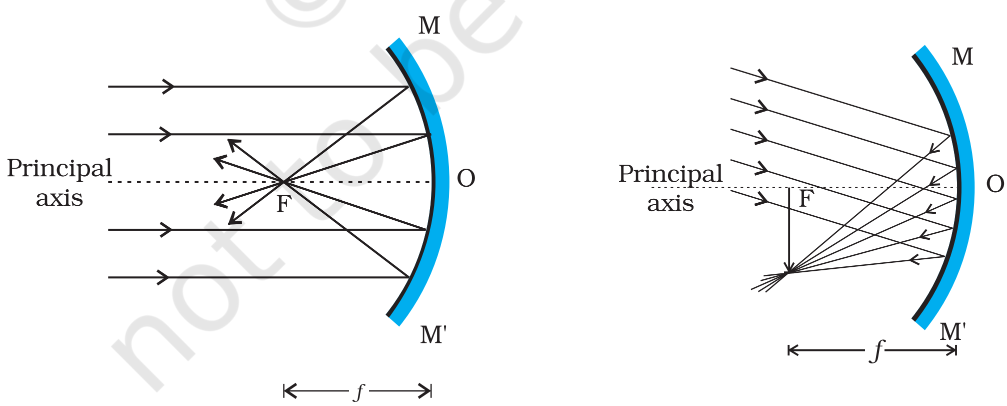


Fig. 36.1 : *Image formation of a distant object by a concave mirror*
(a) incident parallel rays of light are parallel to the principal axis
(b) incident parallel rays of light are not parallel to the principal axis

tree or a distant building) can be considered to be parallel to each other. When parallel rays of light fall on a concave mirror along its axis, the rays meet at a point in front of the mirror after reflection from it. This point is the focus of the mirror. For a parallel beam of light coming from a distant object, a real, inverted and very small image size is formed at the focus of the mirror [Fig. 36.1(a)]. Since the image formed by the mirror is real, it can be obtained on a screen. The distance between the pole O of the concave mirror and the focus F is the focal length of the concave mirror. Thus, the focal length of a concave mirror can be estimated by obtaining a real image of a distant object at its focus.

MATERIALS REQUIRED

A concave mirror, a mirror holder, a small screen fixed on a stand, and a measuring scale.

PROCEDURE

1. Fix a concave mirror in the mirror holder and place it on the table near an open window. Turn the face of mirror towards a distant object (a tree or an electricity pole or a distant building).
2. Place the screen fitted to a stand in front of the concave mirror. Move the screen back and forth until a sharp, clear and inverted image of the distant object is formed on it (Fig. 36.2). A clear and bright image could be obtained if the distant object, say a tree or a building, is illuminated with sunlight and the screen is placed in the shade. A bright image of the sun could also be obtained if the sunlight is made to fall directly on the concave mirror.
3. Mark the position of the centre of the stand holding the mirror and the screen when a sharp image of the distant object has been obtained on the screen. Measure the horizontal distance between the centre of the concave mirror and the screen with the help of a measuring scale. Record your observations in the observation table.

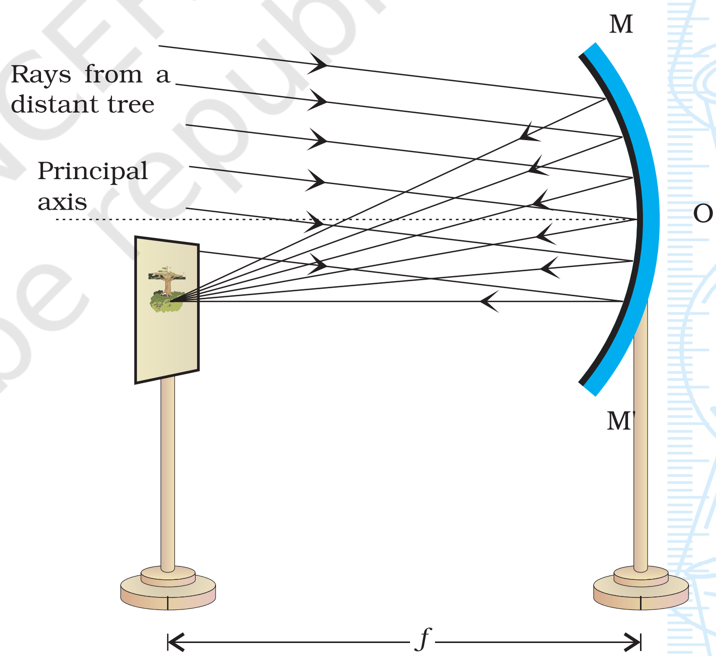


Fig. 36.2 : *Determination of focal length of a concave mirror*

4. Repeat the experiment two more times by obtaining the images of two different distant objects. Measure the distances between the concave mirror and the screen in each case. Record them in the observation table.
5. Find the mean value of the focal length.

Observations and Calculations

Sl. No.	Name of the distant object	Distance between the concave mirror and the screen, f		Mean focal length of the concave mirror, f
		(cm)	(m)	(m)
1.				
2.				
3.				

Results and Discussion

The approximate value of focal length of the given concave mirrror is ____ m.

Precautions

- Concave mirror should be placed near an open window through which sufficient sunlight enters, with its polished surface facing the distant object.
- There should be no obstacle in the path of rays of light from the distant object, incident on the concave mirror.
- The image of the sun should be focussed only on the screen. The image of sun should never be seen directly with the naked eye. Sunlight should never be focussed with a concave mirror on any part of the body, paper or any inflammable materials, as it could be dangerous to do so.
- In order to obtain a sharp and clear image of the distant object on the wall/ground, it must be ensured that the object is well illuminated so that amount of light incident on the concave mirror is suffiecient to produce a well illuminated and distinct image.
- The base of the stands of the concave mirror and screen should be parallel to the measuring scale.
- The mirror holder along with the mirror should be kept perpendicular to the measuring scale for precise measurements.

Note for the Teacher

- Use the concave mirror with focal length preferably between 15 cm to 20 cm.
- A distant object does not necessarily mean a very far off object, like a building or a tree or an electricity pole. A well illuminated window or a glowing bulb at a distance of about 10 to 15 m away, even within the science laboratory, may also be taken as a distant object. Why?

Questions

- How will you distinguish between a concave and a convex mirror?
- To detemine the focal length of a concave mirror, a student focuses a classroom window, a distant tree and the sun on the screen with the help of a concave mirror. In which case will the student get more accurate value of focal length?
- What will be the nature of image formed by a concave mirror for a distant object?
- In reflector type solar cookers, special concave (parabolic) mirrors are used. In such cookers, what should be the preferable position of food vessel for cooking?
- What type of mirror is used in a torch? Give reasons.
- What type of mirror is used as shaving mirror or in vanity boxes?

Experiment 37

AIM

To study the formation of an image of a lighted candle by a concave mirror, when placed slightly beyond the centre of curvature.

THEORY

The position, nature and size of the image of an object formed by a concave mirror can be studied, using new cartesian sign conventions and drawing ray diagrams. The ray diagrams for obtaining image formed by a concave mirror of an object when placed at various positions are given in Experiment 35. The position, nature, and size of the image formed depend on the position of the object with respect to the pole P of the concave mirror MM′.

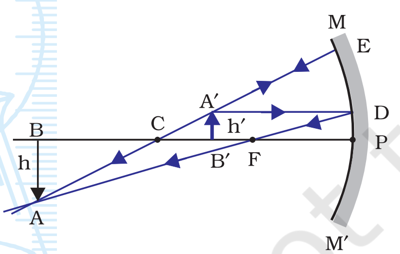


***Fig. 37.1** : Formation of an image A′B′ formed by a concave mirror MM′ (having focal length f and radius of curvature R), when the object AB is placed at slightly beyond the centre of curvature C: A real, inverted and diminished image A′B′ lies between the centre of curvature C and principal focus F*

Fig. 37.1 summarises the formation of image of an object AB formed by a concave mirror when the object is placed slightly beyond the centre of curvature C.

A real, inverted image can be obtained on a screen. The image of the flame of a lighted candle placed beyond the centre of curvature of a concave mirror can also be focused and obtained on the screen. The nature, position, and size of the image and the flame (object) can be noted and measured from pole P of the concave mirror.

Materials Required

A concave mirror, a mirror holder (or a stand), a small rice paper screen fixed to a stand, a measusring scale, a small candle with stand, and a match box.

Procedure

1. Hold concave mirror in hand and determine the approximate focal length *f* of the concave mirror by obtaining sharp image of a distant object (such as the sun or a tree or an electricity pole or a building) on a wall or a screen and measuring the distance between the image and the concave mirror. (This method is explained in detail in Experiment 36) Record it in the observation table. The radius of curvature *R* of the concave mirror may be taken as twice of its focal length *f*.
2. Fix the concave mirror vertically in the mirror holder (or stand) and place it on one side edge of the table. Note and record the position of the concave mirror in the observation table.
3. Mount a small candle vertically on a stand and light it. Place it in front of the concave mirror on the left hand side (Fig. 37.2). Adjust the height of the centre of the concave mirror nearly equal to the height of the flame of the candle. Here we consider the flame to be the object AB. Measure and record the height *h* of the candle flame. (It is important that the flame must not flicker. This will ensure the height *h* of the flame uniform throughout the experiment. Switch off the fans such that wind does not disturb the flame. Perform the experiment at a dark place.)

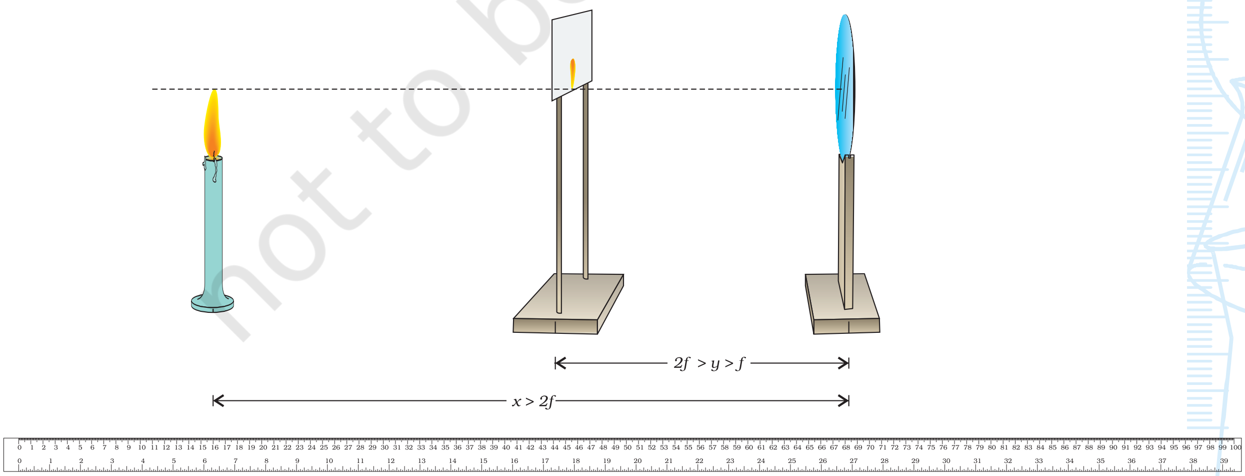


Fig. 37.2 : *Locating the image of a lighted candle flame placed beyond the centre of curvature of a concave mirror*

4. Place the lighted candle in front of the concave mirror MM′ beyond its centre of curvature C (Fig. 37.2). Note and record the position of the candle. Find the distance, x (say) between the pole P of the mirror and candle flame (object). Here $x > 2f$.
5. Place the rice paper (or semi-transparent) screen, fitted to a stand between the centre of curvature C and focus F of the mirror (see Fig. 37.2). The lower level of the screen must be so arranged that it remains just above the principal axis of the mirror. It is suggested to prepare a screen as shown in Fig. 37.2.
6. To locate a sharp image A′B′ of candle flame, adjust the position of the screen. Note and record the position of the screen. Find the distance between the pole P of the mirror and the screen, y (say). Here $2f > y > f$. Also measure and record the height h' of the image of the candle flame obtained on the screen.
7. Repeat the experiment two more times by slightly changing x by changing the position of either the concave mirror or the lighted candle. Locate the sharp image of the flame and record the position and height of the image in each case.

Observations and Calculations

Approximate focal length of the concave mirror, f = ____ cm.

Height of the candle flame, h = ____ cm.

Nature of the image: ________________ .

Sl. No.	Position of the pole P of mirror,	Position of the flame,	Position of the screen,	Distance between pole P and flame,	Distance between pole P and screen,	Size of the image,	Magni-fication
	c	l	s	$x = l - c$	$y = s - c$	h'	(h'/h)
	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)	
1.							
2.							
3.							

Results and Discussion

On the basis of your observations, answer the following:

- What is the position of image (screen) with respect to the concave mirror when the object (the flame of the lighted candle) is placed beyond the centre of curvature? Is the distance of the screen from the concave mirror is less than, more than, or equal to the radius of curvature R (=2f)?

- Is the size of the image of the candle flame less than, more than, or equal to the size of the candle flame (object)? Interpret the result in terms of the magnification produced by the concave mirror.
- What is the nature of the image obtained on the screen? Is it real or virtual? Is it inverted or erect? Is it magnified (enlarged) or diminished?

Precautions and Sources of Error

- For obtaining distinct and sharp images of the candle flame, it is preferable to perform this experiment in a dark room or at least in shade where no direct light reaches the working table.
- To avoid the flickering of the candle flame, perform this experiment in a room with calm air. Switch off the fan while performing this experiment.
- While finding out the approximate value of the focal length *f* of the concave mirror by using sunlight, do not look at the image directly with the naked eye, otherwise it might damage the eyes.
- The concave mirror should be thin and of good quality polished surface.
- The aperture of the concave mirror (diameter of its reflecting surface) should be small for obtaining a distinct image.
- The eye should be placed at a distance of at least 25 cm from the image formed by the concave mirror on the screen.
- The base of the stands of the concave mirror and screen should be parallel to the measuring scale.

Note for the Teacher

- Experiment 35 titled "*To draw the images of an object formed by a concave mirror when placed at various positions*" aims to learn qualitatively about the formation of images of an object and good to do before this experiment to practise. It is therefore advised that students are suggested to this activity first.
- A semi-transparent rice paper screen is good to use in this experiment. A screen may also be prepared by spreading few drops of an edible oil on a paper.
- The focal length of the concave mirror must preferably be between 15 cm and 20 cm.
- This method gives a rough and intuitive description for locating the image formed by the concave mirror.

QUESTIONS

- How will you distinguish between a concave mirror and a convex mirror by holding in hand and looking into them successively?
- In what way will the image of the lighted candle be affected when the experiment is performed in a bright light area and on a windy day?
- A distinct image of the lighted candle has been obtained on screen with fixed position using a concave mirror. Why does the image of the candle becomes blurred if the position of any one of them is slightly disturbed?
- What effect do you expect if the mirror is thick?
- Normally the mirrors used in school laboratories are polished back on a thin glass sheet. If the mirror is front polished, what effect do you expect in this experiment?
- Why is it preferred to perform this experiment in dark or in shade?
- Why do we require a calm atmosphere to perform this experiment?

Experiment 38

AIM

To study the formation of an image of a lighted candle by a concave mirror, when placed between the centre of curvature and the principal focus.

THEORY

The position, nature and size of the image of an object formed by a concave mirror can be studied, using new cartesian sign conventions and drawing ray diagrams. The ray diagrams for obtaining image formed by a concave mirror of an object when placed at various locations position are given in Experiment 35. The position, nature, and size of the image formed depend on the position of the object with respect to the pole P of the concave mirror MM′.

Fig. 38.1 summarises the formation of image of an object AB formed by a concave mirror when the object is placed between the centre of curvature C and focus point F of the concave mirror.

A real, inverted image can be obtained on a screen. The image of the flame of a lighted candle placed between the centre of curvature and focus of a concave mirror can also be focused and obtained on the screen. The nature, position, and size of the image and the flame (object) can be noted and measured from pole P of the concave mirror.

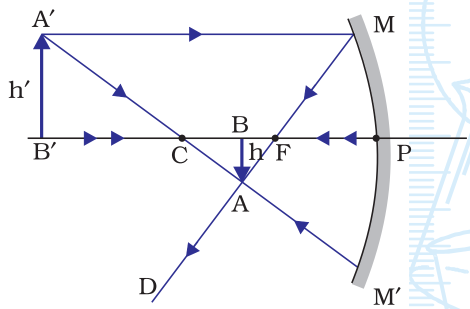


***Fig. 38.1** : Formation of an image A′B′ formed by a concave mirror MM′ (having focal length f and radius of curvature R), when the object AB is placed between the centre of curvature C and focus point F: A real, inverted and larger size image A′B′ lies beyond the centre of curvature C*

Materials Required

A concave mirror, a mirror holder (or a stand), a small rice paper screen fixed to a stand, a meter scale, a small candle with stand, and a match box.

Procedure

1. Hold the concave mirror and determine the approximate focal length *f* of the concave mirror by obtaining sharp image of a distant object (such as the sun or a tree or a building) on a wall or a screen and measuring the distance between the image and the concave mirror. (This method is explained in detail in Experiment 36.) Record it in the observation table. The radius of curvature *R* of the concave mirror may be taken as twice of its focal length *f*.
2. Fix the concave mirror vertically in the mirror holder and place it on one side edge of the table. Note and record the position the concave mirror in the observation table.
3. Mount a small candle vertically on a stand and light it. Place it in front of the concave mirror on the left hand side (Fig. 38.2). Adjust the height of the centre of the concave mirror nearly equal to the height of the flame of the candle. Here we consider the flame to be the object AB. Measure and record the height *h* of the candle flame. (It is important that the flame must not flicker. This will ensure the height *h* of the flame uniform throughout the experiment. Switch off the fans so that wind does not disturb the flame. Perform the experiment at a dark place.)

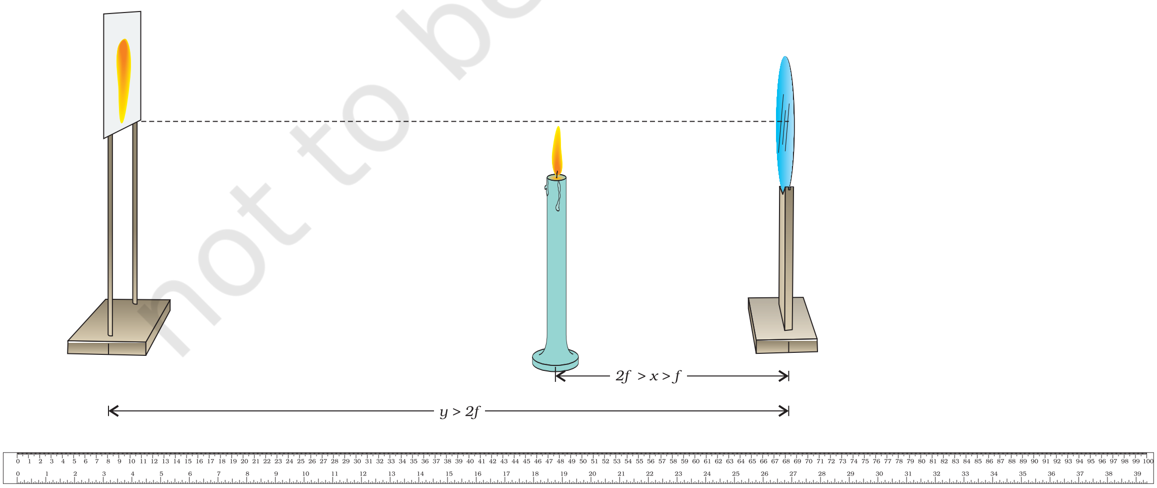


Fig. 38.2 : *Locating the image of a lighted candle flame placed in between the centre of curvature and focus of a concave mirror*

4. Place the lighted candle in front of the concave mirror between the centre of curvature C and focus F of the concave mirror MM′ (Fig. 38.2). Note and record the position of the candle. Find the distance, x between the pole P of the mirror and candle flame (object). Here $2f > x > f$.
5. Place the semi transparent rice paper screen beyond the centre of curvature C of the mirror (Fig. 38.2). [The lower level of screen must be so arranged that it remains just above the principal axis of the mirror. It is suggested to prepare a screen as shown in Fig. 35.2.] Locate a sharp image A′B′ of candle flame by adjusting the position of the screen. Note and record the position of the screen. Find the distance between the pole P of the mirror and the screen, y. Here $y > 2f$. Also measure and record the height h' of the image of the candle flame obtained on the screen.
6. Repeat the experiment two more times by slightly changing x, by changing the position of either concave mirror or the lighted candle. Locate the sharp image of the flame and record the position (y) and height h' of the image in each case.

Observations and Calculations

Approximate focal length of the concave mirror, f = ____ cm.

Height of the candle flame, h = ____ cm.

Nature of the image: __________________ .

Sl. No.	Position of the pole P mirror, c	Position of the flame, l	Position of the screen, s	Distance between pole P and flame	Distance between pole P and screen	Size of the image,	Magnification (h'/h)
	(cm)	(cm)	(cm)	$x = l - c$ (cm)	$y = s - c$ (cm)	h' (cm)	
1.							
2.							
3.							

Results and Discussion

On the basis of your observations, answer the following:

- What is the position of the screen with respect to the concave mirror when the object (the flame of the lighted candle) is placed in between of the centre of curvature and focus of the concave mirror? Is the position of the screen less than, more than, or equal to the radius of curvature R (=2f)? Explain on the basis of your observations.

- Is the size of the image of the candle flame less than, more than, or equal to the size of the object candle flame? Interpret the result in terms of magnification produced by the concave mirror.
- What is the nature of the image obtained on the screen? Is it real or virtual? Is it inverted or erect? Is it magnified (enlarged) or diminished?

Precautions and Sources of Error

- For obtaining distinct and sharp images of the candle flame, it is advantageous to perform this experiment in a dark room (or at least in shade where no direct light reaches to the working table).
- To avoid the flickering of the candle flame, perform this experiment in calm air. Switch off the fan while performing this experiment.
- While finding out the approximate value of the focal length f of the concave mirror by using sunlight, do not look at the image directly with the naked eye, otherwise it might damage the eyes.
- The concave mirror should be thin and of good quality polished surface.
- The aperture of the concave mirror should be small for obtaining the distinct image.
- The eye should be placed at a distance of at least 25 cm from the image by the concave mirror on the screen.
- The base of the stands of the concave mirror and screen should be parallel to the measuring scale.

Note for the Teacher

- Experiment 35 titled "*To draw the images of an object formed by a concave mirror when placed at various positions*" aims to learn qualitatively about the formation of images of an object and good to do before this experiment to practise. It is therefore advised that students are suggested to this activity first.
- A semi transparent rice paper screen is good to use in this experiment. A screen may also be prepared by spreading few drops of an edible oil on a paper.
- The focal length of the concave mirror must preferably be between 15 cm and 20 cm.
- This method gives rough and intuitive description for locating the image formed by the concave mirror.

QUESTIONS

- How will you distinguish between a concave mirror and a convex mirror by holding in hand and looking into them?
- In what way would the image of the lighted candle be affected when the experiment is performed in a bright light and on a windy day.
- A distinct image of the lighted candle has been obtained on screen with fixed position using a concave mirror. Why does the image of the candle get blurred if the position of any one of them slightly is disturbed?
- What kind effect do you expect if the mirror is thick?
- Normally the mirrors used in school laboratories are polished (or coated) on back on a thin glass. If the mirror is front polished, what effect do you expect in this experiment?
- Why is it preferred to perform this experiment in dark or in shade?
- Why do we require a calm atmosphere to perform this experiment?

Experiment 39

AIM

To study the formation of an image of a lighted candle by a concave mirror, when placed at the centre of curvature.

THEORY

The position, nature and size of the image of an object formed by a concave mirror can be studied, using new cartesian sign conventions and drawing ray diagrams. The ray diagrams for obtaining image formed by a concave mirror of an object when placed at various locations position are given in Experiment 35. The position, nature and size of the image formed depend on the position of the object with respect to the pole P of the concave mirror MM′.

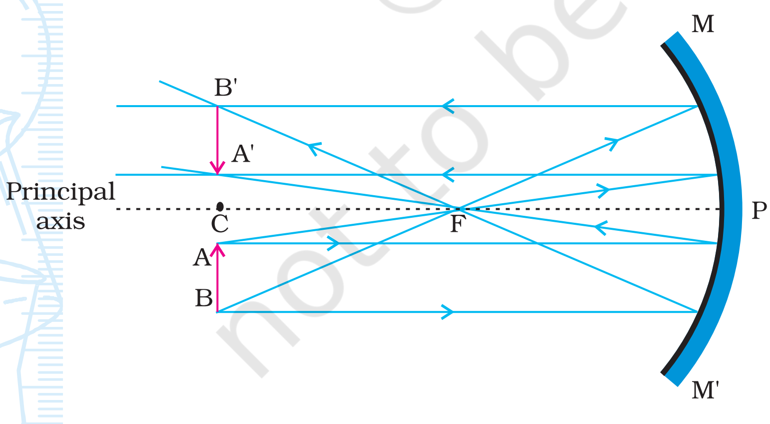


Fig. 39.1 : Formation of an image A′B′ formed by a concave mirror MM' (having focal length f and radius of curvature R) when the object AB is placed at the centre of curvature C: A real, inverted and equal size image A′B′ lies at the centre of curvature C itself

Fig. 39.1 summarises the formation of image of an object AB formed by a concave mirror when the object AB is placed at the centre of curvature C of the concave mirror.

A real, inverted image can be obtained on a screen. The image of the flame of a lighted candle placed at the centre of curvature of a concave mirror can also be focused and obtained on the screen. The nature, position, and size of the image and the flame (object) can be noted and measured from pole P of the concave mirror.

MATERIALS REQUIRED

A concave mirror, a mirror holder, a semi-transparent small rice paper screen fixed to a stand, a meter scale, and a small candle with stand, and a match box.

PROCEDURE

1. Hold concave mirror in hand and determine the approximate focal length f_a of the concave mirror by obtaining sharp image of a distant object (such as the sun or a tree or an electricity pole or a building) on a wall or a screen and measuring the distance between the image and the concave mirror. (This method is explained in detail in Experiment 36.) Record it in the observation table. The radius of curvature R of the concave mirror may be taken as twice of its focal length f.
2. Fix the concave mirror vertically in the mirror holder (or stand) and place it on one side edge of the table. Note and record the position the concave mirror (c) in the observation table.
3. Mount a small candle vertically on a stand and light it. Place it in front of the concave mirror on the left hand side (Fig. 39.2). Adjust the centre of the concave mirror at a height which is slightly more than the height of the flame of the candle. Here we consider the flame as object AB. Measure and record the height h of the candle flame. (It is important that the flame must not flicker. Switch off the fans so that wind does not disturb the flame. Perform the experiment at a dark place.)

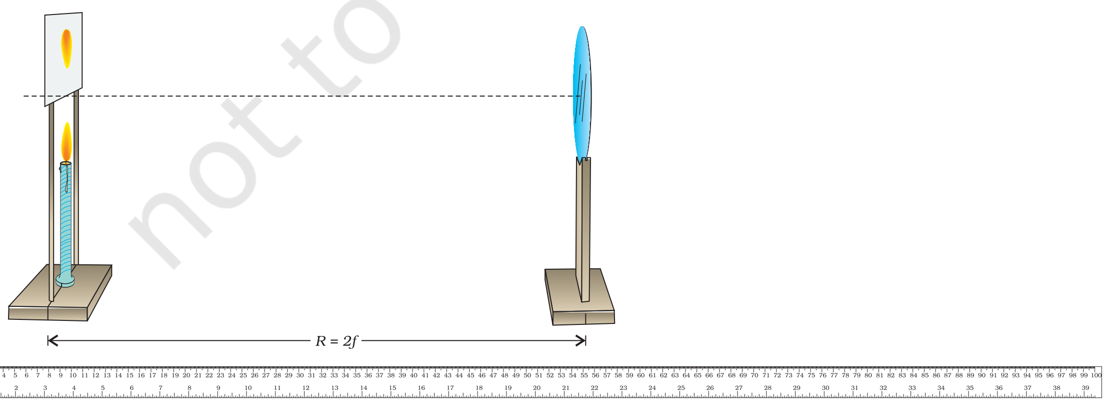


Fig. 39.2 : *Image of a lighted candle flame placed at the centre of curvature of a concave mirror is formed at the centre of curvature itself*

4. Place the lighted candle in front of the concave mirror MM′ at a distance nearly equal to $2f$ or R from the pole P of the mirror (Fig. 39.2). From Experiment 35, we know that the image of an object placed at the centre of curvature of a concave mirror is also formed at the centre of curvature.
5. Place the semi-transparent rice paper screen stand just above the candle flame (Fig. 39.2). The level of screen must be slightly higher than the flame (otherwise the screen may burn). Recall that in this experiment it is suggested to keep the object flame AB below the principal axis of the concave mirror MM′. In this situation, the image of the flame will be formed just above the principal axis of the mirror (Fig. 39.1). Thus you can safely place the candle and screen in the same vertical plane.
6. Adjust the position of the candle flame and screen (together) to get a sharp image A′B′ of candle flame on the screen. (Keep the screen and flame in the same vertical plane.) Note and record the position (s) of the candle/screen. This is the position of the centre of curvature of the given concave mirror. Find the radius of curvature R as the distance between the pole P of the mirror and screen/candle flame.
7. Measure the height h' of the image of the flame formed on the screen. Is it equal to the height of the object flame h?
8. Repeat the experiment at least two more times by changing the position of concave mirror. Record observations in the observation table.
9. Determine the mean value of the radius of curvature R of the concave mirror. Also find the focal length of the mirror.

Observations and Calculations

Approximate focal length of the concave mirror, f_a = ____ cm.

Mean value of the radius of curvature R of the given concave mirror =____ cm.

Focal length of the given concave mirror $f_0 = R/2$ = ____ cm.

Sl. No.	Position of the pole P of the mirror, c	Height of the candle flame, h	Position of the flame/screen, s	Distance between pole P and flame/screen	Nature of the image	Height of the image, h'	Magnification (h'/h)
	(cm)	(cm)	(cm)	$R = s - c$ (cm)		(cm)	
1.							
2.							
3.							

Results and Discussion

The approximate focal length, determined using a rough method, of the given concave mirror is ___ cm. The observed focal length of the mirror is ____ cm. The difference between the two is ____ cm, which is negligibly small (If not, then discuss about the reasons.)

Is the image of flame formed by the concave mirror in the present situation real or virtual? Is it magnified or dimininished or of same size? Is it inverted or erect?

Precautions and Sources of Error

- For obtaining distinct and sharp images of the candle flame, it is preferable to perform this experiment in a dark room (or at least in shade where no direct light reaches to the working table).
- To avoid the flickering of the candle flame, perform this experiment in calm air. Switch off the fan while performing this experiment.
- While finding out the approximate value of the focal length f of the concave mirror by using sunlight, do not look at the image directly with the naked eye, otherwise it might damage the eyes.
- The concave mirror should be thin and of good quality polished surface.
- The aperture of the concave mirror should be small for obtaining the distinct image.
- The eye should be placed at a distance of at least 25 cm from the image by the concave mirror on the screen.
- The base of the stands of the concave mirror and screen should be parallel to the measuring scale.

Note for the Teacher

- Experiment 35 titled "*To draw the images of an object formed by a concave mirror when placed at various positions*" aims to learn qualitatively about the formation of images of an object and good to do before this experiment to practise. It is therefore advised that students may be suggested to this activity first.
- A rice paper screen is good to use in this experiment. However a semi-transparent sheet may also be used. A screen may be prepared by spreading few drops of an edible oil on a paper.
- The focal length of the concave mirror must preferably be between 15 cm and 20 cm.
- Students may find this experiment difficult to perform, as it is quite difficult and cumbersome to mount both the screen and

the lighted candle at the same position on the table. It is advised that the stand of the screen must be so chosen that the lighted candle may be placed in the centre of it (see Fig. 39.2). The candle to be used must also be very small (small candles used for decorating celebration cakes may be used).

QUESTIONS

- In what way will the image of the lighted candle be affected when the experiment is performed in a bright light and on a windy day.
- A distinct image of the lighted candle has been obtained on screen with fixed position using a concave mirror. Why does the image of the candle becomes blurred if the position of any one of them slightly is disturbed?
- What kind of effect do you expect if the mirror is thick?
- Normally the mirrors used in school laboratories are polished on the back on a thin glass. If the mirror is front polished, what effect do you expect in this experiment?
- Why is it preferred to perform this experiment in dark or in shade?
- Why do we require a calm atmosphere to perform this experiment?

Experiment 40

AIM

To trace the path of a ray of light passing obliquely through a rectangular glass slab for different angles of incidence and to measure the angle of incidence, angle of refraction, the angle of emergence and interpret the results.

THEORY

When a ray of light passes from air to glass through a rectangular glass slab, it bends towards the normal at the surface of the air-glass boundary (AD), as shown in Fig. 40.1. The phenomenon of change in the direction of a ray of light when it enters from one medium to the other is known as refraction. In Fig. 40.1, the angle XON between the incident ray XO and normal NOM at the point of incidence O is the angle of incidence (∠*i*). The angle MOO′ between the refracted ray OO′ and the normal NOM is the angle of refraction (∠*r*). Then, the refracted ray OO′ strikes the face BC of the glass slab that forms the glass-air boundary at the opposite face of the glass slab ABCD. It undergoes refraction again. The deviation of the ray of light this time is away from the normal M′O′N′ at the point of incidence O′. The refracted ray O′Y is known as the emergent ray with respect to the incident ray XO incident at the face

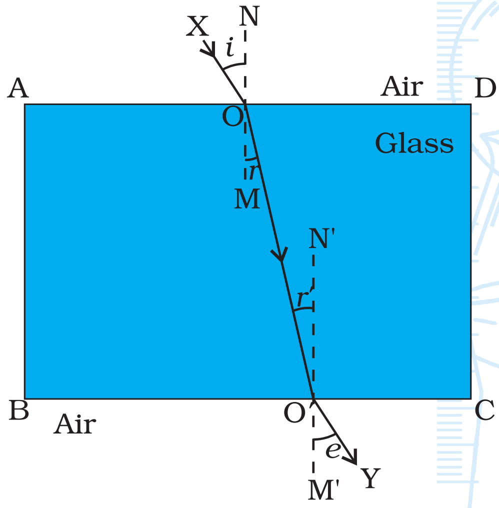


Fig. 40.1 : *Incident and emergent rays in the case of refraction through a glass slab*

AD. The angle between the emergent ray O′Y and the normal M′O′N′ to the face BC (that is angle M′O′Y) is known as angle of emergence (∠*e*).

Materials Required

A rectangular glas slab, drawing board, white sheet of paper, protractor, a measuring scale, pins, and drawing pins or adhesive tape.

Procedure

1. Fix a white sheet of paper on a drawing board. Place the rectangular glass slab in the middle of the paper and mark its boundary ABCD with a pencil (Fig. 40.2).
2. Remove the rectangular glass slab. Draw a thin line XO (with an arrow) inclined to the face AD of the glass slab at any angle preferably between 30º and 60º. It is advisable to take point O in the middle of the line AD. Replace the glass slab exactly over the boundary mark on the paper.
3. Fix two pins P_1 and P_2 vertically about 5 cm apart, by gently pressing their heads with thumb on the line XO. Observe the images of pins P_1 and P_2 through the face BC of the rectangular glass slab. While observing the images of the pins P_1 and P_2 through the face BC of the glass slab, fix two more pins at points P_3 and P_4 such that feet of all the pins appear to be in a straight line. In other words, the pins P_3 and P_4 are collinear with the images of pins P_1 and P_2.

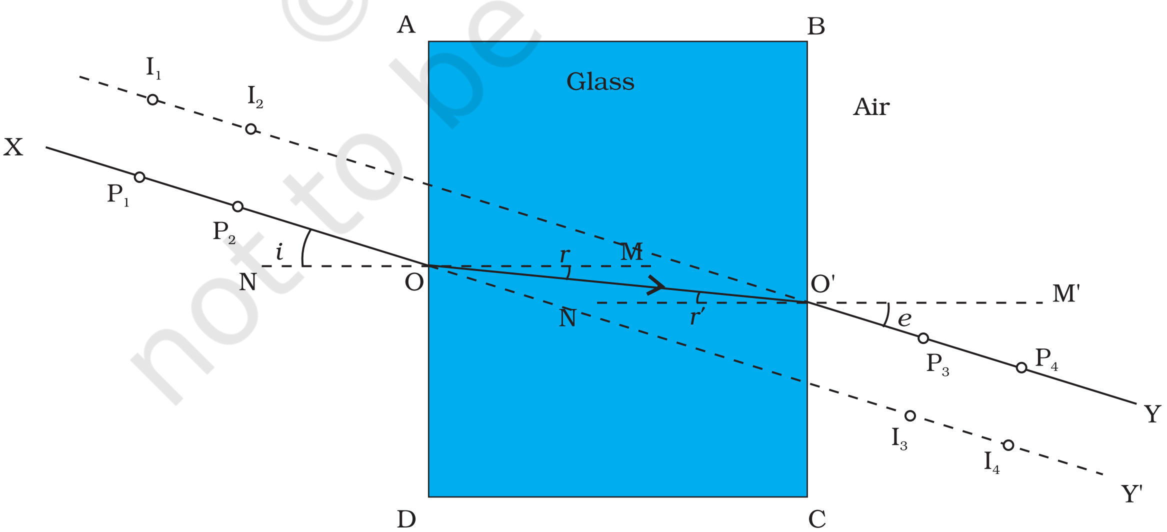


Fig. 40.2 : *The images of pins P_1 and P_2 appear to be at I_1 and I_2 when viewed through the face BC while I_3 and I_4, show the position of the images of pins P_3 and P_4 when viewed through the face AD*

4. You can also verify the collinearity of pins P_3 and P_4 with the images of pins P_1 and P_2 by looking all four pins through the face AD.
5. Remove the pins and the glass slab and mark the positions of the feet of all the four pins. Join points that mark the positions of the pins P_3 and P_4 and extend the line up to point O' where it meets the face BC. Also join the points O and O′ as shown in Fig. 40.2, where XOO′Y shows the path of a ray of light passing through the glass slab. The line XP_1P_2O represents the incident ray. Line OO′ shows the path of refracted ray in glass slab while line $O'P_3P_4Y$ shows the emergent ray.
6. Draw the normal NOM to the face AD at the point of incidence O and similarly the normal M′O′N′, to the face BC at point O′. Measure the angle of incidence XON ($\angle i$), angle of refraction MOO′ ($\angle r$), and angle of emergence M′O′Y ($\angle e$). Record the values of angles $\angle i$, $\angle r$, and $\angle e$ in the observation table.
7. Repeat the experiment for two more angles of incidence in the range 30º to 60º and record the values of angles $\angle i$, $\angle r$, and $\angle e$ in each case.

Observations

Sl. No.	Angle of incidence	Angle of refraction	Angle of emergence	Deviation
	$\angle i = (\angle XON)$	$\angle r = (\angle MOO')$	$\angle e = (\angle M'O'Y)$	$\angle i \sim \angle e$
1.				
2.				
3.				

Results and Discussion

- The paths of different rays of light through a glass slab are shown in Fig. 40.2 (attach all sheets).
- Report on the relation between the angle of incidence, angle of refraction and the angle of emergence based on different sets of observations taken.
- As $\angle r < \angle i$ in each case, the ray entering from air to glass (denser medium) bends towards normal.
- As $\angle i = \angle e$, the emergent ray emerging out of the rectangular glass slab, is parallel to, but laterally displaced with respect to the incident ray.
- Angle of refraction $\angle r$ increases with increase in angle of incidence $\angle i$.

Precautions and Sources of Error

- The glass slab should be perfectly rectangular with all its faces smooth.
- The tips of pins P_1, P_2, P_3, and P_4 should be sharp. These pins fixed on the sheet of paper may not be exactly perpendicular (or vertical) to the plane of paper. Thus, if their heads appear to be collinear, their feet may not be so. It must, therefore, is important to look at the feet of pins and their images while ascertaining collinearity between them. The mark of the pointed end or the foot of a pin on the paper must be considered while marking its position.
- While viewing the collinearity of pins and images, the eye should be kept at some distance from the pins so that the feet of all of them can be seen simultaneously in the same straight line.
- While fixing the pins P_1 and P_2 or the pins P_3 and P_4, care should be taken to maintain a distance of about 5 cm between the two pins. This would help in tracing the direction of incident ray and that of emergent ray with greater accuracy.
- The angle of incidence should preferably be between 30º and 60º.
- Thin lines should be drawn, using a sharp pencil.
- The angles should be measured accurately, using a good quality protractor having clear markings, by keeping the eye above the marking.

Questions

- Why are the incident and emergent rays parallel to each other in case of a rectangular glass slab?
- Why does a ray of light bend towards the normal when it enters from air in a glass slab and bends away from the normal when it emerges out into air?
- Draw the path of a ray of light when it enters perpendicular to the surface of a glass slab.
- While tracing the path of ray of light through a glass slab, the angle of incidence is generally taken between 30º and 60º. Explain the reason on the basis of your performing this experiment for different angles of incidence.
- How does the lateral displacement of emergent ray depend on the width of the glass slab and angle of incidence?

Experiment 41

AIM

To trace the path of a ray of light passing obliquely through a rectangular glass slab and to determine the refractive index of the glass.

THEORY

When a ray of light passes from air to glass through a rectangular glass slab, it bends towards the normal to the surface of the air-glass boundary (AD). as shown in Fig. 41.1. The phenomenon of change in the direction of a ray of light when it enters form one medium to the other is known as refraction. In Fig. 41.1, the angle XON between the incident ray XO and normal NOM at the point of incidence O is the angle of incidence ($\angle i$). The angle MOO¢ between the refracted ray OO′ and the normal NOM is the angle of refraction ($\angle r$). Then, the refracted ray OO′ strikes the face BC of the glass slab that forms the glass-air boundary at the opposite face of the glass slab ABCD. It undergoes refraction again. The deviation of the ray of light this time is away from the normal M′O′N′ at the point of incidence O′. The refracted ray O′Y is known as the emergent ray with respect to the incident ray XO incident at the face AD. The angle between the emergent ray O′Y and the normal M′O′N′ to the face BC (that is angle

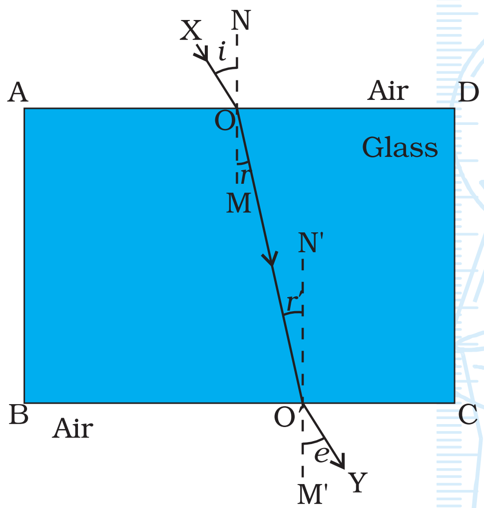


Fig. 41.1 : *Incident and emergent rays in case of refraction through a glass slab*

17-04-2018

M′O′Y) is known as angle of emergence (∠*e*). Line OO′ represent the path of refracted ray in rectangular glass slab.

The refractive index *n* of glass with respect to air is defined as

$$n = \frac{\text{Speed of light in vaccum or air } (c)}{\text{Speed of light in glass } (v)} \qquad (1)$$

Using Snell's law of refraciton of light, and from Fig. 41.1, the refractive index (*n*) of glass can also be expressed as:

$$n = \frac{\sin i}{\sin r}$$

The refractive index of the material of a glass slab is constant for a given colour (or wavelength) and for the given media. The speed of light is greater in a rarer medium (air) than a denser medium (glass). Then, a ray of light, travelling from a rarer medium (air) to a denser medium (glass), slows down and bends towards the normal at the air-glass boundary (Fig. 41.1). When it travels from a denser (glass) to rarer medium (air), it speeds up and bends away from the normal at the glass-air boundary. For air-glass boundary AD, the angle of incidence is angle XON (or ∠*i*), and the angle of refraction is angle MOO′ (or ∠*r*). At the glass-air boundary BC, the angle of incidence is the angle OO′N′ (or ∠*r*′) and angle of refraction (or the angle of emergence, ∠*e*) is angle M′O′Y.

The refractive index of glass can either be calculated at the air-glass boundary AD or at the glass-air boundary BC (Fig. 41.2).

At air-glass boundary AD, $$n = \frac{\sin \angle XON}{\sin \angle MOO'} = \frac{\sin \angle i}{\sin \angle r} \qquad (2)$$

and at glass-air boundary BC, $$\frac{1}{n} = \frac{\sin \angle M'O'Y}{\sin \angle OO'N'}$$

Thus, $$n = \frac{\sin \angle OO'N'}{\sin \angle M'O'Y} = \frac{\sin \angle e}{\sin \angle r} \qquad (3)$$

Materials Required

A rectangular glass slab, drawing board, white sheet of paper, protractor, drawing pins (or adhesive tape), pins, a measuring scale (or a ruler), and Tables of Natural Sines.

PROCEDURE

1. Fix a white sheet of paper on a drawing board. Place the rectangular glass slab in the middle of the paper and mark its boundary ABCD with a pencil (Fig. 41.2).
2. Remove the rectangular glass slab. Draw a thin line XO (with an arrow) inclined to the face AD of the glass slab at any angle preferably between 30º to 60º. It is advisable to take point O in the middle of the line AD. Replace the glass slab exactly over the boundary mark on the paper.

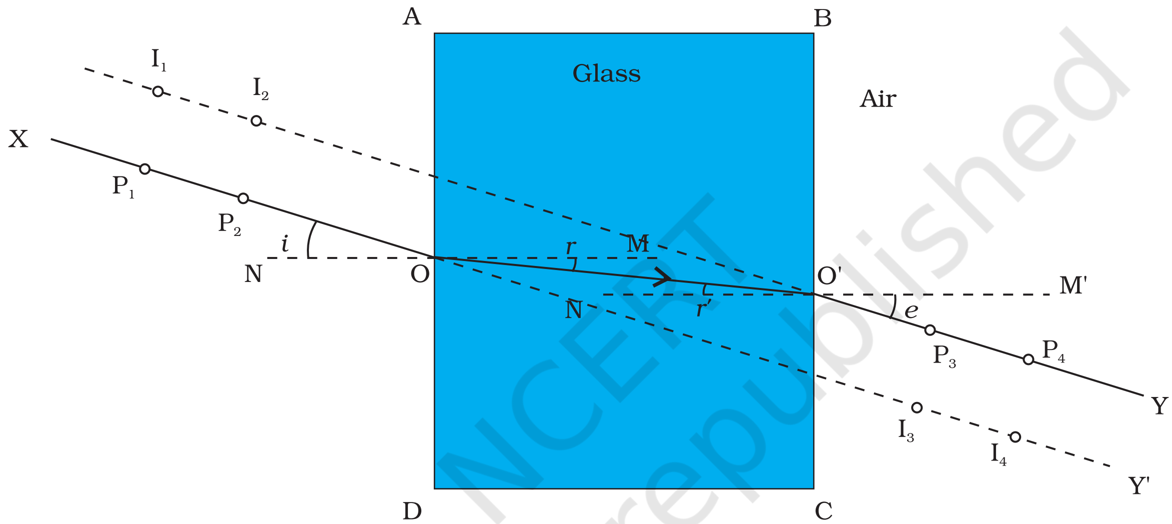


Fig. 41.2 : *The images of pins P_1 and P_2 appear to be at I_1 and I_2 when viewed through the face BC while I_3 and I_4, show the position of the images of pins P_3 and P_4 when viewed through the face AD. And measurement of angles at air-glass boundary AD and at glass-air boudary BC*

3. Fix two pins P_1 and P_2 vertically, by gently pressing their heads with thumb on the line XO. Observe the images of pins P_1 and P_2 through the face BC of the rectangular glass slab. While observing the images of the pins P_1 and P_2 through the face BC of the glass slab, fix two more pins at points P_3 and P_4 such that feet of all the pins appear to be in a straight line. In other words, the pins P_3 and P_4 are collinear with the images of pins P_1 and P_2.
4. You can also verify the collinearity of pins P_3 and P_4 with the images of pins P_1 and P_2 by looking all four pins through the face AD.
5. Remove the pins and the glass slab and mark the positions of the feet of all the four pins. Join points that mark the positions of the pins P_3 and P_4 and extend the line up to point O′ where it meets the face BC.

Also join the points O and O′ as shown in Fig. PX8.2, where XOO′Y shows the path of a ray of light passing through the glass slab. The line XP_1P_2O represents the incident ray. Line OO′ shows the path of refracted ray in glass slab while line $O'P_3P_4Y$ shows the emergent ray.

6. Draw the normal NOM to the face AD at the point of incidence O and similarly the normal M′O′N′, to the face BC at point O′. Measure and record values of the angles ∠XON, ∠MOO′, ∠OO′N′, and ∠M′O′Y.
7. Find the values of sine of angles ∠XON (= ∠i), ∠MOO′ (= ∠r), ∠OO′N′ (= ∠r'), and ∠M′O′Y (= ∠e), using the Tables of natural sines. Using Eqs. (1) and (2), calculate the refractive index of the glass at air-glass boundary AD and at glass-air boundary BC.
8. Repeat the experiment for two more angles of incidence in the range 30º to 60º.
9. Find the average (or mean) value of the refractive index of the glass material of rectangular slab.

Observations and Calculations

Sl. No.	Face AD		Face BC		n at air-glass bounadry AD	n at glass-air boundary BC
	∠XON (= ∠i)	∠MOO′ (= ∠r)	∠M′O′Y (= ∠r')	∠M′O′Y (= ∠e)	[Eq. (2)]	[Eq. (3)]
1.						
2.						
3.						

Results and Discussion

- The path of different rays of light through a rectangular glass slab is as shown in Fig. 41.2 (attach all sheets).
- Are the values of refractive index of glass with respect to air at air-glass boundary AD and glass-air boundary BC same? The mean value of refractive index n is _____ .

Precautions and Sources of Error

- The glass slab should be rectangular with all its faces smooth.
- The tips of pins P_1, P_2, P_3, and P_4 should be sharp. These pins fixed on the sheet of paper may not be exactly perpendicular (or vertical) to the plane of paper. Thus, if their heads appear to be collinear, their feet may not be so. It must therefore is important to look at the feet of pins and their images while ascertaining collinearity between them. The mark

of the pointed end or the foot of an pin on the paper must be considered while marking its position.

- While viewing the collinearity of pins and images, the eye should be kept at some distance from the pins so that the feet of all of them can be seen simultaneously in the same straight line.
- While fixing the pins P_1 and P_2 or the pins P_3 and P_4, care should be taken to maintain a distance of approximately 6 cm between the two pins. This would help in tracing the direction of incident ray and that of emergent ray with greater accuracy.
- The angle of incidence should preferably be between 30º and 60º.
- Thin lines should be drawn, using a sharp pencil.
- The angles should be measured accurately, using a good quality protractor having clear markings, by keeping the eye above the marking.

QUESTIONS

- Why does a ray of light bend towards the normal when it enters from air in a glass slab and bends away from the normal when it emerges out into air?
- Draw the path of a ray of light when it enters perpendicular to the surface of a glass slab.
- If the incident and emergent rays are not parallel to each other in case of a recatangular glass slab, what could be the reason?
- While tracing the path of ray of light through a glass slab, the angle of incidence is generally taken between 30º and 60º. Explain the reason on the basis of your performing this experiment for different angles of incidence.
- How does the lateral displacement of emergent ray depend on the width of the glass slab and angle of incidence?
- On what factors does the refractive index of a medium depend?
- Is Snell's law obeyed in case of normal incidence of light on a rectangular glass slab?

Experiment 42

AIM

To trace the path of a ray of light through a glass prism and to measure the angle of deviation.

THEORY

When a ray of light (DE) from air strikes on a face AB of a triangular glass prism ABC, it gets refracated and bends towards the normal to the plane of the face AB (Fig. 42.1). The refracted ray EF travels inside the prism until

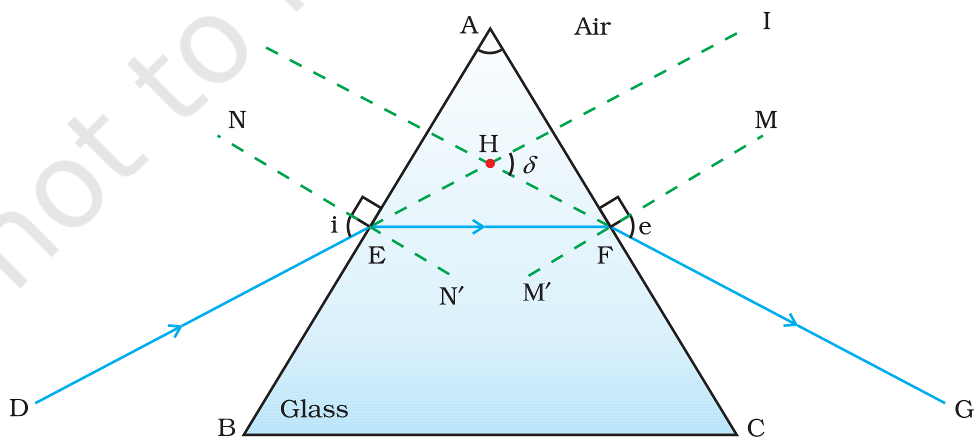


Fig. 42.1 **:** *Refraction of light through a prism*

it strikes its other face AC. Here again, the ray from glass gets refracted into air but bends away from the normal towards the face BC. The ray FG is the ray that emerges out of the glass prism at the glass-air boundary face AC. The ray FG that emerges out of the glass prism at the face AC after successive refractions is the emergent ray (Fig, 42.1). Usually the emergent ray is bent towards the base (BC) of the prism as shown. The angle ∠IHG between the incident ray DE (when extended) and the emergent ray FG, when produced backwards to meet at a point H, is known as the angle of deviation (∠δ).

Materials Required

A glass prism, drawing board, white paper, adhesive tape or drawing pins, pins, a measuring scale, and a protractor.

Procedure

1. Fix a white sheet of paper on a drawing board. Draw a thin line XY at the middle of the paper.
2. Draw a thin line NEN’ normal (perpendicular) to the line XY at point of incidence E (say). Also draw a line DE making any angle, preferabaly between 30º and 60º as shown in Fig. 42.2.
3. Place the prism with one of its refracting surfaces (say AB) along the line XY. Mark the boundary ABC of the glass prism holding it firmly with your hand.
4. Fix two pins P_1 and P_2 vertically, by gently pressing their heads with thumb, on line DE at a distance of about 6 cm from each other. View the images of pins P_1 and P_2 from the opposite face AC of the prism.
5. Fix two more pins P_3 and P_4 vertically such that the feet of pins P_3 and P_4 appear to be on the same straight line as the feet of the images of the pins P_1 and P_2 as viewed through the face AC of the prism.

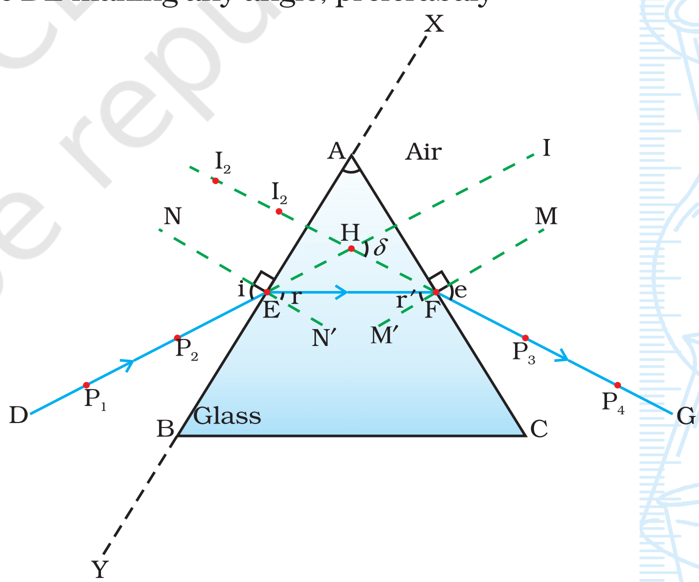


Fig. 42.2 : *The images of pins P_1 and P_2 appear to be at I_1 and I_2 when viewes through the face AC of the glass prism. Rays DE, EF, and FG represent the incident, refracted and emergent rays respectively. ∠DEN is the angle of incidence (∠i) and ∠FHI is the angle of deviation (∠d)*

6. Remove the pins and prism. Mark the position of feet of pins P_3 and P_4 on the sheet of paper. Draw a straight line to join the points that mark the position of pins P_3 and P_4. Extend this line so that it meets the face AC of the prism at point F. The line FG represents the path of the emergent ray.
7. Extend the direction of incident ray DE till it meets the face AFC. Also extend (backwards) the emergent ray FG as shown in Fig. 42.2. These two extended lines meet at point H.
8. Measure ∠DEN as the angle of incidence (∠*i*) and ∠FHM as the angle of deviation (∠*d*). Record these angles in the observation table.
9. Repeat the experiment for one more angle of incidence, preferably between 30º and 60º.

Observations and Calculations

Sl. No.	Angle of incidence (∠*i*) = ∠DEN	Angle of deviation (∠δ) = ∠FHI
1.		
2.		

Results and Discussion

- The path of a ray of light incident on one face of a glass prism is shown by the ray ______.
- The value of the angle of deviation for the angle of incidence _____ is _____ ; and for the other angle of incidence _____ is _____ .

Precautions

- While viewing the collinearity of pins and images, the eye should be kept at a distance from the pins so that all of them can be seen simultaneously. The collinearity of pins fixed on one side of the glass prism and the images of pins on the other side could also be confirmed by moving the head slightly to either side while viewing them. All the pins and images of pins would appear to move together if they are collinear.
- The pins P_1, P_2, P_3 and P_4 fixed on the paper may not be exactly perpendicular (or vertical) to the plane of paper. It is therefore desirable to look at the feet of the pins or their images while establishing their

collinearity. That is why the position of each pin is marked with pointed tip of the pins on the paper.

- In order to locate the direction of incident ray and refracted ray with a greater accuracy, the distance between the pins P_1 and P_2; and that between P_3 and P_4 should not be too short or too large. A separation of nearly 6 cm between the pins would be sufficient.
- The angle of incidence should be between 30º and 60º.

NOTE FOR THE TEACHER

- The glass prism must be triangular, bounded by rectangular refracting faces. The refracting faces should be smooth and transparent without any air bubbles or broken edges.
- A water prism can also be improvised in the lab that can be used in place of a glass prism. For this, first make two identical small equilateral triangles using sticks. Now join their vertices using three more sticks such that an outline structure of a prism is formed. Cover the sides and a base by cellophane sheets using adhesive tape. Fill it with water. The prism is ready to use. One can fill it with different liquids to show the difference in their refractive indices. (A prism can also be improvised by joining three glass sheets to make a triangular prism. Cover its base by an another glass sheet.)

QUESTIONS

- Define angle of deviation.
- List the factors on which the angle of deviation through a prism depend?
- Why does a ray of light bend towards the base when it passes through a glass prism?
- Why does white light split into different colours when passes through a glass prism?
- Why does the white light not split into different colours when it passes through a glass slab?

Experiment 43

AIM

To draw the images of an object formed by a convex lens, when placed at various positions.

THEORY

The light rays when refracted through a convex lens obey the laws of refraction. The formation of images by a convex lens can be studied by drawing ray diagrams, using the New Cartesian Sign Convention.

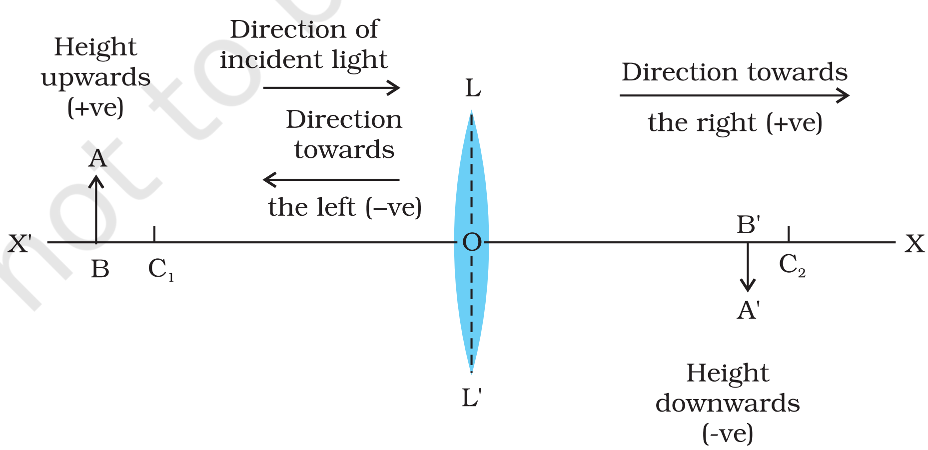


Fig. 43.1 : *The New Sign Convention for a convex lens*

In this convention (Fig. 43.1), the optical centre O of a convex lens LL′ is considered as the origin and its principal axis as the x-axis (X′X) of the coordinate system. The principal axis X′X, is an imaginary straight line passing through the two centres of curvature C_1 and C_2 of the two spherical surfaces of the convex lens LL′. The optical centre O is a point associated with the convex lens such that a ray of light passing through O does not suffer any deviation. Here we consider the convex lens as a thin lens having a small aperture, much less than its radius of curvature.

The new cartesian sign convention can be summarised as below, and is illustrated in Fig. 43.1: (i) The object is always placed to the left of the lens. This implies that the light from the object falls on the lens from the left-hand side; (ii) All distances parallel to the principal axis are measured from the optical centre of the lens; (iii) All distances measured to the right of the origin (that is along the +*x*-axis) are taken as positive while those measured to the left of the origin (that is along (*x*-axis) are taken as negative; (iv) Distances measured perpendicular to and above the principal axis (that is along the +*y*-axis) are taken as positive; and (v) Distances measured perpendicular to and below the principal axis (that is along -*y*-axis) are taken as negative.

For an illuminated extended object AB of finite size, placed in front of a convex lens, its each small portion acts like a point source of light. An infinite number of rays of light comes from each of these point sources which could be considred for drawing the ray diagrams in order to locate the image of an object formed by a convex lens.

For the sake of clarity of ray diagrams, only two rays are considered. These are so chosen as to know their directions easily, after refraction from the convex lens LL′. The intersection of at least two refracted rays gives the position of image of the point object. Any two of the following rays can be considered for locating the image:

(i) A ray of light from the object, parallel to the principal axis, after refraction from a convex lens, passes through the principal focus F_2 on the other side of the lens [Fig. 43.2(a)].

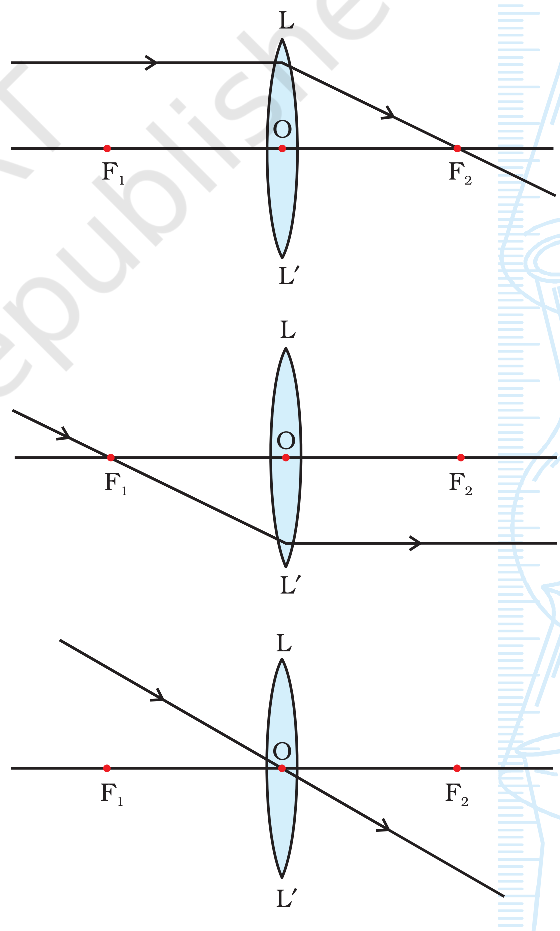


Fig. 43.2 : *Any two of the above rays can be considered for locating the image formed by a convex lens*

(ii) A ray of light passing through a principal focus F_1 after refraction from a convex lens, will emerge parallel to the principal axis [Fig. 43.2(b)].

(iii) A ray of light passing through the opticalcentre O of a convex lens will not suffer any deviation [Fig. 43.2(c)].

The position of the object may be (a) at infinity, (b) beyond $2F_1$, (c) at $2F_1$, (d) between F_1 and $2F_1$, (e) at focus F_1, (f) between focus F_1 and optical centre O of the convex lens.

Neat ray diagrams can be drawn for various positions of an object in front of a convex lens, using the New Cartesian Sign Convention (Fig. 43.1) and convenient rays for locating the image (Fig. 43.2). It may be considered that the convex lens is thin and that it has a small aperture (Is it necessary?). After locating the position of the image, its nature, and size can be determined.

Materials Required

Measuring scale, a drawing board, sheets of white paper, protractor, and drawing pins or adhesive tape.

Procedure

1. Fix a white sheet of paper on a drawing board. Draw a thin line of about 15 - 18 cm length in the middle of the white sheet. Mark a point O at the centre of this line. Make a convex lens LLabout this point O. Assume O as the optical centre of the lens. Mark points F_1

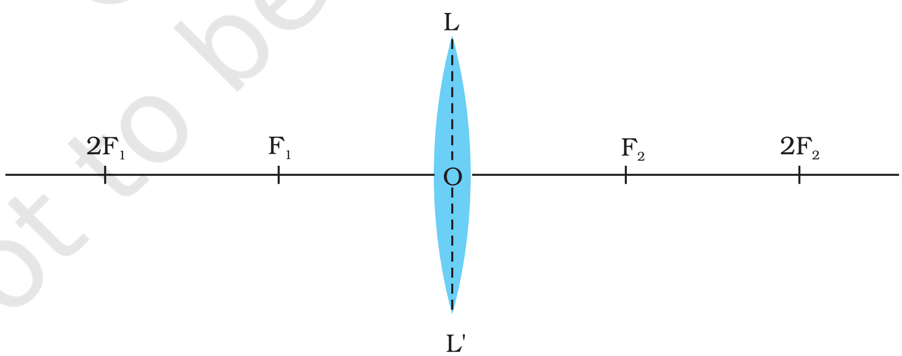


Fig. 43.3 : *A convex lens and its foci*

and F_2 on either side of the lens such that $OF_1 = OF_2$. (Let F_1 and F_2 be two principal focii of the lens.) Also mark points $2F_1$ and $2F_2$ on the line at double the distances OF_1 and OF_2 (Fig. 43.3).

2. Draw an object AB of suitable height h, shown to be placed at infinity as shown in Fig. 43.4(a).

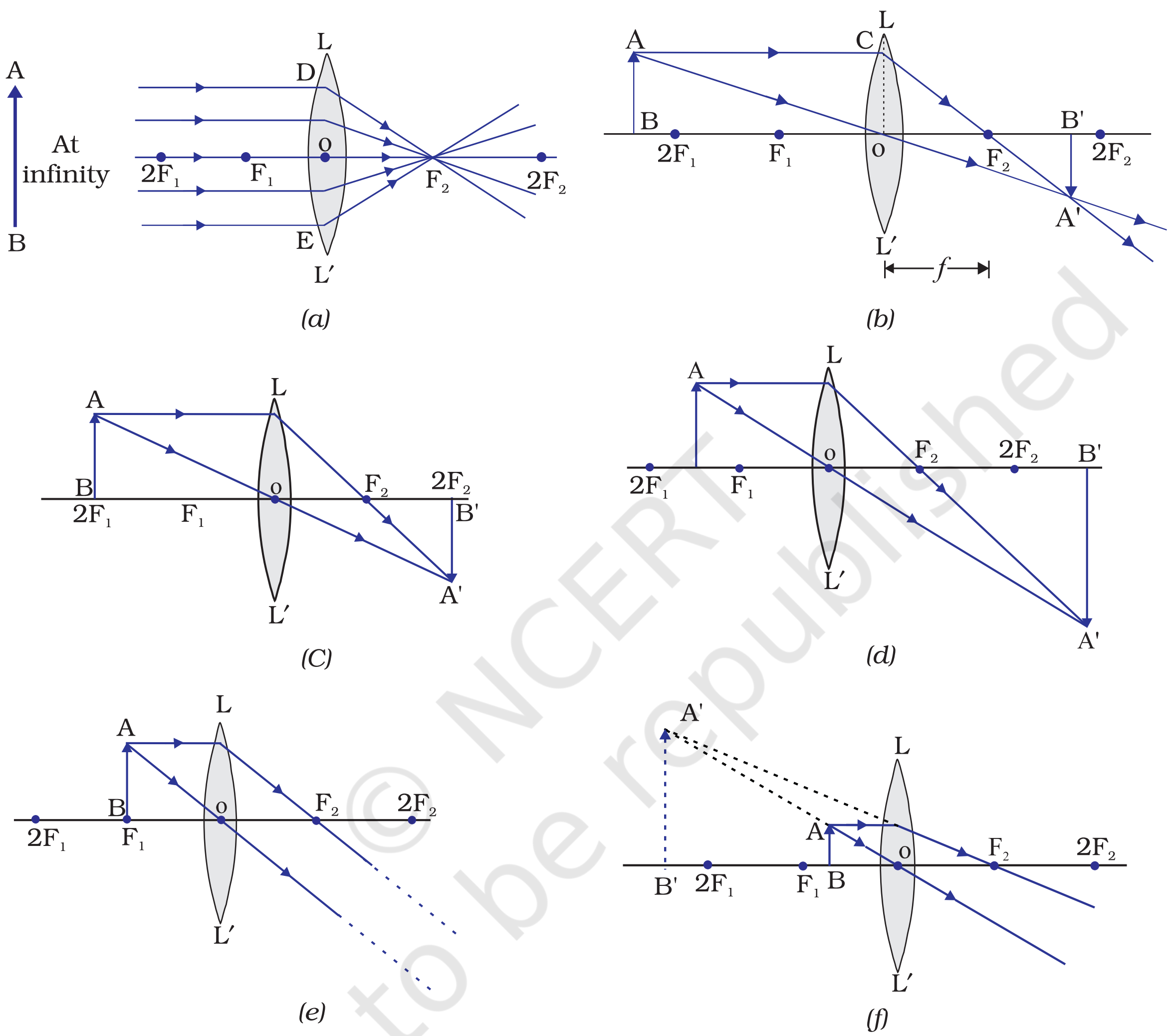


Fig. 43.4 : *The position, size and the nature of the image formed by a convex lens for various positions of the object*

3. Draw thin lines, representing incident rays coming from the object AB parallel to the pricipal axis F_1OF_2, striking the surface of the convex lens LL′ at the points of incidence D, E etc. These rays after refraction through the convex lens LL′ emerge as refracted rays DF_2, EF_2 and so on. These rays intersect at the focus F_2 of the lens on the other side and a diminished image of the distant object is formed at the point F_2, as shown in Fig. 43.4(a).

4. Repeat the above steps, using the New Cartesian Sign convention and considering relevant rays for locating the image. Draw neat ray diagrams for each position of the object, as illustrated in Fig. 43.4(a) - (f).
5. Measure the heights of the object AB (*h*) and its image A′B′ (*h*′), respectively in all cases [Figs. 43.4(a) - (f)]. Record them in the observation table.
6. Desctibe the nature, postion and relative size of the image, formed by the convex lens, of the object placed at various position. Tabulate the results in a convenient format or observation table.

Observations, Result and Conclusion

The characteristics of image formed by a convex lens for various positions of the object [as illustrated in ray diagrams in Figs. 43.4(a) - (f)] are as follows:

Sl. No.	Ray diagram	Postion of the object	Position of the image	Nature of the image	Size of the object, *h*	Size of the image, *h*'	Magnification (*h*'/*h*)
	Fig. 43.4				(cm)	(cm)	
1.	(a)	At infinity	At focus F_2	Real			
2.	(b)	Beyond $2F_1$	Between F_2 and $2F_2$	Real and inverted			
3.	(c)	At $2F_1$	At $2F_2$	Real and inverted			
4.	(d)	Between F_1 and $2F_1$	Beyond $2F_2$	Real and inverted			
5.	(e)	At focus F_1	At infinity	Real and inverted			
6.	(f)	Between focus F_1 and optical centre O	On the same side of the convex lens as the object	Virtual and erect			

Precautions

- Use a very sharp tipped pencil to draw thin lines to represent incident and refracted rays.
- The convex lens drawn should be thin and of small aperture. (This is required for obtaining the distinct image.)

Note for the Teacher

- Normally we use equiconvex lens in a school laboratory. If this lens is not equiconvex then the condition $OF_1 = OF_2$ will not hold good.
- The ray diagrams for the image formation of the object by a convex lens can also be drawn on a graph paper and measurement of the lengths h and h' of the size of the object and its image taken more conveniently.

Questions

- Sometimes, the image formed by a convex lens, of an object placed at $2F_1$ is not of the same size and at location $2F_2$ on the other side of the convex lens. What could be the possible reason(s) for such a situation?
- A ray of light is passing through the principal focus of a convex lens. How will it emerge after refraction through the lens?
- An object is placed on the left side of a lens (having 10 cm focal length) at a distance of 20 cm. What will be the sign of object distance?

17-04-2018

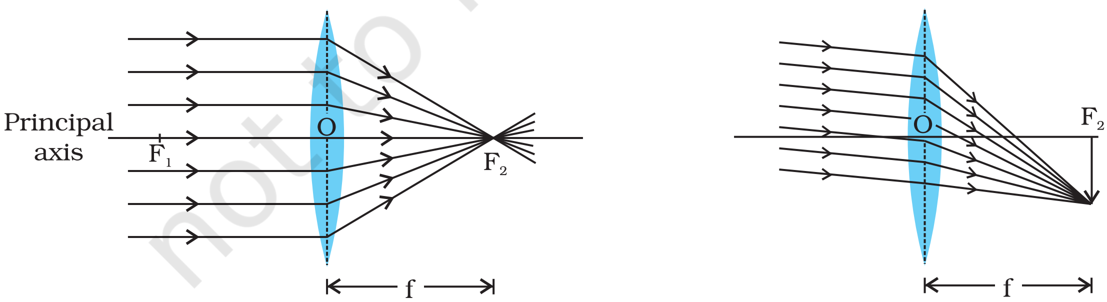
Experiment 44

AIM

To determine the focal length of a thin convex lens by obtaining image of a distant object.

THEORY

The rays of light coming from a distant object such as the sun (or a distant tree or a distant building) can be considered to be parallel to each other. When a parallel beam of light falls on a convex lens, the rays, after refraction, converge at a point on its other side. This point is one of the two foci of the



(a) (b)

Fig. 44.1 : *Image formation of a distant object by a convex lens*

(a) The beam of light incident on the lens is parallel to the principal axis

(b) The beam of light incident on the convex lens is not parallel to the principal axis

lens. If the parallel beam of light comes from a distant object, a real, inverted image of very small size is formed at the focus of the lens [Fig. 44.1]. Since the image formed by the lens is real, it can be obtained on a screen. The distance between the optical centre O of the convex lens and the focus point F_1 or F_2 is its focal length. Thus, the focal length of a convex lens can be estimated by obtaining a real image of a distant object at its focus.

Materials Required

A thin convex lens, a lens holder, a small screen fixed to a stand, and a measuring scale.

Procedure

1. Fix a thin convex lens on a lens holder and place it on the table or platform near an open window through which sufficient sunlight enters. Turn the face of lens towards a distant object (a tree or an electricity pole or a distant building).
2. Place the screen fixed to a stand on the other side of the lens. Adjust the position of screen (by moving it back and forth in front of the convex lens) to get a sharp, clear and inverted image of the distant object on it (Fig. 44.2). A clear and bright image could also be obtained

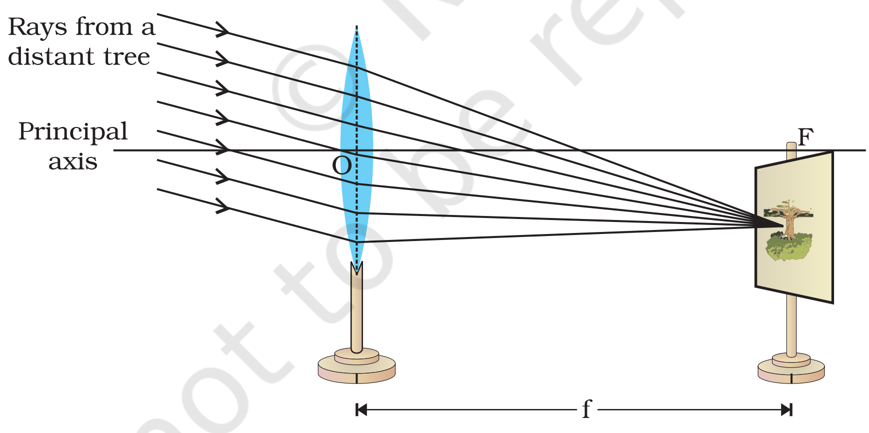


Fig. 44.2 : *Determination of focal length of a thin convex lens*

if the distant object, say a tree or a building, is illuminated with sunlight and the screen is kept in the shade. A bright image of the sun could also be obtained if the sunlight is made to fall directly on the lens.

3. Mark the position of the centre of the stands holding the lens and that of the screen when a sharp image of the distant object has been obtained on the screen. Measure the horizontal distance between the centre of the convex lens and the screen with the help of a measuring scale. Record your observations in the observation table.
4. Repeat the experiment two more times by obtaining the images of two different distant objects. Measure the distance between the convex lens and the screen in each case. Record them in the observation table.
5. Find the average or mean value of the focal length.

Observations and Calculations

Sl. No.	Name of the distant object	Distance between the convex lens and the screen, f		Mean focal length of the convex lens, f
		(cm)	(m)	(m)
1.				
2.				
3.				

Results and Discussion

The approximate value of focal length of the given convex lens is ____ m.

Precautions And Sources of Error

- The principal axis of the convex lens should be horizontal, that is, the lens should be placed vertically.
- There should be no obstacle in the path of rays of light from the distant object incident on the convex lens.
- The image of the sun formed by the lens should be focussed only on the screen. The image of sun should never be seen directly with the naked eye. Sunlight should never be focussed with a convex lens on any part of the body, paper or any inflammable materials, as it can be dangerous to do so.
- Adjust the position of convex lens such that the light rays coming from the distant object fall on the lens without any obstruction.
- In order to obtain a sharp and clear image of the distant object on the screen (or wall), it must be ensured that the distant object is well illuminated. This would allow an appreciable amount of light to fall on

the lens. This is required to produce a well illuminated and distinct image.

- In certain situations, the parallel rays of light originating from a distant object and incident on a convex lens may not be parallel to its principal axis as shown in Figs. 44.1(b) and 44.2. The image in such an event might be formed slightly away from the principal axis of the lens.
- The base of the stands of the convex lens and screen should be parallel to the measuring scale. To determine the focal length, the distance between the convex lens and the screen should be measured horizontally (placed at the focus point on the other side of the lens).

Note for the Teacher

- Use the thin convex lens with focal length preferably between 15 cm to 20 cm.
- A distant object does not necessarily mean a very far off object, like a building or a tree or an electricity pole. A well illuminated window or a glowing bulb at a distance of about 10 m to 15 m away, even within the science laboratory, may also be taken as a distant object.

Questions

- How will you distinguish between a convex and concave lens?
- To detemine the focal length of a convex lens, a student focuses a classroom window, a distant tree and the sun on the screen. In which case will the student is closer to accurate value of focal length?
- What is the nature of an image formed by a thin convex lens for a distant object? What change do you expect if the lens were rather thick?
- You are provided with two convex lenses of same aperure and different thickness. Which one of them will be of shorter focal length?
- If we cover one half of the convex lens while focusing a distant object, in what way will it affect the image formed?
- Can this method be used to find the approximate focal length of a concave lens?
- Which type of lens is used by the watch-makers while repairing fine parts of a wrist watch?

Experiment 45

AIM

To study the formation of an image of a lighted candle by a convex lens when placed at a distance slightly more than the twice of focal length (f) from the optical centre of the lens.

THEORY

The position, nature and size of the image of an object formed by a thin convex lens can be studied, using new cartesian sign convention and drawing ray diagrams. The ray diagrams for obtaining image formed by a thin convex lens, of an object when placed at various positions are given in Experiment 43. The position,nature and size of the image formed depend on the position of the object with respect to the optical centre O of the convex lens LL′.

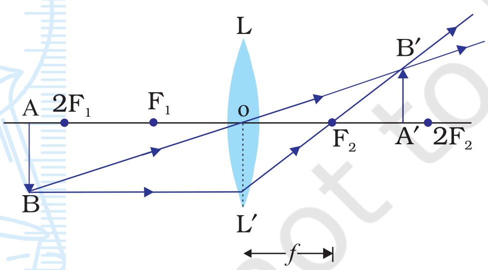


***Fig. 45.1** : Formation of an image A′B′ formed by a thin convex lens LL′ (having focal length f) of an object when placed slightly more (beyond) 2f: A real, inverted and diminished image A′B′ lies between F_2 and $2F_2$. F_2 is the second principal focus on the other side of the thin convex lens*

Fig. 45.1 summarises the formation of image of an object AB formed by a thin convex lens when the object is placed at slightly more than the twice the focal length (beyond 2f) from the optical centre of a thin convex lens. A real, inverted image can be obtained on a screen. The image of the flame of a lighted candle placed beyond a distance 2f on one side of a convex lens can be focused on a screen on

17-04-2018

the other side of the lens. The nature, position, and size of the image can be noted and measured from the optical centre O of the thin convex lens.

Materials Required

A thin convex lens, a lens holder (or a stand), a piece of rice paper screen fixed to a stand, a meter scale, a small candle with stand, and a match box.

Procedure

1. Hold a thin convex lens in hand and determine its approximate focal length f by obtaining a sharp image of a distant object (such as the sun, or a tree or an electricity pole or a building) on a wall or a screen and measuring the distance between the image and the thin convex lens.
2. Fix the thin convex lens LL′ vertically in a lens holder (or stand) and place it near the middle of the table. Note and record the postion (l) of the thin convex lens in the observation table.
3. Mount a small candle vertically on a stand and light it. Place it in front of the convex lens (Fig. 45.2). Adjust the height of the centre of lens nearly equal to the height of the flame of the candle. Here the flame is considered as the object AB. Measure and record the height h of the candle flame. (It is important that the flame must not flicker. This will ensure the height h of the flame uniform through out the experiment. (Switch off the fans. Perform the experiment at a dark place).

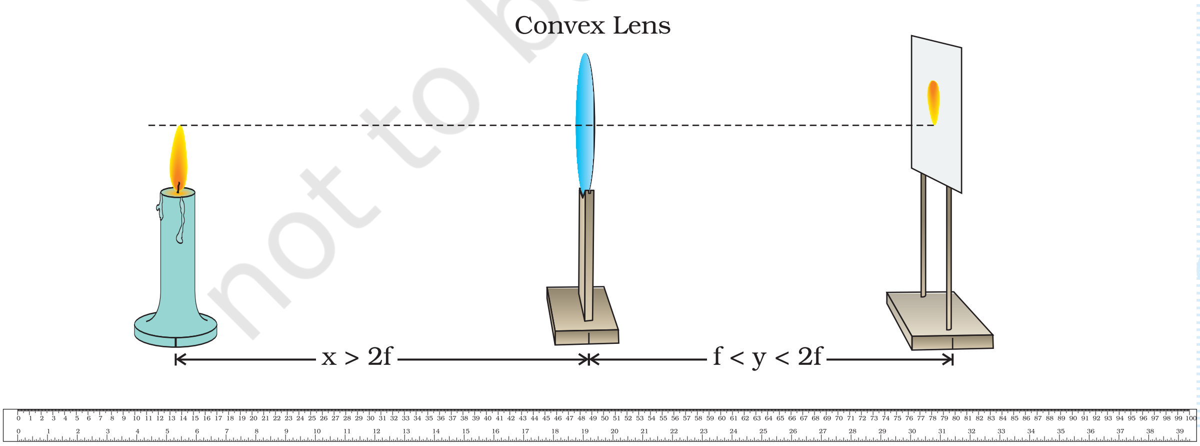


Fig. 45.2 : *Locating the image of a lighted candle flame placed beyond twice the focal length of a thin convex lens*

4. Place the lighted candle in front of the convex lens LL′ beyond twice the approximate focal length (2*f*) of the thin convex lens (Fig. 45.2). Note and record the position of the lighted candle (*c*). Find the distance, *x* (say) between the optical centre O of the lens and candle flame (object).
5. Place the semi-transparent rice paper screen, fitted to a stand between, at a distance of more than the approximate focal length *f* on the other side of the LL′.
6. To locate a sharp image A′B′ of the candle flame AB in the thin convex lens from the other side of the lens, adjust the position of the screen. Note and record the position of the screen, *s*. Find the distance between the optical centre O of the lens and the screen, *y* (say). Also measure and record the height *h*′ of the image of the flame of the lighted candle obtained on the screen.
7. Repeat the experiment two more times by varying *x* by changing the position of either the thin convex lens or the lighted candle. Locate the sharp image of the flame and record the position and height of the image in each case.

Observations and Calculations

Approximate focal length of the thin convex lens, f = _____ cm

Height of the candle flame, h = _____ cm.

Nature of the image: ______________________ .

Sl. No.	Position of the optical centre O of the lens, l (cm)	Position of the flame, c (cm)	Position of the screen, on the other side of lens, s (cm)	Distance between O and flame $x = l \sim c$ (cm)	Distance between O and image, $y = s \sim l$ (cm)	Size of the image, h' (cm)	Magnification (h'/h)
1.							
2.							
3.							

Results and Discussion

On the basis of observations, answer the following:

- What is the position of the screen with respect to the thin convex lens? Is this position less than, more than or equal to 2*f* in the case of a thin convex lens?

- Is the size of the image less than, more than or equal to the size of the object (candle flame)? Interpret the result in terms of magnification produced by the thin convex lens.
- What is the nature of the image obtained on the screen? Is it real or virtual? Is it inverted or erect? Is it magnified (enlarged) or diminisshed?

PRECAUTIONS AND SOURCES OF ERROR

- For obtaining distinct and sharp images of the candle flame, it is advised to perform this experiment in a dark room (or in shade where no direct light reaches to the working table).
- To avoid the flickering of the candle flame, perform this experiment in calm air. Switch off the fan while performing this experiment.
- While finding out the approximate value of the focal length *f* of the convex lens by using sunlight, do not look at the image directly with the naked eye, otherwise it might damage the eyes.
- The convex lens should be thin and of good quality transparent glass, without any scratches to obtain a distinct image.
- The aperture of the thin convex lens should be small for obtaining a sharp image.
- The eye should be placed at a distance of at least 25 cm from the image formed by the convex lens on the screen.
- The base of the stands of the convex lens and screen should be parallel to the measuring scale.

NOTE FOR THE TEACHER

- Experiment 43 titled "*To draw the images of an object formed by a convex lens when placed at various positions*" aims to learn qualitatively about the formation of images of an object and it is better to perform it before.
- A semi-transparent or rice paper screen is good to use in this experiment. A screen may also be prepared by spreading few drops of an edible oil on a paper.
- The focal length of the thin convex lens must preferably be between 15 to 20 cm.
- This method is not very accurate, but gives a quantitative description for recording the positions of the lighted candle, convex lens and the screen.

QUESTIONS

- How will you distinguish between a convex lens and a concave lens by holding in hand and looking the printed page through them.
- In what way will image of the lighted candle be affected when the experiment is performed in a bright light area and on a windy day.
- A distinct image of the lighted candle has been obtained on screen with fixed position, using a thin convex lens. Why does the image of the candle get blurred if the position of any one of them is slightly disturbed.
- What effect do you expect if the lens is thick?

Experiment 46

AIM

To study the formation of an image of a lighted candle by a convex lens when placed at a distance of $2f$ from the optical centre of the convex lens.

THEORY

The position, nature and size of the image of an object formed by a thin convex lens can be studied, using new cartesian sign convention and drawing ray diagrams. The ray diagrams for obtaining image formed by a thin convex lens, of an object when placed at various positions are given in Experiment 43. The position,nature and size of the image formed depend on the position of the object with respect to the optical centre O of the convex lens LL′.

Fig. 46.1 summarises the formation of image of an object AB formed by a thin convex lens when the object is placed at a distance of $2f$ from the optical center O of a thin convex lens.

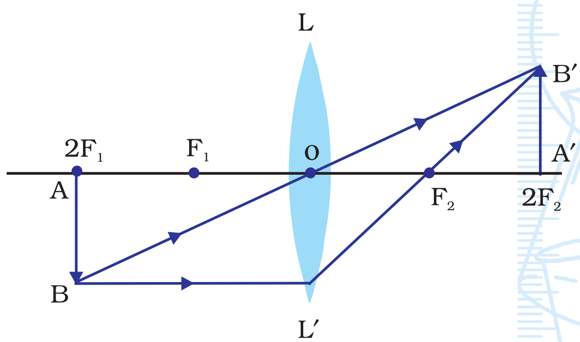


***Fig. 46.1** : Formation of an image A′B′ formed by a thin convex lens LL′ (having focal length f) of an object AB when placed at $2F_1$ at a distance of $2f$ of the thin convex lens. A real, inverted and equal size image A′B′ lies at $2F_2$ on the other side of the lens*

A real, inverted image can be obtained on a screen. The image of the flame of a lighted candle formed for the above situation (Fig. 46.1) can also be focused and obtained on a screen on the other side of the lens. The nature, position, and size of the image can be noted and measured from the optical centre O of the thin concex lens.

MATERIALS REQUIRED

A thin convex lens, a lens holder (or a stand), a small rice paper (or a semi-transparent sheet) screen fixed to a stand, a meter scale (or a ruler), a small candle with stand, and a match box.

PROCEDURE

1. Hold a thin convex lens in hand and determine its approximate focal length (f) by obtaining a sharp image of a distant object (such as the sun, or a tree or an electricity pole or a building) on a wall or a screen and measuring the distance between the image and the thin convex lens (Experiment 44).
2. Fix the thin convex lens LL′ vertically in a lens holder and place it near the middle of the table. Note and record the postion (l) of the optical centre O of the thin convex lens in the observation table.
3. Mount a small candle vertically on a stand and light it. Place it in front of the convex lens (Fig. 46.2). Adjust the height of the centre of lens nearly equal to the height of the flame of the candle. Here the flame is considered as the object AB. Measure and record the height h of the candle flame. (It is important that the flame does not flicker. It will ensure the height h of the flame uniform through out the experiment. Switch off the fans and ensure that wind does not disturb the flame. Perform the experiment at a dark place so that the image can be seen on the screen.)

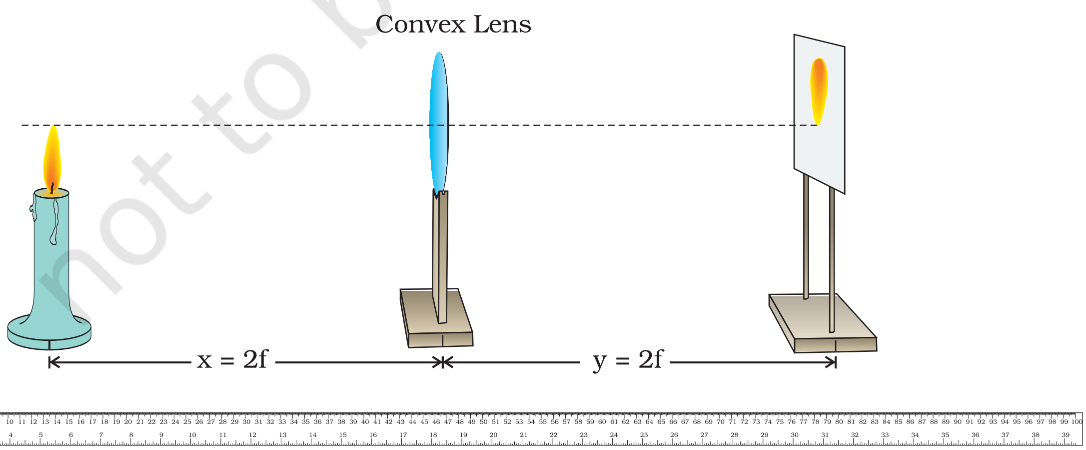


Fig. 46.2 : *Locating the image A′ B′ of a lighted candle flame AB placed at a distance 2f from the optical centre of a thin convex lens*

4. Place the lighted candle in front of the convex lens LL′ at a distance equal to $2f$ from its optical centre O.
5. Place the rice paper (or semi-transparent) screen fitted to a stand, at a distance equal to $2f$ from the optical centre O of the convex lens LL′ on the other side of the lens (Fig. 46.2). Recall that f is approximate focal length of the thin lens.
6. From Fig. 46.1, it is clear that a convex lens forms an inverted optical centre at a distance equal to $2f$ but on the other side of the lens. For realising this situation, adjust the positions of the candle flame AB and screen at equal distances from the lens on either sides of it. Now a sharp image A′B′ of the candle flame will form on the screen, only if the flame is placed at a distance equal to $2f$ from the optical centre O of the lens. Note and record the positions of the candle flame (c) and screen (s). Find the distance (x) between the candle and lens (= $2f$) and the distance (y) between the lens and screen. Is the distance x equal to the distance y ?
7. Measure the height h' of the image of the flame formed on the screen. Is it equal to the height of the object flame h ?
8. Repeat the experiment at least two more times by changing the position of convex lens. Record observations in the observation table.

Observations and Calculations

Approximate focal length of the convex lens, f_a = ____ cm.

Nature of the image: ________________ .

Sl. No.	Position of the optical centre O of the lens, l	Height of the candle flame, h	Position of the candle flame, c	Position of the screen on the other side of lens, s	Distance between O and flame, x = 2f =	Distance between O and image, $y = 2f$ =	Size of the image h′	Magnification (h'/h)
	(cm)	(cm)	(cm)	(cm)	$l \sim c$ (cm)	$s \sim l$ (cm)	(cm)	
1.								
2.								
3.								

Results and Discussion

- What is the position of the screen with respect to the thin convex lens? Is this position less than, more than or equal to $2f$?
- Is the size of the image less than, more than or equal to the size of the object (candle flame)? Interpret the result, on the basis of your observations, in terms of magnification produced by the thin convex lens.
- What is the nature of the image obtained on the screen? Is it real or virtual? Is it inverted or erect? Is it magnified (enlarged) or diminisshed?

Precautions and Sources of Error

- For obtaining distinct and sharp images of the candle flame, it is advised to perform this experiment in a dark room or at least in shade where no direct light reaches to the working table.
- To avoid the flickering of the candle flame, perform this experiment in calm air. Switch off the fan while performing this experiment.
- While finding out the approximate value of the focal length f of the convex lens by using sunlight, do not look at the image directly with the naked eye, otherwise it might damage the eyes.
- The convex lens should be thin and of good quality transparent glass, without any scratches to obtain a distinct image.
- The aperture of the thin convex lens should be small for obtaining a distinct image.
- The eye should be placed at a distance of at least 25 cm from the image formed by the convex lens on the screen.
- The base of the stands of the convex lens and screen should be parallel to the measuring scale.

Note for the Teacher

- In this experiment, it is suggested to use a lighted candle flame as an object. A mash placed on a torch glass is can be another choice.
- Experiment 43 titled "*To draw the images of an object formed by a convex lens when placed at various positions*" aims to learn qualitatively about the formation of images of an object and it is better to perform it before this experiment.
- A semi-transparent rice paper screen is good to use in this experiment. A screen may also be prepared by spreading few drops of an edible oil on a paper.

- The focal length of the thin convex lens can be between 15 to 20 cm.
- This method is not very accurate, but gives a quantitative description for recording the positions of the lighted candle, convex lens and the screen.

QUESTIONS

- How will you distinguish between a convex lens and a concave lens by holding in hand and looking the printed page into them.
- In what way will be image of the lighted candle be affected when the experiment is performed in a bright light area and on a windy day.
- A distinct image of the lighted candle has been obtained on screen with fixed position, using a thin convex lens. Why does the image of the candle get blurred if the position of any one of them is slightly disturbed.
- What effect do you expect if the lens is thick?
- Why do we require a calm atmosphere to perform this experiment?

Experiment 47

AIM

To study the formation of an image of a lighted candle by a convex lens when placed at a distance less than $2f$ but more than f from the optical centre of the convex lens.

THEORY

The position, nature and size of the image of an object formed by a thin convex lens can be studied, using new cartesian sign convention and drawing ray diagrams. The ray diagrams for obtaining image formed by a thin convex lens, of an object when placed at various positions are given in Experiment 43. The position, nature and size of the image formed depend on the position of the object with respect to the optical centre O of the convex lens LL′.

Fig. 47.1 summarises the formation of image of an object AB formed by a thin convex

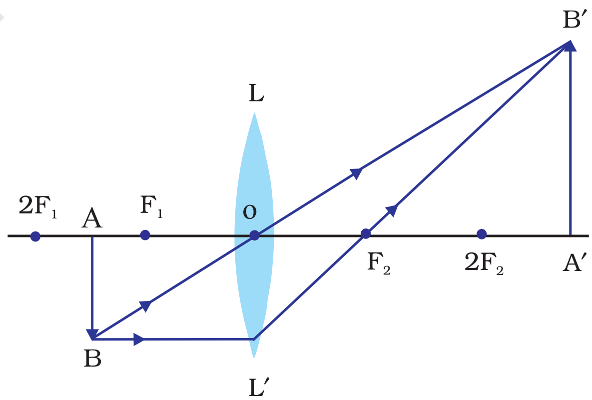


Fig. 47.1 : *Formation of an image A′B′ formed by a thin convex lens LL′ (having focal length f) of an object AB when placed between F_1 and $2F_1$ (that is at a distance less than 2f and more than f from the optical centre O of the thin convex lens). A real, inverted and magnified image A′B′ lies beyond $2F_2$ on the other side of the lens*

lens when the object is placed at a distance less than $2f$ but more than f from the optical centre O of the convex lens.

A real, inverted image can be obtained on a screen. The image of the flame of a lighted candle formed for the above situation in Fig. 47.1 can also be focused on a screen on the other side of the lens. The nature, position, and size of the image can be noted and measured from the optical centre O of the thin convex lens.

Materials Required

A thin convex lens, a lens holder (or a stand), a piece of rice paper (or a semi-transparent sheet) screen fixed to a stand, a meter scale (or a ruler), a small candle with stand, and a match box.

Procedure

1. Hold a thin convex lens in hand and determine its approximate focal length f by obtaining a sharp image of a distant object (such as the sun, or a tree or an electricity pole or a building) on a wall or a screen and measuring the distance between the image and the thin convex lens.
2. Fix the thin convex lens LL′ vertically in a lens holder (or stand) and place it near the middle of the table. Note and record the postion (l) of the thin convex lens in the observation table.
3. Mount a small candle vertically on a stand and light it. Place it in front of the convex lens (Fig. 47.2). Adjust the height of the centre of lens nearly equal to the height of the flame of the candle. Here the flame is considered as the object AB. Measure and record the height h of the candle flame. (It is important that the flame does not flicker. It will ensure the height h of the flame uniform through out the

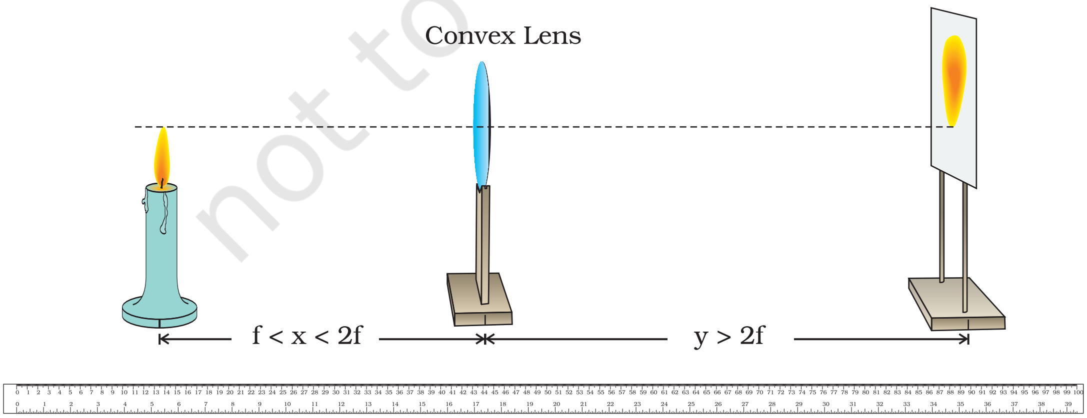


Fig. 47.2 : *Locating the image of a lighted candle flame placed between 2f and f from the optical centre of a thin convex lens*

experiment. Switch off the fans and no wind must disturb the flame. Perform the experiment at a dark place so that the image can be seen on the screen.)

4. Place the lighted candle in front of the convex lens LL′ at a distance between 2*f* and *f* from the optical centre O of the lens (Fig. 47.2). Note and record the position of of the lighted candle (*c*). Find the distance, *x* (say) between the optical centre O of the lens and candle flame (object).
5. Place the rice paper screen, fitted to a stand between, at a distance more than 2*f* from the optical centre of the lens on the other side of the convex lens LL′ .
6. To locate a sharp image A′B′ of the candle flame AB in the thin convex lens from the other side of the lens, adjust the position of the screen. Note and record the position, *s* of the screen. Find the distance between the optical centre O of the lens and the screen, *y* (say). Also measure and record the height *h*′ of the image of the lighted candle obtained on the screen.
7. Repeat the experiment two more times by varying distance *x* slightly by changing the position of either the thin convex lens or the lighted candle. Locate the sharp image of the flame and record the position and height of the image in each case.

Observations and Calculations

Approximate focal length of the thin convex lens, *f* = _____ cm

Height of the candle flame, *h* = _____ cm.

Nature of the image: _________________________ .

Sl. No.	Position of the optical centre O of the lens, *l*	Position of of the flame, *c*	Position of the screen, on the other side of lens,	Distance between O and flame $x = l \sim c$	Distance between O and image, $y = s \sim l$	Size of the image, *h*′	Magni fication (h'/h)
	(cm)	(cm)	*s* (cm)	(cm)	(cm)	(cm)	
1.							
2.							
3.							

Results and Discussion

On the basis of observations, answer the following:

- What is the position of the screen with respect to the thin convex lens? Is this position less than, more than or equal to 2*f* ?

- Is the size of the image less than, more than or equal to the size of the object (candle flame)? Interpret the result in terms of magnification produced by the convex lens.
- What is the nature of the image obtained on the screen? Is it real or virtual? Is it inverted or erect? Is it magnified (enlarged) or diminisshed?

PRECAUTIONS AND SOURCES OF ERROR

- For obtaining distinct and sharp images of the candle flame, it is advised to perform this experiment in a dark room or at least in shade where no direct light reaches to the working table.
- To avoid the flickering of the candle flame, perform this experiment in calm air. Switch off the fan while performing this experiment.
- While finding out the approximate value of the focal length f of the convex lens by using sunlight, do not look at the image directly with the naked eye, otherwise it might damage the eyes.
- The convex lens should be thin and of good quality transparent glass, without any scratches to obtain a distinct image.
- The aperture of the convex lens should be small for obtaining a distinct image.
- The eye should be placed at a distance of at least 25 cm from the image formed by the convex lens on the screen.
- The base of the stands of the convex lens and screen should be parallel to the measuring scale.

NOTE FOR THE TEACHER

- Experiment 43 titled "*To draw the images of an object formed by a convex lens when placed at various positions*" aims to learn qualitatively about the formation of images of an object and it is better to perform it before this experiment.
- A semi-transparent rice paper screen is good to use in this experiment. A screen may also be prepared by spreading few drops of an edible oil on a paper.
- The focal length of the thin convex lens must preferably be between 15 to 20 cm.
- This method is not very accurate, but gives a rough quantitative description for recording the positions of the lighted candle, convex lens and the screen.

QUESTIONS

- How will you distinguish between a convex lens and a concave lens by holding in hand and looking the printed page into them successively.
- A distinct image of the lighted candle has been obtained on screen with fixed position, using a thin convex lens. Why does the image of the candle get blurred if the position of any one of them is slightly disturbed.
- Why do you require a calm atmosphere to perform this experiment?
- What effect do you expect if the lens is thick?
- Why is it preferred to perform this experiment in dark or in shade?

UNIT IV

How Things Work

Experiment 48

AIM

To study the dependence of the potential difference across a resistor on the current through it and to determine its resistance and to verify the Ohm's law.

THEORY

According to the Ohm's law, the potential difference (V) across the ends of a resistor is directly proportional to the current (I) through it provided its temperature remains the same. That is

$$V \propto I$$

or $$\frac{V}{I} = \text{constant} = R$$

or $$V = RI.$$

Here R is a constant for the given resistor at a given temperature and is called its resistance. The SI unit of resistance is ohm (Ω). A graph between the potential difference across the two ends of a resistor and the current through it is a straight line pasing through the origin. The slope of this graph gives the resistance R of the resistor. To verify the Ohm's law, we measure the potential difference across the two ends of a resistor at different currents through it in an electric circuit. The current through the resistor is measured by connecting an ammeter in series with it. The potential difference across the two ends of the resistor is measured by connecting the voltmeter in parallel with it. A straight line graph obtained between V and I verifies the ohm's law.

MATERIALS REQUIRED

A resistor of about 5 Ω, an ammeter (0 - 3 A), a voltmeter (0 - 10 V), four dry cells of 1.5 V each with a cell holder (or a battery eliminator), a plug key, connecting wires, and a piece of sand paper.

PROCEDURE

1. Note the range and least count of the given ammeter and the voltmeter.
2. Fresh connecting wires have an insulating layer on it. Similarly the connecting wires lying unused for some time may also develop an insulating layer. (How?) It is therefore important to clean the ends of connecting wires using a sand paper.
3. Draw a circuit diagram for studying the Ohm's law as shown in Fig. 48.1 in your notebook. Observe how different components like the ammeter, voltmeter, resistor, and the plug key are connected with the cells (or battery eliminator).
4. Set up the circuit by connecting different components with the help of connecting wires. Initially connect only one cell in the circuit (that is make cell connections between points A and B). In case a battery eleminator is used, keep the rating of the eliminator at the minimum (say at 2 V).

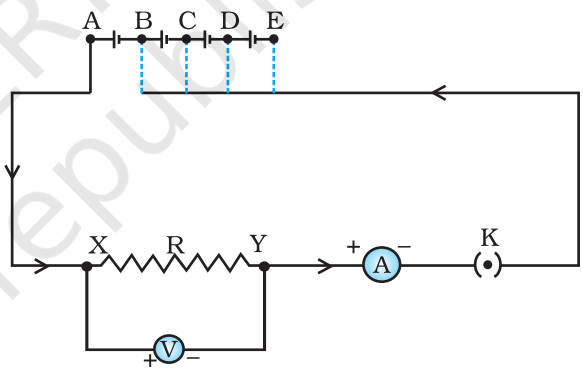


Fig. 48.1 : *An electric circuit for studying Ohm's law*

5. Make sure that the positive and negative terminals of the ammeter and voltmeter are **correctly** connected in the circuit as shown in Fig. 48.1. **Get the circuit set up by you checked by the teacher, before inserting the key into the plug**.
6. Insert the key in the plug to let the current establish in the circuit. Note the readings of the ammeter and voltmeter and record them. The voltmeter measures the potential difference (*V*) across the two ends X and Y of the resistor, and the ammeter measures the current *I* through it. Remove the key from the plug to avoid unnecessary heating of wires. (How does it happen? Think it in accordance with the Joule's law of heating.)
7. Now instead of using one cell in the circuit, connect two cells in the circuit (that is make cell connections between points A and C, in case

a battery eliminator is used, increase its rating. Insert the key in the circuit. Note and record the voltmeter and ammeter readings.

8. Repeat the experiment by connecting three and four cells in the circuit.

Observations and Calculations

(i) Range of the ammeter = ___ - ___ A.
(ii) Least count of the ammeter = ___ A.
(iii) Range of the voltmeter = ___ – ___ V.
(iv) Least count of the voltmeter = ___ V.

Mean value of resistance R of the resistor = _____ Ω.

Sl. No.	Number of cells used in the circuit	Current through the resistor, I	Potential difference across the ends of the resistor, V	Resistance of the resistor, R = V/I
		(A)	(V)	(Ω)
1.	1			
2.	2			
3.	3			
4.	4			

Graph

Find the range of variation in the values of I and V. Choose appropriate scales for the I and V along the x- and y-axes respectively on the graph paper. Mark the points on the graph paper for each value of current I and corresponding value of potential difference V (Fig. 48.2). Join all the points as a smooth line as possible such that most of the points lie on it. Find the slope of this straight line graph by choosing two points P and Q on it. This slope is the resistance of the resistor used in the circuit (Fig. 48.1).

$$\text{slope} = \frac{QM}{MP}$$

$$= \frac{V_2 - V_1}{I_2 - I_1}.$$

Extend the straight line of the graph backwards to check whether it meets the origin of the graph paper.

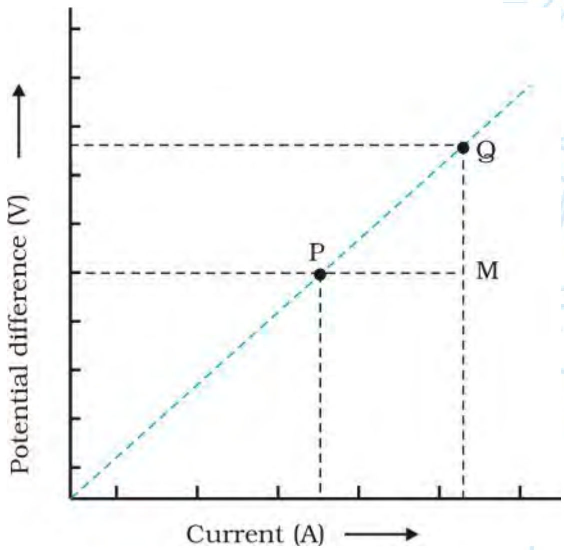


Fig. 48.2 : *Verification Ohm's law*

Results and Discussion

- Compare the value of resistance *R* of the resistor obtained from the calculations (as given in the observation table) and obtained from the graph.
- The value of resistance *R* of resistor for all values of current through it remains the same (or almost same). The graph between *V* and *I* is a straight line and passes through the origin. This verifies the Ohm's law.

Precautions and Sources of Error

- The connecting wires should be thick copper wires and the insulation of their ends should be removed using the sand paper.
- Connections should be tight otherwise some external resistance may introduce in the circuit.
- The ammeter should be connected in series with the resistor such that the current enters at the positve terminal and leaves at the negative terminal of the ammeter.
- Voltmeter should always be connected in parallel to resistor.
- The pointers of the ammeter and voltmeter should be at zero mark when no current through the circuit. If not, then ask your teacher to correct it.
- Current should be passed through the circuit for a short time while taking observations; otherwise current would cause unnecessary heating in the circuit. Heating may change the resistance of resistors.

Note for the Teacher

- If a resistor of known resistance is not available, a piece of nichrome wire of suitable length may also be used.
- In place of dry cells, Leclanche, Daniel cells can be used. A battery eliminator may also be used. In case a battery eliminator is used, it is suggested to guide students accordingly while connecting it in the circuit and taking observations.
- In case if an accumulator or battery is used in place of cells or eliminator to draw the current in the circuit then a rheostat or variable resistance box can be used to change the current flowing through the circuit.
- In case your school laboratory possesses the voltmeter and ammeter of ranges other than the prescribed ranges, then the resistors may be so chosen that an appreciable deflection may appear in the ammeter and voltmeter.

QUESTIONS

- In this experiment it is advised to take out the key from the plug when the observations are not being taken. Why?
- Suppose the ammeter (or voltmeter) you are using in this experiment do not have positive (+) and negative (-) terminal markings. How will you use such ammeter (or voltmeter) in the circuit?
- If the resistor of a known resistance value is replaced with a nichrome wire of 10 cm length (say). How do the values of current through the nichrome wire and potential difference across the two ends of it may change? How the values will change if the replaced wire is of manganin in place of nichrome?
- Suppose in this experiment you see that the deflection on ammeter (or voltmeter) scale goes beyond the full scale. What will you infer from such an observation? What will you infer if the deflection takes place in opposite direction?
- Why is it advised to clean the ends of connecting wires before connecting them?

Experiment 49

AIM

To study the factors that affect the resistance of a resistor.

THEORY

On applying the Ohm's law, it is observed that the resistance of a resistor depends on its length, on its area of cross-section and on the nature of its material. Precise measurements have shown that the resistance (R) of a uniform metallic conductor is directly proportional to its length (l) and inversely proportional to the area of cross-section (A). That is, $R \propto l$ and

$R \alpha \frac{1}{A}$. Thus

$$R = \rho \frac{l}{A} \qquad (1)$$

Here ρ is a constant of proportionality and is called the electrical resistivity of the material of the conductor. The SI unit of resistivity is ohm meter (Ω m).

In this experiment, we study these factors in an electric circuit by employing different resistors (wires) of different lengths and areas of cross-section. Using Ohm's law, the resistance of a conductor in an electric circuit can be determined by measuring the current through it and potential difference across its ends. An ammeter (connected in series with the resistor) measures the current through it and a voltmeter (connected parallely with the resistor) measures the potential difference across its two ends.

Materials Required

Two SWG-20 (standard wire gauge) constantan (or manganin) wires of lengths 10 cm and 20 cm respectively, one SWG-24 constantan (or manganin) wire of 10 cm length, one SWG-20 (or SWG-24) nichrome wire of 10 cm length (all wires must be attached with the connectors at both the ends such as crocodile clips), an ammeter (range 0 – 500 mA), a voltmeter (range 0 – 5 V), four dry cells of 1.5 V each with a cell holder (or a battery eliminator), a plug key, crocodile clips, connecting wires and a piece of sand paper.

The area of cross-section of a SWG-20 wire: 5.178×10^{-7} m^2; and the area of cross-section of a SWG-24 wire: 2.05×10^{-7}m^2.

Procedure

1. Note the range and least count of the given ammeter and the voltmeter.
2. Fresh connecting wires have an insulating layer at the top. Similarly the connecting wires lying unused for some time may also develop an insulating layer. (How?) It is therefore important to clean the ends of connecting wires using a sand paper.
3. Draw a circuit diagram for studying the factors that affect the resistance of a resistor, as shown in Fig. 49.1 in your notebook. Observe how different components like the ammeter, voltmeter, and the plug key are connected with the cells or battery eliminator. Note that a resistor is to be connected in the circuit between points A and B.
4. Set up the circuit by connecting different components with the help of connecting wires. Connect all the four cells in the circuit. In case if a battery eleminator is used, keep the rating of the eliminator at about 6 V.
5. Label the given wires (resistors) as following:

   SWG-20 constantan (or manganin) wire of length 10 cm as **wire 1**, SWG 20 constantan (or manganin) wire of length 20 cm as **wire 2**, SWG-24 constantan (or manganin) wire of length 10 cm as **wire 3**, and SWG-20 (or SWG-24) nichrome wire of length 10 cm as **wire 4**.

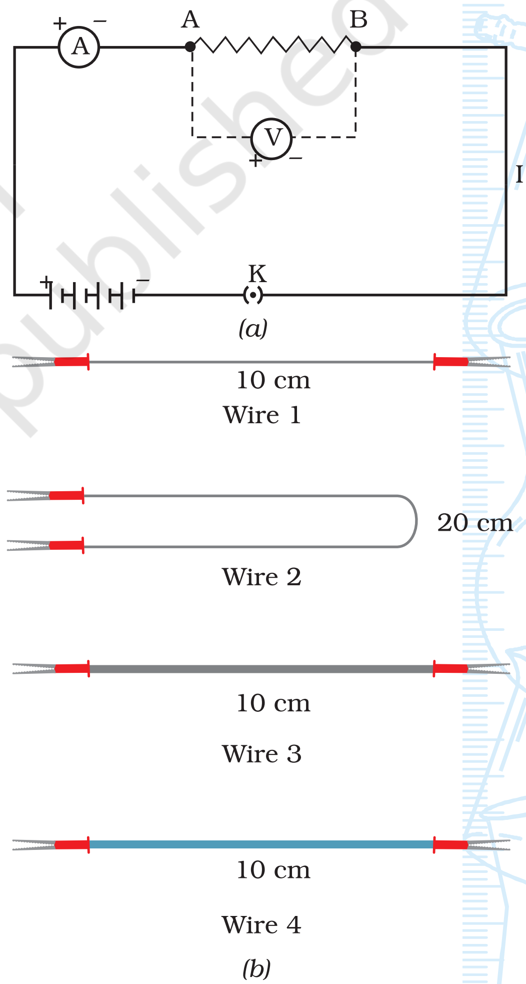


Fig. 49.1 : *(a) Electric circuit for studying the factors that affects the resistance of a resistor; (b) Different wires to be used as resistor*

All the wires must be attached to connectors such as crocodile clips, as shown in Fig. 49.1(b). This will ensure that the entire length of the wire will come in the circuit as a resitor.

6. Connect wire 1 between points A and B. Make sure that the positive and negative terminals of the ammeter and voltmeter are **correctly** connected in the circuit as shown in Fig. 49.1. **Get the circuit checked by the teacher, before inserting the key into the plug**.
7. Insert the key in plug to let the current establish in the circuit. Note the readings of the ammeter and voltmeter and record them. Ensure that the key is removed from the plug just after taking the ammeter and voltmeter readings to avoid unnecessary heating of wires.
8. Now replace the wire 1 by the wire 2. Insert the key in the plug and measure the current through wire 2 and measure the potential difference across the ends of the wire 2. Notice the difference in the values of current and potential difference. Remove the key.
9. Repeat step 8 for wires 3 and 4.

Observations and Calculations

(i) Range of the ammeter = ___ - ___ A.
(ii) Least count of the ammeter = ___ A.
(iii) Range of the voltmeter = ___ – ___ V.
(iv) Least count of the voltmeter = ___ V.

Sl. No.	Label of the Resistor connected between points A and B	Current through the resistor, *I*		Potential difference across the ends of resistor, *V*	Resistance of the resistor, $R = V/I$
		(mA)	(A)	(V)	(Ω)
1.	Wire 1				
2.	Wire 2				
3.	Wire 3				
4.	Wire 4				

Results and Discussion

Infer about the factors that affects the resistance of a resistor and answer the following:

- How does it change with length?
- How does it change with the area of cross-section?
- How does it change with the resistivity of the material of the wire? (Get the resistivity of the materials from the textbook/Appendix - I).

PRECAUTIONS

- The connecting wires should be thick copper wires and the insulation of their ends should be removed using the sand paper.
- Connections should be tight otherwise some external resistance may introduce in the circuit.
- The ammeter should be connected in series with the resistor such that the current enters at the positve terminal and leaves at the negative terminal of the ammeter.
- Voltmeter should always be connected in parallel to resistor.
- The pointers of the ammeter and voltmeter should be at zero mark when no current is flowing through the circuit. If not, then ask your teacher to correct it.
- Current should be passed through the circuit for a short time while taking observations; otherwise current would cause unnecessary heating in the circuit. Heating may change the resistance of resistors.

NOTE FOR THE TEACHER

- The number of cells to be used in the circuit is not fixed. The number of cells or the rating of the battery eliminator will, however, depend on the wires to be used as resistors in the circuit to give an appreciable amount of current to be measured by the ammeter.
- In place of dry cells a battery eliminator or a 9 V battery may be used. In case a battery eliminator is used, it is suggested to guide students accordingly while connecting it in the circuit and taking observations.
- In case your school laboratory possesses the voltmeter and ammeter of ranges other than the prescribed ranges, then the resistors may be chosen such that an appreciable deflection may appear on the ammeter and voltmeter scales.
- In this experiment it is suggested to use SWG-20 and SWG-24 constantan (or manganin) and nichrome wires. However this is suggestive and not mandatory. In case, these are not available other wires may also be used. It is suggested that the choice of wires should be judicious to get an appreciable deflection on the scales of the ammeter and voltmeter available in the laboratory. Further the area of cross-section of each wire should also be provided to the students. Appendix - J may be consulted for this purpose. In case if the standard wire gauge of the wires are not known, the diameter of the wire may be determined using a screw gauge.

QUESTIONS

- A thick and a thin wire of same length and material are connected to the same source. Which of the two will draw more current from the source?
- A copper wire is stretched uniformly to double its length; how will its resistance change? Will its resistivity also be changed?
- What happens to the value of current if positions of battery and ammeter are interchanged in such a manner that the current enters at the positive terminal of the ammeter?
- On what factors does the resistance of a conductor depend?
- If the plug key is interchanged by the ammeter in this experiment, would you be able to perform the experiment?

Experiment 50

AIM

To determine the equivalent resistance of two resistors connected in series combination.

THEORY

When two resistors of resistance R_1 and R_2 respectively are connected in a series combination (Fig. 50.1), then their equivalent resistance R_s is given by

$$R_s = R_1 + R_2. \qquad (1)$$

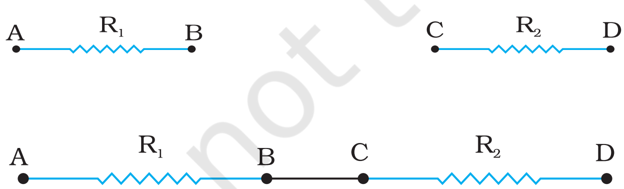


Fig. 50.1: *(a) Two resistors AB and CD are placed one after the other; (b) Two resistors AB and CD are connected in a series combination*

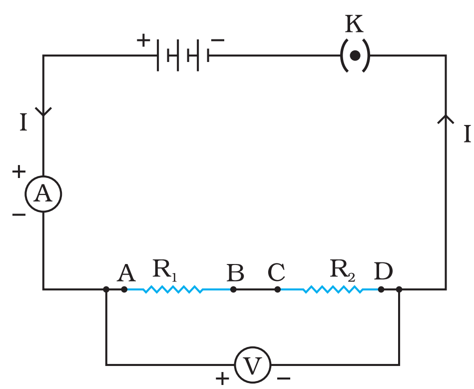


Fig. 50.2 : *Circuit diagram for the series combination of two resistors AB and CD*

In order to determine the resistance of a combination of resistors in series, the current I flowing through the circuit is measured with an ammeter connected in series with the combination. The potential difference V across the combination of resistors is measured with a voltmeter connected in parallel (Fig. 50.2).

MATERIALS REQUIRED

Two resistors of (each of 2 W resistance), an ammeter (range 0 – 5 A), a voltmeter (range 0 – 5 V), three dry cells of 1.5 V each with a cell holder (or a battery eliminator), a plug key, connecting wires and a piece of sand paper.

PROCEDURE

1. Note the range and least count of the given ammeter and the voltmeter.
2. Fresh connecting wires also have an insulating enamel layer at the top. Similarly the connecting wires lying unused for some time may also develop an insulating layer. (How?) It is therefore important to clean the ends of connecting wires using a sand paper.
3. Draw a circuit diagram for the series combination of resistors as shown in Fig. 50.2 in your notebook. Observe how different components like the ammeter, voltmeter, combination of resistors in series (of known resistances R_1 and R_2) and the plug key are connected with the cell(s) (or battery eliminator).
4. Place the given resistors one after the other and join the ends labelled B and C as shown in Fig. 50.1. Set up the circuit by connecting different components with the help of connecting wires as shown in the circuit diagram.
5. Make sure that the positive and negative terminals of the ammeter and voltmeter are correctly connected in the circuit as shown in Fig. 50.2. Get the circuit set up by you checked by the teacher, before inserting the key into the plug.
6. Insert the key in the plug to let the current establish in the circuit. Note the readings of the ammeter and voltmeter and record them. The voltmeter measures the potential difference (V) across the two ends A and D of the series combination of two resistors, and the ammeter measures the current I through the series combination. Remove the key from the plug to avoid unnecessary heating of wires (How does it happen? Think it in accordance with the Joule's law of heating.)
7. Repeat the activity for three different values of current through the circuit and record the readings of the ammeter and voltmeter in each case. The current through the circuit may either be decreased or

increased by changing the number of cells in the circuit (or by changing the settings of the battery eliminator terminal).

Observations and Calculations

Range of the ammeter	= ___ - ___ A.
Least count of the ammeter	= ___ A.
Range of the voltmeter	= ___ - ___ V.
Least count of the voltmeter	= ___ V.
Resistance of first resistor R_1	= ___ Ω.
Resistance of second resistor, R_2	= ___ Ω.

Sl. No.	Number of cells in the circuit	Current through the series combination, I_s	Potential difference across the series V_s	Equivalent Resistance of combination, R_s $R_s = V_s/I_s$	Average value of R_s
		(A)	(V)	(Ω)	(Ω)
1.					
2.					
3.					
4.					

R_1 = ____ Ω, R_2 = _____ Ω

Equivalent resistance [from Eq. (1)] = $R_1 + R_2$ = ___ Ω

Results and Discussion

Compare the observed value of the equivalent resistance of the series combination of the two given resistors (from observation table) with the calculated value of it using Eq. (1).

Precautions

- The connecting wires should be thick copper wires and the insulation of their ends should be removed using the sand paper.
- Connections should be tight otherwise some external resistance may introduce in the circuit.
- The ammeter should be connected in series with the combination of resistors such that the current enters at the positve terminal and leaves at the negative terminal of the ammeter.
- Voltmeter should always be connected in parallel to the combination of resistors.
- The pointers of the ammeter and voltmeter should be at zero mark when no current flows through the circuit. If not, then ask your teacher to correct it.

- Current should be passed through the circuit for a short time while taking observations; otherwise current would cause unnecessary heating in the circuit. Heating may change the resistance of resistors.

Note for the Teacher

- The internal resistance of cells should be much lower than the resistance of external resistors used in the experiment.
- In case if an accumulator or battery is used in place of cells or eliminator to draw the current in the circuit then a rheostat or variable resistance box can be used to change the current flowing through the circuit.
- In case your school laboratory possesses the voltmeter and ammeter of ranges other than the prescribed ranges, then the resistors may be chosen such that an appreciable deflection may appear in the ammeter and voltmeter.

Questions

- If two resistors having resistances of 2 Ω and 4 Ω, respectively are connected in a series combination in an electric circuit, what will be the net resistance in the circuit?
- In an electric circuit, a resistor of 5 Ω resistance is connected to a battery (5 V) through an ammeter and a plug key. Now in this circuit an another resistor of 10 Ω is connected in series with the 5 Ω resistor. Will there be any change in the ammeter reading? How much?
- In above question, what is the potential difference across the two ends of the resistor of 5 Ω resistance, when it is alone in the circuit? What is the potential difference across the two ends of resistor of 5 Ω resistance when it is connected in series with the resistor of 10 Ω resistance. What is the potential difference across the series combination?

Experiment 51

AIM

To determine the equivalent resistance of two resistors connected in parallel combination.

THEORY

When two resistors of resistance R_1 and R_2 respectively are connected in a parallel combination (Fig. 51.1), then their equivalent resistance R_p is given by

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2}$$

or

$$R_p = \frac{R_1 R_2}{R_1 + R_2} \qquad (1)$$

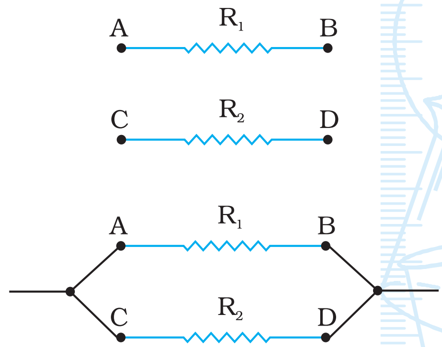


Fig. 51.1 : *(a) Two resistors AB and CD are placed side by side; (b) Two resistors AB and CD are connected in a parallel combination*

In order to determine the resistance of a combination of resistors connected in parallel, the current I flowing through the circuit is measured with an ammeter connected in series with the combination. The potential difference V across the combination of resistors is measured with a voltmeter connected in parallel (Fig. 51.2).

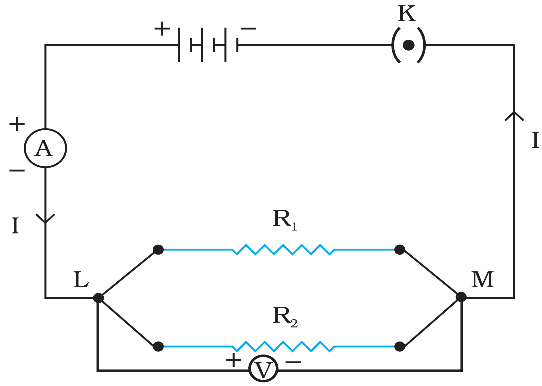


Fig. 51.2 : *Circuit diagram for the series combination of two resistors AB and CD*

MATERIALS REQUIRED

Two resistors of (each of 2 Ω resistance), an ammeter (range 0 – 5 A), a voltmeter (range 0 – 5 V), three dry cells of 1.5 V each with a cell holder (or a battery eliminator), a plug key, connecting wires, and a piece of sand paper.

PROCEDURE

1. Note the range and least count of the given ammeter and the voltemeter.
2. Fresh connecting wires also have an insulating enamel layer at the top. Similarly the connecting wires lying unused for some time may also develop an insulating layer. (How?) It is therefore important to clean the ends of connecting wires using a sand paper.
3. Draw a circuit diagram for the series combination of resistors as shown in Fig. 51.2 in your notebook. Observe how different components like the ammeter, voltmeter, combination of resistors in parallel (of resistances R_1 and R_2) and the plug key are connected with the cell(s) (or battery eliminator).
4. Place the given resistors side by side and join end A with the end C, and end B with end D (Fig. 51.1). Set up the circuit by connecting different components with the help of connecting wires as shown in the circuit diagram (Fig. 51.2).
5. Make sure that the positive and negative terminals of the ammeter and voltmeter are correctly **connected** in the circuit. **Get the circuit set up checked by the teacher, before inserting the key into the plug**.
6. Insert the key in the plug to let the current establish in the circuit. Note the readings of the ammeter and voltmeter and record them. The voltmeter measures the potential difference (*V*) across the two

ends A and D of the series combination of two resistors, and the ammeter measures the current I through the series combination. Remove the key from the plug to avoid unnecessary heating of wires (How does it happen? Think it in accordance with the Joule's law of heating.)

7. Repeat the activity for three different values of current through the circuit and record the readings of the ammeter and voltmeter in each case. The current through the circuit may either be decreased or increased by changing the number of cells in the circuit (or by changing the settings of the battery eliminator terminal).

Observations and Calculations

(i) Range of the ammeter = ____ - ____ A.
(ii) Least count of the ammeter = ____ A.
(iii) Range of the voltmeter = ____ - ____ V.
(iv) Least count of the voltmeter = ____ V.
(v) Resistance of first resistor R_1 = ____ Ω.
(vi) Resistance of second resistor, R_2 = ____ Ω.

Sl. No.	Number of cells in the circuit	Current through the parallel combination	Potential difference across the parallel combination, V_p	Equivalent Resistance of combination, R_p $R_p = V_p/I_p$	Average value of R_p
		I_p (A)	(V)	(Ω)	(Ω)
1.					
2.					
3.					
4.					

R_1 = ____ Ω, R_2 = _____ Ω

Equivalent resistance [from Eq. (1)] = $\dfrac{R_1 R_2}{R_1 + R_2}$ = ___ Ω

Results and Discussion

Compare the observed value of the equivalent resistannce of the parallel combination of the two given resistors (from observation table) with the calculated value of it using Eq. (1).

Precautions and Sources of Error

- The connecting wires should be thick copper wires and the insulation of their ends should be removed using the sand paper.
- Connections should be tight otherwise some contact resistance may introduce in the circuit.
- The ammeter should be connected in series with the combinations of resistors such that the current enters at the positve terminal and leaves at the negative terminal of the ammeter.
- Voltmeter should always be connected in parallel to the combinations of resistors.
- The pointers of the ammeter and voltmeter should be at zero mark when no current through the circuit. If not, then ask your teacher to correct it.
- Current should be passed through the circuit for a short time while taking observations; otherwise current would cause unnecessary heating in the circuit. Heating may change the resistance of resistors.

Note for the Teacher

- The internal resistance of cells should be much lower than the resistance of external resistors used in the experiment.
- In case an accumulator or battery is used in place of cells or eliminator to draw the current in the circuit then a rheostat or variable resistance box can be used to change the current flowing through the circuit.
- In case your school laboratory possesses the voltmeter and ammeter of ranges other than the prescribed ranges, then the resistors may be chosen such that an appreciable deflection may appear in the ammeter and voltmeter.

Questions

- If two resistors having resistances of 3 Ω, and 6 Ω, respectively are connected in parallel, what will be the net resistance in the circuit?
- Two resistors having resistances of 4 Ω and 6 Ω, respectively are connected in a circuit. It was found that the total resistance in the circuit is less than 4 Ω. In what way the resistances would have been connected?
- Two resistors are connected in series and then in parallel. What effect will it have on the readings of voltmeter and ammeter?
- In what way household appliances should be connected?

Experiment 52

AIM

To draw magnetic field lines of a bar magnet.

THEORY

A field of force that exists around a bar magnet is called its magnetic field. We see that when iron filings are sprinkled around a bar magnet, they arrange in a particular pattern as shown in Fig. 52.1. The lines along which the iron filings orient themselves represent magnetic field lines. These lines are closed curves and do not intersect each other. These field lines are crowded around the poles of the magnet. The degree of their closeness represent that the magnetic field is stronger at poles.

The magnetic field lines around a bar magnet can be obtained using a compass needle. (A compass needle is a small magent. Its one end, which points towards north is called its north pole and the other end, which points towards south is called south pole.)

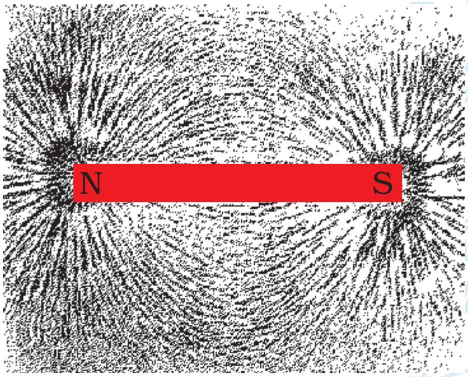


Fig. 52.1 : *Iron filings near the bar magnetalign themselves along the field lines*

MATERIALS REQUIRED

A bar magnet of about 10 cm, a small compass needle, iron filings, drawing board, adhesive tape or drawing pins of brass, and white paper sheets.

PROCEDURE

(a) To observe the pattern of iron filings around a bar magnet

1. Fix a sheet of white paper on a drawing board using adhesive tape or drawing pins of brass.
2. Place a bar magnet on this sheet in the middle of it.
3. Sprinkle iron filings around the bar magnet and gently tap the drawing board till a pattern, as shown in Fig. 52.1, is formed.
4. Observe the pattern. What does it show? Notice that the iron filings are crowded around the poles of the bar magnet.
5. Remove the iron filings from the paper.

(b) To draw the magnetic field lines around a bar magnet

6. Identify the north and south poles of the bar magnet. Place the bar magnet in the middle of the paper. Mark the position of north and south poles and also draw the boundary of the bar magnet.
7. Place a small compass needle very near the north pole of the magnet.
8. You will observe that the south end of the compass needle aligns itself towards the north pole of the bar magnet.
9. Mark the positions of its two ends of the compass needle.
10. Move the compass to a new position such that its south end occupies the position previously occupied by its north pole.
11. In this way, proceed step-by-step till you reach the south pole of the magnet, as shown in Fig. 52.2.
12. Join the points marked on paper by a smooth curve. This curve represents a field line.
13. Repeat the above procedure and draw as many lines as you can. You will get a pattern like the one shown in

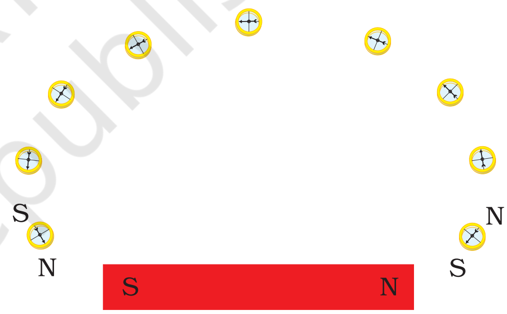


Fig. 52.2 : *Drawing a magnetic field line with the help of a compass needle*

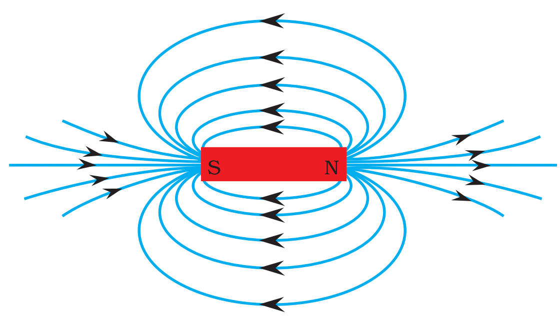


Fig. 52.3 : *Magnetic field lines around a bar magnet*

Fig. 52.3. You might have noticed that the deflection in the compass needle is more when it is placed closer to one of the poles of the magnet.

Observations and Calculations

The attached paper sheet shows the pattern of magnetic field lines drawn around the bar magnet.

Results and Discussion

From the magnetic field lines around a bar magnet, it may be confirmed that:

- the magnetic field lines are closed and continous;
- the deflection in compass needle increases as it is moves towards the poles;
- two magnetic field lines do not intersect; and
- the magnetic field lines are crowded at poles of the bar magnet.

Precautions

- There should not be any other magnetic material near the bar magnet except the compass needle while drawing the magnetic field lines.
- Size of the compass needle should be small.
- The bar magnet should be sufficiently strong to produce an appreciable deflection in the compass needle placed at a distance of 15 cm from the bar magnet.

Note for the Teacher

- If it is found that this experiment, as explained, is difficult to perform within the given time, it may be suggested to draw the magnetic field lines only. The first part to observe the pattern of iron filings around a bar magnet may be skipped.
- North and south poles of a bar magnet can be identified using another magnet of known polarity.
- A small compass needle should be used for drawing the field lines so that sufficient number of field lines can be drawn on a sheet of paper.
- It is advised to place the north and south poles of the bar magnet in the north-south direction. This is to avoid the variation in field patterns due to the effect of earth's magnetic field.

APPLICATIONS

This method can be used to identify the magnetic materials. The strengths of two bar magnets can also be compared.

QUESTIONS

- You are provided an iron strip and a bar magnet. How will you distinguish them?
- How does a compass needle work?
- How will you make a compass using an iron needle, piece of thermo-cole and a magnet?
- Do you think that the needle of a compass is a magnet?
- Why does the needle of a compass point north and south?
- Can an ordinary magnet be used as a compass?
- What does degree of closeness of magnetic field lines indicate?
- Why are more iron filings concentrated around the poles of the magnets?
- In this experiment it is advised to use a small compass needle. What will happen if small compass needle is replaced with a big size compass needle?

Experiment 53

AIM

To draw the magnetic field lines of a current-carrying straight wire.

THEORY

An electric current through a wire (conductor) produces a magnetic field around it. The existance of magnetic field can be observed using a magnetic compass needle. The direction of the magnetic field depends on the direction of the current through the wire. In this experiment we shall make an attempt to draw the magnetic field lines of a current carrying straight wire and find the effect of change of direction of current through the wire on the magnetic field lines.

MATERIALS REQUIRED

A battery (12 V) or a battery eliminator (12 V/2 A), a variable resistance (a rehostat), a plug key, a thick copper wire (prefereably SWG-12) of about 50 cm length, a rectangular wooden plank with a small hole at the centre through which the thick copper wire may comfortably pass, ammeter (0 - 3 A), a white sheet, a small compass needle, a wooden stand, adhesive tape, connecting wires, and a piece of sand paper.

PROCEDURE

1. Note the range and least count of the given ammeter.
2. Fresh connecting wires also have an insulating enamel layer at the top. Similarly the connecting wires lying unused for some time may

also develop an insulating layer. It is therefore important to clean the ends of connecting wires using a sand paper.

3. Draw a circuit diagram connecting a variable resistance (a rheostat), an ammeter, battery (or a battery eliminator), plug key with the thick copper wire XY as shown in Fig. 53.1.

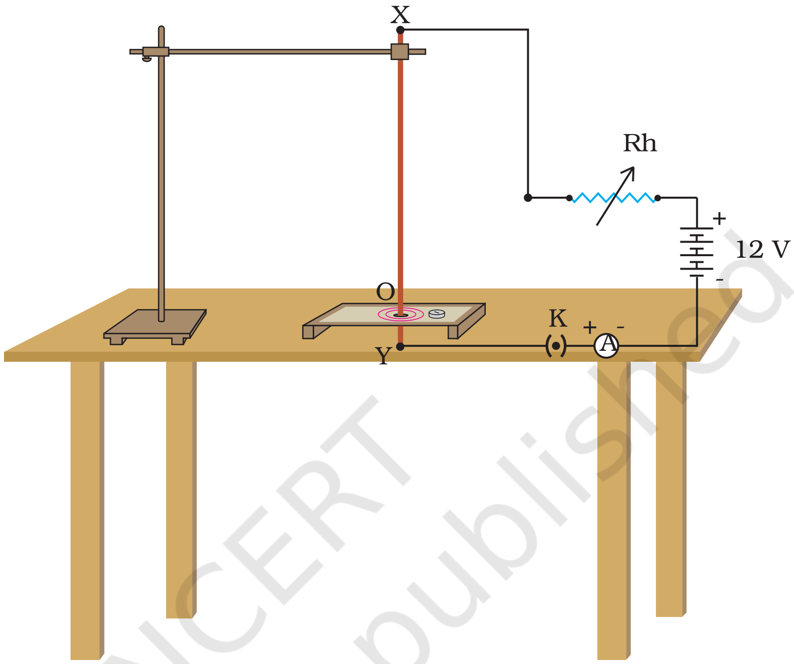


Fig. 53.1 : *An electric circuit to draw the magnetic field lines of a current carrying straight wire*

4. Fix a sheet of white paper on a rectangular wooden plank using adhesive tape. Make a small hole O at the centre of the white sheet such that it overlaps the hole on the plank. Insert the thick copper wire XY through the hole O. Place the plank horizontally on the table as shown.
5. Set up the circuit, as shown in Fig. 53.1, by connecting different components. The position of the thick copper wire XY must be normal to the plane of the rectangular cardboard. The upper end X of the thick copper wire may be fixed on a laboratory (wooden) stand. This will ensure the position of the wire XY to be vertical.
6. Make sure that the positive and negative terminals of the battery (or battery eliminator) and ammeter are **correctly** connected in the circuit. **Get the circuit set up by you checked by the teacher, before inserting the key into the plug**.
7. Insert the key in the plug to let the current flow in the circuit. Change the position of the variable of the rheostat such that a current of about 2 A flows through the thick copper wire XY. Note and record the reading of the ammeter.

8. Place a compass at a point (say P) over the white sheet placed on the rectangular cardboard. Observe the direction of the compass needle. By convention, the direction of the north pole of the compass needle would give the direction of the magnetic field produced by the electric current through the straight wire at point P.
9. Mark the position of the compass needle's two ends and move the compass so that its south end occupies the position previously occupied by its noth end. Again mark the new positions indicated by the two ends of the compass needle. In this way proceed step-by-step till you get a complete circle as shown in Fig 53.1. Also mark the direction of the magnetic field line by an arrow. Thus the magnetic field line of a current carrying straight wire is a circle having the centre at position of the current carrying wire.
10. After drawing one magnetic field line remove the plug key and wait for few minutes so that the wire comes back to its normal temperature.
11. Repeat the above procedure and draw as many concentric circles (representing magnetic field lines) as you can. What happens to the deflection of the needle if the compass is moved away from the thick copper wire. Do you observe that the deflection in the compass needle decreases? What does it mean? It represents that the magnetic field produced by a given current in the conductor decreases as the distance from it increases.
12. Using this circuit, you can also see the effect of change in current through the conductor on the deflection in the compass needle placed at a given point. For this, place the compass needle at a fixed point Q (say). Now by changing the position of the variable contact of the rheostat, increase the current through the thick copper wire. What effect do you observe? The deflection in the compass needle also increases. Do you observe a decrease in the compass needle at a given point Q (say) with a decrease in current through the thick copper wire. It indicates that the magnitude of the magnetic field produced at a given point increases as the current through the thick copper wire increases or vice-versa.
13. Reverse the direction of current through the straight thick copper wire by interchanging the terminals of the battery (or battery eliminator) and observe the direction of the compass needle. Does it get reversed?

OBSERVATIONS

The attached sheet shows the pattern of magnetic field lines around a current-carying straight wire.

Results and Discussion

On the basis of observations on the magnetic field lines, the following can be infered:

- The magnetic field lines around a current-carrying straight wire do not intersect each other.
- The deflection in the compass needle decreases as it is moved away from the current carrying straight wire.
- The deflection in the compass needle changes as the current through the wire changes.
- The direction of magnetic field lines gets reversed if the direction of current through the straight copper wire is reversed.

Precautions

- Plug key should only be inserted in the circuit when you are recording the observations.
- After drawing one magnetic field line remove the plug key and wait for few minutes so that the wire comes back to its normal temperature.
- Please do not touch the hot wire during the experiment, lest you may hurt yourself as the wire may become very hot.
- There should not be any magnetic material near the current carrying straight wire except the compass needle.
- The thick copper wire XY must be positioned straight and vertical through out the experiment. In case a proper wooden stand is not available, then the wire must be passed through a cork that can be clamped in the laboratory stand.
- A resistor of variable resistance (variable resistor) or rheostat should be connected in series with the thick straight copper wire to regulate the current through the straight copper wire.

Note for the Teacher

- In this experiment a variable resistance (a rheostat) is used to change the resistance in the circuit and thereby to change the current through the circuit. A rheostat may be a new instrument for the students. It is suggested to demonstarte its use as a variable resistor. However in place of a rheostat, a resistance box may also be used in the circuit.
- In this experiment, a high current (about 2 A) is required to flow through the circuit for a longer time. Thus the amount of heat generated will be more (Joule's law of heating). A thin wire may not remain straight for the entire duration of the experiment and

may even melt. It is therefore advised to use a thick copper wire (preferably SWG-12) whose diameter is about 2 mm. In case if it is not available, other wires may also be used. Such thick copper wires are often used in the earthing of domestic electric circuits.

- In this experiment, a relatively higher current flows through the circuit and for this reacson, it requires a high voltage battery or a high capacity battery eliminator.

QUESTIONS

- How magnetic field lines of a straight current carrying wire are different from the field lines of a bar magnet?
- What affect you will notice on the pattern of field lines if you interchange a rheostat by the plug key in this experimental arrangement?
- How can the direction of the magnetic field be determined? Suggest one method.
- What will happen to the pattern of field lines if the thick copper wire is kept horizontally straight instead of vertically straight? Discuss in groups.

Experiment 54

AIM

To study the magnetic field of an electromagnet.

THEORY

An electromagnet is a magnet consisting of a soft iron core with a coil of insulated wire wound round it. When a current flows through the wire the core becomes magnetized; when the current ceases to flow, the core loses its magnetization. In this experiment, using a compass needle we shall study the magnetic field produced by an electromagnet. (A compass needle is a small magent. Its one end, which points towards north is called its north pole and the other end, which points towards south is called south pole. A circular scale around the compass needle is used to measure its deflection. We will investigate the variation in the magnetic field produced by the electromagnet by changing the magnitude and direction of the current in the coil; and also the variation in the magnetic field as the compass is moved away from the electromagnet keeping the current through the coil constant.

MATERIALS REQUIRED

A small electromagnet, a compass needle with a circular scale, a battery of at least 6 V, a variable resistance (a rheostat), an ammeter (0 - 3 A), a plug key, measuring scale, connecting wires and a peice of sand paper.

PROCEDURE

1. Note the range and least count of the given ammeter.
2. Clean connecting wires using the sand paper.
3. Using connecting wires, set an electric circuit comprising of an elctromagnet, a battery, a variable resistance (a rheostat), plug, and an ammeter such that the axis of electromagnet lies closer and parallel to one of the side edge of the table, as shown in Fig. 54.1. Initally keep the sliding contact of the rheostat around its maximum. In such a situation, the magnitude of current through the coil will be minimum on inserting the key into the plug.

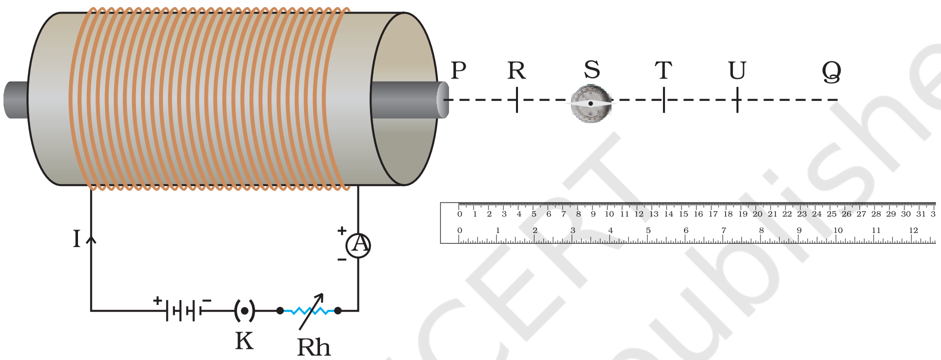


Fig. 54.1 : *The needle of the compass deflects when placed near an electromagnet*

4. From one of the end of the electromagnet, draw a line PQ of more than 20 cm on the table along the axis of the electromagnet. Mark the divisons R, S, T, U at a regular inteval of 5 cm (say) on the line PQ.
5. Place the compass needle on line PQ at point R near an end of the electromagnet such that the centre of compass coincides with the mark of point R. Rotate the compass such that its needle lies at 0°.
6. Insert the key into the plug to allow the current flow through the coil wound round the soft iron core of the electromagnet. The core will become magnetized and will produce magnetic field around it. This will produce a deflection in the compass needle. By means of changing the position of variable connector on the rheostat, adjust the value of current through the coil such that a deflection of about 30° appears in the compass needle placed at point R. Note and record the value of current through the coil and deflection in the compass needle.
7. Increase the current through the coil by changing the position of varaible on the rheostat. What happens to the compass needle? Does it deflect more now? Note and record the ammeter and compass needle readings. Repeat this step for three more values of current through

the coil. Keep the current in the coil such that it does not produce a deflection more than 60° in the compass needle. Remove the key from the plug.

8. To change the direction of the current through the coil, interchange the connections of battery terminals. Observe the change in the deflection of the compass needle.
9. Insert the key into the plug. Again note and record the current through the coil and deflection in the compass needle placed at point R along the axis PQ of the elctromagnet. Remove the key from the plug.
10. Move the compass needle to position S. Ensure that the compass needle lies at 0°. Insert the key into the plug and observe the deflection in the compass needle. Now the compass needle is placed at a distance of 10 cm from the end P of the electromagnet. Observe and record the deflection in the compass needle when placed at different distances from the end P of the electromagnet. That is when the compass needle is placed at points T, U etc. Remove the key from the plug.
11. In this experiment, you might have drawn a few lines on the table. As a courtsey to your friends who might perform this experiment later, please clean the table.

OBSERVATIONS AND CALCULATIONS

Range of the ammeter = ____ - ____ A.

Least count of the ammeter = ____ A.

(a) Variation in the deflection in the compass needle at a point with a change in current through the coil

Position in compass needle from an end of the electromagnet = ____ cm.

Sl.No.	Current in the coil (A)	Deflection in compass needle (°) when current flows in one direction	in reverse direction
1.			
2.			
3.			
4.			

(b) Variation in the deflection in the compass needle as the compass is moved from the electromagnet but the current through the coil remains the same

Current through the coil of the electromagnet = _____ A.

17-04-2018

Sl. No.	Position of the compass needle electromagnet (cm)	Distance of the compass needle from an end of the one direction	Deflection in compass needlle (°) when current flows in reverse direction
1.	Point R	5	
2.	Point S	10	
3.	Point T	15	
4.	Point U	20	

Results and Discussion

From your observations, infer the following:

- The change in the magnetic field strength of an electromagnet at a given point with the change in current through the coil of the elctromagnet.
- The change in the magnetic field strength of an electromagnet with the increase in distance from the electromagnet.
- The effect of change in the direction of electric current through the coil on the direction of magnetic field produced by the electromagnet.

Precautions and Sources of Error

- The connecting wires should be thick copper wires and the insulation of their ends should be removed using the sand paper.
- The ammeter should be connected in series with the electromagnet coil such that the current enters at the positve terminal and leaves at the negative terminal of the ammeter.
- The pointer of the ammeter should be at zero mark when no current flows through the circuit. If not, then ask your teacher to correct it.
- Plug key should only be inserted in the circuit when you are recording the observations.
- There should not be any magnetic material near the electromagnet except the compass needle. Electromagnet should be kept on a wooden table.
- Size of the compass needle should not be very large.
- The amount of current through the coil of the electromagnet should be such that its magnetic field is sufficiently strong to produce an appreciable deflection in the compass needle placed at a distnce of 20 cm from an end of the electromagnet.

NOTE FOR THE TEACHER

- In this experiment a variable resistance (a rheostat) is used to change the resistance in the circuit and thereby to change the current through the coil of the electromagnet. A rheostat may be a new instrument for the students. It is suggested to expose them to use it before they opt for this experiment. However in place of a rheostat, a resistance box may also be used in the electric circuit.
- In this experiment, a relatively higher current flows through the circuit and for this reason, it requires a high voltage battery or a high capacity battery eliminator.
- An electromagnet can be improvised in a school laboratory. Nearly forty turns of insulated thick copper wire (preferably SWG-18 or SWG-20) may be closely wrapped on a soft iron core. When an electric current is passed through the copper wire, the soft iron core gets magnetized and produces a magnetic field around it. The magnetic field produced is directly proportional to number of wrapped turns and the electric current passing through it.

QUESTIONS

- How can you make a simple electromagnet?
- Can you think of an electromagnet that is capable of producing stronger magnetic field than the magnetic field froduced by any permanent magnet?
- How does a current carrying coil of insulated copper wire wound round on a soft iron core affects a compass needle placed near to it?
- Name two ways to increase the strength of magnetic field produced by an electromagnet.
- What factors affect the strength of electromagnet?

Experiment 55

AIM

To study the force on a current-carrying straight conductor in a magnetic field and to verify that the motion of the conductor is according to Fleming's left-hand rule.

THEORY

A current carrying conductor placed in a magnetic field experiences a force (Fig. 55.1). If the direction of the field and that of current are mutually perpendicular to each other, then the force acting on the conductor will be perpendicular to both and that can be determined using the Fleming's left-hand rule (Fig. 55.2). To study the force on a current-carrying conductor, an alminium rod (AB) can be placed in a magnetic field of a horse shoe magnet, as shown in Fig. 55.1. When current establishes in the conductor (aluminium rod), it gets displaced which verifies the existance of a force on the conductor. In this experiment we shall study the dependence of force on the conductor upon the direction of the magnetic field, and upon the magnitude and direction of the current through the conductor.

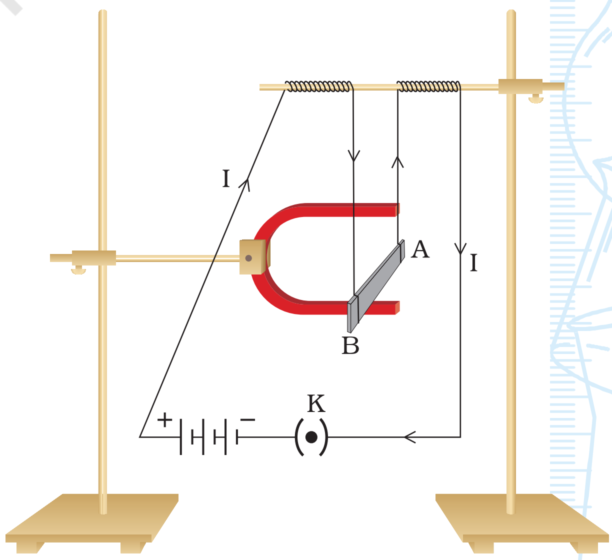


Fig. 55.1 : *A current-carrying rod, AB, experiences a force perpendicular to its length and the magnetic field*

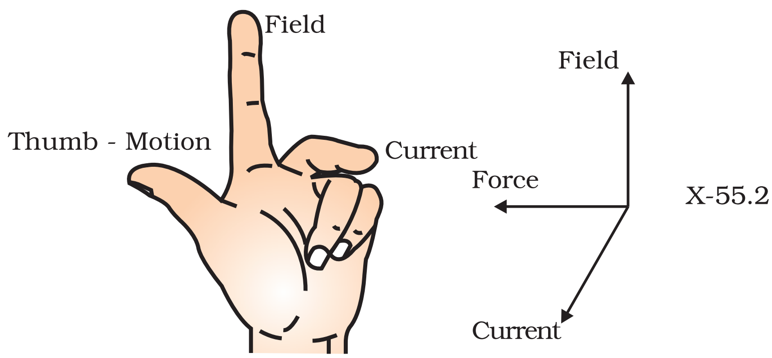


Fig. 55.2 : *Fleming's left-hand rule*

MATERIALS REQUIRED

A strong horse shoe magnet, a small aluminum rod (about 5 cm), an ammeter (0 - 3 A), two wooden stands, four dry cells (each of 1.5 V) with a cell holder (or a 6 V battery or a battery eliminator), a plug key, connecting wires, a piece of sand paper, a card boad, a graph paper, and adhesive tape,

PROCEDURE

1. Using clean connecting wires connect a conductor (a small aluminium rod) in series with dry cell holder (or a battery or a battery eliminator), an ammeter and a plug key. Do not insert the key into the plug.
2. Suspend the aluminium rod on a wooden laboratory stand such that its length AB remains horizontal. Also place a strong horse shoe magnet on another wooden laboratory stand such that its north and south poles lie in the same vertical plane.
3. Align the two laboratory stands such that the aluminium rod lies between the two poles of the magnet with the magnetic field directed upwards, as shown in Fig. 55.1. Hold a cardboard just behind the magnet and aluminium rod assembly. Fix a graph paper on it to mark the deflection in aluminium rod. For this mark the initial position of the aluminium rod on the graph paper.
4. Connect the aluminum rod in series with one cell (or set the battery eliminator on 2 V terminals) and insert the key into the plug to allow the current flow through the conductor. (Let the current flow through point B to A in the conductor.) Note and record the ammeter reading.
5. Do you see any displacement in the conductor? In which direction it moves? Does it move towards the left? Examine that this displacement is in accordance with the fleming's left-hand rule. For this stretch the thumb, fore finger and middle finger of your left hand such that they

are mutually perpendicular (Fig. 55.2). Adjust your fore finger in such a way that it points in the direction of magnetic field (upwards), and the middle finger points in the direction of current (B to A) then your thumb must point towards the left direction. Measure the displacement of the aluminium rod AB, using the graph paper placed behind (step 3).

6. Reverse the direction of electric current passing through the aluminum rod by interchanging the connections of cell (or battery or battery eliminator) and ammeter. (Always ensure that the poistive terminal of ammeter is connected with the positive terminal.) Observe the direction of displacement of conductor. Does it moves in opposite direction? Mark and record it.
7. Repeat steps 4 to 6 for different values of current through the conductor. Use two cell dry cells for 3 V supply, three cells for 4.5 V supply and four cells for 6 V supply. (Change the battery eliminator settings accordingly if a battery eliminator is used.) Note and record the current through the rod AB, its displacemnet (for both the directions of current).

Observations and Calculations

Sl. No.	No. of cells used	Voltage of supply (V)	Current through the rod AB	Displacement of aluminium rod (mm) when current flows through it along	
				BA (deflection towards left)	AB (deflection towards right)
1.	1		1.5		
2.	2		3.0		
3.	3		4.5		
4.	4		6.0		

Results and Discussion

From your observations, infer the following:

- On passing current through a straight conductor (aluminium rod) kept in a magnetic field, the conductor gets displaced.
- The displacement of the conductor increases as the current increases in the conductor.
- The direction of displacement of the conductor rod changes with the change in the direction of current through it.
- The displacement of aluminium rod is in accordance with Fleming's left-hand rule.

PRECAUTIONS

- Clean the ends of the connecting wire using a sand paper to remove the insulating layer from them.
- Aluminium rod (AB) should be suspended in such a way that it should not touch the horse shoe magnet.
- Horse shoe magnet should be fixed a using wooden stand.
- There should not be any other magnetic material near the experimental set-up.
- Plug key should be inserted in the circuit only at the time of recording the observations.

NOTE FOR THE TEACHER

- If a strong horse shoe magnet is not available then a U-shaped magnet can be improvised with the help of two strong bar magnets (Fig. 55.3).

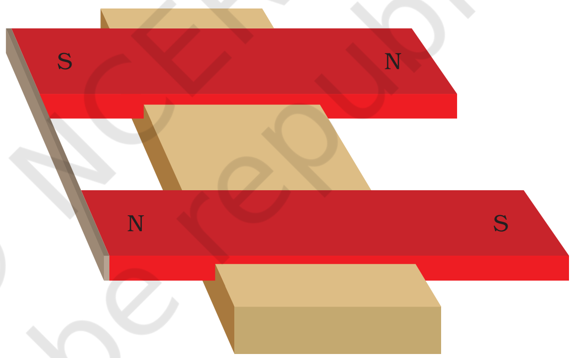


Fig. 55.3 : *Improvising a U-shaped magnet*

- Conductor through which current is passed, should be light in mass so that displacement of the condutor can be noticed easily.
- Fix the graph paper behind the assembly in such a manner that the displacement of the conductor can be measured in both (left and right) directions.
- This method can also be used to show that for a given magnitude of the current, the displacement of the rod is largest (or the magnitude of the force is the highest) when the direction of current is at right angles to the direction of the magnetic field.

QUESTIONS

- Why does the aluminum rod get displaced in this experiment ?
- List the devices used in our everyday life that use current-carrying conductors.
- What do you expect if the position of horseshoe magnet and the aluminium rod are interchanged in this experiment.

Experiment 56

AIM

To study the phenomenon of electromagnetic induction.

THEORY

The phenomenon of electromagnetic induction is the existence of an induced current in a circuit (such as a coil) placed in a region where the magnetic field changes with time. The magnetic field may change due to a relative motion between the coil and a magnet placed near to the coil. We know that a current-carrying conductor also produces magnetic field that changes with a change in the current flowing through it. Thus if a coil is placed near to a current-carrying conductor, an induced current in the coil may set-up due to a change in the current through the current-carrying conductor. In this experiment we first see the effect of moving a magnet in a coil connected with a galvanometer (Fig. 56.1). We will then see the effect of varying current in a coil (coil-1) on another coil (coil-2) connected with a galvanometer (Fig. 56.2).

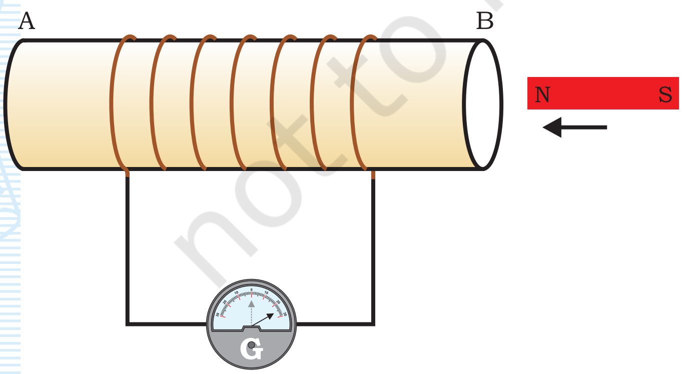


Fig. 56.1 : *Moving a magnet towards a coil sets up a current in the coil circuit, as indicated by deflection in the galvanometer needle*

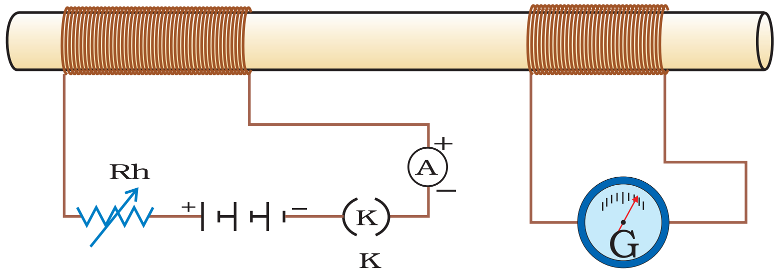


Fig. 56.2 : *Current is induced in coil-2 when current in coil-1 is changed*

Materials Required

Two coils of copper wire each having about 50 turns, a rheostat (variable resistor), an ammeter (0 - 3 A), a galvanometer, a strong bar magnet, a plug key, connecting wires, and a piece of sand paper.

Procedure

A. Existance of induced current in a coil due to the relative motion between a coil and magnet

1. Take a coil AB and connect it with a galvanometer as shown in Fig. 56.1.
2. Take a strong bar magnet and move its north pole (or south pole) towards an end (say B) of the coil. Observe the position of needle of galvanometer. Is there any deflection in it? There is a momentary deflection in the galvanometer needle in one direction (say in right direction). What does this indicate? This indicates the presence of a current in the coil AB.
3. Stop moving the bar magnet. What do you observe now? Does the galvanometer shows any reading? No. The deflection of the galvanometer becomes zero when the motion of the bar magnet stops. What does it mean?
4. Now withdraw the north pole of the magnet away from the coil and observe the deflection in galvanometer. The galvanometer needle now deflects in the opposite side (that is in left side), depicting that the current is now set up in the direction opposite to the first.
5. Move South Pole of the magnet towards the end B of the coil and observe the deflection in the galvanometer needle.

6. Place the magnet stationary at a point near to the coil retaining its north pole towards the end B of the coil and observe it. The galvanometer needle deflects towards the right when the coil is moved towards the north pole of the magnet. Similarly, the needle moves towards the left when the coil is moved away. Deflection of galvanometer drops to zero when coil is kept stationary.
7. Finally keep the coil and the magnet both stationery and observe the deflection. There is no deflection in the galvanometer. It is thus clear that motion of a magnet with respect to the coil produces an induced potential difference which sets up an induced electric current in the circuit as has been noticed by the deflection of galvanometer in above steps. Record your observations.

B. Existance of induced current in a coil due to a change in the current through another coil placed close to it

8. Connect a coil (coil-1, say) of copper wire with a source (a cell or a battery), through a rheostat, an ammeter and a plug key, as shown in Fig. 56.2. Use clean connecting wires to make the circuit.
9. Bring another coil (coil-2) connected with a galvanometer close to the coil-1 circuit.
10. Plug the key and allow a current to flow through coil-1. What do you observe? Does the galvanometer needle connected with coil-2 deflects. Yes it momentarily deflects. It stops at the zero mark as soon as the current in coil-1 becomes steady. (Adjust the variable connector of the rheostat to allow an appreciable current to flow through the coil-1. Note that a rheostat is basically a resistor of variable resistance. It is connected in series in a circuit to change the resistance in the circuit.)
11. Change the current through coil-1, by moving the variable slider on the rheostat coil. What do you observe? Do you see that the galvanometer connected with coil-2, shows deflection in one direction when current in coil-1 circuit increases while the deflection in galvanometer needle reverses when the current in coil-1 circuit decreases.
12. Record your observations in the observation table.

Observations and Calculations

(a) Existance of induced current in a coil due to the relative motion between a coil and magnet (Fig. 56.1)

Sl. No.	Activity	Deflection in the needle of the galvanometer (right/left/no deflection)	Inference
1.	Coil stationary; N-pole of the bar magnet magnet moving toawrds the coil.		
2.	Coil stationary; N-pole of the bar magnet magnet moving away the coil.		
3.	Coil stationary; S-pole of the bar magnet magnet moving toawrds the coil.		
4.	Coil stationary; S-pole of the bar magnet magnet moving away the coil.		
5.	Bar magnet stationary with its N-pole towards the coil; Coil moving towards the magnet.		
6.	Bar magnet stationary with its N-pole towards the coil; Coil moving away the magnet.		
7.	Bar magnet stationary with its S-pole towards the coil; Coil moving towards the magnet.		
8.	Bar magnet stationary with its S-pole towards the coil; Coil moving away the magnet.		
9.	Both coil and magnet stationary		

(b) Existance of induced current in a coil (coil-2) due to a change in the current through another coil (Coil-1) placed close to it (Fig. 56.2)

Sl. No.	Activity	Deflection in the needle of the galvanometer (right/left/no deflection)	Inference
1.	No current through the coil-1.		
2.	Current increasing in coil-1.		
3.	Current decreasing in coil-2.		

Results and Discussion

Write the inferences of the activities in observation table and conclude that the phenomenon of electromagnetic induction is the production of induced current in a coil placed in a region where the magnetic field changes with time. Also comment on the ways you can induce a current in a circuit that does not have any source of electricity.

Precautions

- Clean the ends of the connecting wire using a sand paper to remove the insulating layer from them.
- Bar magnet should move (inside or outside the coil) such that it does not touch the coil.
- Wrapping of copper wire of coils should be uniform.
- There should not be any other magnetic material near the experimental set-up.

Note for the Teacher

- Copper coils can be prepared by uniformly wrapping the insulated copper wire either on a cylindrical plastic or a porclein pipe. The wrapping of the wire must be such that the direction of current through every ring must be in the same direction.

Questions

- What do you conclude if no deflection in the galvanometer is observed in this experiment?
- Explain different ways to induce current in a conducting coil.
- A coil of insulated copper wire is connected to a galvanometer. What will happen if a bar magnet is (i) inserted into the coil, (ii) pulled out from the coil, and (iii) held stationary inside the coil.
- Two current-carrying coils 1 and 2 are placed closed to each other. If the current in the coil 1 is changed, will there be some induced current in the coil 2? Why?
- Name the devices which are based on the phenomenon of electromagnetic induction.