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Examiners' report

TWENTY FIRST CENTURY SCIENCE CHEMISTRY B

J258

For first teaching in 2016

J258/04 Summer 2023 series

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.

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Paper 4 series overview

In general terms, the performance of candidates has improved over recent years. Candidates left few questions unanswered and attempted to use information provided in questions to support their answers. Candidates used all available space and remained engaged throughout the paper. They typically engaged well with the contexts and processed information given.

An area for development is longer answer questions, both Level of Response and longer questions which carry a mark allocation of 3 or more. The most successful responses are succinct and to the point and show evidence that candidates have taken a few minutes to think and to plan their answers to cover the necessary points and access the number of marks provided. In particular, it is important to note that to reach the higher mark in each level of a Level of Response question, the answer needs to be logical without irrelevant content or obvious contradictions. Responses which are significantly longer than the available space provided are less likely to access full marks because they typically are not well structured and include either contradictions or irrelevant content or both.

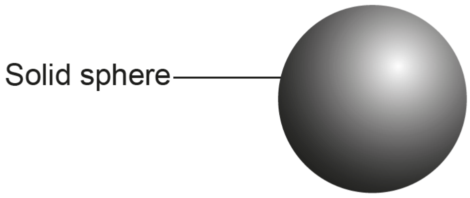
A further area for development is to consider how candidates use scientific terminology. Candidates who confuse key terms such as element, compound, atom, molecule, solute, solvent, bonds and intermolecular forces are less likely to gain marks because the language they use means that the points they raise are incorrect. It is worth practising the correct use of these terms.

Candidates who did well on this paper generally:	Candidates who did less well on this paper generally:
• planned longer answers to fully address the number of marks available • were familiar with the mathematical requirements in Appendix 5e of the specification • read the question carefully and addressed all aspects of the task.	• gave longer answers than necessary, introducing contradictions and errors • repeated information in the question rather than adding information, explanations or interpretations • used contradictory and incorrect language, confusing atoms with molecules or bonds with intermolecular forces.

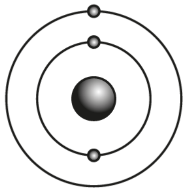
Question 1 (a)

1 Scientists use models to represent atoms. These models have changed over time.

Dalton's model and a modern model of an atom are shown in the diagrams.



Dalton's model



Modern model

(a) Give **two** differences between the modern model and Dalton's model.

1 ....

....

2 ....

....

[2]

Question 1 was the first of the overlap questions, which also appeared on the foundation tier. Higher tier candidates answered this whole question well.

There was a range of possible responses to this first part question. Most candidates identified at least one way that the modern model differs from that of Dalton, stating, for example that the modern model shows shells of electrons, has a nucleus or is mostly empty space. A common reason for only gaining 1 mark was that some candidates gave a detailed response about one difference, rather than identifying two distinct differences. So, for example, discussing the presence of electrons and then giving further detail about their arrangement and orbits is only really identifying one aspect of the atom that differs. The most successful responses mentioned both the nucleus and the electrons. Another common error was to discuss one of the other earlier models, rather than Dalton's model, as shown. Some candidates discussed how the modern model differs from the 'plum pudding' model (Thomson's) which was not relevant to the information presented here.

Question 1 (b)

(b) Which element is represented by the modern model in the diagram?

Explain your answer.

Use the Data Sheet.

Element ....

Explanation ....

....

....
[2]

Almost all candidates identified lithium and most correctly attributed this to the 3 electrons shown. A few candidates mistakenly thought that the atom was hydrogen. Some stated that 'the atomic number is 3'. This was not given a mark, because the atomic number is not directly indicated on the diagram; no protons are shown. The key point was to identify the atom from its electron arrangement.

Question 1 (c) (ii)

(ii) Give **two** reasons why Dalton's formula for chlorine **disagrees** with its modern formula.

1 ....

....

2 ....

....

[2]

This question was the most challenging of the part questions in Question 1. The two key ideas to express are that Dalton's formula does not show an element, but a compound, and that the formula shows 5 atoms rather than two. The most successful responses stated clearly that all the atoms in chlorine should be the same and that chlorine should be represented by a diatomic molecule of two atoms. One of the main reasons candidates were not given a mark was that many answers included contradictions, such as 'Dalton's formula contains four atoms'. Some did not use the word 'atoms' in their response, stating that 'chlorine should have two not five'.

Assessment for learning

A key area for development is the use of chemical language and terminology, such as the words element, compound, atom and molecule. Many candidates gave incorrect answers due to the incorrect use of these important terms.

Question 1 (d)

(d) Put the particles in order from largest to smallest.

Atom **Electron** **Molecule of oxygen** **Polymer** **Proton**

Largest ....

....

....

....

Smallest ....

[2]

Most candidates earned at least 1 mark. The particles that were often misplaced in the sequence of size were polymer and electron. Many thought electrons are larger than protons.

Question 2 (a) (i)

2 Ali works in a laboratory that tests food to make sure it is safe to eat.

He tests some sweets. The sweets are sold to shops in large boxes which each contain 100 packets of sweets.

(a) (i) Describe how Ali should choose sweets to test to make sure that his sample is **representative**.

....

.... **[1]**

Question 2 was the second overlap question. Most candidates answered part (b) more successfully than part (a).

Almost all candidates knew that for representative sampling, it is essential to test a number of different sweets, but there was evident confusion about how these should be chosen. The information clearly stated that the sweets were in packets, with 100 packets per box. Representative sampling needs to take into account this information. The most successful responses identified the need to take multiple random samples from different packets or boxes.

Candidates who did not gain full marks usually did not use the information given or chose unworkable sampling strategies. Some suggested testing 'all of the different flavours'. There was no information about varied flavours or types in the question. Some gave unworkable suggestions such as 'test sweets from every packet'. This would leave no packets left to sell and this strategy is closer to testing all sweets rather than testing a representative sample.

Question 2 (a) (ii)

(ii) Explain why it is important that the sample Ali tests is representative.

....

.... **[1]**

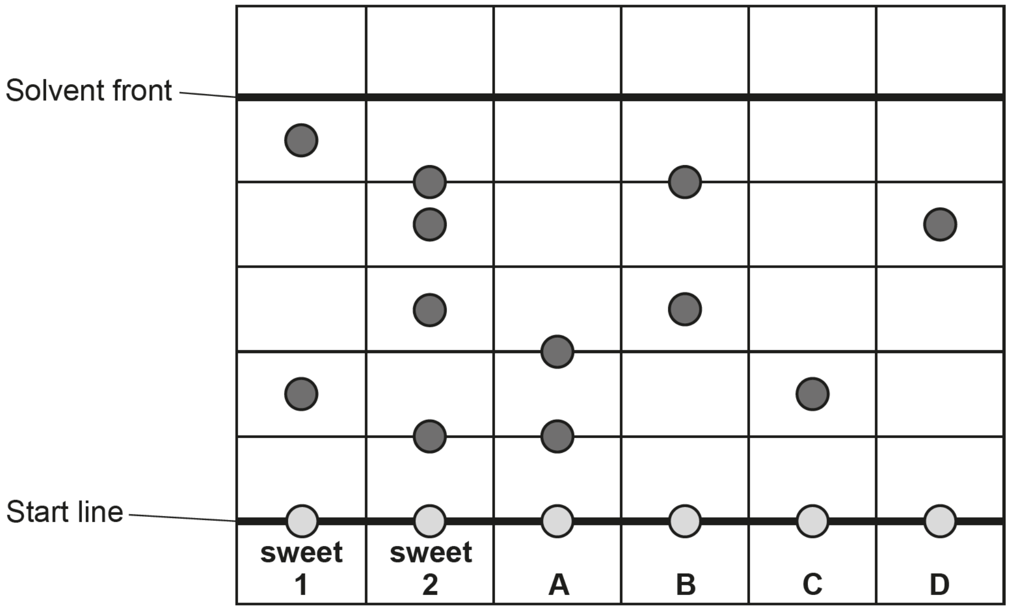
This part question was very challenging. Many candidates struggled to express themselves clearly, resulting in lots of responses restating the original question. 'To make sure the sweets are safe' was a common restatement of the information given. Mostly it was the highest achieving candidates who were able to discuss avoiding bias, or the need to identify any outliers.

Question 2 (b) (i)

(b) Ali uses paper chromatography to test two sweets, sweet 1 and sweet 2.

He also tests some samples of safe food colours, **A**, **B**, **C** and **D**.

The diagram shows Ali's results.



(i) Calculate the Rf value of food colour **D**.

Rf value = ... **[2]**

There were two approaches available to students for this question. They could use the grid on the diagram to calculate the Rf value using 3.5 and 5 as the relative distance travelled by the dot and the solvent front. Many candidates measured the actual distance on the paper using a ruler. As both of these approaches were valid, a range of measurements was accepted as correct to allow for both approaches. Either approach, done correctly, should have led to value close to 0.7.

Many candidates calculated this correctly. Errors included expressing the value as a subtraction (distance travelled by solvent front *minus* distance travelled by dot) or using the distance of the dot from the solvent front, rather than the start line, in the calculation.

Misconception

Candidates did not all know the correct formula to calculate Rf. This is an area worth concentrating on. Many included the distance from the dot to the solvent front, rather than from the start line, in their answer.

Question 2 (b) (ii)

(ii) Which safe food colours, **A**, **B**, **C** and **D**, are pure?

Explain your answer.

Food colours ....

Explanation ....

....

....
[2]

This question was very well answered. Interpretation of chromatograms with unknown substances compared to known substances is well understood. Some used inappropriate language such as 'elements' to describe the components. As this question is an overlap question, such errors were ignored, but candidates need to take care to use appropriate language. A further misuse of language included confusion between solute and solvent.

Question 2 (b) (iv)

(iv) Ali says that he **cannot** be sure that the food colours used in sweet 1 are safe.

Explain why Ali is correct.

....

.... **[1]**

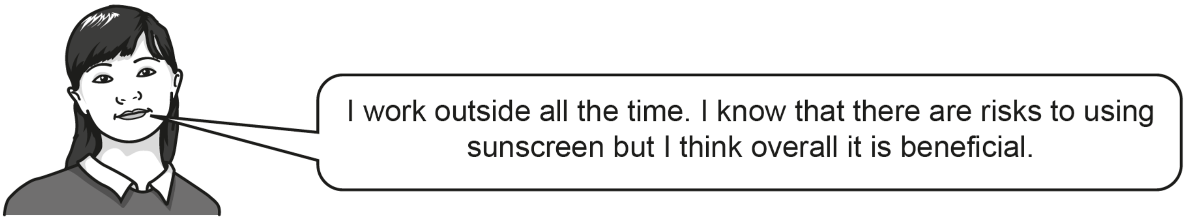
Most candidates correctly stated that sweet 1 gives a dot on the chromatogram that does not line up with any of the known substances, and so this unknown food colour may be unsafe. Some made errors in their interpretation of the chromatogram, however. Some incorrectly stated that the results showed 'unknown colours' (plural) where only one unknown colour was shown. Some said that 'none of the colours are in the safe colours' which is not true. One of the dots lines up with colour C.

Question 3 (a)

3 Some people use sunscreens on their skin when they are exposed to the sun.

The sunscreens contain nanoparticles. The nanoparticles block harmful radiation from the sun.

Mia talks about using sunscreen which contains nanoparticles.



(a) Explain the risks **and** benefits to Mia of using a sunscreen which contains nanoparticles.

....

....

....

.... **[3]**

Most candidates identified some risks of the use of nanoparticles, usually correctly linked to 'not enough research' or 'long term effects are unknown'. Many recognised that they can enter the blood, brain or cells. Fewer stated a clear benefit. Candidates need to take care not to restate information without interpreting it further. 'Blocks harmful radiation' was in the question, so to gain a 'benefit' mark, candidates needed to interpret this in terms of how using nanoparticle sunscreen benefits Mia. The most successful responses referred to protection from skin damage or discussed how nanoparticles can cover a large area on the skin.

Assessment for learning

Longer answer questions, such as this one with a mark allocation of 3 marks, need to be carefully planned before the candidate begins to answer. Candidates need to practise considering both sides of the task to make sure that they access all marks (in this case discussing both risk and benefit without merely restating the question). They further need to make sure that they make enough clear, distinct and separate points to earn all of the marks available. Some candidates only made two points, despite the 3 mark allocation.

Question 3 (b)

(b) Which statements about nanoparticles are **true** and which are **false**?

Tick (✓) **one** box in each row.

	True	**False**
Fullerenes and graphite are examples of nanoparticles.		
Nanoparticles are usually larger than atoms.		
Nanoparticles have a large volume compared to their surface area.		
The properties of nanoparticles are related to their sizes and shapes.		

[2]

This question proved a challenge. Many candidates gained 1 mark. Some thought that both fullerenes and graphite are nanoparticles. Some did not identify that statement 3 is false.

Question 3 (c)

(c) Some data about the diameter of nanoparticles **A**, **B**, **C** and **D** is shown in the table.

Nanoparticle	Diameter (m)
A	8.2×10^{-9}
B	2.1×10^{-9}
C	9.1×10^{-10}
D	8.9×10^{-9}

Put the nanoparticles **A**, **B**, **C** and **D** in order from largest to smallest.

Largest ....

↓ ....

....

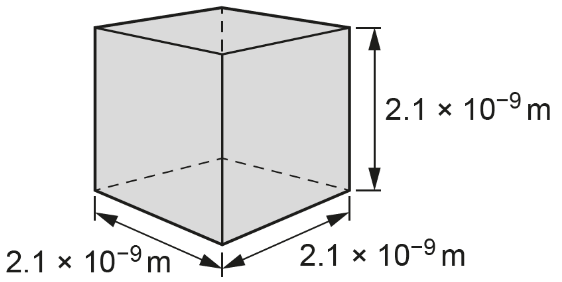
Smallest .... **[2]**

Almost all candidates correctly identified C as being the smallest, showing a good understanding of standard form. However, some gave BAC in the reverse order, smallest to largest.

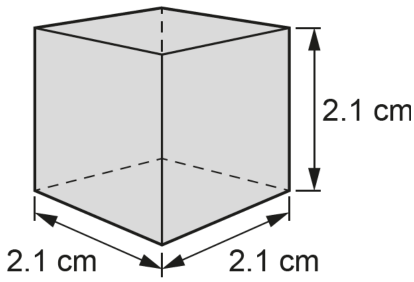
Question 3 (d) (i)

(d) Nanoparticle **B** is the same shape as a cube. Each side of nanoparticle **B** measures 2.1×10^{-9} m.

Mia makes a model of nanoparticle **B**. She makes each side of her model 2.1 cm long.



Nanoparticle B



Model of nanoparticle B

(i) How many times longer is each side of the model compared to nanoparticle **B**?

Put a (ring) around the correct option.

1 000 000 000 x **10 000 000 x** **900 x** **109 x** **100 x**

[1]

The fact that there are 100 cm in a metre was not always taken into account, leading to 1 000 000 000x being the most popular, incorrect choice.

Question 3 (d) (ii)

(ii) Calculate the volume of the model of nanoparticle **B**.

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

Volume = ... cm^3 **[2]**

A very common error in this and the next question was to try to calculate the volume of the nanoparticle, rather than the model, which the question demanded. Almost all candidates knew that the working should include (2.1 x 2.1 x 2.1) but some added powers of 10 to their working (which was unnecessary). Most, but not all, obeyed the instruction to 'Give your answer to 1 decimal place'.

Question 3 (d) (iii)

(iii) The model of nanoparticle **B** has 6 sides.

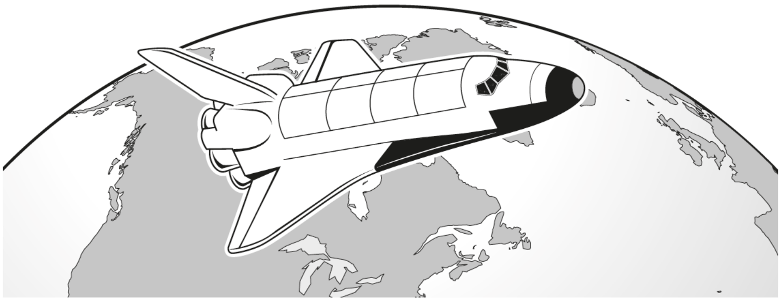
Calculate the surface area of the model of nanoparticle **B**.

Surface area = ... cm^2 **[2]**

In common with the previous question, many candidates included powers of 10 in their working, showing that they were attempting to calculate the surface area of the nanoparticle rather than the model. Almost all candidates included 6 x (2.1 x 2.1) in their answer, however, for at least 1 mark.

Question 4 (a) (i)

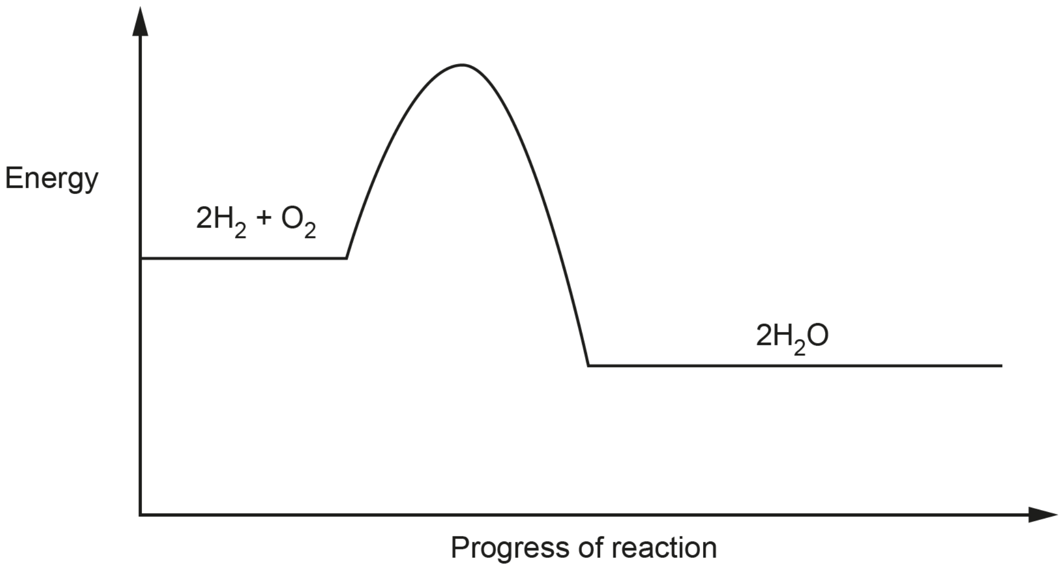
4 Space shuttles are used to transport people into space stations in space.



Space shuttles use hydrogen-oxygen fuel cells to provide some of their power.

The shuttles carry a supply of liquid hydrogen and liquid oxygen stored under pressure.

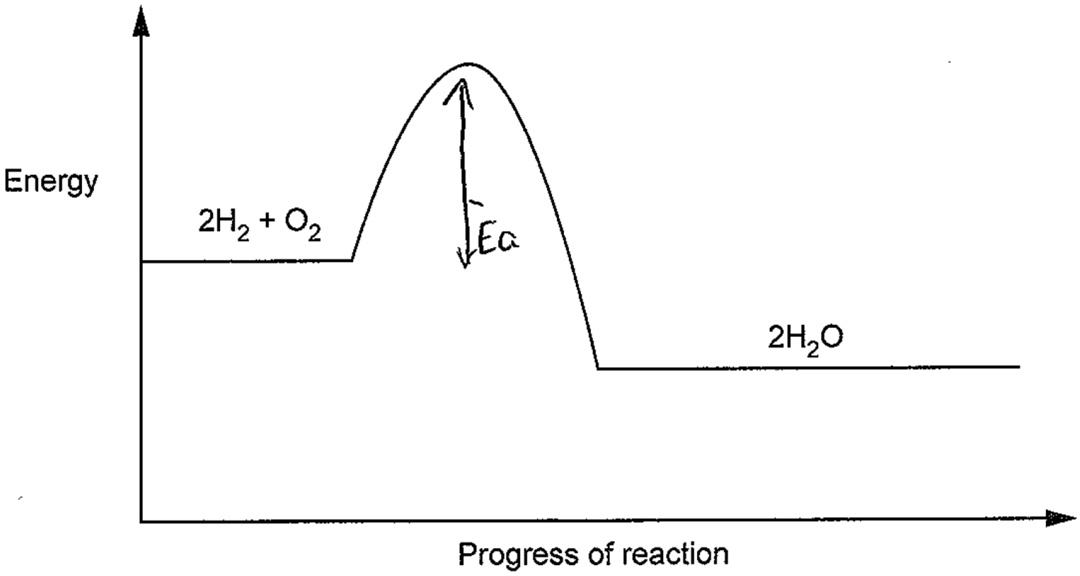
(a) The reaction profile diagram shows the energy change when hydrogen reacts with oxygen.



(i) Label the activation energy, E_a, on the diagram. **[1]**

Almost all candidates had an idea that activation energy should be shown with an upward pointing arrow (although some wrote 'Ea' at the top of the hump with no arrow shown). The most common error, however, was to show the direction of the energy change but to not take care that the arrow started and ended in the correct place. It was common to see the arrow beginning at a level with the products. Another common error was to end the arrow below the top of the 'hump'.

Exemplar 1



This exemplar shows a common error. The candidate has shown Ea with a double headed arrow; this is accepted if it is in the correct place (although teachers should teach candidates that a fully correct representation shows an upwards arrow). However, this candidate has not taken care to start and end their arrow at the correct level. The arrow is well short of the top of the hump, so no mark.

OCR support

Common mistakes like this example are highlighted in our Exam hints for students resource. Teachers put these to good use in several ways: some print (A4) and use them as reference material in exercise books, while others print a large poster form and display in the classroom. Regular referral when completing class activities, or using them to peer/self assess work could help towards avoiding these mistakes in the future.

Question 4 (a) (ii)

(ii) Explain the meaning of **activation energy**.

Use ideas about bonds in your answer.

....

....

....

.... **[2]**

The idea that activation energy is needed to start a reaction was very well known. Many candidates then stated that this energy is needed to break bonds in the reactants. The most common error was to mistakenly say that the energy was also used to make bonds; this is incorrect as making bonds is an exothermic process.

Question 4 (a) (iii)

(iii) Platinum acts as a catalyst for the reaction between hydrogen and oxygen.

Explain the effect of a catalyst on the reaction between hydrogen and oxygen.

Use ideas about activation energy in your answer.

....

....

....

.... **[2]**

Almost all answers correctly stated that a catalyst speeds up the rate of a reaction. The most confident candidates continued to state that this is due to the catalyst lowering the activation energy (by providing an alternate reaction pathway).

Misconception

A common misconception was that a catalyst provides activation energy for the reaction. This is clearly incorrect.

Question 4 (b)

(b) The equation shows the molecules involved in the reaction between hydrogen and oxygen.

H–H + O=O → H–O–H
H–H   H–O–H

The table shows the bond energies of the bonds in the molecules (per formula mass).

Bond	Energy (kJ)
H–H	436
O=O	498
O–H	463

Calculate the energy needed to break all of the bonds in the hydrogen and oxygen molecules and to make all of the bonds in the water molecules.

Use your values to then calculate the overall energy change of the reaction.

Energy needed to break bonds = ... kJ

Energy needed to make bonds = ... kJ

Energy change of reaction = ... kJ
[3]

Many candidates correctly calculated all three values. It was not necessary to show the sign for the final value on this occasion (the energy change of reaction is negative, and so should be expressed as –482 kJ), but candidates should be encouraged to routinely include the sign in such calculations. Candidates who calculated the values incorrectly usually did so because they did not multiple the bond energy of the H-H bond by two or did not multiple the bond energy of the O-H bond by four.

Assessment for learning

It was clear that many candidates who completed the calculation correctly had ticked off the bonds in the equation as they included them in their calculation. This is a good idea and should be encouraged as very successful technique to avoid errors.

Question 4 (c)

(c) Evaluate the advantages **and** disadvantages of using hydrogen-oxygen fuel cells in space shuttles.

....

....

....

....

....

.... **[3]**

In common with Question 3 (a), this is another longer answer which includes different 'sides' to the argument. The highest achieving candidates could address both advantages and disadvantage clearly and took care to express three distinct points to meet the 3 available marks.

A common theme seen in less confident candidate responses were points made which were not fully relevant or were expressed vaguely. Some candidates discussed 'they make water' without identifying that this is the only product and that it is non-polluting (hydrocarbon fuels also produce water). Some said that 'hydrogen is dangerous'. Some less successful responses gave disadvantages that would be true for all fuels, such as saying that oxygen needs to be supplied, or that 'a lot of fuel needs to be carried'. Some mentioned cost, saying that the fuel cells are expensive. Unless qualified by identifying the reason for the cost, cost arguments are not given marks.

Question 5*

5* The box gives information about what happens when calcium chloride and ammonium chloride dissolve in water.

> There is an exothermic change when calcium chloride dissolves in water.
>
> There is an endothermic change when ammonium chloride dissolves in water.

Describe an experiment to show that the information in the box is correct.

Include in your answer:

- what measuring equipment you need
- your method
- how you will control variables
- the measurements you will make and the results that you expect.

....

....

....

....

....

.... **[6]**

The most successful responses were given by candidates who had taken a few minutes to plan their answer. Some Level 3, 6 mark answers were very short and succinct. Typically, very long answers that went onto extra pages often included either a large amount of irrelevant information or included contradictions that meant that the top mark in the level was not awarded. Higher attaining candidates stated that a thermometer should be used to measure the temperature of water before and after each solid has been dissolved. For full marks the answer needed to state that temperature increases when calcium chloride dissolves (as it is an exothermic change) and decreases when ammonium chloride dissolves (as it is an endothermic change). In this case, as the candidates were only asked to differentiate between an exothermic and an endothermic reaction, it was not strictly necessary to control the amounts of reactants used, but of course it is best practice to do so. Successful responses included comments to measure and control the volume of water and the mass of solids used.

Answers that were not awarded full credit included a range of common errors.

Some responses discussed using various methods to control the temperature, which shows a misunderstanding of the dependent variable. Some used an external heat source (such as a Bunsen burner) to heat the water. Many answers discussed the use of a water bath to 'keep the temperature of the water the same'. Both of these ideas are incorrect and would not lead to usable results.

Some responses discussed measuring the time for the solid to dissolve, showing a misunderstanding of the meaning of exothermic and endothermic.

Many stated or implied that calcium chloride and ammonium chloride were either already liquids or in solution at the start of the experiment.

Some attempted to measure the temperature of the surroundings by using a thermometer in the air near the beaker. This is unlikely to be workable.

Some responses that were partially correct but not well expressed typically did not fully describe a workable method. Some measured the solids by volume, using measuring cylinders. Some stated that there was a need to 'measure the temperature change' without describing how this should be done (by taking an initial and final temperature reading).

Exemplar 2

Measuring Equipment: measuring cylinder, thermometer.
Method: Fill a beaker with water, add a spatula of calcium chloride. If the beaker heats up, the reaction is exothermic.
Fill a beaker with water, add ammonium chloride. If the beaker's temperature drops, the reaction is endothermic.
Variable: keep the temperature in the room constant, keep any chlorine levels constant, use the same concentrations

There are some 'good points' about this exemplar. The candidate has expressed their ideas briefly and relatively clearly. They have started by listing the measurement apparatus they will use (measuring cylinder and thermometer) and given an outline of what they will do and some basic indication of the results they will expect. However, the method, which is the main point of the question, lacks detail and contains errors. They discuss 'if the beaker heats up' but do not state either how they will measure this (by taking an initial and final temperature reading). Further 'heating up' is not a result. The result should be linked to an increase in temperature. Also, they have errors in the control variables. Constant room temperature can be ignored, but it is unclear what is meant by 'constant chlorine levels'. This is irrelevant to the task. Concentrations are also irrelevant; the solids should be controlled by mass.

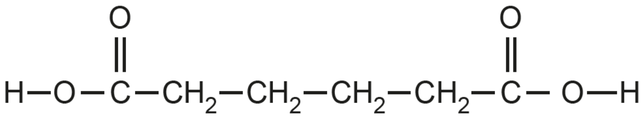
Level 2 was awarded for a partial engagement with the task but the errors, irrelevancies and contradictions included in the response limit the mark to 3 marks.

Question 6 (a) (i)

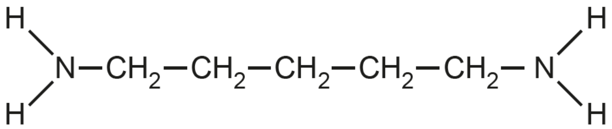
6 Nylon is a condensation polymer.

The structure of the monomer molecules that react together to make nylon are shown in **Fig. 6.1**.

Fig. 6.1



Monomer 1



Monomer 2

(a) (i) Put a ring around each of the functional groups in monomer 1 **and** monomer 2. **[2]**

The functional groups in these two monomers were not usually correctly identified. Some candidates circled part of the functional groups, such as the C=O carbonyl group. Some circled only one in each monomer. Many candidates included the hydrocarbon chain within the ring they used to indicate the groups.

Question 6 (a) (ii)

(ii) Explain why monomers of condensation polymers need to contain functional groups.

....

.... **[1]**

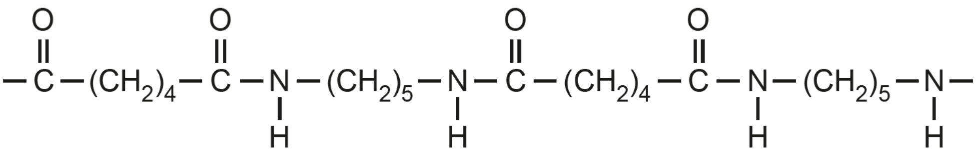
The reason that monomers need to contain functional groups is that they enable the monomers to bond or join together. The elimination of water is a less important by-product of the reaction. Hence, the common answer of 'to form water' was not given a mark. Many candidates gave vague responses such as 'so they can react' or 'so they can form polymers' which are not incorrect but do not sufficiently describe the joining together of the monomer molecules.

Question 6 (b) (i)

(b) Monomer 1 and monomer 2 react to form a polymer of nylon.

The structure of part of the polymer is shown in **Fig. 6.2**.

Fig. 6.2



(i) How many repeating units of the polymer are shown in **Fig. 6.2**?

.... **[1]**

This question was generally well answered, although '4' (the number of monomers) was a common incorrect answer.

Question 6 (c)

(c) Some polymers, such as DNA, are naturally occurring.

Which statements about polymers are **true** and which are **false**?

Tick (✓) **one** box in each row.

	True	**False**
DNA forms a polymer from four different monomers.		
Sugars and amino acids are monomers of naturally occurring polymers.		

[1]

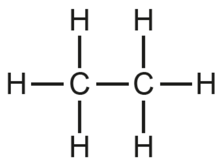
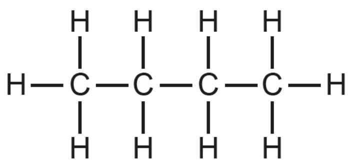
Many candidates assumed that if there are two choices, one must be true and one must be false. In this case both statements are true, so a choice of one of each inevitably lead to no mark.

Question 7 (a) (ii)

7 Fractional distillation separates crude oil into fractions. Each fraction contains hydrocarbons.

(a) **Table 7.1** shows information about two hydrocarbons.

Table 7.1

	Hydrocarbon 1	**Hydrocarbon 2**
Structure		
Empirical formula	CH_3	....

(ii) The general formula for the hydrocarbons in **Table 7.1** is C_nH_{2n+2}.

Explain why this formula is true for hydrocarbon 2.

....

....

....

.... **[2]**

This question was very well answered. Almost all candidates interpreted the structural formula to give a molecular formula of C_4H_{10} and went on to show how the value of n=4 leads to this formula. This question tested algebraic skills and candidates are clearly adept at using algebra to process numbers in general formulae.

Question 7 (a) (iii)

(iii) Name the homologous series to which both hydrocarbons belong.

.... **[1]**

Most candidates correctly identified 'alkanes' as the homologous series, but 'alkenes' was sometimes seen as an incorrect answer.

Question 7 (b) (i)

(b) **Table 7.2** shows information about the hydrocarbons in six fractions of crude oil.

Table 7.2

Fraction number	Number of carbon atoms in the molecules	Boiling point (°C)
1	1 <5	0–30
2	>4 <10	30–180
3	>9 <17	180–260
4	>13 <21	250–350
5	>19 <51	350–580
6	>50	>580

(i) A hydrocarbon in crude oil has a boiling point of 69 °C.

Suggest a formula for this hydrocarbon.

.... **[1]**

Most answers identified hydrocarbons with between 5 and 9 carbon atoms, but not all candidates gave correct formulae. In this case, both alkanes and alkenes were accepted. Some gave formulae with incorrect numbers of hydrogen atoms such as C_5H_9.

Question 7 (b) (ii)

(ii) Give the formula for the smallest hydrocarbon molecule in fraction **5**.

.... **[1]**

This question tested understanding of the mathematical symbol for greater than (>). The correct answer was $C_{20}H_{42}$ ($C_{20}H_{40}$ was also accepted). The most common error was to give the formula $C_{19}H_{40}$ which showed that the candidates did not always process the idea that the smallest hydrocarbon in fraction 5 has more than 19 carbon atoms.

OCR support

The mathematical skills required for the paper are included in the specification in Appendix 5e. It is worth including tasks that develop and reinforce the skills listed there to make sure that candidates can access all of the mathematical skills tested within the papers.

Question 7 (c)

(c) Explain the trend in boiling points of the hydrocarbons in **Table 7.2**.

Use ideas about the size of molecules and intermolecular forces in your answer.

....

....

....

.... **[2]**

Achievement in this question depended on the appropriate use of language and clear trends being stated. Fully correct responses described the trend in the size of the molecules linked to the boiling points by using clearly comparative language such as 'larger' 'greater' 'increases'. Secondly, it was important to then make a further comparative comment about intermolecular forces increasing or becoming stronger with increasing size of the molecule.

Less confident candidates did not make comparative statements, instead giving answers not worthy of credit such as 'down the table the boiling points are high'. Such responses do not clearly identify a trend in either the size of the molecule or the boiling points.

Many responses confused intermolecular forces with bonds between atoms or stated that bonds between atoms become stronger.

Misconception

A very common misconception is to confuse intermolecular forces with bonds within molecules or between atoms. This is an area that it is important to practise with candidates so that they do not confuse the two ideas. Many state that bonds in molecules break during state changes.

Question 7 (d)

(d) Which **two** statements explain why modern life depends on crude oil?

Tick (✓) **two** boxes.

Crude oil is a fossil fuel and is a renewable resource. ☐

Fractional distillation of crude oil is done on a very large scale. ☐

Fuels made from crude oil produce greenhouse gases when they burn. ☐

Hydrocarbons are feedstocks for the petrochemical industry. ☐

There is not a large enough supply of renewable energy sources to meet the needs of modern life. ☐

[2]

This type of question is more difficult than it first appears because all of the statements are true. It is important to work out which statements are relevant to answer the question and which are true, but not relevant. Many candidates ticked statements that do not explain why modern life is dependent on crude oil.

Question 8 (a)

8 Ammonia is made on an industrial scale in a reaction between nitrogen and hydrogen.

The equation to make ammonia is shown.

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

(a) What is the atom economy of this reaction?

Explain your answer.

Atom economy = ... %

Explanation ....

....

.... **[2]**

A range of answers was seen, but many correctly gave the atom economy as 100%. The explanation was more problematic. There appeared to be confusion between conservation of mass, yield and atom economy. Responses such as 'there are the same atoms on both sides' is true for all equations. The key point about reactions with 100% atom economy is that there is either only one product or that all products are useful, with no waste or by-product. Other incorrect responses discussed how unreacted hydrogen and nitrogen can be recycled (perhaps this idea came from part (c)) so that they all eventually react. This is a yield argument and is not relevant to atom economy.

Question 8 (b)

(b) Why does this reaction **not** give a 100% yield?

....

.... **[1]**

Many candidates identified that reversible reactions do not give 100% yield. Some responses incorrectly stated that 'gases are lost' or 'nothing ever reaches 100% yield'.

Question 8 (c)

(c) The reaction used to make ammonia takes place in a reactor.

Unreacted nitrogen and hydrogen left at the end of the reaction are recycled back into the reactor.

Which **two** statements explain why this increases the sustainability of the process?

Tick (✓) **two** boxes.

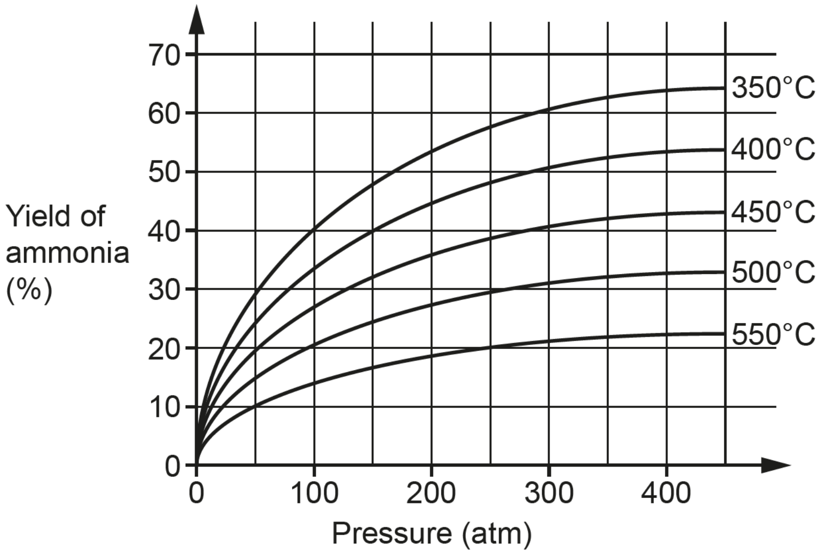
Less feedstock is used.	☐
The atom economy is increased.	☐
The overall yield increases.	☐
The rate of reaction increases.	☐
There is more eutrophication.	☐

[2]

Many candidates correctly linked the recycling of gases to the need for less feedstock and an increase in overall yield. Some incorrectly chose the 'atom economy is increased' option.

Question 8 (d)*

(d)* The graph shows the yield of ammonia when different conditions of temperature and pressure are used.



The table shows the conditions used in an industrial process to make ammonia.

Conditions used	
Temperature (°C)	450
Pressure (atm)	200
Catalyst	Finely powdered iron

Explain why each of these conditions are chosen.

Use the graph and ideas about yield and rate of reaction in your answer.

....

....

....

....

....

.... **[6]**

In common with the other Level of Response question, Question 5, the most successful responses showed evidence of thought and planning and were typically succinct. Long responses which went beyond the available space often included irrelevant information or contradictions which limited the marks because the line of reasoning was unclear and no longer logically structured. Some 6 mark responses were very short.

In order to fully answer the question, it was necessary to discuss the three conditions in the table (pressure, temperature and a catalyst) in terms of yield and rate. The highest scoring candidates did this, showing a logical structure to the layout of the answer. Typically, answers which were less successful either omitted one of the conditions or did not discuss the impact of each condition on both yield and rate. Typically only one condition, usually pressure, was discussed in the context of its impact on yield.

Common errors included stating that a faster reaction (such as that provided by the use of a catalyst) also results in a higher yield. Candidates also often confused the impact of temperature on yield, stating that a higher temperature increases yield. Most, however, identified how at least two conditions impacted rate.

Exemplar 3

Higher temperature decreases the
yeild of ammonia
Higher pressure means a higher
yeild of ammonia however
is very dangerous and expensive.
Catalyst increases the rate of
reaction so more ammonia can
be produced without being used up
Both the temperature of 450°c
and pressure of 200atm is the
balance to reach a high yeild
safely and not expensivly. **[6]**

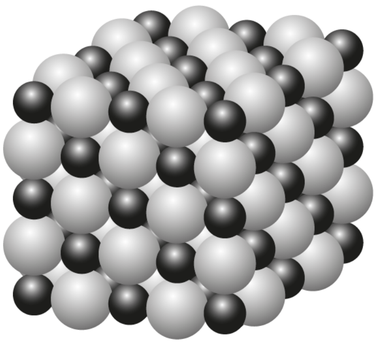
This exemplar response begins well. The candidate correctly discusses the impact of using a higher temperature and a higher pressure on yield of ammonia. The answer includes a correct outcome of the use of a catalyst on rate. Notice too how the candidate used language appropriate to discussing trends by using comparative language such as 'higher' and 'decreases'. So far, the answer is logically structured and clear.

However, the effects of pressure and temperature on rate is not addressed. This omission of part of the task means that a Level 2 was awarded. The clear structure means that a full Level 2 was given, 4 marks.

Question 9 (a)

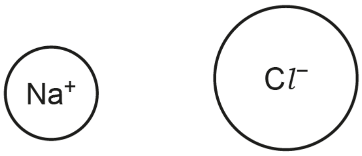
9 A three-dimensional model for solid sodium chloride is shown in **Fig. 9.1**.

Fig. 9.1



(a) Draw a **two-dimensional** diagram to show the arrangement of ions in sodium chloride.

Use these symbols.



Show at least **eight** ions.

[2]

This question was challenging for lots of candidates. There were several common issues. Firstly, the candidates were asked to ‘use these symbols’. This instruction was frequently ignored. Diagrams with very tiny Na^+ ions meant that the structure was difficult to draw. Some used dots and circles. Some used symbols without charges. In terms of the way that the ions were presented, many drew a grid of chloride ions first and inserted the sodium ions between them such that the chloride ions were shown in rows and columns rather than alternating with the sodium ions. Many drew dot and cross diagrams; many showed a layout of different numbers of sodium and chloride ions, not in a 1:1 ratio, which looked more like the layout of atoms in a covalent molecule.

Question 9 (b)

(b) Explain why the model shown in **Fig. 9.1 cannot** be used to show the arrangement of ions in calcium chloride, $CaCl_2$.

....

....

....

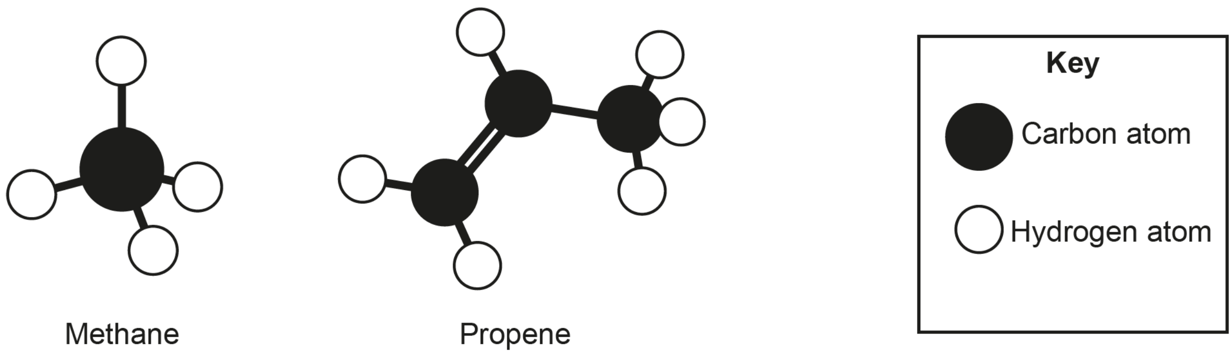
.... **[2]**

Most candidates earned a single mark for recognising that there are two chloride ions for each calcium ion. Fewer realised that two distinct points need to be made for 2 marks, so the other marking points available were not so often seen.

Question 9 (c) (i)

(c) Three-dimensional models for the arrangement of atoms in methane and propene are shown in **Fig. 9.2**.

Fig. 9.2



(i) There are two types of bonds between carbon atoms in propene.

Explain how the different types of bonds between carbon atoms in propene are formed.

Use ideas about electrons in your answer.

....

....

....

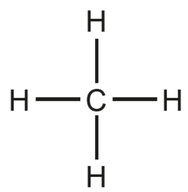
.... **[2]**

This question was only correctly answered by a small minority of candidates. Most identified that the molecule contains a single and a double C-C bond but did not explain the difference in how these are formed clearly. There were two main issues. Firstly, they ignored the instruction to 'use ideas about electrons' and instead discussed the structures in terms of how many hydrogen atoms were bonded to each carbon atom. Secondly, those who discussed electrons did not clearly indicate how a single and a double bond are formed in terms of shared electrons. 'Single bonds share one electron and double bonds share two' was a common ambiguous answer. Highly successful candidates either discussed how many electrons each atom contributed to the shared pairs, or identified the total number of shared electrons in each type of bond.

Question 9 (c) (ii)

(ii) The displayed formula of methane is shown in **Fig. 9.3**.

Fig. 9.3



Draw the displayed formula of propene.

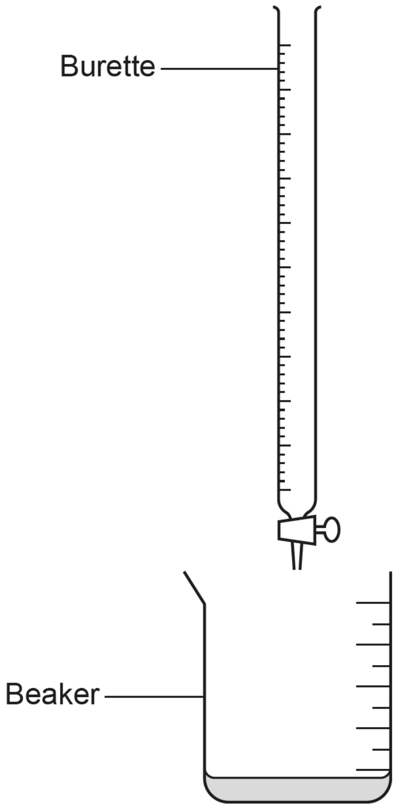
[1]

Many candidates drew the structure of propene correctly. Some incorrectly drew propane instead. A common error was to add an additional hydrogen to the central carbon atom.

Question 10 (a)

10 Nina does a titration using dilute hydrochloric acid and dilute sodium hydroxide.

She uses this apparatus.



(a) Nina uses this method:

- Fill the burette with dilute hydrochloric acid.
- Use a beaker to measure 25 cm^3 of dilute sodium hydroxide.
- Add universal indicator to the dilute sodium hydroxide in the beaker.
- Add the acid to the beaker quickly from the burette.
- Stop adding acid after the indicator has fully changed colour.

Describe **two** improvements that Nina should make to the titration method **and** explain why these will improve her results.

Improvement 1 ....

Explanation ....

....

Improvement 2 ....

Explanation ....

.... **[4]**

Most candidates were able to suggest improvements. Typically, these included adding the acid more slowly, using a measuring cylinder or pipette to measure the volume of dilute sodium hydroxide, swirling the mixture or stopping adding acid at the first indication of a change of colour. Fewer identified the important error that universal indicator is an inappropriate indicator for a titration. In justifying their choices, the most successful responses gave specific outcomes, such as an increase in precision of measurement, rather than vague comments such as 'it makes it more accurate and reliable'.

OCR support

Our Language of measurement in context resource can be used with candidates to help reinforce the correct application of words like reliability and accuracy.

Question 10 (b)

(b) Nina uses an improved method to do more titrations. She uses the same concentration of dilute sodium hydroxide each time.

She uses different concentrations of dilute hydrochloric acid in the burette. She measures the volume of acid needed to neutralise 25.0 cm^3 of dilute sodium hydroxide.

Nina's results are shown in the table.

Concentration of acid (mol/dm^3)	0.1	0.05	0.2
Volume of acid needed (cm^3)	12.5	25.1	6.3

Describe the relationship between the concentration of the acid and the volume of acid needed.

....

....

....

.... **[2]**

Almost all candidates recognised that the more concentrated the acid, the lower the volume needed. Higher scoring candidates identified that the relationship is inversely proportional.

Question 10 (c) (ii)

(c) Nina uses 25.0 cm^3 of dilute sodium hydroxide in each titration.

The equation for the reaction is shown.

$HCl + NaOH \rightarrow NaCl + H_2O$

(ii) Explain your answer to **(c)(i)**.

....

....

....

.... **[2]**

The justification for the choice of the correct answer was more problematic. In order to evidence the correct choice, candidates needed to refer to both the molar ratio in the equation and the implications on this for the concentration of dilute sodium hydroxide.

Most responses incorrectly stated that 'this is the value where the volume of acid is the same as the volume of sodium hydroxide' without relating this to the stoichiometric ratio in the equation.

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