Topic 9: **Answers**
Separation of Mixtures

SYLLABUS RELEVANCE & TEXTBOOK CHAPTERS		
O-LEVEL PURE (5072)	✓	Chapters 3 & 4
O-LEVEL SCIENCE (5116)	✓	Chapters 3 & 4
N-LEVEL SCIENCE (5155)	✓	Chapters 3 & 4

Lesson Package & Accompanying Slides Designed by Alex Lee (2009)
Last Modified by Alex Lee (2011)

1. Elements, Compounds & Mixtures

An **element** is defined as a pure substance that ..cannot be split up into two or more simpler substances by chemical processes or by electricity..

Elements **contain only one type of atom**. It could be a metal such as a block of aluminium metal (Al), a macromolecule such as a diamond (C), a simple molecule such as oxygen gas (O_2), or even a monoatomic structure such as a noble gas (He, Ne, Ar).

An **compound** is defined as a pure substance that ..contains two or more elements chemically combined..

Compounds can be broadly categorized into ionic compounds, such as sodium chloride (NaCl), or covalent compounds, such as water (H_2O) or silicon dioxide (SiO_2).

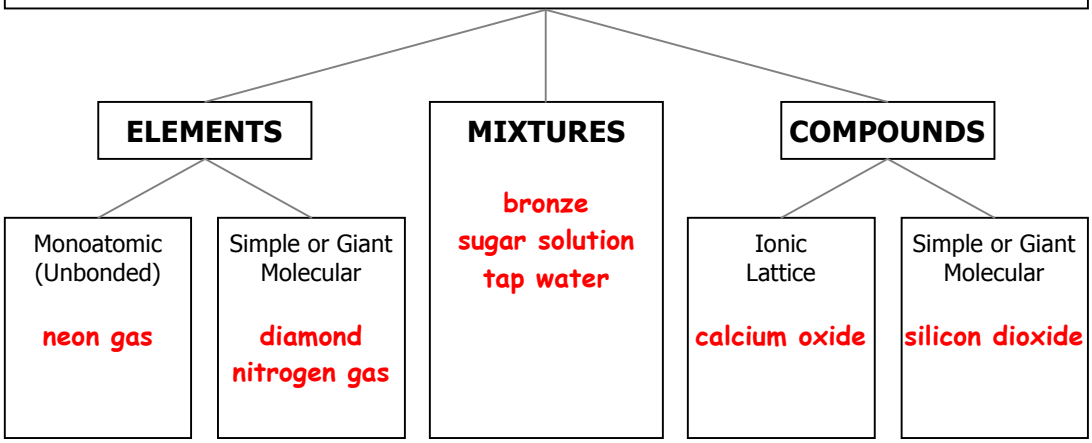
A 'mixture' on the other hand, contains two or more different types of substances which are **NOT chemically bonded together**. Steel, an alloy, is a mixture of two elements – iron (Fe) and carbon (C). On the other hand, salt water, is a mixture of two compounds – water (H_2O) and salt (NaCl). It does not matter whether the substances are elements or compounds, as long as they are not chemically bound to each other.

(a) In the table below, indicate '**yes**', '**no**' or '**maybe**'.

	Compounds	Mixtures
Are the components chemically bonded together?	Yes	No
Is there a fixed ratio of components?	Yes	No
Can the substance be separated by physical means?	No	Yes
Can the substance be separated by chemical means?	Yes	Yes
Does the substance have a homogeneous appearance?	Yes	Maybe
Does the substance have a fixed melting and boiling point?	Yes	No
Do the components retain their original properties?	No	Yes
Is there an energy change during formation?	Yes	No

(b) Below shows a list of eight substances. Sort them into the appropriate boxes.

Bronze	Diamond	Nitrogen Gas	Sugar Solution
Calcium Oxide	Neon Gas	Silicon Dioxide	Tap Water



2. Methods of Separation – An Introduction

In earlier tutorials, we focused on forming chemical **compounds** in the form of covalent and ionic bonding. In this tutorial, we shall turn our attention to **mixtures** instead, in particular how to separate this mixtures.

Below lists seven examples of mixtures. Using the methods listed in the box provided, suggest a suitable method to separate each of the mixtures.

evaporation	**fractional distillation**	**simple distillation**	**sublimation**
filtration	**separating funnel**	**solution-filtration**	**using a magnet**

List the method used to separate

(a) a mixture of alcohol and water. fractional distillation

(b) salt from salt solution. evaporation

(c) water from salt solution. simple distillation

(d) a mixture of iodine crystals and salt. sublimation

(e) a mixture of iron fillings and sand. using a magnet

(f) a mixture of oil and water. separating funnel

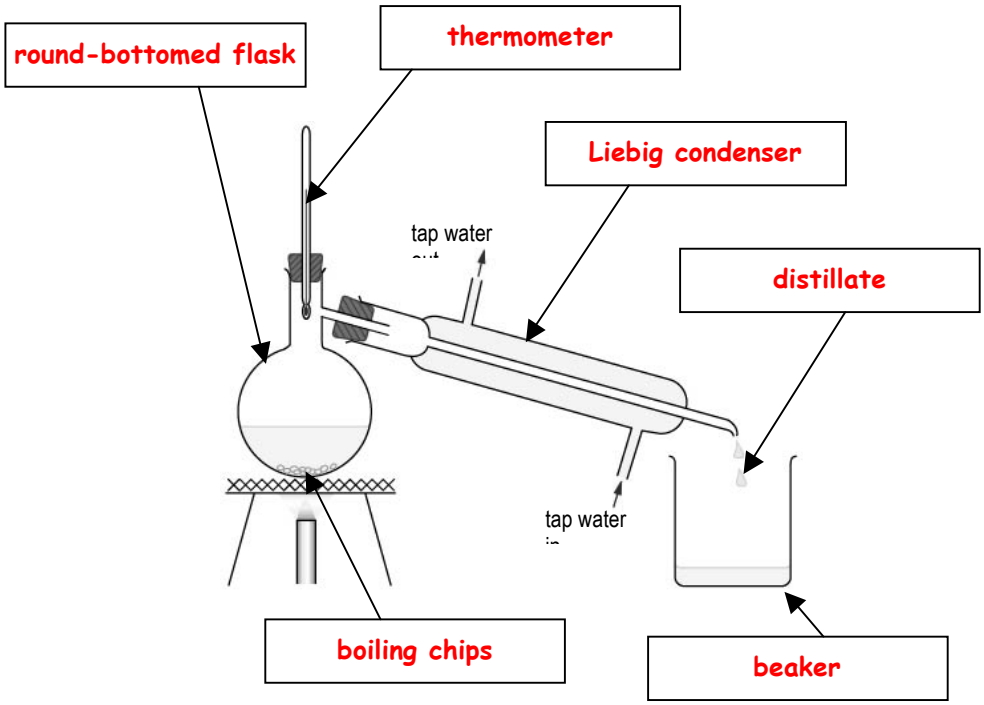
(g) a suspension of flour in water. filtration

(h) flour from table salt. solution-filtration

3. **Simple Distillation**

The diagram below shows the set-up for simple distillation. Using the helping words provided, label the diagram accordingly.

beaker	**distillate**	**round-bottomed flask**
boiling chips	**Liebig condenser**	**thermometer**



Distillation works on the principle of **separating mixtures by their boiling points**. For example, in the distillation of salt water, two substances are present: sodium chloride (boiling point 1465 °C) and water (boiling point 100 °C).

The substance that is distilled out (known as 'distillate') is the one with the **lower boiling point**.

Complete the table below to describe the purposes of selected apparatus in the above set-up.

Apparatus	Purpose
Liebig condenser	To condense the vapour given off (i.e. the substance with the lower boiling point) back into liquid form.
Thermometer	To monitor at the temperature of vapour entering the condenser is not higher than the boiling point of the distillate.
Boiling chips	To ensure smooth boiling.

National Education: Our Water Supply

Distillation is one method used to obtain potable (drinkable) water from the sea; soldiers sometimes use plastic sheets to distill water to drink when they are camping outdoors. The process of obtaining portable water from seawater is known as **desalination**. In September 2005, Singapore opened its first desalination plant, making this the fourth national supply of water.

State the two key steps used in Singapore's desalination plant.

1. Distillation of seawater

2. Usage of membranes to perform reverse osmosis for further purification.

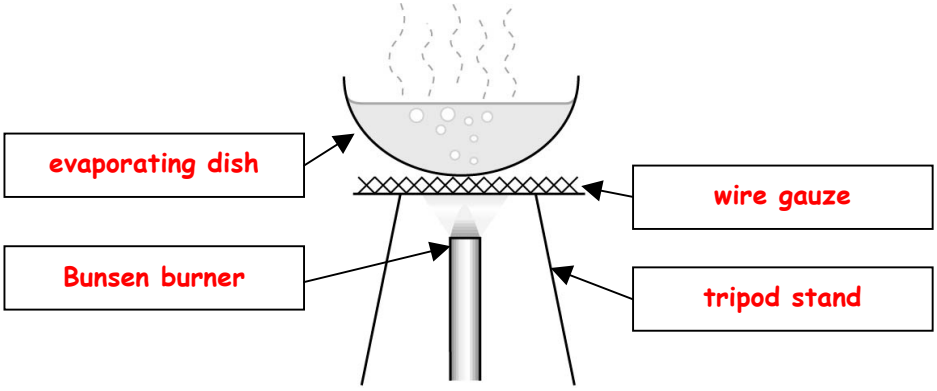
State a few other sources of Singapore's water.

Resevoirs; purchasing untreated water from Malaysia; NEWwater (reclaimed water from sewage through the reverse osmosis process)

4. **Evaporation**

Other than simple distillation, another method of separating a solution (i.e. a solid dissolved in a liquid) is through evaporation. This can be done by heating in an evaporating dish, and waiting until all the liquid has evaporated, leaving solid crystals behind.

Label the diagram below to show the set-up for evaporation.



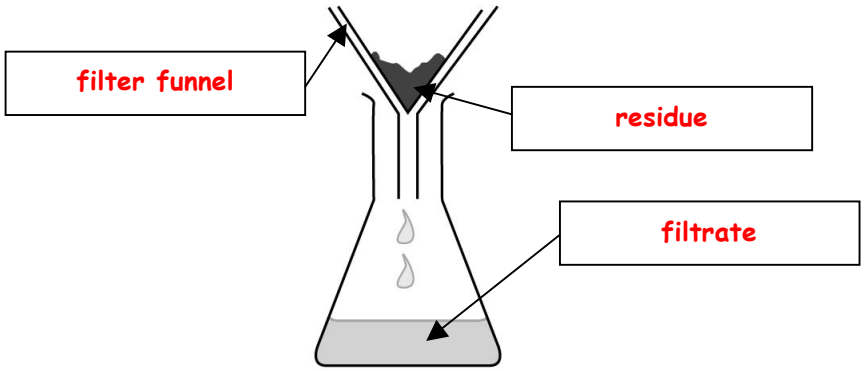
In terms of the products obtained, what is the difference between the evaporation method and the distillation method of separation of salts?

Simple distillation enables us to obtain the substance with the lower boiling point (i.e. in this case, water), while evaporation enables us to obtain the substance with the higher boiling point (i.e. in this case, salt).

5. **Filtration & Decanting**

In the previous two methods, we observed a separation technique which involved removing a liquid from a mixture of a soluble solid and a liquid. What if the solid were insoluble? Separating the mixture would then be much easier, and we can simply use **filtration**.

Label the diagram below which shows the set-up for filtration.



Outline the steps that could be taken to further purify the residue.

Wash the residue by rinsing with distilled water.

Allow the residue to dry between sheets of filter paper.

Describe how you would obtain salt from a dry mixture of salt and sand, using a combination of any of the methods above and any additional steps necessary.

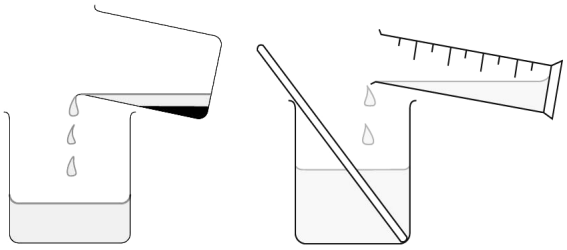
Solution: add excess water to the mixture and stir thoroughly, until all salt dissolves.

Filtration: filter out the sand, which is insoluble. Wash and dry the sand.

Evaporation: heat the salt solution in an evaporating dish until crystals are formed.

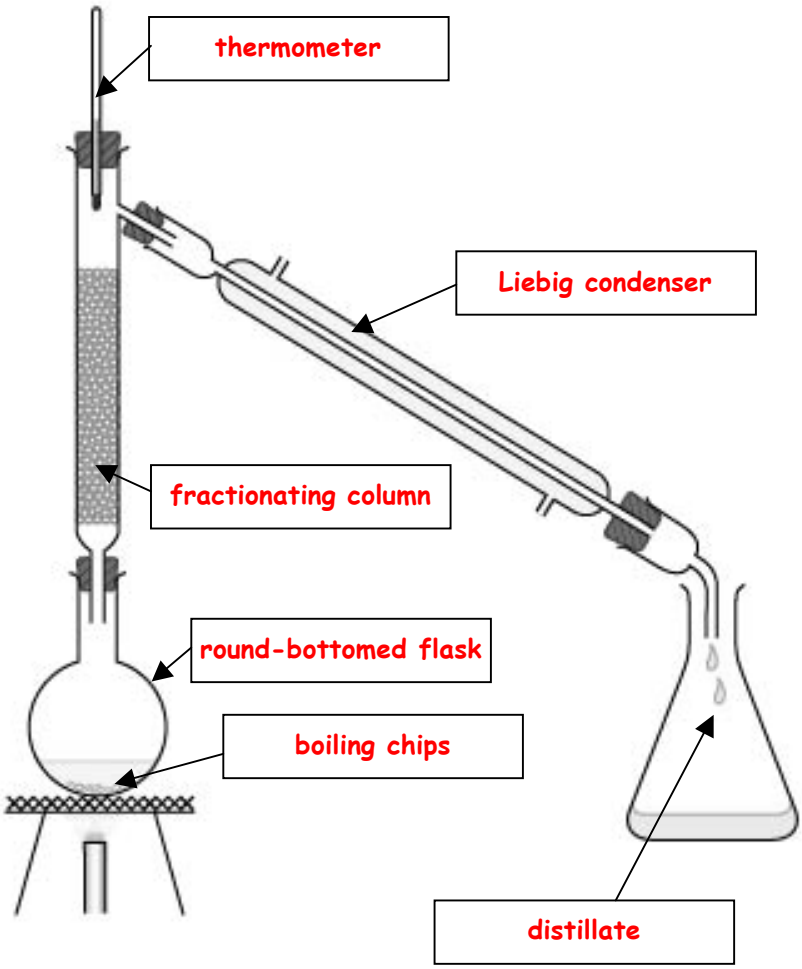
While we typically use filtration for suspensions (i.e. fine particles in water), mixtures that involve larger particles (e.g. large pebbles in a beaker of water) can use a simpler method known as **decanting**.

Decanting is pouring out the liquid carefully, using a glass rod to aid the process.



6. **Fractional Distillation**

The diagram below shows the set-up for fractional distillation. Fill in the missing labels.



You will notice that the set-up for fractional distillation is identical to that of simple distillation, except for the presence of a fractionating column.

A common example used to illustrate the application of fractional distillation is in the separation of a mixture of alcohol (ethanol) and water. Ethanol has a boiling point of 78°C, while water has a boiling point of 100°C.

(a) Which substance will be the distillate – ethanol or water? Why?

Ethanol, as it has the lower boiling point.

(b) What at temperature should the thermometer be maintained at?

78°C – the boiling point of ethanol.

(c) (i) State the **similarity** between simple distillation and fractional distillation, in terms of the means in which the mixtures are separated.

They both separate mixtures based on their boiling points.

(ii) What is the difference in the situation in which simple distillation is used, as compared to the situation in which fractional distillation is used?

Simple distillation is used to separate mixtures with large differences in boiling points (e.g. sodium chloride 1465 °C and water 100 °C), while fractional distillation is used to separate mixtures with small differences in boiling points (e.g. water 100 °C and ethanol 78 °C)

Two industrial applications of fractional distillation are the separation of liquid air and crude oil.

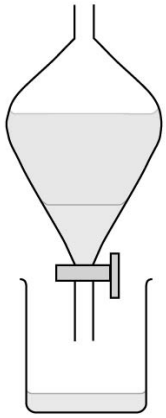
Fractional distillation of liquid air: air is cooled until it condenses to become a liquid mixture. This mixture is then put through fractional distillation in order to obtain nitrogen, oxygen and argon gases for various industrial, medical or technological purposes.

Fractional distillation of crude oil: crude oil is heated and put through fractional distillation to obtain a variety of fuels which serve different purposes – such as gasoline, kerosene and diesel.

7. Separating Funnel

In fractional distillation, we looked at the separation of miscible liquids, such as alcohol and water. However, if the two liquids are **immiscible** (i.e. cannot mix) such as oil and water, the process of separation is much easier.

We can use a simple device known as a separating funnel, as shown below. At the bottom of a separating funnel is a tap, which **releases the liquid with the higher density** from the funnel. The denser liquid can hence be collected in a beaker, while the less dense liquid will be left remaining in the funnel.

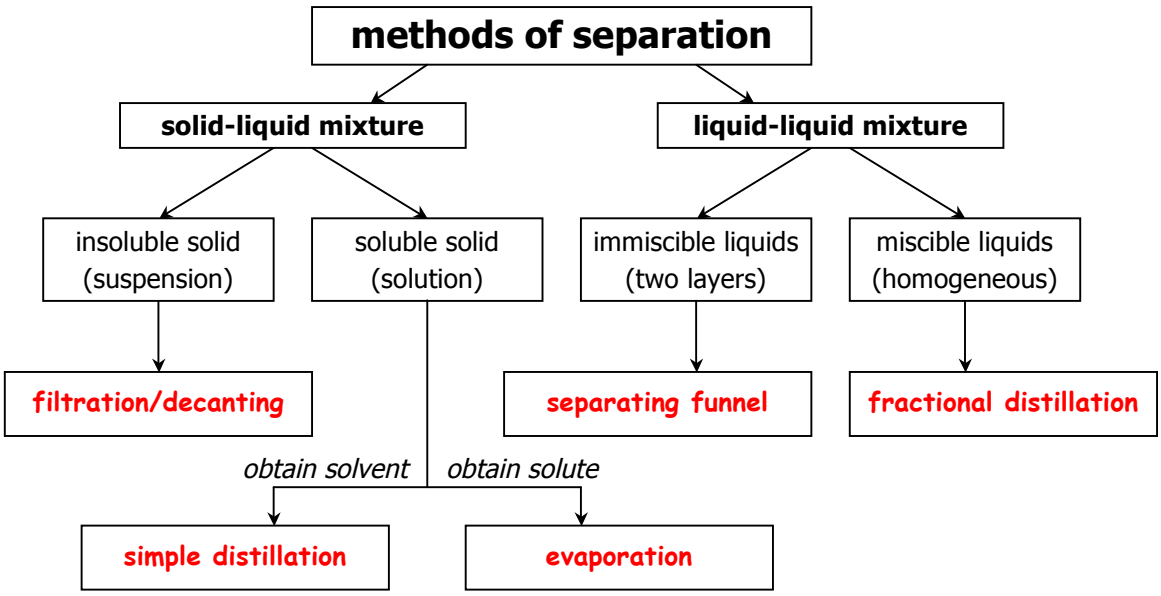


For each of the following mixtures, predict which chemical will be first released when put through a separating funnel.

Mixture	Substance First Released
Cooking Oil + Water	Water
Methylbenzene + Water	Water
Mercury + Water	Mercury

8. **Methods of Separating Mixtures – A Summary**

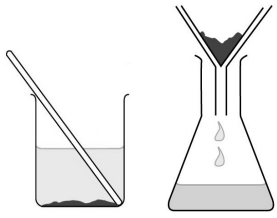
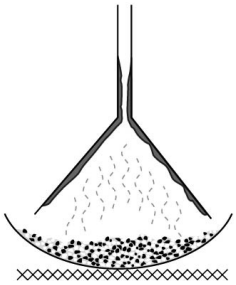
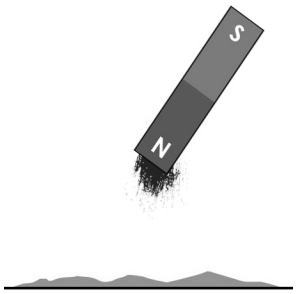
Complete the flow-chart below which categorizes the various methods of separation.



9. **Methods of Separating Solids**

So far, we have looked at methods of separating mixtures involving liquids with solids or liquids with other liquids. However, what if it is a dry mixture – i.e. a mixture of two solids?

In such a situation, we will have to look for special properties between these two solids.

	Solution & Filtration	Sublimation	Magnetism
Type of Mixture	one solid can dissolve in water while the other may not	one solid can sublime while the other may not	one solid can be magnetized while the other may not
Diagram			
Remarks	nil	*Substances that sublime:* ammonium chloride, iodine, dry ice	*Magnetic material:* three metals - iron, nickel, cobalt

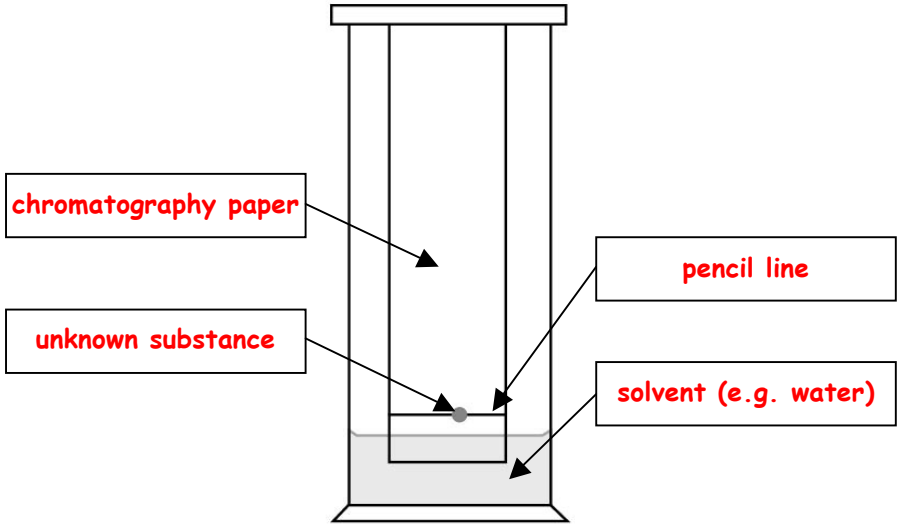
10. **Paper Chromatography**

Another method of separating substances is through chromatography. There are many forms of chromatography, but for our syllabus we shall focus on **paper chromatography**.

It consists of a few simple steps:

① Using a pencil, draw a 'starting line' at one end of the chromatography paper.
② Place a small drop of sample on the line.
③ Dip the end of the paper into a solvent, ensuring that the pencil line is not submerged.
④ Wait for the solvent to travel up the paper.

Label the diagram below:



(a) Briefly explain why chromatography is not a suitable method of 'purification', unlike all the other methods learnt earlier in this tutorial.

Unlike the other methods, e.g. distillation, the separated products of paper chromatography may not be extracted for further use. It is purely for analysis.

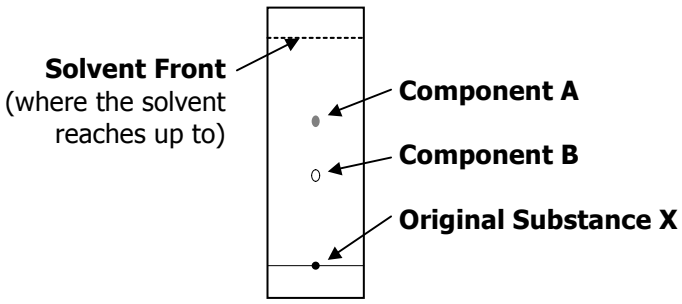
(b) Explain why it is important that the 'start line' be drawn in pencil, and not ink.

If the line were to be drawn in ink, the line would dissolve when placed in contact with the solvent and contaminate the sample being analyzed.

(c) Explain why it is important to ensure that the pencil line is **not** submerged in the solvent.

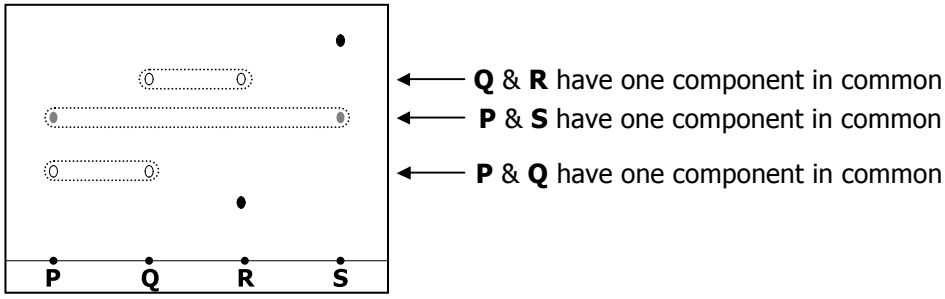
If the pencil line is submerged, the sample will get dissolved into the solvent and will not travel up the chromatography paper.

At the end of the process, a chromatogram like the following will be obtained:



In the above chromatogram, the original substance **X** has separated into two components, **A** and **B**. Note that the solvent will always move further than any of the components.

Often, multiple samples are placed on the same chromatogram for **comparison purposes**:

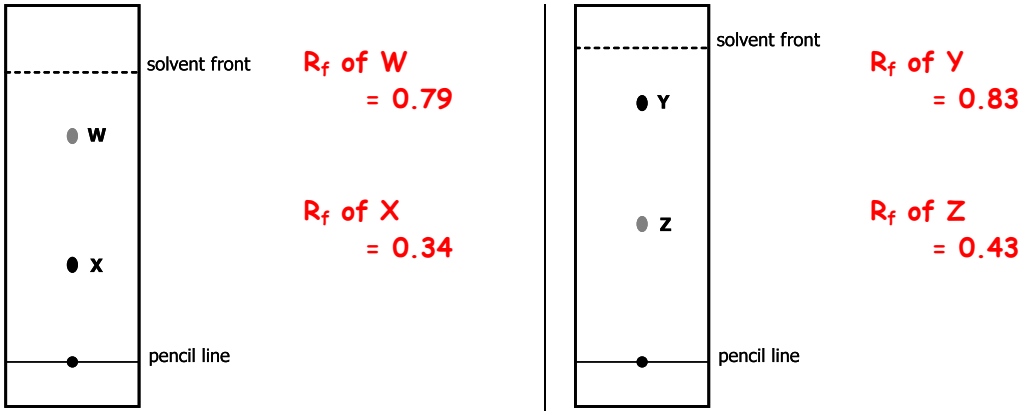


We can calculate the **retardation factor** (R_f) value of a specific component as follows:

$$\mathbf{R_f\ Value} = \frac{\textbf{Distance Moved By Component}}{\textbf{Distance Moved By Solvent}}$$

The R_f value of any particular substance is **always constant**; even if the solvent was allowed to travel up the chromatography paper for a longer distance, the component will move up in the same proportion. Hence by finding out the R_f values, we can often identify the various components of a mixture.

(d) Assuming that the diagrams below are drawn to scale, calculate the R_f value of **all** the components in the chromatograms below to two decimal places.



(e) (i) What is the most important criteria in choosing a solvent for chromatography?

All components in the mixture must be soluble in that solvent.

(ii) Suggest two other possible household solvents, other than water.

Ethanol, Vinegar, Acetone (nail polish remover)

(f) (i) Suggest a few industrial uses for chromatography.

e.g. detecting presence of illegal drugs in urine samples;

analysis of different amino acids in protein samples;

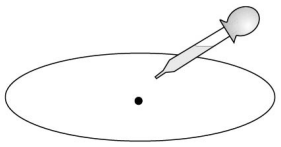
checking for banned colourings in food products

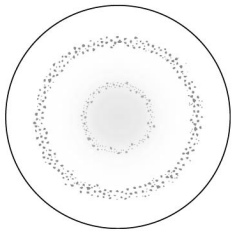
(ii) Briefly describe how chromatography can be performed on colourless substances – e.g. a mixture of amino acids.

By spraying the chromatogram (after it is completed) with a locating agent,

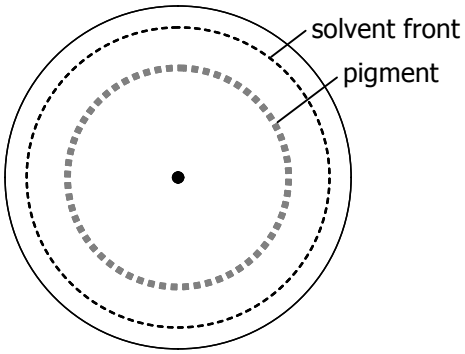
which will 'stain' the various spots and make them visible to the human eye.

Another form of paper chromatography is radial in nature – instead of using a pencil line and soaking one end in a solvent, a drop of the sample is placed in the centre of a piece of filter paper. Following this, a dropper is used to apply solvent (e.g. ethanol) onto the sample. The solvent dissolves the sample, and causes it to spread outwards, forming circles, as shown below.





(g) Calculate the R_f value of the pigment in the chromatogram below to two decimal places.



R_f = distance traveled by solute
+ distance traveled by solvent
= 1.4 cm + 2.0 cm
= 0.70 (2 d.p.)

11. **Review Questions**

Suggest a suitable method to

(a) separate a liquid mixture of methylbenzene and water,

using a separating funnel

(b) remove large pebbles from a sample of water,

decanting

(c) separate a mixture of noble gases (e.g. argon and neon),

liquification, followed by fractional distillation

(d) identify the various types of amino acids in a urine sample,

chromatography, followed by using a locating agent

(e) separate a solid mixture of ammonium chloride and ammonium sulfate,

sublimation

(f) identify whether banned colourings are present in a food sample,

chromatography

(g) to obtain dry crystals from aqueous copper(II) sulfate,

evaporation or crystallisation

(h) separate a suspension of powdered chalk and water.

filtration

(i) separate a solid mixture of sodium chloride and silver chloride,

solution, followed by filtration and evaporation

(j) separate a solid mixture of copper and iodine.

solution, followed by filtration and evaporation OR sublimation

Self-Designed Summary

Supplementary Questions

1. Which of the following materials is **not** magnetic?
   A cobalt **B** copper **C** iron **D** nickel

2. Which of the following pairs of metal powders may be separated from each other through the use of a magnet?
   A chromium and lead
   B cobalt and iron
   C copper and nickel
   D magnesium and zinc

3. A sample of ammonium chloride and sodium chloride are mixed. Which of the following methods would be most appropriate to separate the mixture into its two components?
   A adding water to the mixture, stirring, and then filtering
   B heating the mixture, holding an inverted funnel above it
   C placing the mixture into a separating funnel
   D using a magnet to remove all the ammonium chloride

4. Which of the following substances is **unable** to undergo sublimation?
   A ammonium chloride
   B carbon dioxide
   C iodine
   D silicon dioxide

5. Crude oil can be separated by fractional distillation because its constituents
   A are elements.
   B have different boiling points.
   C have different melting points.
   D are immiscible with water.

6. For two substances to be separated by paper chromatography, it is necessary that
   A they are both liquids.
   B they have difference colours.
   C they are both soluble in the same solvent.
   D they have different densities

7. Margaret is boiling some pasta for in a pot. After the pasta is completely cooked, she carefully tilts the pot over the sink to drain out all the water, leaving the pasta behind in the pot. What method of separation does this most resemble?
   A decanting **B** evaporation **C** filtration **D** separating funnel

8. Which test could be used to show that a sample of water is pure?
   A It freezes exactly at 0°C.
   B It has a colourless, homogeneous appearance.
   C It turns anhydrous cobalt(II) chloride pink.
   D When it evaporates, it leaves no residue.

9. Copper(II) sulfate crystals can be separated from sand using the four processes listed below. The order in which these processes should be used is
   A filtration; evaporation; solution; crystallisation
   B filtration; solution; crystallisation; evaporation
   C solution; evaporation; crystallisation; filtration
   D solution; filtration; evaporation; crystallisation

10. How would a solid mixture of iodine, limestone and table salt best be separated?
    A Allow the iodine to sublime, dissolve residue in excess water and filter.
    B Dissolve in excess water, allow iodine to sublime and then crystallise.
    C Dissolve in excess water, filter and then crystallise the filtrate.
    D Filter the mixture, add water to the filtrate and then heat strongly.

11. A separating funnel may be used to separate two liquids if the two liquids
    A are immiscible.
    B are soluble in water.
    C have different colours.
    D have different densities.

12. When candle wax is heated, it softens and then melts over a range of temperatures. Which statement explains this behaviour of the wax?
    A Wax can be used as a lubricant.
    B Wax is a macromolecule.
    C Wax is a mixture of hydrocarbons.
    D Wax is an insulator of heat.

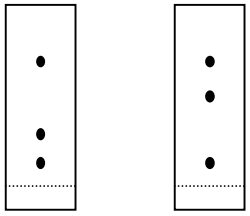
13. You are asked to separate a suspension of sand in a solution of sodium chloride and ammonium chloride so as to obtain all three substances. To do this, the following processes can be used; evaporation, filtration and sublimation. In which order should you carry out these operations?
    A evaporation; sublimation; filtration
    B filtration; evaporation; sublimation
    C filtration; sublimation; evaporation
    D sublimation; filtration; evaporation

14. A pure solid
    A dissolves completely in water.
    B does not react with other chemicals.
    C exists in crystalline form.
    D melts at an exact temperature.

15. A pure liquid
    A boils at an exact temperature.
    B evaporates completely leaving no residue.
    C is colourless, odourless and tasteless.
    D is neutral with a pH of 7.

16. Distillation is a separation technique which involves
    A condensation and then evaporation
    B evaporation and then condensation
    C filtration and then evaporation
    D sublimation and then condensation

17. Two groups of researchers performed a chromatogram to identify the various pigments present in squid ink. Both groups had used the same source of pigments, but obtained different results as shown in the diagram on the right. What could best explain this difference?
    A One group accidentally contaminated the sample.
    B One group used too little solvent.
    C The two groups left the chromatogram for different durations.
    D The two groups used different solvents.


Group **A** Group **B**

18. One of the following substances may be condensed using a condenser. Which is it?

	melting point (°C)	*boiling point (°C)*
A	-150	-55
B	-75	15
C	0	60
D	10	20

19. Which one of the following would be the most suitable method for separating a mixture of methylbenzene (boiling point 111°C) and cyclohexane (boiling point 81°C)?
    A crystallisation **B** evaporation **C** filtration **D** fractional distillation

20. To help diagnose illness, doctors often need to know which amino acids are presenting blood or urine. Which the following methods is used to separate and identify amino acids?
    A chromatography **B** distillation **C** crystallisation **D** sublimation

Supplementary Questions (Answers)

Multiple-Choice Questions

1 B	2 C	3 B	4 D	5 B	6 C	7 A	8 A
9 D	10 A	11 A	12 C	13 B	14 D	15 A	16 B
17 D	18 C	19 D	20 A				

Lecture Slides

Separation of Mixtures

Anglo-Chinese School (Barker Road)

CHEMISTRY
Prepared by Alex Lee

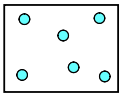
Chapter Overview

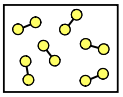
In This Chapter, We Will Learn …

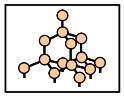
1. Elements, Compounds and Mixtures
2. Separating Solid-Liquid Mixtures
3. Separating Liquid-Liquid Mixtures
4. Separating Solid-Solid Mixtures
5. Paper Chromatography

Elements

- An **element** is a pure substance that **cannot be split up into two or more simpler substances by chemical processes or electricity**.
- Only **one type** of atom present, but not necessarily monoatomic.

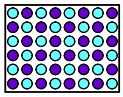

monoatomic element
e.g. argon

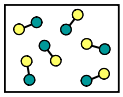

diatomic element
e.g. oxygen

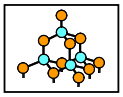

macromolecular
e.g. diamond

Compounds

- A **compound** is defined as a pure substance that **contains two or more elements chemically combined**.
- **At least two types** of atoms **bonded** together.


ionic compound
e.g. sodium chloride


diatomic compound
e.g. hydrogen chloride


macromolecular
e.g. sand

Mixtures

- Two or more different types of substances which are **not chemically bonded** together.
- Examples of mixtures:
  - sea water → mixture of salt (ionic compound) and water (covalent compound)
  - chlorine solution → mixture of chlorine (covalent element) and water (covalent compound)
  - bronze alloy → mixture of copper (metallic element) and zinc (metallic element)
  - steel alloy → mixture of iron (metallic element) and carbon (non-metallic element)
  - natural air → mixture of nitrogen, oxygen (covalent elements), argon (monoatomic element) and carbon dioxide (covalent compound)

Comparing Compounds and Mixtures

	Compounds	Mixtures
Components chemically bonded together?	Yes	No
Is there a fixed ratio of components?	Yes	No
Can be separated by physical means?	No	Yes
Can be separated by chemical means?	Yes	Yes
Have a homogeneous appearance?	Yes	Maybe
Have a fixed melting and boiling point?	Yes	No
Components retain their original properties?	No	Yes
Is there an energy change during formation?	Yes	No

Methods of Separation

- As mentioned in the earlier slides, mixtures can be separated by physical means.
- In this chapter, we shall look at the various physical means in which we can separate mixtures.
- How many of these methods do you know?

filtration	**evaporation**	**separating funnel**
decanting	**crystallization**	**using a magnet**
distillation	**solution-filtration**	**sublimation**

Simple Distillation

Used to separate a solid dissolved in a liquid.

Example: salt solution

Note: **only liquid** obtaine

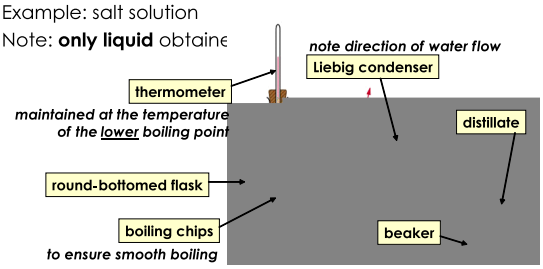


*Image provided by Marshall Cavendish*Chemistry Matters' Textbook.*

Simple Distillation

- The substance with the **lower boiling point** (i.e. the liquid) is obtained, and known as the **distillate**.
- The thermometer is maintained at the **boiling point of the distillate**. For example, when distilling a mixture of water (100 °C) and salt (1400 °C), the thermometer is maintained at 100 °C.
- The Liebig condenser is kept at **room temperature** by running **tap water** through it.

Simple Distillation

Apparatus	Purpose
Liebig condenser	To condense the vapour given off (i.e. the substance with the lower boiling point) back into liquid form.
Thermometer	To monitor at the temperature of vapour entering the condenser is not higher than the boiling point of the distillate.
Boiling chips	To ensure smooth boiling.

Evaporation To Dryness / Crystallisation

Used to separate a solid dissolved in a liquid.

Example: salt solution

Note: **only solid** obtained

In **evaporation to dryness**, the solution is heated until there is no water left, i.e. only a dry residue remains.

However, this may not be suitable for salts which are easily decomposed.

In **crystallization**, we allow the solution to cool once saturation is reached.

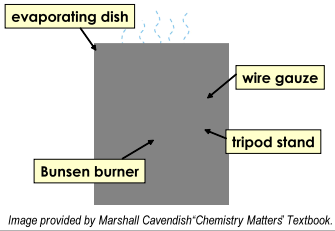


*Image provided by Marshall Cavendish*Chemistry Matters' Textbook.*

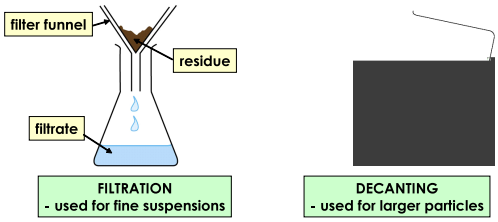
Evaporation To Dryness / Crystallisation

- Both simple distillation and evaporation/crystallization are suitable to separate salt solutions.
- What is the difference in terms of the products?
  - **Simple distillation** enables us to obtain the substance with the **lower boiling point** (i.e. water).
  - **Evaporation/crystallizatio**n enables us to obtain the substance with the **higher boiling point** (i.e. salt)

Filtration / Decanting

Used to separate a solid <u>suspended</u> in a liquid.

Example: flour and water



Images provided by Marshall Cavendish"Chemistry Matters" Textbook.

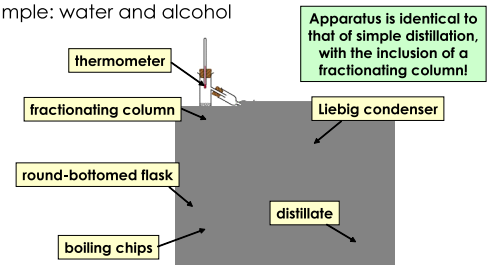
Filtration / Decanting

- After filtration/decanting, we can **further purify the residue** obtained by:
  - **washing** the residue by rinsing with **distilled water**
  - **drying** the residue **between sheets of filter paper**

Fractional Distillation

Used to separate two <u>miscible</u> liquids.

Example: water and alcohol



Images provided by Marshall Cavendish"Chemistry Matters" Textbook.

Fractional Distillation

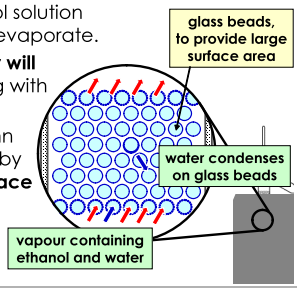
<u>Example:</u>

Mixture of water (100 °C) and ethanol (100 °C)

- Which substance will be the distillate? Why?
  - **Ethanol**, as it has the **lower boiling point**.
- What temperature should the thermometer be maintained at?
  - **78 °C**, the boiling point of the distillate.

Fractional Distillation

- **Why use a fractionating column?**
  - When heating ethanol solution at 78 °C, ethanol will evaporate.
  - However, **some water will also evaporate**, along with ethanol.
  - A fractionating column reduces this problem by **providing a large surface area** for the water vapour to condense!



Fractional Distillation

- **What is the similarity between the types of mixtures separated by simple and fractional distillation?**
  - Both separate mixtures by their boiling points.
- **When would simple or fractional distillation be used?**
  - Simple distillation separates mixtures with **large differences** in boiling points (e.g. sodium chloride 1400 °C and water 100 °C)
  - Fractional distillation separates mixtures with **small differences** in boiling points (e.g. ethanol 78 °C and water 100 °C).

Fractional Distillation

Some industrial applications of fractional distillation:

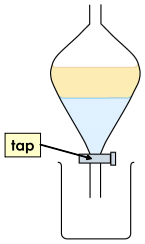
- **Fractional distillation of liquid air –** used to obtain nitrogen, oxygen and argon for a variety of commercial uses.
- **Fractional distillation of crude oil (petroleum) –** used to separate crude oil into different types of fuels, e.g. petrol, kerosene, diesel.

Separating Funnel

Used to separate two <u>immiscible</u> liquids.

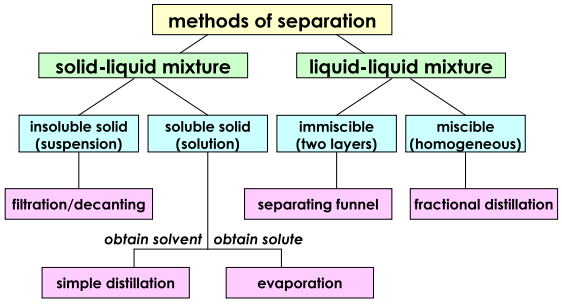
Example: oil and water

It is insufficient that the two liquids are of different densities, e.g. ethanol and water, as they may still be miscible.



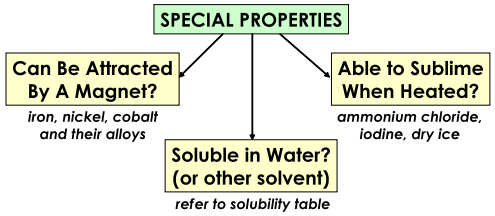
Images provided by Marshall Cavendish"Chemistry Matters" Textbook.

Methods of Separation - Summary



Separating Solid Mixtures

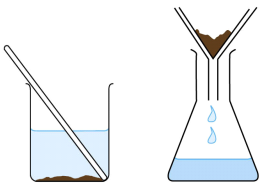
- In separating mixtures of two solids, we have to look for special properties that help us differentiate the two constituents of the mixture.



Solution-Filtration

- Can be used when one solid is **soluble in water**, while the other solid **is not**.

  Example: a mixture of salt and sand



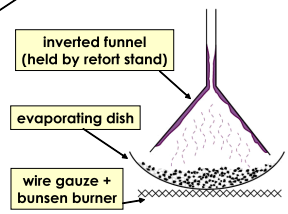
Images provided by Marshall Cavendish"Chemistry Matters" Textbook.

Sublimation

- Can be used when one solid is **able to sublime**, while the other solid **may not**.

  Example: a mixture of iodine and sand

<u>Substances that sublime:</u>
ammonium chloride
iodine
aluminium chloride
naphthalene
carbon dioxide



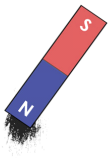
Images provided by Marshall Cavendish"Chemistry Matters" Textbook.

Magnetism

- Can be used when one solid is **attracted by a magnet**, while the other solid **is not**.

Example: a mixture of iron fillings and sand

Substances that are magnetic:
iron
nickel
cobalt
steel (alloy of iron)
samarium-cobalt (alloy of cobalt)



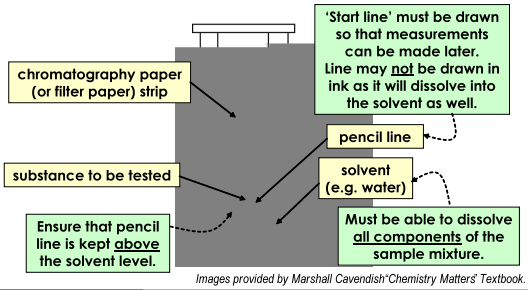
Images provided by Marshall Cavendish"Chemistry Matters" Textbook.

Why Separate Mixtures?

- We separate mixtures for two reasons:
  - **Purification**: in order to obtain a clean sample of each component (e.g. obtaining water for drinking from seawater)
  - **Identification**: in order to analyze the components of that mixture (e.g. finding what types of flavourings have been put in a soft drink)
- So far, the methods we have learnt are methods of purification, i.e. to obtain clean samples.

Paper Chromatography

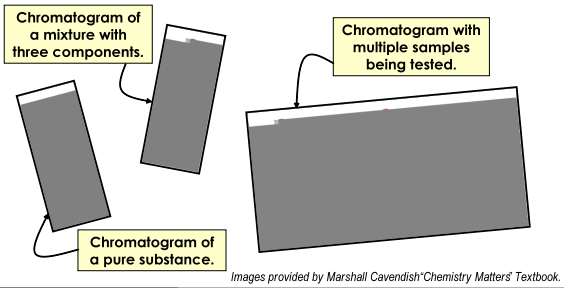
Used to identify components of a mixture



Images provided by Marshall Cavendish"Chemistry Matters" Textbook.

Paper Chromatography

At the end of the process, you will get a chromatogram.

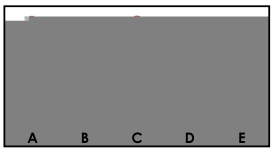


Images provided by Marshall Cavendish"Chemistry Matters" Textbook.

Paper Chromatography

- The relative 'heights' reached by the various components of a mixture can help us detect what components are in the mixture.

How many ink samples were tested?
ANS: Five



Which ink samples are pure?
ANS: B and D

Does ink **A** contain ink **D**?
ANS: Yes

How many components were used in these five inks?
ANS: Six

Does ink **A** contain ink **C**?
ANS: No

Do inks **A** and **C** share a common component?
ANS: Yes

Retardation Factor (R_f)

- R_f is a measure of the **relative solubility** of a pigment (or any other substance) in a particular solvent.
- It can be measured as follows.

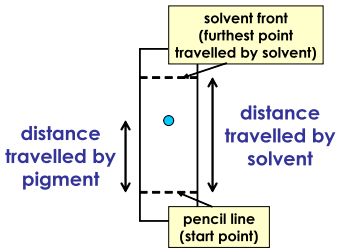
$$\text{Retardation Factor, } R_f = \frac{\text{distance moved by pigment}}{\text{distance moved by solvent}}$$

- The more soluble the pigment, the higher the R_f value!

chemistry | separation of mixtures

Retardation Factor (R_f)

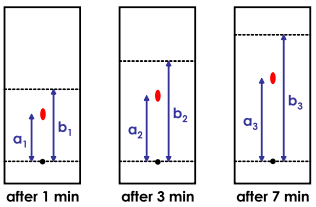
- In order to measure the R_f value of a chromatogram, we must take note of the **solvent front**.



chemistry | separation of mixtures

Retardation Factor (R_f)

- The retardation factor (R_f value) for a chemical is **constant**, as long as it is in the same solvent.

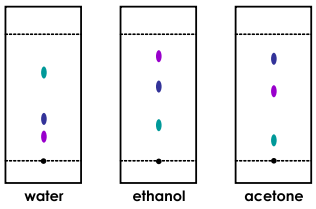


$$\frac{a_1}{b_1} = \frac{a_2}{b_2} = \frac{a_3}{b_3}$$

chemistry | separation of mixtures

Retardation Factor (R_f)

- However, the same chemical may have different R_f values in different solvents.

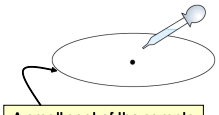


We can observe that the blue pigment is most soluble in acetone and least soluble in water!

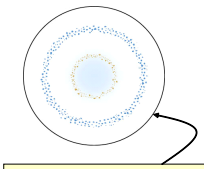
chemistry | separation of mixtures

Paper Chromatography - Radial

- Paper chromatography can only be performed using a circular piece of chromatography paper.



A small spot of the sample is placed in the middle of the circular paper. Solvent is added, drop by drop, to the centre.



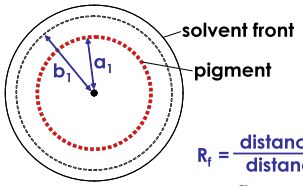
The final product looks like this!

Images provided by Marshall Cavendish 'Chemistry Matters' Textbook.

chemistry | separation of mixtures

Paper Chromatography - Radial

- Calculate the R_f value of the chromatogram below.



$$R_f = \frac{\text{distance moved by pigment}}{\text{distance moved by solvent}}$$

$$= \frac{a_1}{b_1} \quad \textit{(measure to scale)}$$

$$= 0.70$$