Qualification Accredited

Oxford Cambridge and RSA

GCSE (9-1)

Examiners' report

TWENTY FIRST CENTURY SCIENCE CHEMISTRY B

J258

For first teaching in 2016

J258/04 Summer 2024 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. A selection of candidate answers is also provided. 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 and the mark scheme can be downloaded from OCR.

Paper 4 series overview

This paper is the second of two papers to assess specification content for Higher Tier candidates for Twenty First Century Science Chemistry (B). This specification has Ideas about Science (Unit 7 of the syllabus) embedded into both the teaching and assessment, and the specification content is accompanied by a narrative which provides additional guidance regarding the scope and exemplification of the specification statements. In order to assess Ideas About Science, the assessment is characterised by including questions that have unfamiliar information and context that the candidates are expected to interpret and apply in order to answer some questions. This paper tests the depth of knowledge and, as such, requires candidates to show their knowledge, understanding, processing and application of learning of specification content in both depth and detail. The first two questions are shared with the Foundation Tier and so appear on both J258/02 and J258/04.

The paper relies on a short answer format, with some objective questions that require candidates to complete recognition tasks such as to tick or join boxes. In addition, in keeping with the nature of the specification, some questions require candidates to interpret unfamiliar information and use it to support and justify scientific hypotheses, theories and patterns. An example of this is Question 4.

Two questions are Level of Response questions; Question 5 (c) and Question 8. To answer these questions well, it is essential that candidates demonstrate interpretation of all of the data available to them and also that they answer all parts of the task. A common shortcoming in Level of Response answers is that candidates typically do not fully address either all of the provided data or that they omit some aspects of the task. This is the main reason that some candidates are limited to Levels 2 or 1.

Mathematical questions were generally very well answered. Candidates showed themselves proficient at using standard form, interpreting mathematical symbols, carrying out calculations and extracting data from tables and graphs. An area for development is in the drawing of graphs, particularly with regard to drawing lines of best fit and reading negative scales, see detailed comments for Question 7 (a) below.

In general terms, the performance of candidates showed that they are committed to the assessment and interact well with the paper. There were few spaces left blank and few un-attempted part questions. Candidates used all available space and remained engaged throughout the paper. Some candidates add answers on additional pages. It should not be necessary to do this, and candidates who write very lengthy answers often contradict themselves. It is not always the case that longer answers earn more marks.

In common with Paper 03, an area for development is practical skills. All practical questions were significantly less well answered than those that relied on knowledge. It appears that some candidates have significant gaps in practical knowledge that is clearly stated on the specification. Candidates were unsure about the collection of a gas over water in Question 2 (a) (i) and simple separation techniques to separate an aqueous solution from a solid in Question 11 (a).

Candidates who do well have clearly spent time checking their recalled knowledge against the specification and ensuring that they know detailed knowledge 'by heart'. Teachers should note that a significant number of marks are available on the paper for the testing of recall of knowledge. The details of what candidates are expected to recall is itemised in the specification statements. Questions this year included recall of the detail of life cycle assessments (Question 9) and alternative methods of making industrial chemicals (Question 11).

Other areas for focus include ensuring that candidates read questions carefully and address the task fully. This includes taking into account the number of marks available and the information given in the question. The amount of detail expected is also indicated by the number of lines provided. Questions such as 1 (a) where 3 marks were available, should be structured carefully to ensure that the candidate addresses enough points to earn all marks.

One aspect of ensuring that answers fully address the question is to ensure that answers asking candidates to 'Explain why….' include explanations of underlying science rather than re-quote data or information from the question, or only make factual statements. An example of this is in Question 9 (a).

A further area for development is to consider how candidates use scientific terminology. Candidates who confuse key terms such as element, compound, atom, molecule and ion are less likely to gain marks because the language they use means that the points they raise are incorrect. It is worth practising the correct use of these terms. It was common to see relative atomic mass confused with molecular mass in Question 5 (b) (ii).

Candidates who did well on this paper generally:	Candidates who did less well on this paper generally:
• plan longer answers to fully address the number of marks available. • have checked their learning carefully against the specification to make sure that they remember the fine detail of the knowledge they need to recall • read the question carefully and address all aspects of the task • set out their working for mathematical questions carefully so that partial marks may be awarded even if the final answer is incorrect.	• give longer answers than necessary, introducing contradictions and errors. • repeat information in the question rather than adding information, explanations or interpretations. • use contradictory and incorrect language, confusing terms such as atoms, ion, molecules, elements and compounds. • give vague, generic answers such as 'more costly' or 'causes pollution' to justify the reasons for scientific decisions.

Question 1 (a)

1 Millions of tonnes of carbon dioxide (CO_2) are added to the air in the UK every year.

Carbon dioxide is produced when fossil fuels are burned in power stations to generate electricity.

(a) Schemes are being developed to remove carbon dioxide from power station waste gases. These schemes add to the cost of electricity.

Explain why it is important to remove carbon dioxide, despite the cost.

Use ideas of risk and benefit.

....

....

....

....

....

.... **[3]**

Almost all candidates gained at least 1 mark, usually for stating that carbon dioxide is a greenhouse gas or is responsible for climate change. However, the command word for this question is 'explain'. Fewer candidates went on to explain why this is an issue by identifying the risks of releasing carbon dioxide (for example rising sea levels). Some omitted the instruction to 'use ideas about risk and benefit'. In order to discuss risk and benefit it is insufficient to only say that risks and benefits exist, the main point covered in Ideas about Science about risk and benefit is that in any situation, a judgement needs to be made about the relative size of the risk compared to the benefit. Best answers discussed how the relative size of the benefit of removal of carbon dioxide outweighs or is greater than the cost of its removal. Some expressed this well in terms of time, stating that the cost is short-term but leads to a greater benefit in the longer term.

Examination technique

It is important to note that this question has six answer lines and 3 marks. These are both indicators that longer answer to include three distinct points is needed to access the marks. A common reason for lower marks for this question was that many answers only made a single point or omitted to clearly discuss risk and benefit in their answer. Candidates need to tailor their answers by considering the space made available and the mark allocation for each question for longer answers.

Question 1 (b)

(b) The UK government says that the mass of carbon dioxide added to the air during the year 2020 decreased by 400 million tonnes compared to 1990. This is a decrease of 49%.

Calculate the mass of carbon dioxide added to the air during 1990.

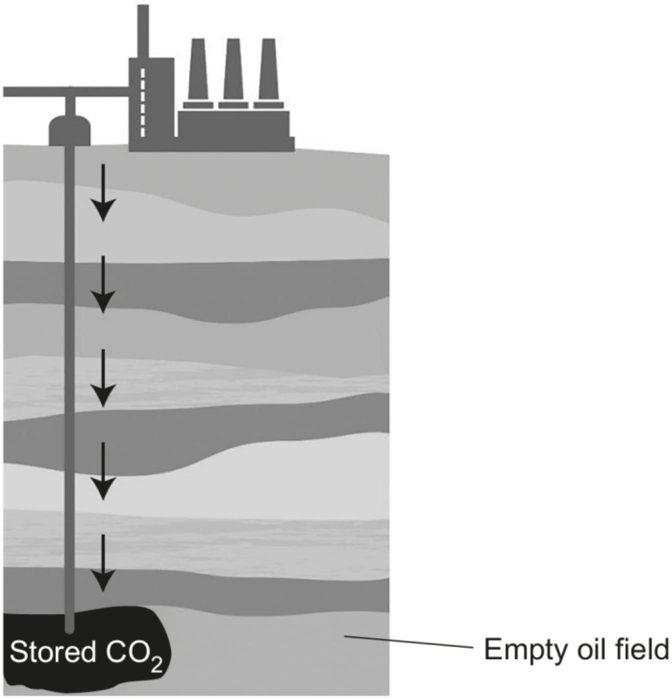
Use the formula: $\text{percentage decrease} = \dfrac{\text{decrease in mass}}{\text{mass added to the air during 1990}} \times 100$

Mass added to the air during 1990 = ... million tonnes **[3]**

This question was very well answered, with almost all candidates selecting values from the information and substituting into the provided formula. A common error was to multiply the final answer by a million, which showed a misinterpretation of the original values for mass, which were already in millions of tonnes.

Question 1 (c) (i)

(c) Scientists are developing a new scheme to remove carbon dioxide from the air and store it in empty oil fields.



Scientists make two predictions:

1. Burning fossil fuels in the UK will add 230 million tonnes of carbon dioxide to the air each year.
2. There is enough space in UK oil fields to store all this carbon dioxide for at least the next 100 years.

(i) Which is the best estimate of the amount of carbon dioxide that can be stored in UK oil fields?

Tick (✓) **one** box.

$< 2.3 \times 10^3$ million tonnes ☐

$> 2.3 \times 10^4$ million tonnes ☐

$< 2.3 \times 10^6$ million tonnes ☐

$> 2.3 \times 10^6$ million tonnes ☐

[1]

Candidates found this question difficult. It was unclear whether it was the mathematical symbols (< and >) that were challenging or the numbers. Candidates need to make sure that they are familiar with the mathematical content listed in Appendix 5e of the specification.

Question 1 (c) (ii)

(ii) The demand for energy for electricity is one factor that affects the amount of fossil fuels we burn.

State **one other** factor that affects the amount of fossil fuels we burn.

....

.... **[1]**

Most answers identified a factor that affects the amount of fossil fuels burned, usually citing a use of fossil fuels, for example for transport, or for stating that the use of renewable energy sources impacts their use. It should be noted that, in general, cost arguments alone are ignored.

Question 2 (a) (i)

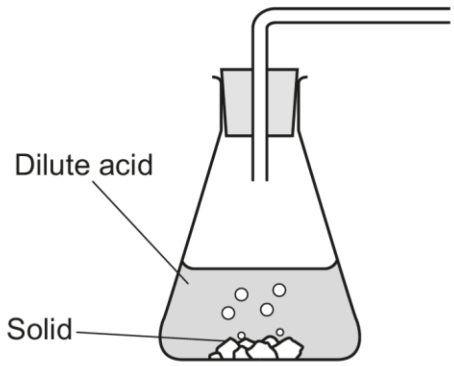
2 A student investigates the rate of reaction when a solid reacts with a dilute acid.

(a) The reaction makes a gas.

The student collects the gas in a measuring cylinder over water.

(i) **Complete** the diagram to show how the student sets up their measuring cylinder to collect the gas over water.

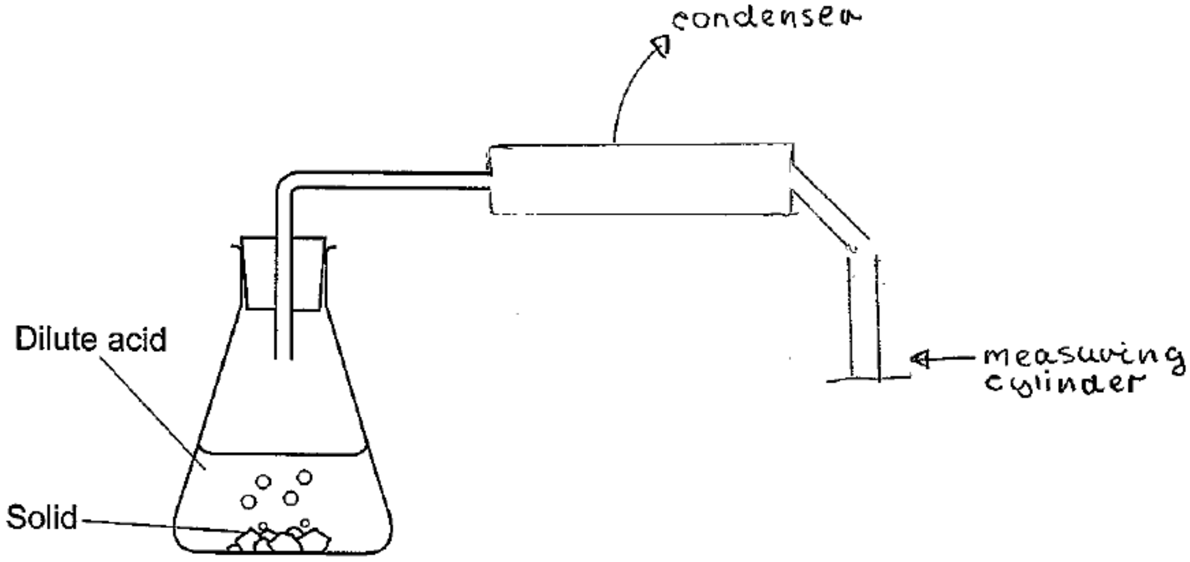
Include labels on your diagram.



[3]

In general across the whole paper, candidates commonly find practical questions more difficult. In this case many did not know how to collect a gas over water. This knowledge is directly stated on the specification as part of C6.2 and PAG8). A range of incorrect attempts were seen, including the use of condensers or incorrect measuring cylinders drawn with side arms. Some drew a test tube or gas syringe, despite the instruction in the question that the set-up needed to include a measuring cylinder. Some partially correct responses did not always show the opening of the measuring cylinder to be clearly below the level of the water.

Exemplar 1



This candidate response was given 0 marks and is typical of many incorrect responses seen. The candidate has attempted to draw an apparatus to collect a gas, but appears to have the misconception that a gas can be condensed into liquid form and be collected in a measuring cylinder.

Question 2 (a) (ii)

(ii) The student finds it difficult to measure the volume accurately in the measuring cylinder.

Suggest another method they could use to get more accurate readings.

....

.... **[1]**

The question asked about accurate measurement of volume. Many candidates knew that a gas syringe gives a more accurate reading than a measuring cylinder. A common error was to state that the mass change could be followed. Although this is an alternative method of following rate, it does not measure volume and so was not given a mark. Candidates need to take care to read the question carefully and ensure that they are answering the question asked.

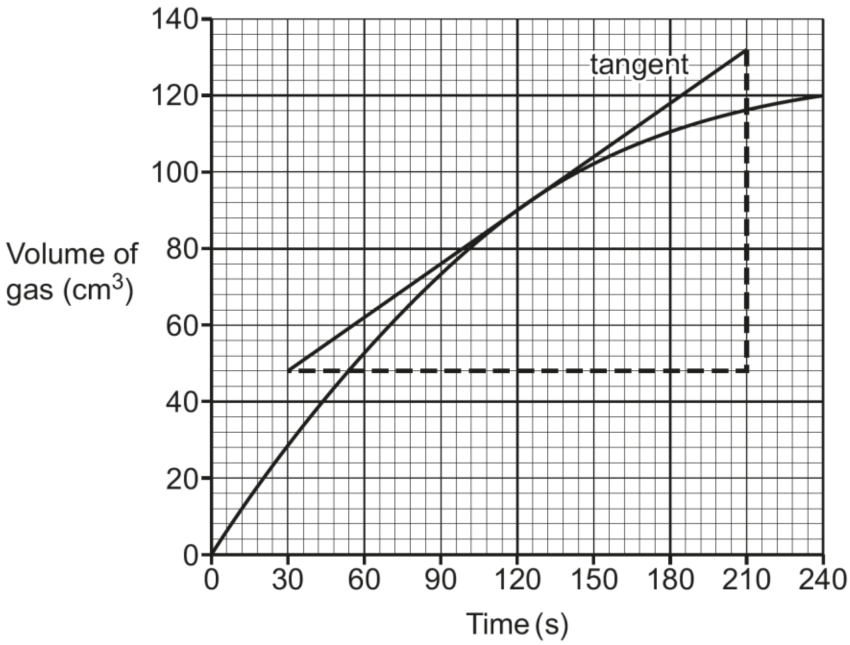
OCR support

Our [Language of Measurement in Context: Chemistry] resource, available on Teach Cambridge, helps students to understand terms like accuracy and make suggestions to improve upon practical methods.

Question 2 (b) (i)

(b) The student plots a graph of their results.

The student draws a tangent to the curve at the point where time = 120 s.



(i) Calculate the gradient of the tangent shown on the graph.

Gradient = ... cm^3/s **[3]**

This question was challenging because the values needed to calculate the gradient needed to each be taken by considering two readings on each axis. Many candidates did this correctly. Most also knew that gradient is calculated by dividing 'rise' by 'run' and computed their values. However, a common error was to ignore the triangle provided and to use readings taken over a much smaller tangent.

Assessment for learning

The mathematical requirements for the syllabus are given in Appendix 5e. It is suggested that assessing candidates against these requirements is used for formative assessment. When calculating a value for a gradient, the largest triangle possible should be drawn and used to determine the values of 'change in x' and 'change in y'. Small triangles give small values with a much greater percentage error.

Question 2 (b) (ii)

(ii) What information does your answer to **(i)** give about the reaction?

Tick (✓) **one** box.

The increase in volume and time at 180 s.	☐
The rate of reaction at 120 s.	☐
The time taken to make 90 cm^3 gas.	☐
The volume of gas made in the first minute of the reaction.	☐

[1]

The idea that the tangent measures the rate of reaction at 120 s was very well known.

Question 2 (c)

(c) The student repeats their experiment using different conditions.

The rate of the reaction increases each time.

Draw lines to connect each **change in condition** with its correct **explanation** for the increase in rate.

Change in condition	**Explanation**
Increased concentration of acid	Frequency of particle collision increases because surface area increases.
Increased temperature	Frequency of particle collision increases because particles are closer together.
Smaller pieces of solid	More particle collisions are successful because the energy of the particles increases.

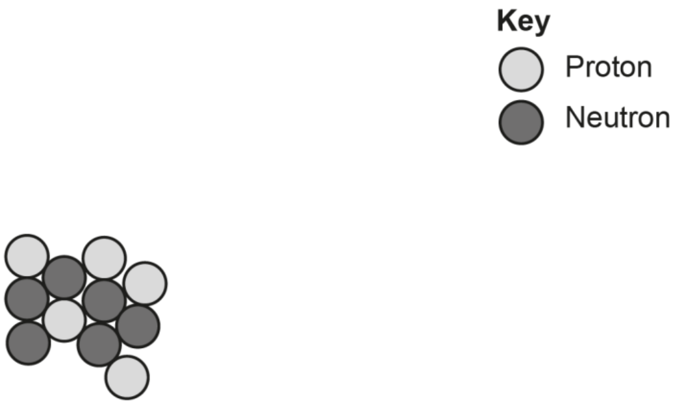
[2]

Collision theory related to change in conditions was well understood. Most candidates gained both marks. In previous papers (and perhaps in the future) collisions theory has been asked in open response questions, which are less well answered. This question is a useful question to use to help candidates to learn to structure their responses to the explanation for each type of change of condition.

Question 3 (a) (i)

3 A student makes a model of an atom.

(a) They use small, coloured beads to represent the protons and neutrons in the nucleus of the model, as shown in the diagram.



The student shows the arrangement of electrons by using more beads to add shells of electrons to their model.

(i) **Complete the diagram** to show the arrangement of electrons in the atom.

Use **X** to represent each electron. **[2]**

The key understanding here is that the atom contains the same number of electrons as protons (five). Many worked this out and correctly showed two electrons in the first shell and three in a second. However, some candidates showed many more shells, implying that they did not link the number of protons to the number of electrons in a neutral atom.

Question 3 (a) (ii)

(ii) Write a description for each of the particles in the atom.

Your description should include the relative charges, relative masses and position of each particle.

Proton ....

....

Neutron ....

....

Electron ....

....

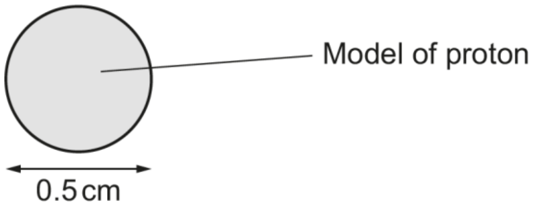
[3]

This question was well answered. Most candidates know the key features of the sub-atomic particles. However, some common errors and omissions were seen, such as:

- some candidates omitted one of the features they were asked to describe. Commonly, some omitted either the masses or the positions of each particle
- giving the mass as a value of +1 or -1 was sometimes seen
- some gave the mass of a neutron as 0
- some attempted to give an actual value for the mass of an electron but gave an unrealistic value such as 0.05g, rather than stating that it has a negligible or very small mass.

Question 3 (b)

(b) In the model, the protons have a diameter of 0.5 cm.



An atom is 1×10^5 times larger than a proton.

If they make their model to scale, what is the diameter of the model atom?

Give your answer in metres.

Diameter of the model atom = ... m **[2]**

Many candidates correctly processed both the standard form data and correctly computed the unit conversion to give 500 m. The most common omission was to omit the unit conversion, leading to a partially correct answer of 50 000.

Question 3 (c) (i)

(c) The student makes a model of some atoms of other elements.

Table 3.1 shows the particles in each atom.

Table 3.1

Element	Number of protons	Number of neutrons	Electron arrangement
A	3	4	2.1
B	8	8	2.6
C	12	12	2.8.2

(i) Identify whether each element is a metal or a non-metal.

Put **one** tick (✓) in each row.

Element	Metal	Non-metal
A		
B		
C		

[2]

Almost all candidates correctly classified the elements as metals or non-metals.

Question 3 (c) (ii)

(ii) Use ideas about electron arrangement to explain how you decided if each element was a metal or a non-metal.

....

....

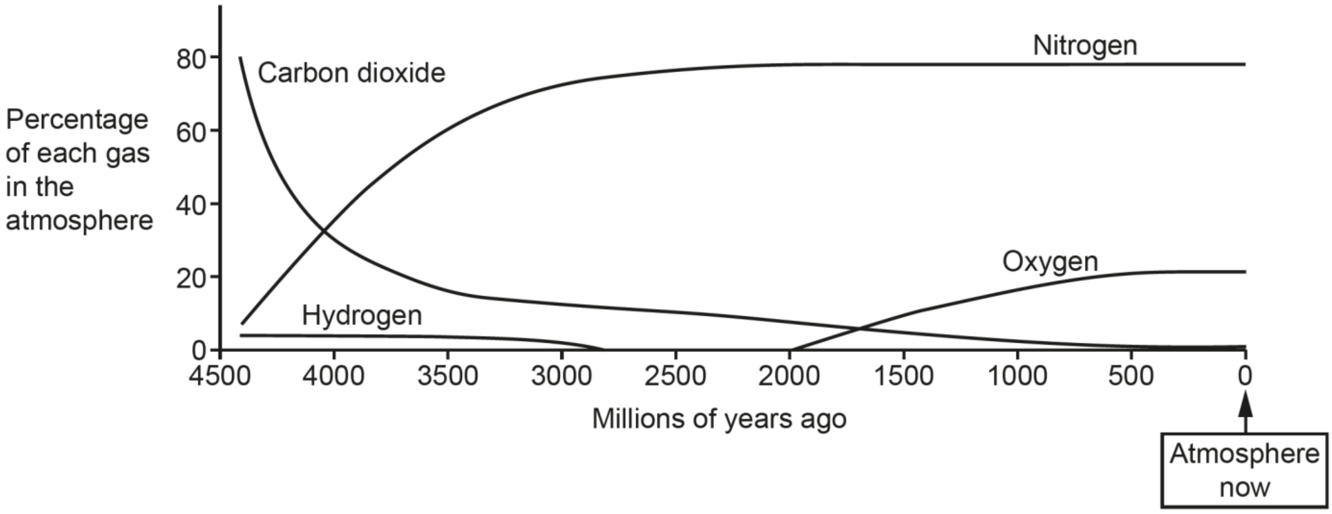
.... **[1]**

This question was less well answered. It asked 'how you decided'. Best answers stated clearly that metals have three or fewer electrons in their outer shells and non-metals have four or more. Many candidates found this idea difficult to clearly express. Some stated that 'metals lose electrons and non-metals gain electrons when they form ions' which is a true statement, but does not link to the data in the table. Some gave incorrect numbers of electrons linked to metallic and non-metallic character, commonly saying that metals contain 4 or fewer electrons or that non-metals contain 3 or more, both of which are incorrect.

Question 4 (a)

4 Scientists collect data to explain how the Earth's atmosphere formed.

The graph shows how the percentages of some gases in the atmosphere have changed since 4400 million years ago.



Scientists also study the composition of gases that come out of active volcanoes today.

The table shows the composition of gases from an active volcano.

Gas	Percentage composition
Water vapour	92
Carbon dioxide	4.6
Hydrogen	0.5
Nitrogen	0.7

(a) Scientists have ideas about where the Earth's atmosphere and oceans came from. They think that:

1. The atmosphere formed from gases that came out of volcanoes.

2. More than 4400 million years ago, water vapour from volcanoes condensed to form the oceans, leaving other gases in the air.

How does the data in the table and the graph support these ideas?

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....

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....

.... **[3]**

This question is a key question type that characterises this specification; the use of information to justify or refute statements made. These questions are challenging and require careful thought. Many candidates made statements about some of the data without clearly answering the question. The question asks how the data in the table and the graph supports each idea. To answer this, candidates needed to justify the statements using data from both. In addition, the question was about the formation of the early atmosphere (not later changes). Commonly, candidates either tried to answer using only information from either the graph or the table (rather than linking both) or discussed later changes (such as the appearance of oxygen) rather than focussing on the formation of the atmosphere. Some attempted to compare the volcano gases to the composition of the atmosphere today, rather than 4400 million years ago.

Best answers compared the early atmosphere with the data in the table, stating for example that the same gases in the early atmosphere are also in volcano gases (carbon dioxide, hydrogen and nitrogen) which supports the first statement. They also stated that volcano gases contain very large amounts of water vapour which is not present in the early atmosphere (supporting the second statement).

Question 4 (b) (i)

(b)
(i) Explain the changes to the percentages of oxygen and carbon dioxide in the atmosphere shown on the graph.

....

....

....

....

....

.... **[3]**

This question was answered well; candidates have clearly learned the processes that have contributed to the changes in the percentages of oxygen and carbon dioxide. Most stated that the evolution of plant life led to photosynthesis which increased the oxygen concentration and reduced that of carbon dioxide. Many also knew the role of the oceans in dissolving and absorbing carbon dioxide from the atmosphere.

Question 4 (b) (ii)

(ii) The percentages of oxygen and carbon dioxide have stayed approximately the same since 500 million years ago.

Explain why.

....

....

....

.... **[2]**

The idea that a balance is established between the use of carbon dioxide and the production of oxygen by plants and the reverse occurring due to respiration in animals was well understood. Fewer stated clearly that the balance is established because the rate of removal and production of each gas is equal and opposite.

Question 5 (a)

5 Steel is an alloy that contains iron and other elements.

(a) State **one** reason why steel is more useful than pure iron.

....

.... **[1]**

The idea that the alloy has improved properties, such as strength, was well known. Corrosion resistance was accepted, as stainless steel is corrosion resistant, although it should be noted that not all steels are more corrosion resistant than iron.

Question 5 (b) (i)

(b) One type of steel alloy contains 97.8% iron and 0.12% carbon by mass.

The ratio by mass of iron : carbon in this steel is greater than 800 : 1.

(i) Show by calculation that this statement is **true**.

[1]

This calculation was well answered. Most correctly calculated that the ratio was actually 815:1 or 800:0.98.

Question 5 (b) (ii)

(ii) The ratio by number of moles of iron : carbon in this steel is approximately 175 : 1.

Explain why the ratio by mass is different to the ratio by number of moles.

....

....

....

.... **[2]**

Candidates found this question very challenging. Most knew that the ratios are 'different' but did not explain why clearly. Some stated that 'masses and moles are different', which is essentially a rewording of the information in the question. Fewer identified that iron and carbon have different relative atomic masses. Almost no candidates expressed the idea that the ratio by mass is greater than the ratio by moles. A very common error was to use incorrect scientific terms such as 'molecular mass' or 'relative formula mass' for the two elements.

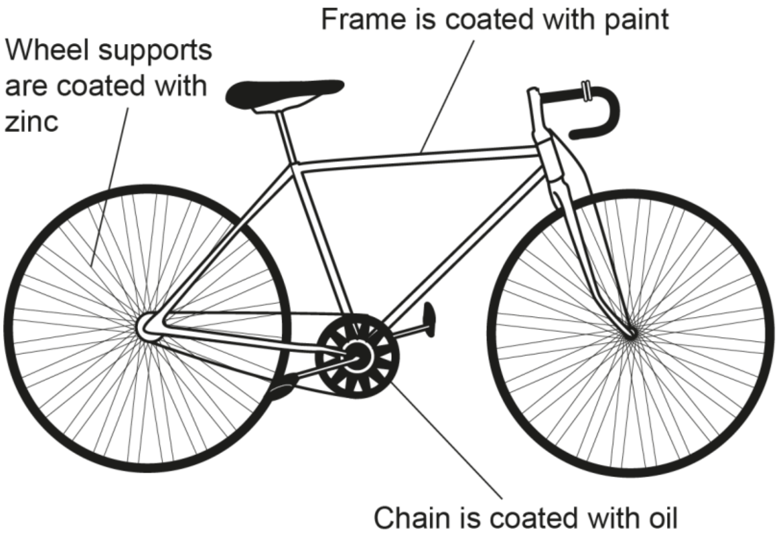
Misconception

A very common misconception by candidates is the confusion of the names of particles. In this case 'molecular mass' or 'M_r' or 'relative formula mass' were often incorrectly used in place of 'relative atomic mass / A_r'.

Question 5 (c)*

(c)* Different parts of a bike are each made from different steel alloys. Each of the alloys contains mainly iron.

The diagram shows the different methods to prevent corrosion that are used on each part of the bike.



Explain how each of the coatings used on the bike prevent corrosion and discuss how effective the coatings are if they become damaged.

....

....

....

....

....

.... **[6]**

This was the first of the two Level of Response questions. The key to answering these questions well is to pause and plan the answer to make sure that all aspects of the question are fully answered. The most common reason for lower marks is omission of parts of the task.

In this case, candidates needed to discuss each of the three coatings (zinc, paint and oil). They needed to explain how they prevent corrosion and to discuss the effectiveness of each coating if damaged. Many candidates omitted some aspect of this task. This commonly limited answers to Level 2, leading to most candidates earning 3 or 4 marks.

Common errors and omissions included:

- some answers discussed how oil and/or paint work by excluding either oxygen or water, rather than stating that they act as a barrier to both
- some answers did not clearly explain the effect of zinc in terms of sacrificial protection or reactivity, stating instead that it excludes oxygen and/or water only
- some answers did not address all three coatings or did not discuss the impact of the damage to the coatings. Many thought that damage to a zinc coating would result in the iron rusting.

Assessment for learning

A key focus for addressing Level of Response questions is planning by the candidate to check that they have answered all aspects of the task. Practising questions and using groupwork or paired work to peer check that they have done this could be used to provided formative feedback for learning. Resources to support with this could be our Candidate exemplars (Level of Response) or How to answer 6 mark LOR activities, both available on Teach Cambridge.

Question 6 (a)

6 A scientist works in a laboratory that tests medicines.

They make up different formulations of medicines for testing.

(a) Which statement is the definition of a formulation?

Tick (✓) **one** box.

A mixture that contains definite proportions of substances. ☐

A solid substance that is soluble in water. ☐

A useful product made under controlled conditions. ☐

Several elements bonded together to make a molecule. ☐

[1]

Most candidates recognised the description of a formulation in this question.

Question 6 (b)

(b) The scientist uses water to make up their medicines.

In their laboratory they have distilled water and tap water.

Explain why distilled water is pure and tap water is impure.

....

....

....

.... **[2]**

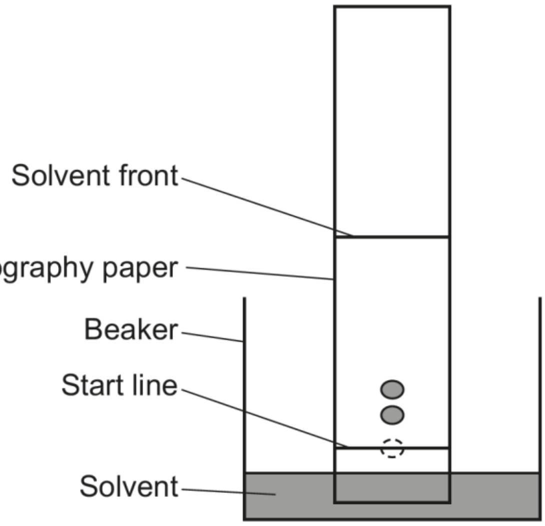
It is important when answering questions that candidates avoid repeating the words used in the question. Answers that stated 'distilled water is pure and does not contain impurities' is almost a repeat of the question, rather than an explanation of why it considered to be pure i.e. it contains only water molecules. This difficulty with the use of language meant that most candidates did not clearly express the meaning of purity. Some gained a single mark for stating that tap water contains other substances such as minerals or chlorine.

Question 6 (c) (i)

(c) The scientist uses paper chromatography to separate the substances in one of their medicines.

They use water as a solvent.

The diagram shows their results.



(i) Identify the stationary phase and the mobile phase in their experiment.

Stationary phase ....

Mobile phase ....
[2]

Most candidates did not know the meaning of the terms stationary phase and mobile phase. Many gave examples of some factor that remained stationary e.g. the start line and one factor that moved, e.g. the solvent front.

Question 6 (c) (ii)

(ii) Use ideas about solubility to explain why the substances separate.

....

....

....

.... **[2]**

This question asked candidates to 'use ideas about solubility'. Some answered this well, correctly stating that more soluble substances move further. However, some used vague language such as 'some dots move up more easily' and some did not mention solubility in their answer at all.

Question 6 (c) (iii)

(iii) The scientist wants to improve the chromatography experiment.

Suggest **one** way they can increase the separation of the substances.

....

.... **[1]**

Most candidates did not suggest a correct amendment to the experiment. Some appeared to think that the solvent was a solution, rather than water. So some incorrect answers included suggestions such as 'use a stronger solvent' or 'use a more concentrated solvent'. Better answers either correctly suggested a different solvent, commonly ethanol, or suggested using a longer paper or a longer time.

Question 6 (d)

(d) The scientist measures the melting point of some of the substances they use to make medicines.

The table shows their results.

Substance	Melting point (°C)
A	102
B	151–156
C	2032
D	1040–1056
E	325–333

Which substances are impure?

Explain your reasoning.

Impure substances ....

Explanation ....

....
[2]

This question was well answered. Many candidates identified the mixtures and justified their choice by stating that a mixture melts over a range of temperatures. The most common misconception is that mixtures have either higher or lower melting points than pure substances, leading to choices of substances with the three highest or lowest values from the table.

Question 7 (a) (i)

7

(a) **Table 7.1** shows the formulae and boiling points of some alkanes.

Table 7.1

Alkane	Formula	Boiling point (°C)
Ethane	C_2H_6	–89
Butane	C_4H_{10}	–0.5
Pentane	C_5H_{12}	36
Hexane	C_6H_{14}	69

(i) Use the data in **Table 7.1** to complete the graph.

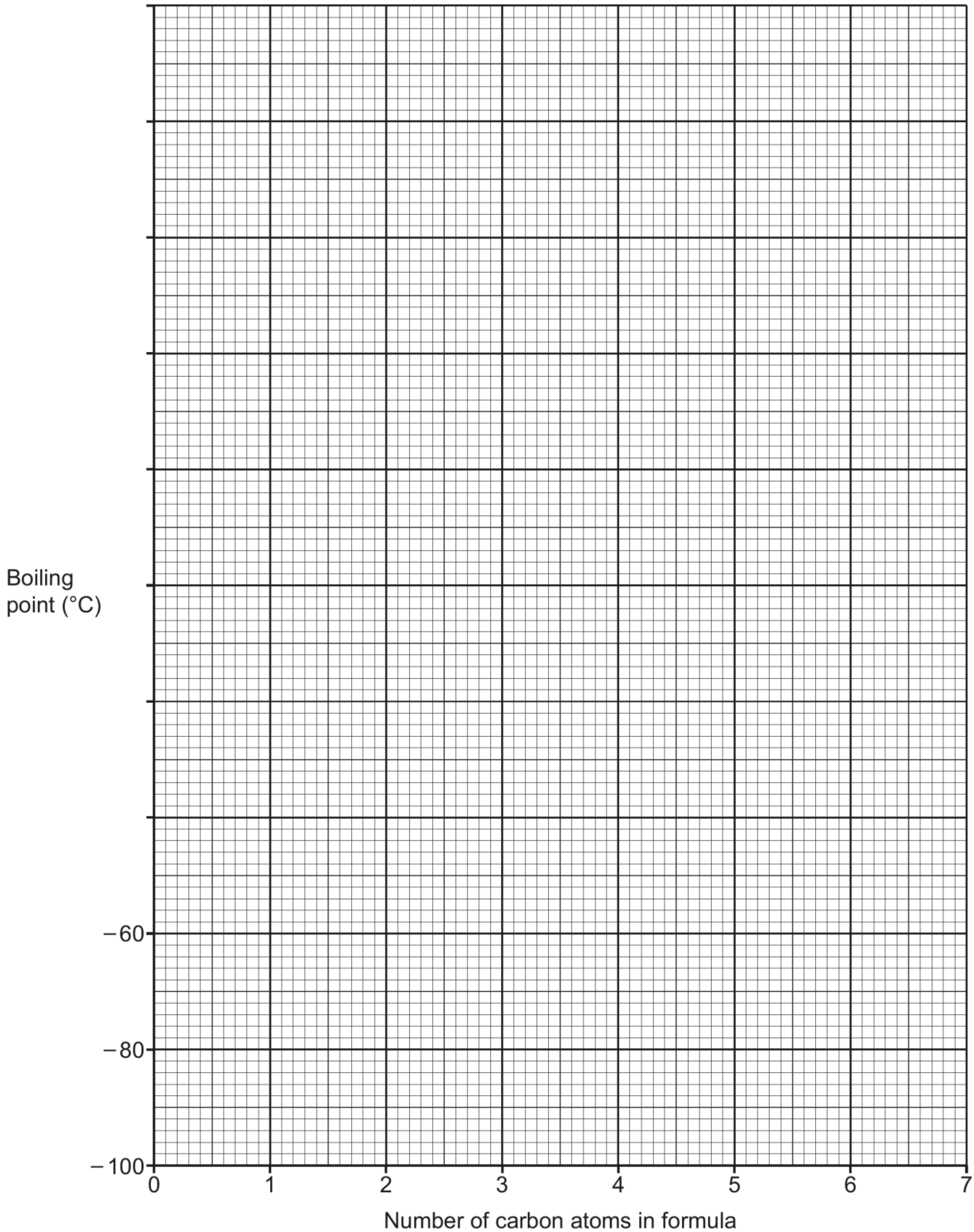
You need to:

- complete the scale on the vertical axis
- plot the boiling point of each alkane
- draw a line of best fit.

Misconception

There are two misconceptions that were commonly seen in drawing the line of best fit. Firstly, many candidates incorrectly assumed that a line of best fit must pass either through the origin or from the first to the last point. Secondly, candidates often try to make the line pass through the most points possible, leading to a line that was often inappropriate for the plotted data. A line of best fit should be drawn so that, where there is a scatter of points, points are evenly spread either side of the line.

Question 7 (a) (ii)



(ii) Use your graph to estimate the boiling point of propane, C_3H_8.

Boiling point of propane = ... °C **[1]**

A range of achievement was seen here. Not all candidates presented their graphs correctly. Most were able to continue the scale and correctly completed the labelling of the vertical axis. Some correctly plotted the points from the data in the table, although the most common error was to plot the boiling point of butane at -5.0 ^{o}C rather than -0.5 ^{o}C. The line of best fit was the most challenging part of the question with most candidates drawing an incorrect line. It should be noted that where the relationship is clearly linear, as it is here, lines of best fit should be drawn using a ruler.

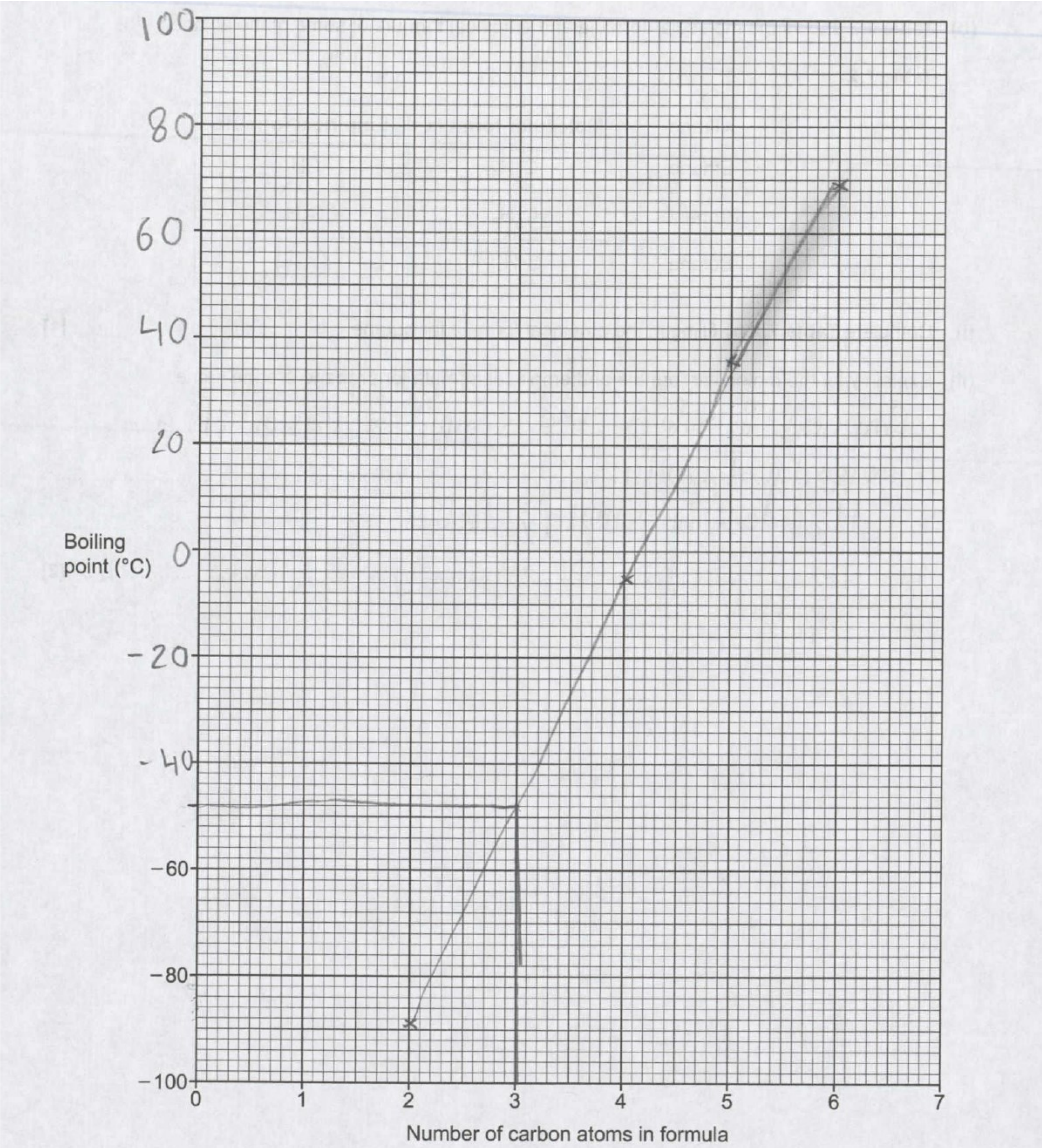
Misconception

There are two misconceptions that were commonly seen in drawing the line of best fit. Firstly, many candidates incorrectly assumed that a line of best fit must pass either through the origin or from the first to the last point. Secondly, candidates often try to make the line pass through the most points possible, leading to a line that was often inappropriate for the plotted data. A line of best fit should be drawn so that, where there is a scatter of points, points are evenly spread either side of the line.

Most answers read the value for propane from the graph, although some omitted the minus sign. A common error was to read the value in the wrong direction from the main grid line. Hence, a value that was 4 squares above the grid line for -50 ^{o}C, for example, was recorded as - 54^{o}C rather than -46 ^{o}C.

Exemplar 2

Boiling point of propane = -52 °C **[1]**



This response illustrates a common error. The candidate has correctly indicated on their graph the position where they need to read the value of the boiling point for propane, but rather than use the negative scale correctly (to read downwards to give a value of 48 °C) they have read it upwards from the nearest gridline, 50, to state an incorrect value of -52 °C. No marks were given.

Question 7 (b) (i)

(b) **Table 7.2** shows the molecular formula and empirical formula of some of the alkanes.

Table 7.2

Alkane	Molecular formula	Empirical formula
Ethane	C_2H_6	CH_3
Propane	C_3H_8	C_3H_8
Butane	C_4H_{10}	....

(i) Complete **Table 7.2** by filling in the empirical formula for butane. **[1]**

Almost all candidates correctly represented the empirical formula for butane as C_2H_5.

Question 7 (b) (ii)

(ii) Explain why the molecular formula and empirical formula for propane are the same.

....

....

....

.... **[2]**

Most recognised that the molecular formula of propane cannot be simplified. However, this question has a 2 mark allocation. Many candidates did not continue to explain why this is the case. Best answers explained this in terms of the lack of common factors for 3 and 8.

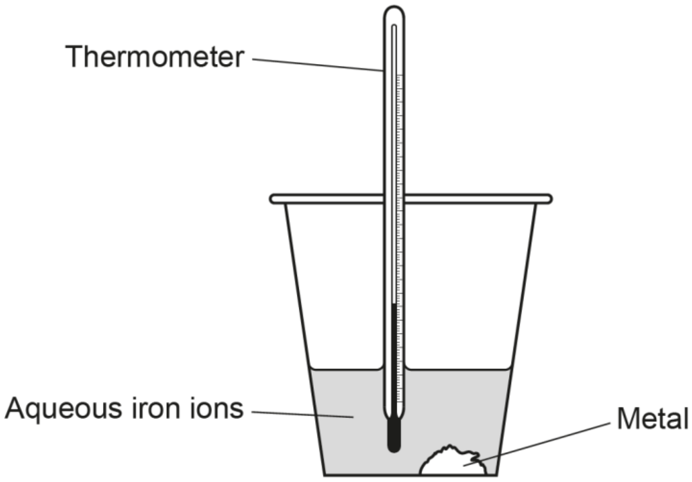
Question 8*

8* Metals react with other metal ions in displacement reactions.

The greater the difference in reactivity between the metal and the metal ion, the greater the energy given out when they react together.

A student does an experiment to find out the order of reactivity of some metals.

They measure the maximum temperature change when each metal is added to a solution that contains aqueous iron ions.



The student repeats their experiment.

This time they add each metal to a solution that contains aqueous copper ions.

The table shows their results.

	Maximum temperature change (°C)	
	When added to aqueous iron ions	**When added to aqueous copper ions**
Calcium	12	15
Lead	0	2
Iron	0	4
Zinc	8	11
Magnesium	10	12

What conclusions can be made about the order of reactivity of the metals, including copper, from the information in the table?

Use ideas about temperature changes and reactivity in your answer.

....

....

....

....

....

.... **[6]**

This is the second of the two Level of Response questions. In common with Question 5 (c), the key to achieving a Level 3 is to ensure that the answer addresses all parts of the task. In this case, candidates were asked to draw conclusions about the order of reactivity of the metals, to include copper and to use ideas about temperature changes and reactivity in the answer. The most common reason for a partial mark was that all aspects of the task had not been addressed. Candidates should note that they should not copy out the data in the table. Statements such as 'Calcium is the most reactive because it has a 12°C temperature change' are not accepted as an explanation. Candidates need to explain the significance of the size of the temperature changes, for example by stating 'Calcium is the most reactive because it has the greatest temperature change with both iron ions and copper ions'.

Other reasons that full marks were not awarded included:

- candidates did not always make use of all of the data, only discussing the reactions of metals with either iron ions or copper ions rather than both
- some answers did not put all five metals in order. Iron, lead and/or copper were often omitted
- some answers put the metals in order but appeared to do this from a learned list, including other metals in the order, such as potassium and sodium. These answers commonly did not clearly refer to the size of the temperature changes
- weaker answers jumbled the order or presented the answer in a contradictory and confusing order so that it was difficult to determine the order of reactivity. Some thought that copper was the most reactive because it 'reacted with all of the metals'
- in common with some other questions on the paper, the incorrect use of scientific terms sometimes hindered the line of reasoning and structure of the answer leading to the lower mark in the level being awarded. A common error was to discuss the reaction between metals themselves, for example 'when calcium reacts with iron…' rather than the reaction of a metal with iron ions or copper ions.

Exemplar 3

~~Magnesium~~ calcium is the most reactive as it has the highest temperature change for both reactions - It is then followed by Magnesium which ~~w~~ had a temperature change of 12° for copper ions. The 3rd most reactive metal is zinc and is followed by iron. Iron had almost 3 times less the temperature change than zinc when aqueous copper irons were added. The 5th most reactive metal was lead with the lowest ~~energy~~ temperature change. It also didn't have a temperature change with irone ions, showing that lead is less reactive than iron. All 5 metals reacted with aqueous copper ions which shows that copper is less reactive than all 5 metals as they can displace the iron. The temperature changes for copper ions are higher than those of iron, **[6]** showing that copper is less reactive and easier to displace.

This is a 'model' response. Notice that the candidate has answered all aspects of the question fully. They have presented their answer logically, in order, from the most to the least reactive metal, justifying each with a clear reference to the relative size of the temperature change. The answer discusses the relevance of all of the temperature changes with copper ions, including placing copper at the bottom of the list, and has also shown how the addition of iron and lead to iron ions is significant in determining the order. Finally, note the appropriate use of language 'iron ions' and 'copper ions'. This is a clear Level 3, 6 mark response.

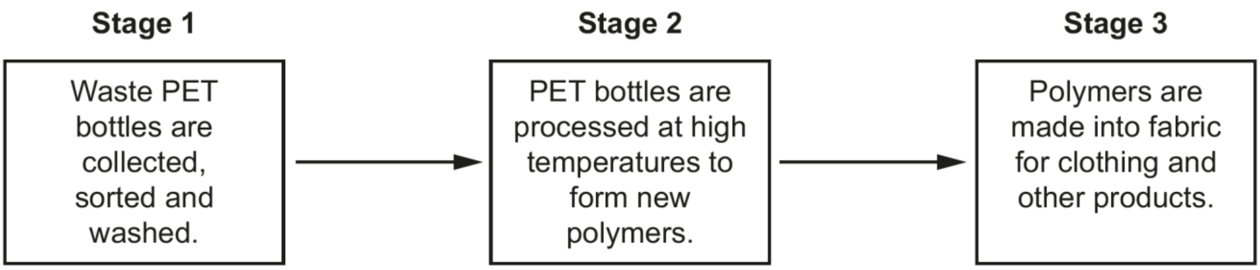
Question 9 (a) (i)

9 PET is a polymer made from crude oil. Most plastic water bottles are made from PET.

A recycling process uses PET from waste bottles to make new polymers.

These new polymers can be used to make fabric for clothing and other products.

The diagram below shows the three stages involved in the recycling process.



(a) A scientist carries out a life cycle assessment for this recycling process.

They find that the recycling process uses large amounts of energy.

(i) Explain why the process shown in the diagram uses large amounts of energy.

....

....

....

.... **[2]**

There is a clear and important skill in extracting relevant information from a flow chart, but where a question asks candidates to 'explain why….' the answer must include some explanation rather than a copy of the information. So in this case, an answer that stated 'energy is needed to collect, sort and wash bottles' is insufficient. Best answers stated clearly that the collection involves energy used to transport the bottles or that sorting and washing use automated machinery, requiring input of energy. An common allowed mark was for identifying that reaching the high temperature in Stage 2 is energy intensive, and most candidates did gain that mark.

Question 9 (a) (ii)

(ii) Explain why the use of energy is an important factor to consider when carrying out a life cycle assessment.

....

....

....

.... **[2]**

This type of question is deceptively challenging because many candidates answer vaguely and do not give enough specific information to fully address the 'explain why' command. Some gave generic answers such as 'saves resources' or 'more sustainable' or 'avoids pollution'. None of these were enough to gain a mark.

There are two key issues to energy use. The first is that most of our energy still comes from finite sources and fossil fuels and the second is that the use of these fuels causes specific environmental issues. Vague answers such as the need to 'save energy' were not awarded marks. Best answers identified specific environmental issues such as naming a pollutant that is a product of burning fossil fuels. It should be noted that 'it is cheaper' is not awarded a mark.

OCR support

It should be noted that the specification is very specific in this area. Specification area C4.5 sets out in some detail the issues that candidates need to discuss when considering life cycle assessments. Candidates need to recall these issues so that they can use them effectively in answering questions and to help them to avoid vague, generic answers.

Question 9 (b)

(b) The scientist concludes that recycling PET bottles reduces harm to the environment despite its use of energy.

Suggest **two** reasons why recycling PET bottles reduces harm to the environment.

1 ....

....

2 ....

.... **[2]**

Most candidates gave clear suggestions for harm to the environment that is avoided if PET bottles are recycled. Many stated that less landfill will be needed. Some stated that recycling reduces microplastics in oceans. In common with other part questions, however, some gave vague answers to describe what recycling is rather than why it reduces environmental harm, for example only stating that 'recycling re-uses waste'.

Question 9 (c)

(c) The fabric at the end of the process is used for different products.

Two of the products made from the fabric are padded jackets and insulation for houses.

Suggest why the life cycle assessments of these two products are different.

....

....

....

.... **[2]**

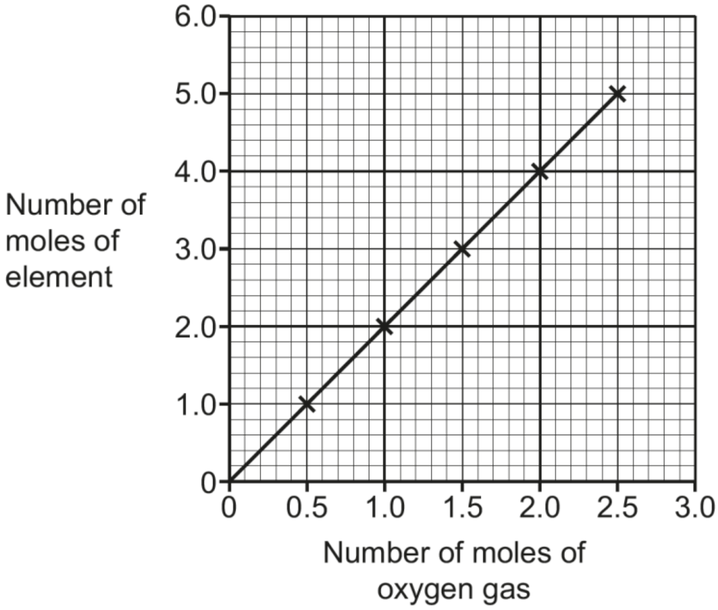
In common with the comment for Question 9 (a), answers tended to be too generalised and vague rather than accessing the learning detailed in specification section C4.5. Some misunderstood the context and stated that 'different materials are used', even though the question states that a single fabric is used for two purposes. Many candidates gained a mark for correctly identifying the issue that the lifespan of the two products is significantly different.

Question 10 (a)

10 A student investigates the reaction of an element with oxygen gas, O_2, to make an oxide.

They calculate the number of moles of the element that react with different numbers of moles of oxygen gas.

The graph shows their results.



(a) The student concludes that the graph shows this relationship:

number of moles of element $\propto$ number of moles of oxygen

The student is correct.

Explain why.

....

....

....

.... **[2]**

Most candidates understood that the graph shows a proportional relationship, some stating clearly that the number of moles of the element is directly proportional to the number of moles of oxygen. Some correctly stated that the proportional relationship is shown because it is a straight line that goes through the origin. Some correctly recognised that as one factor doubles, so does the other.

A common incorrect explanation for proportionality is that the 'values go up by the same every time'. This was not accepted as correct, because it is only a correct explanation if the values also start at (0,0). Other answers that are insufficient to be awarded a mark are answers that incorrectly confuse the term 'proportional' with 'correlation'. Further, answers that state only that the relationship is a straight line or that 'as one increases so does the other'. None of these answers are sufficient to explain proportionality.

Question 10 (b)

(b) Calculate the mass of oxygen gas that reacts with 1.5 moles of the element.

Use:
- data from the graph
- the Periodic Table.

Mass of oxygen gas = ... g **[3]**

There are three key parts to a fully correct answer. Firstly, candidates need to work out, from reading their graph, the number of moles of oxygen that react (0.75). Most did this successfully although a common error was to assume a 1:1 reacting ratio, hence using 1.5 in the calculation.

Secondly, candidates needed to work out the relative formula mass of oxygen (32). Again, many did this correctly, but a common error was not to take into account the diatomic nature of oxygen and use a value of 16.

Thirdly, candidates needed to compute the mass by multiplying the two values. Almost all candidates did this correctly. Error carried forward was allowed for correct working based on incorrect values. Candidates who set out their working clearly could be awarded marks even if their answer was incorrect. Candidates who do not present any working cannot be awarded partial credit if their final answer is incorrect.

Question 10 (c) (i)

(c) The student suggests an equation for the reaction. They use X to represent the symbol of the element.

(i) Which equation for the reaction is correct?

Use information from the graph.

Tick (✓) **one** box.

$X + O_2 \rightarrow XO_2$ ☐

$2X + O_2 \rightarrow 2XO$ ☐

$4X + O_2 \rightarrow 2X_2O$ ☐

$4X + 3O_2 \rightarrow X_2O_3$ ☐

[1]

Candidates found this question challenging. About half of the candidates selected the correct equation.

Question 10 (c) (ii)

(ii) Explain how you worked out your answer to **(c)(i)**.

....

.... **[1]**

The prompt to Question 10 (c) (i) instructed candidates to 'use information from the graph' and it was expected that the explanation here should refer to how the candidate had used this information. Commonly, however, candidates did not refer to their graph in attempting to justify their choice. 'It is a balanced equation' was a common incorrect answer.

Question 11 (a)

11

(a) Ammonium sulfate, $(NH_4)_2SO_4$, is made in an industrial process for use as a fertiliser.

Aqueous ammonium carbonate reacts with **excess** solid calcium sulfate.

$(NH_4)_2CO_3(aq) + CaSO_4(s) \rightarrow (NH_4)_2SO_4(aq) + CaCO_3(s)$

Suggest the method used to separate aqueous ammonium sulfate from the mixture of products at the end of the reaction.

Explain your reasoning.

Method ....

Explanation ....

.... **[2]**

In common with earlier practical questions, this question was poorly answered. Candidates did not routinely identify that the mixture should be filtered to remove the excess solid. A very wide variety of processes were suggested including evaporation and both simple and fractional distillation.

Question 11 (b)

(b) Ammonium sulfate can also be made on a small scale in a laboratory.

Aqueous ammonia, $NH_3(aq)$, reacts with dilute sulfuric acid to make aqueous ammonium sulfate.

Write a **balanced symbol** equation, with state symbols, for this reaction.

.... **[2]**

This question was very challenging for candidates. Very few knew the correct formula for sulfuric acid. SO_4 was a common incorrect formula given.

Question 11 (c)

(c) Which statements about industrial processes and laboratory reactions are **true** and which are **false**?

Tick (✓) **one** box in each row.

	True	False
Industrial processes are usually continuous, laboratory reactions prepare chemicals in batches.		
By-products of industrial processes are disposed of as waste.		
In industry, more than one process is often used to make the same product.		

[2]

This question is based on the required knowledge in topic C6.4. Most candidates knew that industrial processes are usually continuous but the second two statements were not generally known.

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