IGCSE CHEMISTRY • EXERCISE SHEET

12.4 Separation and purification

Name: _____ Class: _____ Date: _____ **Total: 28 marks**

KEY WORDS filtration 过滤 • boiling point 沸点 • melting point 熔点 • distillation 蒸馏 • crystallisation 结晶

Objective

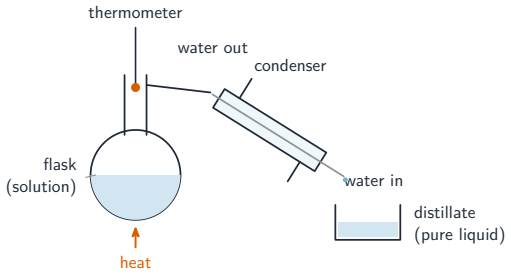
Build the skills to answer exam questions on **separation and purification** 分离与提纯 — choosing **filtration** 过滤, **crystallisation** 结晶, **distillation** 蒸馏, and checking purity.

You must be able to:

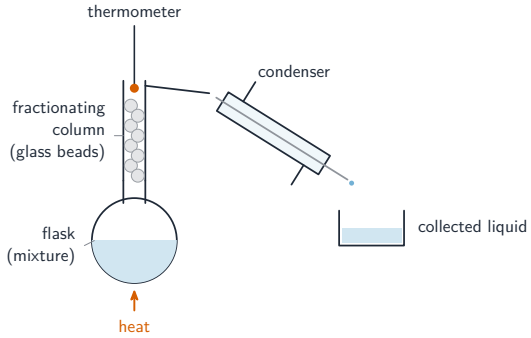
- choose the right method for a given mixture
- describe simple and fractional distillation
- check purity using melting and boiling points

1 Worked examples

Distillation methods



Simple distillation separates a solvent from a solution



Fractional distillation separates liquids with different boiling points

- filtration: insoluble solid from a liquid; crystallisation: soluble solid from solution.

Choosing the technique from what you are separating

Read the mixture, not the apparatus — the exam gives you a mixture and expects the method plus a reason.

You want to separate	Method	Why it works
an insoluble solid from a liquid	**filtration** 过滤	the solid is too large to pass through the filter paper's pores; the **residue** stays, the **filtrate** passes
a dissolved solid from its solution, keeping the solid	**crystallisation** 结晶	evaporate to the point of crystallisation, cool, then filter and dry — gentle enough not to decompose the solid
a solvent from a solution, keeping the liquid	**simple distillation** 蒸馏	the solvent boils, is condensed and collected; the solute stays behind
two miscible liquids with different boiling points	**fractional distillation** 分馏	the fractionating column lets the lower-boiling liquid pass while the higher-boiling one condenses and runs back
coloured or soluble substances in a mixture	**chromatography** 色谱法	each substance has a different attraction to the paper and the solvent, so each moves a different distance

Fractional distillation, in the order the marks come: heat the mixture; the liquid with the **lower boiling point** vaporises first; its vapour rises up the column

while any higher-boiling vapour condenses and falls back; the vapour passes into the condenser, is cooled and is collected as the first fraction; the temperature then rises and the second liquid distils.

Chromatography and R_f. Draw the pencil baseline **above** the solvent level, or the spots dissolve away. Then

$$R_f = \frac{\text{distance moved by the spot}}{\text{distance moved by the solvent front}}$$

R_f has **no units** and is always **less than 1**. Two substances with the same R_f in the same solvent are likely to be the same substance; a colourless spot is revealed with a **locating agent** or UV light.

Worked example. A spot moves 3.6 cm while the solvent front moves 8.0 cm. Find R_f, and state what it means if a known sample gives 0.45 on the same paper. $R_f = \dfrac{3.6}{8.0} = 0.45$. The two have the same R_f under the same conditions, so the unknown is likely to be that substance.

2 Practice

2.1 Name the method to separate an insoluble solid from a liquid. [1]

2.2 State how impurities affect the melting point of a substance. [1]

2.3 Name the method used to obtain pure water from sea water, and state the principle it relies on. [2]

2.4 Explain why the baseline in chromatography is drawn in pencil and above the solvent level. [2]

2.5 A spot travels 2.7 cm and the solvent front 9.0 cm. Calculate the R_f value. [2]

3 Exam-style questions

3.1 To separate two liquids with different boiling points, you would use: [1]

- **A** filtration
- **B** crystallisation
- **C** fractional distillation
- **D** chromatography

3.2 A student wants pure water from salty water.

(a) Name the method to use. [1]

(b) Describe how it separates the water from the salt. [2]

3.3 Explain how you could check that a sample of a solid is pure. [2]

3.4 A student is given a mixture of sand, salt and water, and separately a mixture of ethanol (b.p. 78 °C) and water.

(a) Name the method used to remove the sand, and state which part of the apparatus retains it. [2]

(b) Describe how the student would obtain solid salt from the remaining solution, and explain why crystallisation is preferred to boiling the solution dry. [3]

(c) Name the method used to separate the ethanol from the water, and describe how it works. [4]

(d) State which liquid is collected first and explain why. [2]

(e) The student also uses chromatography on a food dye. One spot moves 4.4 cm while the solvent front moves 8.0 cm. Calculate the R_f value and state what could be concluded if a known dye gives the same value. [3]

Solutions

2.1 filtration.

2.2 impurities lower the melting point.

2.3 Simple distillation; the water boils, is condensed and collected, while the dissolved salts remain behind because their boiling points are far higher.

2.4 Pencil, because ink would itself dissolve and separate in the solvent; above the solvent level, so the spots are not washed off into the solvent instead of travelling up the paper.

2.5 $R_f = \dfrac{2.7}{9.0} = 0.30$.

3.1 **C**. Fractional distillation separates liquids with different boiling points.

3.2 (a) simple distillation.
(b) the water boils off and is cooled back to a liquid in the condenser; the salt is left behind in the flask.

3.3 measure its melting (or boiling) point; a pure substance melts at a sharp, fixed temperature, while impurities lower it / give a range.

3.4 (a) Filtration; the sand is left in the filter paper as the residue.
(b) Heat the solution to evaporate some of the water until the point of crystallisation, then leave it to cool so crystals form, and filter and dry them; crystallisation is preferred because boiling dry can decompose the solid or leave impurities behind with it.
(c) Fractional distillation; the mixture is heated and the ethanol, which has the lower boiling point, vaporises first; its vapour passes up the fractionating column while any water vapour condenses and runs back down; the ethanol vapour is then cooled in the condenser and collected.
(d) Ethanol, because its boiling point of 78 °C is lower than water's 100 °C, so it vaporises and distils over first.
(e) $R_f = \dfrac{4.4}{8.0} = 0.55$; if a known dye gives the same R_f under the same conditions, the unknown is likely to be that same dye.