Mixtures

4.1.1.2 · Atomic structure and the periodic table · revision notes

What a mixture is and the physical processes used to separate one: filtration, crystallisation, simple distillation, fractional distillation and chromatography. Questions ask you to choose a method for a given mixture, justify it and describe how to carry it out.

Key facts

- Mixture: two or more substances not chemically combined; each keeps its own properties
- Filtration: insoluble solid from a liquid (residue and filtrate)
- Simple distillation: solvent from a solution
- Chromatography: separates dissolved substances, e.g. dyes
- Physical separation: no chemical reaction, no new substances
- Crystallisation: soluble solid from a solution
- Fractional distillation: liquids with different boiling points
- Condenser: cools the vapour so it condenses back to a liquid

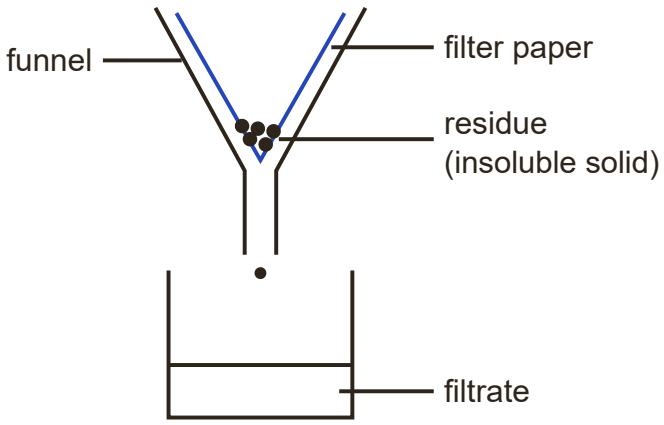
Notes

What a mixture is

- A **mixture** is two or more elements or compounds that are **not chemically combined** together.
- Each substance in a mixture keeps its own chemical properties. For example, iron filings mixed with sand are still attracted to a magnet.
- The amounts of each substance in a mixture can vary, unlike the fixed proportions in a compound. Air and sea water are mixtures.
- Mixtures are separated by **physical processes**. These do not involve chemical reactions, so no new substances are made.

Separating solids from liquids

- **Filtration** separates an **insoluble** solid from a liquid. The solid (the residue) stays on the filter paper; the liquid (the filtrate) passes through.

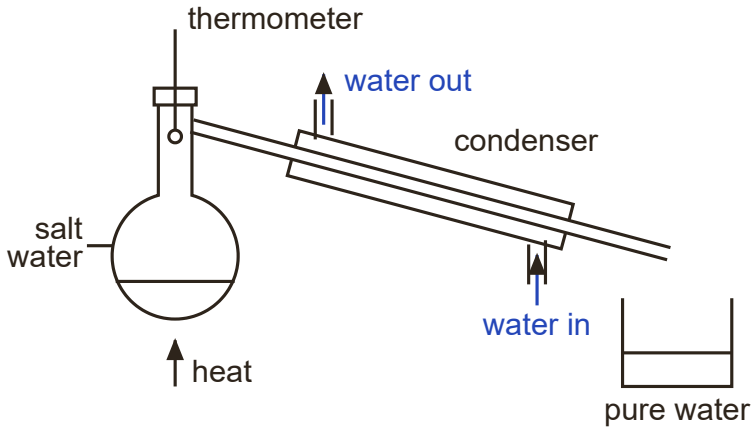


Filtration: the insoluble solid stays on the filter paper.

- **Crystallisation** gets a **soluble** solid out of a solution. Heat the solution to evaporate some of the water, then leave it to cool so crystals form. Filter off the crystals and dry them.
- Crystallisation gives better crystals than evaporating to dryness, and avoids breaking down solids that decompose when heated strongly.

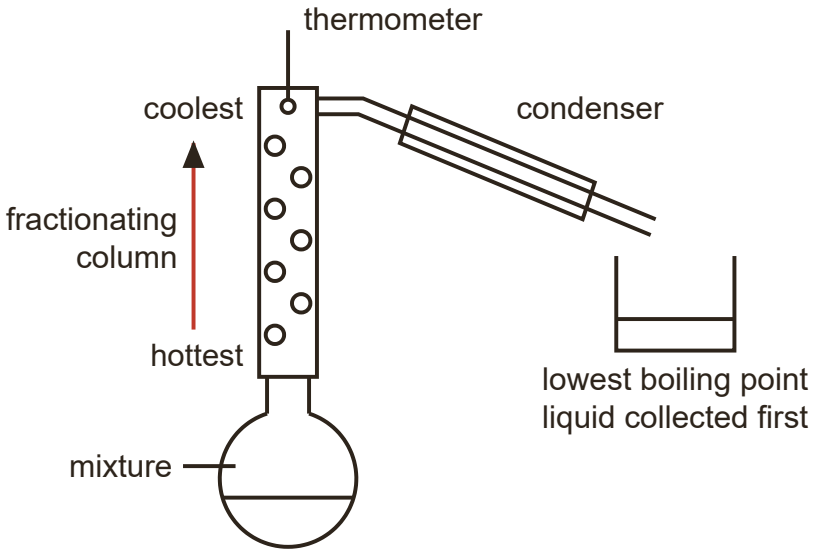
Separating liquids

- **Simple distillation** separates a solvent from a solution, e.g. pure water from salt water. The water boils, and its vapour is cooled in a **condenser**, where it condenses back to a liquid and is collected. The salt stays behind.



Simple distillation: the water boils, condenses in the condenser and is collected. The salt stays in the flask.

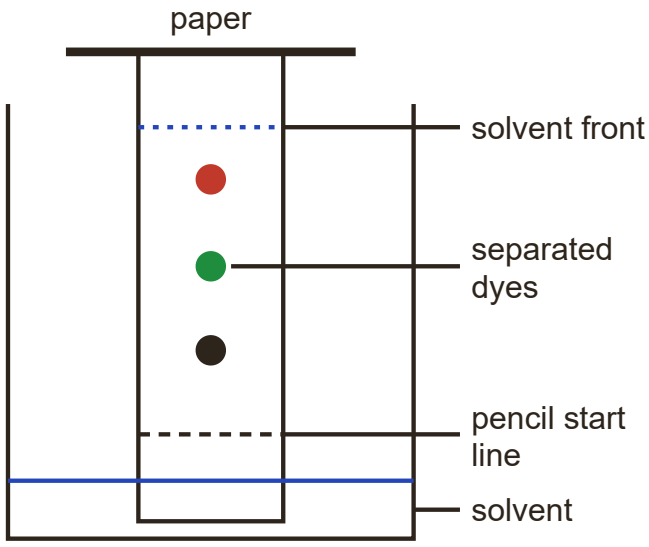
- **Fractional distillation** separates liquids that mix, but have **different boiling points**, e.g. ethanol and water, or the fractions in crude oil.
- A **fractionating column** is hottest at the bottom and coolest at the top. The liquid with the lowest boiling point reaches the top and is collected first; the thermometer reading rises when the next liquid starts to distil over.



Fractional distillation: the liquid with the lowest boiling point reaches the top first.

Chromatography

- **Chromatography** separates substances dissolved in a solvent, e.g. the dyes in an ink.
- The substances move different distances up the paper because they are attracted differently to the paper and to the solvent. (R_f values are covered in Chemical analysis.)



The start line is drawn in pencil, above the level of the solvent.

Choosing a method

- Insoluble solid and a liquid → filtration.
- Dissolved solid, and you want the solid → crystallisation.
- Dissolved solid, and you want the solvent → simple distillation.
- Liquids that mix, with different boiling points → fractional distillation.
- Several dissolved substances, e.g. coloured dyes → chromatography.
- Pure dry samples of both parts of salt and sand: stir the mixture in water so the salt dissolves, filter, wash the sand on the paper with water and dry it, then crystallise the salt from the filtrate.

How to answer each type of question

Suggest a separation method and give a reason 1 to 2 marks **Grade 4**

1. Decide what is in the mixture: insoluble solid, dissolved solid or liquids.
2. Decide what you want to keep.
3. Name the method and give the property it relies on: solubility or boiling point.

Example. A student has a mixture of sand and copper sulfate solution.
Name the method the student should use to remove the sand. Give a reason for your answer.

Model answer. Filtration (1). Sand is insoluble (in water), so it stays on the filter paper while the solution passes through (1).

Describe how to obtain pure crystals from a mixture

4 marks | Grade 5

1. Dissolve the soluble substance in water.
2. Filter to remove any insoluble substance.
3. Heat the filtrate to evaporate some water, then leave it to cool so crystals form.
4. Filter off the crystals and dry them.

Example. Rock salt is a mixture of sodium chloride and sand. Sodium chloride dissolves in water; sand does not.
Describe how you would obtain pure, dry crystals of sodium chloride from rock salt.

Model answer. Add the rock salt to water and stir so that the sodium chloride dissolves (1). Filter the mixture to remove the sand (1). Heat the filtrate to evaporate some of the water, then leave it to cool so that crystals form (1). Filter off the crystals and dry them between pieces of filter paper or in a warm oven (1).

Explain how distillation separates a mixture

2 to 3 marks | Grade 5

1. Say what boils (evaporates) and why the other substance does not.
2. Say that the vapour is cooled in the condenser.
3. Say that it condenses to a liquid, which is collected.

Example. Explain how simple distillation produces pure water from sea water.

Model answer. The water boils, but the dissolved salts do not because they have much higher boiling points (1). The water vapour passes into the condenser, where it is cooled (1). It condenses back to liquid water, which is collected (1).

Use boiling point data to choose a method

2 marks | Grade 5

1. If the liquids mix and have different boiling points, choose fractional distillation.
2. The liquid with the lower boiling point is collected first.

Example. Methanol (boiling point 65 °C) and water (boiling point 100 °C) mix completely.
Name the method used to separate them and state which liquid is collected first. Give a reason.

Model answer. Fractional distillation (1). Methanol is collected first because it has the lower boiling point (1).

Don’t lose marks

- ✗ Saying filtration separates salt from salt water. Dissolved substances pass straight through filter paper.
- ✗ Mixing up soluble (dissolves) and insoluble (does not dissolve). Filtration only removes an insoluble solid.

- Choosing evaporation when the question wants the solvent. Evaporating loses the water; distillation collects it.
- Saying that separating a mixture makes new substances or involves a chemical reaction.
- Describing crystallisation as heating until all the water has gone.

More tips

Memory tricks

- Ask two questions every time: does it dissolve, and what do I want to keep?
- Distil = boil, then condense. Fractional = more than one liquid to collect.
- The residue 'resides' in the filter paper; the filtrate 'filters through'.
- Condenser water goes in at the bottom and out at the top, so the condenser stays full of cold water.

Exam technique

- For 'describe how' questions, write the steps in order and name the equipment: beaker, filter funnel and paper, evaporating basin, condenser.
- Always justify a choice with a property: solubility for filtration and crystallisation, boiling point for distillation.
- Use the specification's names exactly: filtration, crystallisation, simple distillation, fractional distillation, chromatography.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3 — **Define a mixture**
Two or more elements or compounds that are not chemically combined together.

Grade 4 — **Match each separation method to its use**
Filtration, crystallisation, simple distillation, fractional distillation or chromatography, depending on what is in the mixture.

Grade 4 — **Describe filtration and crystallisation**
Filter off an insoluble solid; evaporate some water from a solution, then cool it so crystals of the dissolved solid form.

Grade 5 — **Describe simple distillation**
The solvent boils off, is cooled and condensed in a condenser, and is collected, leaving the dissolved solid behind.

Grade 5 — **Describe fractional distillation**
Liquids with different boiling points are separated using a fractionating column; the lowest boiling point liquid is collected first.

Grade 5 — **Choose a method from given data**
Use information about solubility and boiling points to choose and justify a separation technique.

Grade 5 — **Plan a separation with several steps**
Combine methods in a sensible order, e.g. dissolve, filter, then crystallise to get pure salt from rock salt.

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