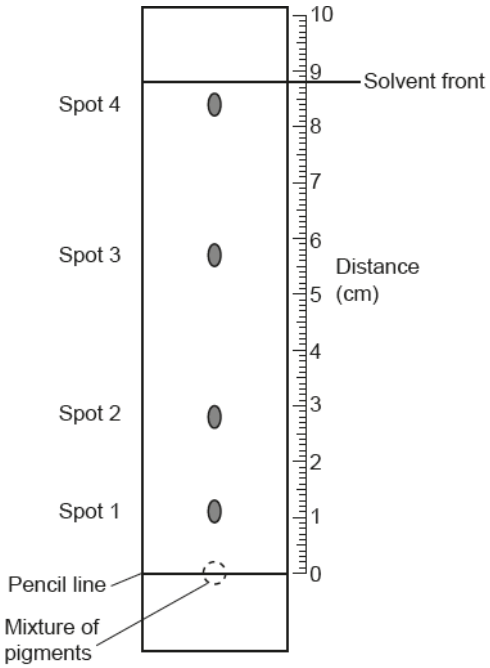
1. * A student wants to find out which pigments are in a plant.

She does a chromatography experiment on a sample from the plant.

Look at her results.



Distance to **spot 1**	= 1.1 cm
Distance to **spot 2**	= 2.8 cm
Distance to **spot 3**	= 5.7 cm
Distance to **spot 4**	= 8.4 cm

The R_f values for some pigments are shown in the table.

Pigment	Rf value
A	0.95
B	0.45
C	0.32
D	0.25
E	0.15

Calculate the R_f value for each spot.

Describe and explain which pigments are in the sample from the plant and suggest why further analysis of the plant pigments is needed.

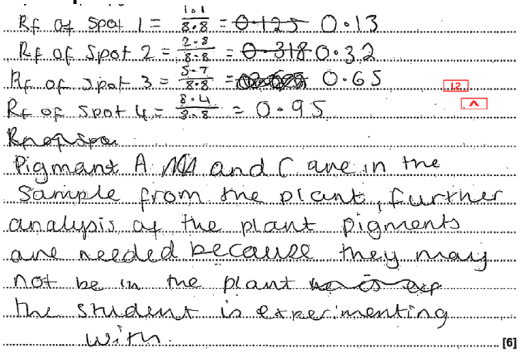
---

[6]

END OF QUESTION PAPER

Question			Answer/Indicative content	Marks	Guidance
1			**Level 3 (5–6 marks)** Demonstrates knowledge of the formula for Rf and applies knowledge and understanding to calculate all Rf values correctly. **AND** Correctly analyses the results obtained and assigns spots to pigments. **AND** Analyses the results to suggest why further analysis of the plant pigments is needed *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Demonstrates knowledge of the formula for Rf and applies knowledge and understanding to calculate most of the Rf values correctly. **AND** Correctly analyses the results obtained and assigns at least 2 spots to pigments. *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.* **Level 1 (1–2 marks)** Demonstrates knowledge of the formula for Rf and applies knowledge and understanding to calculate some of the Rf values correctly. **OR** Analyses their results to suggest why further analysis of the plant pigments is needed *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** *No response or no response worthy of credit.*	6 (AO1 × 1.2) (AO1 × 2.2) (AO2 × 3.2b) (AO2 × 3.3b)	**AO1.2 Demonstrates knowledge of the formula to calculate Rf values.** $R_f = \frac{\text{distance to spot}}{\text{distance to solvent front}}$ **AO2.2 Applies knowledge and understanding of formula to calculate Rf values for the 4 spots** At L1 & L2 **IGNORE** rounding errors **AO3.2b Analyses information to draw conclusions about the pigments:** Spot 1 = Could be Pigment E, because it is closest but cannot confirm, as Rf value does not match exactly. Spot 2 = Pigment C Spot 3 = unknown Spot 4 = Pigment A **AO3.3b Analyses information to identify improvements that could be made in order to identify spot 3.** Look up Rf values of other pigments in order to match to spot 3 Further investigation needed if Rf value not found Examiner's Comments Some candidates knew how to calculate Rf values and made a reasonable attempt to state the Rf formula and to calculate some or all of the Rf values correctly. Rounding errors stopped some candidates accessing higher levels. Not all identified pigments A and C, although some knew they were present but did not link them to spots in the chromatogram. A few higher ability candidates accessed Level 3 by explaining

Spot	Rf value	Allow
1	0.13	0.125
2	0.32	0.318 / 0.3182
3	0.65	0.648 / 0.6477
4	0.95	0.955 / 0.9545

Question	Answer/Indicative content	Marks	Guidance
			that spot 3 did not relate to any of the known pigments that had been tested, but most did not realise that the identity of spot 1 is ambiguous as its Rf value did not match any pigments exactly. Most simply restated the stem of the question to say that further analysis is needed, but did not clearly suggest why or what should be done. Virtually no one suggested looking up the Rf values of other pigments. Many candidates did not attempt this question, and some just wrote irrelevant facts about plant pigments used for photosynthesis. Some candidates gained little credit as they were unable to present their answers in a coherent and logical way. **Exemplar 1**  Rf of spot 1 = $\frac{1.1}{8.8}$ = ~~0.125~~ 0.13 Rf of spot 2 = $\frac{2.8}{8.8}$ = ~~0.318~~ 0.32 Rf of spot 3 = $\frac{5.7}{8.8}$ = ~~0.648~~ 0.65 Rf of spot 4 = $\frac{8.4}{8.8}$ = 0.95 ~~Reason~~ Pigment A and C are in the sample from the plant, further analysis of the plant pigments are needed because they may not be in the plant ~~as~~ as the student is experimenting with. [6] This candidate has measured the solvent front accurately and used the Rf formula to calculate all four Rf values correctly. They have analysed the information to conclude that pigments A and C were in the sample. However, they have not explained which spots they relate to on the chromatogram. They state that further analysis is needed (as given in the stem of the question), but have not made any relevant suggestions as to why this is necessary. This response was credited Level 2 with 3 marks. With improved communication to link spot 4 to pigment A, and spot 2 to pigment C the candidate would have been credited Level 2 with 4 marks.
	Total	6	