

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

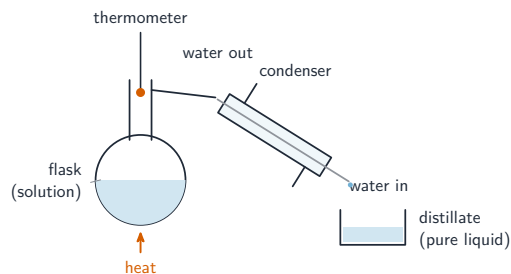
Build the skills to answer exam questions on **separation and purification** 分离与提纯 — choosing **filtration** 过滤, **crystallisation** 结晶, **distillation** 蒸馏, and checking purity.

You must be able to:

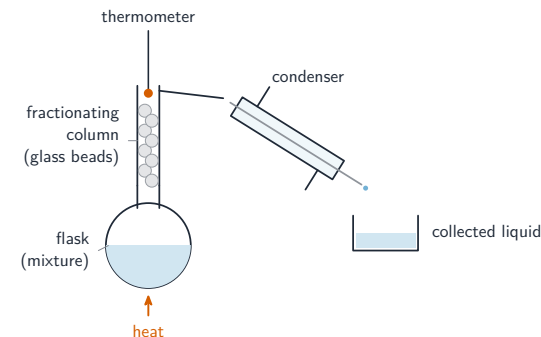
- choose the right method for a given mixture
- describe simple and fractional distillation
- check purity using melting and boiling points

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.

$R_f = \frac{3.6}{8.0} = 0.45$. 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	B
C	D

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]