1. Some people have warts on their skin.

Warts can be removed by treating them with a corrosive solution of acids.

Ellen uses chromatography to find out what acids are in a medicine used to treat warts.

She needs to use a locating agent on her chromatogram.

Explain why a locating agent is needed.

--- [2]

2(a). Eve works in a laboratory where food dyes are tested.

Some dyes are banned because they are known to be harmful.

Eve is going to test a jelly that will be exported to the USA.

Below is a table of the Rf values of dyes. The first four are banned in the USA.

Food dye	Rf value in 1.755 g/dm^3 sodium chloride solution
Yellow 5	0.71
Blue 2	0.22
Yellow 6	0.52
Red 3	0.10
Red 40	0.25
Blue 1	0.88

Eve prepares a chromatogram of the jelly.

(i) Calculate what concentration of sodium chloride in mol/dm^3 she needs to use.

concentration of sodium chloride _____ mol/dm^3 **[2]**

(ii) Describe how Eve should set up her chromatography experiment of the jelly.
You may use a diagram in your answer.

---

[4]

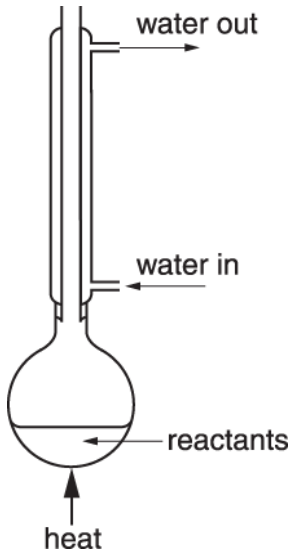
(b). * Eve's finished chromatogram is shown below.

Explain the conclusions Eve can make about the jelly. Include what she could do to increase the confidence in her conclusions.

---

[6]

3(a). Sue makes an ester by heating the reactants together using this apparatus.



Why did Sue fit a vertical condenser to the flask?

---

[3]

(b). After the reaction the mixture is not pure.

Sue carries out two further stages.

- She separates the ester from the reaction mixture.
- She purifies the ester.

How does she do each stage?

---

[2]

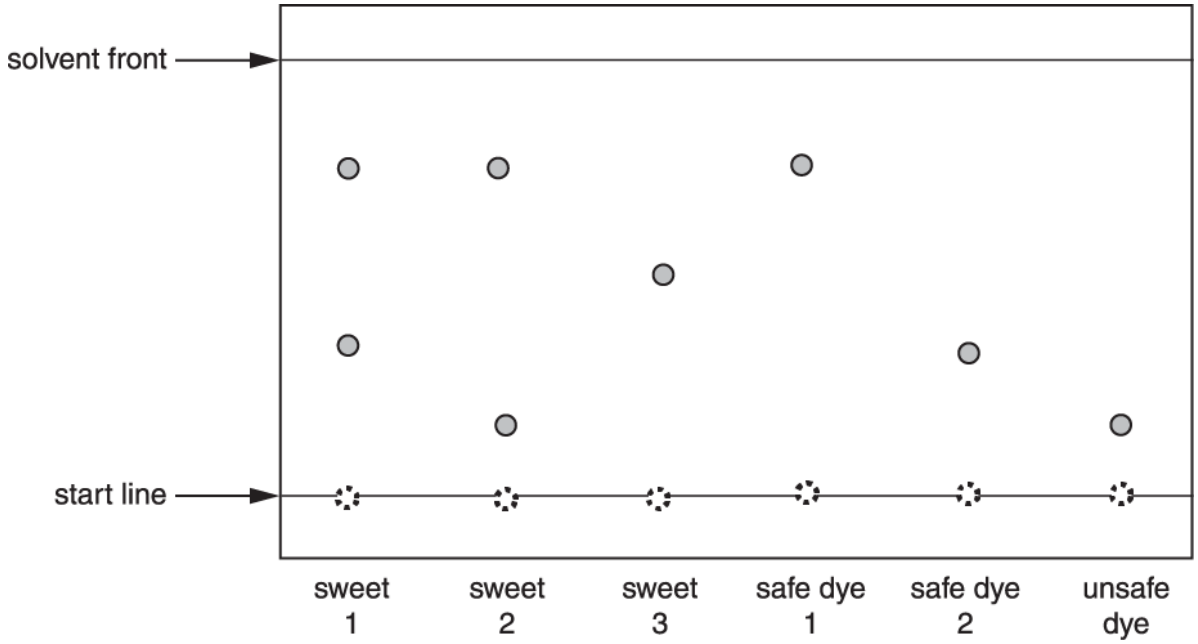
4(a). Alex uses chromatography to analyse the food dyes used in a packet of sweets.

The packet contains three different coloured sweets.

Alex tests one sweet of each colour.

He uses two known safe food dyes and one known unsafe dye as references.

Here is the chromatogram showing his results.



How many different dyes have been used in the three sweets?

---

[1]

(b). Alex looks at the results and makes this statement:

'The results show that it is possible that two of the sweets contain an unsafe dye.'

Explain how the results of the chromatogram support Alex's conclusion.

---

[2]

(c). Alex decides to calculate the *Rf* of safe dye 1.

What measurements does he need to make from the chromatogram to use in his calculation?

---

[2]

(d). Alex also uses chromatography to identify the **flavourings** used in the sweets.

He sprays his chromatogram with a locating agent.

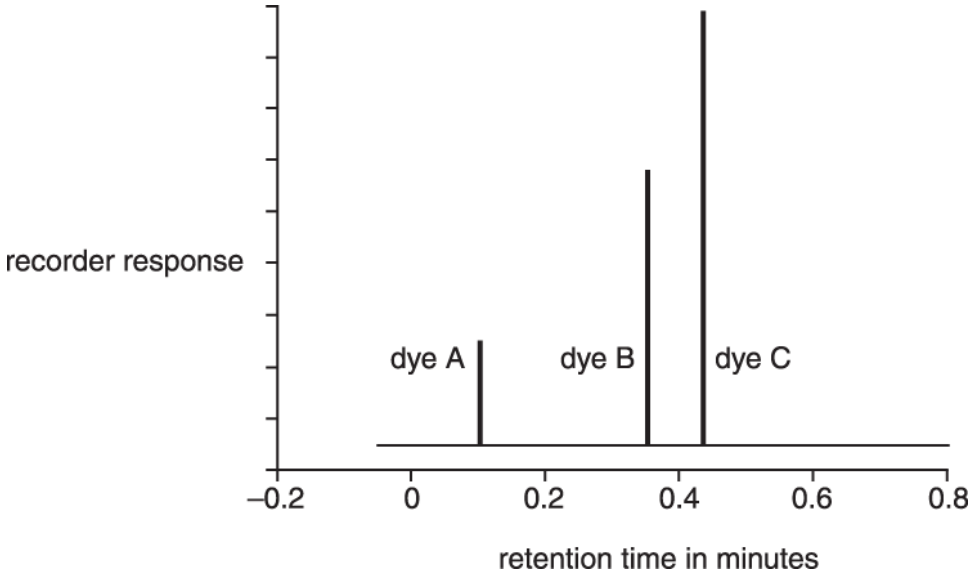
Why does Alex need to use a locating agent?

---

[1]

(e). Alex uses a chromatography machine to analyse the food dyes from a different type of sweet.

This is the printout he gets.



(i) The printout shows that three dyes have been used in the sweet.

Which dye has been used in the largest quantity?

Explain how you can tell.

[2]

(ii) Alex wants to identify dye A.

He uses data from the chromatography printout.

He also uses data from printouts for known dyes.

How does he use the data to identify dye A?

[2]

(iii) Alex says that the chromatography printout gives both **qualitative** and **quantitative** information about the dyes used in the sweet.

Explain why this is true.

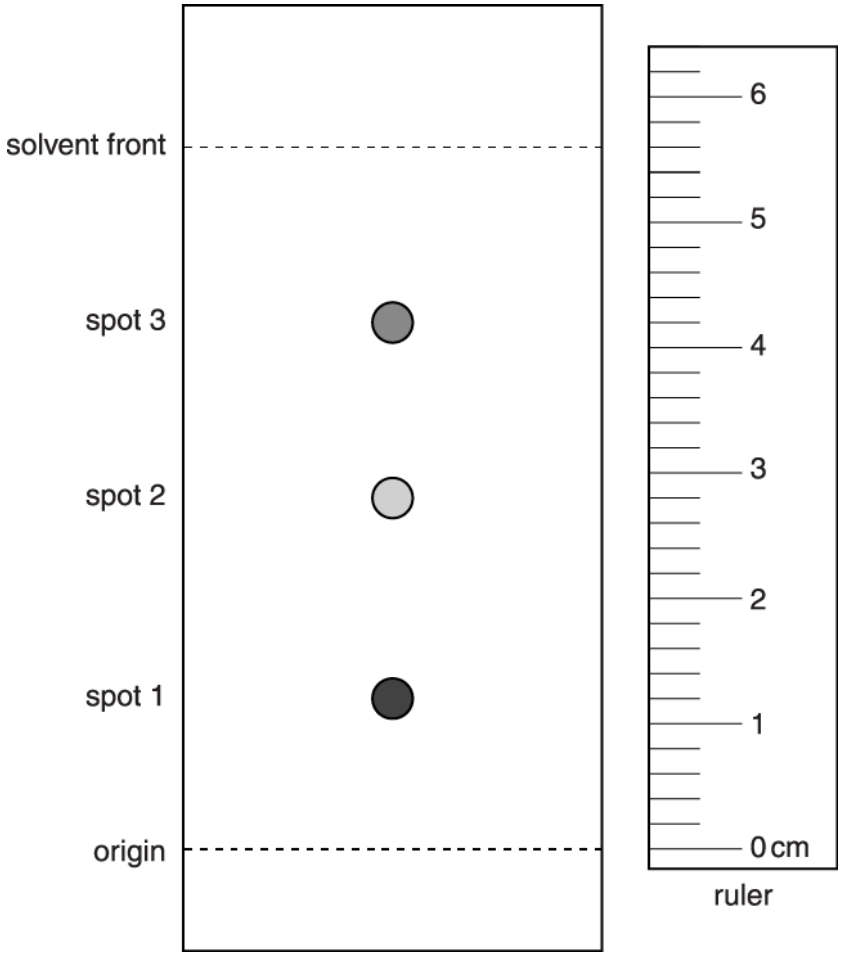
[2]

5(a). Peter is testing the food colourings in soft drinks made by different companies.

He wants to find out if any of these drinks contains a banned dye chemical.

Peter uses paper chromatography to separate and identify the dye chemicals in the soft drinks.

Here is Peter's chromatogram for one of the soft drinks.



Explain why the three spots travel different distances up the chromatogram.

The quality of written communication will be assessed in your answer.

_____

_____

_____

_____

_____

_____

_____ [6]

(b). Peter uses Rf values to identify the dye chemicals in a soft drink.

(i) Work out the Rf value of spot 3.

Rf value = _____ [2]

(ii) Peter finds the Rf values for dye chemicals in several different soft drinks.

How can Peter check if any of the soft drinks contain a banned dye chemical?

_____

_____

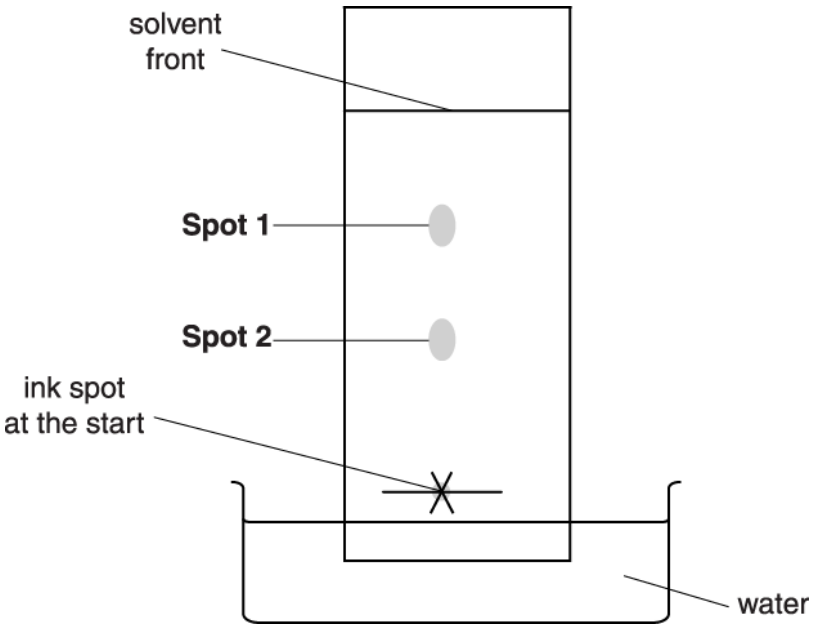
_____

_____ [2]

6(a). Ben uses paper chromatography to analyse the ink from his pen.

He puts the bottom of the paper in water and leaves it for a few hours.

The diagram shows his result.



Calculate the *Rf* value for **Spot 1**.

Show your working.

Rf for **Spot 1** = _____ [3]

(b). Ben knows that chromatography depends on the attractions between the ink, the solvent and the paper.

Explain why **Spot 1** and **Spot 2** end up in different places.

The quality of written communication will be assessed in your answer.

---

[6]

(c). Thin-layer chromatography can be used instead of paper chromatography.

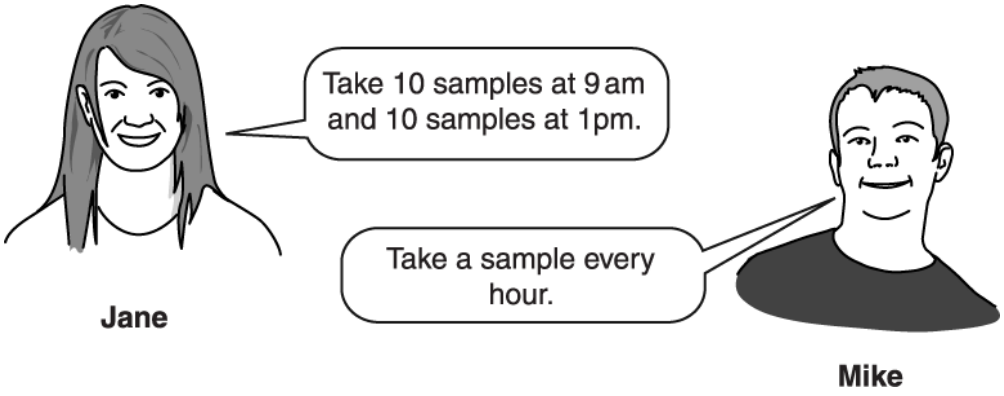
Give **one** similarity and **one** difference between the two methods.

---

[2]

(d). A factory makes ink. The ink is made continuously throughout the day.
Chromatography is used to test samples of the ink.

Jane and Mike discuss how to take the samples.

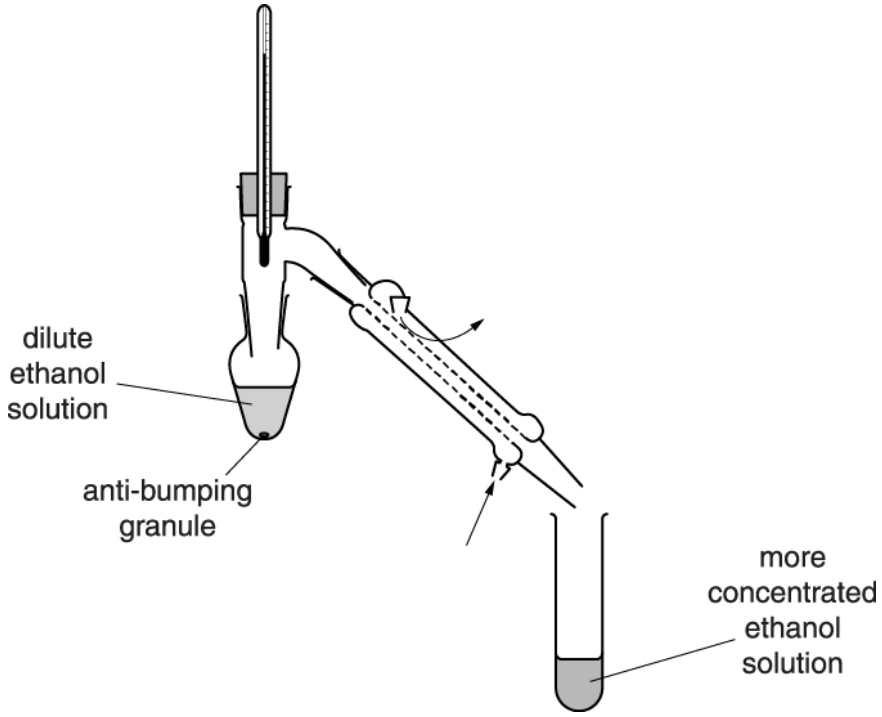


Explain who has the best approach.

--- [3]

7. Kate and William decide to make some ethanol.
Ethanol is an alcohol.
They add yeast to sugar solution and leave it to ferment.
This makes a dilute solution of ethanol.

Kate and William decide to make their dilute ethanol solution more concentrated.
They use this apparatus.



Describe how they use this equipment to make their dilute ethanol solution more concentrated, and why it works.

The quality of written communication will be assessed in your answer.

---

[6]

8. Mauritius is a country of small islands surrounded by sea.
There is almost no fresh water in Mauritius.

Seawater cannot be used as drinking water because it contains a large amount of salt.

(a) The flowchart shows the stages in a process which produces drinking water from seawater.

(i) Which stage removes the salt from the seawater?

Explain your answer.

Stage ----------

Explanation ----------

---------- [3]

(ii) Explain why there are no harmful bacteria in the water **after stage 2**.

---------- [2]

(iii) Explain why **stage 3** is needed.

---------- [1]

END OF QUESTION PAPER

Question			Answer/Indicative content	Marks	Guidance
1			acids are colourless / cannot be seen ✓ locating agent gives spots colour / dyes the spots ✓	2	
			Total	2	
2	a	i	FIRST CHECK THE ANSWER ON THE ANSWER LINE If answer = 0.03 (mol/dm^2) award 2 marks RFM of NaCl = 23.0 + 35.5 = 58.5 ✓ therefore $\frac{1.755}{58.5}$ = 0.03 (mol/dm^2) ✓	2	
		ii	draw start line with pencil ✓ put a dot of dye on start line ✓ add sodium chloride / solvent to beaker / put paper into solvent ✓ make sure solvent is below level of dot ✓	4	all points may be scored from a clearly labelled diagram

Question			Answer/Indicative content	Marks	Guidance
	b		* Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question. **Level 3 (5–6 marks)** *Shows correct understanding of output of the chromatogram and calculates correctly the Rf of each spot, including linking the Rf values to the table of food dyes, leading to identification of issues.* ***And*** *makes correct conclusions about the jelly* ***And*** *Suggests improvements to increase confidence in the result.* *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)** *Shows correct understanding of output of the chromatogram and calculates correctly the Rf of some of the spots, including linking the Rf values to the table of food dyes.* ***And*** *makes some conclusions about the jelly or suggests improvements.* *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)** *Shows correct understanding of output of the chromatogram and calculates correctly the Rf of some of the spots.* *The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.*	6	**Indicative scientific points may include** **AO3.2b: making conclusions about the dye dyes by comparing results with table of Rf values** For example • not clear result • one spot possibly a safe dye • possibly two banned dyes • cannot be exported to USA **AO2.2: directly linking spots Rf values** For example • calculates the Rf of dyes: 0.22 / 0.25 / 0.88 • noticed two spots that have very close Rf values and have merged into one spot • comments on difficulty of calculating the Rf of the all spots • compares spots with table **AO1.2: understanding of the output from a chromatogram** For example • jelly contains 3 dyes • shows how to calculate RF value **AO3.3b: making improvement to increase confidence** For example • use a different solvent • suggest a different method

Question			Answer/Indicative content	Marks	Guidance
			0 marks No response or no response worthy of credit.		
			Total	**12**	
3	a		**3 from:** Reflux; (1) Discusses vapour/gas/steam/evaporate [even if wrong species];(1) [Vapour] condenses / turn back to liquid; (1) Returns to flask / doesn't escape; (1) [To allow] further reaction; (1)	3	Remember to look for annotations on the diagram. **Examiner's Comments** Almost all candidates made an intelligent attempt at describing the role of a condenser and were able to gain some credit, and some even recognised that a condenser in this configuration is called a reflux condenser. The most able candidates, however, had a very clear understanding of why it is used.
	b		distillation; (1) [purify using] a tap [separating] funnel / add drying agent; (1)	2	Allow answers in diagrammatic form. **Ignore** evaporation / heating Drying – must convey the idea of ***how*** the liquid is dried. **Ignore** name of drying agent ['add NaCl as a drying agent' =1, but 'add NaCl' with no further comment = 0] **Ignore** 'drying' without reference to drying agent **Examiner's Comments** Distillation was widely recognised as the first stage in purifying the ester, but there was then much confusion. In many cases a variety of solids were added, sometimes 'to remove the acid' but often merely 'to purify it'. Examiners were uncertain what candidates meant when they used phrases such as 'tapping out' without further explanation, so in this case did not give credit for the term.
			Total	**5**	

Question			Answer/Indicative content	Marks	Guidance
4	a		4; (1)	1	Examiner's Comments Most candidates could use the chromatogram to decide how many dyes were present in the sweets. The most common wrong answers were three and five, presumably because there were three sweets, and the three sweets showed five spots on the chromatogram.
	b		sweet 2 contains an unsafe dye; (1) unknown dye in sweet 3 / Sweet 3 doesn't match up with a safe dye / no reference for dye in sweet 3; (1)	2	Must have correct reference to sweet 2 and sweet 3 Examiner's Comments The vast majority of candidates realised that sweet 2 had an unsafe dye as the spots matched, and many also noticed that sweet 3 had an unidentified dye which could also be unsafe.
	c		distance travelled by spot; (1) distance travelled by solvent; (1)	2	Examiner's Comments Many candidates had clearly carried out paper chromatography and could describe the measurements to take in order to calculate R*f* values, and often used terms such as 'mobile phase'. However, answers such as "he needs to measure the spot and the solvent front" suggested that some candidates were unable to express their understanding clearly enough to gain credit.
	d		to see the spots / spots are colourless; (1)	1	**Accept** any reasonable argument about making it easier to see **Accept** 'show', **Ignore** 'find or identify' Examiner's Comments Most candidates realised that locating agents are used when there is a problem with visibility of spots. As answers such as 'to identify or locate the dye' did not address this underlying aspect, they were unable to gain credit.

Question			Answer/Indicative content	Marks	Guidance
	e	i	dye C; (1) has the highest peak/ recorder response; (1)	2	The reason must be in terms of peak/line height or recorder response, ie obvious what is to be measured. **Ignore** 'highest result' If a correct **and** an incorrect reason given, do not award the second mark. Eg discusses retention time. **Examiner's Comments** Most candidates could identify dye C as the one used in the largest quantity. The more able candidates could see that it was the peak height that gave this information, whereas the others quoted both peak height and retention time and so failed to get the second mark.
		ii	Idea of matching [with a reference dye] (1) retention time/Rf value (1)	2	**Ignore** 'recorder response' **Examiner's Comments** Most candidates appreciated that one should compare the printouts in order to identify the dye, and able candidates went on to specify that it was the Rf values or retention times that should be compared.
		iii	[qualitative because] can show which dyes are used; (1) [quantitative because] can show how much of each dye is used; (1)	2	**Allow (1) only** for '[quantitative because] shows how many dyes are used.' **Ignore** statements about retention time or recorder response. 'shows which dyes are used and how much' = (2) **Examiner's Comments** Most candidates were able to give examples of quantitative information which can be obtained from chromatography, but the term 'qualitative' was less well understood.
			Total	12	

Question			Answer/Indicative content	Marks	Guidance
5	a		**Level 3 (5–6 marks)** Answer uses idea of equilibrium position between phases to explain why somechemicals move quicker than others. Quality of written communication does not impede communication of the science at this level. **Level 2 (3–4 marks)** Answer partially explains why some chemicals move quicker than others. Quality of written communication partly impedes communication of the science at this level. **Level 1 (1–2 marks)** Answer includes idea that some chemicals move quicker than others with little or no explanation. Quality of written communication impedes communication of the science at this level. **Level 0 (0 marks)** Insufficient or irrelevant science. Answer not worthy of credit.	6	**This question is targeted at grades up to A*.** **Indicative scientific points may include:** • solvent is mobile phase • (water in) paper is stationary phase • chemicals are attracted to (water in) paper • chemicals are attracted to solvent • an equilibrium is established for each chemical in solvent and in paper • for each chemical there is distribution / partition between solvent and paper • solvent moves up paper • different chemicals move up paper at different rates • the more the chemical is attracted to the solvent the quicker it moves up the paper / ora • the more the chemical is towards the solvent side of the equilibrium the quicker it moves up the paper / ora. **accept** dissolve in / spend more time in instead of attracted to **do not accept** ideas of chemicals reacting with solvent / paper / phases **Use the L1, L2, L3 annotations in Scoris; do not use ticks.** **Examiner's Comments** This was a six-mark extended-writing question. Stronger candidates candidates related distance moved by the dye chemicals to affinity for or solubility in the mobile phase and stationary phase. Only the strongest candidates used ideas of dynamic equilibrium to explain the different distributions of the dye chemicals between the two phases. Very few candidates referred to differences in the speed of travel of the dye chemicals. Many weaker candidates based their answers on incorrect parameters of the dye chemicals such as difference in mass. For a number of candidates the only credit-worthy part of

Question			Answer/Indicative content	Marks	Guidance
					their answer was the naming of the two phases. Some named these as stages rather than phases, applying a chronological basis to their answer.
	b	i	Rf = 4.2/5.6 (1) = 0.75 (1) [for braille scripts only: Rf = 4/6 (1) = 0.66 (1)]	2	both marks for correct answer without working **allow** (use of 4.0 / 4.4 or between in calculation giving) answer of 0.71 / 0.79 or between for one mark only **allow** answers with more than two figures after decimal point **do not credit** 5.6/4.2 **Examiner's Comments** In (i) stronger candidates read off the correct values from the chromatogram and used them to calculate the Rf of the third spot. Rf = 4.2/5.6 = 0.75 Many candidates read off incorrect values from the chromatogram. A common error was to divide the distance travelled by the solvent front by the distance travelled by the spot.
		ii	*'method' mark* compare measured dye chemical Rf with published / reference Rf values of banned dye chemicals / run known samples of banned dye chemicals on a chromatogram and calculate Rf values for comparison (1) *'use of results' mark* if measured dye chemical Rf is same as Rf of a banned dye chemical the soft drink contains a banned dye chemical / the same chemical will always have the same Rf value (1)	2	allow only one mark for idea of running banned dye chemicals and soft drink dye chemicals on same chromatogram and comparing distances travelled **ignore** idea that same chemical always travels same distance unless made clear that this is under identical conditions **Examiner's Comments** In (ii) stronger candidates realised that Peter should compare Rf values of the dyechemicals in his chromatogram with those of the banned dye chemicals to see if they match. Few could suggest how Peter would obtain the Rf values of the dye chemicals. A common error was to suggest comparing distances run by the dye chemicals, even though they were not run on the same chromatogram.

Question			Answer/Indicative content	Marks	Guidance
			Total	10	

Question			Answer/Indicative content	Marks	Guidance
6	a		0.7 [3 marks]	3	If not correct, **maximum** of 2 marks from Rf = spot distance / solvent distance = 1 mark Look for the numbers 5 AND 3.2 to 3.7 = 1 mark $\frac{3.2 \text{ to } 3.7}{5}$ [2 marks] Special case one mark answer $\frac{3.5}{5.4}$ [1 mark] Accept measurements in mm **Examiner's Comments** This question was designed to allow candidates to show that they knew which distances to measure when calculating Rf values. To that end the diagram had seven horizontal lines and no fixed ruler. The working of most candidates indicated that they recognised that the two important measurements were the spot distance and the solvent distance, and almost all measured the spot distance correctly. However, a very significant number thought the solvent distance was the distance from the water surface to the solvent front. A third of candidates who got the wrong answer scored at least one mark for showing their working. Many of these could have scored a further mark if they had written the general relationship for calculating Rf value. An unusually high number of candidates did not attempt this question.

Question			Answer/Indicative content	Marks	Guidance
	b		Level 3 Makes suitable comparison of attractions of both spots with both phases Links that comparison to movement of spots. *Quality of written communication does not impede communication of the science at this level.* (5 – 6 marks) Level 2 Makes suitable comparison of attractions of each spot with one phase only. Links that difference to movement of spot. OR Makes suitable comparison of attractions of only one spot with each phase. Links that difference to movement of spot. *Quality of written communication partly impedes communication of the science at this level.* (3 – 4 marks) Level 1 Discusses attractions of at least one spot with at least one phase. *Quality of written communication impedes communication of the science at this level.* (1 – 2 marks) Level 0 *Insufficient or irrelevant science. Answer not worthy of credit.* (0 marks)	6	This question is targeted at grades up to A* Indicative scientific points may include: Level 3 minimum response • [Spot 1] ***more*** attracted to mobile phase AND [spot 2] ***more*** attracted to stationary phase therefore [Spot 1] moves further Level 2 minimum response • [Spot 1] ***more*** attracted to mobile phase therefore moves further • [Spot 1] ***more*** attracted to stationary phase therefore moves less Level 1 • [spot 1] is attracted to the mobile phase • [spot 2] is attracted to the stationary phase At level 2&3 if not linked to movement, QWC impeded **Accept** 'the spot that moves further' = Spot 1 **Accept** 'moves faster' instead of 'moves further' **Accept** 'solvent' or 'liquid' instead of 'mobile phase' and 'paper' instead of 'stationary phase' Spot 1 may ***like / prefer / favours / has affinity for*** the mobile phase more ? QWC impeded **Ignore** spends more time in the mobile phase **Ignore** reference to attractions between the spot and the ink **Ignore** equilibrium arguments, the question is about attractions **Use the L1, L2, L3 annotations in Scoris; do not use ticks.** Examiner's Comments

Question			Answer/Indicative content	Marks	Guidance
					Examiners were pleased to see that the vast majority of candidates introduced the terms 'mobile phase' and 'stationary phase', and used these terms correctly. However, a minority missed the significance of the word 'attractions' in the question stem, and appeared to be writing out a general explanation of paper chromatography without reference to the specific cueing of the question. Explanations in terms of density of the spots were not uncommon.
	c		**simple similarity** Both use a liquid / solvent [as the mobile phase] / same mobile phase **simple difference** idea that a different solid / stationary phase is used [tlc] solid is mounted on a glass or plastic plate [tlc] quicker	2	**Ignore** 'uses the same method' **Ignore** 'both have a mobile phase and a stationary phase' [ie this is a general statement about chromatography.] **Accept** '[tlc] uses silica gel' **Examiner's Comments** Most candidates were able to state either a similarity or a difference between the two types of chromatography. More able candidates provided both.
	d		Any three points from [Jane] gives feedback on the technique idea of accurate / reproducible / reliable can take an average remove outliers [Mike] Gives checks throughout the day / regular check / continuous Shows up if a drift / pattern / change with time Shows up if a sudden change / problem	3	Marks for arguments only Arguments may be in reverse e.g. Jane's method does not show up changes as soon as they happen Ignore 'Sample taken every hour' [stem] **Examiner's Comments** Candidates across the full range of the ability spectrum were able to make sensible comments about the two approaches to sampling.
			Total	**14**	

Question			Answer/Indicative content	Marks	Guidance
7			[Level 3] Gives operational points AND theoretical points which describe the distillation including a reference to BPt difference [from water]. Quality of written communication does not impede communication of the science at this level. (5 – 6 marks) [Level 2] Gives operational points AND theoretical points which describe the distillation. OR Makes reference to BPt and operational OR theoretical points. Quality of written communication partly impedes communication of the science at this level. (3 – 4 marks) [Level 1] Gives indicative points which describe the distillation. Quality of written communication impedes communication of the science at this level. (1 – 2 marks) [Level 0] Insufficient or irrelevant science. Answer not worthy of credit. (0 marks)	6	This question is targeted at grades up to C CHECK FOR INFORMATION ON THE DIAGRAM Indicative operational points may include: • boil / heat [the dilute ethanol] • antibumping granules control the boiling • condenser used • [condenser] is cold / cooled / water flows through • use of thermometer • keep the liquid that collects around the boiling temperature of the alcohol • stop when temp too high Indicative theoretical points may include: • boiling points different / boiling point of alcohol lower than water • gas / vapour / evaporation [of ethanol] • vapour contains both alcohol and water • [vapour] richer in alcohol • [Vapour] condenses / turns to liquid [in the condenser] • vapour contains increasing amounts of water as distillation proceeds If answer includes incorrect points (e.g. BPt of ethanol higher than water) then consider quality of communication to be impeded at levels 2 and 3 Use the L1, L2, L3 annotations in Scoris; do not use ticks. Examiner's Comments Candidates gave good explanations of alcohol distillation and discussed the difference in boiling point between alcohol and water. However, there was often confusion between the use of a condenser in this context and its use for refluxing. Other candidates recalled their notes indiscriminately and described fractionating columns. Weaker candidates had great

Question			Answer/Indicative content	Marks	Guidance
					difficulty in describing what happens in a condenser.
			Total	6	

Question			Answer/Indicative content	Marks	Guidance
8		i	Stage 2 / distillation ✓ water evaporates / becomes a vapour/gas (and then condenses)✓ salt is left behind ✓	3 (AO 3× 1.2)	 ALLOW boils ALLOW for 'distillation separates soluble substances and water/a solvent' ✓ <u>Examiner's Comments</u> This question was well answered. Some candidates chose 'filtration' believing that this would filter out the salt, but most identified distillation correctly. Similarly the explanation of distillation was well understood, most stating that water evaporates and salt is left behind.
		ii	(distillation uses) high temperatures/heat/100°C ✓ bacteria are killed/die ✓	2 (AO 2× 1.2)	ALLOW 'boiling' IGNORE 'remove' bacteria ALLOW bacteria left behind with salt / do not evaporate <u>Examiner's Comments</u> Again, this was well answered with most candidates recognising that the high temperatures used kill any bacteria, earning two marks. Some went on further to correctly state that any bacteria would remain behind with the salt and would not be collected in the water.

Question			Answer/Indicative content	Marks	Guidance
		iii	to kill bacteria / idea that bacteria may enter water later / keep water free of bacteria ✓	1 (AO 1.1)	ALLOW microbes / micro-organisms / pathogens for bacteria <u>Examiner's Comments</u> This question was interesting because it is different to the usual water treatment in the UK. In this case at stage 3 the water is already bacteria free. Candidates did not always engage fully with the context to realise this. 'Chlorine kills bacteria' was accepted as correct, but candidates who understood the process gave higher level answers than this, for example by pointing out that the chlorine is a precautionary measure to ensure that any bacteria entering the water during distribution are killed.  AfL 'Chlorine removes bacteria' is not enough to gain any marks. To be technical, the bacteria are still in the water, but they are dead. It is important that candidates learn that 'chlorine kills bacteria' in water. Key  AfL Guidance to offer for future teaching and learning practice.
			Total	6	