Cambridge Assessment International Education

Interactive

Interactive Example Candidate Responses
Paper 52 (May/June 2016), Question 2

Cambridge International AS & A Level
Chemistry 9701

Version 1.0

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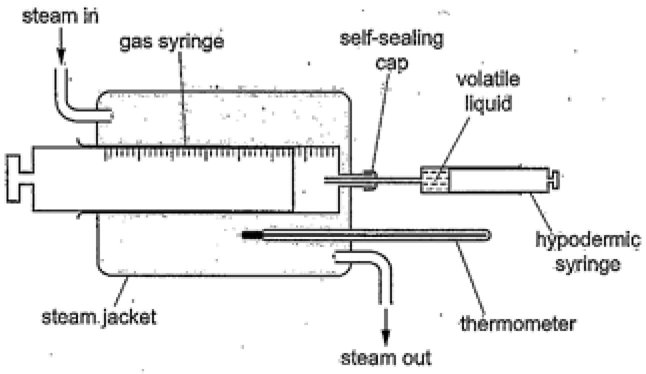

A known mass of volatile liquid is injected into the gas syringe using a hypodermic syringe. The injected volatile liquid vaporises and the volume of vapour is recorded.

The experiment can be repeated using different samples of the same volatile liquid. The following mathematical relationship can be used to calculate the relative molecular mass if the experiment is carried out at 100 °C and 1.01×10^5 Pa.

$$V = \left(\frac{3.07 \times 10^4}{M_r}\right) \times m$$

m is the mass of the volatile liquid in g.
V is the volume of the volatile liquid in cm³ when vaporised.

A graph of V against m can be plotted.

A group of students is given a volatile liquid hydrocarbon, **Y**, and asked to find its relative molecular mass in a series of experiments using this procedure.

- A 100 cm³ gas syringe is placed in a steam jacket.
- Approximately 5 cm³ of air is pulled into the gas syringe.
- The temperature is allowed to reach a constant 100 °C.
- Once the air in the gas syringe has stopped expanding, its volume is recorded.
- The hypodermic syringe is filled with liquid **Y**.
- The total mass of the hypodermic syringe and liquid **Y** is recorded.
- A little liquid **Y** is injected into the hot gas syringe.
- The total mass of the hypodermic syringe is recorded again.
- The maximum volume of air and vapour in the gas syringe is recorded.
- The mass of liquid **Y** injected into the gas syringe is calculated and recorded.

Select page

HIGH MIDDLE LOW

Your Mark

2(a)

2(b)

2(c)(i)

2(c)(ii)

2(d)(i)

2(d)(ii)

2(e)

Q2 Mark scheme

	Expected answer
(a)	(see table below) All mass values. [1] All volume values. [1]
(b)	Candidate's points plotted correctly from table in 2(a). [1] Line of best fit drawn. [1]
(c)(i)	Y evaporates from the (hypodermic) syringe OR Y evaporates before injection OR Y evaporates before weighing / after injection [1]
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(d)(i)	correct co-ordinates. [1 correct calculation of the gradient must be three significant figures [1]
(d)(ii)	Calculation of Mr = 3.07×10^4 / gradient in 2(d)(i) Answer [1]
(e)	Mr (from mass spectrum) = 84 OR empirical formula = CH_2 OR ratio of C and H seen as 1:2 Y is C_6H_{12} [1] Total: [12]

Mass of liquid Y used / g	Volume of vapour Y / cm³
0.15	48
0.10	35
0.21	72
0.17	58
0.24	83
0.09	31
0.20	70
0.23	79
0.12	41
0.22	73

EXAMINER COMMENTS

MARK SCHEME

The results from the group of students are given in the table.

mass of syringe + liquid Y before injection /g	mass of syringe + liquid Y after injection /g	volume of air in gas syringe before injection /cm³	volume of air + vapour Y in gas syringe after injection/cm³	mass of liquid Y used/g	volume of vapour Y/cm³
4.83	4.68	7	55	0.15	48
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4.85	4.64	13	85	0.21	72
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5.57	5.48	8	39	0.09	31
5.32	5.12	9	79	0.20	70
5.17	4.94	12	91	0.23	79
4.84	4.72	7	48	0.12	41
5.05	4.83	11	84	0.22	73

(a) Process the results in the table to calculate both the masses of volatile liquid Y used and the volumes of vaporised Y. [2]

(b) Plot a graph on the grid on page 9 to show the relationship between mass of liquid Y and volume of vapour Y.
Use a cross (x) to plot each data point.
Draw the line of best fit. [2]

Select page

HIGH MIDDLE LOW

Your Mark

2(a)

2(b)

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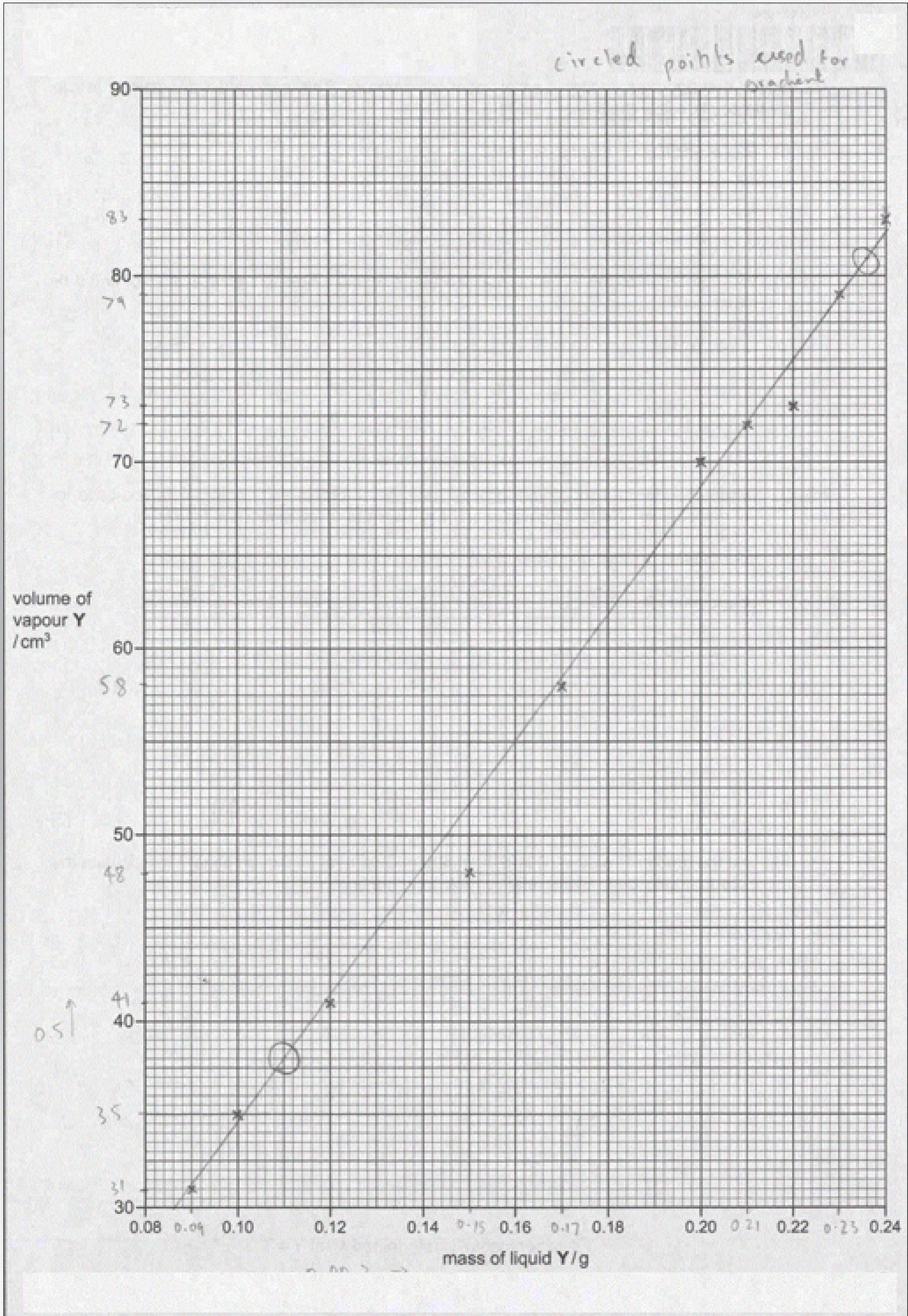
EXAMINER COMMENTS

MARK SCHEME



Your Mark

2(a)

2(b)

2(c)(i)

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EXAMINER COMMENTS

MARK SCHEME

Select page

HIGH | MIDDLE | LOW

(c) Liquid Y evaporates easily, even at room temperature. This can cause anomalous results giving points below the line of best fit.

(i) Explain how such anomalies occur.

The liquid Y evaporates from the hypodermic syringe between when the mass readings are taken. [1]

(ii) With reference to the experimental procedure, explain how this source of error could be minimised.

The mass of hypodermic syringe + Y should recorded as quickly as possible after injecting the liquid. The hypodermic syringe could also be cooled (in an ice water bath for example) so that Y doesn't evaporate too much. [1]

(d) (i) Determine the gradient of your graph. State the co-ordinates of both points you used for your calculation. Record the value of the gradient to **three** significant figures.

co-ordinates 1 (0.236 , 81)

co-ordinates 2 (0.110 , 38)

$$\text{gradient} = \frac{81 - 38}{0.236 - 0.110}$$

$$= 341.2$$

gradient = 341 $cm^3 g^{-1}$ [2]

(ii) Use the gradient value in (i) and the mathematical relationship on page 7 to calculate the experimentally determined relative molecular mass of Y.

$$V = \left(\frac{3.07 \times 10^4}{M_r}\right) \times m$$

$$\text{gradient} = \frac{3.07 \times 10^4}{M_r}$$

$$M_r = \frac{3.07 \times 10^4}{341.2}$$

$$= 89.95$$

experimentally determined M_r of Y = 90 [2]

Your Mark

2(a)

2(b)

2(c)(i)

2(c)(ii)

2(d)(i)

2(d)(ii)

2(e)

Q2	Mark scheme
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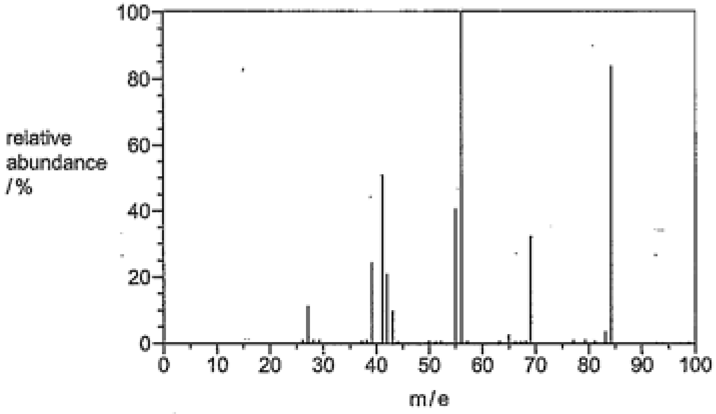
EXAMINER COMMENTS

MARK SCHEME

(e) Compound Y is a hydrocarbon that contains 85.7% carbon by mass.

The diagram shows the mass spectrum of compound Y.



Use all the information given to determine the molecular formula of Y.

%	C	H
	85.7	14.3
dividing by Ar	$\frac{85.7}{12}$	$\frac{14.3}{1}$
	= 7.14	14.3
Simplest ratio	1 :	2

molecular formula of Y ......C_6H_{12}........ [2]

[Total: 12]

∴ Empirical formula = CH_2

mass of molecular formula = n × mass of empirical formula

$84 = n \times (12+2)$

$n = \frac{84}{14}$

$n = 6$

C_6H_{12} mass of molecular ion = 84

~~molecular form~~

$CH_2 \times 6 = C_6H_{12}$

~~∴ C_6H_{12}~~

Your Mark

2(a)

2(b)

2(c)(i)

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2(e)

Q2 Mark scheme

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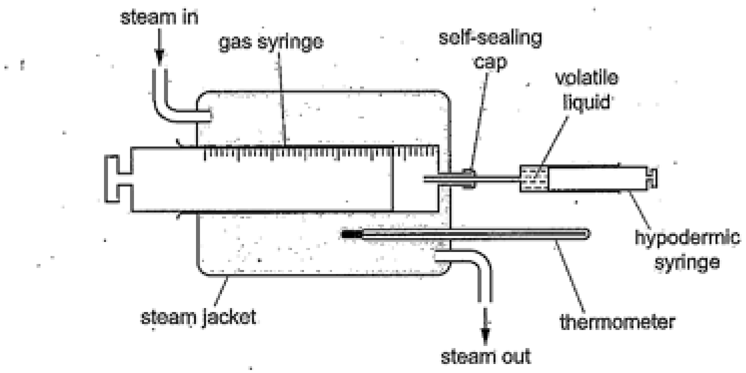
2 The relative molecular mass, M_r of volatile liquids can be determined using the apparatus below.



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- A little liquid **Y** is injected into the hot gas syringe.
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- The mass of liquid **Y** injected into the gas syringe is calculated and recorded.

Your Mark

2(a)

2(b)

2(c)(i)

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EXAMINER COMMENTS

MARK SCHEME

Select page

HIGH MIDDLE LOW

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(b) Plot a graph on the grid on page 9 to show the relationship between mass of liquid Y and volume of vapour Y.
Use a cross (x) to plot each data point.
Draw the line of best fit. [2]

Your Mark

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Q2	Mark scheme
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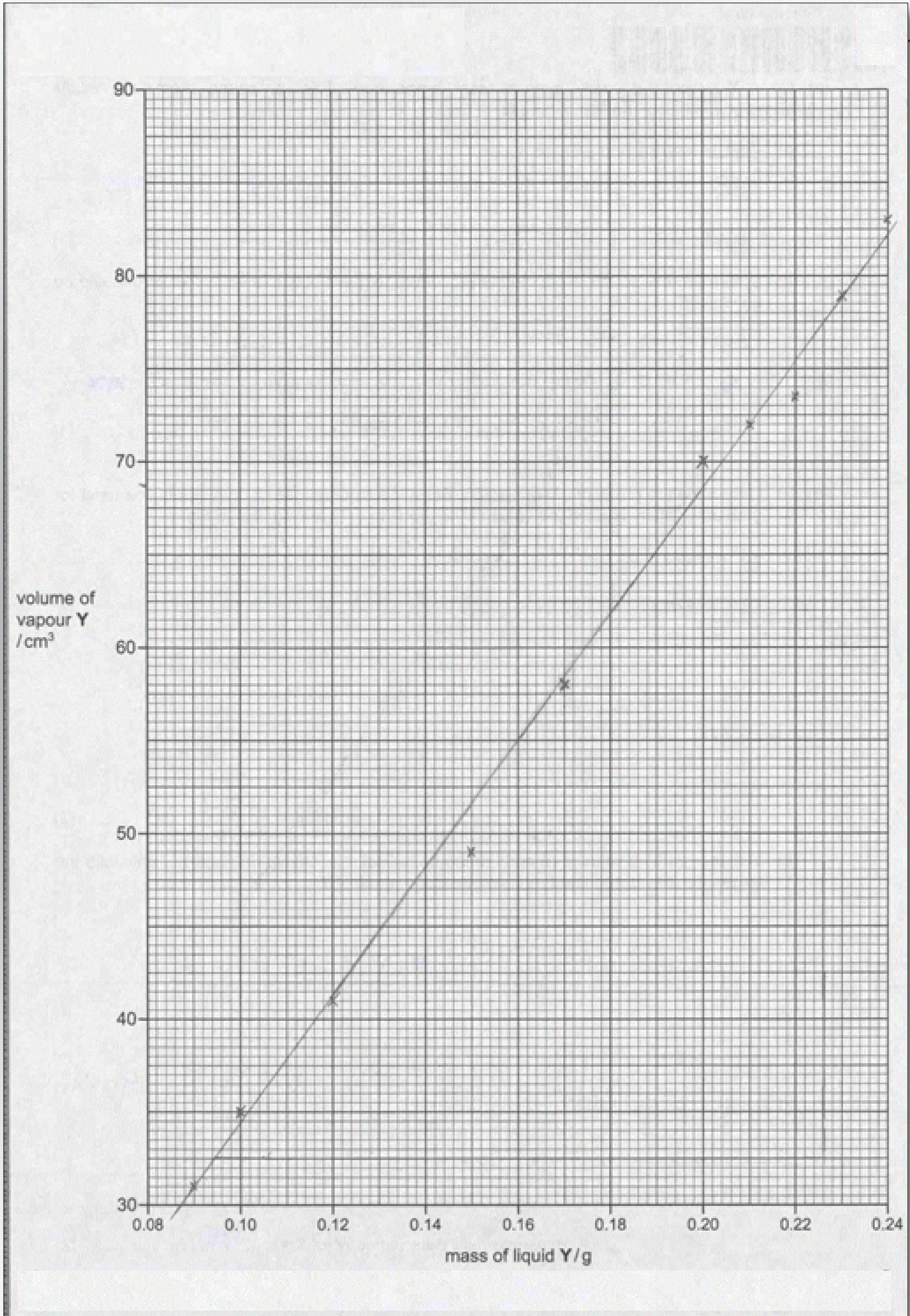
EXAMINER COMMENTS

MARK SCHEME



Your Mark

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Q2 Mark scheme

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All mass values. **[1]**

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(b)	Candidate's points plotted correctly from table in 2(a). Line of best fit drawn.	**[1]** **[1]**
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		Total: [12]

EXAMINER COMMENTS

MARK SCHEME

(c) Liquid Y evaporates easily, even at room temperature. This can cause anomalous results giving points below the line of best fit.

(i) Explain how such anomalies occur.

Some amount of liquid Y evaporates in the hypodermic syringe after injection. [1]

(ii) With reference to the experimental procedure, explain how this source of error could be minimised.

Make sure the liquid in the syringe is and compressed as it can be so ~~it~~ it is less likely to evaporate. [1]

(d) (i) Determine the gradient of your graph. State the co-ordinates of both points you used for your calculation. Record the value of the gradient to **three** significant figures.

co-ordinates 1 (0.094 , 32.5)

co-ordinates 2 (0.226 , 77.5)

$$\frac{y_2 - y_1}{x_2 - x_1} = \frac{77.5 - 32.5}{0.226 - 0.094} = 340.9$$

gradient = 341 [2]

(ii) Use the gradient value in (i) and the mathematical relationship on page 7 to calculate the experimentally determined relative molecular mass of Y.

$$V = \frac{(3.07 \times 10^4)}{Mr} \times m$$

~~gradient =~~

$$Mr = \frac{3.07 \times 10^4}{\text{gradient}} = \frac{3.07 \times 10^4}{341} = 90.02$$

experimentally determined M_r of Y = 90 [2]

Select page

HIGH | MIDDLE | LOW

Your Mark

2(a)

2(b)

2(c)(i)

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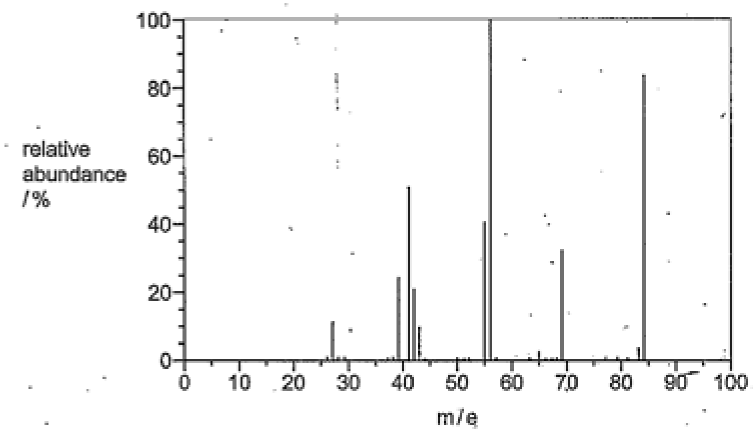
EXAMINER COMMENTS

MARK SCHEME

(e) Compound **Y** is a hydrocarbon that contains 85.7% carbon by mass.

The diagram shows the mass spectrum of compound **Y**.



Use all the information given to determine the molecular formula of **Y**.

2 : 1·7   90 × 85·7 / 100   77·13

mol ratio   77·13/12 = 6·43

90 × (100 − 77·13) / 100 = 20

molecular formula of Y ...C_6H_6........... [2]

[Total: 12]

Select page

HIGH   MIDDLE   LOW

Your Mark

2(a)

2(b)

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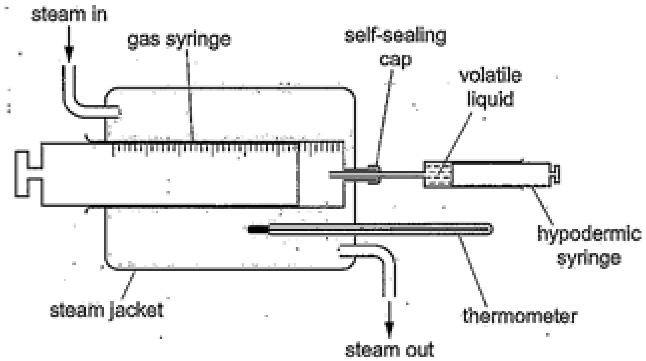
EXAMINER COMMENTS   MARK SCHEME

2 The relative molecular mass, M_r, of volatile liquids can be determined using the apparatus below.



A known mass of volatile liquid is injected into the gas syringe using a hypodermic syringe. The injected volatile liquid vaporises and the volume of vapour is recorded.

The experiment can be repeated using different samples of the same volatile liquid. The following mathematical relationship can be used to calculate the relative molecular mass if the experiment is carried out at 100 °C and 1.01 × 10⁵ Pa.

$$V = \left(\frac{3.07 \times 10^4}{M_r}\right) \times m$$

m is the mass of the volatile liquid in g.
V is the volume of the volatile liquid in cm^3 when vaporised.

A graph of *V* against *m* can be plotted.

A group of students is given a volatile liquid hydrocarbon, Y, and asked to find its relative molecular mass in a series of experiments using this procedure.

- A 100 cm^3 gas syringe is placed in a steam jacket.
- Approximately 5 cm^3 of air is pulled into the gas syringe.
- The temperature is allowed to reach a constant 100 °C.
- Once the air in the gas syringe has stopped expanding, its volume is recorded.
- The hypodermic syringe is filled with liquid Y.
- The total mass of the hypodermic syringe and liquid Y is recorded.
- A little liquid Y is injected into the hot gas syringe.

Your Mark

2(a)

2(b)

2(c)(i)

2(c)(ii)

2(d)(i)

2(d)(ii)

2(e)

Q2 Mark scheme

Expected answer

(a)

Mass of liquid Y used / g	Volume of vapour Y / cm^3
0.15	48
0.10	35
0.21	72
0.17	58
0.24	83
0.09	31
0.20	70
0.23	79
0.12	41
0.22	73

Part	Expected answer	Mark
(a)	All mass values.	[1]
	All volume values.	[1]
(b)	Candidate's points plotted correctly from table in 2(a).	[1]
	Line of best fit drawn.	[1]
(c)(i)	Y evaporates from the (hypodermic) syringe OR Y evaporates before injection OR Y evaporates before weighing / after injection	[1]
(c)(ii)	(Stop evaporation by) Keeping the syringe as cool as possible OR Closing off the needle end to stop evaporation OR Minimising length of time between each weighing	[1]
(d)(i)	correct co-ordinates.	[1
	correct calculation of the gradient must be three significant figures	[1]
(d)(ii)	Calculation of Mr = 3.07×10^4 / gradient in 2(d)(i)	
	Answer	[1]
(e)	Mr (from mass spectrum) = 84 OR empirical formula = CH_2 OR ratio of C and H seen as 1:2 Y is C_6H_{12}	[1]
		Total: [12]

EXAMINER COMMENTS

MARK SCHEME

Select page

HIGH MIDDLE LOW

The results from the group of students are given in the table.

mass of syringe + liquid Y before injection /g	mass of syringe + liquid Y after injection /g	volume of air in gas syringe before injection /cm³	volume of air + vapour Y in gas syringe after injection/cm³	mass of liquid Y used/g	volume of vapour Y/cm³
4.83	4.68	7	55	0.150	48
5.33	5.23	9	44	0.100	37
4.85	4.64	13	85	0.210	72
5.09	4.92	11	69	0.170	58
5.31	5.07	14	97	0.240	83
5.57	5.48	8	39	0.090	31
5.32	5.12	9	79	0.200	70
5.17	4.94	12	91	0.230	79
4.84	4.72	7	48	0.120	41
5.05	4.83	11	84	0.220	73

(a) Process the results in the table to calculate both the masses of volatile liquid Y used and the volumes of vaporised Y. [2]

(b) Plot a graph on the grid on page 9 to show the relationship between mass of liquid Y and volume of vapour Y.
Use a cross (x) to plot each data point.
Draw the line of best fit. [2]

Your Mark

2(a)

2(b)

2(c)(i)

2(c)(ii)

2(d)(i)

2(d)(ii)

2(e)

Q2	Mark scheme
	Expected answer
(a)	see table below All mass values. **[1]** All volume values. **[1]**
(b)	Candidate's points plotted correctly from table in 2(a). **[1]** Line of best fit drawn. **[1]**
(c)(i)	Y evaporates from the (hypodermic) syringe OR Y evaporates before injection OR Y evaporates before weighing / after injection **[1]**
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(d)(i)	correct co-ordinates. **[1** correct calculation of the gradient must be three significant figures **[1]**
(d)(ii)	Calculation of Mr = 3.07×10^4 / gradient in 2(d)(i) Answer **[1]**
(e)	Mr (from mass spectrum) = 84 OR empirical formula = CH_2 OR ratio of C and H seen as 1:2 Y is C_6H_{12} **[1]** **Total: [12]**

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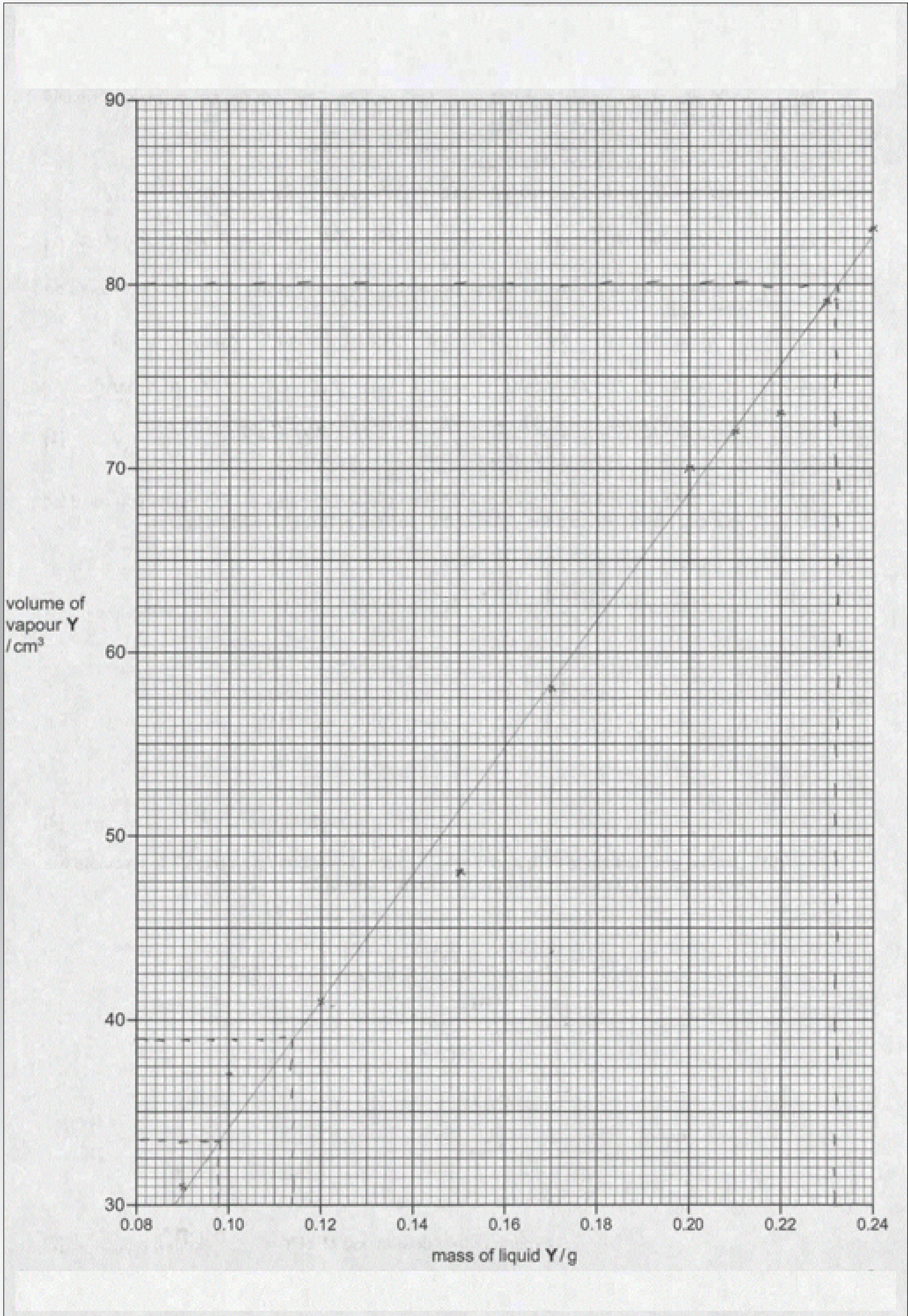
EXAMINER COMMENTS

MARK SCHEME



Your Mark

2(a)

2(b)

2(c)(i)

2(c)(ii)

2(d)(i)

2(d)(ii)

2(e)

Q2	Mark scheme	
	Expected answer	
(a)	(see table below) All mass values.	[1]
	All volume values.	[1]
(b)	Candidate's points plotted correctly from table in 2(a).	[1]
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(c) Liquid **Y** evaporates easily, even at room temperature. This can cause anomalous results giving points below the line of best fit.

(i) Explain how such anomalies occur.

The liquid Y evaporates easily at room temperature hence its rate of diffusion will be greater than air and hence less dense. [1]

(ii) With reference to the experimental procedure, explain how this source of error could be minimised.

To minimise this error we should conduct experiment in controlled temperature and allow the liquid Y to make equilibrium with air of rate of diffusion. while measuring volume of Y and air in syringe. [1]

(d) **(i)** Determine the gradient of your graph. State the co-ordinates of both points you used for your calculation. Record the value of the gradient to **three** significant figures.

co-ordinates 1 ...0.232 , 80....

co-ordinates 2 ...0.114 , 39....

$$\text{gradient} = \frac{80-39}{0.232-0.114}$$

gradient = ...347... [2]

(ii) Use the gradient value in **(i)** and the mathematical relationship on page 7 to calculate the experimentally determined relative molecular mass of **Y**.

$$V = \left(\frac{3.07\times10^4}{Mr}\right) \times V.$$

$$\text{gradient} = \frac{3.07\times10^4}{Mr}.$$

$$\frac{347}{3.07\times10^4} = Mr.$$

experimentally determined M_r of Y = ...0.0113... [2]

Your Mark

2(a)

2(b)

2(c)(i)

2(c)(ii)

2(d)(i)

2(d)(ii)

2(e)

Q2	Mark scheme
	Expected answer
(a)	Mass of liquid Y used / g — Volume of vapour Y / cm³: 0.15 – 48; 0.10 – 35; 0.21 – 72; 0.17 – 58; 0.24 – 83; 0.09 – 31; 0.20 – 70; 0.23 – 79; 0.12 – 41; 0.22 – 73 All mass values. [1] All volume values. [1]
(b)	Candidate's points plotted correctly from table in 2(a). [1] Line of best fit drawn. [1]
(c)(i)	Y evaporates from the (hypodermic) syringe OR Y evaporates before injection OR Y evaporates before weighing / after injection [1]
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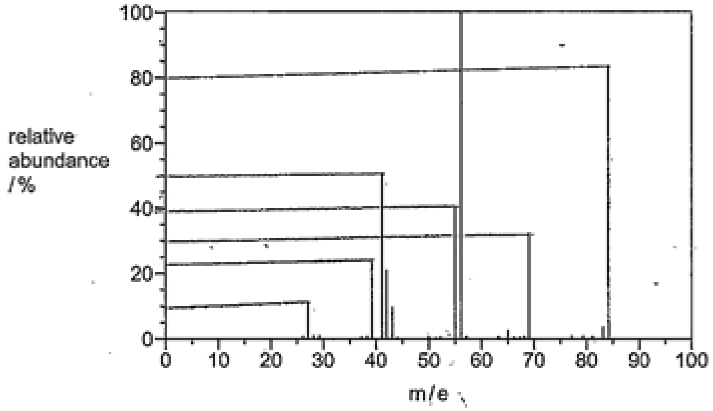
(e) Compound **Y** is a hydrocarbon that contains 85.7% carbon by mass.

The diagram shows the mass spectrum of compound **Y**.



Use all the information given to determine the molecular formula of **Y**.

$$\frac{27\times10+41\times60+100\times5+69\times30+84\times80+85{\cdot}7\times12}{100}$$

181·5

molecular formula of **Y** ......~~[illegible]~~........................ [2]

[Total: 12]

Your Mark

2(a)

2(b)

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2(c)(ii)

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2(e)

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