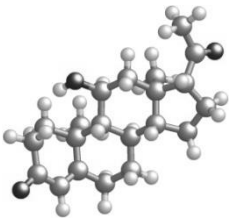

Sc!ence

Name: …… **( )**

Class: ……

Date: …… **/** …… **/** ……

Purification and Separation Techniques – Change and Systems

Introduction:

Many things in the world around us are mixtures. Some mixtures are useful and can be used as they are. Other mixtures are problematic or harmful if they are used directly, and the desired component of the mixture must be separated before it can be used for a specific purpose. In this unit, you will study…

- How scientists identify mixtures.
- How scientists decide the best way to separate a specific mixture.
- The different separation techniques that are available, and the principles by which they work.
- How scientists decide whether a substance is pure.
- Applications of purification and separation techniques in our everyday lives.

Conceptual Lenses: Change and Systems

- What do you understand about the concept of *change*? Think about examples of changes in the world around you and write down your ideas.

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- What do you understand about the concept of *systems*? Think about examples of systems in the world around you and write down your ideas.

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When the components of a mixture are separated, a *change* takes place to the composition of the mixture. This *change* can be considered to be reversible, since the components can be recombined to form the original mixture once again. The process used to separate the mixture is chosen based upon the properties of the components within the mixture. This process can be considered to be a *system*, since it is composed of several components which work together, following certain rules, to bring about the separation.

Guiding Questions:

Some of these questions you may be able to answer now. Other questions you might only be able to give complete answers near the end of the unit.

1. What are the characteristics of a mixture? How do you recognise a mixture?

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2. Why is it important to separate mixtures?

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3. How do we identify which component of a mixture is important?

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4. Which physical properties of a mixture allow us to choose the most appropriate separation technique?

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5. Once a mixture has been separated, how do we know that the products are pure? What is purity? What are acceptable levels of purity?

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……

6. What are some important separation techniques that are relevant to our everyday lives?

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7. What would happen if separation techniques were *not* used in our everyday lives?

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• **Method One – Magnetic attraction:**

a) What type of mixture(s) can be separated by magnetic attraction?

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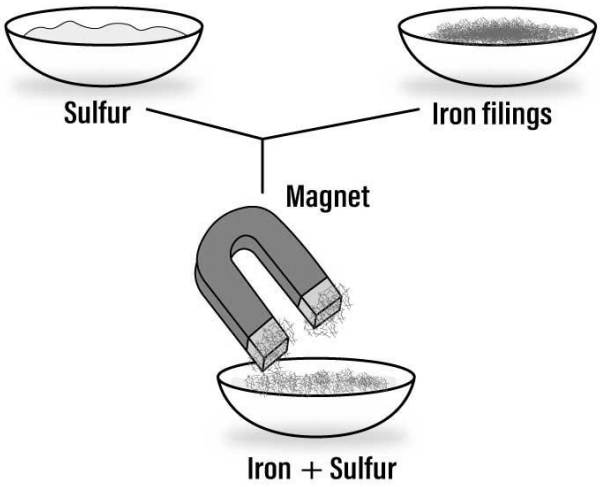
……...



b) In the example given above, iron is a magnetic material and is attracted towards the magnet, while sulfur is not a magnetic material and is not attracted towards the magnet. Iron filings are attracted towards the magnet and separated from the sulfur which remains behind in the dish.

✓ **Quick Check on Magnetic Attraction:**

Explain how magnetic attraction is used to separate a mixture of different materials at a recycling plant.

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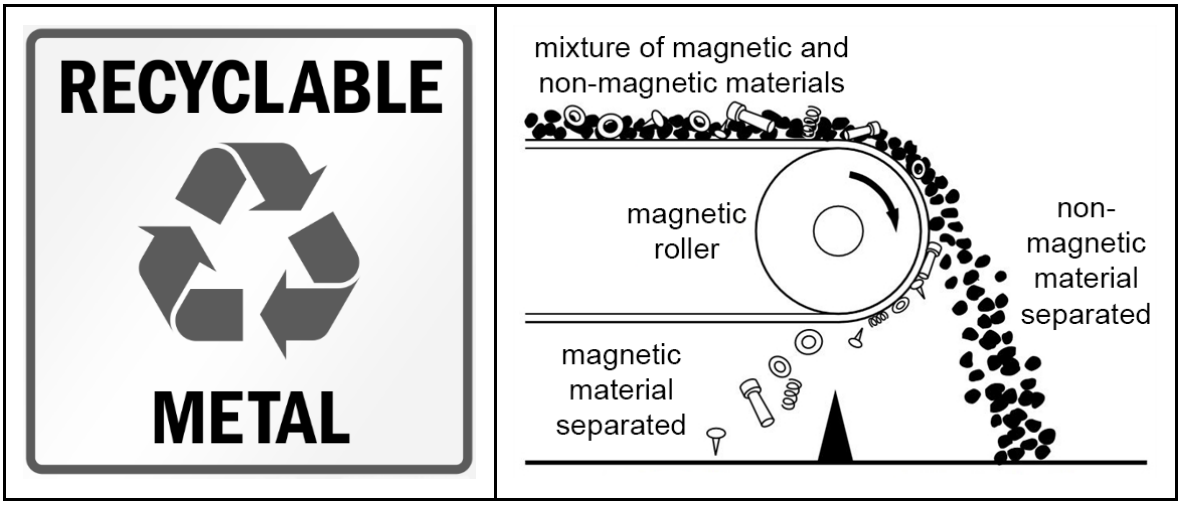

• **Method Two – Filtration:**

a) What type of mixture(s) can be separated by filtration?

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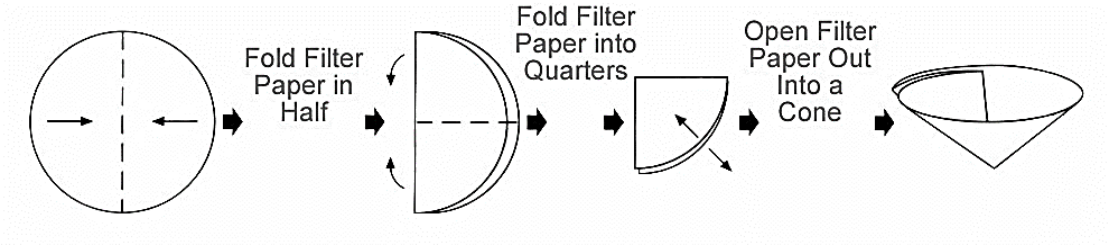
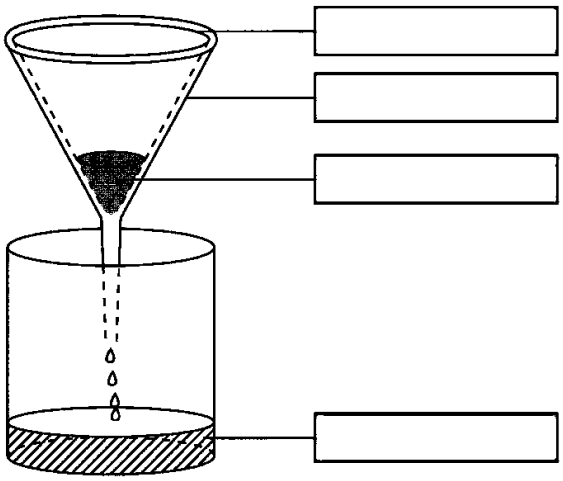
b) A mixture of copper(II) sulfate (blue crystals which are soluble in water) and sand can be separated by filtration and crystallisation. A summary of the procedure is given in the diagram below.



Label the diagram of the filtration apparatus given below:



c) In the example given above, crystals of copper(II) sulfate are dissolved in water to form a blue solution. Sand is insoluble and does not dissolve in water. The mixture is poured into a filter funnel lined with filter paper. The small particles of copper(II) sulfate dissolved in water pass through small gaps in the filter paper, but the grains of sand are too large to pass through and get trapped in the filter paper. Sand is collected as the residue and the copper(II) sulfate solution is collected as the filtrate.

d) After the filtration is complete, what additional steps need to be taken to obtain a sample of *pure*, *dry* sand?

……...

……...

e) Give examples of how filtration is used to separate substances in our everyday lives.

	…… …… …… …… …… …… ……

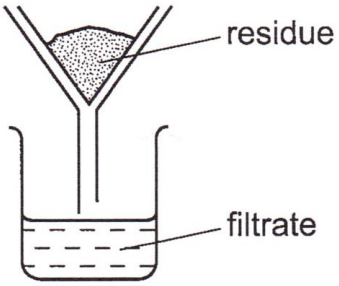
✓ **Quick Check on Filtration:**

The table shows the colours and solubilities in water of four solids.

solid	colour	solubility in water
W	blue	insoluble
X	blue	soluble
Y	white	insoluble
Z	white	soluble

A mixture containing two of the solids is added to excess water, stirred and filtered.

A blue filtrate and white residue are obtained.



Which solids are present in the mixture?

A **W** and **X** **B** **W** and **Y** **C** **X** and **Y** **D** **X** and **Z**

• **Method Three – Crystallisation:**

a) How can *crystals* of copper(II) sulfate be obtained from an aqueous solution of copper(II) sulfate efficiently?

…… …… …… …… …… …… ……	

• **Method Four – Chromatography:**

a) What type of mixture(s) can be separated by chromatography?

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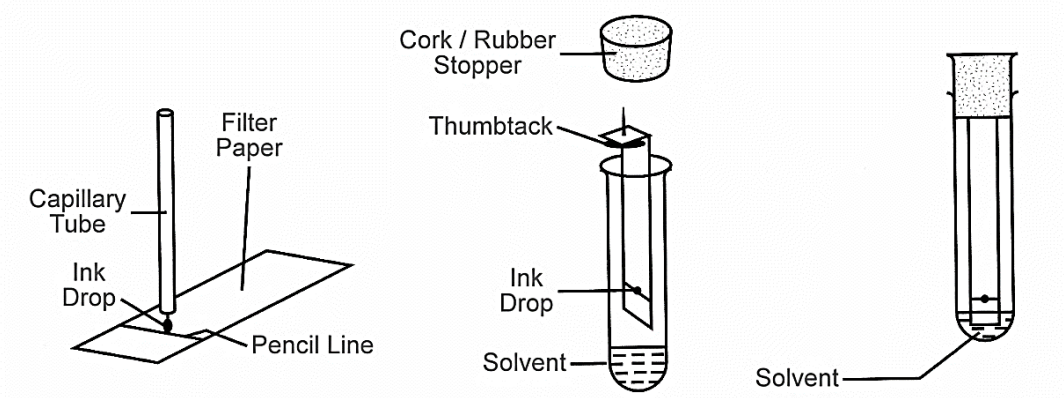
b) One possible way to separate a small mixture of chemicals that are often, but not necessarily, coloured is to use chromatography. The essential steps to perform chromatography are given below:



Chromatography works because the different solutes in the mixture have different solubilities in the same solvent. The solvent soaks into the filter paper and moves up the filter paper. Dyes in the ink dissolve in the solvent, but *different dyes have different solubilities*. A dye that is very soluble in the solvent will travel up the filter paper a greater distance than a dye that is less soluble in the solvent, hence the two different dyes will be separated from each other based upon their different solubilities in the solvent.

c) Explain how chromatography can be used to show whether a chemical is *pure*.

……...

……...

d) Why must the starting line on the filter paper be drawn in *pencil*?

……...

……...

e) Why is it essential for the ink drop be *above* the level of the solvent?

……...

……...

f) Why must the spot of ink be *small* and *concentrated*?

……...

……...

g) Why should the solvent be allowed to travel as far up the filter paper as possible?

……...

……...

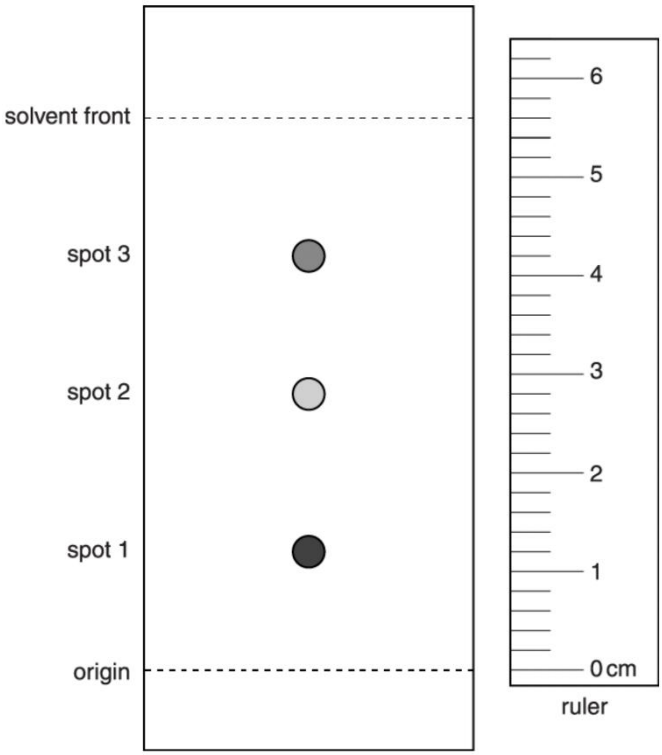
h) What additional step(s) must be taken when performing chromatography on a mixture of *colourless* chemicals?

……...

……...

i) Using the ruler provided in the question, calculate the R_f values of spot 2 and spot 3.

Which spot is *least* soluble in the solvent, and which spot is *most* soluble in the solvent?



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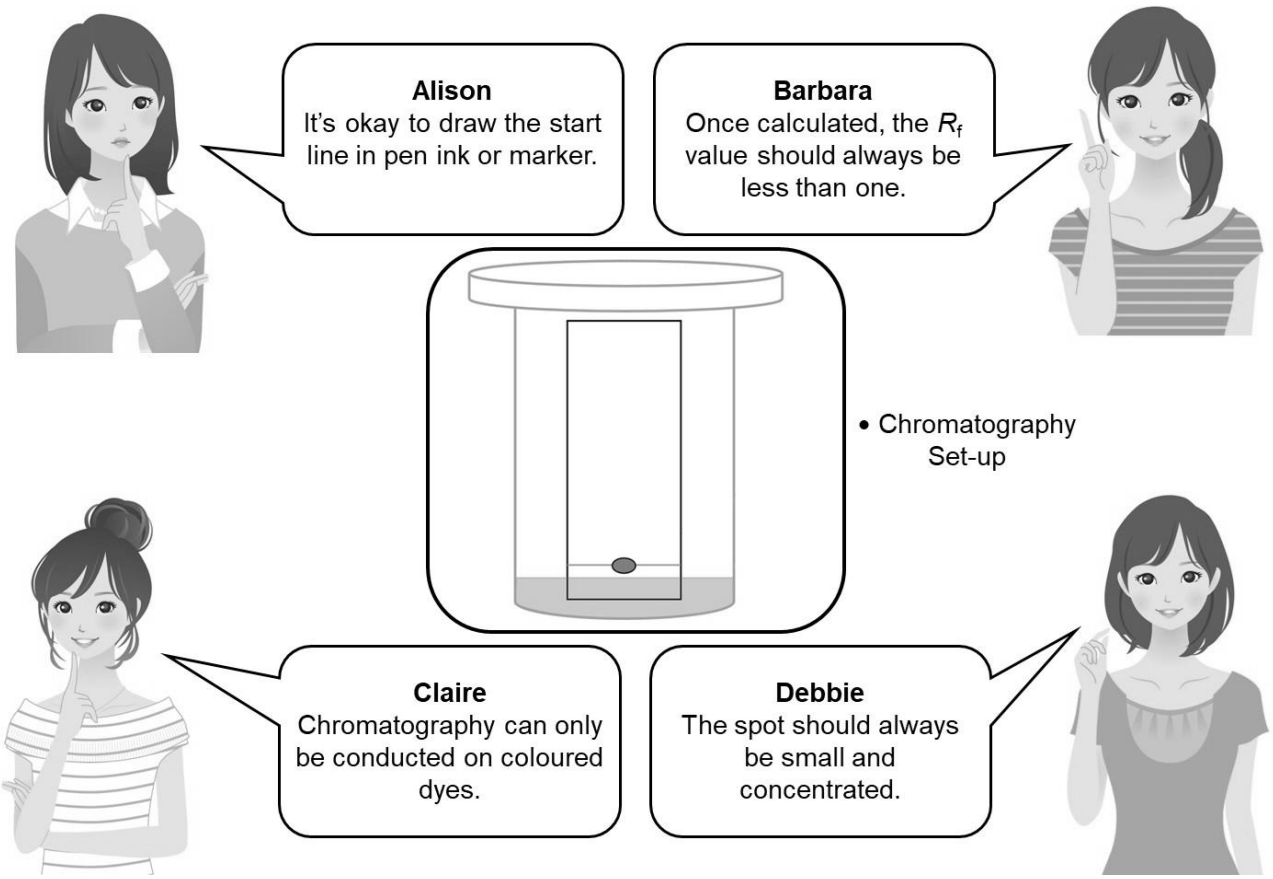
✓ **Quick Check on Chromatography – Concept Cartoon #1:**

Four students are discussing the separation of a mixture using chromatography.

Their discussion is shown below.



- **Two** of the students have made **correct** statements about chromatography. Identify the two students and explain why their statements are correct.

  Student 1: ……

  Explanation: ……

  ……

  Student 2: ……

  Explanation: ……

  ……

- **Two** of the students have made **incorrect** statements about chromatography. Identify the two students and explain why their statements are incorrect.

  Student 1: ……

  Explanation: ……

  ……

  Student 2: ……

  Explanation: ……

  ……

• **Method Five – Simple Distillation:**

a) **i)** What change in state is *boiling*?

……...

ii) What change in state is *condensation*?

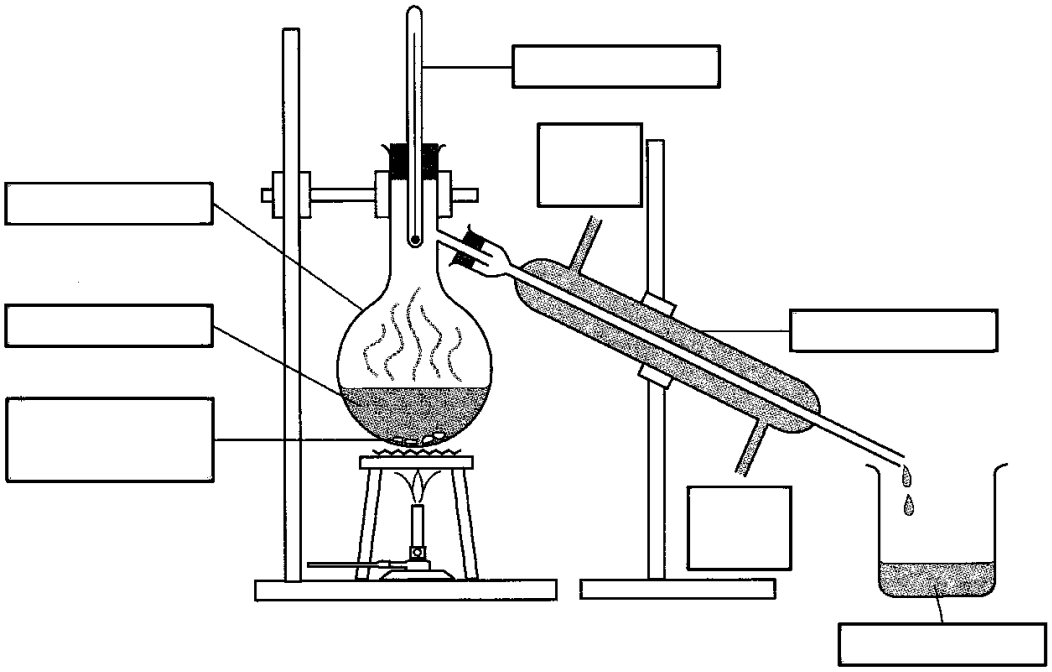
……...

b) What type of mixture(s) can be separated by simple distillation?

……...

……...

c) A mixture of ethanol (boiling point = 78°C) and water (boiling point = 100°C) can be separated by simple distillation. Label the diagram of the simple distillation apparatus given below:



d) In the example given above, the mixture of ethanol and water is heated. The ethanol has the lower boiling point (78°C), and so it will boil first, the water (100°C) remaining a liquid. The ethanol vapour rises upwards – some will condense on the bulb of the thermometer which will read 78 °C. The ethanol vapour enters the condenser, where it is cooled by the surrounding cold water, and condenses to a liquid. The liquid ethanol flows down the condenser and is collected in the beaker as the *distillate*. The water with a boiling point of 100 °C will remain as the *residue* in the flask, hence the two liquids are separated.

e) What is the role of the *smooth boiling granules* in the simple distillation apparatus?

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f) Pay careful attention to where the *thermometer* is located in the simple distillation apparatus. Why is the bulb of the thermometer placed at this exact location?

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……...

g) In which direction does the water flow through the *condenser*? Why is the direction in which the water flows through the condenser important?

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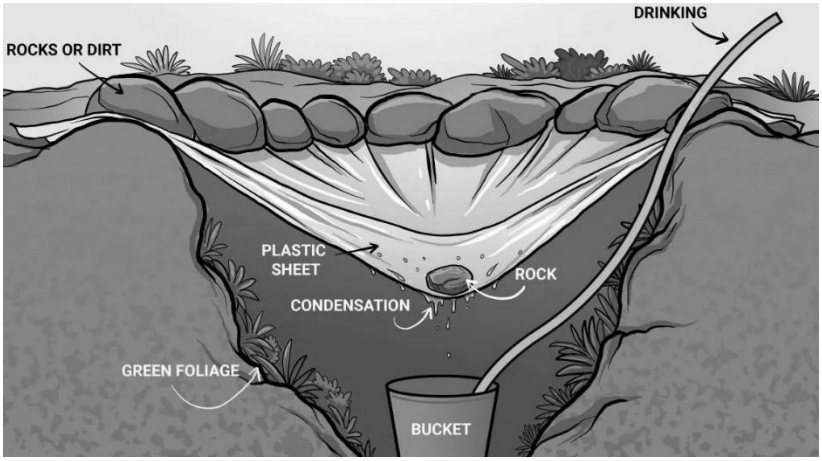
h) The diagram below shows how drinking water can be obtained from impure water by a process known as *solar distillation*.



Briefly explain how solar distillation can be used to obtain drinking water from impure water in the ground.

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i) Give examples of how distillation is used to separate substances in our everyday lives.

……...

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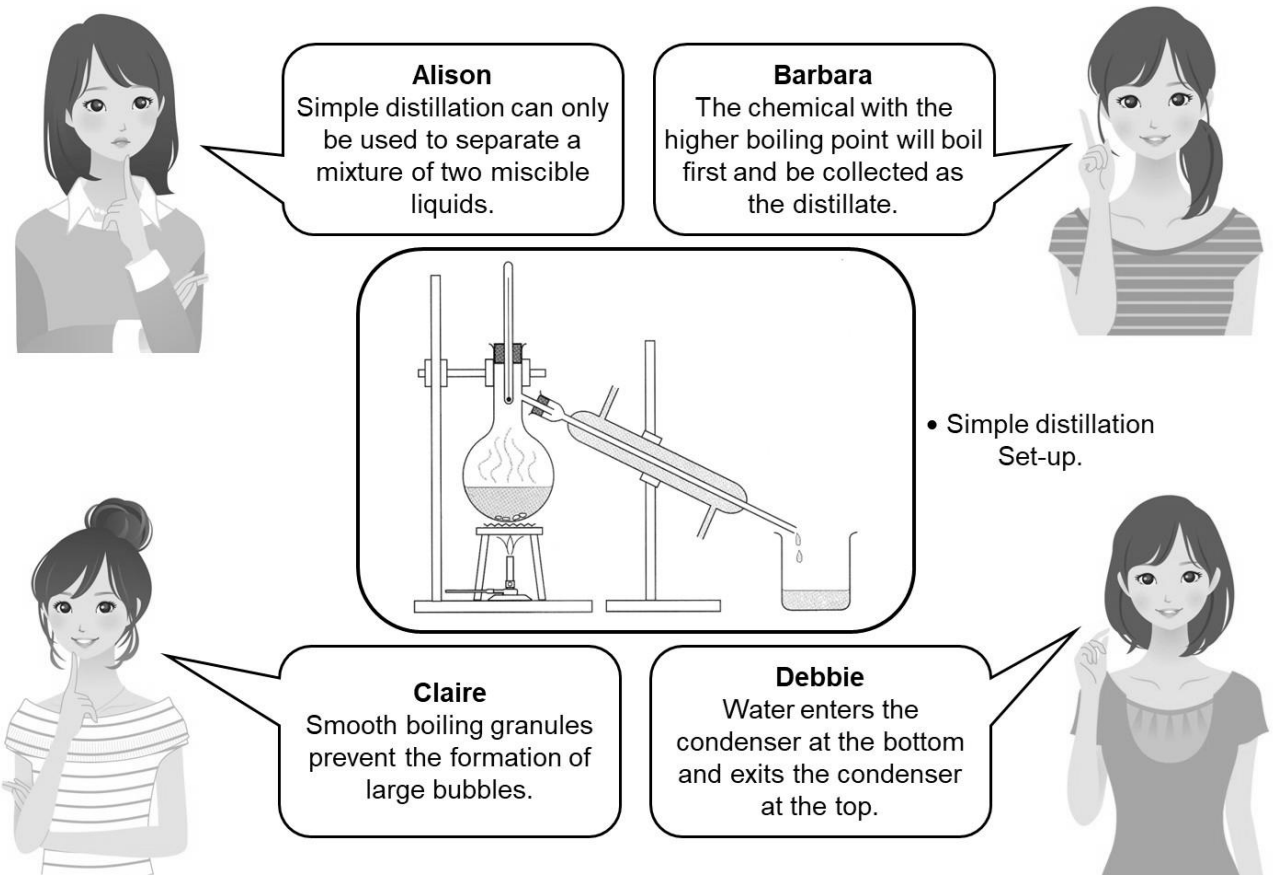
✓ **Quick Check on Simple Distillation – Concept Cartoon #2:**

Four students are discussing the separation of a mixture using simple distillation.

Their discussion is shown below.



- **Two** of the students have made **correct** statements about chromatography. Identify the two students and explain why their statements are correct.

  Student 1: ……

  Explanation: ……

  ……

  Student 2: ……

  Explanation: ……

  ……

- **Two** of the students have made **incorrect** statements about chromatography. Identify the two students and explain why their statements are incorrect.

  Student 1: ……

  Explanation: ……

  ……

  Student 2: ……

  Explanation: ……

  ……

• **Method Six – Separating Funnel:**

a) What type of mixture(s) can be separated using a separating funnel (tap funnel)?

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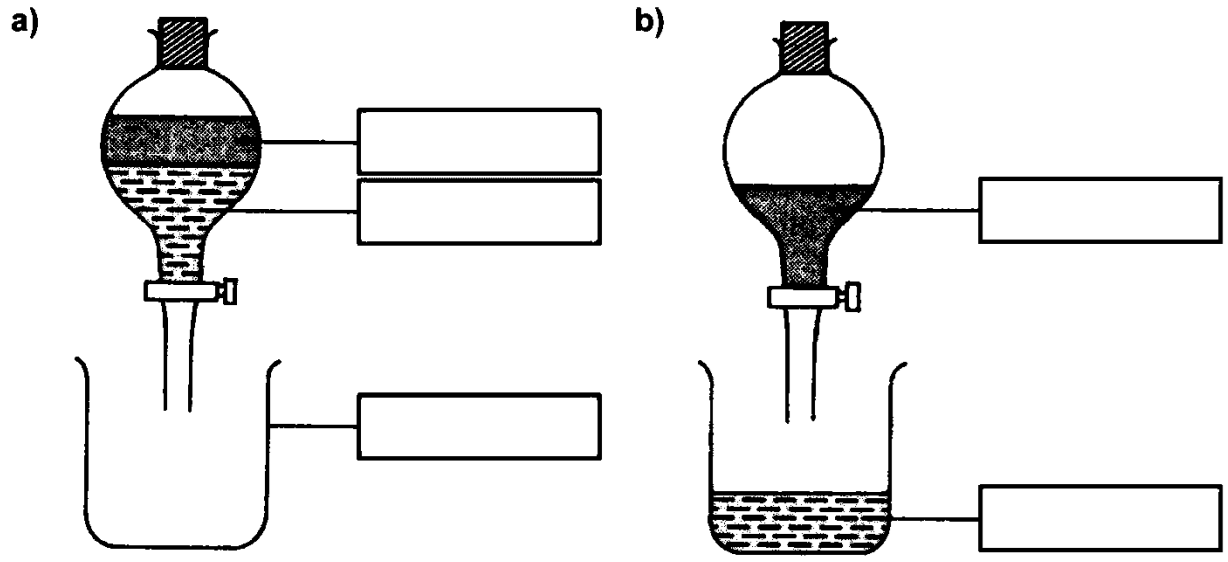
b) A mixture of oil and water can be separated by using a separating funnel (tap funnel). A brief description of the procedure is given in the diagram below. Label the diagram below of the separating funnel experiment:



c) Oil and water are two immiscible liquids, *i.e.* they do not mix with each other. The less dense oil floats on the surface of the more dense water. The stopper is removed from the separating funnel, and then the tap is opened. Water (the bottom layer) will flow into the beaker. Just as the layer of oil reaches the tap, the tap is closed, leaving the water in the beaker and the oil in the separating funnel.

✓ **Quick Check on Separating Funnel:**

Study the following mixtures.

1 Olive oil and table salt.
2 Olive oil and water.
3 Water and alcohol.
4 Water and table salt.

Which mixture(s) can be separated using a tap funnel?

A 1 only **B** 2 only **C** 2 and 3 only **D** 3 and 4 only

• **Method Seven – Sublimation:**

a) What change of state is sublimation?

……...

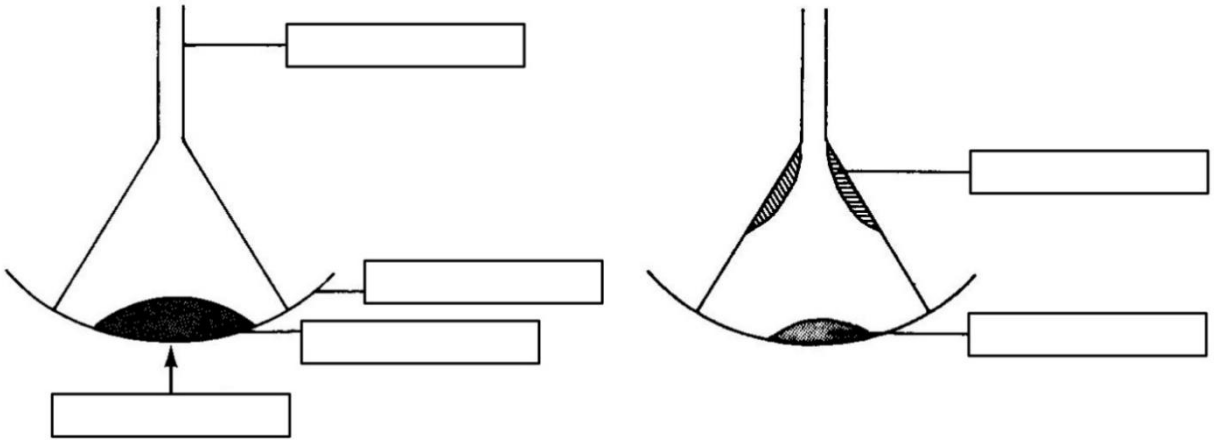
b) What type of mixture(s) can be separated by sublimation?

……...

……...

……...

c) A mixture of sodium chloride and ammonium chloride can be separated by sublimation. A brief description of how sublimation can be used to separate a mixture of sodium chloride and ammonium chloride is shown in the diagram below. Label the diagram to show how this separation can be accomplished.



d) The mixture of ammonium chloride and sodium chloride are heated gently (it might be advisable to heat the mixture gently over a water bath rather than heat directly over a Bunsen burner, as the non-luminous flame of the Bunsen burner might be too hot). The volatile ammonium chloride will sublime – change directly from solid to gas – while the solid sodium chloride will remain unchanged in the dish. When the ammonium chloride vapour comes into contact with the cold filter funnel, it will change from a gas back to a solid again (this is called *deposition*) hence the ammonium chloride and sodium chloride are separated.

✓ **Quick Check on Sublimation:**

Which one of the following mixtures can be separated by sublimation?

A Iodine and sand.

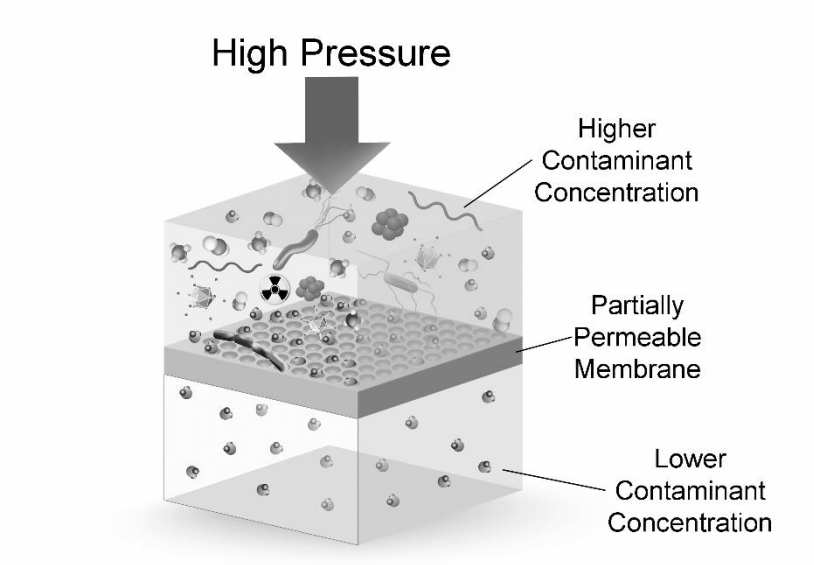
B Iodine and dry ice (solid carbon dioxide).

C Table salt and sand.

D Table salt and iron filings.

• **Method Eight – Reverse Osmosis:**

Reverse osmosis is an important separation technique as it allows countries with limited natural resources, such as Singapore, to obtain pure drinking water from seawater. Osmosis is similar to the concept of diffusion, but applied specifically to *water*. Osmosis is defined as the net movement of water molecules from a region of higher water potential (*e.g.* pure water) to a region of lower water potential (*e.g.* seawater) across a partially permeable membrane. In the case of *reverse osmosis*, a high pressure forces water molecules to move in the opposite direction – from a region of lower water potential (seawater) to a region of higher water potential (pure water) across a partially permeable membrane.



• Diagram showing the process of reverse osmosis. A high pressure is applied to water that is contaminated with impurities. Only water molecules are small enough to be forced through the partially permeable membrane, creating water that is low in contamination and suitable for drinking.

a) You may recall that *simple distillation* can also be used to separate salt (the solute) from water (the solvent). What advantage does reverse osmosis have over simple distillation as a method of obtaining pure water from seawater?

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✓ **Quick Check on Reverse Osmosis:**

Which one of the following pieces of apparatus is necessary to obtain pure drinking water from seawater by reverse osmosis in a school laboratory?

A Bunsen burner.

B High pressure pump.

C Filter paper.

D Water cooled condenser.

• **Essential Questions and Decisions for Separation Techniques:**

What questions need to be asked, and what decisions need to be made, in order to achieve a complete and efficient separation of a mixture of chemicals?

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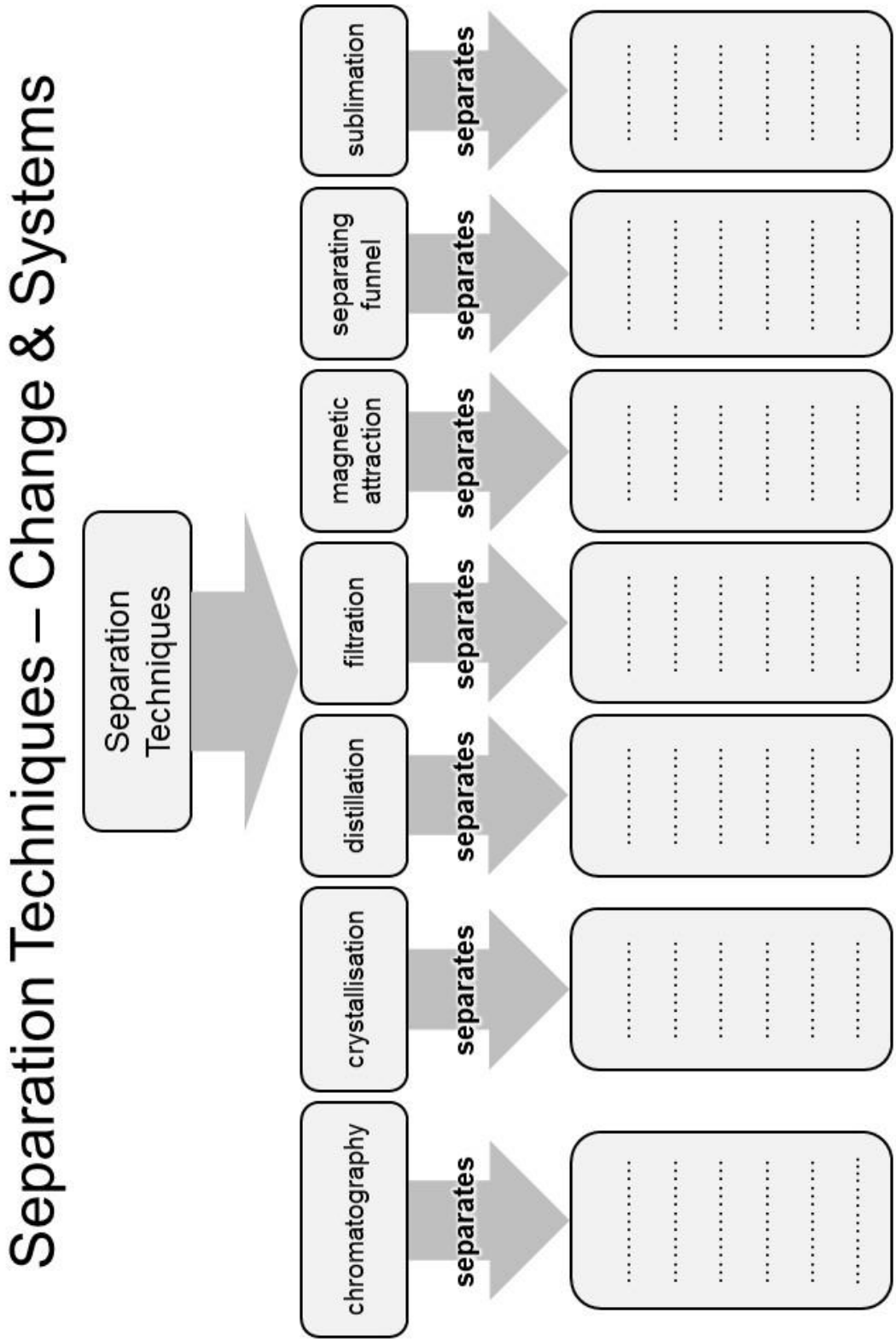
Self-check for Separation Techniques

- Tick the checkbox ☑ that best applies to your current situation. To give a truthful answer, think whether or not you could explain the answer to your friend. If you think that you need a little more help, then please consult your teacher.

Main Learning Objectives	Yes, I'm okay ☺	I need a little more help ☹
I understand why it is important to separate a mixture to obtain a pure substance.	☐	☐
I can give examples of where mixtures are separated in our everyday lives.	☐	☐
Knowing the components of a mixture, I can suggest the most suitable method to separate the mixture.	☐	☐
I understand the properties of a mixture that can be separated by *magnetic attraction*, and I know the principles behind how the separation technique works.	☐	☐
I understand the properties of a mixture that can be separated by *filtration*, and I know the principles behind how the separation technique works.	☐	☐
I understand the properties of a mixture that can be separated by *crystallisation*, and I know the principles behind how the separation technique works.	☐	☐
I understand the properties of a mixture that can be separated by *chromatography*, and I know the principles behind how the separation technique works.	☐	☐
I understand the properties of a mixture that can be separated by *simple distillation*, and I know the principles behind how the separation technique works.	☐	☐
I understand the properties of a mixture that can be separated using a *separating funnel*, and I know the principles behind how the separation technique works.	☐	☐
I understand the properties of a mixture that can be separated by *sublimation*, and I know the principles behind how the separation technique works.	☐	☐
I understand the properties of a mixture that can be separated by *reverse osmosis*, and I know the principles behind how the separation technique works.	☐	☐

Summary of Separation Techniques

- Complete the table below to give *general examples* of the types of chemicals that can be separated by each separation technique. For example, chromatography is essentially used to separate chemicals that have different solubilities in the same solvent.



QR Codes for Videos of the Different Separation Techniques

1. Magnetic Attraction https://youtu.be/uaMed_oml-Q	
2. Filtration https://youtu.be/w4UJur5EH1s	
3. Crystallisation https://youtu.be/LcMcODYtCLI	
4. Chromatography https://youtu.be/jl0ib6eFhNE	
5. Simple Distillation https://youtu.be/J1aAmhonF0s	
6. Separating Funnel https://youtu.be/iDzCm3EgNsU	
7. Sublimation https://youtu.be/YMP5s7cPvgo	

- Scan the QR code below for the answers to this assignment.

http://www.nygh.sg/lower_secondary_science/sec_one_science/sec_one_chemistry/separation_techniques/purification_worksheet_ans.pdf