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GCSE (9-1)

Examiners' report

GATEWAY SCIENCE COMBINED SCIENCE A

J250
For first teaching in 2016

J250/04 Summer 2019 series

Version 1

Contents

Introduction

Our examiners' reports are produced to offer constructive feedback on candidates' performance in the examinations. They provide useful guidance for future candidates. The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

Where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report. A full copy of the question paper can be downloaded from OCR.

Paper 4 series overview

J250/04 is the fourth of six foundation tier papers for Gateway Combined Science A. This component assesses Topics C4, C5 and C6, with assumed knowledge of Topics C1, C2, C3 and Topic CS7 (PAGs C1-C5), and is worth 16.7% of the total GCSE.

To do well on this paper, candidates need to demonstrate knowledge and understanding of scientific ideas, techniques and procedures across all three topics. They need to be able to apply their knowledge and understanding to unfamiliar contexts as well as displaying the ability to analyse information. Candidates also need to be familiar with a range of experimental procedures.

J250/04 has an equal emphasis on knowledge and understanding of the learning outcomes from the specification, application of this knowledge and analysis of information and ideas.

Writing an answer in pencil and then overwriting in ink should be discouraged as it makes answers difficult to decipher. In addition, candidates wishing to change an answer to a multiple-choice question should be encouraged to cross out the original answer and write their final response in the space to the right of the answer box. Overwriting an answer often makes it illegible to the examiner.

Section A overview

Very few candidates omitted any of the multiple-choice questions.

Questions on the reactivity series of metals (4), rate of reaction from a graph (6) and inertness of Group 0 (9) were well answered.

Questions on catalysts (1), percentage composition of the atmosphere (3) explanation of metal reactivity (8) and calculating the surface areas of two shapes (10) proved to be the most difficult for candidates.

Question 1

1 How does a catalyst speed up a reaction?

A It decreases the activation energy.

B It decreases the energy of the reactant particles.

C It increases the activation energy.

D It increases the energy of the reactant particles.

Your answer ☐ **[1]**

Candidates found this very difficult, with very few choosing the correct response. C was the most common incorrect response.

Question 2

2 Which process leads to the greenhouse effect?

A Radiation absorbed by carbon dioxide

B Radiation causing plants to grow

C Radiation causing pollution

D Radiation damaging the ozone layer

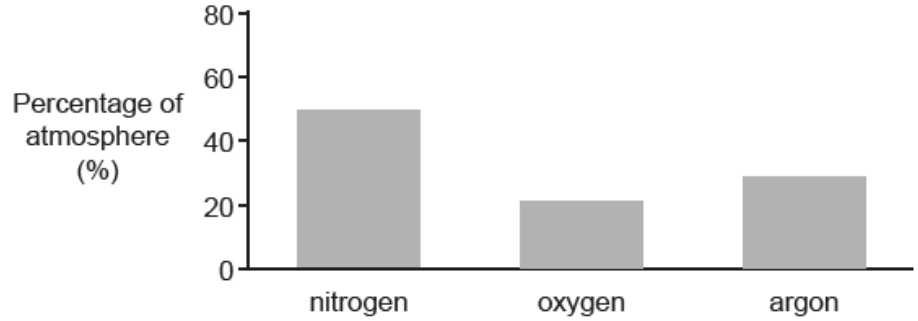
Your answer ☐ **[1]**

Candidates found this challenging. C was the most common incorrect response

Question 3

3 Which graph shows the correct percentages of the three main gases in the atmosphere today?

A



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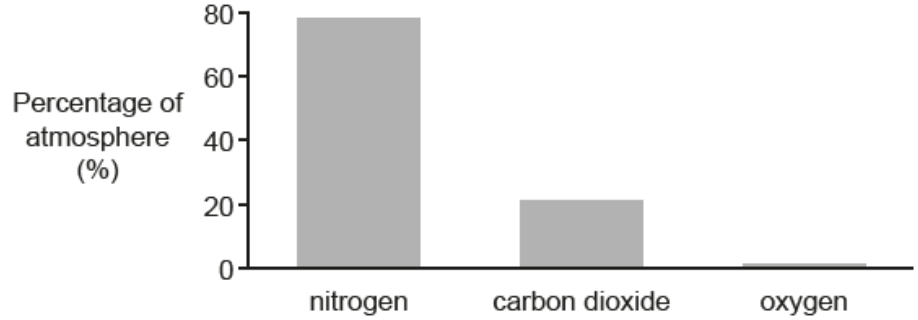

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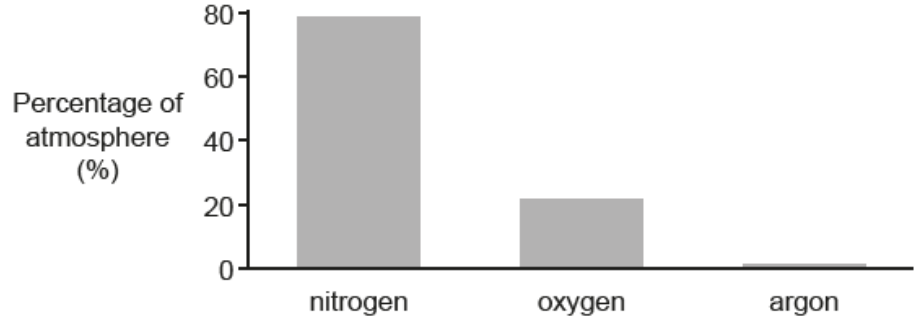

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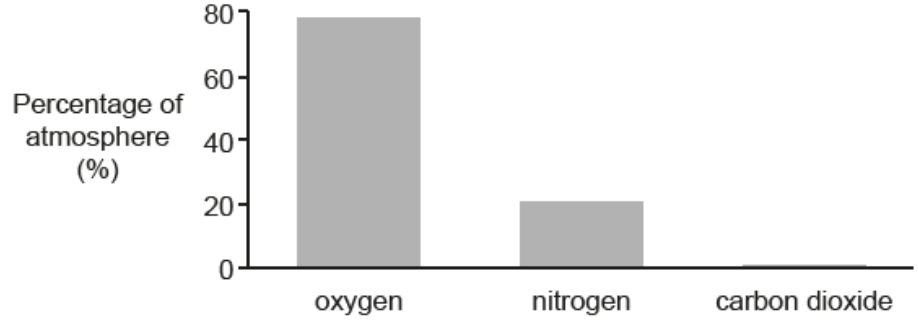


Your answer ☐ **[1]**

Candidates found this difficult with very few choosing the correct response. D was the most common incorrect response.

Question 4

4 This is part of the reactivity series.

Which statement is correct?

A Copper can displace tin from tin chloride.

B Lead can displace copper from copper chloride.

C Lead can displace tin from tin chloride.

D Silver can displace copper from copper chloride.

Your answer ☐ **[1]**

Most candidates answered this question well, selecting the correct response. A and C were common incorrect responses.

Question 5

5 Which row of the table describes Group 1 and Group 7 elements?

	Group 1 elements	Group 7 elements
A	metals with low melting points	metals with high melting points
B	metals with low melting points	non-metals with low melting points
C	non-metals with high melting points	non-metals with low melting points
D	non-metals with low melting points	metals with high melting points

Your answer ☐ **[1]**

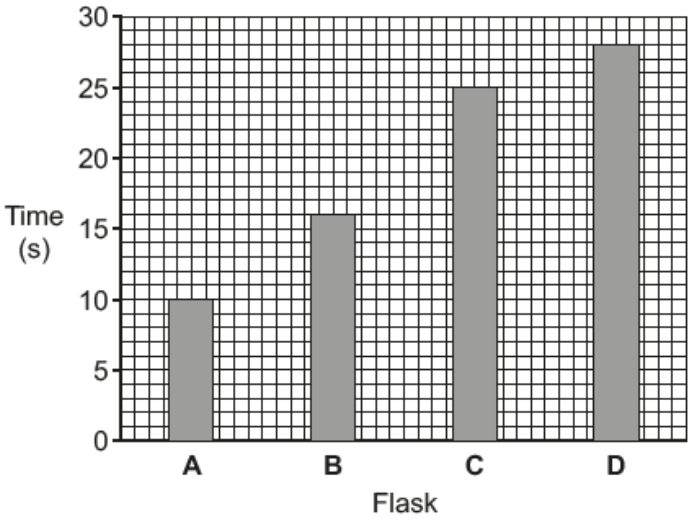
Candidates found this challenging. D was the most popular incorrect response.

Question 6

6 A teacher adds calcium carbonate to an acid in four separate flasks, **A**, **B**, **C** and **D**.

He measures the time it takes for the same volume of carbon dioxide to be produced in each flask.

This is a graph of his results.



Which flask has the fastest rate of reaction?

Your answer ☐ **[1]**

Candidates answered this question well with most choosing the correct response. D was the most popular incorrect response.

Question 7

7 Aluminium is extracted from aluminium oxide using electrolysis.

Carbon cannot be used to do this.

Why is electrolysis used?

A Aluminium is more reactive than carbon.

B Aluminium oxide dissolves in water.

C Aluminium oxide has a high melting point.

D Electrolysis uses less energy than extraction with carbon.

Your answer ☐ **[1]**

Candidates found this question challenging with few choosing the correct response. D was the most popular incorrect response.

Question 8

8 Some metals react faster with an acid than others.

Which statement explains why?

A The acid gives off hydrogen atoms more easily.

B The acid gives off hydrogen gas more easily.

C The metal forms a negative ion more easily.

D The metal forms a positive ion more easily.

Your answer ☐ **[1]**

Candidates found this difficult with few choosing the correct response. B was the most popular incorrect response.

Question 9

9 The elements neon and argon in Group 0 are unreactive.

Which statement explains why?

A These elements have 8 electrons in the nucleus.

B These elements have 8 electrons in the outer shell.

C These elements have 8 protons in the nucleus.

D These elements have 8 protons in the outer shell.

Your answer ☐ **[1]**

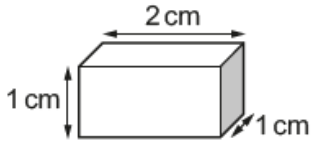
Candidates answered this question well with most choosing the correct response. C was the most popular incorrect response.

Question 10

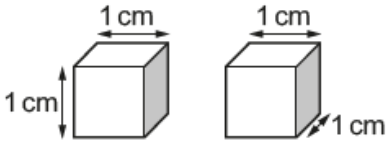
10 Two pieces of chalk, **X** and **Y**, both have the same volume.

A student cuts **Y** into two pieces.

The student reacts **X** and both pieces of **Y** with separate samples of an acid.



Chalk **X**



Chalk **Y** after cutting

The two pieces of chalk **Y** react faster than chalk **X**.

Which row on the table shows the surface area of **X** and **Y**?

	Surface area of X	**Total surface area of the two pieces of Y**
A	$10\,cm^2$	$10\,cm^2$
B	$10\,cm^2$	$12\,cm^2$
C	$10\,cm^2$	$20\,cm^2$
D	$12\,cm^2$	$10\,cm^2$

Your answer ☐ **[1]**

Candidates found the calculations very difficult, with few choosing the correct response. A was the most common incorrect response.

Section B overview

Candidates who did well on this section generally were able to do the following:

- Explain the reactivity of Group 1 elements: 11(a)(iv).
- Calculate, giving answers to the required precision: relative density 11(b)(i), percentage composition 12(d).
- Explain displacement reactions of the halogens: 11(c)(iii).
- Determine the formula of methane: 13(a).
- Draw conclusions from data: 14, 16(a), 16(d).
- Identify independent and control variables: 16(b)(i), 16(b)(ii).
- Apply knowledge and understanding to questions set in a novel context.

Candidates who did not do well on this section generally were unable to do the following:

- Apply what they had learnt to unfamiliar situations.
- Name an element from a symbol: 11(a).
- Perform correct calculations: 11(b)(i), 11(b)(ii), 12(d).
- Read data from a graph: 12(e).
- Label axes give a linear scale or draw a line of best-fit: 13(b)(i).
- Draw conclusions from data: 14, 16(d).
- Identify independent and control variables: 16(b)(i), 16(b)(ii)

There was no evidence that candidates did not have enough time to complete the paper.

Question 11 (a) (i)

11 This question is about Group 1 and Group 7 elements.

(a) A Group 1 element **D** reacts with water.

This is the equation:

$2\mathbf{D} + 2H_2O \longrightarrow 2NaOH + \mathbf{E}$

(i) Name element **D**.

..... **[1]**

This question was quite well answered with over half being able to name sodium. A significant number gave the symbol Na. Lithium, potassium and hydrogen were common incorrect responses as was Dubnium.

Question 11 (a) (ii)

(ii) A teacher shows this reaction to his class.

Describe **one** safety precaution he should use.

.....

..... **[1]**

This question scored the most highly on the paper with most candidates being able to name a suitable safety precaution. Goggles was the most common response.

Question 11 (a) (iii)

(iii) **E** is a colourless gas.

How can you show if the gas is hydrogen or oxygen?

Describe the tests for hydrogen and oxygen, and the results you would expect with gas **E**.

test for hydrogen .....

.....

result with gas **E** .....

test for oxygen .....

.....

result with gas **E** .....

[2]

Candidates found this question very difficult and many omitted it.

Some knew the test for hydrogen but many either used a splint which was not lit or only referred to the squeaky pop test.

The test for oxygen was more well-known but a very small number of candidates appreciated that the test was performed on gas E, which is hydrogen, and so the glowing splint would not relight. Some discussed blowing out a lighted splint or using a recently blown out splint, neither of which are creditworthy replacements for a glowing splint.

Question 11 (a) (iv)

(iv) Group 1 elements are very reactive.

Write down the reason why.

.....

..... **[1]**

Candidates found this very challenging. Common incorrect responses included: high reactivity, reactivity increasing down the group, high/low boiling point, high/low melting point, low relative atomic mass, wanting to lose electrons, filled outer shell and gases.

Question 11 (b) (i)

(b) **Table 11.1** shows the densities of the first four Group 1 elements at room temperature.

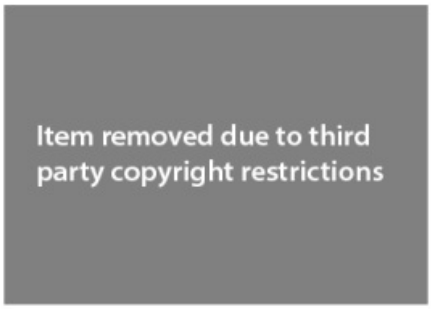


Table 11.1

(i) Calculate how many times larger the density of **rubidium** is than the density of **lithium**.

Give your answer to **1** significant figure.

Number of times larger = ... **[2]**

Few candidates gained full credit. Those candidates who divided the values correctly often gave the answer to 2 or 3 significant figures. The most popular incorrect manipulation was subtraction, usually with the answer given to 3 significant figures. Some candidates just gave a value with no working, where the answer was incorrect there could be no allocation of marks.

Question 11 (b) (ii)

(ii) 1 g of **sodium** and 1 g of **potassium** are mixed to form an alloy.

Calculate the density of the alloy.

Density = ... g/cm^3 **[1]**

The majority of candidates added the two values together with few then dividing this value by 2. Multiplying the values was a common error.

Question 11 (b) (iii)

(iii) The element caesium (Cs) is also in Group 1. Caesium is found below rubidium in the Periodic Table.

Use the information in **Table 11.1** and your knowledge of trends in properties for Group 1 elements to estimate the density of caesium.

Density of caesium = ... g/cm^3 **[1]**

Almost half of the candidates followed the trend and gave an appropriate value. Many candidates omitted this question.

Question 11 (c) (i)

(c) A student reacts a solution of KBr with chlorine, Cl_2.

(i) Balance the equation for this reaction. **[1]**

Most candidates balanced the equation correctly. Common incorrect figures included 1 and 1, 2 and 3, 2 and 4. Some candidates changed the formulae of the halides in order to balance the equation. A significant number omitted the question.

Question 11 (c) (ii)

..... KBr + Cl_2 → ..... KCl + Br_2

(ii) What is the name of the chemical KBr?

Tick (✓) **one** box.

Bromine ☐

Potassium ☐

Potassium bromide ☐

Potassium bromine ☐ **[1]**

Just over half of the candidates chose the correct response. The most popular incorrect response was potassium bromine.

Question 11 (c) (iii)

(iii) What does the reaction tell you about the reactivity of Br_2 and Cl_2?

Explain your answer.

.....

.....

..... **[2]**

Candidates found this question challenging, few discussed the relative reactivity of chlorine and bromine and many omitted the question. Similar reactivity, both reactive, reactivity increases down the group and reactivity decreases down the group were the more common incorrect responses.

Question 12 (a)

12 The reaction between sulfur dioxide and oxygen is reversible.

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$

(a) In a closed system the reaction between sulfur dioxide and oxygen reaches a dynamic equilibrium.

Use a symbol from the list to complete the sentence.

> < = $\frac{1}{2}$

At equilibrium, the rate of the forward reaction is ..... the rate of the reverse reaction. **[1]**

Nearly half of candidates chose the correct symbol. All options were seen with 1/2 being the most common. Many candidates omitted the question.

Question 12 (b)

(b) What is meant by the term **reversible reaction**?

.....

..... **[1]**

Candidates found this difficult to explain with many using 'reverse' in their answer. Many described a physical change by discussing going back to the original state or discussed water changing to ice and back to water again.

Question 12 (c) (i)

(c) (i) Name **one** source of sulfur dioxide in the atmosphere.

..... **[1]**

Candidates found this very difficult with few gaining credit. Incorrect responses included carbon dioxide, nitrogen, nitrogen dioxide, oxygen, factories, acid rain and pollution. Many candidates omitted the question.

Question 12 (c) (ii)

(ii) Describe **two** problems caused by the release of sulfur dioxide into the atmosphere.

1 .....

.....

2 .....

.....

[2]

Few candidates gained credit and a significant number omitted the question. More common incorrect responses included: greenhouse gas, climate change, global warming, toxic and depleting ozone.

Question 12 (d)

(d) The table shows some relative atomic masses.

Element	Relative atomic mass
Sulfur	32.1
Oxygen	16.0

Calculate the percentage, by mass, of oxygen in SO_2.

Give your answer to **1** decimal place.

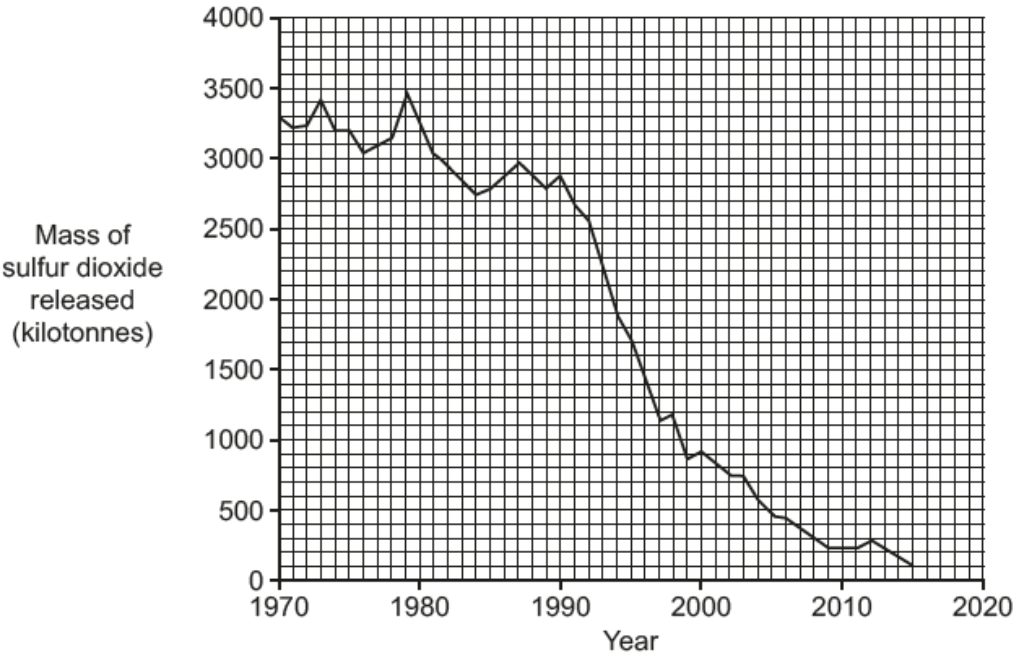
Percentage = ... % **[3]**

Candidates found this very challenging with few gaining credit. Adding them together was the more popular response but various multiples were added, multiplied or divided or a combination of these. A significant number omitted the question.

Question 12 (e)

(e) The amount of sulfur dioxide released in the UK is decreasing.

This graph shows how it has decreased since 1970.



How much did the sulfur dioxide decrease between 1975 and 2015?

Sulfur dioxide decrease = ... kilotonnes **[2]**

More than half of the candidates answered correctly. The value for 2015 was better answered than the value for 1975 and most candidates who answered the question subtracted their two values. Some candidates just gave a value with no working, where the answer was incorrect there could be no allocation of a mark for working.

Exemplar 1

How much did the sulfur dioxide decrease between 1975 and 2015?

3300 − 100 = 3200

Sulfur dioxide decrease = ... 3200 ..... kilotonnes **[2]**

Although the value 100 for 2015 is correct, the value 3200 for 1975 is incorrect, so does not gain a mark. The subtraction is correct and evaluated correctly, so gains a mark for the working.

Question 13 (a)

13 One homologous series of organic compounds is called the alkanes.

They have the general formula C_nH_{2n+2}.

(a) The alkane with one carbon atom, $n = 1$, is called methane.

Write down the formula of methane.

..... **[1]**

Candidates found this question challenging with few gaining the mark. Common incorrect responses included C_nH_{2n+2}, $C_1H_{2 \times 1 + 2}$ or a formula including Me. Many omitted the question. While C_1H_4 is not incorrect, by convention the 1 is not normally included in a formula.

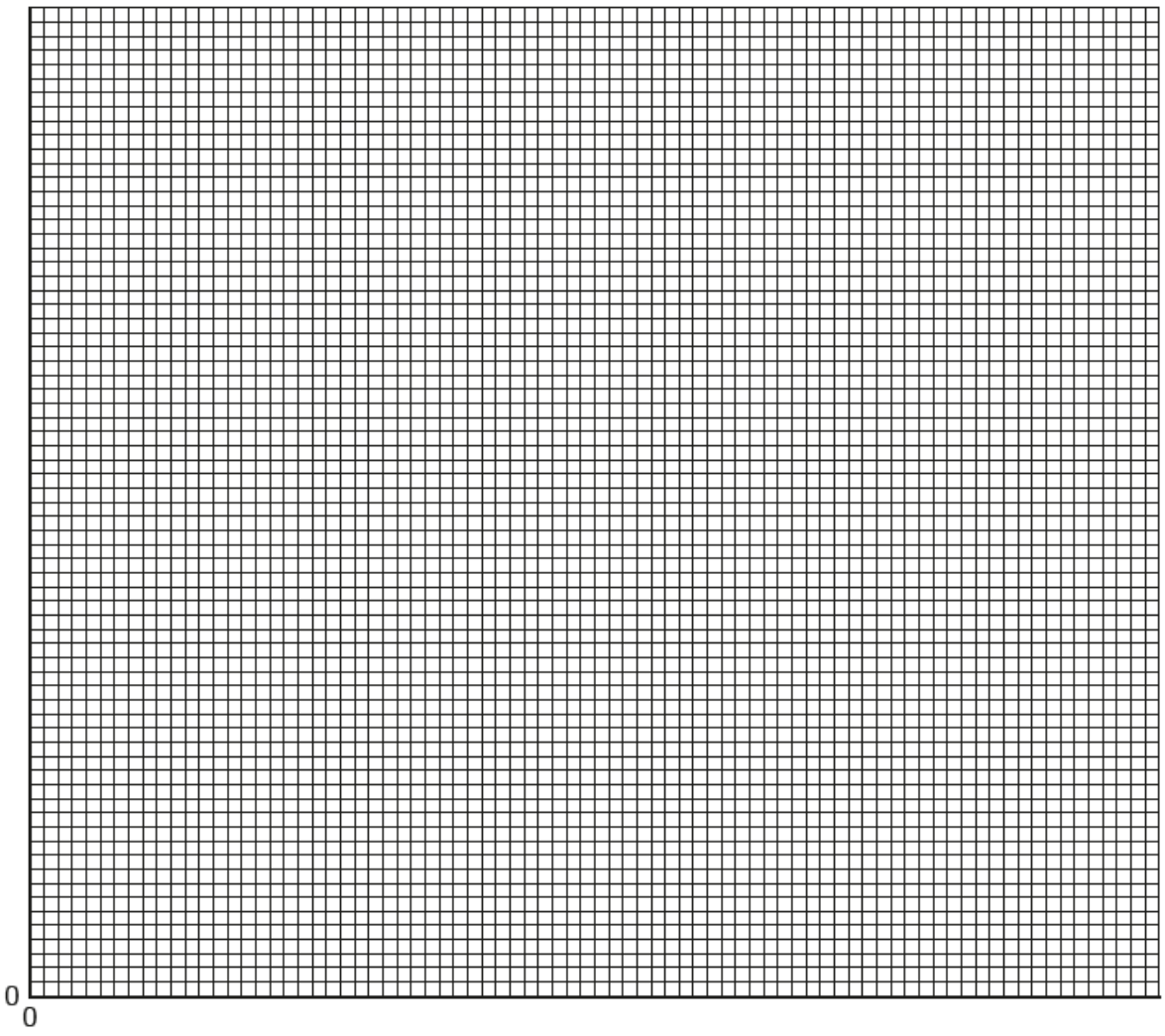
Question 13 (b) (i)

(b) **Table 13.1** shows the energy released when some alkanes burn in oxygen.

Alkane	Number of C atoms	Energy released (kJ/mol)
C_3H_8	3	2220
C_4H_{10}	4	2877
C_5H_{12}	5	3510
C_6H_{14}	6	4163
C_7H_{16}	7	4816
C_8H_{18}	8	5470

Table 13.1

(i) Plot a graph of number of carbon atoms against energy released using the data in **Table 13.1** and draw a line of best fit.



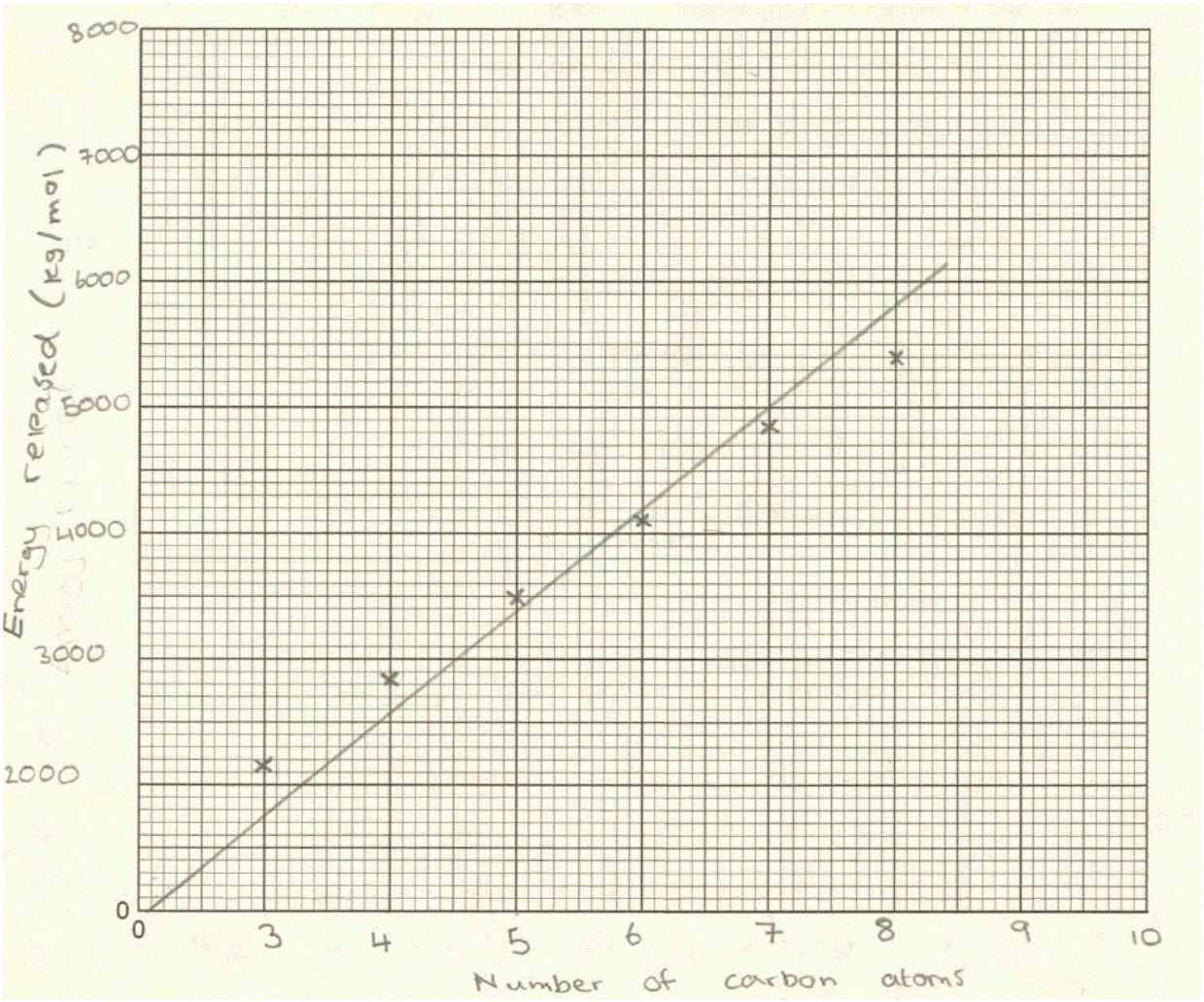
[4]

Many candidates gained at least partial credit for this graph. The axes were often labelled but a significant number omitted either the quantity and unit or more often just the unit for energy. Some reversed the axes. The x-axis was usually linear and covering more than half of the grid. The y-axis usually covered more than half of the grid but was often non-linear. The plotting of the points was usually correct. The line of best-fit caused more difficulty, there were several sketchy or dot-to-dot lines and many were placed through the origin where the points gave a best-fit line that would not go through the origin.

Many candidates ignored the origin, (0 0) already given on the graph.

A significant number omitted this question.

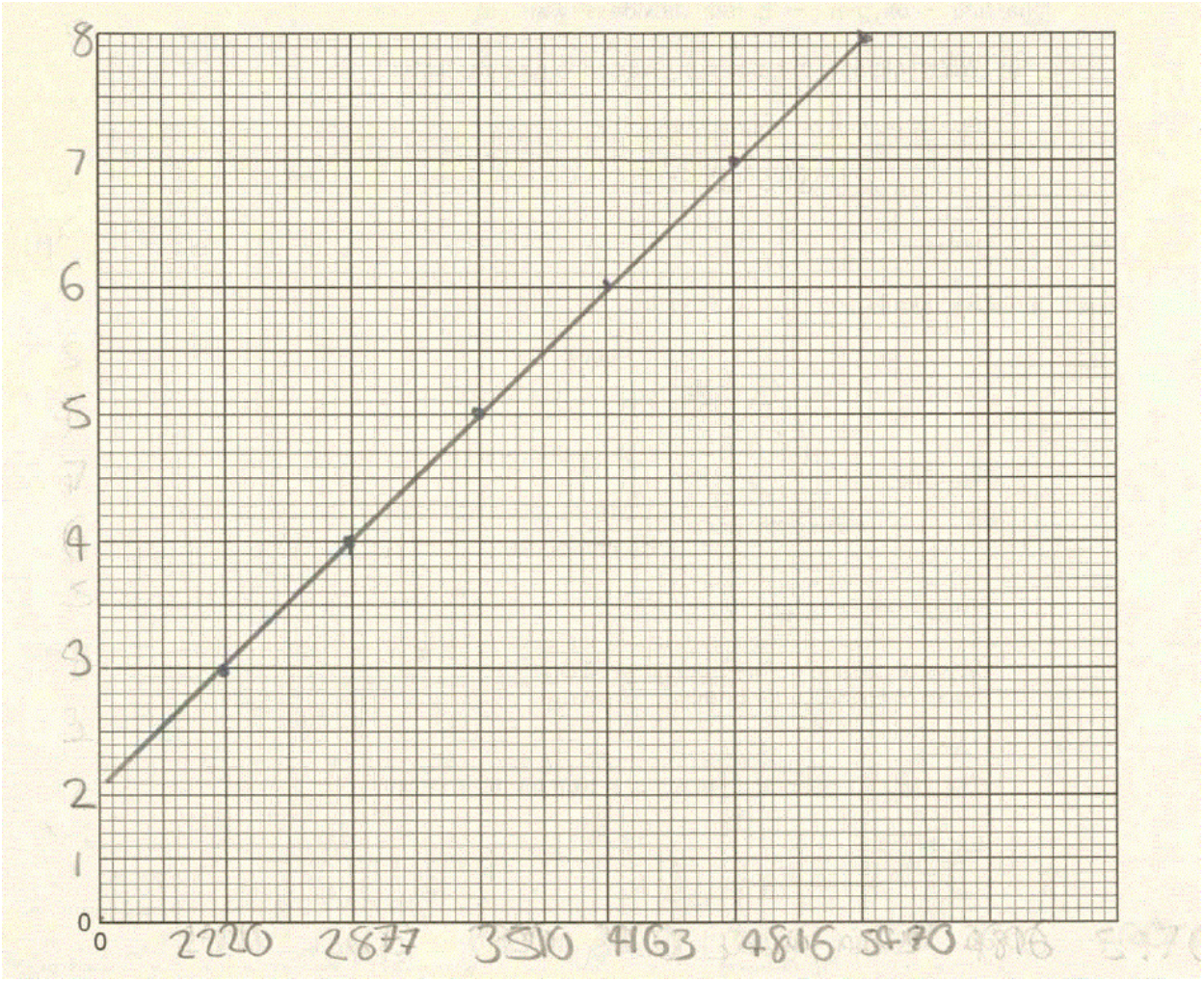
Exemplar 2



The y-axis is non-linear, the first scale division is 2000 whereas all of the others are 1,000. Marking point two is not gained.

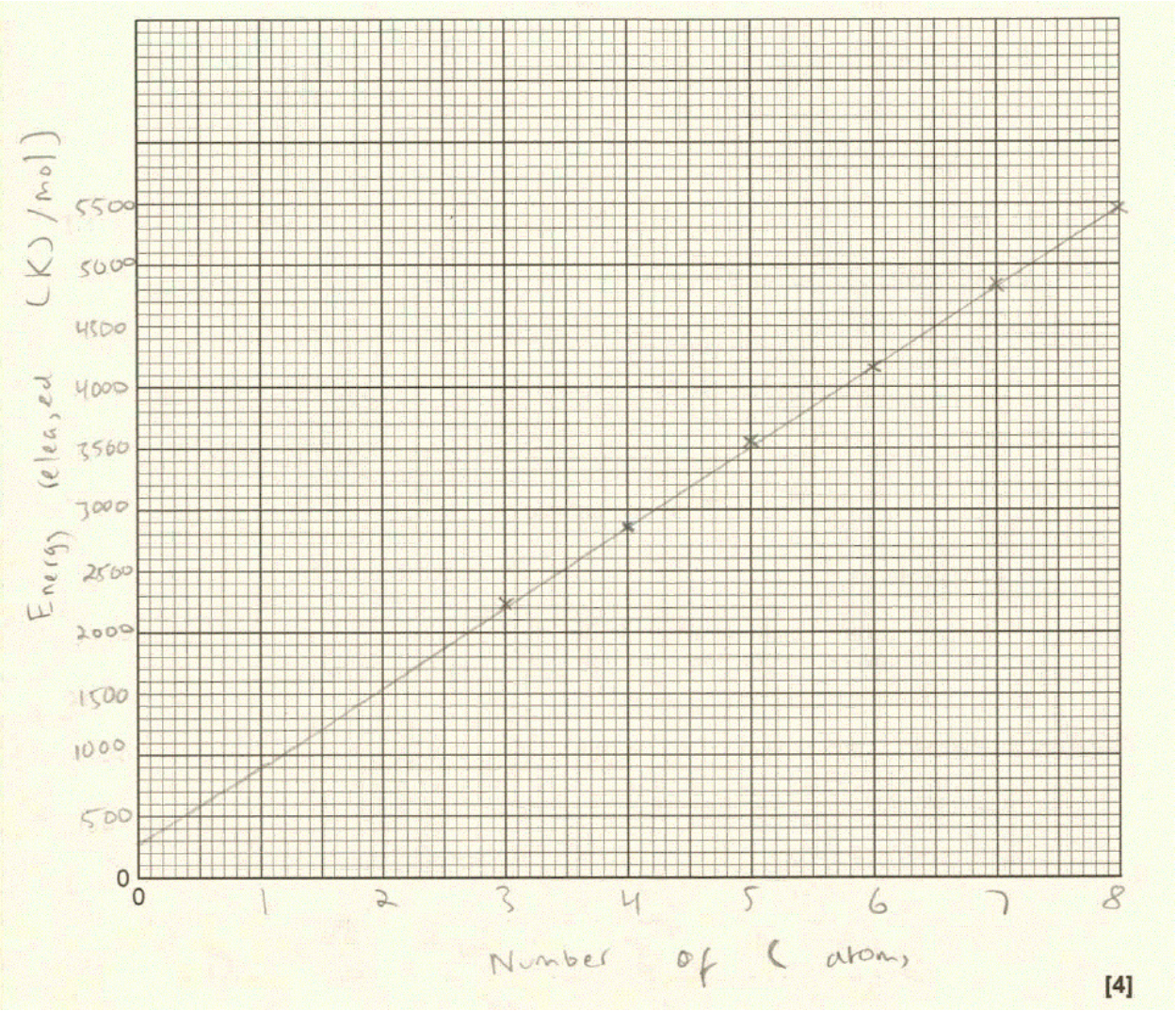
The points give a best-fit line which should not go through the origin, marking point four is not gained.

Exemplar 3



While this graph does not gain marking points one, two or three, there is a best-fit line through the plotted points and so gains making point four.

Exemplar 4



This graph scores all four marks.

Question 13 (b) (ii)

(ii) Use the graph to predict the energy released when methane burns (1 carbon atom).

Energy released = ... kJ/mol **[1]**

Those candidates who drew a high scoring graph usually gave a correct response. many candidates omitted the question.

Question 13 (c) (i)

(c) Hexane is a liquid alkane that burns in oxygen.

hexane + oxygen → carbon dioxide + water

(i) Which element in hexane is oxidised to produce water?

Give a reason for your answer.

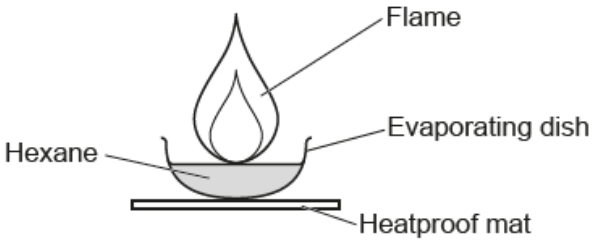
element .....

reason ..... **[1]**

Candidates found this very difficult, few chose hydrogen with a reason and many omitted the question. Oxygen, carbon and hexane were the most common incorrect responses

Question 13 (c) (ii)

(ii) A student burns 10.0 g of hexane.



These are his results.

Mass of hexane before burning = 10.0 g
Mass of hexane after burning = 0.0 g

The law of conservation of mass is **true** for this reaction.

Explain why.

.....

.....

.....

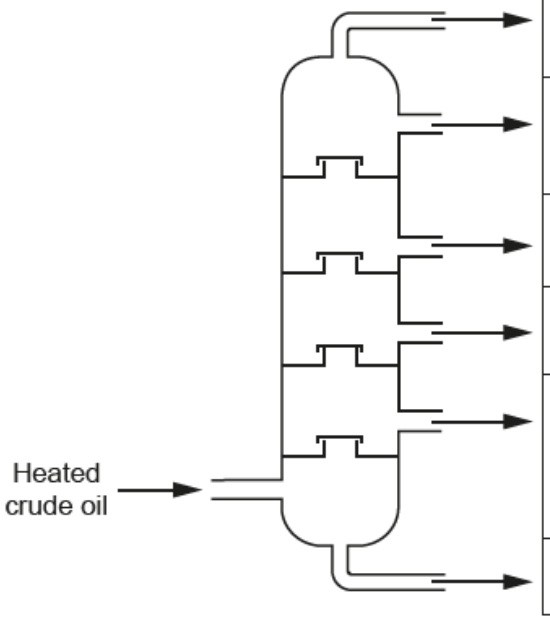
..... **[2]**

Candidates found this very difficult, only a small number knew the law of conservation of mass or appreciated that the products were gases. Many discussed the evaporation of hexane or argued that the mass going to 0 g proved the law or combined both of these. Many candidates omitted the question.

Question 14

14* Fractional distillation can be used to separate different fractions from crude oil.

Fig. 14.1 gives some information about the process.



Fraction	Boiling point (°C)	Average number of carbon atoms in alkanes present in fraction
LPG	<40	3
Naphtha	40–190	10
Kerosene	190–270	15
Gas oil	270–360	20
Lubricating oil	360–540	35
Residue	>540	40

Fig. 14.1

Explain how fractional distillation produces the different fractions from crude oil.

Use the information in **Fig. 14.1** and include ideas about intermolecular forces in your answer.

.....

.....

..... **[6]**

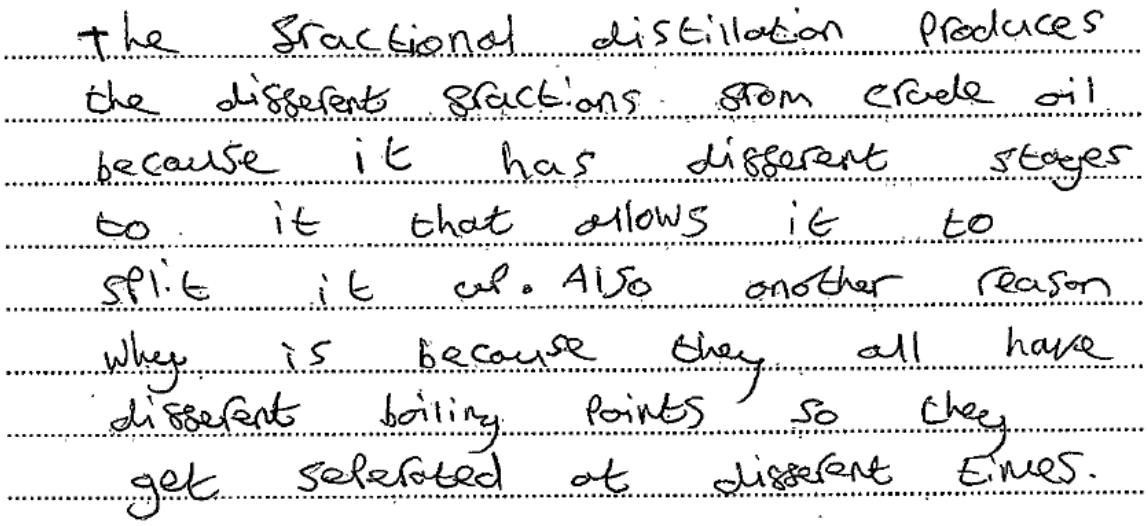
Candidates found this question difficult and many omitted the question.

Those candidates who answered could often either make a general comment about the information provided or make a basic link between a fraction or height in the column to boiling point or number of carbon atoms. Some confused melting point and boiling point.

More able candidates used more of the information provided and made a direct link between boiling point and number of carbons, often giving an example of a fraction or heights in the column.

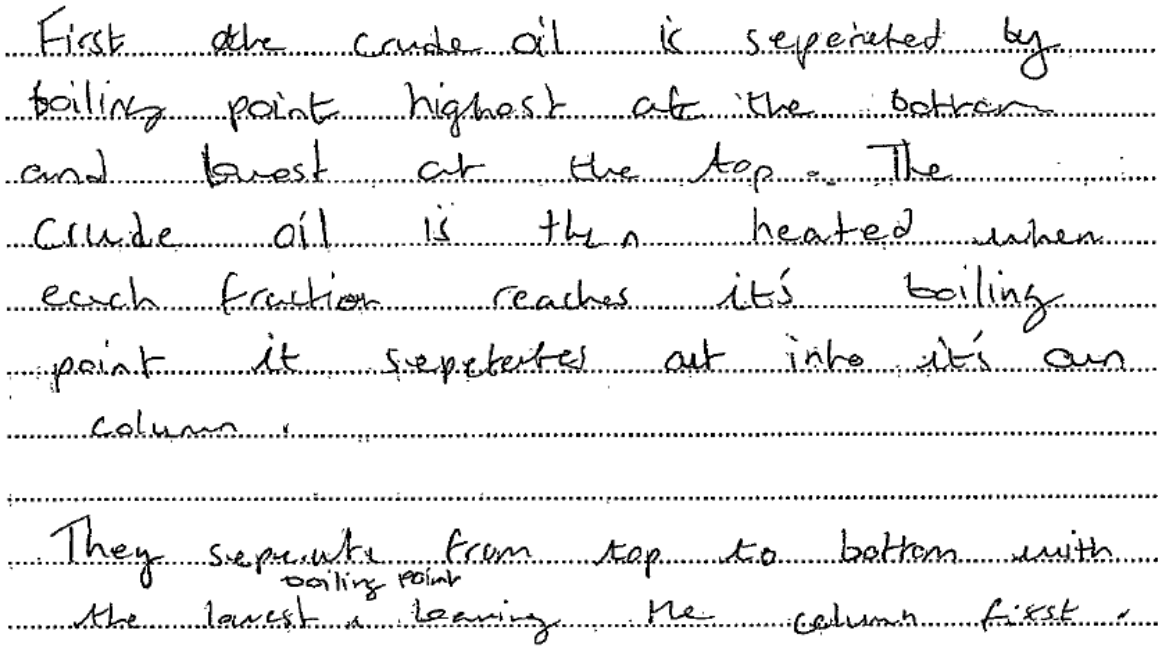
A small number of the higher ability candidates included correct links to intermolecular forces (as well as boiling point and number of carbons) which was the aspect of the question where the concept needed was not provided in the given information.

Exemplar 5



The candidate has said that the fractions have different boiling points. This is a general comment from the information given and is at Level 1, scoring one mark. This was a popular answer.

Exemplar 6



The candidate has made a basic link between the height in the column and the boiling point and is at Level 1, scoring 2 marks.

Exemplar 7

Fractional distillation produces different fractions of crude oil because the temperature increases throughout. This is shown in Figure 14.1 as the higher the boiling point the more average number of carbon atoms in the present fractions. The increasing number of carbons show that fractional distillation produces different fractions from crude oil.

The candidate links boiling point to the number of carbon atoms, this is Level 2, 3 marks. To gain 4 marks the candidate needs to reference either an example of a fraction or the height in the column.

Exemplar 8

All of the different fractions produced has different boiling points so they will all Sperate at different times. LPG will seperate first because it has the ~~tees~~ lowest boiling point and the weakest intermolecular forces. Residue will be the last thing left because it has the highest boiling point and the strongest intermolecular forces. As the boiling point increases for the different fraction the number of ~~c~~ carbon atoms ~~present~~ present also increases.

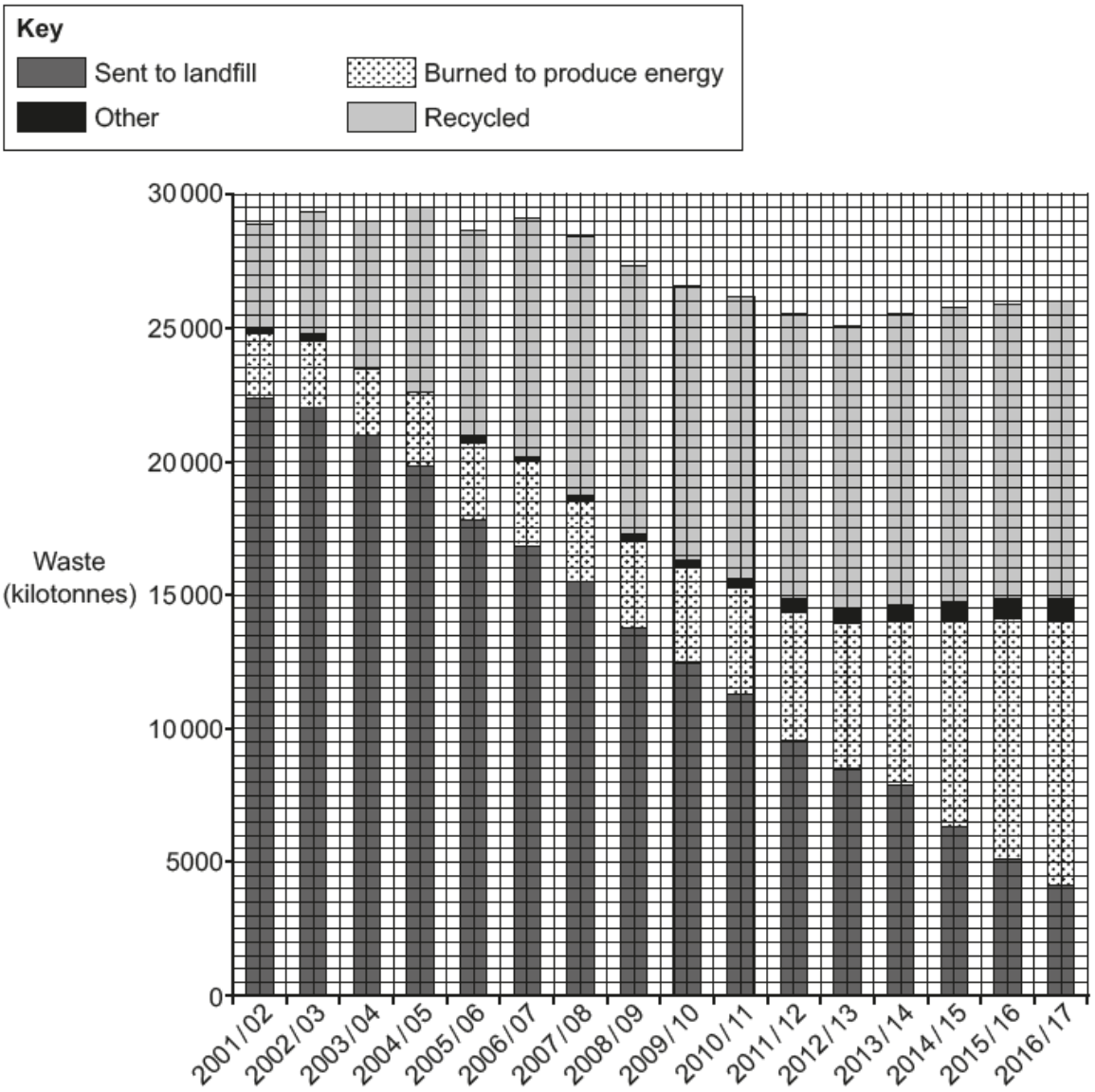
This candidate has linked all of the aspects boiling point, number of carbons and intermolecular forces and has given an example of a fraction, this is Level 3, 6 marks.

This is an example where all of the links between properties have clearly been made but the links are in separate parts of the answer.

Question 15 (a)

15 Local councils collect waste from households.

The graph shows what happened to the waste between 2001 and 2017.



(a) Describe **and** explain **one** trend shown by the graph.

.....

.....

.....

..... **[2]**

Candidates found the interpretation of the graph challenging. Nearly half gave a correct trend from the graph, often less waste going to landfill, but many then quoted numbers from the graph as their reason rather than either looking at the changes in the other methods or using their prior knowledge to explain the trend given. Some read the top of the bars for recycling and described the amount being recycled as decreasing and then increasing.

Question 15 (b)

(b) State **one** disadvantage of recycling.

.....

..... **[1]**

Many candidates misread the question and either gave an advantage rather than a disadvantage or discussed burning the waste or argued that not all materials can be recycled.

Question 16 (a)

16 A student adds some magnesium to dilute hydrochloric acid (HCl).

Magnesium chloride ($MgCl_2$) and hydrogen gas is formed.

(a) Write a **balanced** symbol equation for this reaction.

..... **[2]**

Candidates found this question challenging and many omitted the question. Most candidates gave the formula of hydrogen as H.

Question 16 (b) (i)

(b) She wants to investigate how changing the concentration of hydrochloric acid affects the rate of reaction.

The student uses:

- hydrochloric acid with a concentration of 1 mol/dm^3
- magnesium ribbon
- a conical flask
- a measuring cylinder
- a mass balance
- a stopwatch.

(i) Identify the independent variable in the investigation.

..... **[1]**

Candidates did not understand the term independent variable, and most chose a piece of equipment from the list. Those that chose hydrochloric acid usually gave the specific concentration of 1 mol/dm^3 rather than identifying concentration as the variable.

Question 16 (b) (ii)

(ii) Identify **two** control variables in the investigation.

1 .....

2 .....

[2]

Candidates generally did not understand the term control variable, and most chose pieces of equipment from the list. A small number identified an aspect of magnesium.

Question 16 (c)

(c) The student measures the time it takes from adding the magnesium to the hydrochloric acid until the reaction mixture stops bubbling.

The table shows the student's results.

Concentration of acid (mol/dm^3)	Time 1 (s)	Time 2 (s)	Time 3 (s)	Mean (average) time (s)
1.00	15	15	15	15
0.75	65	55	41	54
0.50	85	90	88	88
0.25	300	290	295	295

The results at 0.75 mol/dm^3 are **not** precise.

Suggest **one** reason why this might have happened.

.....

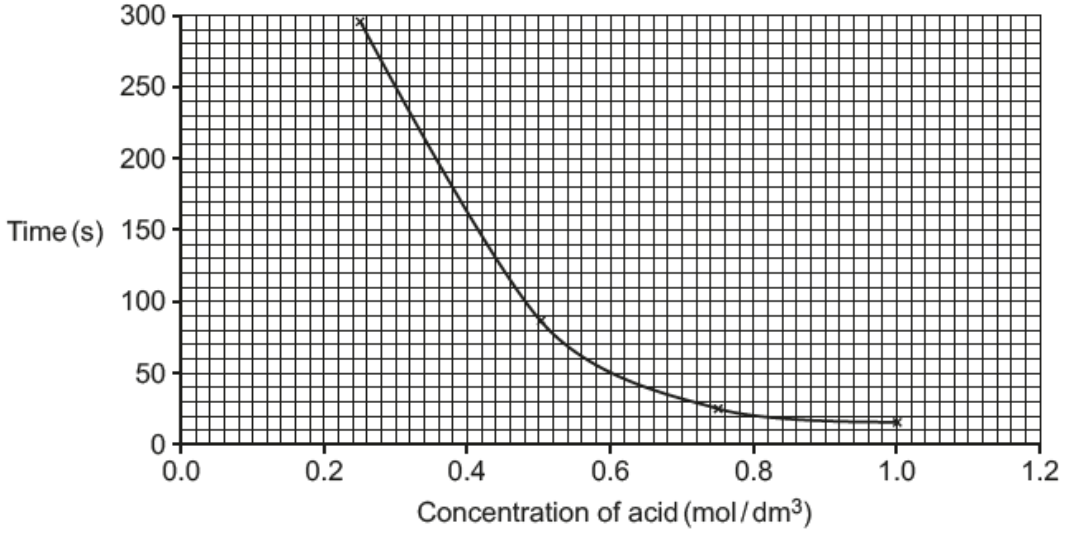
..... **[1]**

Candidates found this challenging, and many omitted the question. Many explained why the results could be considered anomalous such as the times were all very different or gave generalised comments such as human error or the results were rounded. A described timing error was the most popular correct response.

Question 16 (d)

(d) The results at 0.75 mol/dm^3 are repeated.

This is a graph of the student's results.



What conclusion can you make from these results?

Include ideas about **particles** in your answer.

.....

.....

.....

.....

.....

.....

..... **[3]**

Candidates found this question challenging, and many omitted the question. Some candidates correctly discussed the link between concentration and rate. Some candidates knew that there were more particles in the more concentrated acid but did not appreciate that these were in the same volume of the acid or that the particles were more crowded, many discussed the particles having more energy or moving more quickly. Some candidates discussed the greater number of collisions, but few appreciated that they were more frequent. Some thought the graph was the rate of one concentration varying with time and so discussed the rate decreasing during the course of a reaction.

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Question 12 (e)

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