EXPERIMENTAL TECHNIQUES

BASIC CONCEPTS

- The liquid that passes through the filter paper is called Filtrate.
- A technique is used to separate a liquid by boiling the liquid and condensing the vapour is called **Distillation**.

  The **distillate** is the product obtained from condensation during distillation.
- A solid that remains on the filter paper after filtration or solid that remains in the distillation flask after distillation is called **Residue** .
- A technique for separating a mixture of liquids with different boiling points is called **Fractional distillation**. In fractional distillation, the distillation apparatus is fitted with a fractionating column.
- A single substance that is not mixed with other substances is called **pure substance**.
- A technique is used to separate the solutes by adding a solvent in a mixture is called **Chromatography**.The **chromatogram** is the chromatography paper with the separated components.
- The R_f value is the ratio between the distance travelled by the substance and the distance travelled by the solvent .

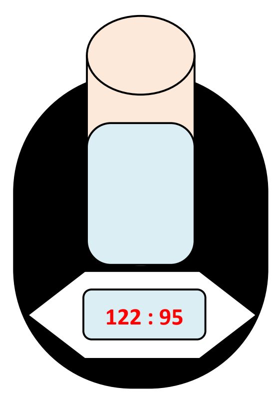
1.1 EXPERIMENTAL DESIGN:

1. A **stopwatch** and a **stopclock** are used to measure time. the **S.I.**units for time is the **second**(**s**).

2. A **thermometer is** used to measure temperature. The **S.I.** unit for temperature is the **Kelvin** (**K**). the other unit for temperature is the **degree Celsius**(^oC).

3. A **beam balance** and an **electronic balance** are used to measure mass. The **S. I.** unit for mass is the **Kilogram** (**kg**).

STOPWATCH



ELETRONIC BALANCE

4. The **S.I.** unit for volume is the **cubic meter** (m^3).The **cubic centimeter** (cm^3), **the liter** (*l*) and the **milliliter** (*ml*) are also used .

$$1\ m^3 = 1000\ l$$

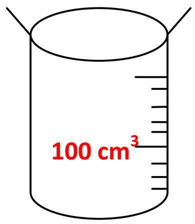
$$1000\ cm^3 = 1\ dm^3 = 1\ l$$

Apparatus for measuring volume

Beaker

Measures approximate

Volume,e.g.- 100 cm³

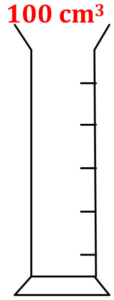


Measuring cylinder

Measures volume to the nearest cm³,

e.g.- 54 cm³

100 cm³



Burette

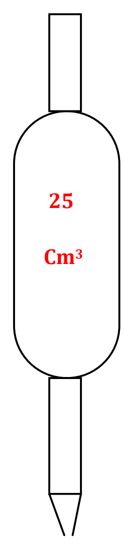
Measures the volume of liquid to the nearest ± 0.1 cm³

The burette reading is accurate to ± 0.05 cm³ e.g. 26.70 cm³ Or 26.75 cm³ .

50 cm³

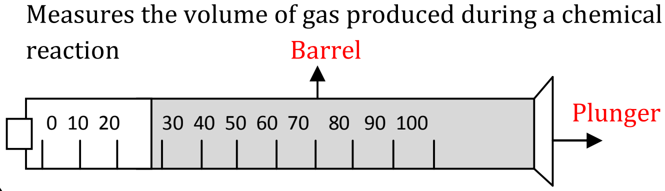
Pipette

Measures fixed volume very accurately, e.g. 100 cm³, 200cm³ and 25.0cm³



Gas syringe

Measures the volume of gas produced during a chemical reaction



TIP FOR STUDENTS:
✓ When you are asked to draw apparatus for gas measurement, make sure it is air – tight, i.e. no space for gas to escape. ✓ For example, you don't draw gas syringe with the plunger much smaller than the syringe barrel.
✓ A burette or a pipette is far more accurate than a measuring cylinder as for accuracy point of view, when you are asked to select an apparatus to measure the volume.

COMMON ERROR	ACTUAL FACT
✗ The accuracy of burette is ± 0.01.	✓ The accuracy of burette is ± 0.05. Thus the butrette reading can be 15.60 cm^3 or 15.65 cm^3 but not 15.64 cm^3.

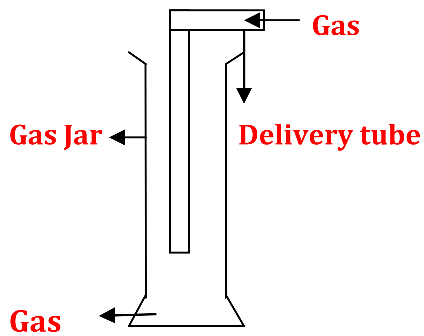
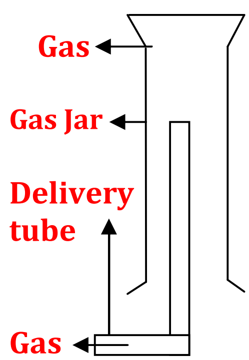
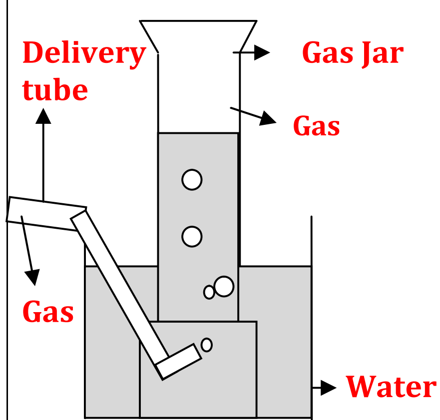
1.2 COLLECTION OF GASES:

1. The method used for collecting a gas depends on two factors.

a) Solubility of the gas in water

b) Density of the gas compared to air

2 .The method and the apparatus set –up for collecting gases are shown below .

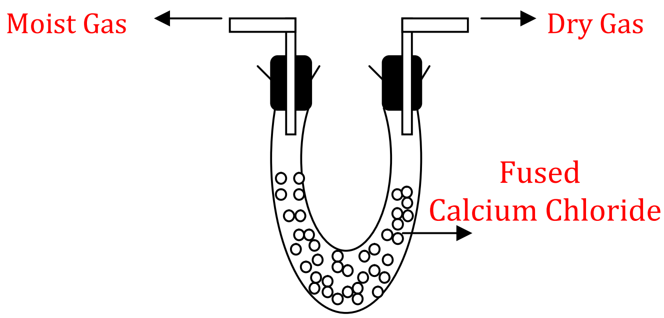
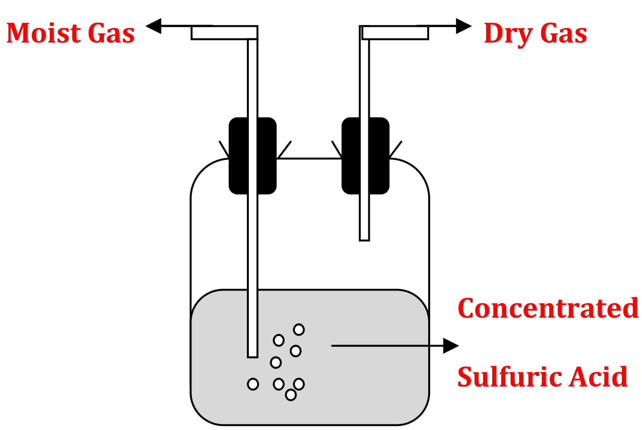
METHOD	APPARATUS SET – UP	FUNCTION
Downward delivery (upward displacement of air)		This method is used to collect gases that are soluble in water and heavier (denser) than air . Example : Chlorine and hydrogen chloride
Upward delivery (downward disolacement of air)		This method is used to collect gases that are soluble in water and lighter (less dense) than air . Example : Ammonia
Displacement of water		This method is used only if the gas is insoluble or slightly soluble in water . Example : Hydrogen, oxygen and carbon dioxide

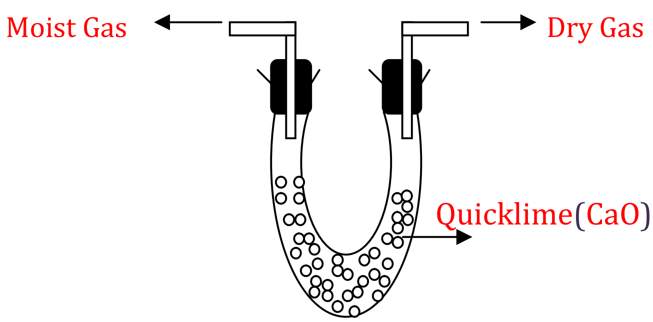
3. **Drying agents for gases**

a) There are three types of gases: acidic gases, neutral gases and alkaline gases .

b) We can dry a gas by passing the gas through a drying agent . The choice of the drying agent will depend on whether the gas is acidic, neutral or alkaline .

c) The table on the next page shows the apparatus set – up and the drying agents used to dry gases.

DRYING AGENT	**FUNCTION**
FUSED CALCIUM CHLORIDE (i.e.calcium chloride that has been heated to remove all traces of water) . 	➢ For drying most gases (except ammonia, because ammonia reacts with calcium chloride).
CONCENTRATED SULFURIC ACID 	➢ For drying gases such as hydrogen and oxygen. ➢ For drying acidic gases such as chlorine, Hydrogen chloride and sulfur dioxide. ➢ Cannot be used for drying alkaline gases such as ammonia because it reacts with ammonia.

TIP FOR STUDENTS: 1. The tube where the gas flows in should be immersed into the acid . 2. The tube where the gas flows out should not be immersed.	
Quicklime (calcium oxide)  	➢ For drying alkaline gases, such as ammonia. ➢ Cannot be used for drying acidic gases.

1.3 CRITERIA OF PURITY:

1. A pure solid has a sharp and constant (fixed) melting point and a pure liquid has a sharp and constant (fixed) boiling point .

2. Effect of impurities on melting point and boiling point:

a) Impurities lower the melting point and raise the boiling point of a substance.

b) Impurities also cause melting and boiling to take place over a range of temperatures.

The greater the amount of impurities, the lower the melting point and the higher the boiling point.

3. Hence, melting and boiling points can be used to

a) Identify a substance,

b) Determine whether a substance is pure.

EXAMPLE:

a) The melting point of naphthalene is 80^0 C . Pure naphthalene will melt completely at 80^0 C but impure naphthalene will melt over a range of temperature below 80^0 C .

b) The boiling point of pure water is 100^0 C. Impure water. Such as seawater, will boil over a range of temperatures above 100^0 C .

4. **Measurement of purity in substances used in everyday life**

It is important to determine the purity of substances such as foodstuffs and drugs.

Any impurities in medicine and foodstuffs could harm people.

COMMON ERROR	ACTUAL FACT
✗ **Lemon juice is a pure substance.**	✓ **Lemon juice is not a pure substance. It is a mixture of two different substances such as citric acid and water.**

ANALYSE:

- ✓ **Describe methods of separation and purification including the use of a suitable solvent, filtration and crystallisation or evaporation, sublimation, distillation and fractional distillation, use of a separating funnel and paper chromatography.**
- ✓ **Suggest suitable methods of separation and purification given information about the types of mixtures: solid – solid, solid- liquid and liquid- liquid (miscible and immiscible) mixtures.**
- ✓ **Interpret the chromatograms.**

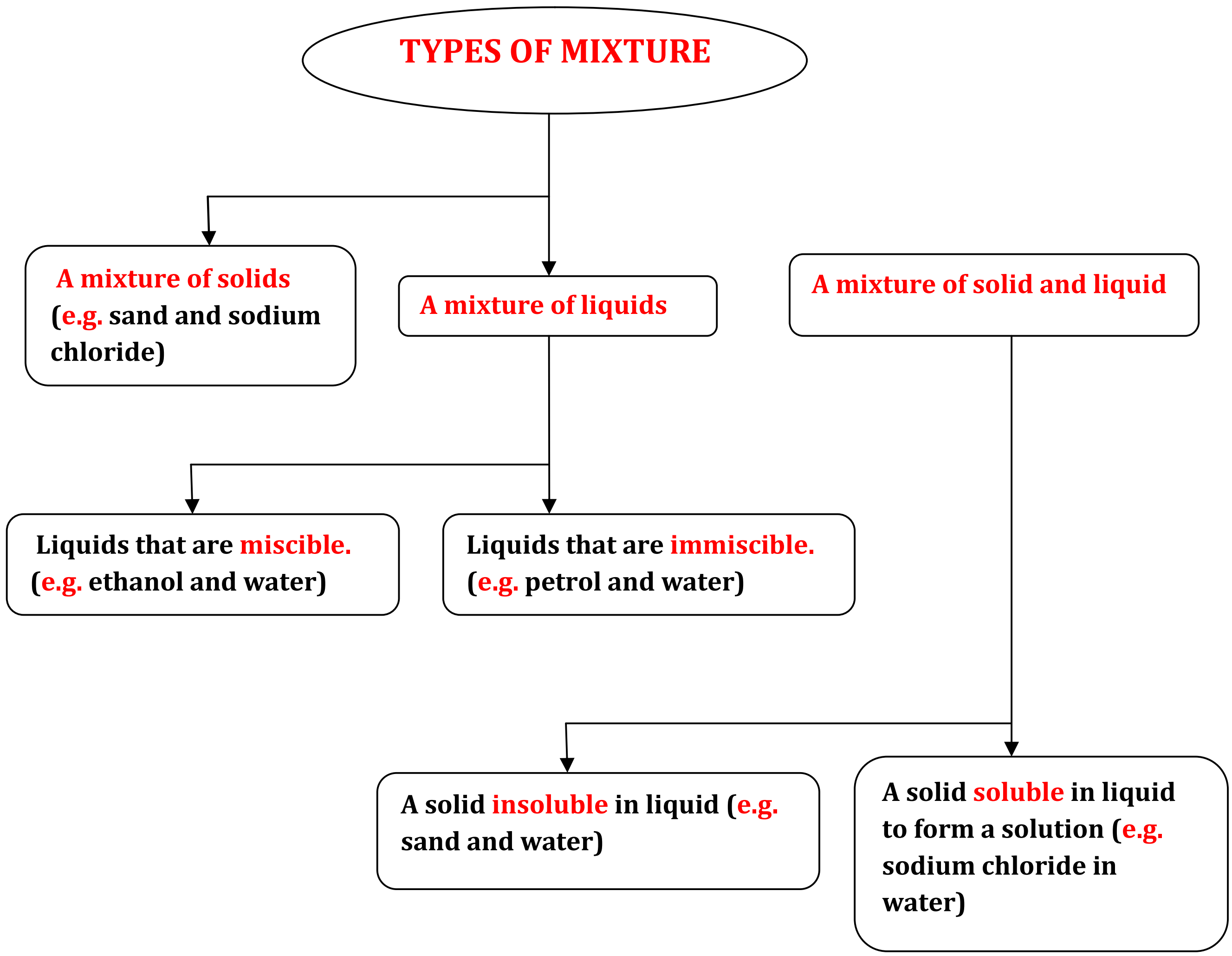
1.4 METHODS OF SEPARATION AND PURIFICATION:

1. There are three types of mixtures involving solids and liquids:

a) Solid – solid

b) Solid- liquid

c) Liquid- liquid



2. Separating a solid from solid – liquid mixture:

a) **Filtration: separating an insoluble solid from a liquid .**

This method is used to separate an insoluble solid from a liquid.

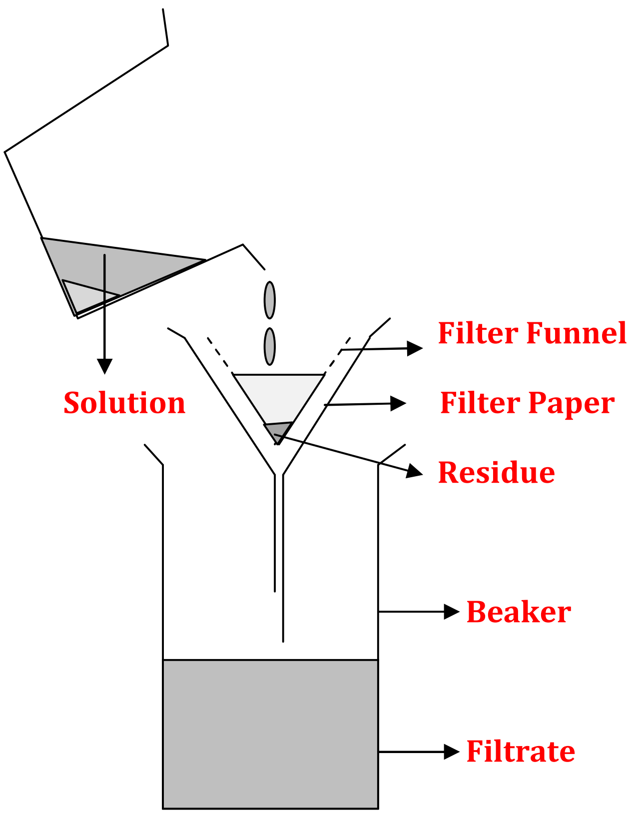
EXAMPLE:

To separate solid calcium carbonate from the reaction mixture

- When sodium carbonate solution is added to calcium chloride solution, calcium carbonate is precipitated.

  Sodium carbonate + calcium chloride $\longrightarrow$ calcium carbonate + sodium chloride

- The diagram below show how solid calcium carbonate is separated from the reaction mixture .



FILTRATION

STEP 1 : The filter paper is moistened with distilled water and placed inside the filter funnel .

↓

STEP 2 : The mixture of calcium carbonate ansodium chloride solution is then poured into the

↓

STEP 3 : The residue (calcium carbonate) remains on the filter paper . The filtrate is collected

↓

STEP 4 : The residue is washed with distilled water and dried with filter paper . Pure calcium carbonate is obtained .

b) **Crystallisation and evaporation to dryness: separating a soluble solid from a solution**

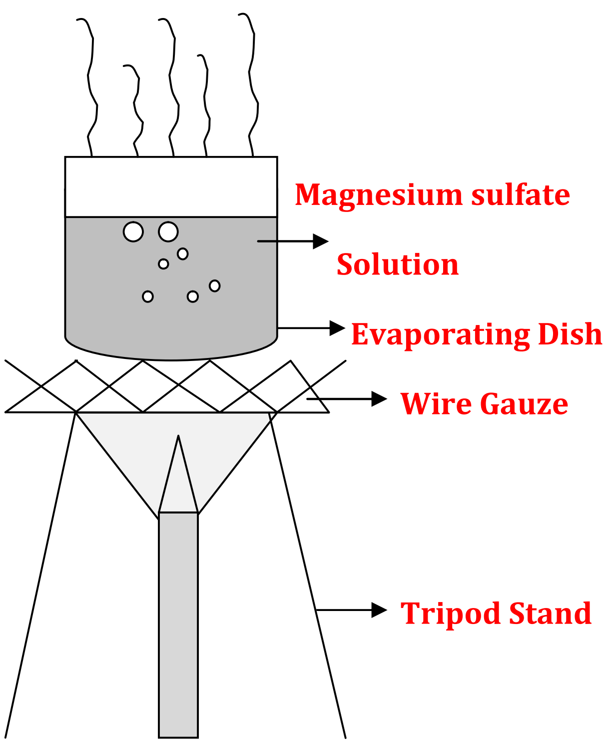
When a solid dissolves in a liquid, a solution is formed. The solid is called the solute, and the liquid is called the solvent. For example, sodium chloride solution consists of the solute sodium chloride and the solvent water.

✓ **CRYSTALLISATION**

This method is suitable for salts that decompose if evaporated to dryness (e.g. potassium nitrate from its aqueous solution and copper(II) sulfate from its aqueous solution).

EXAMPLE :

To separate magnesium sulfate from magnesium sulfate solution.



CRYSTALLISATION

STEP 1: The solution is heated until saturated, that is,at crysataillisation point

STEP 2 : The solution is left to cool. As the solution cools, magnesium sulfate crystal are formed.

STEP 3 : The crystals are filtered out, washed with distilled water and dried.

✓ **EVAPORATION TO DRYNESS:**

This method is suitable only for salts that do not decompose on heating.

EXAMPLE :

To separate sodium chloride from its aqueous solution.

When an aqueous solution of sodium chloride is heated, evaporation occurs. Water will escape from the solution. Finally, only solid sodium chloride is left behind.

c) Simple distillation: separating a liquid from a solution

- ✓ A pure solvent, for example, water, can be separated from a solution by simple distillation.

- ✓ The liquid that distils over is called the distillate. The solid that remains in the distillation flask is called the residue.

EXAMPLE :

To separate water from an aqueous solution of sodium chloride

STEP 1 : In the distillation flask, the solution boils and the steam rises into the condenser.

STEP 2 : In the condenser, the steam condenses to form pure water.

STEP 3 : The pure water, called distilled water, is collected in the breaker.

STEP 4 : The Sodium chloride remains in the distillation flask.

3. Separating a solid from solid-liquid mixture:

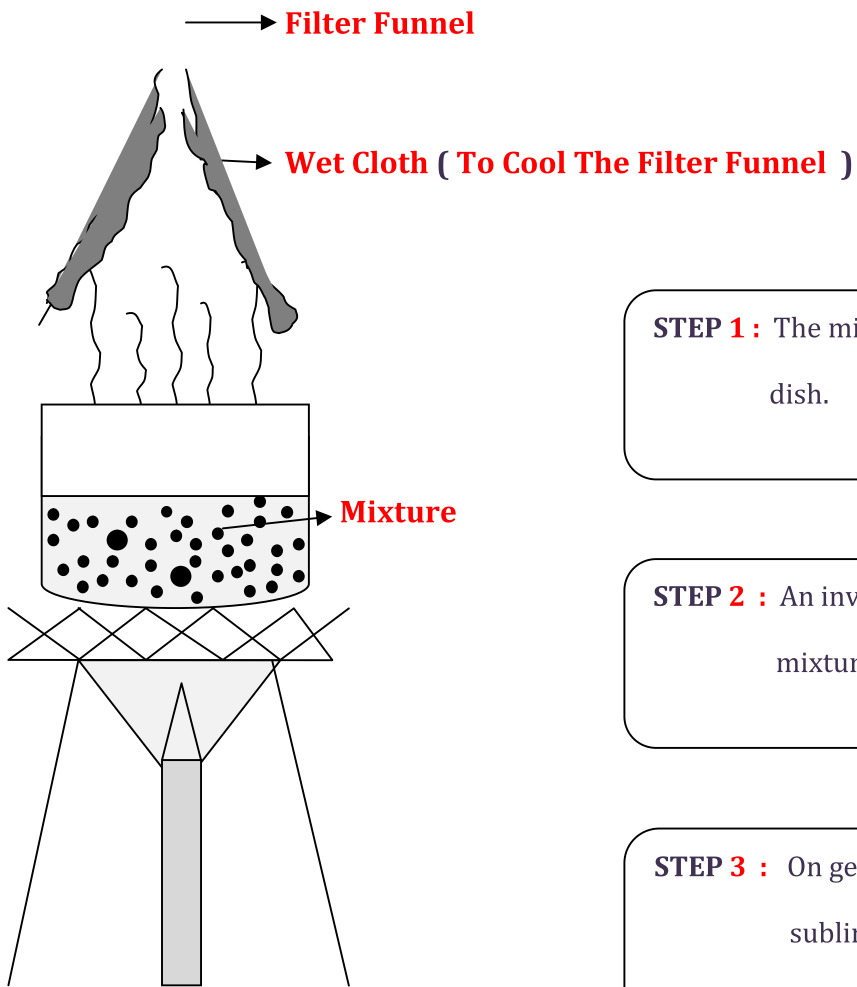
a) **SUBLIMATION**: separating a solid that sublimes on heating

This method is used to separate a solid that sublimes on heating from another substance with a high melting point.

EXAMPLE :

To separate ammonium chloride from a mixture of ammonium and sodium chloride

Ammonium chloride is a solid that sublimes. If a mixture of ammonium chloride and sodium is heated in a breaker, the ammonium chloride changes from solid to vapour directly.



SUBLIMATION

STEP 1 : The mixture is placed in an evaporating dish.

STEP 2 : An inverted filter funnel is placed over the mixture.

STEP 3 : On gentle heating, ammonium chloride sublimes and is deposited on cold filter funnel

This method has limited uses because very few solids will sublime on heating. Among those that will are ammonium salts, anhydrous aluminium chloride (A\CI$_3$) and iodine.

b) **DISSOLVING AND FILTRATION : when only one solid is soluble**

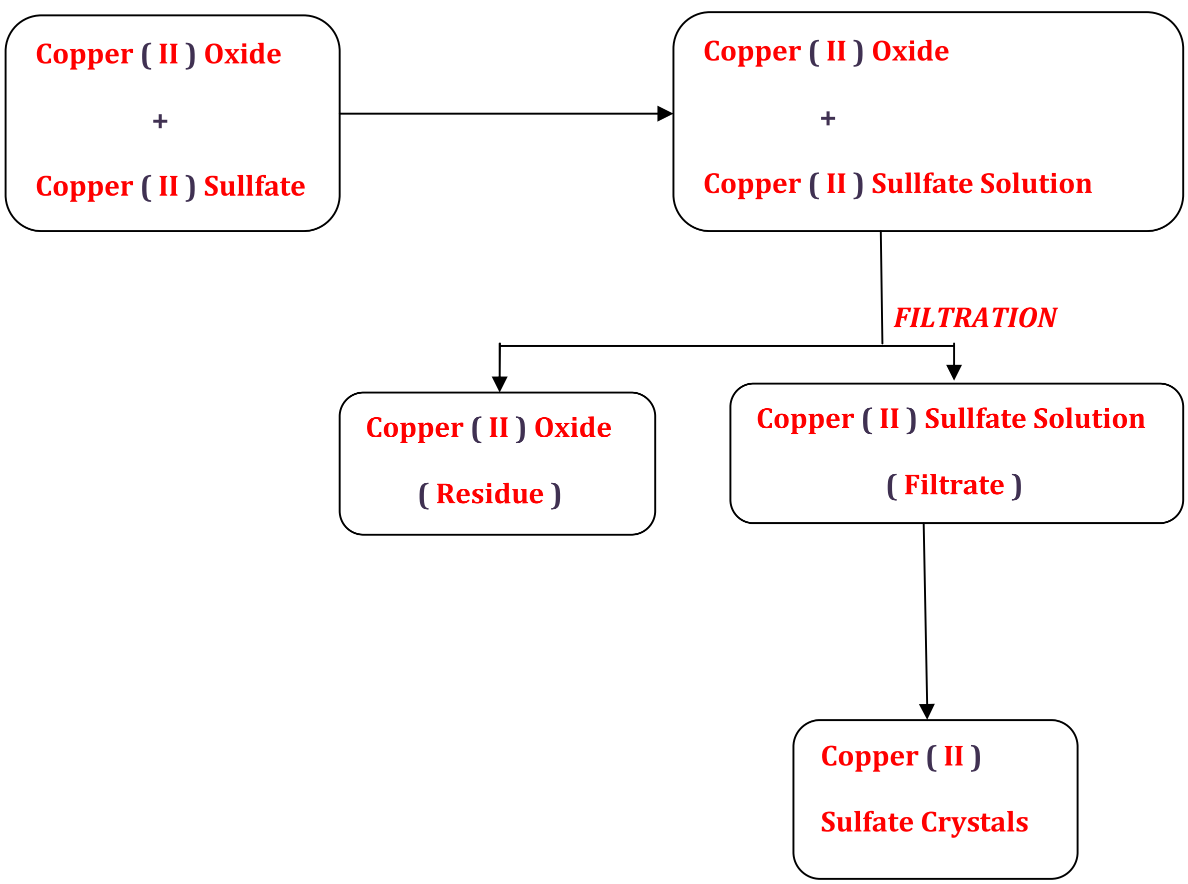
A mixture of two solids can be separated by carefully choosing a solvent (such as water or dilute acids) in which only one of the solids is soluble.

EXAMPLE:

To separate copper(II) sulfate from a mixture of copper(ii)oxide and copper (II) sulfate

- ✓ Copper (II) oxide is insoluble in water , whereas copper (II) sulfate is soluble in water.

- ✓ The flow chart on the next page summarises the steps taken to separate copper (II) sulfate from the mixture.



TIP FOR STUDENTS:

Do not get confused with the terms filtrate, distillate and residue.

- ✓ When a mixture is filtered, the solution that passes through is called the filtrate.
- ✓ Similarly, when a solution is distilled, the liquid that distils over is called the distillate.
- ✓ The solid left on the filter paper is called the residue.
  Similarly, the solid that remains in the distillation flask is also called the residue

4. SEPARATING A LIQUID-LIQUID MIXTURE:

a) **Saparating Funnel**: separating immiscible liquids

Liquids that do not dissolve in each other are described as immiscible. Oil and water are immiscible in each other

EXAMPLE :

To separate petrol and water:

STEP 1 : Pour the mixture of petrol and water into the separating funnel. Wait until two layers are formed Water is denser than petrol. It will form the bottom layer.

↓

STEP 2 : Open the tap. Allow water (the bottom layer) to run into a breaker. Close the tap before the top layer runs out.

↓

STEP 3 : Place a another breaker below the funnel. Open the tap to allow the petrol to run out.

b) **FRACTIONAL DISTILLATION**: **separating miscible liquids**

- ✓ Miscible liquids are liquids that dissolve in each other completely to form a solution. Ethanol and water are miscible in each other

- ✓ Fractional distillation can be used to separate

  - ➢ Oxygen and nitrogen form liquid air,

  - ➢ Useful products (e.g. petrol and kerosene) from crude oil (petroleum) .

EXAMPLE ***:***

To separate ethanol and water

- ✓ Ethanol has a lower boiling point (78^0C) and is distilled over first, followed by water (boiling point 100^0C)

STEP 1: When the mixture is heated, ethanol and water vapour will rise up to th fractionating column.

STEP 2: In the fractionating condensation and vaporization occur. Eventually ethanol vapour reaches the top and distills over at 78^0C

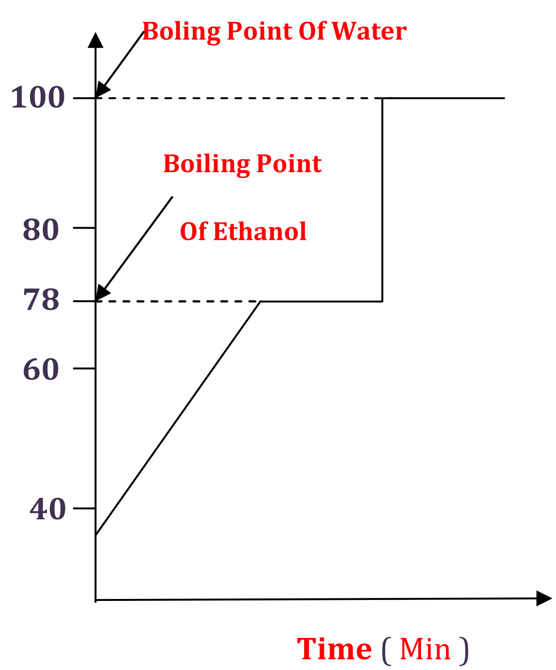
STEP 3 : In the liebig condenser, ethanol vapour condenses to form liquid ethanol

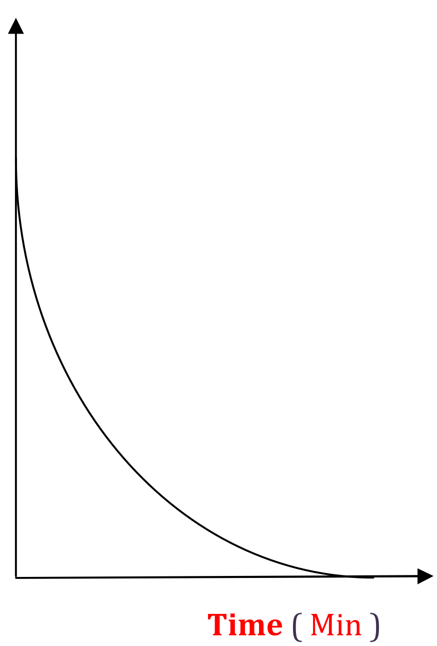
STEP 4 : Ethanol is collected in the conical flask.

STEP 5 : When all the ethanol has distilled over, the temperature rises to 100⁰C, At 100⁰C, water distills over.

✓ Graph (a) is obtained when the thermometer reading against time is plotted. As distillation proceeds, the percentage (or concentration) of ethanol in the distillation flask decreases (graph (b)).

Thermometer reading (⁰C) **Percentage (or connentration) of Ethanol**





a) Fractional distillation of ethanol/water mixture b)Decrease in the percentage of ethanol

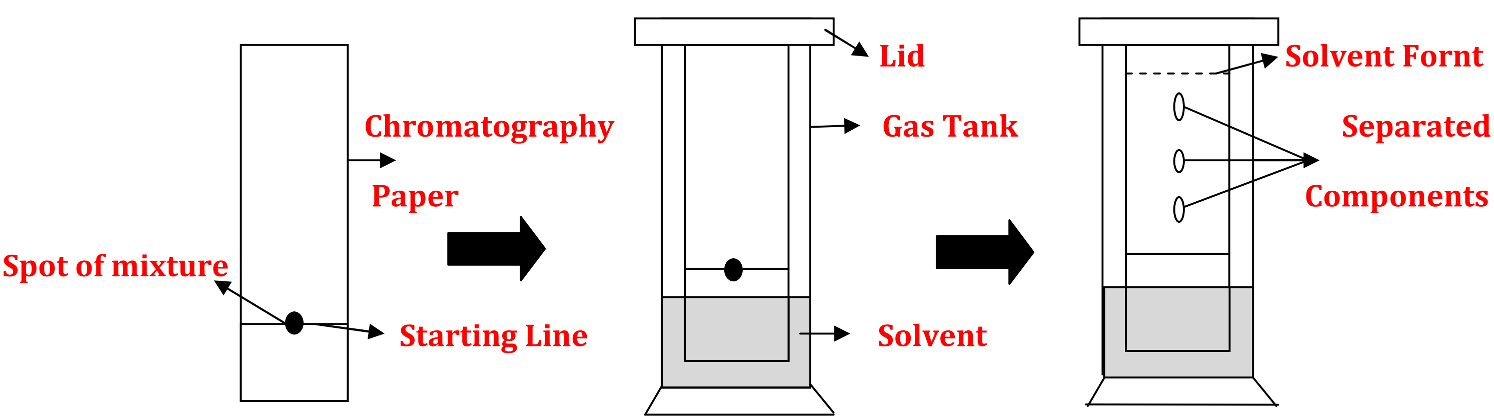
COMMON ERROR	ACTUAL FACT
✘ A mixture of substances with different melting points can be separated by fractional distillation.	✓ Fractional distillation is used to separate a mixture of liquids with different boiling points

5. PAPER CHROMATOGRAPHY:

SEPARATING A MIXTURE OF SOLUTES IN SOLUTION

a) An easy way of determining the number of substances present in a solution is by paper chromatography.

b) The set- up and the procedure for using paper chromatography are described below.



✓ A drop of the mixture is placed on a strip of chromatography paper.

✓ The chromatography paper is suspended inside a glass tank containing a solvent.

✓ The solvent travels up the paper. After some time, coloured spots are seen.

c) The speeds at which different solutes travel up the paper depend on their solubility in the solvent . The most soluble solute will travel fastest up the paper. The least soluble solute will be left behind .

d) As the solutes travel at different speeds up the paper, they become separated.

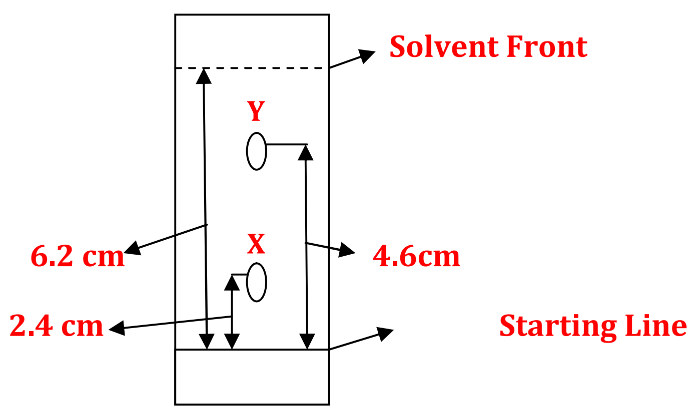
e) The chromatography paper is then taken out of the glass tank, when the solvent evaporates, the solutes are left on the paper as coloured spots .

f) If the spots are colourless, the dried chromatography paper has to be sprayed with special locating agent which shows up the components as coloured spots.

g) Different substances have different R_f values.

$$R_f = \frac{\textit{Distance Travelled By The Substance}}{\textit{Distance Travelled By the Solvent}}$$

h) A typical chromatogram is shown below.



A pure substance should give only one sport on the chromatogram

R_f value of Compound *X* = $\frac{2.4\ cm}{6.2\ cm}$ **= 0.39**

R_f value of Compound *Y* = $\frac{4.6\ cm}{6.2\ cm}$ **= 0.74**

- ✓ **Paper chromatography** is used to

- ➢ Separate the components in a sample,
- ➢ Identify the number of components in a sample,
- ➢ Identify the components present in a sample,
- ➢ Determine whether a sample is pure.

COMMON ERROR	ACTUAL FACT
✗ **In paper chromatography, the starting line should be drawn with ink.**	✓ **The starting line should be drawn with pencil and not with ink. This is because ink contains dyes that will dissolve in the solvent.**

STRUCTURAL QUESTIONS AND ANSWERS:

1. Calcium carbonate reacts with hydrochloric acid to give calcium chloride , water and Carbon dioxide gas.

Duke wants to find out the time it takes for 10 cm^3 of carbon dioxide to evolve when 1.00 g of calcium carbonate is added to excess hydrochloric acid. he conducts an experiment. First he pours 100 cm^3 of 1 mol/dm^3 dilute hydrochloric acid into the conical flask. he removes the stopper and adds 1.00 of calcium carbonate into the conical flask and quickly replaces the stopper and starts the stopwatch.

(a) What apparatus did Duke use to measure the volume of carbon dioxide evolved?
(b) Suggest two significant sources of errors in this experiment and explain how these errors affect the results.

Duke stops the stopwatch when 10cm^3 of carbon dioxide gas has evolved.

(c) What time measurement should Duke record? Explain your answer.

ANSWER:

1. **a) Gas syringe**

   b) Firstly, some carbon dioxide might have escaped before the stopper could be replaced. This would result in the time measured by Duke to be longer than the actual time it takes for 10 cm^3 of carbon dioxide to evolve . Secondly, it is difficult for Duke to replace the stopper and start the stopwatch at the same time. Duke might have needed to start the stopwatch before or after the stopper has been replaced. This would also contribute to the inaccuracy of the time measured.

   c) He should record the time as 9 s . This is because although the stopwatch can read up to a precision of 1/100 s, the error in the time measurement should be taken into account . Hence, the time should be recorded to the nearest second.

2.) Reverse osmosis is one of the techniques commonly used in desalination plants to purify seawater. In this proces, pressurised seawater is forced through a partially permeable membrane by increased pressure.the partially permeable membrane allows fresh water,but not the dissolved salt,to pass through. fresh water can thus be collected on the other side of the membrane.

(a) Name one other technique that is also commonly used in desalination plants to obtain pure water from seawater.

(b) Draw a labeled diagram to show how the technique that is need in (a) can be carried out in the laboratory on a small scale.

(c) Briefly describe the technique that is named in (a).How does it compare with the reverse osmosis technique?

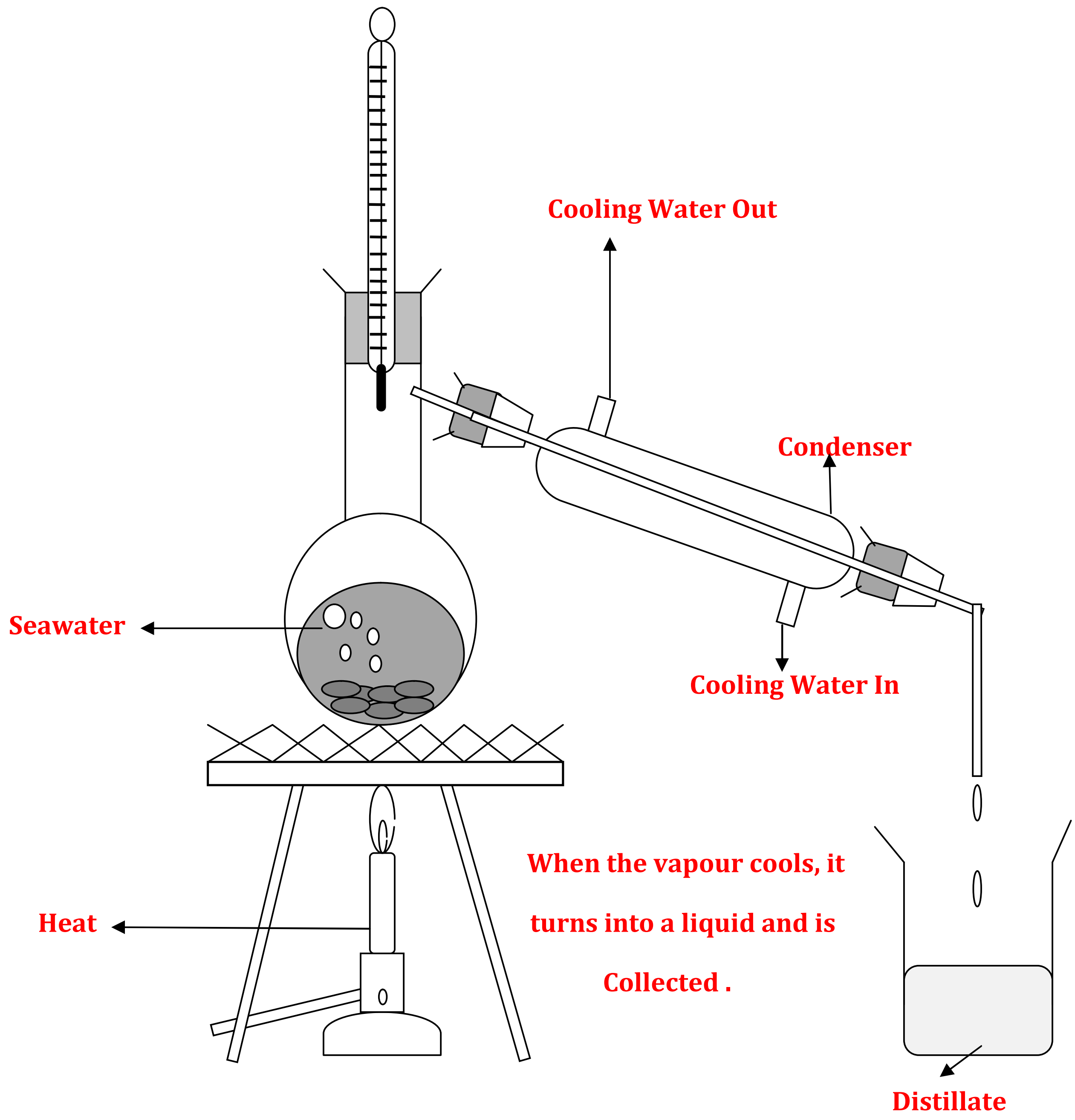
(d) Both the techniques mentioned on the previous page are used to obtain pure water from sea water. Name a technique that is used to obtain salt from seawater.

(e) Draw a labeled diagram to show how the technique that is named in (d) can be carried out in the laboratory on a small scale.

ANSWER:

2. a) other technique that is also commonly used is Distillation.

b)

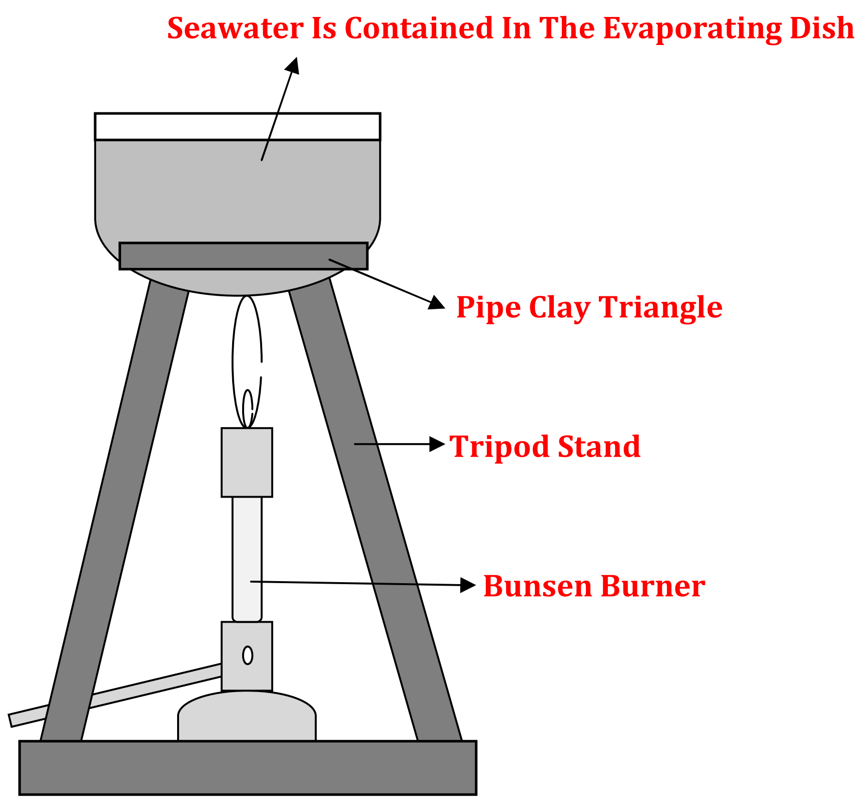


c)In distillation, the seawater is heated so that water boils and subsequently escapes as steam . The steam is then cooled, condensed and collected as the distillate.

Distillation is a much simpler and more straightforward process than reverse osmosis. but it is also more expensive as large amounts of energy are required to boil the water .

d) Evaporation or Crystallisation.

e)



3.)Your are given a homogenous mixture containing liquids X, Y and Z.

	Liquid X	Liquid Y	Liquid Z
Boiling point	82 ^{o}C	138 ^{o}C	115 ^{o}C

(a)(i) Liquids X,Y and Z can be seperated by fracional distillation. draw a diagram to illustrate the separation of this mixture by this method.

label all the apparatus used.

(ii)What is the function of a fractionating column? Briefly explain how it works.

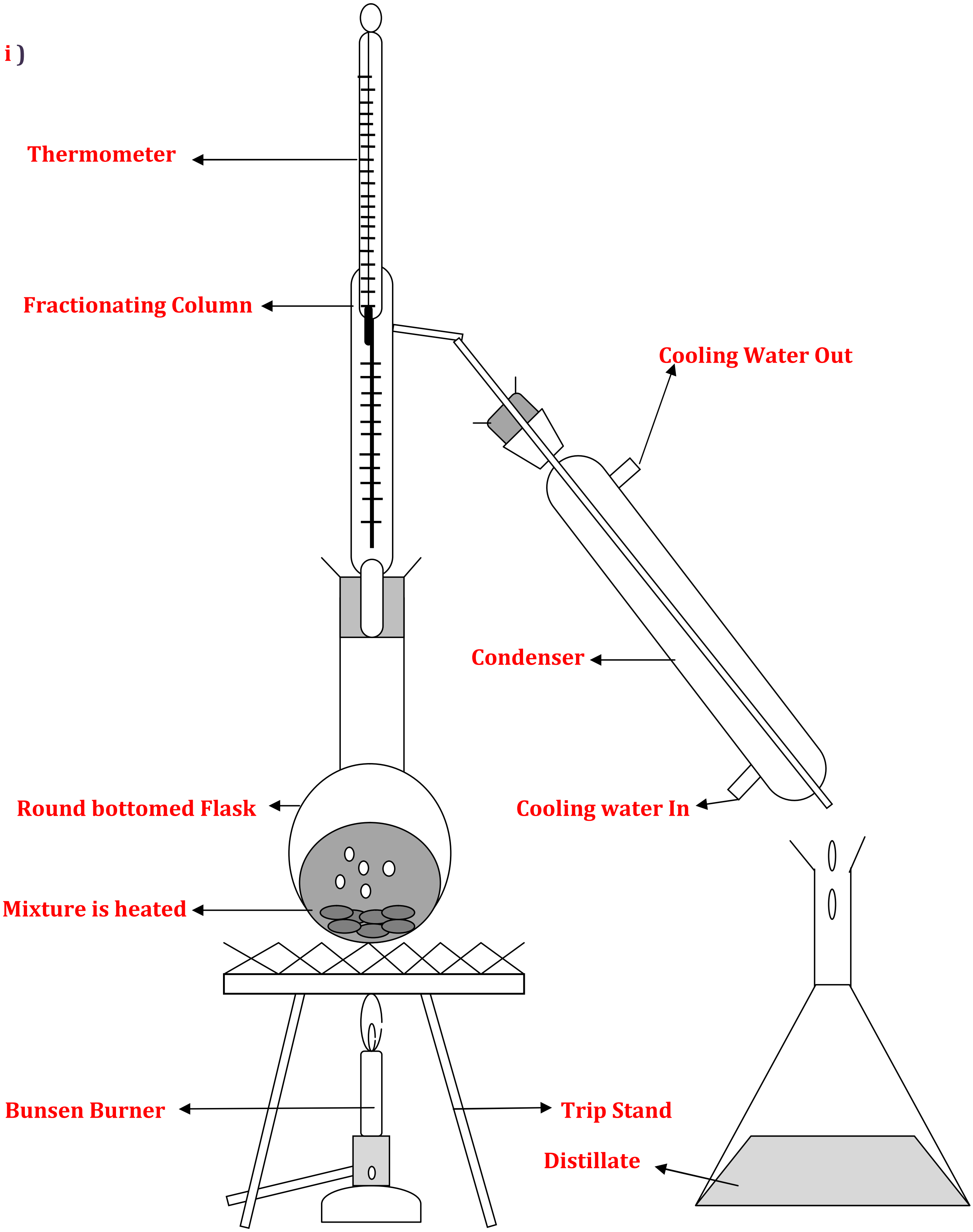
(iii) Predict the order in which the liquids will be collected.

(iv) Plot a graph to show the variation of temperature at the top of a fractionating column with time.

(b) The three liquids dissolve to different extents in water. Name another method which can be used to separate liquids X, Y and Z based on this property.

ANSWER:

3. a) i)

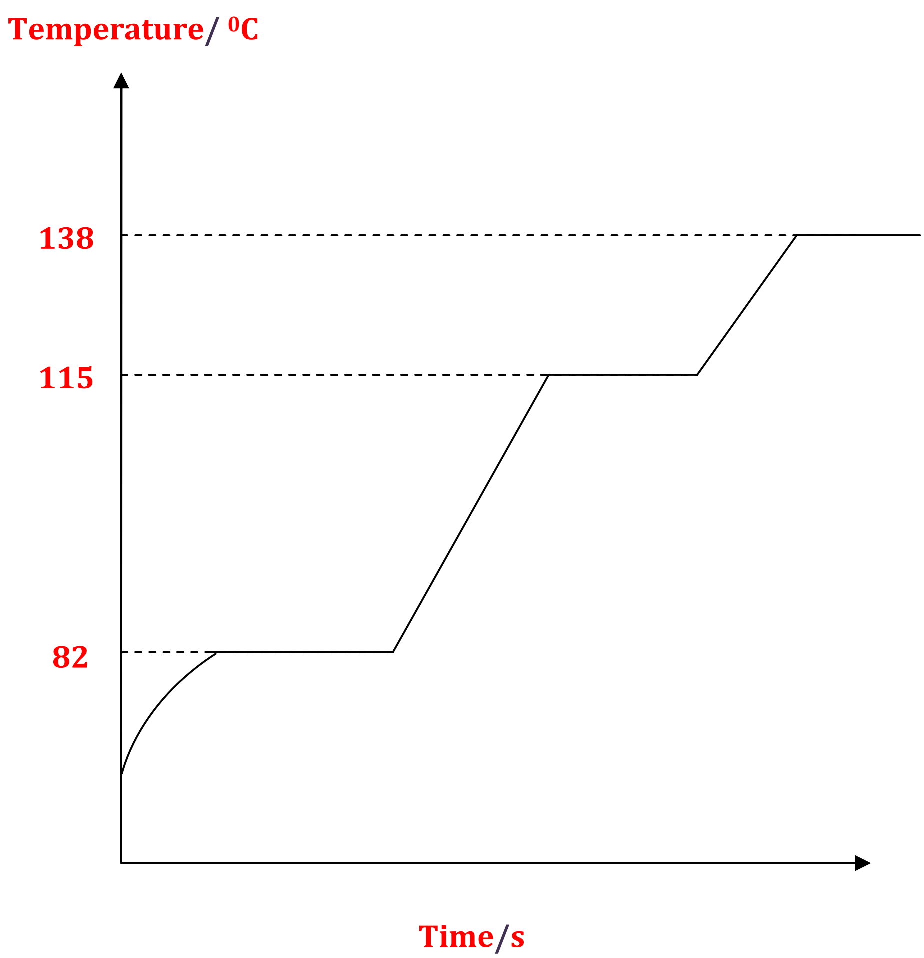


Thermometer
Fractionating Column
Cooling Water Out
Condenser
Round bottomed Flask
Cooling water In
Mixture is heated
Bunsen Burner
Trip Stand
Distillate

ii) **A Fractionating column separated liquids by order of their boiling points . as vapour from the heated mixture moves up the column, it repeatedly condenses and boils . Each time the mixture boils further up the column, the vapour produced will contain a larger proportion of molecules from the liquid with the lowest boiling point . At the top of the fractionating column, pure vapour from the liquid with the lowest boiling point is obtained .**

iii) Liquid *X* will be collected first, followed by *Z*, and finally *Y* .

iv)



b) Chromatography

4.) In nature, most substances are found in mixtures. Before we can make use of these substances, we have to purify them.

(a) Explain why there is a need for substances to be pure specially those that we consume.

(b) (i) A 7.2 g sample of impure salt contains salt and some other solids. Describe clearly how you would use apparatus commonly found in the laboratory to obtain pure salt. Include the name (s) of the purification method(s) that you have used.

(ii) Name one way by which you can determine whether the salt that you had obtained is pure.

(iii) Suppose 4.9g of pure salt was obtained at the end. Calculate the percentage purity of the salt.

(iv) Is purificaton a physical or chemical process? Name two methods of purification other then what you have used in(i)

ANSWER:

4. a) Impurities in substances such as in food and drugs, that we consume can lead to health hazards which promotes poisoning and various diseases.

b)i)Firstly, the sample of impure salt is transferred to a beaker and dissolved in water. The beaker is then heated gently over a Bunsen burner to completely dissolve all the soluble salt .

Next, the hot mixture is poured into a filter paper in a filter funnel to remove

the insoluble impurities . the filtrate is first collected in a clean beaker or flask, and then transferred into an evaporating dish.

the evaporating dish is then placed on a tripod and gently heated. Heating is stopped when almost all the water is evaporated.

the solution is then allowed to cool.

the cooled solution is then poured away to obtain pure salt crystals at the bottom of the evaporating dish .

The pure salt crystals are then dried by pressing them between sheets of filter paper.

The purification methods used are filtration and crystallization.

ii) If the salt is pure, it will melt at a fixed melting point.

iii) Percentage Purity $= \frac{\text{Mass of Pure Salt}}{\text{Mass of Impure Sample}} \times 100\%$

$= \frac{4.9}{7.2} \times 100\%$

$= 68\ \%$ **(correct to 3 s. f.)**

iv) Purification is a physical process. Two other purification methods are distillation and chromatography.

5.) A chemist, Scarlet, tried to synthesize compound A. Compound A is known to have an R_f value of 0.62 with water as a solvent.

(a)(i) Scarlet used chromatography to analyse her product using water as a solvent. She then sprayed a locating agent on her chromatogram, which tuned out as shown in the diagram below.

Why did she spray a locating agent on the chromatogram.

(ii) Was Scarlet successful in obtaining compound A? Was the product she obtained pure or impure? Justify your answer.

(iii) Compound A dissolved in ethanol to a different extent from water. Would the R_f value of A be the same if ethanol had been used as the solvent instead of water? Why or why not?

(b)

(i) Dr. Runy works at a government health agency's laboratory. She received samples of two new food products, Y and Z which are awaiting regulatory approval for sale. The chromatograms of Y and Z as well as those of permitted food dyes and flavourings,are shown below.

Should two products be approved for sale? Justify your answer.

(ii) Why is it important that only permitted food dyes and flavourings are used in food?

ANSWER:

5. a) i) She sprayed a locating agent, which reacts with colourless substances (compound *A* in her experiment) to produce coloured compounds, to allow her to see the spots on the chromatogram .

ii) The large and darker spot on the chromatogram has an R_f value of 0.62, corresponding to compound A . However, there is another lighter spot with an R_f value of 0.50 on the chromatogram, indicating the presence of a substance.

In other words, Scarlet **had obtained an impure substance.**

iii) No. Since A dissolves to a different extent in ethanol, the speed at which it moves up the chromatogram would also differ ethanol was used instead of water.Consequently, a different R_f value would be obtained.

b) i)Product *Y* can be approved, but not product *Z* . From the chromatogram, *Y* contains only permitted dye *A* and flavouring *C* . On the other hand, while *Z* contains permitted flavouring *D*, it also contains at least one other unapproved dye or flavouring .

ii) Permitted food dyes and flavouring have been tested by relevant health authorities to ensure that they are safe for consumption .

6.) Miss Jia is demonstrating the use of a separating funnel to her students.

(a) After pouring in a mixture of oil and water, Miss Jia allowed the mixture to stand for a few minutes before continued her demonstration.

Explain why she did so.

(b) What is the function of the tap at the bottom of the separating funnel?

(c)(i) Explain why Miss Jia did not choose to use a mixture of ethanol to use a mixture of ethanol and water for her demonstration.

(ii) Name a technique that could be used to separate a mixture of ethanol and water.

ANSWER:

6. a) **This is to give the mixture of oil and water sometime to separate into different layers.**

b) **The tap at the bottom of the separating funnel allows the two different liquids to be drained into other containers after being separated .**

c)i) **Oil and water are not soluble in each other . On the other hand, ethanol and water are completely miscible and form a solution . Thus, a mixture of ethanol and water will not separate into two layers even after standing for a long time .**

ii) **Distillation**

7.a) Nasri was asked by his teacher to identify an unknown salt A.

(i) When Nasri added ammonia solution to an aqueous solution of A, there was no reaction. Which cation(s) could be present in A.

(ii) Next, he mixed some aqueous sodium hydroxide with an aqueous solution of A. A colourless, pungent gas, which turned damp red litmus paper blu, was produced on warming. Identify the gas,and hence the cation in A.

(iii) Nasri then added dilute nitric acid to a solution of the salt, followed by some barium nitrate solution. He observed that some whit eprecipitate was formed. Identify the anion present in A.

(iv) Name and give the chemical formulae of salt A.

(b) Nasri's classmate, Yao Xi, was asked to identify another salt B.

(i) When Yao Xi added aqueous sodium hydroxide to an aqueous solution of B, she observed the formation of a blue precipitate. The precipitate was not soluble in excess sodium hydroxide. Identify the cation present in B.

(ii) What should Yao Xi expect to observe is she mixed ammonia solution with an aqueous solution of B?

(iii) Yao Xi then added dilute nitric acid to a solution of B. When silver nitrate solution was then added, a white precipitate was formed. Identify the anion present in B.

(iv) Name and give the chemical formula of salt B.

ANSWER:

7.(a)(i) Ca^{2+}or NH_4^-

(ii) Ammonia gas was produced. NH_4^+ is present.

(iii) SO_4^{2-} is present

(iv) Salt A is ammonium sulfate, $(NH_4)_2 SO_4$

(b)(i) Cu^{2+} is present

(ii) She would observe the formation of a blue precipitate. The precipitate dissolvs in excess ammonia to give a dark blue soluion.

(iii) $Cl^-$is present

(iv) Salt B is copper (II) chloride, $CuCl_2$

8.Describe what you would expect to observe for the following reactions:

(a) Ammonia solution is added to an aluminium chloride solution.

(b) A solution of zinc sulfate is reacted with some aqueous sodium hydroxide.

(c)A solution of sodium nitrate is warmed together with some aqueous sodium hydroxide and a piece of aluminium foil.

(d) Lead (II) nitrate solution s added to an aqueous solution of potassium iodide that has been acidified with dilute nitric acid.

(e) Ammonia solution is added to an aqueous solution of iron(III)chloride.

ANSWER:

a) A white precipitate (aluminium hydroxide) , insoluble in excess ammonia Solution, is formed.

b) A white precipitate (zinc hydroxide) is formed which dissolves in excess sodium hydroxide to give a colourless solution.

c) A colourless, pungent gas (ammonia gas), which turns damp red litmus paper blue. is produced .

d) A yellow precipitate (lead (II) iodide) is formed .

e) A reddish – brown precipitate (lead (III) hydroxide) , insoluble in excess ammonia solution, is formed

9.)You are given an unknown solution R which may contain NH_4^+, NO_3^- or both ions. Describe how you will carry out an experiment to find out whether R contains NH_4^+,NO_3^- or both ions.Your answer should include the reagents you will use and the observations you will see if the ions are present.

ANSWER:

9.) a) To a small amount of solution *R* in a test tube, add aqueous sodium hydroxide.

b)Warm the mixture and test any gas evolved with moist red litmus paper. If NH_4^+ is present in solution *R*, ammonia gas, which will turn moist red litmus paper blue, will be evolved .

c) If gas is evolved, continue heating the mixture until no more ammonia gas is detected.

d) Add a few pieces of aluminium foil to the mixture (containing solution *R* and aqueous sodium hydroxide).

e) Warm the mixture gently and test any gas evolved with a moist red litmus paper. If NO_3^- is present in solution *R*, ammonia gas which will turn moist red litmus paper blue, will be evolved .

10.) A solution Z was made by dissolving two salts, X and Y in water. When excess aqueous sodium hydroxide was added to a test tube containing a sample of this solution, a dirty green precipitate was obtained. A gas with a strong smell which turned damp red litmus paper blue was also produced. After being exposed to air for some time, the dirty green precipitate slowly turned brown. Excess dilute nitric acid was added to a second test tube containing another sample of soluion Z. A colourless, odourless gas which gave a white precipitate with limewater was produced. When silver nitrate solution was added to this test tube, a white precipitate was obtained.

(a) Why did the dirty green precipitate that was formed in the first test tube turn brown over time?

(b) Identify the ions that are present in solution Z. Justify your answer.

(c) Predict what would be observed if excess ammonia solution was added to a sample of solution Z.

(d) No reaction was observed when ammonia solution was added to an aqueous solution of salt Y. Give the names and chemical formulae of salts X and Y. Justify your answer.

ANSWER:

10.) a) Iron (II) was oxidised to iron (III) by oxygen in air .

b) The ions are : Fe^{2+}, Fe^{2+}, CO_3^{2-} and Cl^- .

Addition of sodium hydroxide led to the formation of a dirty – green precipitate which turned brown over time . This is evidence of the presence of Fe^{2+} ions .

In the same test tube, the production of the strong smelling alkaline ammonia gas is evidence of the presence of Fe^{2+} cations .

In the second tube, carbon dioxide gas, which gave a white precipitate with limewater, was produced with the addition of an acid, Suggesting the presence of CO_3^{2-} anions .

Finally, also in the second tube, the formation of a white precipitate in the acidified solution, of *Z* with the addition of silver nitrate suggests the presence of Cl^- ions .

c) A dirty – green precipitate would be formed. It would remain insoluble in excess ammonia solution, and would solely turn brown on standing in air .

d) Salt X is iron (II) chloride, $FeCl_2$; salt *Y* is ammonium carbonate, $(NH_4)_2CO_3$.

Based on the four ions identified, the possible combinations are : either $FeCl_2$ and $(NH_4)_2CO_3$, or NH_4Cl and Fe_2CO_3 . However, Fe_2CO_3 is an insoluble salt, so the two salts must be $FeCl_2$ and $(NH_4)_2CO_3$. Since there was no reaction when ammonia solution was added to an aqueous solution of salt *Y*, *Y* must be the ammonium salt and as such, *X* must be the other .

2. Scientists use a technique called gel electrophoresis to separate DNA fragments according to their sizes. In this technique, an electric field is used to move the DNA fragments. The gel formed a porous lattice, and the DNA fragments must slip through the h'holes' in this lattice in order to move.

(a)The diagram shows a schematic representation of a gel at the end of the experiment. The DNA fragments were placed in the 'well' at the start of the experiment. Given that DNA fragments are negatively charged, should the poles at the top and the bottom be positive or negative?

(c) The DNA markers are standards that allow scientists to estimate the sizes of the DNA fragments. The sizes of the DNA fragments are measured kb, which stands for kilobase pairs. Suggest why fragments with smaller sizes are found at the bottom of the gel.

(d) For the gel in the diagram, estimate the sizes of the DNA fragments present in the sample.

(e) Which separation technique is gel electrophoresis similar to?

ANSWER:

2.(a) The pole at the bottom should be positive, while pole at the top should be negative.

(b) The DNA fragments must slip through the holes in the lattice as they move down the gel.It will be simpler for smaller fragments to go through these holes, and hence,these travel further than the larger fragments.

(c) The fragments are approximately 20 kb, 3.8 kb and 1 kb respectively.

(d) Chromatography.

SUMMMARY AND KEY POINTS

1.) The liquid that passes through the filter paper is called Filtrate.

2.) A technique which is used to separate a liquid by boiling the liquid and condensing the vapour is called Distillation.

The distillate is the product obtained from condensation during distillation.

3.) A solid that remains on the filter paper after filtration or solid that remains in the distillation flask after distillation is called Residue.

4.) A technique for separating a mixture of liquids with different boiling points is called Fractional distillation.

5.) A single substance that is not mixed with other substances is called pure substance.

6.) A technique is used to separate the solutes by adding a solvent in a mixture is called

Chromatography. The chromatogram is the chromatography paper with the separated components.

7.) The R_f value is the ratio between the distance travelled by the substance and the distance travelled by the solvent .

8.) A stopwatch and a stopclock are used to measure time.

9.) A thermometer is used to measure temperature.

10.) A beam balance and an electronic balance are used to measure mass.

11.) The method used for collecting a gas depends on two factors:

a) Solubility of the gas in water

b) Density of the gas compared to air

12.) a) There are three types of gases: acidic gases, neutral gases and alkaline gases .

b) We can dry a gas by passing the gas through a drying agent.

The choice of the drying agent will depend on whether the gas is acidic, neutral or alkaline .

13.) A pure solid has a sharp and constant (fixed) melting point and a pure liquid has a sharp and constant (fixed) boiling point .

14.) Impurities lower the melting point and raise the boiling point of a substance.

15.) melting and boiling points can be used to

a) Identify a substance,

b) Determine whether a substance is pure.

16.) There are three types of mixtures involving solids and liquids:

a) Solid – solid

b) Solid- liquid

c) Liquid- liquid

17.) **Filtration** is a method which is used to separate an insoluble solid from a liquid.

18.) **Crystallisation** method which is suitable for salts that decompose if evaporated to dryness.

19.) **Simple distillation** is a method which is used to separate a liquid from a solution.

The liquid that distils over is called the **distillate**.

The solid that remains in the distillation flask is called the **residue**.

20.) **Sublimation is a method of separating a solid that sublimes on heating.**

This method is used to separate a solid that sublimes on heating from another substance with a high melting point.

21.) **Fractional Distillation** is a method of separating miscible liquids.

22.) **Paper Chromatography** is a technique of separating a mixture of Solutes in solution.

23.) Different substances have different R_f values.

$$R_f = \frac{\textit{Distance Travelled by the Substance}}{\textit{Distance Travelled by the Solvent}}$$

24.) Paper chromatography is used to

a.) Separate the components in a sample,
b.)Identify the number of components in a sample,
c.) Identify the components present in a sample,