



## CHAPTER – 2

### Pure substances and mixtures

Nature is full of different materials like rocks, soils, water, air. We also see other materials like milk, tea, coffee, butter, spices, ink, chalk, brass, bronze, copper, silver, gold. We purchase many items like salt, sugar, ghee, mustard oil, honey, turmeric powder from the market. *How many of these materials are pure?* For a common person pure means having no adulteration. But if we observe minutely the constituents of these materials, we can see that all these things are actually mixtures of different substances. For example, milk is actually a mixture of water, fats, proteins etc. To a scientist a *substance is said pure if it consists of only one type of particle.*

#### 2.1. What are Mixtures?

A pure form of matter which cannot be separated into other kinds of matter by any physical process is known as a *substance*. Mixtures contains two or more substances mixed together. For example when sugar is dissolved in water, it can be separated by the physical process of evaporation. However, sugar is itself a substance and cannot be separated by physical processes into other constituents. Similarly sodium chloride, naphthalene, copper, iron are substances because each of them contain only one kind of pure matter.

Soil, rocks, minerals, soft drinks, sea water are not single substances. A substance whatever be the source will always have the same characteristic properties. A mixture, on the other hand contains more than one substance and hence will have varying properties.

#### 2. 2. Type of mixtures:

A mixture may be *homogeneous* or *heterogeneous*. A homogeneous mixture has a uniform composition throughout. It has no visible boundaries of separation between the various constituents. Sugar or salt dissolved in water, alcohol water mixture, brass, air, kerosene oil etc are homogeneous mixtures.

Those mixtures in which there are varying proportions of constituent particles and the constituents remain separated are called heterogeneous mixtures. A mixture of sugar and sand, petrol and water, are also heterogeneous mixtures.

#### Activity 2.1

- \* Take 100 mL water in four beakers A, B, C and D.  
Add and stir propely using a glass rod :
  - (i) Few crystals of sugar or salt in A.
  - (ii) One tablespoonful of sugar or salt in B.
  - (iii) Chalk powder (or sand powder) in C.
  - (iv) Few drops of milk in D.

- \* Direct a beam of light from a torch through the beaker containing the mixture and observe from the front.
- \* Leave the mixtures undisturbed for sometime and in the meantime, set up a filtration apparatus.
- \* Filter the mixture one after another.
- \* Observe carefully the differences in the mixtures.

We have (i) two solutions in beakers A and B (ii) a suspension in C and (iii) a colloidal dispersion in D.

***What are the characteristics of these three types of mixtures?***

### **2.2.1. Solution:**

A homogeneous mixture of two or more substances is called a solution. We have come across various types of solutions in our daily life. Soft drinks like soda water, red tea, saline water, glucose in ampoules are all examples of solutions.

When we add some common salt in water in a beaker and stirred, the salt seems to disappear in water. We get a transparent salt solution. The dissolved salt particles cannot be seen even with a microscope, and the salt does not settle down on keeping. The salty taste of the liquid, however, shows that salt is present in it. This shows that particles of salt are evenly distributed in the solution, that is, there is homogeneity at the particle level.

A solution has a *solvent* and a *solute* as its components. The component of a solution which dissolves the other component in it, that is, the component present in larger amount is called the *solvent*. The component that is dissolved in the solvent that is the component present in lesser quantity is called *solute*.

#### ***Examples:***

- (i) When sugar is dissolved in water, we get sugar solution. In this solution, sugar is the solute and water is the solvent. It is a *solid in liquid solution*.
- (ii) A solution of glycerine in water is a *liquid in liquid solution*. Glycerine is the solute and water the solvent.
- (iii) Aerated drinks like soda water etc. are *gas in liquid solutions*. These contain carbon dioxide gas as solute and water (liquid) as solvent.
- (iv) Normally air is a mixture of *gas in gas*. Its main constituents are Nitrogen (78%), Oxygen (21%) and other gases like carbon dioxide, water vapour etc in small quantities. It is a homogeneous mixture and hence a *solution of gas in gas*.
- (v) Usually we think of a solution as a liquid that contains either a dissolved solid, liquid or gas in it. But we can also have *solid solutions*. For example, alloys are mostly homogeneous mixtures of metals and therefore regarded as solutions. For example, brass is a mixture of approximately 30% Zinc and 70% copper. It is prepared by mixing molten zinc with molten copper and cooling their mixture. Alloys mostly retain the properties of its constituents and can have variable composition.

**Properties of a solution:**

- (i) A solution is a homogeneous mixture.
- (ii) The particles of a solution are extremely small – less than 1nm in diameter (1 nanometre =  $10^{-9}\text{m}$ ). So, they cannot be seen by naked eye, even with a microscope.
- (iii) Particles in a solution cannot scatter light (the path of light is not visible) passing through the solution. This is because of small size of the particles.
- (iv) The solute particles cannot be separated from the mixture by filtration, nor they settle down when left undisturbed. So, solutions are very stable.

**Concentration of a solution:**

Many substances dissolve in water. But can we dissolve any quantity of a solid in a given amount of water?

**Activity 2.2**

Take 25 mL of water in a beaker.

Add a small amount of common salt to the beaker by means of a teaspoon and stir with a glass rod. Observe what happens.

Add a fresh quantity of salt in the above solution and stir. See if it dissolves.

Add more of the salt to the above solution and stir well. Does it dissolve as readily as in the earlier cases?

Add another quantity of the salt and observe whether it too dissolves.

We find that the first addition of the common salt dissolves readily in water. Second addition also dissolves. The third addition of the salt dissolves rather slowly while the fourth addition does not completely dissolve in the same quantity of water (solvent). This means that one cannot go on dissolving a substance in a solvent endlessly and there is a limit to the solubility of a substance in a solvent. From careful experiment it can be calculated that about 35 g of common salt can be dissolved in 100 g of water at room temperature. No more salt can be dissolved after this. **A solution which can dissolve no more of the solute at a given temperature is called a saturated solution.**

*The solubility of a substance is usually defined as the maximum number of grams of the substance that can be dissolved in 100 g of solvent at a certain temp. It may also be defined as the amount of the solute present in 100 g of the saturated solution at the given temperature.*

If the amount of solute contained in a solution is less than the saturation level, it is called an *unsaturated solution*.

We can repeat the above experiment by taking definite mass of sugar or any other substance instead of common salt and dissolving in a fixed quantity of water. The following table shows the maximum solubility of some substances in grams per 100 grams of water at 30°C.

**Table 2.1. Solubility of some substances in water at 30°C**

| Substance                           | Solubility in g/100 g of water |
|-------------------------------------|--------------------------------|
| 1. Common salt<br>(sodium chloride) | 36.3                           |
| 2. Sugar                            | 220                            |
| 3. Copper sulphate                  | 25                             |
| 4. Quick lime (Calcium oxide)       | 0.16                           |

Thus, the solubility of different substances in water varies. The solubility of a majority of substances also increases with temperature.

The *amount of solute present in a given amount (mass or volume) of a solution*, or the amount of solute dissolved in a given mass or volume of solvent is termed the concentration of solution.

$$\text{Thus, Concentration of solution} = \frac{\text{Amount of solute}}{\text{Amount of solution}}$$

$$\text{OR, Concentration of solution} = \frac{\text{Amount of solute}}{\text{Amount of solvent}}$$

Concentration of a solution may be expressed in terms of mass by mass percentage or mass by volume percentage.

(i) Mass by mass percentage of a solution

$$= \frac{\text{Mass of solute}}{\text{Mass of solution}} \times 100.$$

(ii) Mass by volume percentage of a solution

$$= \frac{\text{Mass of solute}}{\text{Volume of solvent}} \times 100$$

### **Example 2.1**

A saline solution contains 30 g of sodium chloride in 250 g. of water. Calculate the concentration of the solution in terms of mass by mass percentage of the solution.

#### **Solution:**

Mass of solute (sodium chloride) = 30 g

Mass of solvent (water) = 250 g.

Mass of solution = Mass of solute + Mass of solvent

$$= 30 \text{ g} + 250 \text{ g}$$

$$= 280 \text{ g.}$$

$$\begin{aligned} \text{Mass \% of solution} &= \frac{\text{Mass of solute}}{\text{Mass of solution}} \times 100 \\ &= \frac{30}{280} \times 100 \\ &= 10.71\% \text{ (nearly)} \end{aligned}$$

**Example 2.2**

A solution contains 25 g of glucose dissolved in 250 ml of water. Calculate the concentration of the solution in terms of mass by volume percentage of the solution.

**Solution:**

Mass of solute (glucose) = 25 g.

Volume of solvent / solution = 250 ml

$$\begin{aligned}\text{Concentration of solution} &= \frac{\text{Mass of solute}}{\text{Volume of solution}} \times 100 \\ &= \frac{25 \text{ g}}{250 \text{ ml}} \times 100 \\ &= 10 \% \text{ g. ml}^{-1} \text{ (M/V)}\end{aligned}$$

**Example 2.3**

A glucose saline solution is labelled as 0.96% (W/V) sodium chloride. How much salt is present in 500 ml of the solution?

**Solution:**

0.96% (w/v) sodium chloride solution means 0.96 parts by mass of sodium chloride present in 100 parts by volume of solution.

Hence, considering common solutions, it contains 0.96 g of sodium chloride per 100 mL of the solution.

∴ Amount of salt (Sodium chloride) present in

$$\begin{aligned}500 \text{ ml} &= \frac{0.96 \text{ g} \times 500 \text{ ml}}{100 \text{ ml}} \\ &= 4.80 \text{ g.}\end{aligned}$$

**Example 2.4**

If 10 ml of alcohol is present in 200 ml of its aqueous solution, calculate the concentration of the solution in volume by volume percentage.

**Solution :**

Volume of solute (alcohol) = 10 ml

Volume of solution = 200 ml

$$\begin{aligned}\text{Concentration of solution} &= \frac{\text{Volume of solute}}{\text{Volume of solution}} \times 100 \\ &= \frac{10 \text{ ml}}{200 \text{ ml}} \times 100 \\ &= 5\% \text{ (by volume)}\end{aligned}$$

**2.2.2. Suspensions:**

When some chalk powder is stirred in water contained in a beaker, we can see the fine particles of chalk suspended throughout the water without dissolving in it. If the

mixture is kept undisturbed for some time, the chalk particles settle at the bottom of the beaker. This shows that the mixture is unstable. If we filter the mixture through a filter paper, the chalk particles are left behind as a residue on the filter paper and clear water is obtained as a filtrate.

*A heterogenous mixture in which small particles of a solid are spread throughout a liquid without dissolving in it is called a suspension.*

**Properties of a suspension :**

- (i) Suspension is a heterogeneous mixture
- (ii) The particles in a suspension is larger than 100 nm in diameter and can be seen by the naked eye.
- (iii) The particles of a suspension scatter a beam of light passing through it and makes its path visible.
- (iv) The particles of a suspension settle down when the suspension is kept undisturbed for some time. They can be separated from the mixture by the process of filtration.

**2.2.3. Colloids :**

When we stir few ml of milk (or soap powder) in water in a beaker, we get a colloidal dispersion or colloid. The mixture is not perfectly transparent, it is somewhat translucent. The particles of a colloid are uniformly spread throughout the mixture. Due to the smaller size of particles as compared to that of suspension, the mixture appears to be homogeneous. But actually, a colloidal dispersion is heterogeneous consisting of two parts or phases. One part consists of the colloidal particles known as the *dispersed phase*, and the other is the *dispersion medium* which consists of the continuous matter into which the colloidal particles are dispersed.

Although we cannot see colloidal particles with naked eyes because of their small size, yet they are big enough to scatter light. When a beam of light is allowed to pass through the colloidal dispersion, the path of the light beam is illuminated and becomes visible (as observed in activity 2.2). *The scattering of light by colloidal particles is known as Tyndall effect* after the name of the scientist who discovered it (Fig. 2.1).

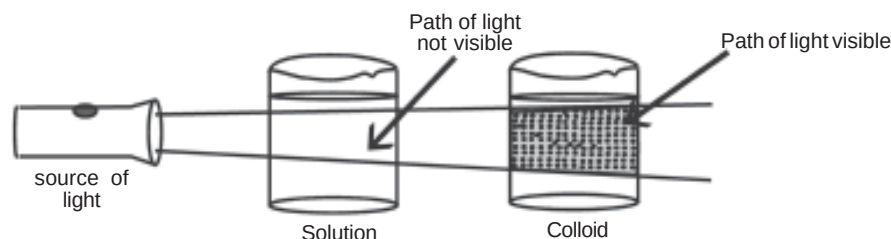


Fig. 2.1. Tyndall effect.

The Tyndall effect is analogous to the scattering of light by dust particles when a beam of sunlight enters a darkened room through a partly opened door or a slit in a wall. The dust particles suspended in air, many of them too small to be seen, look like bright points in the beam of light. We also observe a similar phenomenon when the projector in a darkened cinema hall begins to throw picture on the screen, We can also observe Tyndall effect when we focus our torch light on a rainy night.

Since both the dispersed phase and the dispersion medium may be either a gas, a liquid, or a solid, there are eight types of colloidal systems (Table 2.2). There is no colloidal system in which both the dispersed and the dispersion phases are gases because there is only one phase in any mixture of gases.

**Table 2.2 Types of Colloids**

| Dispersed phases | Dispersion medium | Type name      | Examples                            |
|------------------|-------------------|----------------|-------------------------------------|
| Solid            | Liquid            | Sol            | Mud, starch dispersed in water,     |
| Solid            | Gas               | solid aerosol  | Smoke, dust, automobile exhaust.    |
| Solid            | Solid             | Solid sol      | Milky glass, coloured gemstone.     |
| Gas              | Liquid            | Foam           | Soap suds, whipped cream            |
| Gas              | Solid             | Solid foam     | Pumice, sponge, foam                |
| Liquid           | Gas               | Liquid aerosol | Fog, clouds, mist                   |
| Liquid           | Liquid            | Emulsion       | Milk, face cream                    |
| Liquid           | Solid             | Gel            | Jelly, cheese, butter, shoe polish. |

**Properties of colloids:**

- (i) A colloid is a heterogeneous system
- (ii) The size of particles of a colloid is in between those in a true solution and those in a suspension. It is between 1nm and 100nm in diameter.
- (iii) Colloid scatter a beam of light passing through it and makes its path visible.
- (iv) They do not settle down when left undisturbed, that is, a colloid is quite stable and the particles can pass through filter paper.

**Let us answer these :**

1. What are homogeneous and heterogeneous mixtures? Give examples.
2. How are the size of the particles in a solution, colloid and suspension different from each other?
3. Bring out the differences between sol, aerosol, foam and emulsion.

### 2.3. Can we get pure substance from mixtures?

Most of the materials derived from natural sources are seldom pure. They are often mixed with other substances. To study the properties and uses of a substance, it must be first of all obtained in a pure state. The methods employed for the separation and

purification of substances depend on the nature of the substance and the impurities present in it.

Heterogeneous mixtures of two or more substances can be separated into their constituents by simple physical methods like handpicking, sieving, sedimentation and decantation, and filtration that we use in our daily life.

Sometimes special techniques have to be used for the separation of the constituents of a mixture.

### 2.3.1 Separation by Centrifugation:

If we have a mixture of fine suspended particles in a liquid, we can separate it by the process of filtration using filter paper. Sometimes the solid particles in a liquid are very small and pass through a filter paper. For such particles the filtration technique cannot be used for their separation. Such mixtures can be separated by a technique known as *centrifugation*. The principle of the technique is that when the mixture is rotated rapidly, the heavier particles are forced to the bottom and the lighter particles stay at the top. Centrifugation is done by using a machine called *centrifuge* (Fig.2.2) which may be electrically operated or hand driven.



(a) Electric centrifuge



(b) Hand cantrifuge

Fig. 2.2. Centrifuge

In this method, the mixture of fine suspended particles in a liquid is taken in a test tube. The test tube is placed in the centrifuge machine and rotated rapidly for some time. The rotative force (centrifugal force), pushes the heavier suspended particles at the bottom of the test tube while the clear liquid being lighter, remains on top. They can now be separated by decantation.

By this method cream is separated from milk. Cream being lighter is collected from the top of the liquid.

**Application :** The method is found used in

- (i) diagnostic laboratories for blood and urine tests.
- (ii) dairies and home to separate butter from milk.
- (iii) washing machines to expel out water from wet clothes.

### 2.3.2. Separation by Sublimation :

We have learnt in previous chapter that there are substances which change directly from solid to gaseous state on heating and vice versa. Ammonium chloride, iodine, camphor, naphthalene and anthracene are sublimable substances. They can be separated from their mixtures in salt, sand, earthy materials by the process of sublimation (Fig. 2.3).

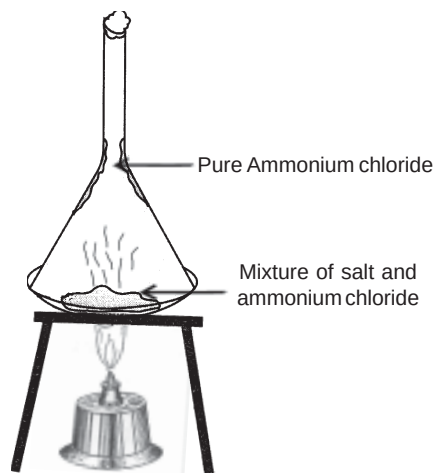


Fig. 2.3. Separation of salt and ammonium chloride by sublimation.

### 2.3.3. Separation by Chromatography :

Chromatography is a technique used for identification and separation of solutes which are present in a solution in small quantities.

#### Activity 2.3.

- \* Take a rectangular sheet of filter paper of approximately 10 cm × 8 cm.
- \* Draw a pencil line on it, about 2 to 3 cm from its lower edge and put a cross (×) mark at the centre of the line (Fig.2.4a).
- \* Prepare a mixture by mixing red and blue inks in equal proportions.
- \* With the help of a dropper, put a drop of the ink on the cross (×) marked on the line. Let the ink dry.
- \* Fix the paper to the lower surface of the cover of a gas jar with the help of cello tape.
- \* Lower the filter paper into a jar or beaker containing water so that the drop of ink on the paper is just above the water level and the jar or beaker is kept covered (Fig.2.4b).
- \* Leave it undisturbed.
- \* Watch carefully, as the water rises up on the filter paper.
- \* Record your observations.

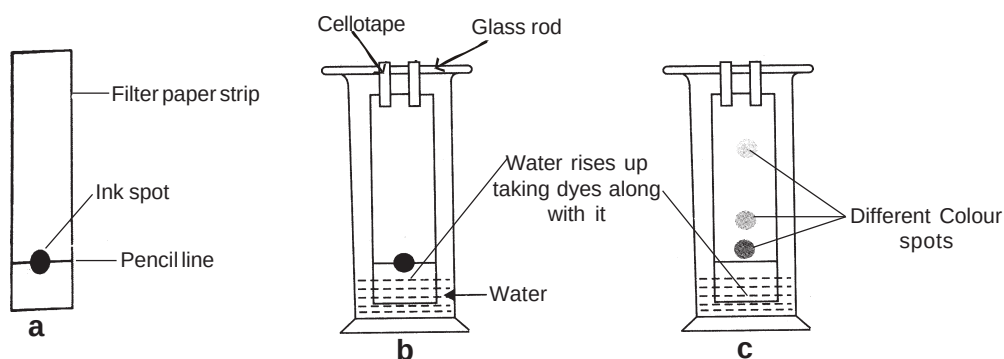


Fig. 2.4. Separation of dyes in ink by paper chromatography.

The ink that we use has water as the solvent and two or more colours (dyes) soluble in it. As the water gradually rises up the filter paper, different dye particles are carried by water at different rates along the filter paper and finally gets separated (Fig.2.4.c). The name chromatography comes from the Greek word *kroma* which means colour. This technique was first used for separation of colours. So this name was given.

With the advancement in technology, newer techniques of chromatography have been developed. You will learn more about chromatography in higher classes.

**Application :**

Some of the important applications of chromatography are :

- (i) Separation of coloured substances (dyes and pigments) in solution.
- (ii) In forensic science to detect and identify trace amounts of drugs in the contents of bladder or stomach and blood.
- (iii) To separate small amounts of products of chemical reactions.

**2.3.4. Purification by Crystallisation :**

Crystallisation is a technique that separates a pure solid in the form of its crystals from a solution.

*How can we get pure potash alum from an impure sample?*

**Activity 2.4.**

The process involves the following steps.

- \* Dissolve the impure solid in a minimum quantity of water to form a solution.
- \* Filter the impurities out.
- \* Heat the clear solution gently to get a saturated solution in a china dish. (This can be tested by dipping a glass rod in the hot solution and taking out from time to time. When small crystals form on the glass rod, the solution is saturated).
- \* Allow the hot saturated solution to cool slowly.
- \* Crystals of pure solid are formed. Impurities remain dissolved in solution.
- \* The crystals of pure solid can be separated by filtration and dried.

The process of crystallisation is used to purify a large number of water soluble solids. For example, common salt from sea water contains many impurities. It is purified by crystallisation.

Crystallisation technique is better than simple evaporation technique. Some solids like sugar may get charred on heating to dryness during evaporation. No such problem will be faced in crystallisation. Some impurities may remain dissolved in the solution after filtration. On evaporation these impurities contaminate the solid.

**2.3.5. Separation and purification of liquids :**

Various methods are employed for separation and purification of liquids depending upon the nature of liquids and the impurities present.

Liquids which do not mix with each other and form separate layers when put in a container are called *immiscible* liquids. For example, oil and water are immiscible

liquids. A mixture of immiscible liquids such as kerosene oil and water can be separated by using separating funnel (Fig.2.5).

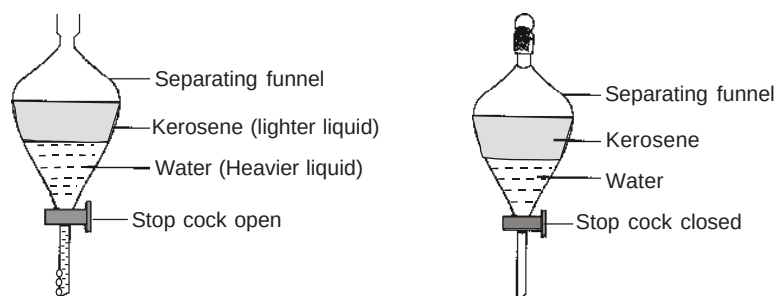


Fig. 2.5. Separation of immiscible liquid mixture.

Liquids which boil under ordinary pressure without decomposition and are associated with non-volatile impurities are generally purified by simple *distillation*. The apparatus is shown in Fig. 2.6. The impure liquid is taken in a distillation flask fitted with a thermometer and heated. The liquid vaporises and the vapours are condensed as they pass through the water condenser. The pure liquid is collected in the receiver while the non-volatile impurity is left behind.

Two or more liquids which mix together in all proportions are called *miscible liquids*. A mixture of miscible liquids having different boiling points can also be separated by distillation. When a mixture of two liquids A and B is heated in the distillation flask, the more volatile liquid A (having lower boiling point), along with a little of high boiling constituent B changes into vapour. The vapours, on being cooled in the condenser, collect in the receiver. The two fractions are further purified by repeating the process a number of times.

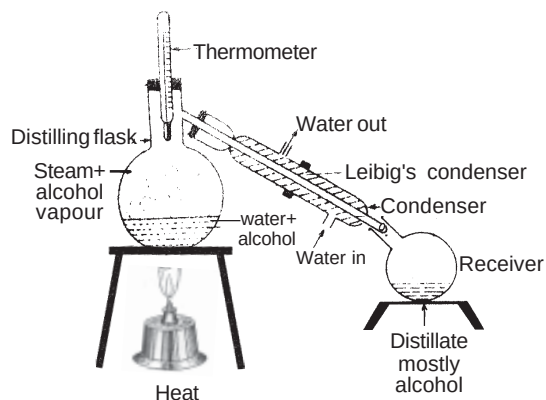


Fig. 2.6. Separation by distillation.

For example, alcohol (or ethanol) and water are completely miscible. Alcohol (ethanol) boils at  $78.5^{\circ}\text{C}$  and water boils at  $100^{\circ}\text{C}$ . So a mixture of the two can be separated by distillation. The distillate is collected at about  $80^{\circ}\text{C}$ . It contains the alcohol and a little water. It is redistilled. The resultant distillate will be richer in alcohol.

Collecting the distillate and redistilling it several times takes a long time. Complete separation is not possible if the difference in boiling points is less than  $30^{\circ}\text{C}$ . If the difference is less, a fractionating column is fitted over the distilling flask. A fractionating column provides a temperature gradient, higher temperature at the bottom and lower temperature at the top. Different types of fractionating columns are available; one is shown in Fig. 2.7.

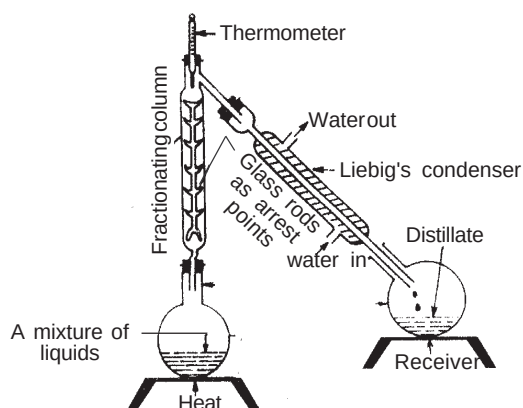


Fig. 2.7. Fractional distillation

Fractional distillation is widely used in industry to purify and separate miscible liquids.

The process is used in the separation of gases from liquid air. Pure air is converted into liquid air. The liquid air is then fractionated to get liquid nitrogen (b.p.  $-196^{\circ}\text{C}$ ) and liquid oxygen (b.p.  $-183^{\circ}\text{C}$ )

*How can we get different gases from air?*

The process involves the following steps:

- \* Air is first filtered to remove dust, then water and carbon dioxide are removed.
- \* Air is compressed to a high pressure and then cooled.
- \* The cooled air is then allowed to expand quickly into a chamber through a jet. When air is compressed and then allowed to expand suddenly, its temperature falls.

The phenomenon of producing lowering of temperature when a gas is made to expand suddenly from a region of high pressure into a region of low pressure, is known as Joule Thomson Effect or Joule – Kelvin Effect.

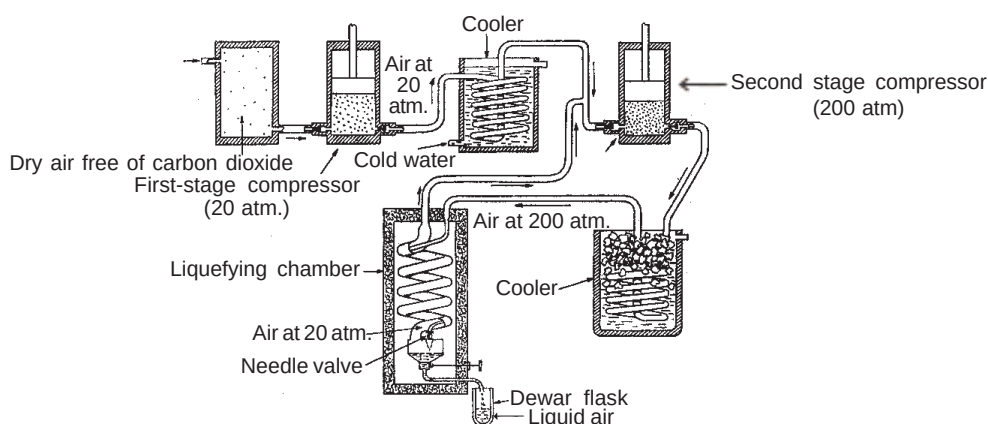


Fig. 2.8 Apparatus for liquefying air.

\*The process of compression, cooling and rapid expansion of air is repeated again and again making the air more and more cool. Finally, the air gets so cooled that it becomes liquid.

\* Liquid air is a mixture of liquid nitrogen (b.p. – 196°C) and liquid oxygen (b.p. – 183°C).

(Apparatus for liquefying air is shown in Fig.2.8.)

\* They can now be separated by fractional distillation, liquid nitrogen with lower boiling point will distill first leaving behind liquid oxygen which distill later.

Similarly, crude petroleum is fractionally distilled to get various fractions, some of which are (i) petroleum gas (ii) gasoline or petrol (iii) kerosene (iv) diesel oil (v) lubricating oil (vi) fuel oil. Fig.2.9. shows a diagrammatic representation of the apparatus used for the fractional distillation of crude petroleum and uses of various fractions.

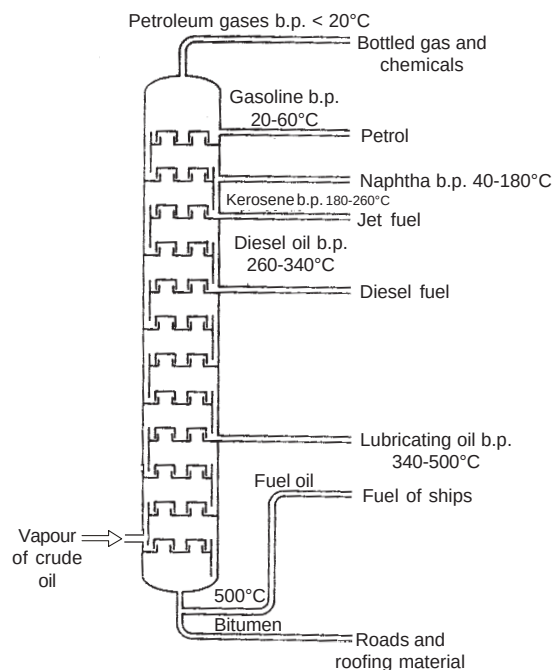


Fig. 2.9. Fractional distillation of crude petroleum.

### 2.3.6. How is water purified for human consumption?

Drinking water should be colourless clear, transparent, and harmless.

In towns and villages, many people get their water supply from water works. The source of water for water works is either a nearby river or lake and needs purification before use. This is done in the following way.

River water is pumped and sent to large *sedimentation* tanks through pipe lines (Fig. 2.10). The coarse suspended impurities get settled in this tank.

From the sedimentation tank, water is sent to a "*loading tank*". Here alum is added to coagulate colloidal particles. They settle down at the bottom of the tank. The precipitate also carries down with it most of the suspended organic matter, including living organisms.

The water is then passed through *filter tanks*. These tanks have fine sand layer at the top, coarse sand layer in the middle and gravel as the bottom layer. These layers act as filters and remove suspended materials that fail to settle out.

The third stage is to remove the harmful microbes that may cause diseases. The clear water from the filter tanks is passed into a disinfecting or chlorination tank. Here,

the water is treated with small quantities of chlorine (less than one part per million part of water) to destroy harmful organisms.

This purified water is then stored in large overhead tanks for supply to the homes through pipe lines. A flow diagram of a typical water works is shown in Fig.2.10.

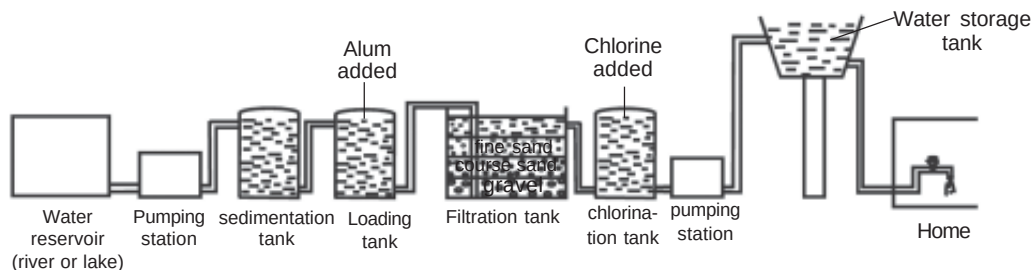


Fig. 2.10. scheme for supply of drinking water.

**Let us answer these:**

1. How will you separate a mixture of common salt and sand?
2. What process will be used to get camphor from a mixture of camphor and common salt?
3. Name the method used to separate a mixture of chalk powder and water.
4. How can cream be separated from milk?
5. Name the process by which common salt is obtained from sea water.
6. How can common salt be purified?
7. Name the process by which mixture of dyes can be separated from their mixtures.
8. How will you separate water and mustard oil?
9. What types of mixtures are separated by the process of fractional distillation.

## 2.4. Physical and chemical changes:

Substances possess many features, qualities or characteristics by which they may be identified. We know that each substance has its own characteristic properties. But every substance is liable to change under certain conditions. Almost all of the changes taking place in matter can be classified into two categories: *physical change* and *chemical change* depending on the composition and properties of the original substances and the products of the change.

### 2.4.1. Physical change

In the previous chapter, we have learnt about a few physical properties of matter. Properties of substances that can be observed and specified like colour, odour, hardness, texture, thermal and electrical conductivity, boiling point, melting point etc are physical properties.

- \* When we cut a paper into two or more pieces, the size of the paper has changed. But the paper pieces retain all the properties of paper.
- \* When sugar is dissolved in water, it retains its sweetness. The dissolved sugar can be recovered by evaporation of the solution.
- \* We have learnt that water is changed from its solid state (ice) to the liquid state (water) and from the liquid state to its gaseous state (water vapour). We also know that water can be changed to ice by cooling.
- \* When ammonium chloride is heated on a china dish, it changes to vapour which, on reaching the cooler part of the funnel (activity 2.3.2) again forms solid ammonium chloride.
- \* When a piece of soft iron like a knitting needle is rubbed by a bar magnet several times, it attracts small pieces of iron (it is magnetised). Then when it is dropped on the floor several times, it loses its magnetism.
- \* When an electric current is switched on an electric bulb, the filament becomes white hot, and hence it glows. The same filament returns to its original state when the current is switched off.

In these changes, the size, physical appearance and the state of the substances are changed. The changes can be reversed by reversing the conditions, hence the changes are temporary. Internal composition of the substances are not changed.

*Changes in which the physical properties such as texture, shape, size and the state of substances are made to change but their internal composition remains the same, are called physical changes.*

#### **2.4.2. Chemical changes:**

Instead of cutting a paper, if it is burnt, it turns to ash. It is mostly carbon, it does not have any of the properties of paper.

Similarly if sugar is charred, the resulting black substance is a different substance altogether.

When milk becomes curd, the taste is different. New substances with different properties are formed. *Changes which result in the formation of new substances which are entirely different from those of the original substances are called chemical changes.*

#### **Activity 2.4.**

- \* Take some washing soda (sodium carbonate) or sodium bicarbonate in a test tube.
- \* Add to it a few mL of lemon juice or any other acid available.
- \* Observe what happens.
- \* Bring a lighted matchstick over the mouth of the test tube.
- \* Pass the gas into lime water contained in a test tube.
- \* What happens?
- \* Draw your conclusions.

We observe that when an acid comes in contact with sodium bicarbonate or carbonate there is brisk effervescence of carbon dioxide gas which turns lime water milky. The gas is neither combustible nor a supporter of combustion. We cannot get back the washing soda and the acid from the products. The *change is not reversible*.

**Activity 2.5.**

- \* Introduce a cleaned magnesium ribbon held between a pair of tongs in the flame of a spirit lamp.
- \* Hold a piece of magnesium ribbon with a pair of tongs and take it to the flame of a spirit lamp.
- \* Observe what happens. (Do not look directly to the dazzling white light produced).
- \* What product is formed?

Magnesium burns with a dazzling light and changes into a white powder. The white powder has entirely different properties from that of magnesium.

We find that when an iron object is left out in moist air, it slowly changes into a brittle, dull brown substance, called *iron rust*. Experiment shows that rust is not elementary iron. It is hydrated iron oxide. It is a new substance, i.e. it is entirely different from iron. This is an example of chemical change.

The process of chemical change is also called *chemical reaction*. The original substances taken before the change are called *reactants* while the substances formed as a result of the reaction are called products.

Both water and kerosene oils are liquids. They differ in odour and inflammability. We know that oil burns in air whereas water extinguishes fire. We say that the chemical characteristics and composition of these substances are different. That is, it is the chemical properties that makes oil and water different.

Burning is a chemical change. During a chemical change, one substance reacts with another resulting in the formation of new substances having different chemical composition and properties.

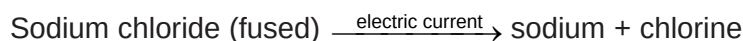
**Let us answer these:**

1. Name the process by which we get new substances?
2. What is the essential condition for a substance to undergo a change in chemical composition?
3. Classify the following changes as physical or chemical?
  - (i) Decay of vegetables.
  - (ii) Formation of clouds
  - (iii) Burning of a candle.Give reasons for your answer.
4. How can you say whether or not a chemical change takes place when
  - (i) milk turns sour.
  - (ii) iron changes into iron rust ?

## 2.5. Types of pure substances:

We have learnt how to obtain pure substances by processes involving physical changes. Having obtained the pure substance the physical processes can be continually repeated, but no further separation into different substances will take place. For example, pure salt can be obtained by crystallisation (article 2.3.4). It can be redissolved in water, and the water evaporated over and over again, but only salt will be left each time.

It is however possible to melt salt and pass an electric current through it, and this brings about an altogether different change in which an element called sodium and a yellowish green poisonous gas chlorine are obtained. You will learn the details of this process in higher classes.



Similarly, by passing electric current, water can be decomposed to hydrogen and oxygen. An electric current is used to break salt and water into other substances

### Activity 2.6.

- \* Take some mercuric oxide in a hard glass test tube.
- \* Clamp the test tube on an iron stand (Fig. 2.11)
- \* Heat the test tube strongly.
- \* Notice the change in colour.
- \* Heat further till the tube is filled with fumes.
- \* Hold a glowing splinter into the test tube. (splinter is lit and then the flame blown out so that only the tip glows red hot).
- \* Observe how the wooden splinter bursts into flame.
- \* Observe the shiny appearance on the side of the test tube.

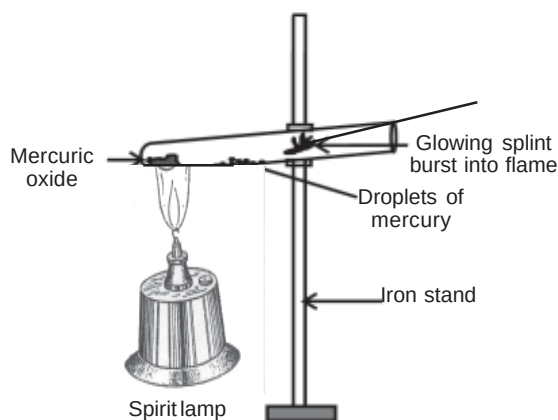


Fig. 2.11. Heating mercuric oxide.

Actually, on heating, mercuric oxide decomposes by the heat into mercury and oxygen. The mercury vaporises and then liquefies on the cooler parts of the test tube. The oxygen is responsible for the glowing splint to burst into flame, because it supports combustion. It is a chemical change.

Since the process of breaking up pure substance has begun, the question now is, can it be continued?

Is it possible to go on breaking up pure substances?

There are many changes which are carried out in which pure substances are involved; some break down and others build up (when magnesium burns, it combines with oxygen to form magnesium oxide). In breaking down, a stage is reached where it is no longer possible to divide a substance any further. In the case of the experiment already carried out, this stage is reached when mercury and oxygen are obtained from mercuric oxide.

So, pure substances can be broken down into different substances. Some pure substances cannot be further broken down. *A pure substance which cannot be split up into anything else by physical and chemical processes is known as an element.* Robert Boyle (1627-1691) is responsible for this modern idea of an element. In 1661, he published a book entitled "*The sceptical chemist*" in which he suggested that an element should be thought of as a substance which could not be broken down further into other substances.

At present, about 115 elements have been identified. Ninety-two elements are naturally occurring and the rest are synthetic i.e. man made. Majority of the elements are in solid state. Two elements mercury and bromine are liquid at room temperature while the elements, gallium and cesium become liquid at a temperature slightly above room temperature (30°C or 303K). Eleven elements are in gaseous state at room temperature.

Elements are normally divided into *metals*, *non-metals* and *metalloids*

Examples of metals are iron, copper, aluminium, tin, lead, zinc, sodium, potassium, mercury, silver, gold, etc. Metals usually show some or all of the following properties:

- (i) They have shining appearances called *metallic lustre* on freshly cut surfaces.
- (ii) They are *good conductors of heat and electricity*.
- (iii) They are *malleable*, that is, they can be hammered into sheets.
- (iv) They are *ductile*, i.e., they can be drawn into wires.
- (v) They are *sonorous*, i.e., they produce a ringing sound when struck.
- (vi) Most of them have *high melting and boiling points*. (Sodium, potassium and gallium however, have low melting points. Mercury is a liquid at room temperature.)
- (vii) They have *high tensile strength*. (However, sodium and potassium have low tensile strength).
- (viii) They have *silvery-grey or golden yellow colour*.

***Non metals usually show some or all of the following properties:***

- (i) They are not lustrous, sonorous or malleable.
- (ii) They are non – ductile.

- (iii) They are poor conductors of heat and electricity
- (iv) They have low melting and boiling points.
- (v) They are generally soft and have low tensile strength.

There are exceptions, however. Graphite carbon and iodine have lustre. Carbon fibre is ductile. Graphite is a good conductor of electricity, it has also a high melting point.

Examples of non -metals are hydrogen, oxygen, nitrogen, chlorine, bromine, iodine, carbon, sulphur, phosphorus etc. Diamond and graphite are carbon.

Some elements have intermediate properties between those of metals and non-metals. They are called *metalloids*. Arsenic, antimony, silicon, germanium are examples.

### **Compounds:**

When two or more elements combine, they produce a variety of substances called compounds. We use and come across many compounds in our daily life. Salt, sugar, water, iron rust, sodium bicarbonate, sulphuric acid etc are all compounds. It is for this reason that elements are regarded as the building blocks of all types of substances.

### **How is a compound formed?**

#### **Activity 2.7.**

- \* Prepare a mixture of iron filings and sulphur.
- \* Observe the mixture with the help of a magnifying lens. We find that the iron filings and the sulphur powder lie side by side.
- \* Take a magnet and plough it near the mixture.
- \* The iron filings will be attracted by a magnet.
- \* Put a portion of the mixture in a beaker containing water, shake and observe. The dark grey iron powder sinks in water while sulphur powder remains floating on the surface.
- \* Take a small portion of the mixture in a test tube and pour dilute sulphuric acid into it.

The iron filings react with dilute sulphuric (or hydrochloric) acid and a colourless, odourless gas is evolved. It is hydrogen gas.

- \* Pour a little of carbon disulphide to a portion of the mixture taken in a test tube. Sulphur powder dissolves in carbondisulphide leaving behind iron filings.

*What conclusion can you draw from this experiment?*

No new substance is formed just by mixing iron and sulphur. The iron filings and sulphur powder lie side by side and can be separated by easy means.

This shows that a chemical reaction does not take place in the process of just mixing iron and sulphur.

#### **What happens when the mixture is heated?**

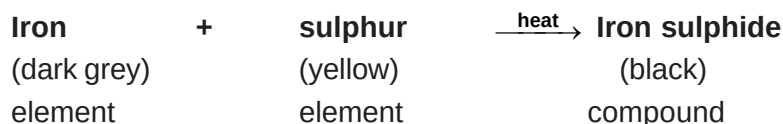
- \* Mix 14 g of iron powder and 8 g of sulphur powder intimately.
- \* Fill about half a test tube with the mixture and heat it in the flame of a spirit lamp.
- \* Observe what happens.

- \* Remove the source of heat when the heated portion of the mixture begins to glow. (Once the reaction starts it will continue to do so, and an intense heat is generated in the contents).
- \* When the reaction stops, cool the test tube and break it carefully.
- \* Remove the glass pieces with a pair of forceps and powder the substance formed.
- \* Observe the powdered mass through a magnifying lens.
- \* Plough a magnet near this powder.
- \* Drop a small quantity of the powder into a beaker containing water.
- \* Take a small quantity of the powder into a test tube, and pour dilute sulphuric acid or hydrochloric acid into it.
- \* Draw your conclusion.

When the mixture of iron and sulphur powder in a definite proportion by mass is heated, a new substance is formed. The colour of the new substance (product) is different from that of the initial mixture. It sinks in water. No iron powder can be separated from this new substance with the help of a magnet, nor sulphur powder be removed by dissolving in carbon disulphide liquid.

When dilute sulphuric or hydrochloric acid is poured into the substance, no hydrogen gas is evolved. Instead it gives hydrogen sulphide gas which has a rotten egg smell. The substances iron and sulphur have lost their original properties. A new substance having altogether different properties is formed.

The new substance is a compound of iron and sulphur and is called iron sulphide. The reaction may be represented as follows:



Thus, we may define "compound as a substance composed of two or more elements, chemically combined with one another in a fixed proportion" The composition of a compound is the same throughout.

Notice the difference between elements, compounds and mixtures as shown in the following figures.

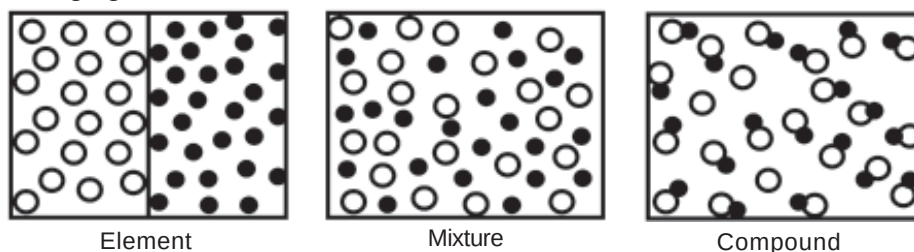


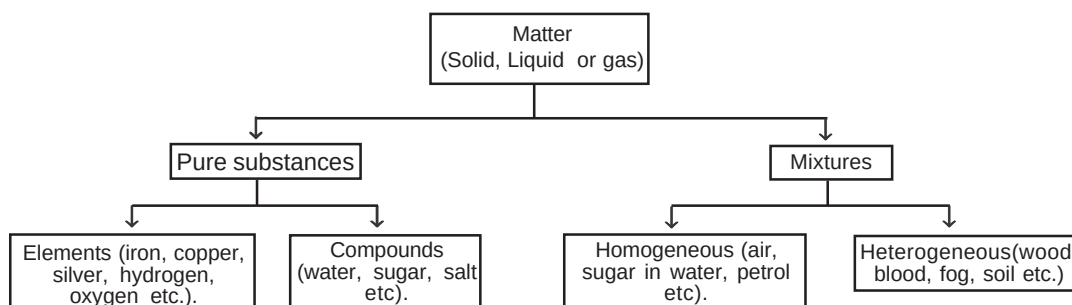
Fig. 2.11, Fig. 2.11. Black and white balls represent different elements. In the middle figure they are simply mixed and remain side by side. But in the right figure, they have combined to form a compound.

The differences between mixtures and compounds are given in the following table (table 2.3)

**Table 2.3. Difference between Mixtures and compounds.**

| Mixtures                                                                                                                | Compounds.                                                                                                          |
|-------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|
| 1. Elements or compounds just mix together, not to chemically combined and hence no new substance (compound) is formed. | 1. Elements react and combine together form new substances (compounds).                                             |
| 2. A mixture has variable composition and shows the properties of its constituents.                                     | 2. A compound has the specific elements combined in a fixed proportion and it has totally different properties.     |
| 3. The constituents can be separated fairly easily by physical methods.                                                 | 3. The components cannot be separated by physical means, but only by chemical or electrochemical means (reactions). |
| 4. The formation of a mixture is a physical change.                                                                     | 4. The formation of a compound is a chemical change.                                                                |
| 5. A mixture does not have fixed melting point and boiling point.                                                       | 5. A compound has a fixed melting point and boiling point.                                                          |

Now we can show the classification of matter as follows:



**Let us answer these:**

- Explain why the following are examples of physical changes:
  - Mixing of iron and sulphur
  - Boiling of water
  - Sublimation of iodine.
- Explain why the following are examples of chemical changes:
  - Charring of sugar
  - Burning of charcoal
  - Digestion of food.
- What is meant by saying metals are malleable and ductile?
- Name one solid, one liquid and one gaseous non- metal.
- Classify the following into elements, compounds and mixtures: graphite, brass, chalk, air, petroleum, sea water, milk, zinc, sodium bicarbonate.

6. List three characteristics by which compounds can be distinguished from mixtures.

### SUMMARY

1. A mixture contains two or more elements or compounds mixed in any proportion and not chemically combined together.
2. A mixture can be separated into its constituents (pure substances) by physical processes.
3. A solution is a homogeneous mixture of two or more substances. The substance present in larger proportion in a *solution* is called the *solvent*, and the substance present in smaller proportion, the *solute*.
4. The concentration of a solution is the amount of solute present per unit volume or per unit mass of the solution or solvent.
5. A suspension is a heterogeneous mixture in which small particles of solid visible to the naked eye are spread in a solvent without dissolving in it.
6. A colloid or a colloidal system is a heterogeneous mixture in which particles which are too small to be seen with the naked eye, but is big enough to scatter light are dispersed in a medium called dispersion medium, the particles being called the dispersed phase.
7. Pure substances can be elements or compounds.
8. An element is a substance which cannot be broken down to other simple substances by physical and chemical processes.
9. A compound is a substance formed by two or more elements chemically combined together in a fixed proportion.
10. The properties of a compound are quite different from those of its constituent elements, whereas a mixture shows the properties of its constituent elements or compounds.

### EXERCISES

1. *What is sublimation? Give the differences between evaporation and sublimation.*
2. *What are distillation and fractional distillation?*
3. *What separation techniques will you use to separate the following?*
  - (a) Common salt from sea water
  - (b) Sand and water
  - (c) Iodine from a mixture of iodine and sodium chloride
  - (d) Different colouring materials from an extract of flower petals
  - (e) Butter from milk

- (f) Hydrated copper sulphate from its aqueous solution
  - (g) Powdered chalk and sugar
  - (h) Iron pins from sand
  - (i) Oil from water
4. Name three commercial materials obtained from petroleum and state the method used to obtain them
5. What is a pure substance? Give three examples each of the two classes of pure substances
6. Give the main classification of elements. Mention at least two examples of each type
7. Give two pieces of evidences to prove that water is a compound.
8. Explain with examples:
- (a) saturated solution.
  - (b) colloid
  - (c) suspension
  - (d) physical changes
  - (e) chemical changes.
9. Classify the following as elements, compounds and mixtures:  
*tap water, distilled water, sugar, paint, filtered tea, air, copper, iodine, wood, soil, soda water.*
10. Which of the following materials fall in the category of a pure substance?
- (a) iron
  - (b) wood
  - (c) mercury
  - (d) brick
  - (e) ice
  - (f) air
  - (g) milk
  - (h) carbon dioxide
  - (i) soap
11. What is Tyndall effect? Which of the following will show Tyndall effect?
- (a) sugar solution
  - (b) copper sulphate
  - (c) starch solution
  - (d) potassium permanganate solution.
12. Classify the following into physical and chemical changes:
- (a) Burning of incense stick
  - (b) Sublimation of camphor
  - (c) Digestion of food
  - (d) Glowing of electric bulb
  - (e) Rusting of iron