Chemistry
Mixtures 03

3.1 Types of mixtures

Let us pay our attention to the composition of the air around us. Air is composed of gases like nitrogen, oxygen, argon and carbon dioxide, water vapour, and very small particles such as dust. So, you may understand that air is a mixture of several substances.

Therefore, if some matter contains two or more substances, such matter is referred to as mixtures. You have already learnt that elements and compounds are pure substances. But, mixtures are not pure substances. Natural environment mostly contains mixtures, not pure substances. Air, soil, sea water, river water and rocks around us are examples. The things that we drink such as cool drinks, fruit drinks, tea, coffee and food items such as ice cream, yoghurt and fruit salad are also mixtures. Let us do the following activity to study more about the components of a mixture.

Activity 3.1.1

Materials required; - Hydrated copper sulphate, naphthalene, (moth balls), mortar and pestle

Method; - Take some copper sulphate and naphthalene (moth balls) into a mortar, grind them together with the pestle into a powder and mix well. Transfer the powder onto a piece of paper and observe.

At a glance, you may not be able to see two substances, copper sulphate and naphthalene but, you have a mixture of the two. A blend of two or more pure substances is called a mixture and individual substances that form the mixture are known as components.

Activity 3.1.2

Materials required ;- Two beakers, a glass rod, a funnel, a filter paper, hand lens.

Method ;- Transfer the mixture made in activity 3.1.1 above into a small 100 ml beaker, add about 50 ml of water to it and stir well. Then, place a filter paper in a funnel, glass and filter this solution into another beaker. Allow the residues on the filter paper to dry and observe with a hand lens. Observe the filtrate as well.

From this activity, you would have understood that the remains on the filter paper is naphthalene powder. Since the solution is blue in colour, the substance that dissolved in water is copper sulphate.

The above activity clarifies another feature of a mixture. That is, even when the components are in a state of being mixed, their chemical nature remains unchanged. In other words, the identity of the components constituting a mixture does not change even in the mixture. Moreover, the above activity shows that the components in a mixture can be separated by physical methods.

How the components in a mixture can be separated by physical methods will be discussed under the sub unit 6.3.

Thus mixtures can be defined as follows: **Mixtures are matter consisting of two or more components which are not chemically combined, and can be separated by physical methods.**

Table 3.11 shows the components of some commonly known mixtures.

Table 3.1.1

Mixture	Components
Cement mortar	Sand, cement, water
Cake	Sugar, flour, water, colouring, butter
Well water	Water, dissolved oxygen, dissolved carbondioxide and various salts.
Sea water	Water dissolved oxygen and salts such as sodium chloride, magnesium chloride, magnesium sulphate, calcium sulphate

When considering mixtures, it is very important that how well the components are mixed. Understand this thoroughly with the help of the following examples.

Ex:- 1. When making colours by mixing paints, application of the paint will not give a uniform colour unless they are mixed well.

2. If the components used to make cake are not mixed well, different parts of the cake taste differently. Also, the rising will be different in different parts.

3. The medicinal property of tablets, capsules or liquid mixtures is not even in all the parts if the components are not mixed well when producing medicines.

Investigate into more instances like the above examples.

Let us do activities 3.1.3 and 3.1.4 to study how the components are distributed in a mixture.

Activity 3.1.3

Materials required ;- A beaker, clay, water, a piece of cloth

Method ;-

(i) Take about 500 ml of water into a beaker. Add about 10g of clayey soil to it, stir well and allow to stand still for about one minute. Then filter the muddy coloured water into another beaker using a piece of cloth. Allow to stand still for about an hour and see whether the muddy colour is uniformly distributed throughout the solution. See if the clearness of the solution is similar from top to bottom.

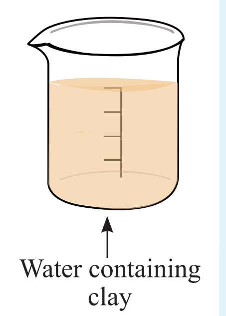


Figure 3.1.1

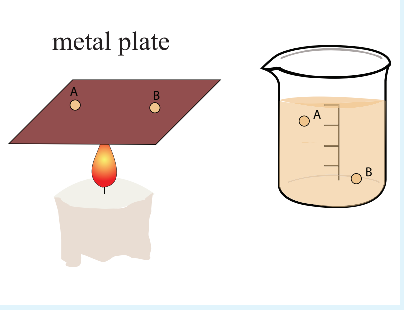


Figure 3.1.2

(ii) Take a piece of a metal sheet with a lustrous surface. As shown in figure 3.1.2, take two identical drops of the solution from two places A and B with a pipette or glass rod, place them on the spots marked as A and B respectively, on the piece of metal and let them vaporize. Check to see which water sample contains more residual matter, See, water obtained from which place contains more residual matter.

The above activity leads to the following conclusions. In the mixture formed by dissolving clay in water,

- The colour/transparency is different from place to place.
- The amount of clay particles in a unit volume is different from place to place.

Activity 3.1.4

Materials required ;- A beaker, water, common salt, a piece of cloth

Method ;- Take about 250 ml of water into a beaker add about 10 g of pure salt into it, stir till the salt dissolves and filter the solution with a piece of cloth. Allow to stand still for about one hour and see whether the clearness of the solution is equal from top to bottom. Repeat what you did in activity 3.1.2 for this solution as well.

Following conclusions can be drawn from the above activity. In the mixture formed by dissolving salt in water,

- The transparency is equal throughout the solution.
- The amount of salt particles in a unit volume of the solution is equal throughout the solution.

Pay your attention again to the mixtures you studied in activities 3.1.3 and 3.1.4. According to the nature of the distribution of components, mixtures can be divided into two categories.

- Mixtures in which the composition of the components is uniform throughout the mixture.

Ex: mixture prepared by dissolving common salt in water.

- Mixtures in which the composition of the components is not uniform throughout the mixture.

Ex: mixture prepared by dissolving clay in water

The mixtures in which the components are separated from one another are called heterogeneous mixtures. The mixtures whose composition of the components are uniformly distributed throughout are known as homogenous mixtures.

Homogeneous mixtures

The mixtures in which the components cannot be observed separately from one another and the properties and composition are similar throughout are termed **homogenous mixtures.** In a homogeneous mixture, the physical properties such as colour, transparency and density are identical everywhere. Homogenous mixtures are also known as solutions.

Examples: salt solution, sugar solution

Heterogeneous mixtures

The mixtures in which the components can be distinguished from one another and their are known as a **heterogeneous mixtures.** The physical properties of the mixture such as colour, transparency and density are different from place to place, in a heterogeneous solution.

Examples: Water in which clay is dissolved, water in which laundry blue (the powder used for whitening of clothes) is dissolved, cement mortar, sherbet drinks, fruit salad

Activity 3.1.5

Dissolve the following substances in water and record the observations.

Common salt, washing powder, laundry blue (added to clothes), copper sulphate, potassium permanganate, wheat flour, ethyl alcohol

Classify the various mixtures you prepared as homogeneous and heterogeneous

Heterogeneous and homogeneous mixtures can be classified further depending on the physical state of the components. Study and understand the facts given in table 3.1.2 describing mixtures of two components.

Table 3.1.2

First component	Second component	Nature of the mixture	How the mixture is termed
Wheat flour(Solid)	water(liquid)	heterogeneous	solid-liquid heterogeneous
Salt (solid)	Water (liquid)	homogeneous	solid-liquid homogeneous
coconut oil (liquid)	Water (liquid)	heterogeneous	liquid-liquid heterogeneous
Ethyl alcohol (liquid)	Water (liquid)	homogeneous	liquid-liquid homogeneous
Sugar (solid)	Salt (solid)	heterogeneous	solid-solid heterogeneous
Copper (solid)	Zinc (solid)	homogeneous	solid-solid homogeneous *
Carbon dioxide (gas)	Hot water (liquid)	heterogeneous	gas-liquid heterogeneous
Carbon dioxide (gas)	Cold water (liquid)	homogeneous	gas-liquid homogeneous

* Brass is an alloy composed of 65% of copper and 35% of zinc. This is a solid-solid homogeneous mixture.

Assignment 3.1.1

Prepare a list of mixtures used in various occasions in the laboratory and day-to-day life. State the components in those mixtures. Differentiate them as homogeneous and heterogeneous. Indicate how those mixtures can be named according to the state in which the components exist.

Solute and solvent of a solution

It was mentioned that a homogenous mixture is also called a solution. A solution is composed of a solvent and one or more solutes. Of the components mixed to form the solution, the component present in excess is the solvent. The rest of the components are solutes.

Hence, it can be represented as,

Solvent + Solute = Solution

This can be further understood by paying attention to the solutions used in day-to-day life.

Ex: Salt + Water =Salt solution

Copper sulphate + Water = Copper sulphate solution

Sugar + Water = Sugar solution

• Solubility of a solute

What will happen if a small amount of a given solute is added to a solvent? It will dissolve and disappear.

What quantity of a solute can be dissolved like this in a given volume of the solvent? Do the following activity to find it out.

Activity 3.1.6

Materials required ;- A beaker, salt, a glass rod

Method ;- Measure 100 ml of water into a clean beaker. Weigh 100 g of pure salt (NaCl). Add salt, little at a time into the beaker of water and stir with the glass rod to dissolve it. Do not add more salt until the salt added before dissolves completely. When no more salt dissolves, stop adding more salt and weigh the remaining amount of salt. Approximately, What is the maximum mass of salt that can be dissolved in 100 ml of water?

Is the amount of other components that dissolve in the same volume of water, the same? To investigate this, conduct the following activity.

Activity 3.1.7

Materials required ;- A beaker, calcium hydroxide, a glass rod

Method ;- Weigh 10 g of calcium hydroxide at the laboratory. Take 100 ml of water to a beaker and dissolve calcium hydroxide in it, by adding a very small amount at a time while stirring. Stop the addition of solid when no more calcium hydroxide dissolves in solution and weigh the remaining solid. Approximately what is the maximum mass of calcium hydroxide that can be dissolved in 100 ml of water?

Compare the results of the activity 3.1.7 with those of 3.1.6

The above activities show that the quantity dissolved is more for some substances, while it is less for same other substances in the same volume of water.

Repeat activities 3.1.6 and 3.1.7 using 100 ml of hot water of about 80 ^{0}C instead of water at room temperature. See whether the dissolved mass of the solute changes. It would be observed that a greater amount of the solute dissolves at a higher temperature than it does in an equal volume of water at room temperature.

In order to compare the dissolution of various solutes in a given solvent, the amount of solutes dissolved in the same volume of the same solvent at the same temperature should be compared. Therefore solubility is defined as follows.

The solubility of a solute at a given temperature can be defined as the mass of that solute which dissolves in 100 g of the solvent at a certain temperature.

Ex:- at 25 ^{0}C, the solubility of magnesium chloride in water is 53.0 g.

At the same temperature, solubility of potassium sulphate in water is 12.0 g.

Factors affecting solubility

You have already identified temperature as a factor affecting the solubility of a solute in a given solvent. Try the following activities to investigate the other factors affecting solubility.

Activity 3.1.8

Materials required ;- Two small beakers, common salt, sugar

Method ;- Take 50 ml of water at the same temperature into each of two small beakers. Accurately Weigh 50 g each of salt and sugar. Adding a little at a time, dissolve salt in one beaker and sugar in the other. When it comes to the point beyond which no more solid dissolves, stop adding the substance and weigh the remaining solid. See whether the amounts left are equal.

You will be able to see that at the same temperature, different solutes dissolve in different amounts in equal volumes of the same solvent. Hence, it can be said that the nature of the solute affects the solubility.

Activity 3.1.9

Materials required ;- Two small beakers, kerosene, sugar

Method ;- Take 50 ml each of the solvents water and kerosene at the same temperature into two small beakers. Add 5 g of sugar into each of them and stir. In which solvent does sugar dissolve?

You will be able to see that the sugar completely dissolves in water but sugar added to kerosene remains almost undissolved.

This shows that the solubility of the same solute is different in equal volumes of different solvents at the same temperature.

Therefore, it can be said that the nature of the solvent affects solubility.

According to the observations of the above activities, it is confirmed that the following factors affect solubility.

1. Temperature
2. Nature of the solute
3. Nature of the solvent

Of the above factors, except temperature, the nature of the solute or the solvent are properties of matter. The characteristic properties of matter are imparted by the particles that make the matter. The nature of molecules which constitute the solute and solvent is a factor that determines the solubility. In grade 10 you have learnt about the polarity of a chemical bond. Based on the polarity chemical compounds can be classified into two categories; polar and non polar. At the same time, chemical compounds can also be classified into two types organic and inorganic - according to the constituent elements of the compound.

Hence, solutes and solvents can be classified under four classes.

1. Polar organic solutes/solvents
2. Non - polar organic solutes/ solvents
3. Polar inorganic solutes/solvents
4. Non - polar inorganic solutes/solvents

From the following schematic diagram, you can identify the examples relevant to those four classes.

Chemical compounds

- Organic compounds
  - Polar
    - Alcohol
    - Formalin
    - Acetone
  - Non-polar
    - Hexane
    - Benzene
    - Carbon Tetrachloride
- Inorganic compounds
  - Polar
    - Water
    - Ammonia
    - Hydrogen chloride
  - Non-polar
    - Carbon disulphide liqiud
    - Carbon dioxide

Based on the above classification, a general concept on solubility such as the one below can be composed.

Polar solutes are soluble in polar solvents

Ex 1 :- Ethanol is a polar compound. Water is a polar compound. Therefore, ethanol is soluble in water.

Ex 2 :- Ammonia is a polar compound. Water is a polar compound. Therefore, ammonia dissolves in water.

Non-Polar solutes are soluble in non-Polar solvents

Ex 1:- Grease is a non-polar solute. Kerosene is a non-polar solvent. Therefore, grease dissolves in kerosene.

Ex 2:- Jak glue (koholle) is a non-polar solute. Kerosene is a non-polar solvent. Therefore, jak glue is soluble in kerosene.

On that account, it can be concluded that solutes and solvents of similar polarity properties dissolve in each other (like dissolves like).

• Solubility of a gas

Do gases really dissolve in water? Recall the following experiences to answer this.

- As soon as a bottle of soda water or a fizzy drink is opened, gas bubbles evolve from the solution.
- When a beaker of water is heated, gas bubbles can be seen on the walls of the beaker.

In both of these instances, it is the gases that were dissolved in water that got liberated. During the production of soda water, carbon dioxide gas is mixed with water under the special conditions of high pressure using machinery. Because of this more gas dissolves in water. However, atmospheric gases are always in contact with natural water. Then gases like carbon dioxide and oxygen dissolve only in small quantities.

When water is heated, the dissolved gases are evolved. Therefore, the amount of gases remaining dissolved in hot water is very small. Accordingly, temperature can be taken as a factor affecting the solubility of a gas.

Generally, the solubility of a solid substance in a solvent can be increased by increasing the temperature. But the solubility of a gas in a given solvent decreases with the rise in temperature. Are there any more factors affecting the solubility of a gas in water? See what conclusion could be drawn from the observations of the following activity.

Activity 3.1.10

Materials required ;- an unopened bottle of soda water (plastic), an empty bottle of the same type.

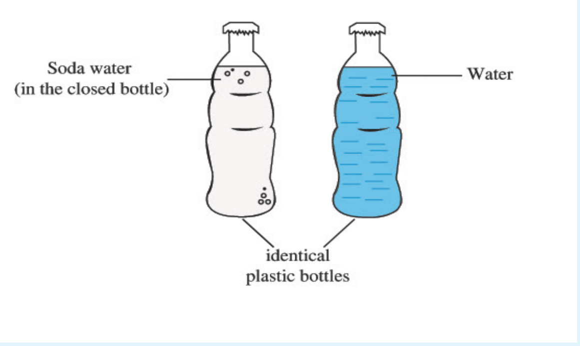


Figure 3.1.3

Method ;- Take an un opened bottle of soda water available in the market. To an identical empty bottle, add water equal in quantity to that of soda water and close the cap tightly. Now squeeze both bottles with hand and select the harder bottle.

You may feel that the unopened soda bottle is very hard that it cannot be pressed. Think why it is so. In the bottle of soda above the liquid, there is carbon dioxide gas under high pressure. The moment the cap is opened, carbon dioxide gas escapes, and the rigidity of the bottle is lost. When the pressure of a gas in contact with water is increased, the solubility of that gas in water too increases. Thus, the solubility of a gas in water depends on two factors.

1. Temperature
2. Pressure

Figure 3.1.4

3.2 Composition of a mixture

Activity 3.2.1

Materials required ;- Two beakers, potassium permanganate

Method ;- Add 50 ml of water in each of to two beakers. Add 0.2 g and 0.4 g potassium permanganate separately to the two beakers and stir well with a glass rod. Record your observations.

You will be able to see, that the solution in the beaker with 0.2 g potassium permanganate is light purple in colour whereas the purple colour of the solution with 0.4 g potassium permanganate is relatively more intense.

When preparing the above two solutions, the volumes of water taken into the two beakers were equal. That means, the volumes of the solvent were equal. However, the masses of potassium permanganate used as the solute were different. In the solution with a more intense purple colour , a unit volume contains more solute particles. Therefore, the composition of these two solutions is different.

When preparing mixtures of weedicides and insecticides, they must be prepared in correct composition. Prescribed composition should be used when preparing solutions using pharmaceuticals. Laboratory work often involve the preparation of solutions of fixed composition. Therefore, understanding about the composition of mixtures is very important in everyday life as well as in laboratory experiments. There are several ways to express the composition of a mixture. Some of those are discussed in the following sections.

3.2.1 Composition of a mixture as a mass fraction (m/m)

Let us consider a mixture comprising of two components A and B. The mass fraction of A in that mixture can be expressed as follows.

$$\text{Mass fraction of A in the mixture} = \frac{\text{Mass of A}}{\text{Mass of A} + \text{Mass of B}}$$

Hence, the mass fraction of a given component of a mixture is the ratio of the mass of that component to the total mass of the mixture.

Worked examples :-

1) 100 g of the solution contains 5 g of a solute. Give the composition of the solute of this mixture as a mass fraction.

$$\text{Mass fraction of the solute} = \frac{\text{Mass of the solute}}{\text{Mass of the solvent}}$$

$$= \frac{5\text{ g}}{100\text{ g}}$$

$$= \frac{1}{20}$$

$$= 0.05$$

2) When 250 g of a salt (NaCl) solution was weighed accurately and all the water in it was evaporated, 10 g of salt was left. Indicate the composition of salt in the solution as a mass fraction.

$$\text{Mass fraction of salt} = \frac{10\text{ g}}{250\text{ g}}$$

$$= \frac{1}{25}$$

$$= 0.04$$

3.2.2 Composition of a mixture as a volume fraction (V/V)

Volume fraction is used to indicate the composition of a mixture when both of its components exist either in the liquid state or in the gaseous state.

In a mixture containing two components A and B, the volume fraction of a A can be given as follows.

$$\text{Volume fraction of A} = \frac{\text{Volume of A}}{\text{Total volume of the mixture of A and B}}$$

Accordingly the volume fraction of a given component of a mixture is the ratio of the volume of that component to the total volume of the mixture.

Worked examples:-

1) A solution of final volume 250 cm^3 was made by adding distilled water to 25 cm^3 of ethyl alcohol (C_2H_5OH). What is the volume fraction of ethyl alcohol in this solution?

$$\text{Volume fraction of ethyl alcohol} = \frac{\text{Volume of ethyl alcohol}}{\text{Total volume of the solution}}$$

$$= \frac{25\ cm^3}{250\ cm^3}$$

$$= 1/10$$

$$= 0.1$$

2) How do you prepare 500 cm^3 of an aqueous solution of acetic acid of composition 1/25 (V/V) ?

$$\text{Volume fraction of acetic acid} = \frac{\text{Volume of acetic acid}}{\text{Final volume of the solution}}$$

$$\text{Volume of acetic acid} = \text{Volume fraction of acetic acid} \times \text{Final volume of the solution}$$

$$= \frac{1}{25} \times 500\ cm^3$$

$$= 20\ cm^3$$

Therefore, an acetic acid solution with the composition of 1/25 (V/V) is obtained by measuring 20 cm^3 of acetic acid accurately and adding water to make the final volume upto 500 cm^3.

3.2.3 The compostion of a mixture as a mole fraction

The mole fraction of each component of a mixture containing only two component A and B can be expressed as follows.

$$\text{Mole fraction of A} = \frac{\text{Amount of moles of A}}{\text{Amount of moles of A} + \text{Amount of moles of B}}$$

$$\text{Mole fraction of B} = \frac{\text{Amount of moles of B}}{\text{Amount of moles of A} + \text{Amount of moles of B}}$$

Thus, the mole fraction of a component of a mixture is, the ratio of the amount of moles of that component to the total amount of moles of all the components in the mixture.

Worked examples :-

1) What is the mole fraction of sodium hydroxide (NaOH) in a solution made by dissolving 40 g of sodium hydroxide in 180 g of water?

Molar mass of water $= (1 \text{ x } 2 + 16) \text{ g mol}^{-1}$
$= 18 \text{ g mol}^{-1}$

Amount of moles of water in the solution $= \dfrac{180 \text{ g}}{18 \text{ g mol}^{-1}}$

$= 10 \text{ mol}$

Molar mass of sodium hydroxide $= (23+16+1) \text{ g mol}^{-1}$

$= 40 \text{ g mol}^{-1}$

Amount of moles of sodium hydroxide

in the solution $= \dfrac{40 \text{ g}}{40 \text{ g mol}^{-1}}$

$= 1 \text{ mol}$

Mole fraction of sodium hydroxide in the solution $= \dfrac{\text{Amount of moles of sodium hydroxide}}{\text{Amount of moles of water + Amount of moles of sodium hydroxide}}$

$$= \frac{1}{10 + 1}$$

$$= \frac{1}{11}$$

Similarly, the mole fraction of water in the above solution can be calculated.

Mole fraction of water $= \dfrac{\text{Amount of moles of water}}{\text{Amount of moles of water} + \text{Amount of moles of sodium hydroxide}}$

$$= \frac{10}{10 + 1}$$

$$= \frac{10}{11}$$

Sum of mole fractions = Mole fraction of water + Mole fraction of sodium hydroxide

$$= \frac{10}{11} + \frac{1}{11}$$

$$= \frac{11}{11}$$

$$= 1$$

The sum of mole fractions of all the components in a mixture is one. The sum of mass fractions or volume fractions of all the components in a mixture is equal to one. There are no units for the mass fractions, volume fractions or mole fractions of a mixture.

The composition of a mixture expressed as a fraction can also be expressed as a percentage or as parts per million (ppm).

Composition as a percentage = Fraction x 100

Composition as parts per million (ppm) = fraction x 1 000 000

Worked examples:

1) 20 g of magnesium oxide contains 12 g of magnesium. Calculate the mass fraction of magnesium and express it as a mass percentage.

$$\text{Mass fraction of magnesium} = \frac{12\ g}{20\ g} = 0.6$$

Magnesium composition as a percentage = 0.6 x 100 = 60%

3.2.4 Expressing composition of a mixture in terms of mass/ volume (m/v)

This expresses the mass of solute contained in a unit volume of a mixture.

1 dm^3 of Jeewani solution contains 5 g of sodium chloride. Find the composition of sodium chloride in it, in terms of m/v

$$\begin{aligned} \text{Composition of solute (m/v)} &= \frac{\text{Mass of sodium chloride}}{\text{Volume of solution}} \\ &= \frac{5\ g}{1 dm^3} \\ &= 5\ g\ dm^{-3} \end{aligned}$$

3.2.5 Expressing composition of a mixture in terms of amount of moles / volume (n/v)

This is used to express the composition of a homogeneous mixture (solution). 'Mole' is the international unit for the amount of matter. Here, the composition is given in terms of the amount of moles of solute contained in unit volume of a solution. The composition expressed in this way is called the concentration (C). In chemistry, very often concentration of a solution is expressed in terms of the amount of moles of solute contained in a cubic decimetre of the solution.

Worked examples :-

1) 2 dm^3 of a solution contains 4 moles of sodium hydroxide (NaOH). Find the sodium hydroxide concentration of this solution.

Amount of moles of sodium hydroxide in 2 dm^3 of the solution = 4 mol

$$\begin{aligned} \text{Amount of moles of sodium hydroxide in 1 dm}^3 \text{ of the solution} &= \frac{4\ mol}{2\ dm^3} \times 1\ dm^3 \\ &= 2\ mol \end{aligned}$$

Concentration of sodium hydroxide in the solution $= \dfrac{2\ \text{mol}}{1\ \text{dm}^{-3}}$

$= 2\ \text{mol dm}^{-3}$

2) (i) What is the mass of glucose ($C_6H_{12}O_6$) required to prepare 1 dm^3 of a 1 mol dm^{-3} glucose solution? (C =12, H = 1, O = 16)

For this, 1 mol of glucose is required

Molar mass of glucose $= (12\text{x}6 + 1\text{x}12 + 16\text{x}6)\ \text{g mol}^{-1}$

$= 180\ \text{g mol}^{-1}$

Mass of glucose required $= 180\ \text{g mol}^{-1}\ \text{x}\ 1\ \text{mol}$

$= 180\ \text{g}$

(ii) Work out the mass of glucose that should be weighed to prepare 500 cm^3 of a 1 mol dm^{-3} glucose solution.

Mass of glucose required to prepare 1000 cm^3 of the solution $= 180\ \text{g}$

Mass of glucose required to prepare 500 cm^3 of the solution $= \dfrac{180\ \text{g}}{1000\ \text{cm}^3}\ \text{x}\ 500\ \text{cm}^3$

$= 180\ \text{g}/\ 2$

$= 90\ \text{g}$

Preparation of standard solutions

During chemical experiments, standard solutions are required to be prepared. A standard solution is a solution in which the concentratrion is very accurately known. The relationships among the following units are very important in the preparation of standard solutions.

$1\text{dm}^3 = 1\ \text{l (Litre)}$

$1\text{dm}^3 = 1000\ \text{cm}^3$

$1\text{dm}^3 = 1000\ \text{ml}$

$1\text{cm}^3 = 1\ \text{ml}$

The following laboratory equipment are required to prapare a solution of a specified concentration.

Volumetric flasks corresponding to the volume of the solution

Wash bottle

Watch glass

Funnel

Figure 3.2.1 - Laboratory equipment required to prepare a solution.

Let us study how 500 cm^3 of a 1 mol dm^{-3} sodium chloride solution is prepared. First, the mass of sodium chloride required for this should be calculated.

Molar mass of sodium chloride $= (23.0 + 35.5)\ g\ mol^{-1}$

$= 58.5\ g\ mol^{-1}$

Mass of sodium chloride in 1000 cm^3 of a 1 mol dm^{-3} solution $= 58.5\ g$

Mass of sodium chloride in 500 cm^3 of a 1 mol dm^{-3} solution $= \dfrac{58.5\ g}{1000\ cm^3} \times 500\ cm^3$

$= 29.25\ g$

- Next, weigh 29.25 g of sodium chloride very accurately onto a watch glass using a laboratory balance (triple beam balance/ four beam balance/ chemical balance). (Get instructions from the teacher as to how weighing is done accurately using the balance).
- Select a clean 500 cm^3 volumetric flask.
- Remove its stopper and place a clean funnel as shown in the figure.

Figure 3.2.2 - Preparation of a standard solution

- Transfer the weighed sodium chloride on the watch glass completely through the funnel using the wash bottle. Wash the surface of the watch glass and the inner surface of the funnel and transfer the washings into the flask.
- Add about 2/3 of the required volume of water and stopper the volumetric flask.
- Shake the flask so that all of the sodium chloride dissolves well. (Get instructions from the teacher about how mixing should be done.)
- After all the salt is dissolved well, add water carefully, keeping the eye at the level of the volume mark of the flask. Stop adding water when the meniscus is at the position of the mark, as shown in the figure 3.2.3.
- Stopper the flask and mix again. (Get instructions from the teacher regarding how mixing should be done)

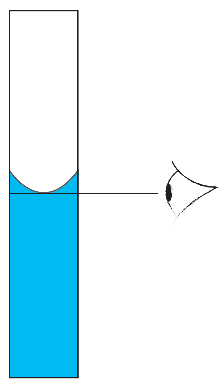


Figure 3.2.3

When preparing a solution of a specific concentration, following factors should be taken into consideration.

1. Cleanliness of all the equipment used
2. Weighing the solute accurately
3. Washing well and transfering the substance sticking on to the watch glass and the funnel into the flask.
4. Use the correct technique for mixing.
5. Adjusting the final volume carefully.
6. Prevention of the entry of impurities into the solution.

Activity 3.2.2

a) 250 cm^3 of 1 mol dm^{-3} sodium chloride ($NaCl$)

b) 100 cm^3 of 1 mol dm^{-3} glucose ($C_6H_{12}O_6$)

c) 500 cm^3 of 1 mol dm^{-3} urea ($CO(NH_2)_2$)

d) 250 cm^3 of 1 mol dm^{-3} copper sulphate ($CuSO_4$)

1. Divide the class into four groups and prepare the above four solutions using the correct method.
2. In the solutions you have prepared,
   - name the solute and solvent
   - indicate the amounts of the solvents and the solutions used with their units.
   - indicate the name, concentration and the date of preparation.
3. Give examples for the instances of preparing solutions in everyday life.

Assignment 3.2.2

Make a list of instances in which solutions of very accurate composition should be prepared.
Ex: Preparation of saline solutions

Thoroughly study the following worked examples in order to get a better understanding of the composition of solutions.

Worked examples :-

1. A solution was prepared by weigheing 17 g of sodium nitrate ($NaNO_3$) very accurately dissolving it in a 200 cm^3 volumetric flask and diluting with water up to a final volume of 200 cm^3 . What is the concentration of this solution?

   (Na = 23, N =14, O =16)

Molar mass of sodium nitrate $= \{23+14+ (16x3)\}g\ mol^{-1}$

$= 85\ g\ mol^{-1}$

Amount of moles of sodium nitrate in 17 g $= \dfrac{17\ g}{85\ g\ mol^{-1}}$

$= 0.2\ mol$

Final volume of the solution $= 200\ cm^3$

Amount of moles of sodium nitrate in 1 dm^3 (1000 cm^3) of the solution $= \dfrac{0.2\ mol}{200\ cm^3} x\ 1000\ cm^3$

$= 1$

Concentration of sodium nitrate in the solution $= \dfrac{1\ mol}{1\ dm^3}$

$= 1\ mol\ dm^{-3}$

2. What is the mass of potassium carbonate (K_2CO_3) required to prepare 500 cm^3 of a 1 mol dm^{-3} potassium carbonate solution? (K = 39, C = 12, O = 16)

Molar mass of potassium carbonate $= \{(39x2)+12+(16x3)\}g\ mol^{-1}$

$= 138\ g\ mol^{-1}$

Mass of potassium carbonate in 1000 cm^3 of a 1 mol dm^{-3} solution $= 138g$

Mass of potassium carbonate in 500 cm^3 of a 1 mol dm^{-3} solution $= \dfrac{138\ g}{1000\ cm^3} x\ 500\ cm^3$

$= 69\ g$

Mass of potassium carbonate required $= 69\ g$

3. A solution of 1 dm^3 is prepared by dissolving 12 g of urea $\{CO(NH_2)_2\}$ in distilled water. Find the concentration of this solution. (C = 12, O = 16, N = 14, H = 1)

Molar mass of urea $= \{12 + 16 + (14 \times 2) + (1 \times 4)\}\ g\ mol^{-1}$

$= 60\ g\ mol^{-1}$

Amount of moles of urea in 60 g $= 1$ mol

Amount of moles of urea in 12 g $= \frac{1 mol}{60\ g} \times 12\ g$

$= 0.2$ mol

Amount of moles of urea in 1 dm^3 $= 0.2$ mol

Concentration of urea in the solution $= \frac{0.2\ mol}{1\ dm^3}$

$= 0.2\ mol\ dm^{-3}$

4. To a 250 cm^3 volumetric flask, 18 g, of glucose ($C_6H_{12}O_6$) was transferred and distilled water was added until the total volume of the solution was 250 cm^3. What is the concentration of this solution?

Molar mass of glucose $= \{(12 \times 6) + (1 \times 12) + (16 \times 6)\}\ g\ mol^{-1}$

$= 180\ g\ mol^{-1}$

Amount of moles of glucose in 180 g $= 1$ mol

Amount of moles of glucose in 18 g $= \frac{1 mol}{180\ g} \times 18\ g = 0.1$ mol

Amount of moles of glucose in 250 cm^3 $= 0.1$ mol

Amount of moles of glucose in 1000 cm^3 $= \frac{0.1 mol}{250\ cm^3} \times 1000\ cm^3$

$= 0.4$ mol

Concentration of the solution $= \frac{0.4\ mol}{1\ dm^3}$

$= 0.4\ mol\ dm^{-3}$

The concentration of a solution can be lowered by adding more solvent to it. Deacreasing the concentration by adding more solvent is known as dilution. Most of the acids in laboratory stores are concentrated acids. Mostly the acid solutions prepared by diluting those concentrated acids are used for laboratory experiments.

For your attention

As a safety measure, when diluting concentrated solutions, always the acid should be added to water. It is because the dilution of concentrated acids is highly exothermic and may be dangerous.

When **n** moles of a solute are dissolved in a solution of volume **V**, its concentration **C** can also be found using the following equation.

$$\boxed{C = \frac{n}{V}}$$

When **n** is in moles (mol) and V is in cubic decimetres (dm^{-3}), concentration C is given in moles per cubic decimetre ($mol\ dm^{-3}$)

Using the above equation, solve the previously studied worked examples to calculate the concentration.

3.3 Separation of compounds in mixtures

Many substances essential for our daily affairs are available in the Earth's crust. Metals, mineral oils, salts, sand, clay, coal, minerals and rocks are some of them. These rarely exist in pure form in the Earth's crust. Naturally they occur mixed with other substances. Therefore, the essential components should be separated from those mixtures.

Some instances where components from mixtures should be separated, are given below.

- Removal of stones and sand from rice
- Separation of salt from sea water
- Separation of various minerals from mineral sands.
- Separation of various fuels by the mineral oil refinery
- Separation of sugar from molasses
- Separation of gases such as oxygen, nitrogen and argon from atmospheric air
- Obtaining distilled water from common well water or river water
- Preparing potable water from sea water

Many more such occasions can be given as examples. In this chapter we study about several methods of separating components in mixtures.

3.3.1 Mechanical separation

You know that rice is sifted to remove the sand mixed with it. In this, sand is removed from rice based on the difference of the densities of the components. The separation of components in a mixture using the difference of their physical properties such as density, particle size, particle shape, magnetic properties and electric properties is called mechanical separation. Study the examples given in table 3.3.1 and have a further understanding about mechanical separations.

Table 3.3.1

Mechanical method	Occasion of using	Physical property based
Winnowing	Removal of chaff from rice	Difference in denisties of the components
Sieving	Removal of gravel from sand	Difference in the size of component particles
Sifting	Removal of sand from rice	Difference in denisties of the components
Floating on water	Removal of dud seeds from seed paddy	Difference between the densities of components and water
Directing into a stream of water	Separating gold from ores	Difference in densities of the components
Magnetic seperation	Separating certain minerals from mineral sands	Magnetic property of the components

The methods such as winnowing, sieving, sifting, floating and subjecting to magnetism that separate components of a mixture are called mechanical methods. Methods such as these are frequently used in day to day life.

Assignment 3.3.1

Prepare a list of examples for the occasions where components are separated by mechanical methods in day to day life.

3.3.2 Vapourisation/Evaporation

You may have observed the extraction of salt from sea water. What happens here is that the water evaporates due to solar heat. Water gets evaporated and the dissolved salts get precipitated. **During vapourization, the unnecessary components are vaporized by supplying heat to a mixture and the essential component is isolated.**

When metals are dissolved in mercury a special solution known as an amalgam is formed.

When impure gold is dissolved in mercury, a solution of pure gold is obtained. This is known as the gold amalgam. When gold amalgam is heated, mercury is evaporated and the pure gold is remained. The evaporated mercury is cooled and used again.

3.3.3 Filtration

Have you seen adding coconut milk to some curries when they are cooked at home? How is coconut milk made? Water is added to the coconut scraped by a coconut scraper, and then crushed and squeezed by hand. Parts of the white liming remain suspended in water without going into the solution. When the stuff is put into a milk-strainer the milky solution filters off leaving the pieces of solid coconut in the strainer.

Filtration can be used to separate from a mixture, the components that remain suspended in a liquid without going into the solution. A filter is required to filter a mixture. Milk-strainer is such a device. The filter paper used in laboratories is another such filter. Water purifying plants have sand filters.

A filter has small holes. Particles smaller than the holes can pass through. But particles larger than those holes cannot pass through them. This is the concept used in filtration. In filtration, the substance left in the filter is called the residue while the solution that gets filtered is known as the filtrate.

Activity 3.3.1

Materials required ;- Dry soil, salt, filter papers, a funnel, a beaker, glass rod, flask

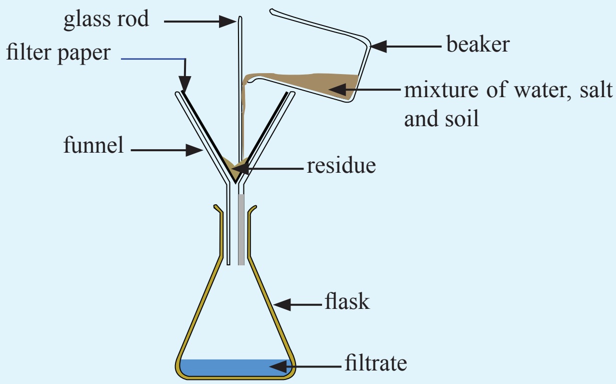


Figure 3.3.1

Method ;- Mix well, about 10 g of dry soil and about 5 g of salt (NaCl). Take about 50 cm^3 of water to a beaker, add the above mixture into it and stir. Arrange the apparatus as shown in figure 3.3.1 and filter. After filtration is over, observe the filter paper. Add about 10 cm^3 of the filtrate to an evaporating dish and vaporize. See whether there is anything left in the dish.

Large clay particles in the sample of soil do not pass through the filter, and they are held back by the filter paper. Since water and salt are made up of smaller particles, they pass through the filter and get into the filtrate.

3.3.4 Crystallisation

Let us consider instances where a solid dissolves in a solvent to form a homogeneous mixture. At a certain temperature, there is a maximum concentration of a substance that stays dissolved in a solution. Such solutions are said to be saturated with that substance.

If this saturated solution is vaporized, the concentration of that substance in the solution increases further. When the concentration of the solute exceeds the maximum possible concentration in the solution, the solute separates out forming crystals.

Crystallization is thus the method of separating solid substances by concentration when a solute that can turn into a solid is present in a solution.

Manufacturing of sugar is an industry that utilities crystallization. Stems of Sugarcane are crushed and squeezed and the juice is purified. Its concentration is increased by vaporisation. Then, sugar separates out from the juicy solution as crystals.

Production of salt from sea water is another industry that adopts crystallization. During the production of salt in salterns, several salts that are dissolved in sea water get crystallized.

Assignment 3.3.2

Obtain salt by the vaporisation or evaporation of a concentrated salt solution.

3.3.5 Recrystallization

Recrystallization is used to separate pure substances from solid, crystalline substances carrying impurities. The process of dissolving a solid, crystalline substance and turning it again into crystals is called recrystallization . Crystals of high quality without impurities can be obtained by recrystallization.

In recrystallization, the impure solid is dissolved in the hot solvent till it becomes saturated. Afterwards, to separate the impurities in the impure solid, above solution is filtered while it is still hot. Pure crystals of the solid is obtained by cooling the filtrate. Here, crystallization occurs because the cold solution is saturated with the solute although the hot solution is not. The soluble components present as impurities in minor quantities are not crystallized as the solution is not saturated in them.

Activity 3.3.2

Take about 50 g of common salt available in the market. Take about 50 cm^3 of water at a temperature of about 90 ^0c, into a beaker and dissolve crystals of salt until the solution is saturated. Filter the solution while it is still hot, using filter paper. Take the filtrate into a beaker, place it in a container of ice and shake slowly. Observe the crystals formed.

3.3.6 Solvent extraction

You have learnt that the nature of both solute and solvent affect solubility. Some solutes are soluble in large amounts in one solvent but dissolve in very small quantities in another solvent. For example, when solid iodine is added to water, a very small amount dissolves giving a light coloured solution. But a larger amount of iodine dissolves in solvents like carbon tetrachloride and cyclohexane.

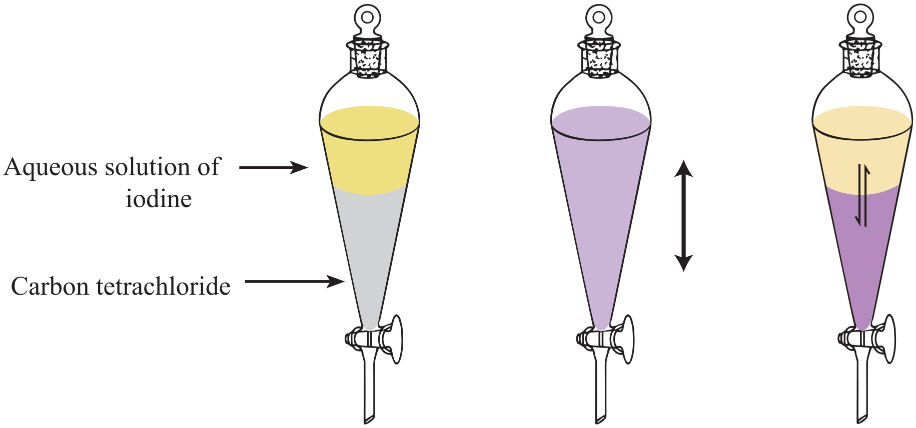


Figure 3.3.2

When carbon tetrachloride is added to an aqueous solution of iodine, they do not mix, and the layers get separated. After some time, it can be seen that the carbon tetrachloride layer turns violet while the aqueous layer becomes pale. What has happened here is the extraction of iodine from the aqueous layer into the carbon tetrachloride layer in which it is more soluble. The specialty here is the adequacy of a small volume of carbon tetrachloride to extract the iodine from a large volume of aqueous solution.

After this, iodine can be recovered by separating layers and evaporating carbon tetrachloride.

Hence, solvent extraction is the method of drawing up a substance from a solvent in which it is less soluble, into another solvent in which it is more soluble, where the two solvents are immiscible and are in contact with each other.

The medicinal components in some plants are found only in trace amounts. Medicinal solutions of higher concentration are prepared using solvent such as ethanol. Solvents extraction is used in the production of medicinal extracts and potions.

3.3.7 Simple distillation, fractional distillation and steam distillation

The separation of components by boiling a solution or a mixture and condensing the vapour is called distillation.

So, there must be a mechanism to cool the distillate or the vapour that evolves when a given mixture is heated. The Liebig condenser in the school laboratory is an apparatus designed for this. The vapour is allowed to pass through the condenser and cold water is circulated around it, in order to cool down the vapour. This condenser has an inlet and an outlet for water.

Figure 3.3.3 - The Liebig condenser

Activity 3.3.3

Collect a sample of distilled water using the Liebig condenser available in the laboratory. Discuss with your science teacher the special facts that should be taken into consideration when setting up this apparatus.

Assignment 3.3.3

Investigate into how an improvised lie big condenser can be made. Make such an apparatus, show it to the science teacher and find its merits and demerits.

- Simple distillation

Simple distillation is used to separate components in a mixture which contains a volatile component with other non-volatile components. Only the volatile components are vaporized during distillation. The other components are left in the solution. For example, let us assume that a sample of well water is subjected to distillation.

In addition to water, it contains various salts and some gases dissolved in it. When heated slightly, the gases escape without getting condensed. Boiling points of salts are higher than that of water. Therefore, when the sample of well water is heated and vaporized, only the water vaporizes. Salts can be seen deposited at the bottom of the container. For this kind of distillation, special control of conditions is not essential. Hence, this is known as simple distillation. For this use of simple equipment such as the lie big condenser is adequate. The figure illustrates the apartments set up to obtain distilled water from a sample of well water. Some countries use this method to obtain potable water from sea water.

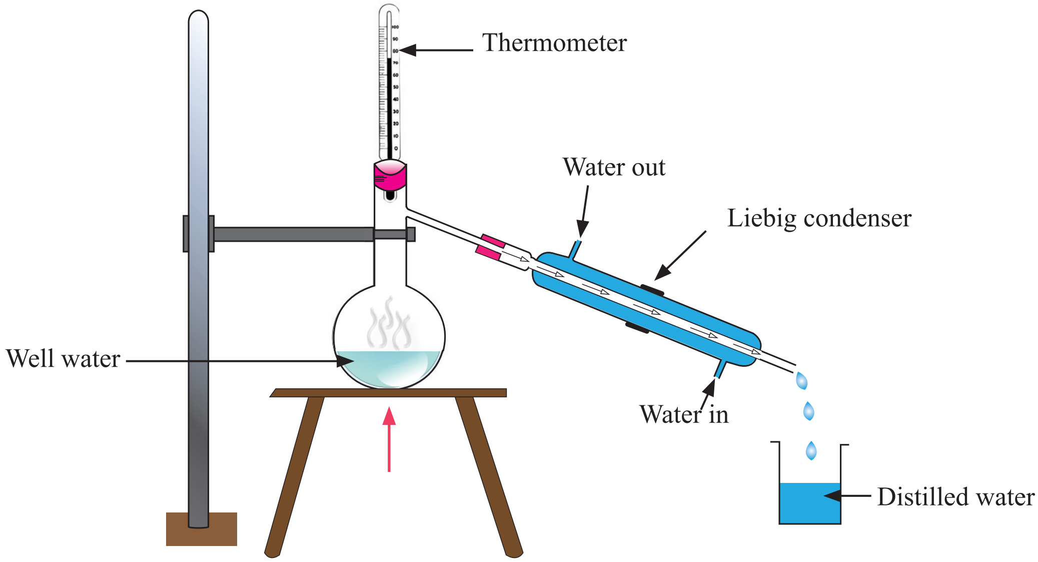


Figure 3.3.4 - Simple distillation

• Fractional distillation

If the solution or the mixture subjected to separation contains several volatile components, simple distillation or the apparatus used in simple distillation cannot be used to separate them. It has to be perfumed under controlled conditions and for it, a fractionating column should be used. If two liquids are to be separated by fractional distillation, there should be a considerable difference in their boiling points. That means, their volatilities need to be considerably different. Here, the vapour contains a higher percentage of the more volatile

Component and a lower percentage of the less volatile component.

Let us assume that the boiling point of a component a in A mixture is 80 ^{0}C and the boiling point of a component B is 40 ^{0}C. Upon heating, the mixture containing A and B begins to boil at a temperature slightly above 40 ^{0}C. Therefore, the vapour formed is richer in component B. When this vapour is collected and condensed at a temperature closer to 40 ^{0}C, the resulting liquid contains more B. **A** is present in smaller amount. When more of B gets removed from the mixture like this, its percentage of **A** increases. Then, the temperature at which the mixture boils also increases. This way, the components can be separated by collecting the vapours at different temperatures and condensing them. Separation of several components by distillation under controlled cooling conditions like this, is known as fractional distillation.

Crude oil is a mixture of many hydrocarbon components. When refining crude oil, a fractionating tower is used to control the cooling conditions. In this tower, the temperature is appropriately controlled at different level and the components are separately withdrawn at the respective positions. Components with lower boiling points are separated from the upper levels of the tower. Components with high boiling points are (bitumen) deposited at the bottom of the tower. This can be further understood by studying figure 3.3.5.

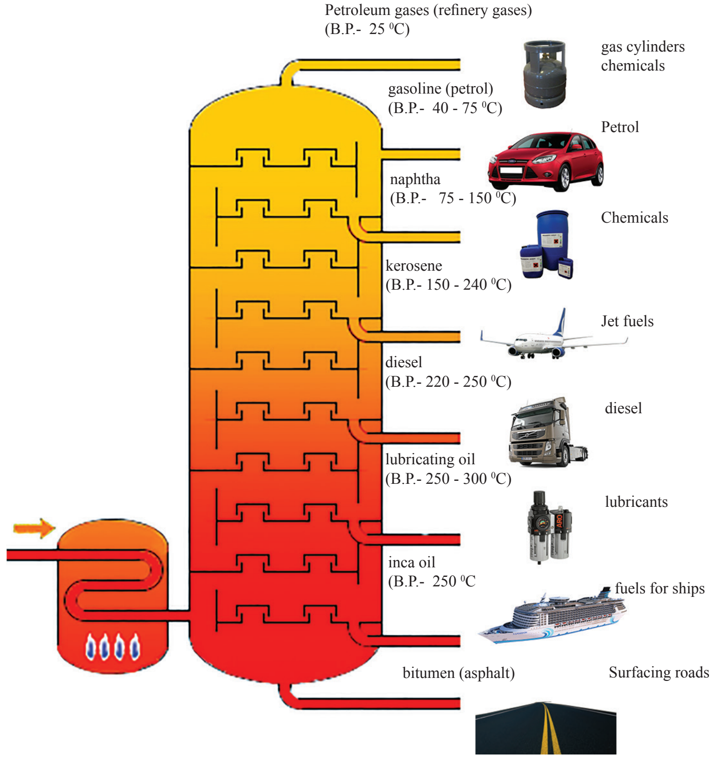


Figure 3.3.5 - Fractionating tower

Extra knowledge

Fractional distillation is also used to separate the components in atmospheric air. When air is pressurised and cooled to about - 200 ^{0}C, it liquifies. This liquid is also a mixture of several components which vaporize at their boiling points. likewise, nitrogen boils off at - 196 ^{0}C whereas oxygen and carbon dioxide boil at - 183 ^{0}C and - 78.5 ^{0}C respectively.

• Steam distillation

We know that certain parts of plants contain volatile components. Cinnamon, clove, cymbopogon, nutmeg and cardamom are few such examples. It is difficult to increase the temperature uniformly up to the boiling point of these compounds. Moreover, at the temperatures close to the boiling point, there is a possibility of destruction of these compounds by decomposition or getting converted into other compounds. Therefore, heat is supplied to the mixture by steam.

When water soluble compounds are mixed with water, the boiling point of such mixtures are above the boiling point of water. On the other hand, when the compounds that do not mix well with water are together with water, the boiling point of the mixture drops below the boiling point of water.

Most of the essential oils are immiscible with water and their boiling points are greater than that of water. They occur in living cells, mixed with water. Extraction of essential oils can be demonstrated in the laboratory by using an apparatus such as the one given below.

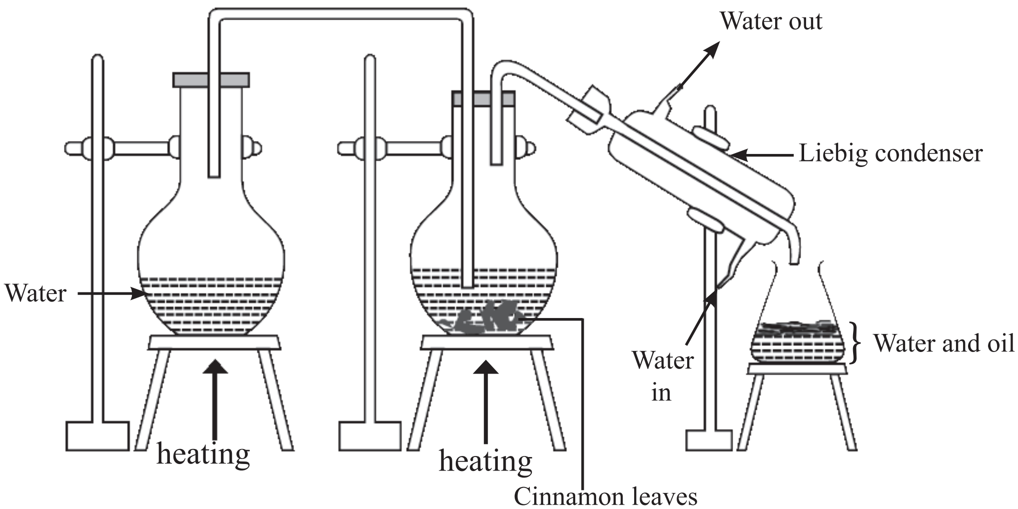


Figure 3.3.6 - Steam distillation

When heat is supplied to these mixtures by steam, both water and the essential oil get liberated as a mixture of vapors at a temperature below the boiling point of water (100 ^{0}C). When the distillate (vapour) is cooled it separates into two layers because water and the essential oil are immiscible. Therefore, they can be easily separated as pure substances.

Extra knowledge

Essential oils have many uses.

- Used as flavours and condiments in food.
- Used to produce perfumes.
- Used as ingredients in toothpaste
- Used to produce pharmaceuticals

Assignment 3.3.4

Prepare a list of plants used to produce essential oils in Sri Lanka. Find out which parts of these plants contain more of those essential compounds.

3.3.8 Chromatography

Chromatography is used to separate and identify the components present in a mixture (solid or liquid) containing non-volatile components. There are many different types of chromatography. The method carried out using paper (cellulose) is known as **paper chromatography.**

Add a little amount of water to a petri dish and dip one end of a dry strip of a filter paper in it. It can be observed that a stream of water particles is soaked up the strip of paper from bottom to top. Even when water is replaced by compounds such as acetone, ether and ethyl alcohol, a flow of liquid which flows up from the bottom to top can be seen. The strip of paper is called the stationary phase while the solvent that is soaked into it is called the mobile phase. When a small portion of the mixture whose components need to be separated is placed on this paper, the components in the mixture dissolve in the solvent and move up with the solvent front. This upward movement depends on the forces of attraction of the components of the mixture, to the stationary phase. For example, if one component in the mixture is strongly attracted to the stationary phase (the paper), its rate of upward movement decreases. If there is another component in the mixture that is relatively less attracted to the mixture, it moves up faster through the stationary phase. Because of this difference in the speed of movement of the components in the mixture, they get separated from one another. Let us do the following activity to separate out the components in a chlorophyll mixture using paper chromatography.

Activity 3.3.4

Materials required ;- Chromatography papers or filter papers or A_4 papers, spinach leaves, mortar and pestle, a thin piece of silk cloth, a boiling tube, a rubber stopper with a hook

Method ;- Crush a few spinach leaves thoroughly using mortar and the pestle available in the laboratory. Collect the chlorophyll extract onto a watch glass by placing the crushed paste on a piece of thin silk cloth and squeezing it.

- Cut a strip of chromatography/filter/A_4 paper
- Take a little bit of the chlorophyll extract to a capillary tube and place it on the strip of the paper a little above the end of it as shown in the diagram. The solvent vaporizes leaving chlorophyll on the paper. Place another drop on same spot.

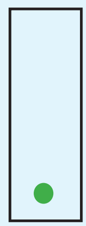


Figure 3.3.7

- Connect a piece of string to the end of the paper strip opposite to that with the chlorophyll drop.
- Add a solvent such as acetone/kerosene/petrol to the boiling tube and stopper it. Leave it to saturate. Connect a hook to the stopper as shown in the diagram and suspend the strip on the hook so that its other end dips in the solvent. Ensure that the sides of the strip do not touch the walls of the boiling tube.

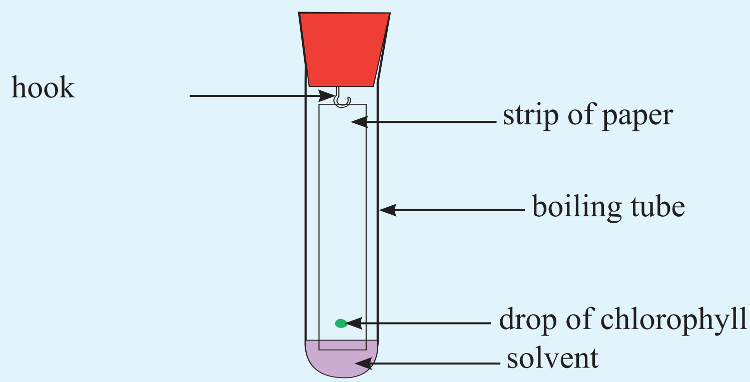


Figure 3.3.8

Leave it for some time and then take out the strip of paper and observe It can be seen that the components of different colours are separated. This leads to the conclusion that chlorophyll contains different components.

Therefore, chromatographic technique can be used to separate and identitfy several components when they are mixed together. Chromatography is used to find whether poisonous chemicals are mixed with water. It is also used to check whether harmful substances are associated with food items. Chromatographic technique is also useful in identifying active chemical compounds in plants.

Uses of separating techniques

Extraction of salt from sea water

In sri lanka salt is produced by the evaporation of sea water in salterns. The sea water collected in the salt pans are concentrated by evaporation during which salt crystallizes out finally. The separating techniques **evaporation** and **crystallization** are used in this method.

The location and structure of a saltern is very important in the production of salt. The geographical and environmental factors that should be taken into consideration when setting up a saltern are as follows.

1. A flat land situated closer to a coastal area to obtain sea water easily
2. Presence of a clayey soil with minimum percolation of water
3. Prevailence of dry and hot climate with bright sunlight and wind throughout the year
4. An area with minimum rainfall.

Regarding the structure of a saltern, three types of tanks can be identified.

- Large, shallow tanks
- Medium tanks
- Small tanks

Figure 3.3.9 A saltern

The main steps of the production of salt in a saltern are as follows.

Step 1 :- The sea water is either made to flood into the big, shallow tanks during high tide or is pumped into them and allowed to evaporate by sunlight. When the concentration is twice as double the initial concentration of sea water, calcium carbonate ($CaCO_3$) begins to crystallize and precipitate at the bottom of the first tank.

Step 2 :- This water is then transfered into the medium- sized tanks in which the water evaporates further. When the concentration of water is about four times the initial concentration, calcium sulphate ($CaSO_4$) crystallizes and settles down at the bottom.

Step 3 :- Following the precipitation of calcium sulphate, the solution is allowed to flow from the medium tanks into the smaller tanks in which water is evaporated further. When the concentration is nearly ten times the concentration of initial sea water, salt (NaCl) crystallizes and precipitates at the bottom.

While salt is precipitating, the concentration of the solution increases further. Even before the total precipitation of sodium chloride is complete, magnesium chloride ($MgCl_2$) and magnesium sulphate ($MgSO_4$) begin to precipitate. These give a bitter taste to salt. The solution left after the precipitation of salt is known as mother liquor or bittern.

Salt deposited in the third tanks is taken out, heaped in prismatic piles at another place and stored for a period of six months. Pure sodium chloride is not hygroscopic. But if salt contains magnesium chloride and magnesium sulphate, it becomes bitter and hygroscopic, when exposed to the atmosphere. But, as magnesium chloride and magnesium sulphate absorb moisture in the atmosphere and go into solution, with the elapse of about six months most of them get removed, salt is retained as a solid.

Extraction of essential oils

Volatile compounds obtained from plant materials are referred to as essential oils. The reason for the characteristic aroma of some plant materials is these volatile compounds these they contain. Some main essential oils produced in our country are :

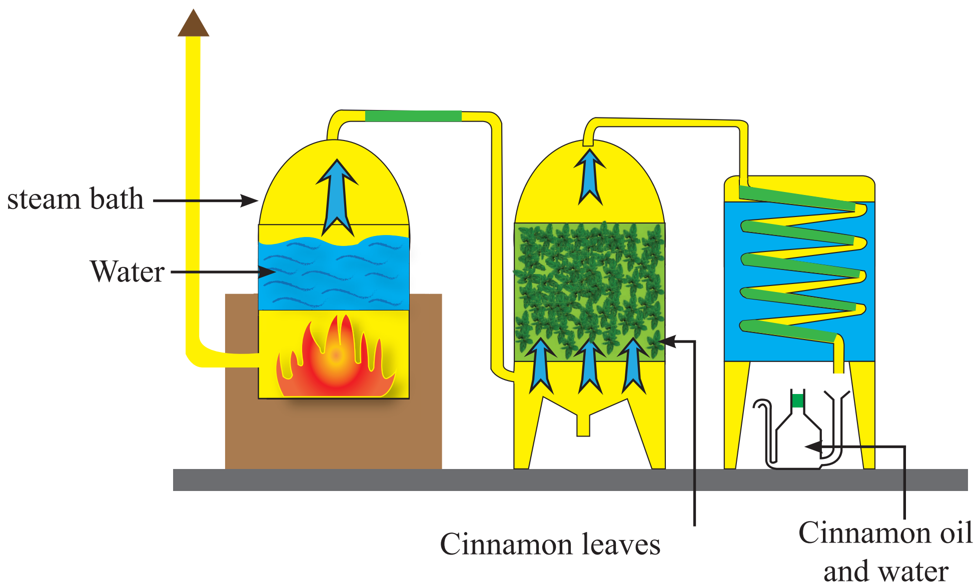
- Cinnamon leaf oil
- Cinnamon bark oil
- Citronella oil
- Pepper oil
- Cardamom oil
- Nutmeg oil
- Clove bud oil
- Eucalyptus oil

Cinnamon bark oil, pepper oil and cardamom oil promote the flavour and the scent of food. Cinnamon leaf oil, pepper oil and cardamom oil have medicinal properties as well and are frequently used in the production of medicinal ointments, toothpaste and the perfumes added to soap. Some plant parts in which essential oils are formed are given below.

Plant/Plants	Part (s) in which essential oils are formed
Veitiveria	Roots
Sandalwood	Steam
Cinnamon	Bark, Root, Leaf
Citronella	Leaf
Lemongrass	Leaf
Eucalyptus	Leaf
Clove	Floral parts
Rose, Jasmine	Flower
Lemon, Lime	Fruit
Nutmeg	Seed

The separating techniques such as steam distillation and solvent extraction are used to extract essential oils. From cinnamon leaves, oil is obtained by passing steam through them.

Extraction of essential oils by steam distillation



In this method steam generated by the steam bath is passed through the plant parts. Essential oils, being mixed with water vapour, vapourises at a temperature below 100 ^{0}C. Condensation of this mixture of vapours gives essential oil and water. As they are immiscible, they can be obtained separately.

Assignment 3.3.5

Inquire into the traditional method of cinnamon oil extraction in Sri Lanka and prepare a report.

Obtaining essential oils by solvent extraction

Solvent extraction is another method of extracting essential oils. Organic solvents such as ether, chloroform and toluene are used in this method. When plant parts are shaken with the solvent, essential oil dissolves in the solvent. The essential oil is separated by letting the solvent to vaporize.

Volatile oils in some plant parts can also be obtained by compressing them under a suitable pressure.

Summary

- Matter can be divided into two parts, pure substances and mixtures.
- In natural environment, pure substances are very rare and what is more abundant are mixtures.
- The substances formed by mixing two or more substances without any chemicalchanges are called mixtures. The physical and chemical properties of the components are retained even in the mixture. The components of a mixture can be separated by physical methods.
- A mixture is a homogeneous mixture when its components are uniformly distributed. If not, it is a heterogeneous mixture.
- A homogeneous mixture is also referred to as a solution. Characteristics such as concentration, colour, density and transparency of any minute part of a solution are identical. In heterogeneous mixtures these are different.
- In a solution the component present in a greater proportion is called the solvent and the component that is less in proportion is known as the solute.

- Dissolving of a solute in a solvent depends on temperature, polar characteristics related to the molecular properties of the solute and solvent as well as organic or inorganic nature.
- The solubility of a gas in water depends on the pressure of that gas over water and temperature.
- Different notations are used to indicate the composition of a mixture. Mass fraction (m/m), volume fraction (V/V), mole fraction, mass-volume ratio (m/V) and mole-volume ration (n/V) are some of them.
- Among the different notations used, mole-volume ratio (n/V) is also known as the concentration. It has the units of mol dm^{-3} (moles per cubic decimetre)
- Solutes of known composition need to be prepared for various tasks in day to day life. For this, various apparati are used in the laboratory.
- The components of mixtures are separated in everyday life as well as in industry. Various methods are used for it.
- During sifting, flatting and winnowing, components are separated by using the difference in density of the components. Seiving and filtration are carried out making use of the difference in size of the component particles.
- Components can be separated by vaporization due to the difference in their boiling points.
- The concentration of a solution is used in crystallization and recrystallization where the concentration is made to exceed the saturated concentration.
- Some substances have a higher solubility in one solvent and lower solubility in another.
- In solvent extraction, a solute dissolved in smaller eqantity in one solvent is drawn into another solvent in which it is more soluble. For this, the two solvents must be immiscible
- When separating components by distillation, the mixture is heated. The components, that vaporize at their boiling points get removed from the mixture and are collected at a different place by cooling.
- Depending on the differences of the techniques used and the properties of components, distillation can be divided into three modes-simple distillation, fractional distillation and steam distillation.
- In paper chromatography, a stream of a volatile solvent is passed through a drop of a mixture placed on a special paper. In this, components are separate dfrom one another because of the difference of speed with which they travel through the paper which in turn is caused by the differences in the strength of attraction of the components to the paper (cellulose).

Exercises

01. Explain the meaning of the following terms.

a. Mixture b. Homogeneous mixture

c. Solvent d. Solute

f. Solution g. Solubility

02. Write two properties of a homogeneous mixture or a solution

03. Explain how a solvent can be polar or non- polar

04. Explain the following observations scientifically.

a. Jak latex (koholle) cannot be washed away with water.

b. Styrofoam (regifoam) can be dissolved in petrol.

c. The moment the cap of a bottle of soda water is removed, gas bubbles evolve.

05. Stones mixed with rice are removed by sifting. This is a mechanical method. Which physical property of the components rice and stones is helpful in this separation?

06. Write a similarity and a difference between vaporization and distillation used to separate components in mixtures.

07. Calculate the concentration of the solutions given in the following table.

Solute	Molar mass (g mol^{-1})	Mass dissloved (g)	Amount of moles/ mol	Final volume	Concentration of the of the solution (mol dm^{-3})
NaOH	40	10	$\frac{10}{40} = 0.25$	200 cm^3	$\frac{0.25}{200} \times 1000 = 1.25$
$CaCl_2$	11	27.75	$\frac{27.75}{111} =$ 0.25	500 cm^3	
Na_2CO_3	106	53	$\frac{53}{106} = 0.5$	2 dm^3	
HCl	36.5	36.5	$\frac{36.5}{36.5} = 1.0$	0.5 dm^3	

08. What is the mass of magnesium chloride ($MgCl_2$) required to prepare 500 cm^3 of a 0.5 $moldm^{-3}$ magnesium chloride solution.
(Mg= 24, Cl = 35.5)

09. Select mixture/ mixtures that the components can be seperated by crystallization
a) Mixture of salt water
b) Mixture of ethanol andwater
c) Mixture of acetic acid and water
d) Mixture of copper sulphate and water

10. Several salts are precipitated in the tanks during the production of salt. Arrange the precipitated salts $CaCO_3$, $CaSO_4$, NaCl and $MgCl_2$ according to the desending order of their solubility.

11. What are the mixture/mixtures that dissolve in the atmospheric water vapour out of the following? (mixtures with deliquescent quality)
$CaCO_3$, $CaSO_4$, NaCl, $MgCl_2$

12. You are given a saturated solution of a salt. What could you do to dissolve some more salt in that solution?

13. Iodine is not soluble in water. Name two solvents that more Iodine be dissolved?

14. Name two instances that solvent extraction is used.

15. What are the qualities of existing and the second solvents when the mixture is seperated from an existing solvent in to a another solvent?

16. What physical qualities of the components are used when they are seperated by using distillation?

17. State one similarity and one difference between simple and Fractional distillation

18. When setting the Liebig condensor for distillation. It is fixed with a slant and the vapour is inserted through the top end of the condensor. The water is inserted from the bottom. What is the improtance of.
I. Inserting vapour from the top
II. Inserting water from the bottom

19. Name some essential oils produced by vapour distillation in Sri Lanka.

20. What is the technique you can use to find out the component of a toffee in the market

Glossary

Mixtures	-	මිශ්‍රණ	-	கலவைகள்
Homogeneous	-	සමජාතීය	-	ஏகவினமான
Heterogeneous	-	විෂමජාතීය	-	பல்வினமான
Components	-	සංඝටක	-	பதார்த்தங்கள்
Solution	-	ද්‍රාවණය	-	கரைசல்
Solvent	-	ද්‍රාවකය	-	கரைப்பான்
Solute	-	ද්‍රාව්‍ය	-	கரையம்
Solubility	-	ද්‍රාව්‍යතාව	-	கரைதிறன்
Organic Solvents	-	කාබනික ද්‍රාවක	-	சேதன கரைப்பான்
Inorganic Solvents	-	අකාබනික ද්‍රාවක	-	அசேதன கரைப்பான்
Concentration	-	සාන්ද්‍රණය	-	செறிவு
Distillate	-	ආස්‍රැතය	-	ஆவி
Crystallization	-	ස්ඵටිකීකරණය	-	பளிங்காக்கல்
Recrystallization	-	පුනස්ඵටිකීකරණය	-	மீளப்பளிங்காக்கல்
Precipitation	-	අවක්ෂේපවීම	-	வீழ்படிவு
Solvent Extraction	-	ද්‍රාවක නිස්සාරණය	-	கரைப்பான் பிரித்தெடுப்பு
Distillation	-	සරල ආසවනය	-	காய்ச்சி வடிப்பு
Fractional Distillation	-	භාගික ආසවනය	-	பகுதிபடக் காய்ச்சி வடிப்பு
Steam Distillation	-	හුමාල ආසවනය	-	கொதி நீராவிக் காய்ச்சி வடிப்பு
Chromatography	-	වර්ණලේඛ ශිල්පය	-	நிறப்பகுப்பியல் முறை