8.1 Purity, formulations and chromatography

Name: _____ Class: _____ Date: _____ **Total: 30 marks**

KEY WORDS pure substance • formulation • chromatography

Objective

Use purity evidence, recognise formulations and interpret chromatography. Original questions and authored marking guidance for 4.8.1.1–4.8.1.3, both tiers. Actual supervised RP6 is recorded separately.

1 Key knowledge and worked examples

A **pure substance** is one element or compound. Compare its sharp transition with a reference under the same conditions; a lower/broader melting interval often indicates impurity. One matching temperature supports an inference, not unique proof of identity. A **formulation** is a useful mixture with measured components serving stated purposes.

Chromatography separates substances because they distribute differently between the stationary phase (paper in this GCSE model) and the mobile phase (solvent). Draw a pencil baseline above the solvent. Apply small spots; run the solvent; mark its front immediately. Measure from the same baseline to the spot centre and to the front.

$$R_f = \frac{\text{spot distance}}{\text{front distance}}$$

Worked method. Spot 3.6 cm, front 6.0 cm gives Rf = 3.6 cm ÷ 6.0 cm = 0.60, with no unit. Compare references under the same conditions. Two spots show at least two detected components. One spot can hide substances travelling together; a second solvent can help.

Worked product decision. A cleaner contains a measured amount of detergent to remove grease and perfume for scent. It is a formulation because the components and proportions were chosen for useful properties, not simply because it contains more than one substance.

2 Practice

2.1 State one melting behaviour that often indicates impurity in a solid. [1]

2.2 Give two examples of formulations. [2]

2.3 A chromatography run uses water as the solvent. Which phase is the moving water? [1]

2.4 A pencil baseline is 1.0 cm above the bottom edge. A spot centre is 4.2 cm above that edge and the solvent front is 9.0 cm above it. Calculate Rf, showing both corrected distances. [3]

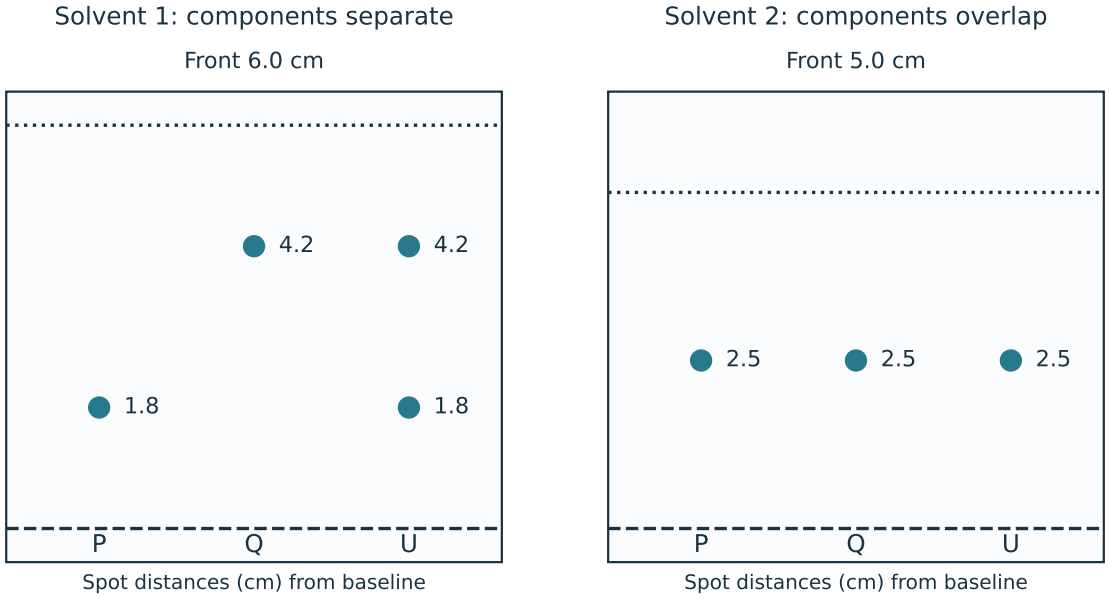
3 Exam-style questions

3.1 A reference solid melts at 80.0 °C. Under the same conditions A melts at 79.8–80.2 °C and B at 72.0–78.0 °C. Explain which sample appears purer and one limit of the conclusion. [3]

3.2 Describe how to separate ink dyes by paper chromatography and explain their different travel distances. Include two choices that prevent misleading extra/lost spots. [5]

3.3 X gives two spots in one solvent. Explain what this shows and why a single spot in another solvent would not prove X pure. [3]

3.4 These fictional references and unknown are run under identical conditions within each panel. Identify the detected components of U and explain the apparently different spot count in solvent 2. [4]



3.5 A 200 g paint formulation uses 12% pigment and 8% binder; the rest is solvent. Calculate pigment and solvent masses and explain why the proportions matter to a useful product. [4]

3.6 A student reports Rf = 1.4 and concludes that a colourless component is absent because it made no visible spot. Identify a problem in each claim and suggest a suitable improvement for each. [4]

Solutions

2.1 A wider melting interval, or a lower melting temperature relative to the pure reference (any one B1). Compare under the same conditions; neither is a universal rule for every mixture.

2.2 Any two useful designed mixtures: fuels, cleaners, paints, medicines, alloys, fertilisers, foods. Not every accidental mixture is a formulation.

2.3 Mobile phase.

2.4 Spot distance = 4.2 − 1.0 = 3.2 cm; front distance = 9.0 − 1.0 = 8.0 cm; Rf = 3.2/8.0 = **0.40**, no unit. Dividing 4.2 by 9.0 uses the wrong origin.

3.1 A appears purer because its interval is narrow and close to the reference; B's lower, wider interval supports impurity; another substance could have a similar transition, so A's result alone does not uniquely identify it/prove absolute purity.

3.2 Pencil baseline and small sample spots; solvent surface below baseline to avoid dissolving samples into the reservoir; solvent rises through paper and carries dissolved components; different distributions between mobile and stationary phases give different distances; mark solvent front promptly before it evaporates, retaining valid distance data. Accept cleaning/reference control as a sensible additional improvement; do not replace the separation explanation with particle mass alone.

3.3 At least two detected substances in X. In another solvent the components may move together; one observed spot therefore does not prove purity, although a pure compound gives one spot in suitable solvents.

3.4 U's solvent-1 spots match P at 1.8/6.0 = 0.30 and Q at 4.2/6.0 = 0.70. In solvent 2 both references travel 2.5/5.0 = 0.50 and overlap, so U's single spot is consistent with both components rather than proof of purity. Matching references supports identification within the given possibilities.

3.5 Pigment = 0.12 × 200 g = **24 g**. Solvent share = 100 − 12 − 8 = **80%**, so mass = 0.80 × 200 g = **160 g**. Measured proportions control useful properties such as coverage/adhesion/flow; simply mixing arbitrary quantities may not give the intended paint. Check binder 16 g, and 24 + 16 + 160 = 200 g.

3.6 Rf above 1 conflicts with a spot remaining behind the solvent front; remeasure both distances from the same baseline to spot centre/front, then divide spot by front. A colourless substance may be present but undetected visually; use an appropriate supplied detection method/another suitable analytical test rather than infer absence. No specific unintroduced locating reagent is required.