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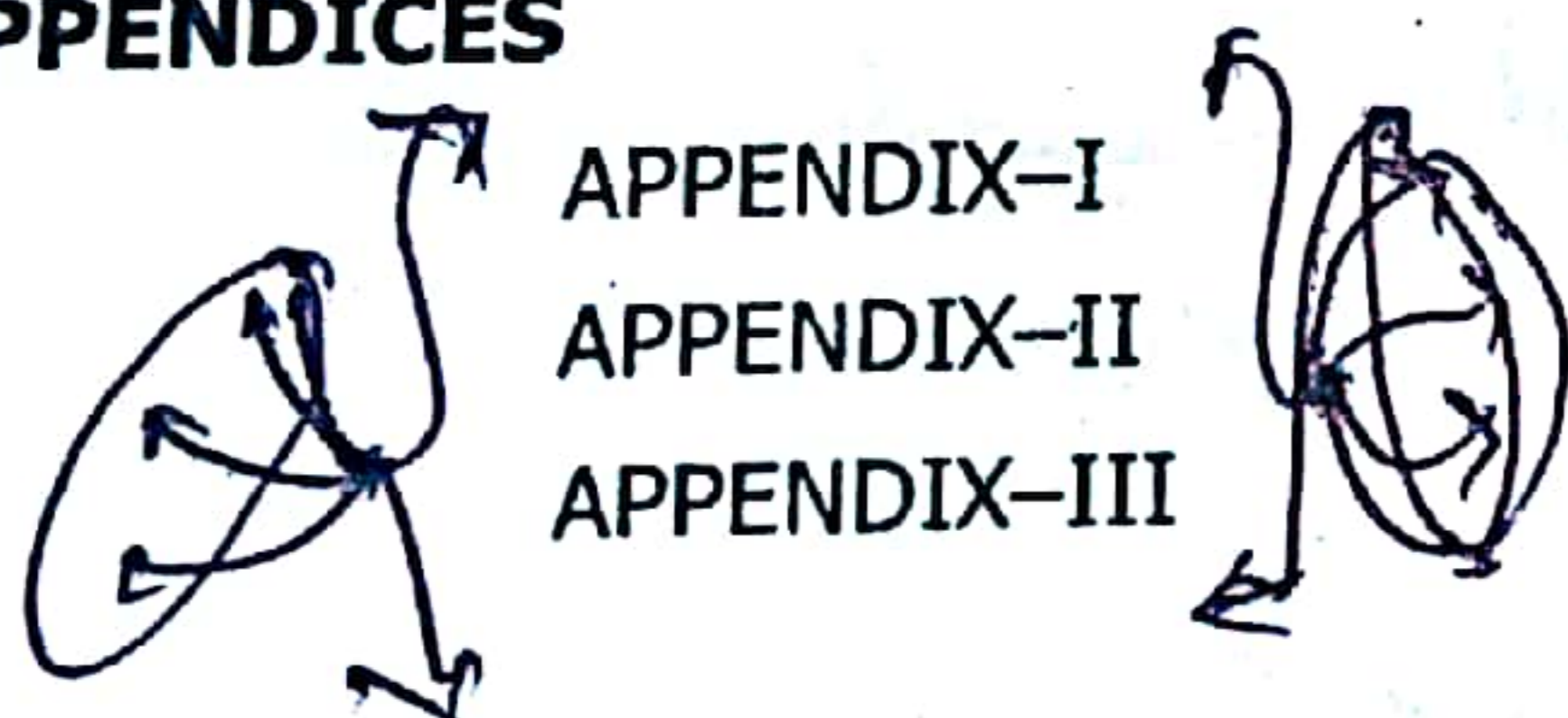
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# THE CHEMIST AND HIS TOOLS

The chemist bases his thinking on experiments and gets facts from them.

In doing his experiments, the scientist uses many special tools.

## COMMON APPARATUS USED IN THE LABORATORY

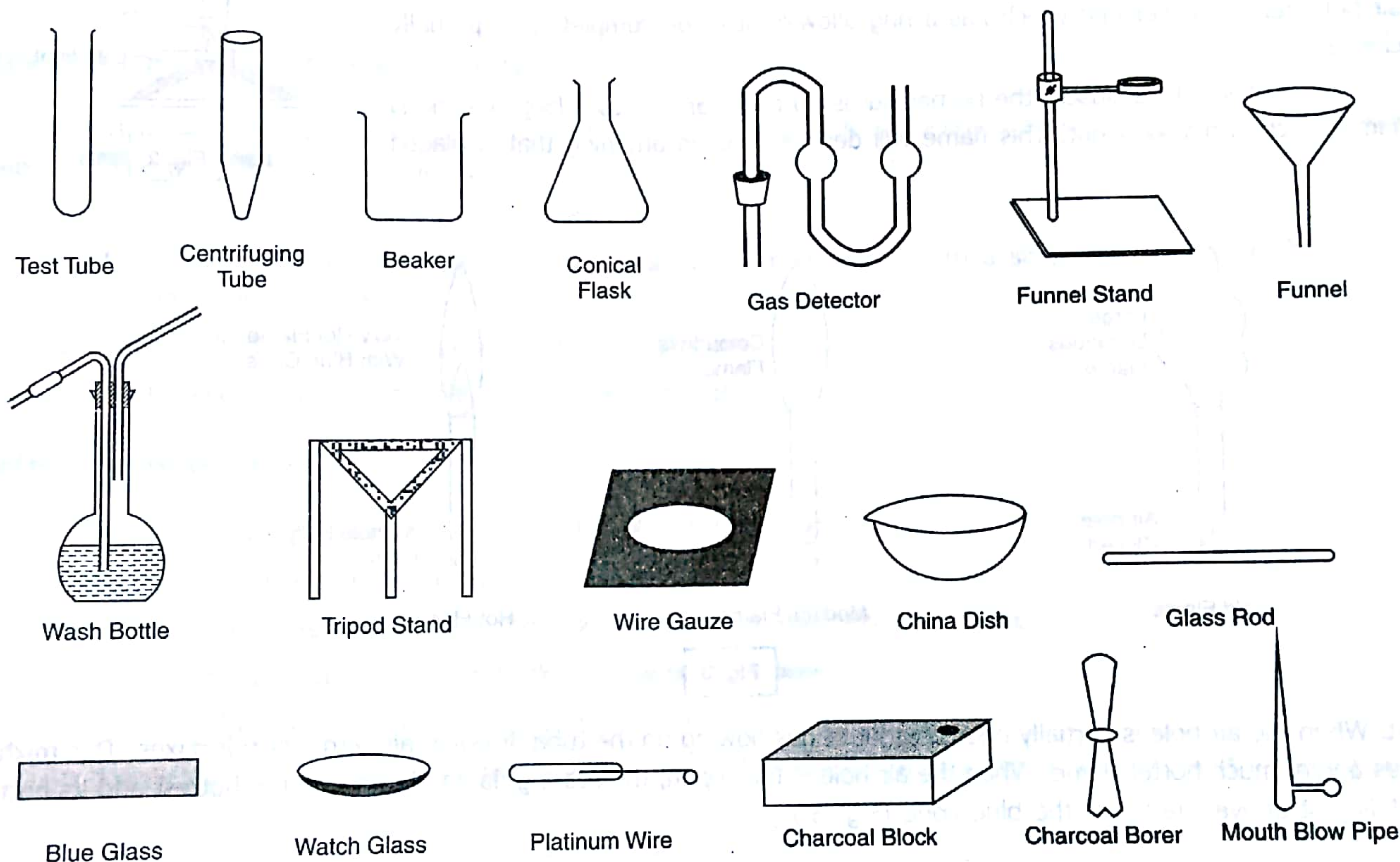


Fig. 1

### 1. Test Tubes

Test tubes of different sizes and shapes are used in the laboratory. Centrifuging tubes and boiling tubes are used in salt analysis.

### 2. Beakers

Beakers of different capacities such as 100 ml, 150 ml, 200 ml are used for handling various liquids. These are made of soft glass or corning glass.

### 3. Conical Flask

It is used for carrying out titration in volumetric analysis.

### 4. Gas Detector

It is used for testing various gases in salt analysis.

### 5. Funnel

It is used for filtration and transferring solutions from one container to another.

### 6. Measuring Cylinder

It is used in quantitative analysis for measuring liquids of a particular volume.

### 7. Glass Rod

It is used for stirring purposes.

### 8. China Dish

It is made of porcelain material. It is used for concentrating solutions in the process of crystallisation.

### 9. Wire Gauze

It is kept on the tripod stand above the flame of burner. It is used to prevent breaking of glass apparatus due to direct heating on the flame.

### 10. Tripod Stand

It is used for various apparatus like china dish or beaker to be heated.

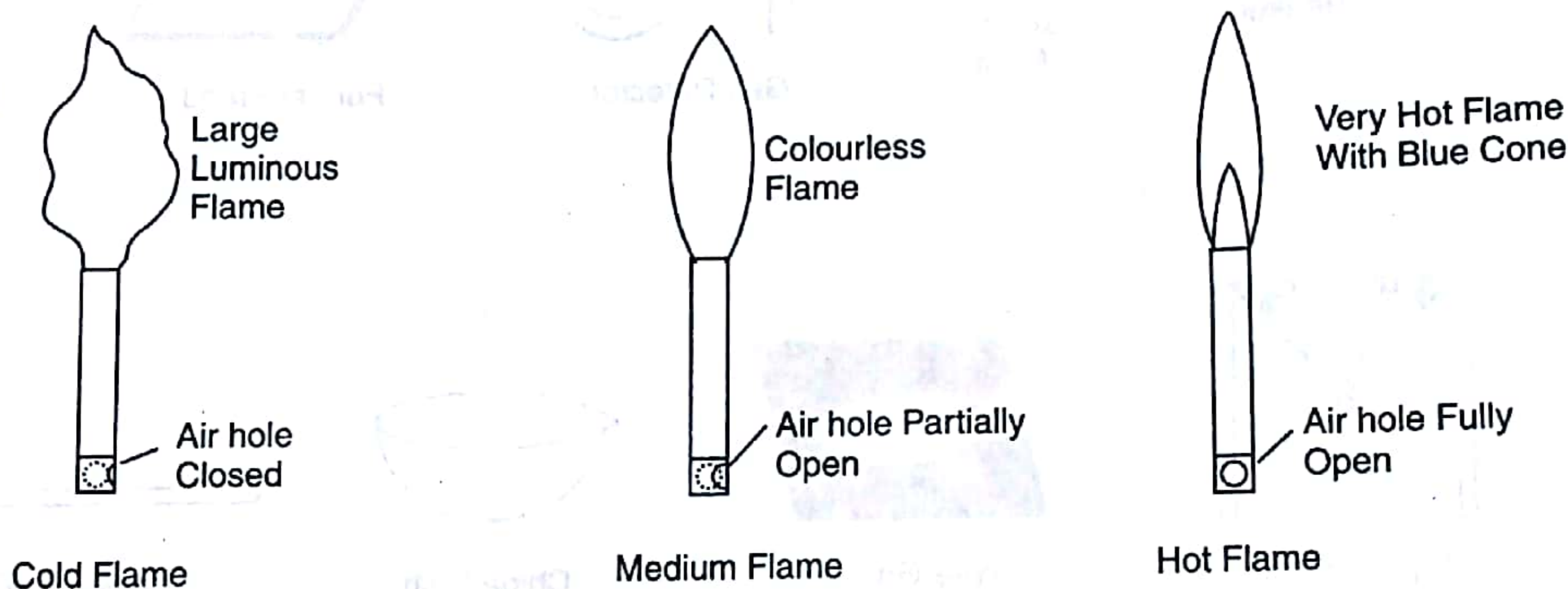
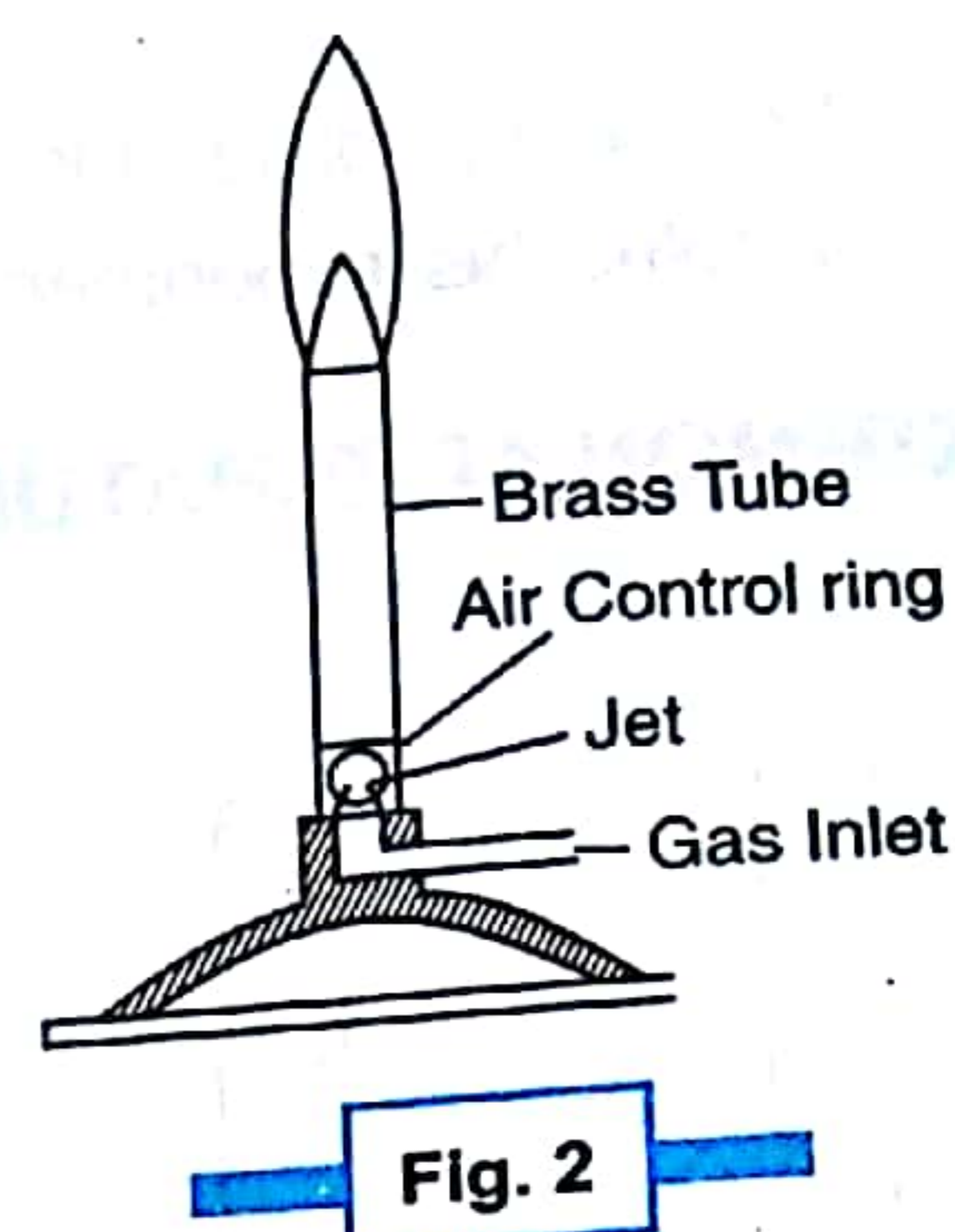
Various other apparatus like test-tube holder, tongs, burette, pipette, watch-glass, centrifugal machine, weighing balance etc. are used in the laboratory.

## Bunsen Burner

The Bunsen burner is a gas burner especially designed for use in the laboratory; it is named after its inventor, the German Chemist Bunsen. It burns liquid petroleum gas (LPG).

Fig. 2 shows a typical gas-burning Bunsen burner. The brass tube has a circular air hole near its lower end which has a ring allowing it to be completely or partially closed.

When this hole is closed, the burner burns pure gas and gives a large luminous flame which is not very hot. This flame will deposit soot on anything that is placed



in it. When the air hole is partially open, the jet of gas flowing up the tube draws in air with which it mixes. This mixture gives a very much hotter flame. When the air hole is fully open, the roaring flame obtained is the hottest and its hottest part is just above the tip of the blue cone (Fig. 3.)

## Instructions for laboratory work

Some general instructions for conducting the work in laboratory are as follows :

1. A student must have a practical notebook, pencil, eraser, scale, rough notebook, a laboratory coat, a platinum wire and fractional weights.
2. Pay attention to teacher's instructions, note down important points and precautions regarding the experiment in the rough notebook.
3. Clean the apparatus thoroughly.
4. Wear safety glasses when they are required.
5. Laboratory coat must be worn all the time during the practical.
6. Be economical with the reagents.
7. Wash your hands after finishing the experiments.

## **Important points to be kept in mind**

The laboratory work involves certain hazards. To avoid the risk of any accident, following points must be kept in mind.

1. Do not touch chemicals with hand as they may be corrosive.
2. Do not taste a chemical, it may be poisonous.
3. Do not bring inflammable liquids such as ether, alcohol near the naked flames.
4. Do not keep the reagent bottles open.
5. Do not put unused chemicals back into the reagent bottles.
6. Do not heat beakers or flasks directly on the flame. Always use a wire gauze.
7. Do not throw solid waste materials like filter papers or broken test tubes into the sink.
8. Do not use cracked glass apparatus such as beakers for heating purposes.

## **Recording the laboratory work**

All work done in the laboratory is recorded carefully and systematically in the practical notebook. While entering your observations in the practical notebook, always remember the following points :

1. Do not tear off pages from the notebook.
2. Do not erase anything in the notebook. Cross the wrong entries with a single line and write the correct statement in its place.
3. Record all laboratory data directly into the notebook.
4. Be honest in your record. Never cook the readings.

## **Safety precautions**

Observe the following precautions while working in the laboratory.

1. Never work alone in the laboratory.
2. Avoid loose dress and tie back the long hair to keep away from the flame.
3. Do not throw a burning match stick into the waste box.
4. Do not heat the inflammable liquids directly on the flame.
5. Never heat the bottom of the test tube containing the solution to avoid splashing out. Heat it from a point at the highest level of the solution.
6. Use a test tube holder for heating a test tube.
7. Never smell the vapours or gas directly. Do it by keeping the test tube at least six inches away from your nose and fan the vapours towards the nose with your hand.
8. Never perform an unauthorised experiment.
9. Never dilute an acid by adding water to the concentrated acid because it is an exothermic reaction and the liquid may bump out. Always dilute acid by adding acid slowly to water with stirring.

## **First Aid in laboratory**

An accident may occur in the laboratory due to carelessness or by chance. Common possible accidents and their **First aid treatment** are summarised herewith.

S.No.	Types of Accident	First Aid Treatment
1.	<b>Cuts</b> (i) Minor cuts (ii) Serious cuts	Remove the glass piece if any, apply a little methylated spirit and cover with a piece of cotton. Apply pressure on the cut for about ten minutes to stop bleeding. Consult a doctor.
2.	<b>Eye Injuries</b> (i) Acid in the eye (ii) Alkali in the eye (iii) Foreign particle in the eye	Wash thoroughly with water and then with 1% $\text{Na}_2\text{CO}_3$ solution. Wash with water followed by 1% boric acid solution. Do not rub the eye. Remove the particle carefully with a soft handkerchief. Wash with water.
3.	<b>Burns</b> (i) Burns caused by dry heat (flame or hot object) (ii) Burns caused by acid (iii) Burns caused by alkali	Apply Burnol or Sarson oil. Wash with 10% $\text{NaHCO}_3$ solution followed by water. Apply Burnol. Wash with 1% acetic acid solution and then with water. Dry the wound and apply Burnol.
4.	<b>Poisons</b> (i) Poison in the mouth and not swallowed (ii) Acid swallowed (iii) Alkali swallowed (iv) Salt of heavy metal swallowed. (v) Arsenic or mercury salt (vi) Inhalation of poisonous gas like $\text{Cl}_2$ , $\text{Br}_2$ or $\text{SO}_2$ gas	Spit out and wash thoroughly with water. Drink lots of lime water. Drink lemon or orange juice and then excess of water. Take milk or white of an egg. Take one table spoon of common salt or zinc sulphate in a glass of water. Move the affected person to open air. Inhale vapours of dilute ammonia and gargle with dilute solution of sodium bicarbonate ( $\text{NaHCO}_3$ )
5.	<b>Fires</b> (i) Clothes on fire (ii) Electrical fire (iii) Inflammable material in the flask, beaker catches fire.	Wrap with blanket and lie on the ground and roll. Do not run. Switch off immediately and throw sand over the object. Do not throw water. Cover the container with a wet cloth.

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**WHAT ARE COLLOIDS AND CRYSTALLOIDS ?**

**Thomas Graham** (1861) studied the rates of diffusion of large number of solutions of substances through a parchment membrane and classified the substances into two types :

**Crystalloids**

Solutions of substances like sodium chloride, urea and sugar which diffuse readily through the parchment paper membrane were named as crystalloids because these compounds can be easily obtained in the crystalline state.

**Colloids**

Solutions of substances like glues, gelatin and starch which diffuse very slowly through the parchment membrane were classified as colloids (Greek-kolla means glue).

**Colloidal State of Matter**

It was discovered that there is no basic difference between the colloids and the crystalloids. A substance may behave as crystalloid when dissolved in one solvent and colloid when dissolved in the other. Soap in alcohol behaves as a crystalloid and colloid when dissolved in water. The two substances differ only in size of the particles in solution. Thus the term 'colloidal state' was introduced. *Colloidal state of a substance is defined as that state in which the diameter of the particles is between 1 to 100 nm.* These particles can easily pass through pores of the filter paper but not through the parchment membrane. The size of the colloidal particles lies between the true solution and a suspension.

If the size of the particles is less than 1 nm, the solution is called a *true solution* which is homogeneous and can pass through filter paper as well as parchment membrane. On the other hand, if the size of the particles is more than 100 nm, these can neither pass through filter paper nor through the parchment membrane. Such a heterogeneous mixture of solid and liquid is known as **suspension**. Colloidal solutions in water are commonly called '**Sols**'.

A colloidal solution is heterogeneous in nature in which one phase is dispersed into the other. *The colloidal particles dispersed in the solvent constitute the 'dispersed phase' and the solvent in which the particles are dissolved is called as 'dispersion medium'.*

**Dispersed Phase**

*It is the component present in small proportion and consists of particles of colloidal dimensions (1–100 nm).*

**Dispersion Medium**

*The medium in which colloidal particles are dispersed is called dispersion medium.* In a colloidal solution of sulphur in water, sulphur particles constitute dispersed phase and water as dispersion medium.

The dispersed phase and dispersion medium can be solid, liquid or gas. Gases cannot form colloidal solutions because a mixture of gases is always homogeneous in nature.

**Lyophilic and Lyophobic sols**

Depending upon the interaction between dispersed phase and the dispersion medium, the colloidal solutions are divided into two types.

**Lyophilic sols**

*In this type of sols, the dispersed phase has great affinity for the dispersion medium.* For example : Substances like gum, starch and albumin readily form colloidal solution when treated with water or other suitable solvent. Such substances

are called lyophilic colloids (lyophilic – love for liquid). "Thus *lyophilic sols* are *sols* which are obtained by direct mixing of the substance into the dispersion medium."

In such colloids, the dispersed phase does not get precipitated easily and the sols are quite stable. The solids obtained after evaporation may be reconverted to the sol state by simply agitating them with the dispersion medium. Such sols are called **reversible sols**. If water is the dispersion medium, these are called *hydrophilic sols*.

### Lyophobic sols

In these sols, the dispersed phase has no affinity for the dispersion medium. For example : Substances like  $\text{As}_2\text{S}_3$ ,  $\text{Fe}(\text{OH})_3$  and gold do not form colloidal solution when mixed with water. Their colloidal solutions are prepared by indirect methods. Such substances are called lyophobic sols (lyophobic means hatred for the liquid). These sols are relatively less stable than lyophilic sols. These sols are easily precipitated or coagulated on addition of small amounts of electrolytes, by heating or shaking. Their precipitated or dried mass cannot be brought back into the colloidal state by simply shaking them with the dispersion medium. They need stabilising substances. Therefore, these colloids are known as *irreversible colloids*. If water is the dispersion medium, these are known as *hydrophobic colloids*.

## PREPARATION OF SOME LYOPHILIC SOLS

### EXPERIMENT 2.1 To prepare colloidal solution (sol) of starch.

#### Theory

Starch forms a hydrophilic sol, when dissolved in water. The formation of the sol is accelerated by heating. It is prepared by heating starch with water at about  $100^\circ\text{C}$ . It is quite stable and is not affected by small amounts of electrolytes or other impurities.

#### Apparatus

Pestle and mortar, 250 ml beakers, glass rod, funnel, filter paper, funnel stand.

#### Chemicals

Starch and distilled water.

#### Procedure

1. Grind thoroughly about 2.0 gms of starch in the mortar with the help of a pestle. Add distilled water to prepare a thin paste of starch.
2. Take about 100 ml of distilled water in a 250 ml beaker and heat it to boiling point.
3. Add the paste of the starch slowly to boiling water with constant stirring.
4. After the complete addition of the paste, boil the contents of the beaker for about 5 minutes.
5. Cool the solution to room temperature and then filter. The filtrate is the sol of starch.

#### Precautions

1. Use only distilled water for preparation of solution.
2. Convert starch into fine paste before adding to water.
3. Add starch in the form of a thin stream to boiling water.
4. Stir the contents continuously during the preparation of sol.

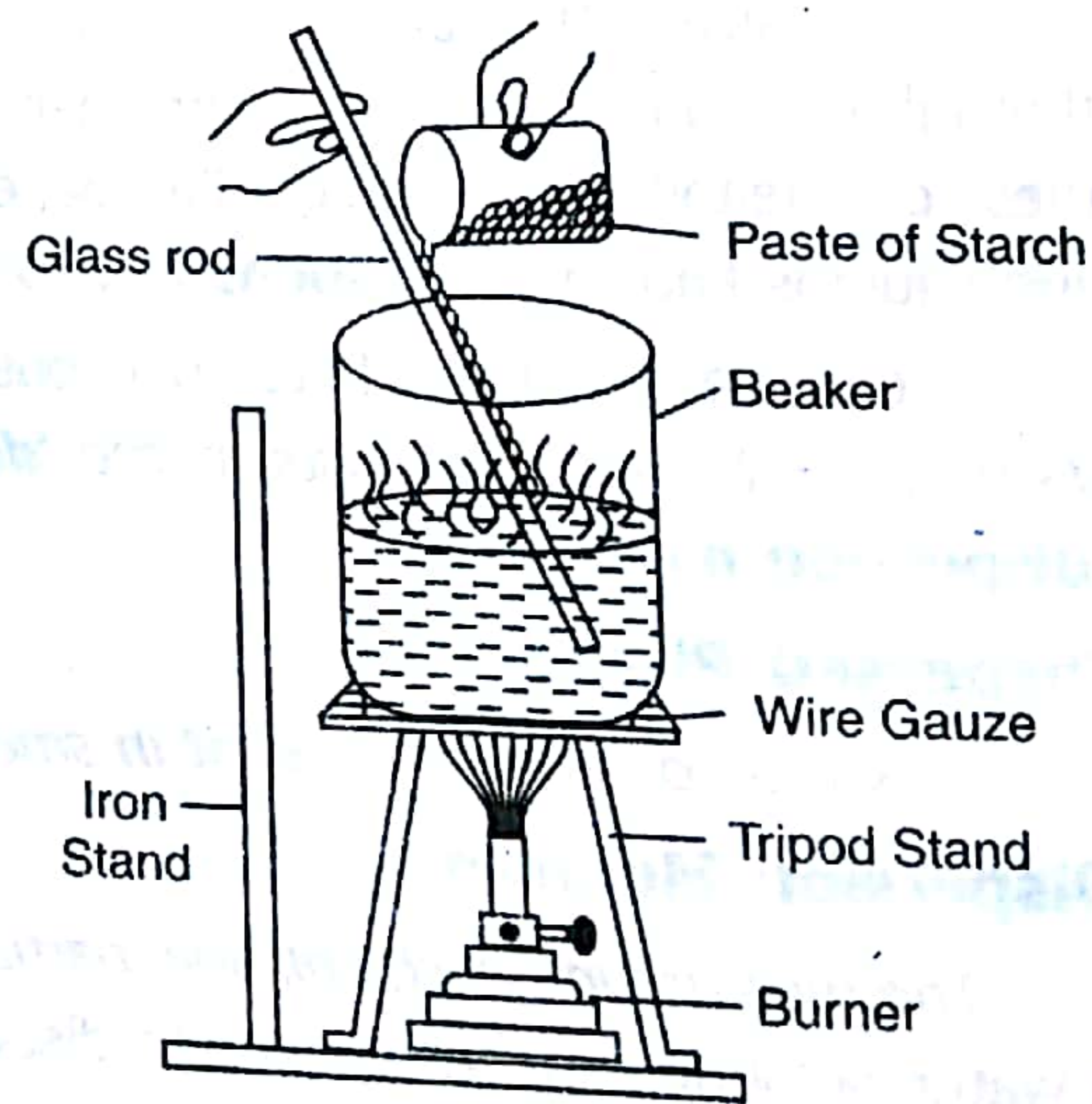


Fig. 1. Preparation of starch sol.

## EXPERIMENT 2.2 To prepare a colloidal solution of gum.

### Theory

Gum is a lyophilic sol and its colloidal solution can be easily prepared by dissolving gum in water.

### Apparatus

250 ml beaker, glass rod, tripod stand, bunsen burner, wire gauze, pestle and mortar.

### Chemicals

Gum arabic = 5.0 g, Distilled water.

### Procedure

1. Take 250 ml beaker and clean it thoroughly with distilled water.
2. Take 5 g of gum arabic and grind it to powder in the mortar.
3. Take powdered gum arabic in a clean beaker and pour 25 ml of hot water into it. Stir the mixture with a glass rod till the solid gum passes into the required sol known as gum arabic sol.

### Precautions

1. The apparatus used in the experiment should be clean, free from ionic impurities.
2. Before adding gum arabic into water, it must be powdered thoroughly in the mortar.
3. Use distilled water for preparing gum sol.

## EXPERIMENT 2.3 To prepare a colloidal solution (or sol) of egg albumin.

### Theory

Egg albumin is the colourless part of the egg. It is also known as white of an egg. It forms a hydrophilic sol with cold water. Its sol is prepared by stirring the albumin with water. The sol is quite stable and is not affected by small amounts of impurities.

### Apparatus

Beaker (250 and 50 ml), glass rod, funnel, filter paper, tripod stand.

### Chemicals

Egg and distilled water.

### Procedure

1. Break the outer shell of the egg by striking with a glass rod and collect the contents in a beaker. Decant the colourless liquid into another beaker. This colourless liquid is known as white of an egg or egg albumin.
2. Take about 100 ml of distilled water in a beaker and add to it egg albumin in small lots with constant stirring. It should take about 15–20 minutes.
3. Filter the contents of the beaker through a filter paper fixed in a funnel and collect the filtrate. The filtrate is **egg albumin sol**.

### Precautions

1. Use only **cold water** for the preparation of egg albumin sol because egg albumin gets coagulated in hot water.
2. The yellow yolk should be separated completely from the egg albumin.
3. Add egg albumin very slowly with constant stirring to disperse the colloidal particles completely.

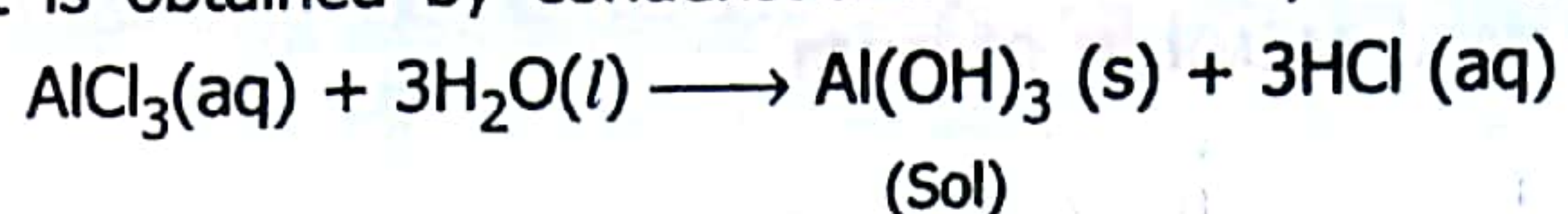
## PREPARATION OF LYOPHOBIC SOLS

## EXPERIMENT 2.4 To prepare a colloidal solution (sol) of aluminium hydroxide $[\text{Al}(\text{OH})_3]$ .

### Theory

Aluminium hydroxide is *lyophobic* and irreversible colloid. Its colloidal solution cannot be obtained directly by

shaking with water. It is obtained by condensation method by the hydrolysis of aluminium chloride.



$\text{Al}(\text{OH})_3$  molecules undergo aggregation to form particles of colloidal dimension. The particles adsorb  $\text{Al}^{3+}$  ions from the solution and become positively charged. The positively charged particles of the sol repel one another and the sol gets stabilised.  $\text{HCl}$  formed is removed by dialysis otherwise it will destabilise the sol.

### Apparatus

250 ml conical flask, test tube, dropper, wire gauze, beaker and tripod stand.

### Chemicals

2% aluminium chloride solution and distilled water.

### Procedure

- (i) Clean 250 ml conical flask by washing thoroughly with distilled water. Also clean the test tube and dropper.
- (ii) Take 100 ml of distilled water in the clean flask and heat to boil.
- (iii) Take 20 ml of 2%  $\text{AlCl}_3$  solution in a clean test tube. Add  $\text{AlCl}_3$  solution drop by drop with the help of dropper into boiling water in the flask with constant shaking.
- (iv) Continue the addition of  $\text{AlCl}_3$  solution with constant shaking till a colourless sol of  $\text{Al}(\text{OH})_3$  is obtained.
- (v)  $\text{HCl}$  formed during the reaction is removed by dialysis, otherwise the sol will become unstable.

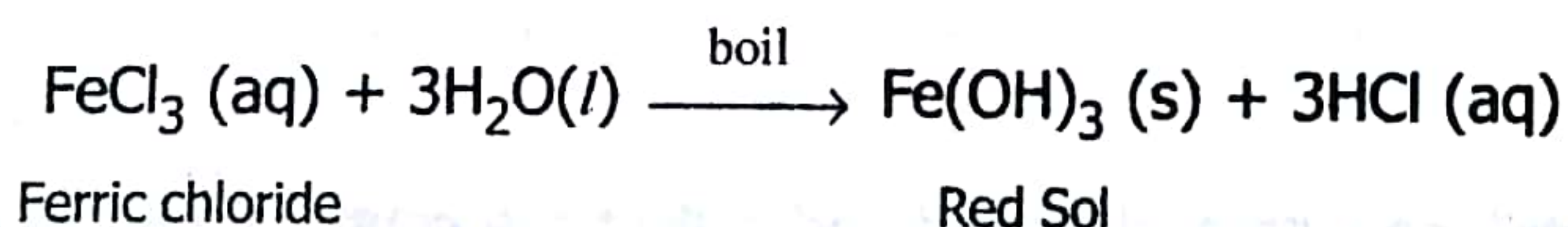
### Precautions

1. Use properly cleaned glass apparatus.
2. Add  $\text{AlCl}_3$  solution drop by drop into boiling water.
3. Remove excess of  $\text{HCl}$  (formed during hydrolysis) by dialysis.

## EXPERIMENT 2.5 To prepare a colloidal solution (sol) of ferric hydroxide $[\text{Fe}(\text{OH})_3]$ .

### Theory

Ferric hydroxide is a *lyophobic irreversible sol*. It is prepared by hydrolysis of ferric chloride solution with boiling distilled water.



Insoluble ferric hydroxide particles are produced on hydrolysis which undergo *agglomeration* to yield bigger particles of colloidal dimensions. These particles adsorb  $\text{Fe}^{3+}$  ions from the solution to impart positive charge to the colloidal particles. Due to similar charge on the colloidal particles they keep on repelling each other and cannot aggregate to form bigger particles. This prevents their coagulation and is responsible for the stability of the sol. *Hydrochloric acid produced during hydrolysis tends to destabilise the sol, therefore it is separated from the sol by dialysis process.*

### Apparatus

Conical flask (250 ml), beaker (250 ml), boiling tube, glass rod, funnel, round bottomed flask, Iron stand with clamp, wire gauze, tripod stand, burner and a dropper.

### Chemicals

2% solution of ferric chloride and distilled water.

### Procedure

1. Take a 250 ml conical flask and clean it by steaming out process as shown in Fig. 2.
2. To this clean flask, add 100 ml of distilled water and heat it to boil.

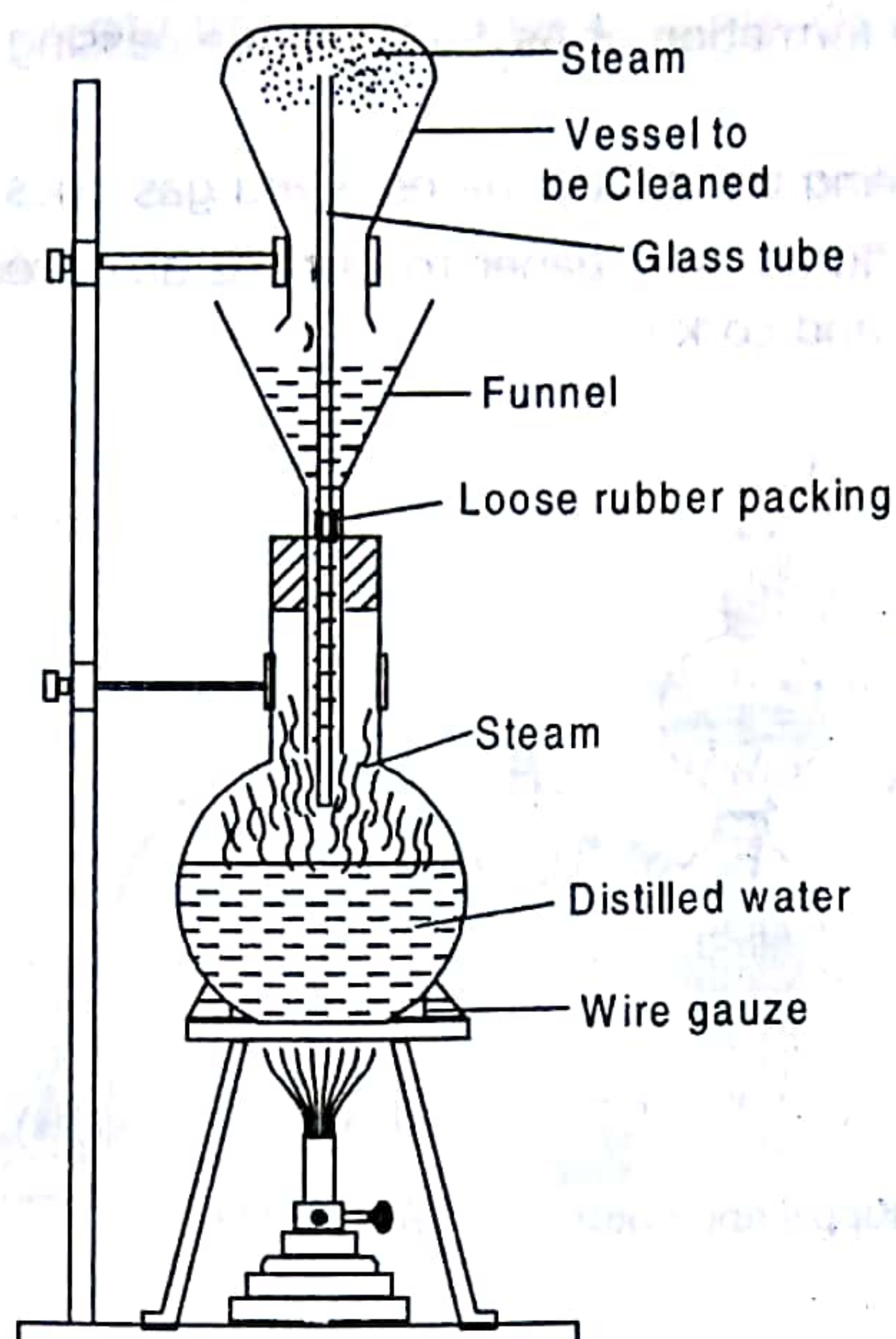


Fig. 2. Steaming-out process for cleaning conical flask.

3. Add ferric chloride solution dropwise with the help of a dropper to the boiling water. Continue heating after the addition till a deep red or brown solution of ferric hydroxide is obtained.
4. Allow it to stand undisturbed for some time at room temperature, filter to remove any precipitate of ferric hydroxide, collect the filtrate in a beaker. It is **ferric hydroxide sol**.
5. It contains HCl as impurity which can be removed by dialysis.

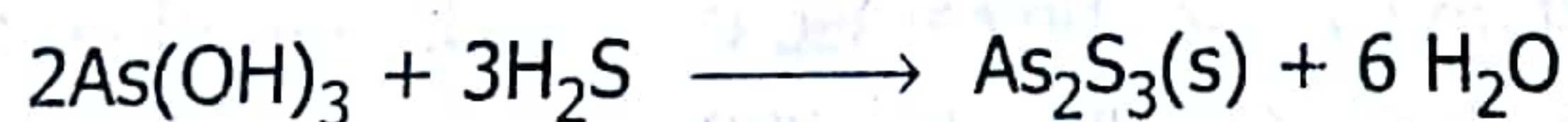
### Precautions

1. Clean the apparatus by steaming out process before use.
2. Add ferric chloride solution dropwise to boiling water.
3. Remove HCl immediately after the preparation of the sol.

## EXPERIMENT 2.6 To prepare colloidal solution of arsenious sulphide, $[\text{As}_2\text{S}_3]$ .

### Theory

Arsenious sulphide,  $\text{As}_2\text{S}_3$  is a lyophobic colloid. Arsenious sulphide sol is obtained by the hydrolysis of arsenious oxide with boiling water followed by passing  $\text{H}_2\text{S}$  gas through the solution of arsenious oxide.



Any coarse precipitate of  $\text{As}_2\text{S}_3$  formed is removed by filtration.

### Apparatus

250 ml beaker, conical flask, funnel, funnel stand, filter paper,  $\text{H}_2\text{S}$  gas generator or Kipp's apparatus.

### Chemicals

Solid arsenious oxide (2.0 gm),  $\text{H}_2\text{S}$  gas and distilled water.

### Procedure

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1. Take 2.00 gm of pure arsenious oxide ( $\text{As}_2\text{O}_3$ ) in 250 ml beaker, add to it 200 ml of water and boil for about 10-15 minutes. Cool the solution and filter to remove undissolved  $\text{As}_2\text{O}_3$  so that a clear solution is obtained.

2. Take clear solution of  $\text{As}_2\text{O}_3$  in a conical flask and pass  $\text{H}_2\text{S}$  gas through it slowly as shown in Fig. 3. The liquid becomes yellow turbid due to formation of  $\text{As}_2\text{S}_3$ . Continue passing  $\text{H}_2\text{S}$  gas till the colour of solution does not change further.
3. Remove excess of  $\text{H}_2\text{S}$  by boiling the sol till the escaping gas does not turn lead acetate paper black.
4. Filter the solution through a fluted filter paper to remove any precipitate of  $\text{As}_2\text{S}_3$ . Collect the bright yellow filtrate (sol) in a conical flask and cork it.

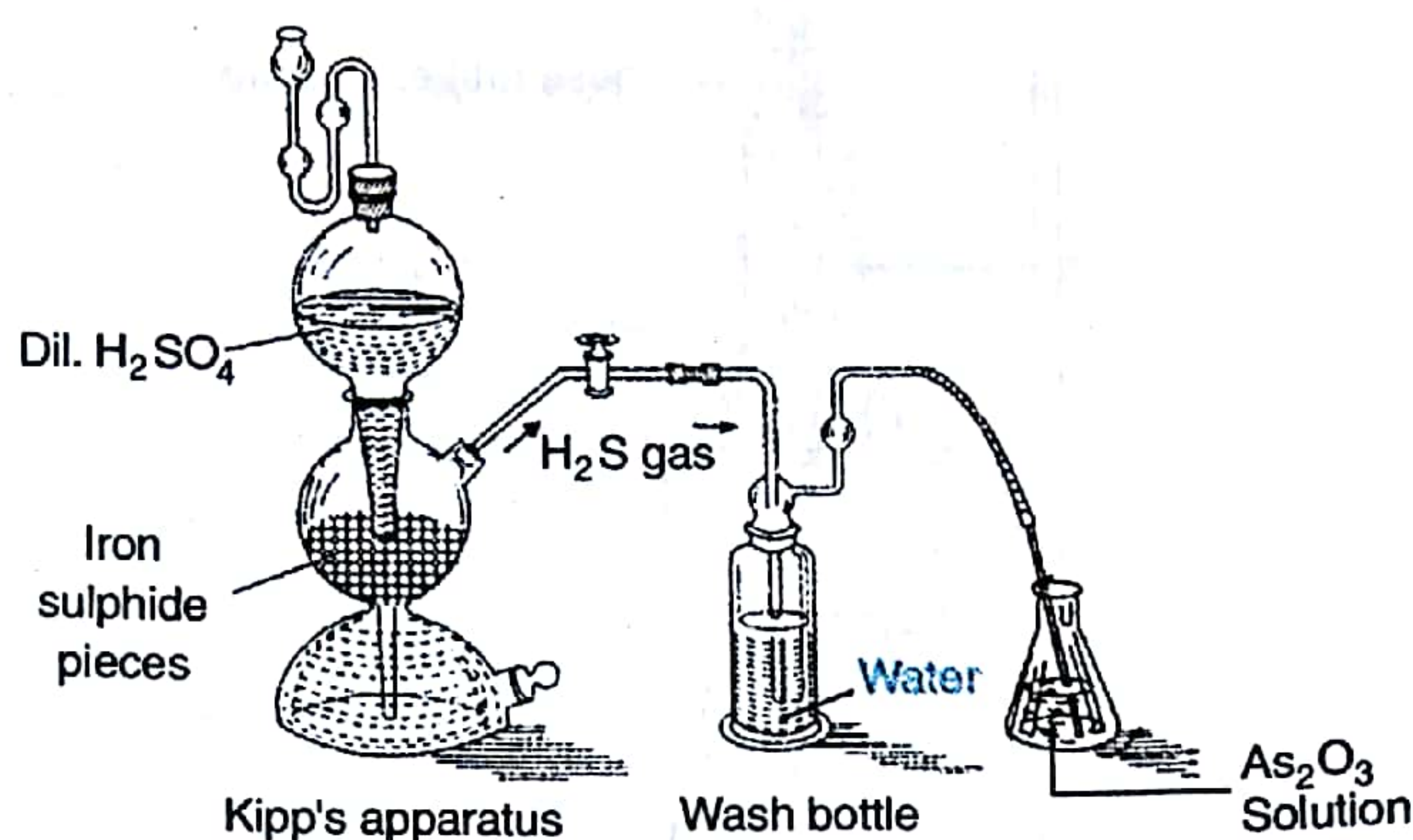


Fig. 3. Preparation of  $\text{As}_2\text{S}_3$  sol

### Precautions

1. Use clean apparatus because  $\text{As}_2\text{S}_3$  sol may be affected even by traces of impurities.
2. Handle  $\text{As}_2\text{S}_3$  carefully because it is highly poisonous.

## PURIFICATION OF SOLS

The sols prepared by chemical methods contain particles of electrolyte as impurities. They render the sol unstable if not removed. Two methods employed for purification are :

### Dialysis

When a solution containing colloidal particles and molecules of the electrolyte is taken in parchment membrane and placed in water, the particles of the electrolyte pass through the pores of the membrane into water, leaving behind colloidal particles in solution. *The separation of the particles of an electrolyte from the colloidal sol by diffusion through a semi-permeable membrane is called dialysis.* The apparatus used for this purpose is called 'dialyser'. The parchment membrane which allows the molecules of electrolyte to pass through it and not the colloidal particles is known as "semi-permeable" membrane. Apparatus employed is shown in Fig. 4.

### Ultrafiltration

The separation of a crystalloid from a colloidal system can also be carried out by ultrafiltration. It involves filtration through special filter papers whose pores are reduced by soaking in a solution of gelatin followed by hardening with formaldehyde. Such type of filter papers are known as *ultrafilters* and the process as *ultrafiltration*. When a solution containing particles of colloids and crystalloids is filtered through such a filter paper, molecules of the crystalloids pass through the pores of the filter paper, leaving behind the particles of the colloidal size.

## EXPERIMENT 2.7 To purify the given starch sol containing sodium chloride as impurity by dialysis.

### Theory

Parchment membranes are semipermeable in nature and allow the passage of electrolytes through them and not the colloidal starch particles. Sodium chloride can be separated from the sol by dialysis.

## Apparatus

500 ml beaker, funnel with a long stem, parchment membrane, clamp stand, test tubes, dropper.

## Chemicals

- (i) Impure starch sol
- (ii) Silver nitrate solution
- (iii) Iodine solution

## Procedure

1. Take a parchment paper and shape it into the form of a bag.
2. Take a long stem funnel and tie the parchment paper bag with the funnel with the help of a thread (Fig. 4.).
3. Pour impure starch solution into the parchment bag through the funnel till  $\frac{3}{4}$  of the bag is filled with the starch solution.
4. Now fix the funnel in the clamp in such a way that the bag is immersed in distilled water taken in the beaker. Allow the system to remain undisturbed for about an hour.
5. Withdraw about 1 ml of water from the beaker in a test tube with the help of a dropper and add 1 drop of iodine solution. No appearance of blue colour indicates that starch particles have not diffused through the parchment bag.
6. Now again withdraw one ml of water from the beaker with a dropper in another test tube and add a few drops of  $\text{AgNO}_3$  solution when a white ppt. is immediately formed. This indicates that  $\text{Cl}^-$  ions have diffused from the starch solution along with  $\text{Na}^+$  ion. In this way, the starch sol steadily gets free from NaCl impurity when distilled water in the beaker is renewed frequently.

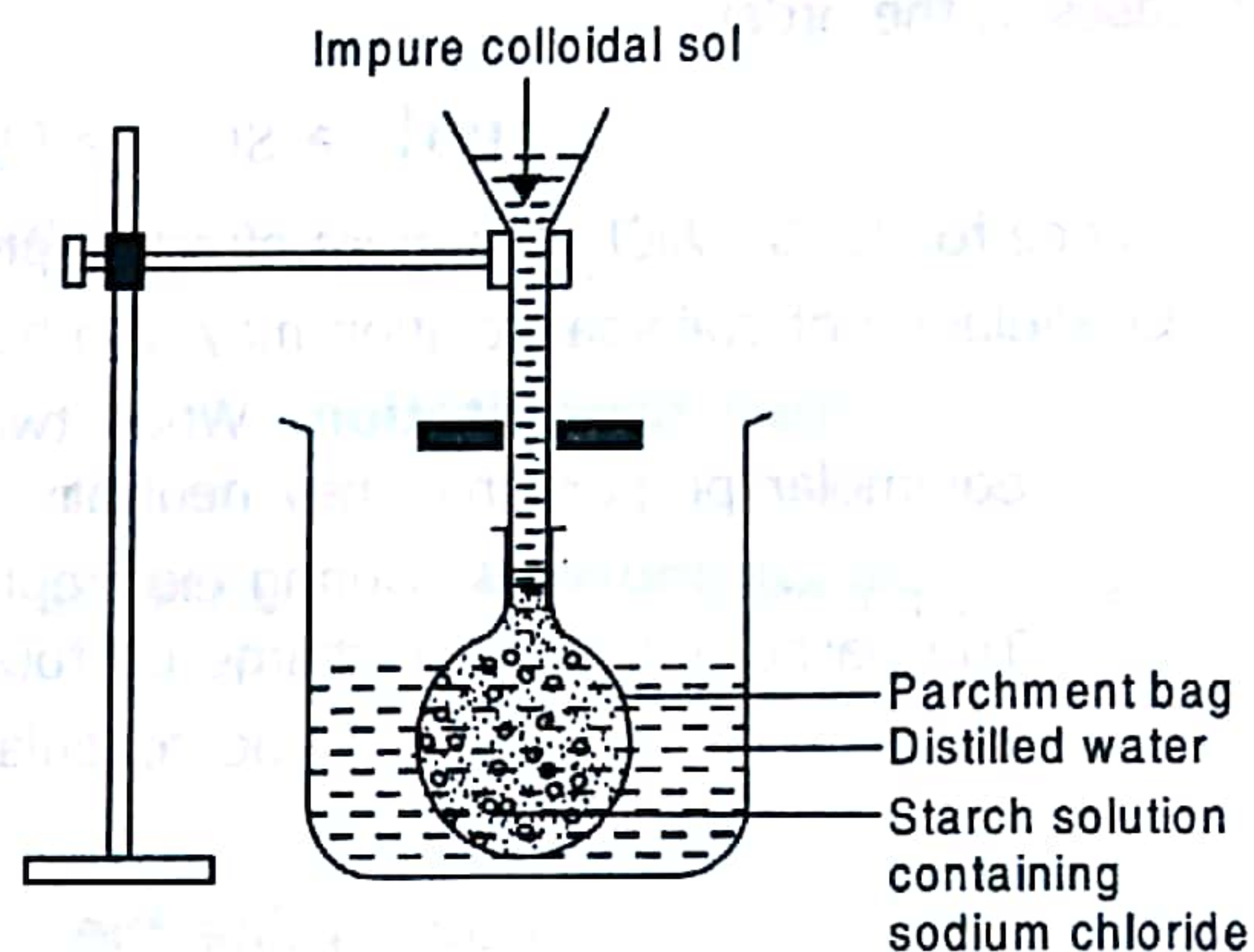


Fig. 4 Dialyser

## Precautions

1. Fill  $\frac{3}{4}$  of the parchment bag with impure starch solution.
2. Keep the bag completely immersed in distilled water in the beaker.
3. Use distilled water for dialysis.

## NOTE

- (i) Hot water may be used in the dialysis of starch to speed up the process of dialysis. This is known as **hot dialysis**.
- (ii) Hot water cannot be used for the purification of egg albumin by dialysis because egg albumin undergoes coagulation on heating.
- (iii) The most important application of dialysis is the purification of blood by artificial kidney machine. The waste ions in the blood pass through cellophane membrane and the haemoglobin particles cannot.

## COAGULATION OR PRECIPITATION OF COLLOIDAL SOLUTIONS

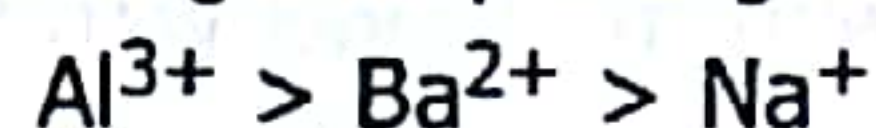
It is observed that the colloidal sols are quite stable and do not settle down even on keeping for a long time. The **stability of the sols** is explained on the basis of charge on the colloidal particles. When a colloidal sol is prepared, its **particles adsorb preferentially** one type of ions from the electrolyte present in the solution and acquire a positive or negative charge. This is known as theory of preferential adsorption of ions. Due to same type of charge on all the colloidal particles, they keep on repelling each other and cannot aggregate together to form bigger particles.

Ferric hydroxide sol is prepared by hydrolysis of ferric chloride. The colloidal particles of  $\text{Fe}(\text{OH})_3$  adsorb  $\text{Fe}^{3+}$  ions from the solution and acquire a positive charge. The  $\text{Fe}^{3+}$  ions are produced in solution due to ionisation of  $\text{FeCl}_3$ . In the same way,  $\text{As}_2\text{S}_3$  sol particles develop negative charge due to adsorption of  $\text{S}^{2-}$  ions produced due to ionisation of hydrogen sulphide gas.

**Coagulation** is the process by which the colloidal particles come closer and result in the precipitation of the dispersed phase. It may be brought about by addition of small amounts of electrolyte. These electrolytes dissociate in solution to form positive as well as negative ions. As the colloidal particles are charged particles, they are attracted towards the oppositely charged ions, their charge is neutralised and they aggregate to form bigger particles which settle down as a precipitate.

It is observed that the coagulating power of an electrolyte depends upon the charge on the ions produced by the electrolyte having charge opposite to the particles of the colloids. Greater the valency of the ion, greater will be its power to cause precipitation. This is commonly referred to as **Hardy-Schulze Rule**, according to which **"The higher the valency of the coagulating ion added, the greater will be its power to cause precipitation."**

In the coagulation of the negatively charged sol of  $\text{As}_2\text{S}_3$ , the coagulating power decreases in the order



Similarly, in the coagulation of the positively charged sol of Ferric hydroxide  $\text{Fe}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$ , the coagulating power decreases in the order



Hence for  $\text{As}_2\text{S}_3$ ,  $\text{AlCl}_3$  is a more effective precipitating agent than  $\text{NaCl}$ .

Coagulation of colloidal solution may also be brought about :

- (i) **By mutual precipitation.** When two oppositely charged sols such as  $\text{Fe}(\text{OH})_3$  and  $\text{As}_2\text{S}_3$  are mixed in equimolar proportions, they neutralise each other and get coagulated.
- (ii) **By electrophoresis.** During electrophoresis, the sol particles move towards oppositely charged electrodes. The particles lose their charge on touching the electrode and get precipitated.
- (iii) **By heating.** The sol may be coagulated even by simple heating.

## EXPERIMENT 2.8

**To determine the flocculation values of sodium chloride, barium chloride and aluminium chloride for arsenious sulphide sol.**

Arsenious sulphide ( $\text{As}_2\text{S}_3$ ) is a negatively charged sol and can be coagulated by addition of positively charged ions. The precipitation or coagulation power of the +ve ions depends upon the magnitude of the +ve charge or valency of the ion. Sodium ion ( $\text{Na}^{+}$ ) has the lowest valency, therefore lowest precipitation power. Therefore, large amount of the sodium salt will be needed for coagulation. Aluminium ion ( $\text{Al}^{3+}$ ) has the maximum valency and is most effective for precipitation. Therefore, small amount of the aluminium salt is needed for coagulation.

10.0 ml of arsenious sulphide ( $\text{As}_2\text{S}_3$ ) is taken in three different conical flasks, 0.1 M  $\text{NaCl}$ , 0.01 M  $\text{BaCl}_2$  and 0.001 M  $\text{AlCl}_3$  solutions are added to flask 1, 2 and 3 respectively till a yellow ppt. of  $\text{As}_2\text{S}_3$  is formed. The volume of each solution added is noted. Then the flocculation value is calculated by the relation :

$$\text{Flocculation or precipitation value} = \frac{\text{Molarity of electrolyte} \times \text{Vol. of electrolyte used}}{\text{Total volume}} \times 1000$$

### Apparatus

Three conical flasks (100 ml), a burette and beakers.

### Materials

Arsenious sulphide sol, 0.1 M  $\text{NaCl}$  solution, 0.01 M  $\text{BaCl}_2$  solution, 0.001 M  $\text{AlCl}_3$  solution.

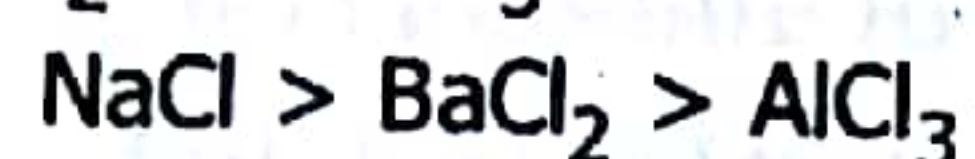
### Procedure

1. Take three conical flasks and label them as 1, 2 and 3.
2. Add 10.0 ml of arsenious sulphide sol to each flask.
3. Add 0.1M  $\text{NaCl}$  to flask No. 1 dropwise shaking gently after each addition till a yellow precipitate of  $\text{As}_2\text{S}_3$  is just formed. Note the volume of  $\text{NaCl}$  solution used.
4. Add 0.01M  $\text{BaCl}_2$  solution and 0.001 M  $\text{AlCl}_3$  to flask No. 2 and 3 respectively in the same way till a yellow ppt is just formed. Note the volume of  $\text{BaCl}_2$  and  $\text{AlCl}_3$  solution used for coagulation of the sol.

Flask No.	Vol. of $\text{As}_2\text{S}_3$ sol taken	Electrolyte added	Conc. of electrolyte	Vol. of electrolyte used	Total Volume	Flocculation value
1	10 ml	NaCl	0.1 M	x ml	$10 + x = V_1$ ml	$\frac{0.1 \times x \times 1000}{V_1}$
2	10 ml	$\text{BaCl}_2$	0.01 M	y ml	$10 + y = V_2$ ml	$\frac{0.01 \times y \times 1000}{V_2}$
3	10 ml	$\text{AlCl}_3$	0.001 M	z ml	$10 + z = V_3$ ml	$\frac{0.001 \times z \times 1000}{V_3}$

### Result

Flocculation values of NaCl,  $\text{BaCl}_2$  and  $\text{AlCl}_3$  are in the order :



Therefore, the coagulation powers of these electrolytes are in the order :



### Precautions

1. The apparatus used should be clean.
2. After addition of each drop of the electrolyte, *shake the conical flask gently* to ensure mixing of the electrolyte with the sol.
3. Do not shake vigorously.
4. Look vertically downward to detect the precipitation of the sol.

## EMULSIONS AND EMULSIFYING AGENTS

**Emulsions are the colloidal systems in which the dispersion medium as well as the dispersed phase are the liquids.** Any two immiscible liquids can form an emulsion. One of the components is usually water and the other is an oily substance insoluble in water. For example,

- (i) Milk is an emulsion of the particles of liquid fat dispersed in water.
- (ii) Cod liver oil is an emulsion of particles of water dispersed in oil.

The emulsions are of two types :

### 1. Oil in Water emulsions

In these type of emulsions, oil acts as dispersed phase and water as dispersion medium. *Milk* and *vanishing cream* are oil in water emulsions (in which fat globules are dispersed in water).

### 2. Water in Oil emulsions

In these type of emulsions, water acts as dispersed phase and oil as dispersion medium. This type of emulsion may also be called an *oily emulsion*. *Butter* and *cod-liver oil* are examples of this type of emulsion.

### Preparation of Emulsions

The process of making an emulsion is known as **emulsification**. When two immiscible liquids, such as oil and water are shaken together vigorously, an emulsion is formed.

However, the emulsion formed by merely shaking the two immiscible liquids together is not stable. On standing, the two liquids soon separate, the oil globules rise to the top and form a separate oil phase. In order to have stable emulsions, it is necessary to add another substance known as an **emulsifier or emulsifying agent**, in a small quantity. Emulsifier can be a lyophilic colloid such as agar agar, gelatine, gum or proteins. These compounds stabilise the emulsion by forming a protective coating around the globules of dispersed phase.

Long chain compounds with polar groups such as soaps and detergents also act as emulsifiers.

### Demulsification

The decomposition of an emulsion into its constituent liquids is called **demulsification**. Demulsification may be carried out by : (i) freezing (ii) boiling (iii) filtration (iv) centrifugation (v) electrostatic precipitation or (vi) chemical

methods. Any chemical compound which can destroy emulsifying agent will cause demulsification. For example, cream is separated from milk by the method of centrifugation.

### Applications of Emulsions

Emulsions play an important role in industry and our daily life. Some applications are :

1. Washing action of soap is due to emulsification of grease and washing away with water.
2. Most of the pharmaceutical preparations are emulsions. These are readily acted upon by the digestive juices in the stomach and digested easily.
3. Disinfectants such as phenol, dettol and lysol form oil in water emulsions when mixed with water.
4. Metallurgical operations like concentration of sulphide ores by froth floatation process involve formation of emulsions.

## EXPERIMENT 2.9

To compare the effectiveness of different common oils (castor oil, cotton seed oil, coconut oil, kerosene oil, mustard oil) in forming emulsions.

### Theory

Emulsions are formed when mixtures of oil and water are shaken thoroughly. All emulsions are not equally stable. They have different stabilities due to different physical and chemical characteristics of the oils. The relative stabilities can be easily compared by noting the time taken for the separation of the two liquids. Samples of different emulsions are prepared and time for demulsification is noted. Time taken for demulsification is directly proportional to the stability of the emulsion. Hence longer the time taken for demulsification, more stable is the emulsion.

### Apparatus

Four conical flasks with stoppers, 100 ml measuring cylinder and 10 ml pipette, stop watch.

### Chemicals

Coconut oil, kerosene oil, cotton seed oil, mustard oil and 1% solution of soap.

### Procedure

1. Wash and dry the conical flasks. Label them as A, B, C and D.
2. Add 10.0 ml of coconut oil to flask A, 10.0 ml of kerosene oil to flask B, 10.0 ml of cotton seed oil to flask C and 10.0 ml of mustard oil to flask D.
3. Add 10.0 ml of distilled water to each flask with the help of measuring cylinder.
4. Shake the contents of flask 'A' for half a minute and then put it on the table.
5. Start the stop watch and note the time taken ( $t_1$ ) for the separation of the two layers of the liquids.
6. Similarly, take flasks B, C, D and note the time taken for the separation of two layers in each case.
7. Now add 5 drops of 1% soap solution or 1% sodium oleate solution to each of the four flasks and find out the time taken for the two layers to separate. Record the observations.

### Observations

#### Without Adding Emulsifying Agent

Flask	Oil	Volume of Oil (ml)	Volume of water (ml)	Time taken for the separation of two layers
A	Coconut	10.00	10.00	$t_1$ seconds
B	Kerosene oil	10.00	10.00	$t_2$ seconds
C	Cotton seed oil	10.00	10.00	$t_3$ seconds
D	Mustard oil	10.00	10.00	$t_4$ seconds

### With Emulsifying Agent

Flask	Oil	Volume of oil (ml)	Volume of water (ml)	Amount of 1% soap sol.	Time taken for separation of two layers
A	Coconut oil	10.00	10.00	5 drops	$t_1$ sec.
B	Kerosene oil	10.00	10.00	5 drops	$t_2$ sec.
C	Cotton seed oil	10.00	10.00	5 drops	$t_3$ sec.
D	Mustard oil	10.00	10.00	5 drops	$t_4$ sec.

### Result

Suppose  $t_1 > t_2 > t_3 > t_4$ .

The longer the time taken for separation of two liquids, the more stable is the emulsion, hence the stability of the emulsions is in the same order.

.....oil takes longest time to separate from its emulsion

.....oil takes the minimum time to separate from its emulsion.

$\therefore$  The decreasing order of effectiveness of various oils to form emulsions is .....

### Precautions

- (i) Clean the pipette every time before taking the next liquid.
- (ii) Shake the bottle for the same duration each time.
- (iii) Start the stop watch immediately after shaking.

## EXPERIMENT 2.10

**To compare the effectiveness of various emulsifying agents in forming emulsions.**

### Theory

Different emulsifying agents have different capacities for emulsifying a given oil. An emulsifying agent lowers the interfacial tension between water and oil and gets concentrated at the surface between two liquids. Due to the reduced interfacial tension, the tiny droplets of oil do not coalesce and thus the emulsions become stable. Since different emulsifying agents have different tendencies to lower the interfacial tensions, they have different capacities for emulsifying a given oil.

### Apparatus

Five stoppered flasks, measuring cylinder, stop-watch or simple watch, 5 ml pipettes.

### Chemicals

Castor oil, 1% solution of sodium oleate, soap, detergent, gelatine and gum acacia.

### Procedure

1. Take five clean stoppered flasks and label them as A, B, C, D and E.
2. Take 5 ml of castor-oil in each of five flasks A, B, C, D and E.
3. Add 5 ml of distilled water to each flask.
4. Add 5 drops of sodium oleate solution to flask A, shake it vigorously for one minute and allow it to stand.
5. Note the time taken for the two layers to separate out.
6. Similarly, take flasks B, C and D and E and add 5 drops of soap solution, detergent solution, gelatine solution and gum acacia solution **respectively** to them. Shake vigorously for about one minute and allow them to stand undisturbed. Note the time taken for the two layers to separate out in each flask. Record the observations.

### Observations

Volume of castor oil taken in each tube = 5 ml

Volume of distilled water added = 5 ml

## To Study the Effect of Concentration and Temperature on Rate of Reaction

A chemical reaction involves breaking of the old bonds in the reactants and formation of new bonds in the product molecules. Since the energies involved in the breaking and making of different bonds are different, therefore the rates of different reactions are different. **Rate of a reaction** is defined as the rate of change in concentration of any of the reactants or products at a particular instant of time.

The branch of chemistry which deals with the study of rates of reactions and their mechanisms is known as **Chemical Kinetics**.

**The factors which affect the rate of a reaction are :** (i) Nature of reactants (ii) Concentration of reactants (iii) Temperature (iv) Catalyst (v) Surface area.

Concentration of the reactants is the most important factor affecting the rate of a chemical reaction. As the reaction proceeds, the concentration of reactants falls continuously. The rate of a reaction also decreases with passage of time. Obviously, the rate of a reaction is directly proportional to the concentration of the reactants. The reaction rate increases when the concentration of any of the reactants is increased.

**Temperature** has a very significant effect on the rate of a reaction. This is due to an increase in the number of effective collisions. In most of the reactions, the rate of reaction doubles for every  $10^\circ$  rise in temperature.

In the following experiments, we will study the effect of concentration and temperature on the rates of reactions.

### EXPERIMENT

3.1

To study the effect of concentration on the rate of reaction between sodium thiosulphate and hydrochloric acid.

### Theory

According to the *law of mass action*, the rate of a chemical reaction is directly proportional to the product of molar concentrations of the reactants. So the rate of reaction increases with the increase in the concentration of reactants. In the given experiment the reaction between sodium thiosulphate and hydrochloric acid can be written as :



The rate of the reaction increases with increase in concentration of any one of the two reactants. The insoluble sulphur formed during the reaction gives a milky appearance and renders the reaction mixture opaque. The rate of the reaction can be determined by noting the time taken to produce colloidal sulphur to make some mark invisible on the paper kept below the reaction vessel. The effect of change of concentration is determined by turnwise changing the concentration of  $\text{Na}_2\text{S}_2\text{O}_3$  and  $\text{HCl}$ .

### Apparatus

Five 100 ml conical flasks, two 10.0 ml pipettes, two burettes and a stop watch.

### Chemicals

0.1 M  $\text{Na}_2\text{S}_2\text{O}_3$  solution and 1.0 M  $\text{HCl}$  solution.

### Procedure

#### (a) Study of effect of concentration of sodium thiosulphate

1. Select a set of five clean and dry 100 ml conical flasks and label them as 1, 2, 3, 4 and 5 respectively.
2. With the help of a burette, add 50, 40, 30, 20, and 10 ml of 0.1M  $\text{Na}_2\text{S}_2\text{O}_3$  solution to the flasks 1, 2, 3, 4 and 5 respectively.
3. Now add 10.0, 20.0, 30.0, 40.0 ml of distilled water to flasks 2, 3, 4 and 5 respectively. No distilled water is to be added to flask 1.