Chromatography

AQA 7405 · A level

Show your working where needed. Check the worked answers when you finish.

Name _____ Date _____

1. Calculate a retention factor

From the pencil baseline, a spot moves 3.2 cm and the solvent front moves 8.0 cm. Calculate the Rf value and state whether it has units.

2. Check a TLC setup

A student draws the starting line on a TLC plate with a pen, adds the samples and stands the plate in solvent. The solvent initially covers the spots. Explain two changes to the setup that would improve the chromatogram.

3. Explain different retention factors

Substances A and B have Rf values 0.33 and 0.75 on the same TLC plate. A student claims B interacts more strongly with the stationary phase relative to the solvent. Use the results to assess the claim.

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4. Compare with a standard

An unknown mixture gives spots at Rf 0.28 and 0.59. A pure standard run on the same plate under the same conditions gives Rf 0.59. State the strongest conclusion supported by this evidence.

5. Read a gas chromatogram

An unknown gives peaks at 2.3, 4.7 and 6.2 min. In the same conditions standards X and Y give retention times of 2.3 and 6.2 min respectively. Identify any possible matches and explain why the two matching peaks have different retention times.

6. Compare two fractions from a column

A mixture of X and Y runs through a column with a solid stationary phase and a liquid solvent. X appears in a fraction collected before Y. Use the relative attractions to the two phases to explain the order.

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7. Identify components with GC-MS

A gas chromatogram has peaks P and Q, with molecular ions at m/z 46 and 60 respectively. The candidates are ethanol (M_r 46) and two isomeric alcohols A and B (both M_r 60).

Under the same conditions, standard A elutes at 3.9 min and standard B at 5.1 min. Q elutes at 5.1 min. Suggest the best match for P and Q and explain why both techniques are useful.

8. Choose a technique for each stage

A chemist wants to compare an ink with four available standards, and to separate a mixture of two volatile liquids before measuring the masses of their molecular ions. Choose a technique for each task and explain your choices.

9. Extra challenge · Use two separations and mass evidence

A sample and a pure reference are run in separate lanes on one TLC plate. Each lane shows one spot 1.8 cm from the baseline. The solvent front has moved 6.0 cm.

The volatile sample gives GC peaks at 3.1 and 5.7 min. The reference elutes at 5.7 min. Both sample peaks have molecular-ion m/z 88. Calculate the matching Rf, explain how the two GC observations help, and state the limit of the identification.

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Worked answers

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1. Calculate a retention factor

Rf = distance moved by the spot ÷ distance moved by the solvent front = 3.2 ÷ 8.0 = 0.40. The ratio has no units.

2. Check a TLC setup

Lower the solvent level below the sample spots. If covered, the samples can wash into the solvent reservoir.

Draw the baseline in pencil because graphite stays in place. Some components of pen ink may travel with the solvent and give extra spots.

3. Explain different retention factors

A is retained more strongly relative to its attraction to the solvent. It has the lower Rf and spends a greater proportion of its time retained by the stationary phase.

4. Compare with a standard

One component could be the standard. Matching Rf values under the same conditions support that identification. Different compounds can give the same Rf, so a further separating system or technique can strengthen the identification.

5. Read a gas chromatogram

The first peak is consistent with X and the last is consistent with Y. The 4.7 min peak has no supplied match. The later-eluting component spends a greater fraction of its journey retained by the stationary phase.

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Worked answers

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6. Compare two fractions from a column

X spends more of its time in the moving solvent relative to Y, so it travels faster. Y spends a greater fraction of its time interacting with the stationary phase.

7. Identify components with GC-MS

The molecular-ion m/z of P is consistent only with ethanol from the given candidates. Q has the right m/z for either isomeric alcohol.

Q matches standard B's retention time. Chromatography separates the mixture and helps distinguish the two candidates with the same molecular-ion m/z.

8. Choose a technique for each stage

TLC compares the ink spots and standards under identical conditions. GC separates the volatile components as they travel through the column, and the mass spectrometer can then give mass evidence for each separated component.

9. Extra challenge · Use two separations and mass evidence

The matching Rf is 1.8 ÷ 6.0 = 0.30. The TLC system does not distinguish two substances that migrate the same distance.

GC evidence supports the presence of two components. Their shared molecular-ion m/z cannot distinguish the structures. The 5.7 min peak is consistent with the reference under the same conditions, while the 3.1 min peak has a different retention time. Matching measurements support the identification, and one match alone cannot prove molecular structure.

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