Mixtures and Separation of Mixtures (Advanced)

Standard difficulty · 20 questions · 40 marks · Time: 36 minutes

Name: _____ Date: _____ Score: ____ / 40

Show your working for Sections B and C. Answers are on the last page — try every question first!

Section A — Choose the correct answer 8 × 1 = 8 marks

1. Methanol (b.p. 65 °C) and water (b.p. 100 °C) mix completely. The best way to separate them is:
   (a) fractional distillation **(b)** simple distillation
   (c) using a separating funnel **(d)** filtration

2. A mixture of ethanol (b.p. 78 °C) and toluene (b.p. 111 °C) is distilled. Which collects first in the receiver?
   (a) ethanol **(b)** neither: they cannot be separated
   (c) both together **(d)** toluene

3. A mixture of three dyes is separated on a silica gel column. How strongly each is held by the silica gel (1 weakest, 9 strongest): brown 8, pink 4, orange 1. Which dye comes out of the column first?
   (a) the brown dye **(b)** the pink dye
   (c) all three together **(d)** the orange dye

4. In a refinery's fractionating column, which of these fractions is collected highest up?
   (a) lubricating oil **(b)** kerosene
   (c) petroleum gas **(d)** diesel

5. Chromatography was first developed in 1906 by:
   (a) Mikhail Tswett **(b)** Antony van Leeuwenhoek
   (c) Robert Hooke **(d)** J. J. Thomson

6. A mixture of octane (b.p. 126 °C), benzene (b.p. 80 °C), toluene (b.p. 111 °C) is separated by fractional distillation. In what order are they collected?
   (a) benzene, octane and toluene **(b)** octane, toluene and benzene
   (c) toluene, benzene and octane **(d)** benzene, toluene and octane

7. 300 mL of a mixture of ethanol and water gives 155 mL of ethanol on distillation. The percentage of ethanol by volume in the mixture was: (Give the answer to 2 decimal places where needed.)
   (a) 155% **(b)** 48.33% **(c)** 51.67% **(d)** 106.90%

8. Assertion (A): Methanol (b.p. 65 °C) and ethanol (b.p. 78 °C) can be separated well by simple distillation. Reason (R): Simple distillation works when boiling points differ by at least 25 °C; closer boiling points need a fractionating column.
   (a) Both A and R are true, and R is the correct explanation of A.
   (b) Both A and R are true, but R is not the correct explanation of A.
   (c) A is true, but R is false.
   (d) A is false, but R is true.

Section B — Short answer — 8 × 2 = 16 marks

9. Name the method you would use to separate benzene (b.p. 80 °C) from toluene (b.p. 111 °C), which mix completely.

10. Methanol boils at 65 °C and water at 100 °C. Find (a) the difference in their boiling points and (b) which liquid distils over first.

11. Three dyes are separated on an alumina column. How strongly each sticks to the alumina (1 weakest, 9 strongest): pink 8, orange 2, brown 4. List the dyes in the order they come out of the column.

12. A 420 mL sample of a mixture of ethanol and water gives 206 mL of ethanol by fractional distillation. Find the percentage of ethanol by volume. (Give the answer to 2 decimal places where needed.)

13. A mixture of ethanol and toluene contains 53% ethanol by volume. How many mL of ethanol can be collected from 810 mL of it?

14. A mixture of octane (b.p. 126 °C), toluene (b.p. 111 °C), benzene (b.p. 80 °C) is heated in a fractional distillation set-up. The thermometer stays steady at three temperatures in turn. Which liquid is being collected at the second steady reading?

15. List these crude oil fractions from the top of the fractionating column to the bottom: fuel oil, petroleum gas, diesel.

16. A column separates a mixture into 11 mg of compound A and 95 mg of compound B, with nothing lost. What percentage of the mixture, by mass, was A? (Give the answer to 2 decimal places where needed.)

Section C — Word problems — 4 × 4 = 16 marks

17. A mixture of heptane (b.p. 98 °C) and octane (b.p. 126 °C) is to be separated. (a) What is the difference in their boiling points? (b) Name the best method. (c) Which liquid is collected first? (d) Explain why repeated condensation and vaporisation in a fractionating column improves separation.

18. A mixture contains 23 mL of chloroform (b.p. 61 °C), 89 mL of benzene (b.p. 80 °C), 64 mL of toluene (b.p. 111 °C). (a) List the liquids in the order they are collected. (b) What is the smallest difference between two of the boiling points? (c) What percentage of the mixture, by volume, is benzene? (Give the answer to 2 decimal places where needed.)

19. In column chromatography of a dye mixture, how strongly each dye is held by the stationary phase is (1 weakest, 9 strongest): brown 4, blue 2, green 6. (a) Name a solid used as the stationary phase. (b) Which dye comes out first? (c) Which comes out last? (d) What is the liquid poured through the column called?

20. Fractional distillation of 130 litres of crude oil gives 39 L of diesel, 21 L of fuel oil, 40 L of lubricating oil, and the rest is residue. Find (a) the percentage of diesel and (b) the percentage of lubricating oil. (c) Which of these three fractions is collected highest in the column? (Give the answer to 2 decimal places where needed.)

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Answer key

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Q	Answer	Working
1	**(b) simple distillation**	the boiling points differ by 35 °C, which is at least 25 °C
2	**(a) ethanol**	the liquid with the lower boiling point, 78 °C, vaporises first
3	**(d) the orange dye**	the least strongly adsorbed component moves fastest with the solvent
4	**(c) petroleum gas**	the column is hottest at the bottom: the lowest boiling fraction condenses at the top
5	**(a) Mikhail Tswett**	he separated plant pigments
6	**(d) benzene, toluene and octane**	in order of increasing boiling point
7	**(c) 51.67%**	155 ÷ 300 × 100
8	**(d) A is false, but R is true.**	A is false: they differ by 13 °C, less than 25 °C, so fractional distillation is needed. R is true.
9	**simple distillation**	difference 31 °C: at least 25 °C
10	**(a) 35 °C; (b) methanol**	(a) 100 − 65; (b) the lower boiling point
11	**orange, brown, pink**	weakest adsorbed first, strongest last
12	**49.05%**	206 ÷ 420 × 100
13	**429.3 mL**	53% of 810 = 53 × 810 ÷ 100
14	**toluene**	steady readings come at the boiling points in increasing order: 80, 111, 126 °C
15	**petroleum gas, diesel, fuel oil**	the lower the boiling point, the higher up the fraction condenses
16	**10.38%**	11 ÷ (11 + 95) × 100
17	**(a) 28 °C; (b) simple distillation; (c) heptane; (d) each time the vapour condenses and boils again on the column's surfaces it becomes richer in the lower-boiling liquid, so the vapour reaching the condenser is nearly pure**	(a) 126 − 98; (b) at least 25 °C; (c) lower boiling point
18	**(a) chloroform, benzene, toluene; (b) 19 °C; (c) 50.57%**	(a) increasing boiling point; (b) 80 − 61 and 111 − 80; (c) 89 ÷ 176 × 100
19	**(a) silica gel (or alumina); (b) blue; (c) green; (d) eluent**	the solvent (mobile phase, the eluent) carries the least adsorbed dye fastest
20	**(a) 30%; (b) 30.77%; (c) diesel**	(a) 39 ÷ 130 × 100; (b) 40 ÷ 130 × 100; (c) the lowest boiling point rises highest

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