1. The empirical formula of a compound **Y** is CH_2O.

Compound **Y** has a relative formula mass of 90.

What is the molecular formula of compound **Y**?

A $C_2H_2O_4$
B $C_3H_6O_3$
C $C_4H_{10}O_2$
D $C_6H_{12}O_6$

Your answer ☐

[1]

2(a). Lead nitrate solution is added to sodium sulfate solution.

A white precipitate is formed.

Explain how a pure sample of the precipitate can be separated from the mixture.

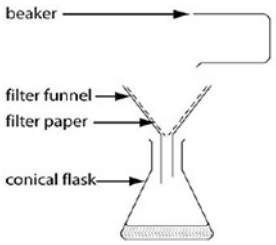
Refer to one of the diagrams in your answer.

---

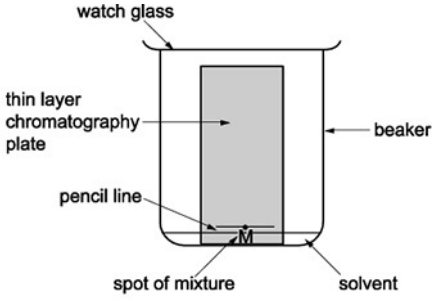
[3]

(b). Look at the diagrams.

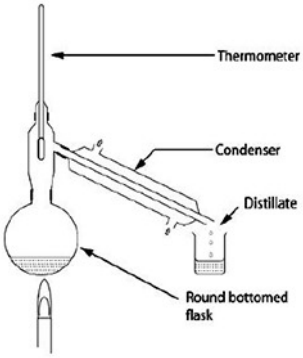
They are not to the same scale.



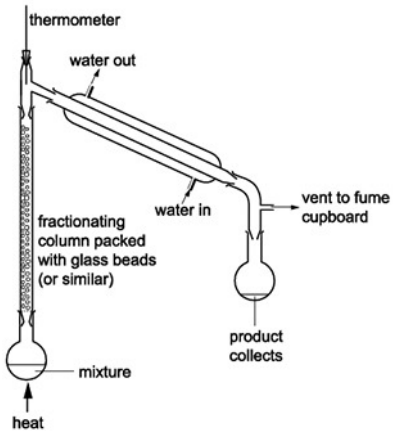
A



B



C



D

Write down the name of the separating technique used in diagram **D**?

---

[1]

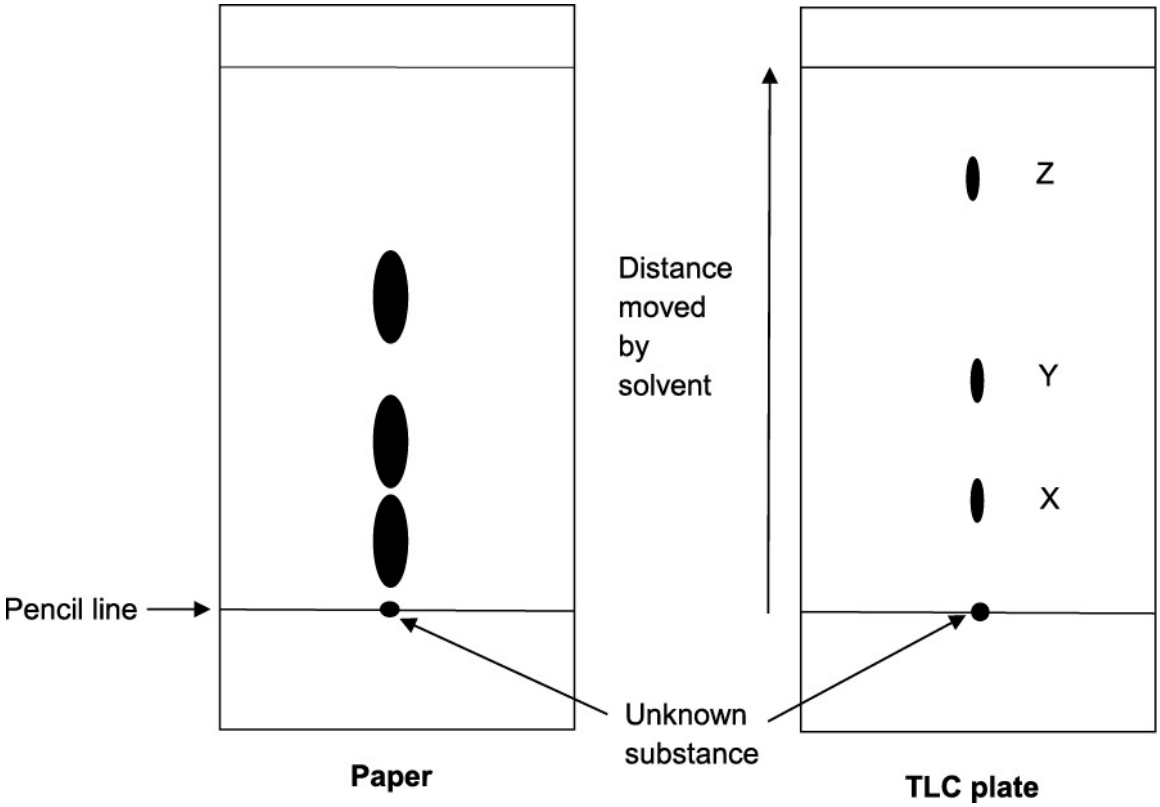
(c). Two scientists investigate an unknown substance.

One scientist uses apparatus **B**.

Another scientist uses the same apparatus but uses a thin layer chromatography (TLC) plate instead of paper.

They put an unknown substance on the centre of the pencil line.

The results are shown below.



(i) Use the thin layer chromatogram to work out the R_f value for substance Y.

R_f value = _____

[2]

(ii) Suggest **two** reasons why TLC might be better than paper.

---

[2]

3. Fractional distillation is used to separate crude oil into a range of other substances. The process uses a fractionating column.

Which of these statements about fractional distillation is / are correct?

1 propane, C_3H_8, is found in the fraction obtained from the top of the column
2 crude oil is heated before it enters the bottom of the column

A 1 only
B 2 only
C both 1 and 2
D neither 1 nor 2

Your answer ☐

[1]

4. Hydrogen peroxide solution breaks down to make water and oxygen.

hydrogen peroxide → water + oxygen

The molecular formula for hydrogen peroxide is H_2O_2.

Calculate the relative formula mass, M_r, of hydrogen peroxide.

The relative atomic mass of H = 1 and of O = 16

relative formula mass = ----------

[1]

5. A pharmaceutical company makes several batches of aspirin.

They test the melting point of each batch to check that it is pure.

The melting point of pure aspirin is 135 °C.

Look at their results.

Batch	Melting point in °C
A	128
B	131–134
C	134
D	138

Which batch contains the purest sample of aspirin?

Answer _____

Explain your answer.

_____

_____

_____ [2]

6(a). Hydrogen peroxide solution, H_2O_2, breaks down to make water, H_2O, and oxygen, O_2.

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

Mass is conserved during a chemical reaction.

(i) Calculate the relative formula masses, M_r, of hydrogen peroxide, water and oxygen.

The relative atomic mass of H = 1 and of O = 16.

M_r of hydrogen peroxide ----------

M_r of water ----------

M_r of oxygen ---------- [1]

(ii) Use these relative formula masses to show that mass is conserved during the chemical reaction.

[1]

(b). What mass of oxygen, O_2, can be made from 680 g of hydrogen peroxide, H_2O_2?

The relative atomic mass of H = 1 and of O = 16.

mass of oxygen = ---------- g [2]

7. One way to test if a pharmaceutical drug is pure is to find its melting point.

Sarah finds the melting point of five different samples of a pharmaceutical drug.

Look at her results.

Sample	Melting point in °C
A	152
B	153–158
C	155
D	155–157
E	157– 160

Sarah knows that a pure sample of the pharmaceutical drug has a melting point of 157 °C.

Sarah concludes that sample **E** is the purest sample of the drug.

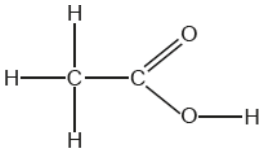
Do the results support her conclusion?

Explain your answer using evidence from the table.

---

[2]

8. Look at the molecule below:



Write down the **empirical formula** for this molecule.

---

[1]

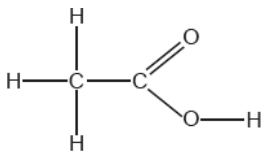
9. Waste aluminium and iron can be separated from one another easily.

Explain why. Use ideas about their properties.

---

[2]

10. Look at the molecule below:



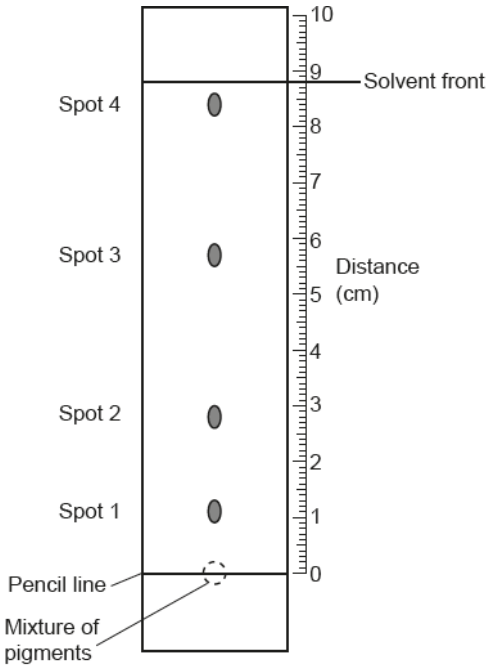
Calculate the **relative formula mass**, M_r, for this molecule.

Answer = ---------- [1]

11. * 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]

12. Which statement best describes the **stationary phase** in thin layer chromatography (TLC)?

A A glass plate with chromatography paper

B Alumina powder in ethanol

C A plastic plate coated in glue

D Silica spread on a glass plate

Your answer [ ] [1]

END OF QUESTION PAPER

Question			Answer/Indicative content	Marks	Guidance
1			B	1	
			Total	**1**	
2	a		(Use apparatus A) Filter / pour the mixture in the funnel, liquid runs through into conical flask (1) Wash precipitate with distilled water (1) Dry the precipitate (1)	3	**ALLOW** AW throughout
	b		Fractional distillation	1	**DO NOT ALLOW** distillation
	c	i	Distance moved by spot = 29 mm +/– 2 mm **AND** distance moved by solvent = 69 mm +/– 2 mm (1) R_f = 29÷ 69 = 0.42 (1)	2	Both distances correct for first mark **ECF** for R_f value **ALLOW** values between 0.38 – 0.46
		ii	**Any two from** Takes less time to separate/solvent moves faster (1) Spots are more distinct/better separated (1) The solvent moves more evenly (1)	2	
			Total	**8**	
3			C	1	
			Total	**1**	
4			34 (1)	1	**ignore** any units given
			Total	**1**	

Question			Answer/Indicative content	Marks	Guidance
5			batch **C** (1) **any one from:** **C** is just below real melting point (1) **C** is not a range / **C** is a precise number (1) the more impure a substance the lower its melting point (1)	2	**allow** 134 **allow C** is close(st) to real melting point (1) **allow C** is an exact / **C** is a definite number (1) **Examiner's Comments** Candidates were able to use the information about the melting points of different substances to determine that batch C contains the purest sample of aspirin. They also gave the reason for selecting batch C as the melting point is not a range and that it is just below the real melting point of aspirin.
			Total	2	

Question			Answer/Indicative content	Marks	Guidance
6	a	i	hydrogen peroxide = 34 water = 18 **and** oxygen = 32 (1)	1	**all three required** **ignore** any units given
		ii	idea that 68 = 36 + 32 (1)	1	**allow** 68 = 68 (1) if answer space is blank, check space in 5a(i) for answer
	b		320 (g) (2) **but if answer incorrect then** use of 680/68 **or** idea that 10 x more hydrogen peroxide used **or** 68 grams of hydrogen peroxide makes 32 g of O_2 (1)	2	**allow** full marks for correct answer **allow** 20 (moles of hydrogen peroxide used) (1) **allow** 640 (g) (1)
			Total	**4**	

Question			Answer/Indicative content	Marks	Guidance
7			no **any two from:** melting point cannot be higher than actual value (1) melting point should be sharp / melting point should **not** be a range / should be a smaller range (1) **D** (is most likely the most pure) (1)	2	**no** marks for no on its own if **yes 0** marks for the question **allow** highest melting point should be 157°C / up to 157°C (1) **allow** melting point **not** exactly 157°C /(in **E** the) melting point is between 2 numbers (1) **allow** so it is **D** (1) **allow D** has a smaller range (2)
			Total	2	
8			CH_2O	1 (AO2.1)	**ALLOW** elements in any order **DO NOT ALLOW** CH_2O / CH_2O Examiner's Comments A few candidates correctly gave CH2O, but most candidates did not understand what was meant by an empirical formula, so marks were rarely credited. Most tried to write a molecular formula, but some attempted a symbol equation. Some candidates wrote both molecular and empirical formulae so did not gain credit.
			Total	1	

Question			Answer/Indicative content	Marks	Guidance
9			iron is magnetic / is attracted to a magnet (1) aluminium is not magnetic / is not attracted to a magnet (1)	2	**allow only** iron is magnetic / only aluminium is not magnetic (2) If no other mark awarded then **allow** one mark for use of magnet or magnetism e.g. use a magnet (1) e.g. one is magnetic the other is not (1) **allow** aluminium is magnetic but iron is not (1)
			Total	2	
10			60 ✓	1 (AO2.2)	Examiner's Comments Some candidates calculated this correctly but working was frequently not shown. A common wrong answer was 30 instead of 60. Many did not attempt an answer.
			Total	1	

<table>
<tr><th colspan="3">Question</th><th>Answer/Indicative content</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>11</td><td></td><td></td><td>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.</td><td>6
(AO1 × 1.2)
(AO1 × 2.2)
(AO2 × 3.2b)
(AO2 × 3.3b)</td><td>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

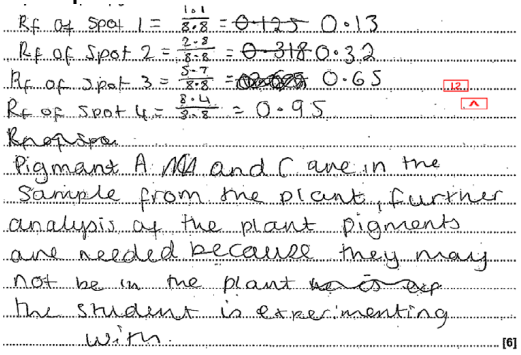
<table>
<tr><th>Spot</th><th>Rf value</th><th>Allow</th></tr>
<tr><td>1</td><td>0.13</td><td>0.125</td></tr>
<tr><td>2</td><td>0.32</td><td>0.318 / 0.3182</td></tr>
<tr><td>3</td><td>0.65</td><td>0.648 / 0.6477</td></tr>
<tr><td>4</td><td>0.95</td><td>0.955 / 0.9545</td></tr>
</table>

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

<u>Examiner's Comments</u>
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</td></tr>
</table>

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 = $\frac{5.7}{8.8}$ = ~~0.647~~ 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	

Question			Answer/Indicative content	Marks	Guidance
12			D ✓	1 (AO 1.2)	<u>Examiner's Comments</u> Only higher ability candidates were successful at identifying the stationary phase in TLC. The most common incorrect responses identified 'A'. Perhaps a lack exposure to the practical equipment in some centres may have reduced the number of candidates' ability to access this mark.
			Total	1	