Pearson Edexcel

Examiners' Report
June 2019

IAL Chemistry WCH11 01

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Introduction

This is the second examination in the Pearson Edexcel Advanced Subsidiary Level in Chemistry Paper WCH11_01, though it is the first June issue.

The style of the paper is similar to the legacy paper WCH01 with 20 multiple choice questions in Section A and 60 marks of structured questions in Section B.

The paper is different to the legacy paper in that it contains 20% Level 2 or above mathematics, including the use of the Ideal Gas Equation. Shapes of molecules and ions is now assessed on this paper (whereas before it was on WCH02) and enthalpy is now tested on papers WCH12 and WCH14.

Some candidates scored very high marks and were well prepared for the examination, showing excellent learning and teaching has taken place.

Many had a sound knowledge of the specification and could demonstrate this in their explanations and descriptions. However, a small minority of students found the questions challenging and needed to express their understanding of Chemistry more clearly. The calculations were generally well attempted with the main errors being in the use of significant figures. The mean mark for the paper was 49.

Section A

The mean mark on the multiple choice questions was 14.

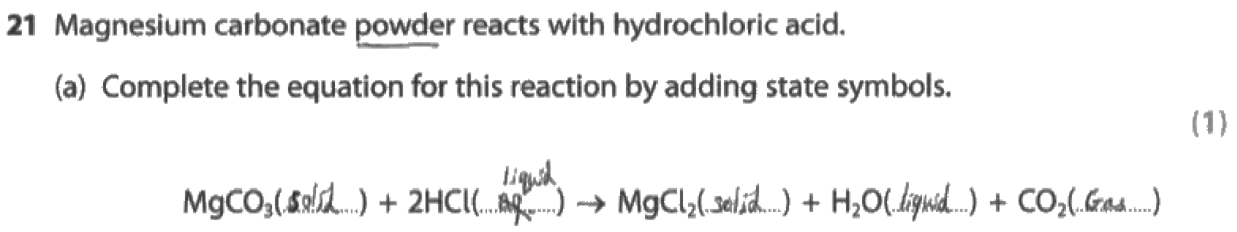
The questions that candidates found most difficult were Q05 (strength of ionic bonding, Specification reference 3.6), Q14 (trends in melting temperatures, 2.18i) and Q09 (selecting the graph of first ionisation energy down a group, 2.10), with under 55% of candidates achieving these marks.

Q13 (ionisation energy equations), Q10 (isotopes) and Q07 (relative atomic mass references) proved were more accessible to candidates, with over 90% of candidates scoring these marks.

Question 21 (a)

The most common errors here were to give the state of magnesium chloride as (s) or water as (aq).

70% of candidates achieved this mark.



21 Magnesium carbonate powder reacts with hydrochloric acid.

(a) Complete the equation for this reaction by adding state symbols.

(1)

$MgCO_3$(solid) + 2HCl(~~aq~~ liquid) → $MgCl_2$(solid) + H_2O(liquid) + CO_2(Gas)

ResultsPlus
Examiner Comments

The candidate did not score for this answer as they have not used the required state symbols. Magnesium chloride is soluble so should have the state symbol (aq). The candidate shows good practice in underlining key words in the question.

ResultsPlus
Examiner Tip

Learn the state symbols and practise using them every time you write a balanced equation.

Question 21 (b)

This question is based on Core Practical 1 and candidates were expected to be familiar with the procedure, graph and calculation from their work in lessons.

The majority of candidates scored two or three marks for their drawing of the graph.

Occasionally candidates lost a mark for having the axes the wrong way around, but the most frequent error was in the line of best fit. Candidates were expected to have points on either side of the line (ideally it should pass through the origin for this experiment) and use a ruler to draw a single straight line.

The upside-down measuring cylinder proved challenging for some candidates but transfer errors were given if they continued with their answer through the calculation. The common incorrect answers were 54cm^3 and, to a lesser extent, 45cm^3.

Part Q21(b)(iii) was sometimes answered using the table or the gradient of the line, rather than the candidates' own graph, but this was allowed.

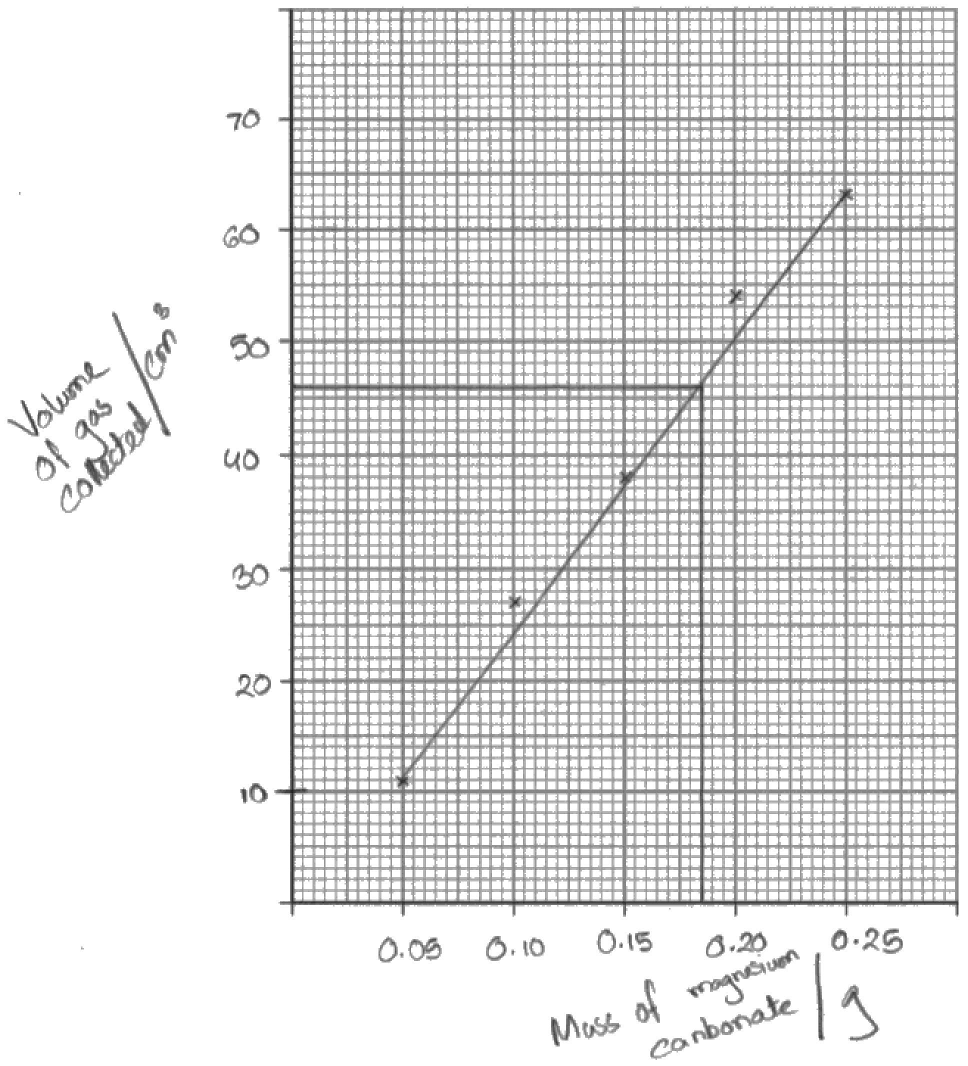
The most frequent error in part Q21(b)(iv) was the failure to use the volume from the measuring cylinder in their calculation. Often candidates quoted the molar volume and tried to use this to calculate the experimental molar volume. The final mark was for an answer of 2 or 3 significant figures with units.

Part Q21(b)(v), the calculation of the minimum concentration, was answered well with over half of candidates scoring both marks. Some errors in rounding were seen, but significant figures were not tested here. The common errors were omission of the 1:2 molar ratio or forgetting to convert the volume into dm^3 and still giving the units as mol dm^{-3}.

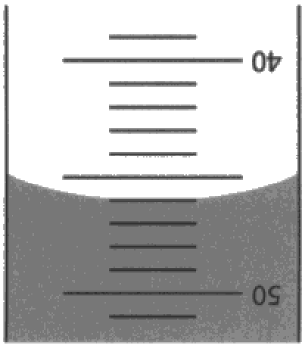
This clip of a candidate's work exemplifies some common errors.

(i) **Plot a graph of these results.**

(3)



(ii) **A student carried out a further experiment using a different mass of magnesium carbonate.**



Give the volume of gas collected using the inverted measuring cylinder.

(1)

46 cm³

(iii) Determine the mass of magnesium carbonate added in the experiment in (b)(ii), using your graph.

(1)

0.185 g

(iv) Calculate the molar volume of carbon dioxide using your answers to parts (b)(ii) and (b)(iii). Give your value to an appropriate number of significant figures and include units.

[A_r values: Mg = 24.3 C = 12.0 O = 16.0]

(4)

~~Mol =~~

mol of magnesium carbonate,

$$\frac{0.185}{24.3+12+3(16)}$$

$$= \frac{37}{16860} = 2.19 \times 10^{-3} \text{ mol}$$

Molar ratio,

$CO_2 : MgCO_3 = 1 : 1$

$\therefore CO_2 = \frac{37}{16860} = 2.19 \times 10^{-3}$ mol

~~Mol =~~

$$\text{mol} = \frac{\text{volume}}{24}$$

$\Rightarrow$ volume $= 2.19 \times 10^{-3} \times 24$

$= 0.0526$

(v) The acid must be in excess for each experiment.

Calculate the **minimum** concentration of hydrochloric acid needed for 30 cm^3 of acid to completely react with 0.25 g of magnesium carbonate.

$$MgCO_3 + 2HCl + MgCl_2 + H_2O + CO_2$$

(2)

Mol of $MgCO_3$,

$$\frac{0.25}{24.3 + 12 + 3(16)}$$

$$= \frac{5}{1686} = 2.97 \times 10^{-3} \text{ mol}$$

Molar ratio,

$HCl : MgCO_3 = 2:1$

$\therefore HCl = 2 \times \frac{5}{1686}$

$$= \frac{5}{843} = 5.93 \times 10^{-3} \text{ mol}$$

$\therefore \frac{5}{843} = \frac{30}{1000} \times conc.$

$\Rightarrow conc. = \frac{\frac{5}{843} \times 1000}{30}$

$\Rightarrow conc. = 0.197 \text{ mol dm}^{-3}$

ResultsPlus
Examiner Comments

This graph is just acceptable for three marks. Ideally the line would pass through the origin and show white space between the line and at least one of the points. The candidate has clearly shown on the graph how their answer to part Q21(b)(iii) has been obtained.

In part Q21(b)(iv), this answer shows a common error. The candidate has not read the question properly and has failed to use their answer to Q21(b)(ii), instead trying to use the molar volume. This calculation scores two marks as the moles of magnesium carbonate have been calculated correctly. The final answer lacks units.

In part Q21(b)(v), the candidate performs the calculation correctly but incorrectly rounds their answer down - this would not give the minimum concentration.

ResultsPlus
Examiner Tip

Always label the origin and consider if it is appropriate that your best fit line should pass through it.

Clearly show how you have obtained answers from your graph.

Read questions carefully to check which previous answers you should refer to.

Always check your rounding of answers and practise giving answers to appropriate numbers of significant figures.

(iv) Calculate the molar volume of carbon dioxide using your answers to parts (b)(ii) and (b)(iii). Give your value to an appropriate number of significant figures and include units.

[A_r values: Mg = 24.3 C = 12.0 O = 16.0]

(4)

$$\frac{0.185}{(24.3+12+16\times3)} = 0.002195 \text{ mol}$$

0.002195 mol of CO_2 occupies 46 cm^3.

$$\frac{1}{0.002195} \times 46 = 20957$$

$$\approx 21.0 \text{ dm}^3$$

(v) The acid must be in excess for each experiment.

Calculate the **minimum** concentration of hydrochloric acid needed for 30 cm^3 of acid to completely react with 0.25 g of magnesium carbonate.

$$MgCO_3 + 2HCl + MgCl_2 + H_2O + CO_2$$

(2)

$$\frac{0.25}{24.3+12+16\times3} = 0.002966$$

$$0.002966 \times 2 = 0.005932$$

$$\frac{0.005932}{30} \times 1000 = 0.1977$$

$$\approx 0.198$$

$\therefore$ 0.198 mol dm^{-3}

ResultsPlus
Examiner Comments

This example of the calculations shows a candidate who has clearly shown their working in the minimum number of steps.

Answers have been given to an appropriate number of significant figures with correct units.

ResultsPlus
Examiner Tip

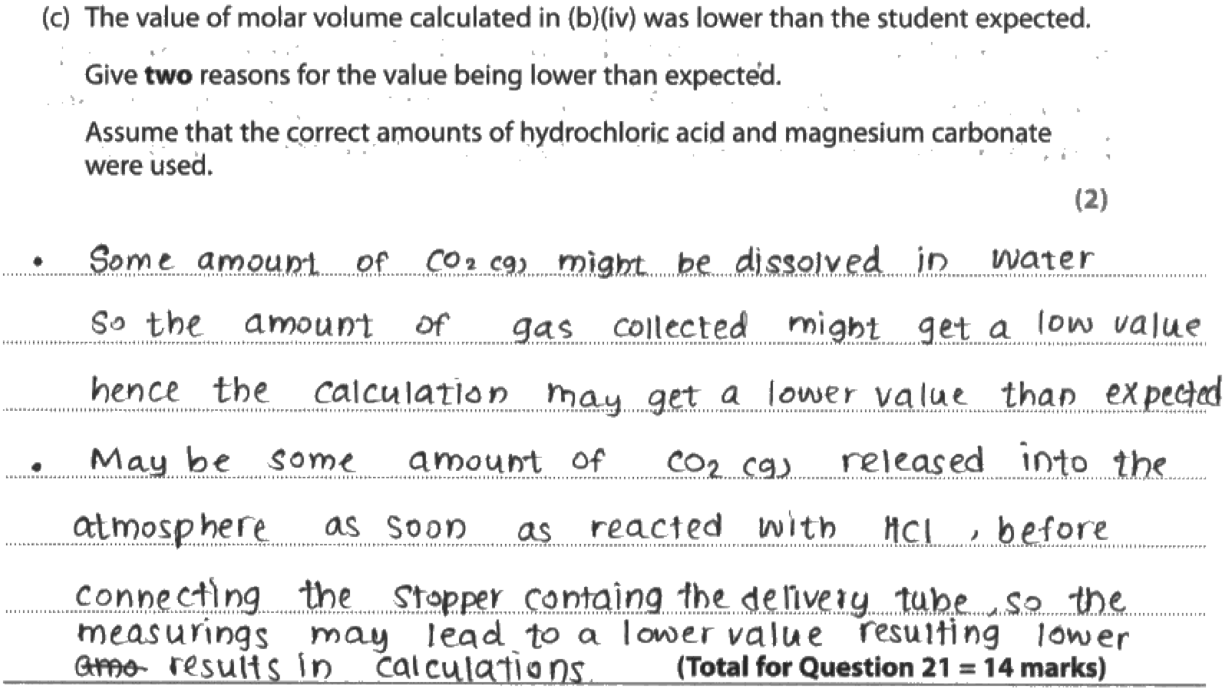
Show your working clearly.

Always give units for your answers.

Question 21 (c)

This question continues from Q21(b) and candidates are expected to be familiar with experimental issues that may arise in Core Practical 1 and, in this situation, apply their experience to an unexpected result of a calculation.

Most candidates gained one mark here, usually for saying that the carbon dioxide had dissolved in the water. "Leaks" was not acceptable without an explanation of how the loss of gas occurred. References to conditions being different to standard conditions had to be qualified. Frequently, candidates talked about the reaction being incomplete or there being impurities in the magnesium carbonate which were not accepted answers. Some also mentioned human errors such as reading errors (including parallax).



(c) The value of molar volume calculated in (b)(iv) was lower than the student expected.

Give **two** reasons for the value being lower than expected.

Assume that the correct amounts of hydrochloric acid and magnesium carbonate were used.

(2)

- Some amount of CO_2 (g) might be dissolved in water so the amount of gas collected might get a low value hence the calculation may get a lower value than expected
- May be some amount of CO_2 (g) released into the atmosphere as soon as reacted with HCl, before connecting the stopper containg the delivery tube, so the measurings may lead to a lower value resulting lower ~~amo~~ results in calculations.

(Total for Question 21 = 14 marks)

ResultsPlus
Examiner Comments

This response scored two marks as the candidate clearly states when the gas may have escaped for the second mark.

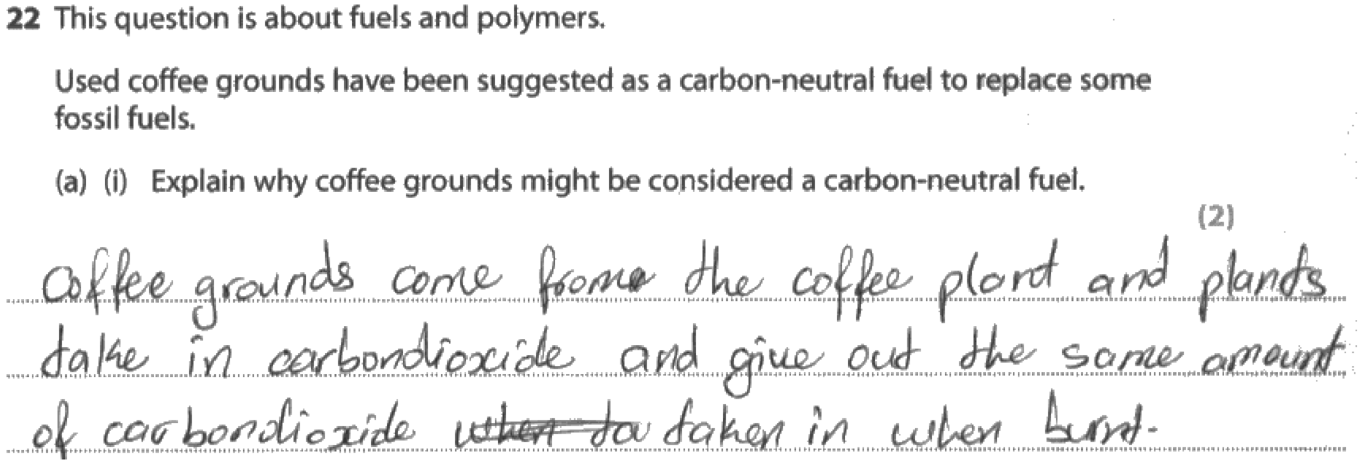
ResultsPlus
Examiner Tip

Apply your experiences in class experiments to your answers. Be as specific as you can.

Question 22 (a) (i)

This question was poorly answered and candidates needed to be more precise in their explanations. Half of the candidates did not gain any credit in this question. A surprising number of candidates thought that there was no carbon in coffee grounds.

Some candidates did not reference carbon dioxide as part of a definition of carbon neutrality and intake of "carbon" on its own was not credited. A minority of answers were seen where coffee grounds were absorbing carbon dioxide rather than the idea that the **plant** was photosynthesising or taking in CO_2. Answers which referred to net CO_2 release could score 1 mark.



22 This question is about fuels and polymers.

Used coffee grounds have been suggested as a carbon-neutral fuel to replace some fossil fuels.

(a) (i) Explain why coffee grounds might be considered a carbon-neutral fuel.

(2)

Coffee grounds come frome the coffee plant and plants take in carbondioxide and give out the same amount of carbondioxide ~~when to~~ taken in when burnt.

ResultsPlus
Examiner Comments

This response is acceptable for two marks. The candidate has considered how and when the carbon dioxide is taken in and released. The response could be improved by use of scientific terms such as "photosynthesis" and "combusted".

22 This question is about fuels and polymers.

Used coffee grounds have been suggested as a carbon-neutral fuel to replace some fossil fuels.

(a) (i) Explain why coffee grounds might be considered a carbon-neutral fuel.

(2)

Coffee grounds are taken from plants. Plants ~~t~~ take in and use up ~~co~~ CO_2 when they grow and respire. When the coffee grounds are burnt, they release CO_2. As they both take in CO_2 and give out CO_2, they are considered ~~carbon~~ carbon-neutral.

ResultsPlus
Examiner Comments

This response only scored one mark as the candidate references respiration taking in carbon dioxide. While knowledge of respiration is not required on the specification, incorrect scientific ideas cannot be credited.

ResultsPlus
Examiner Tip

Use scientific terms carefully.

Question 22 (a) (ii)

This question was poorly answered with many candidates mixing correct ideas of carbon dioxide and the greenhouse effect with acid rain and the ozone layer. While acid rain and ozone layer depletion are environmental problems, they should not be referred to in a question about climate change.

Candidates should state that carbon dioxide is released when fossil fuels are burnt. Descriptions of temperature increase were credited along with increasing the greenhouse effect and global warming. Consequences of climate change were ignored as this is not asked in the question.

(ii) Explain how the use of fossil fuels causes climate change.

(2)

when you burn fossil fuels, it releases a large quantity of CO_2 to the atmosphere. which ~~will~~ leads to global warming.

ResultsPlus
Examiner Comments

This response quickly answers the question.

ResultsPlus
Examiner Tip

Be clear in your explanations.

(ii) Explain how the use of fossil fuels causes climate change.

(2)

Burning the fossil fuels can release carbon dioxide. This carbon dioxide ~~is~~ causes global warming by not letting the uv ray to penetrate to the space. Incomplete combustion of fossil fuels may release soot and CO. CO is a silent killer. There is some oxides of ~~sulphur~~ sulfur which causes acid rain. Acid rain ~~damages~~ kills the aquatic animals in lakes, ponds and damages the forests and crops.

ResultsPlus
Examiner Comments

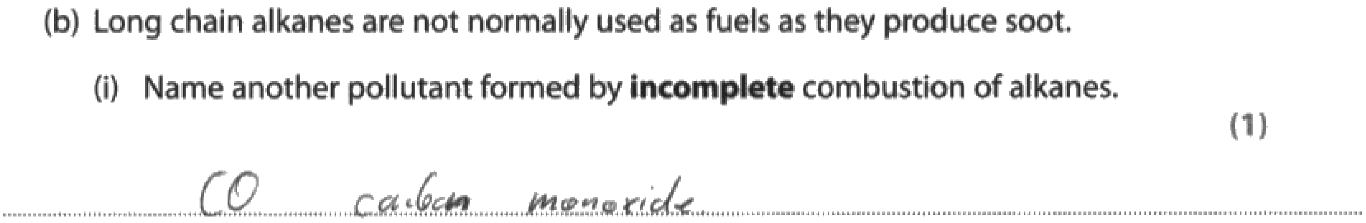
This response is correct in the beginning but then goes on to discuss carbon monoxide, sulfur emissions and the consequences of acid rain. This is irrelevant and shows a lack of understanding of climate change so negates the marks.

ResultsPlus
Examiner Tip

Do not add unnecessary information to the end of explanations.

Question 22 (b) (i)

The only accepted answer for this question was carbon monoxide, though some candidates provided multiple answers. 88% of candidates achieved this mark.



(b) Long chain alkanes are not normally used as fuels as they produce soot.

(i) Name another pollutant formed by **incomplete** combustion of alkanes.

(1)

CO carbon monoxide

ResultsPlus
Examiner Comments

In this response the candidate has correctly given the formula and the name of the pollutant. If one was incorrect however, the mark would be negated.

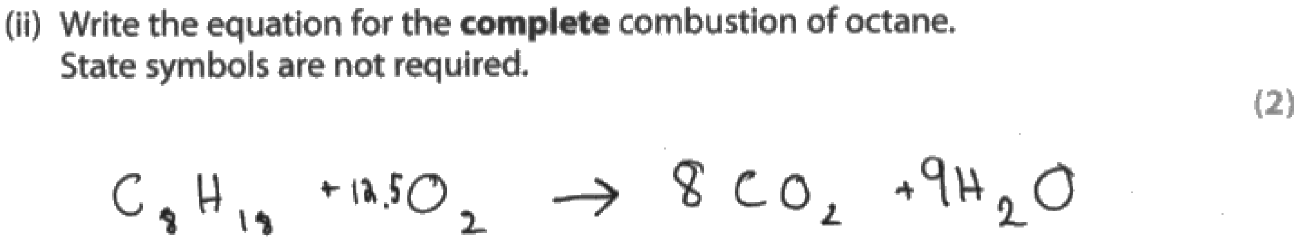
ResultsPlus
Examiner Tip

Do not give multiple answers if only one is required. Any incorrect answer could mean that your mark is not awarded.

Question 22 (b) (ii)

The most frequent errors seen here were in the formula of octane and then in the balancing of the equation.

Almost all candidates knew that the products were carbon dioxide and water. A transfer error was allowed for viable eight carbon hydrocarbons, namely C_8H_{16}. 70% of candidates were awarded both marks for this question.



(ii) Write the equation for the **complete** combustion of octane.
State symbols are not required.

(2)

$C_8H_{18} + 12.5O_2 \rightarrow 8CO_2 + 9H_2O$

ResultsPlus
Examiner Comments

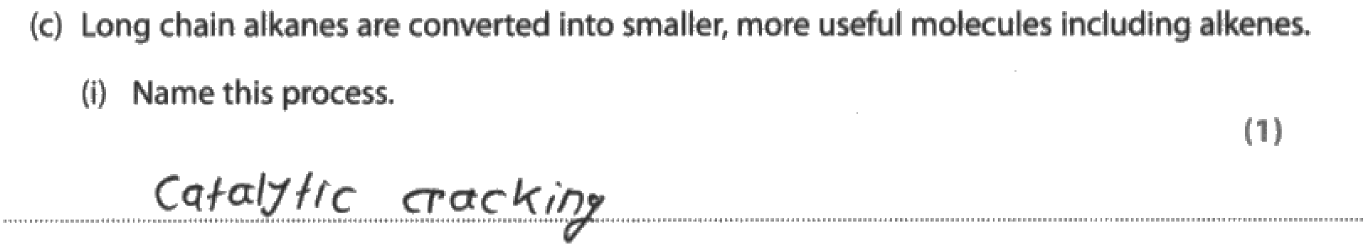
In this example, the candidate has used 12.5 to balance the equation. This is perfectly acceptable.

ResultsPlus
Examiner Tip

When writing equations, always leave space before your formulae to add the balancing numbers.

Question 22 (c) (i)

The expected answer here was 'cracking', which 87% of students gave.



(c) Long chain alkanes are converted into smaller, more useful molecules including alkenes.

(i) Name this process.

(1)

Catalytic cracking

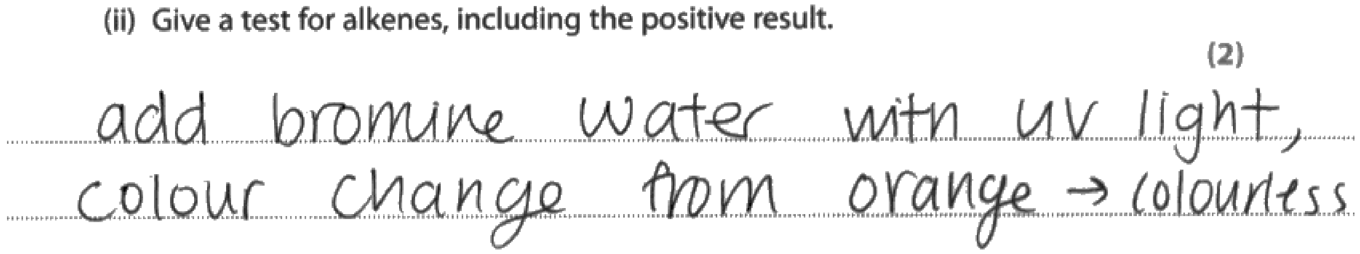
ResultsPlus
Examiner Comments

This response scores 1 as catalytic cracking and thermal cracking were both acceptable.

Question 22 (c) (ii)

Bromine solution can be described as colours from yellow to orange to brown, as this would depend on its concentration. The word "decolourises" for this test is allowable.

Candidates showed a good knowledge of this test, though occasionally unnecessary reaction conditions were seen such as heat.



(ii) Give a test for alkenes, including the positive result.

(2)

add bromine water with uv light,
colour change from orange → colourless

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Examiner Comments

This candidate has the correct reagent and result but the addition of an incorrect condition negates a mark, so scores 1.

ResultsPlus
Examiner Tip

Revise the reaction conditions for chemical tests carefully.

(ii) Give a test for alkenes, including the positive result.

(2)

potassium ~~mag~~ manganate (VII) in aqueous acid. purple to colourless, $C=C$ be broken, two OH group formed.

ResultsPlus
Examiner Comments

This response scores 2 as an alternative answer. The acid is a necessary condition in order for the marks to be awarded.

ResultsPlus
Examiner Tip

Revise the colour changes seen with different reagents for chemical tests. Remember to include the initial and final colours.

Question 22 (d) (i)

Only 45% of candidates achieved this mark.

The most frequent error was to forget the "n" on the left hand side to balance the equation. Brackets are allowable around the monomer as were 90° bond angles.

(d) Alkenes, such as ethene, can be used to make polymers.

(i) Write a balanced equation for the polymerisation of ethene using displayed formulae.

(1)

ResultsPlus
Examiner Comments

An example of the most frequent error. As this would be expected at GCSE, we must insist on the equation being balanced at AS Level.

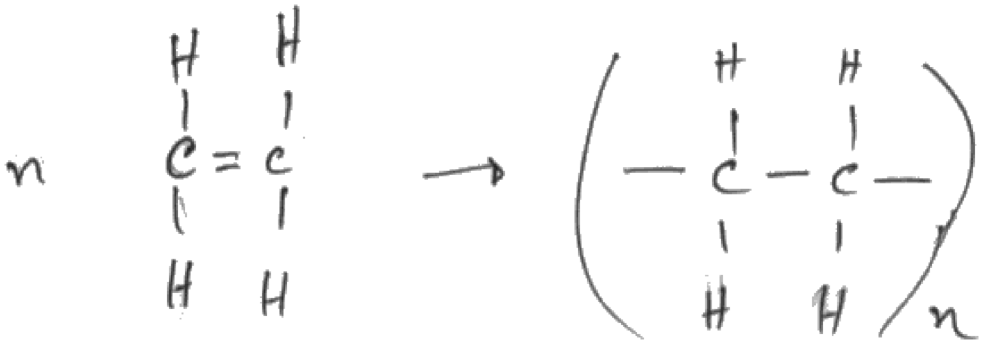
ResultsPlus
Examiner Tip

Ensure that all equations are balanced.

(d) Alkenes, such as ethene, can be used to make polymers.

(i) Write a balanced equation for the polymerisation of ethene using displayed formulae.

(1)



ResultsPlus
Examiner Comments

This response did not gain credit as the extension bonds do not reach outside of the brackets.

ResultsPlus
Examiner Tip

Remember that knowledge from GCSEs is expected at AS.

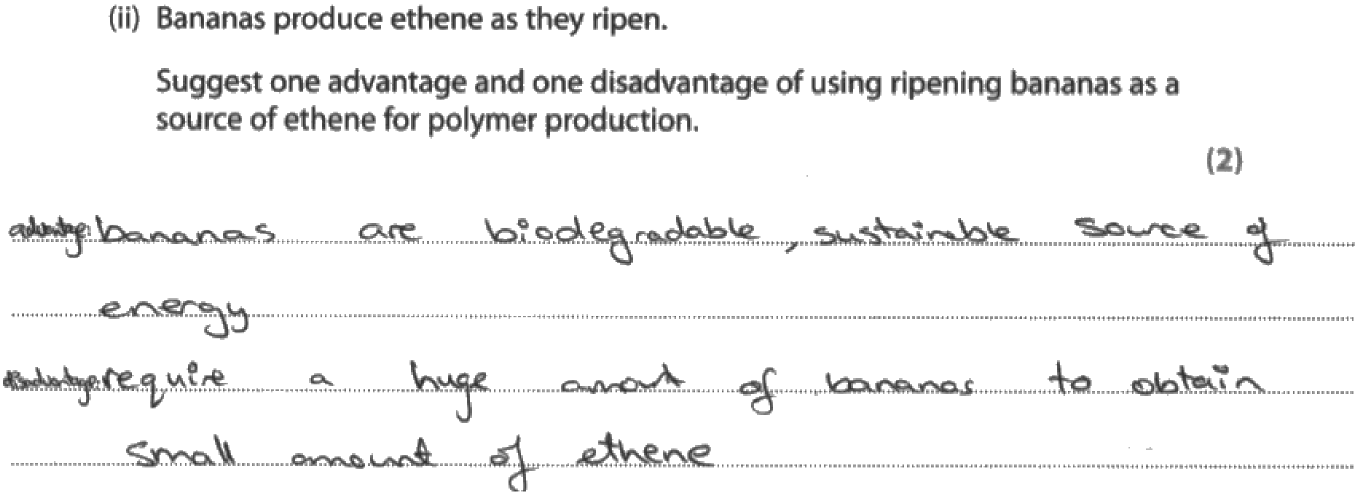
Question 22 (d) (ii)

Candidates found this question challenging. "Suggest" as the command word implies that more than one answer is possible and the mark scheme included many examples while sensible suggestions would also be credited.

Candidates were expected to contrast bananas as a source of ethene to the cracking of crude oil in their answers, even if they did not specifically state this.

A wide variety of examples were seen but many were ignored as irrelevant as they were not answering the question in reference to the production of ethene for polymer manufacturing.

More candidates gained credit for a disadvantage rather than an advantage. "Sustainable" alone was not suitable advantage as the process is unlikely to be economically sustainable even if it were environmentally sustainable.



(ii) Bananas produce ethene as they ripen.

Suggest one advantage and one disadvantage of using ripening bananas as a source of ethene for polymer production.

(2)

advantage: bananas are biodegradable, sustainable source of energy

disadvantage: require a huge amont of bananas to obtain small amount of ethene

ResultsPlus
Examiner Comments

In this response, the candidate achieves one mark for their disadvantage. The advantage does not gain credit. Biodegradable is an ignored response, as is sustainable. This question also wasn't about energy.

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Examiner Tip

It is good practice to label your answer lines when you are asked for two parts to an answer.

Using ripening bananas to produce ethene may be considered carbon neutral so contribution to global warming is low. However ~~since it~~ as a source for polymer production large amounts of ethene is required, which may be difficult and time taking as amount of ethene given out is likely to be very low, so low yield will make using this method inefficient.

ResultsPlus
Examiner Comments

This candidate also scores 1 for the response. The banana skins are not being used as a fuel, so cannot be described as carbon-neutral in this context.

ResultsPlus
Examiner Tip

Underline key words in the question to help you structure your answer.

advantage

Renewable source

Disadvantage

The amount of ethene produced would be less and impure.

ResultsPlus
Examiner Comments

Here the candidate scores 1. They gain credit for two with one advantage and one disadvantage, but lose a mark for suggesting the ethene would be impure (the gases produced from cracking would also need to be purified).

ResultsPlus
Examiner Tip

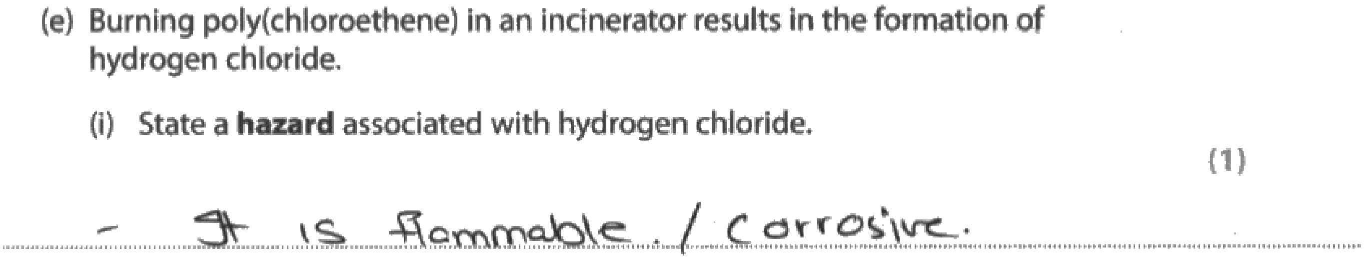
Underlining is a great way to emphasise your answers.

Question 22 (e) (i)

The word 'hazard' was emboldened here to emphasise that a word associated with a hazard symbol would be required.

Toxic and corrosive were both accepted answers and poisonous and irritant were allowed.

A frequent incorrect answer was flammable which is interesting as the gases in the situation were coming out of an incinerator.



(e) Burning poly(chloroethene) in an incinerator results in the formation of hydrogen chloride.

(i) State a **hazard** associated with hydrogen chloride.

(1)

- It is flammable. / Corrosive.

ResultsPlus
Examiner Comments

The candidate here would gain the mark for corrosive but has unfortunately also written flammable, which negates the mark.

ResultsPlus
Examiner Tip

Read the stem of the question carefully, so you can apply the context to your answer.

Revise hazard symbols for reagents used in experiments, so you can use this information in less familiar circumstances.

(i) State a **hazard** associated with hydrogen chloride.

(1)

A hazard is that hydrogen chloride is it is highly acidic and can burn flesh if in contact

ResultsPlus
Examiner Comments

Here the candidate correctly describes the hazard, but hasn't used the terminology necessary to get the mark.

ResultsPlus
Examiner Tip

Revise the words associated with hazard symbols.

(e) Burning poly(chloroethene) in an incinerator results in the formation of hydrogen chloride.

(i) State a **hazard** associated with hydrogen chloride.

(1)

toxic and poisonous

ResultsPlus
Examiner Comments

The candidate has included two words in their response here, but only poisonous is accepted. This answer scores 1.

ResultsPlus
Examiner Tip

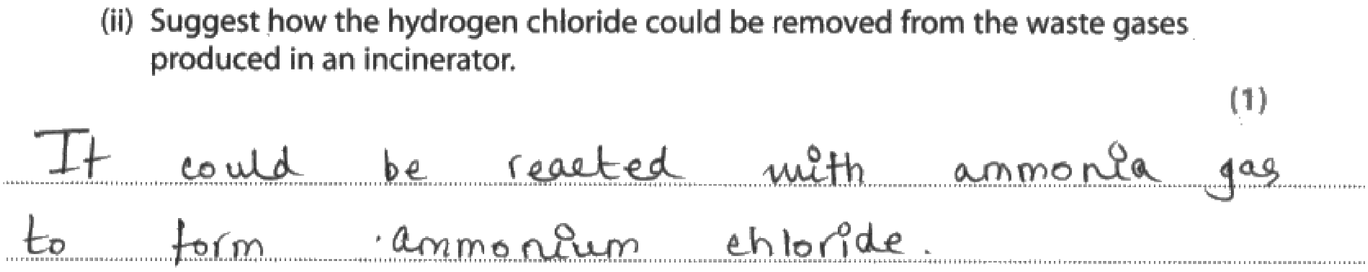
Underlining key words in the question may help you focus your answer.

Question 22 (e) (ii)

A wide variety of answers were seen here. The word "scrubbers" alone was insufficient for the mark.

Frequent incorrect answers were the fractional distillation of the gases, or using a catalytic converter or a fume cupboard.

Fewer than 40% of candidates achieved this mark.



(ii) Suggest how the hydrogen chloride could be removed from the waste gases produced in an incinerator.

(1)

It could be reacted with ammonia gas to form ammonium chloride.

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Examiner Comments

This response scores 1 as a basic compound is named and the candidate states the product of the reaction.

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Examiner Tip

Be prepared to apply knowledge from the specification in less familiar contexts.

Addition of a weak base ($NaHCO_3$) to ~~dilute~~ neutralise the hydrogen chloride (acid).

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Examiner Comments

The candidate here shows knowledge of the need to neutralise the hydrogen chloride. The response would have scored 1 mark even without the addition of a named compound, though the candidate emphasises their understanding using the brackets.

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Examiner Tip

Using brackets is a good way to show your reasoning for an answer.

React with water to form hydrochloric acid.

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Examiner Comments

This response also scores 1 as the hydrogen chloride is soluble. Some candidates went on to describe what the hydrochloric acid could be used for or how it was removed which was unnecessary, but did not negate the mark.

ResultsPlus
Examiner Tip

Use logic to suggest suitable answers in unfamiliar contexts.

Question 23 (a)

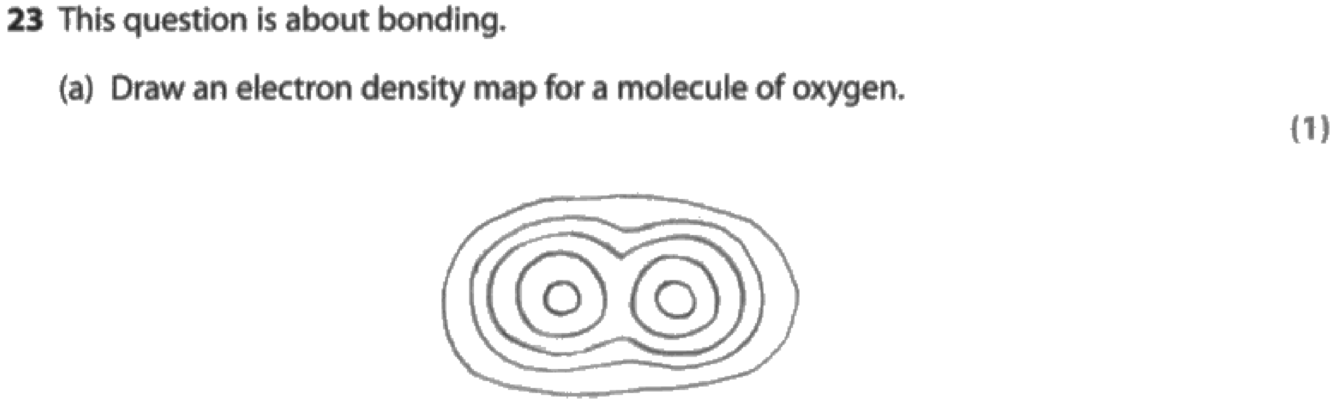
A wide variety of diagrams were seen here but only 53% of candidates achieved this mark.

Occasional dot and cross diagrams were seen, but frequently the correct diagram had been attempted but not executed correctly, such as omitting an indented contour around both atoms.

A few examples are seen below.

Marking was generous with respect to the (non)symmetrical nature of the molecules during an exam.

Some candidates chose to label their diagram "supposed to be symmetrical" which is an example of good practice when they are not satisfied with their attempt, but were conscious of time constraints.



23 This question is about bonding.

(a) Draw an electron density map for a molecule of oxygen.

(1)

ResultsPlus
Examiner Comments

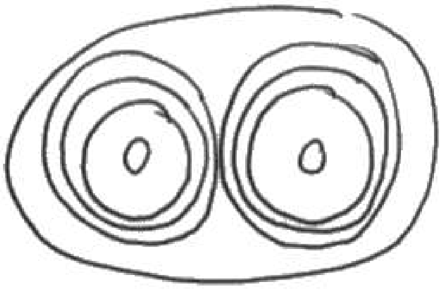
This is a good example of a response that gains the mark.

ResultsPlus
Examiner Tip

Do not feel the need to overcomplicate your diagrams - they should be as clear as possible.

(a) Draw an electron density map for a molecule of oxygen.

(1)



ResultsPlus
Examiner Comments

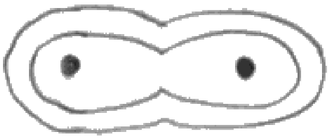
This candidate does not get the mark as there is no contour line with an indentation around both the atoms.

ResultsPlus
Examiner Tip

Practise drawing electron density maps for simple symmetrical and non-symmetrical molecules.

(a) Draw an electron density map for a molecule of oxygen.

(1)



ResultsPlus
Examiner Comments

This diagram did not gain the mark as the two black circles seem to be nuclei rather than areas of electron density.

ResultsPlus
Examiner Tip

Electron density maps should show individual contours around each atom.

(a) Draw an electron density map for a molecule of oxygen.

(1)

ResultsPlus
Examiner Comments

This is the bare minimum that was accepted for the mark. It shows a clear understanding and has made a good attempt at producing a symmetrical diagram.

ResultsPlus
Examiner Tip

Feel free to label your diagram if you doubt your drawing skills.

Question 23 (b)

Candidates were not expected to name the shape of the water molecule, but many added this information anyway.

Dot and cross diagrams were accepted if they showed the correct arrangement of the atoms.

3D representations were accepted, along with molecules with lone pairs or (partial) charges, even if these were incorrect, as they were not what the question was testing.

Double bonds between the hydrogen and oxygen atoms were not awarded.

The bond angle mark was independent and marked either on the diagram or from the answer line. If two different numbers were provided, the mark was negated.

(b) Draw a diagram to show the shape of a water molecule.
Give the bond angle.

(2)

Bond angle ....

ResultsPlus
Examiner Comments

This response scores the mark for the shape of the molecule, but not the mark for the bond angle.

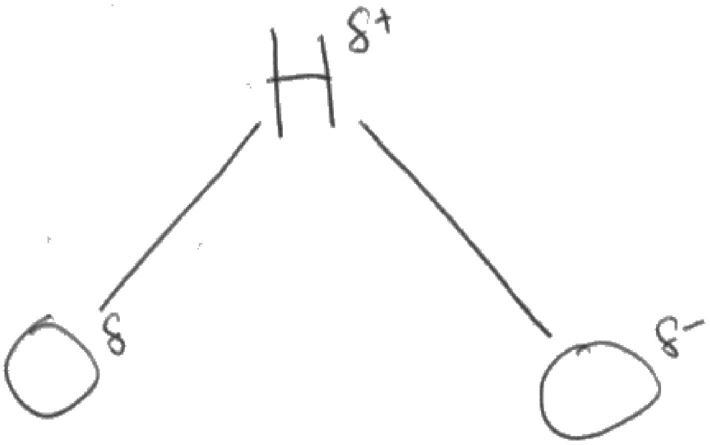
The angle stated is incorrect, but is also labelled in the wrong location which would have negated the mark if the correct numerical value had been used.

ResultsPlus
Examiner Tip

Use the answer lines where available.

(b) Draw a diagram to show the shape of a water molecule.
Give the bond angle.

(2)



Bond angle 105°

ResultsPlus
Examiner Comments

Some less able candidates drew molecules other than water, which could not gain the mark for the shape.

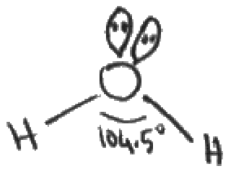
The bond angle mark was independent so this response scores 1.

ResultsPlus
Examiner Tip

Write down the formula of the molecule you are drawing if it is not stated in the question.

(b) Draw a diagram to show the shape of a water molecule.
Give the bond angle.

(2)



Bond angle ....

ResultsPlus
Examiner Comments

This response scored two marks: for the correct shape (lone pairs are ignored but correct) and the bond angle that has been labelled on the diagram.

ResultsPlus
Examiner Tip

Learn the shapes of the molecules on the specification and practise drawing them, including their bond angles.

Question 23 (c)

Two bonding patterns were acceptable answers here. The lack of lone pairs was only penalised once and this was the most common reason for less than full marks being awarded for the bonding diagram.

Explanations of electron pair repulsion theory were mixed, with candidates most often neglecting the four areas of electron density (allowed as phosphorous bonds or bonding pairs).

Some confusion was seen about the relationship between separation and repulsion.

The most frequent incorrect answer for the shape was pyramidal. This was regularly seen with dot and cross diagrams showing dative covalent bonding as candidates did not take the oxygen into account when describing the shape of the molecule - or trigonal bipyramidal, when candidates thought there were five areas of electron density.

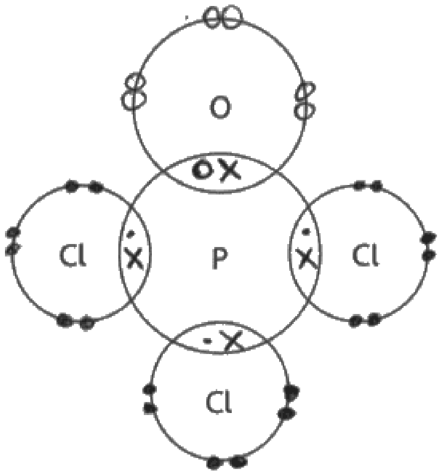
Some candidates included unnecessary information about the differing repulsion between bonding pairs and lone pairs.

(c) The compound $POCl_3$ has a simple molecular structure.

(i) Complete the dot-and-cross diagram for the $POCl_3$ molecule.

Use crosses (x) for the phosphorus electrons, dots (•) for the chlorine electrons and circles (o) for the oxygen electrons.

(2)



(ii) Explain the shape of this molecule using the electron-pair repulsion theory.

(3)

This ~~molecules~~ molecule has a tetrahedral shape with bond angle 109.5°. This is because the molecule has 4 bonding pairs. The bonding pairs repel each other to points of maximum distance in order to minimize repulsion and make the molecule more stable.

ResultsPlus
Examiner Comments

Here the candidate scores 1 mark for the bonding diagram, for the correct phosphorous-chlorine bonds. A dative bond from the phosphorous to the oxygen is acceptable, as are any representation of the electrons throughout the diagram, but the electrons within the dative bond must appear to be the same, as they come from the same atom.

ResultsPlus
Examiner Tip

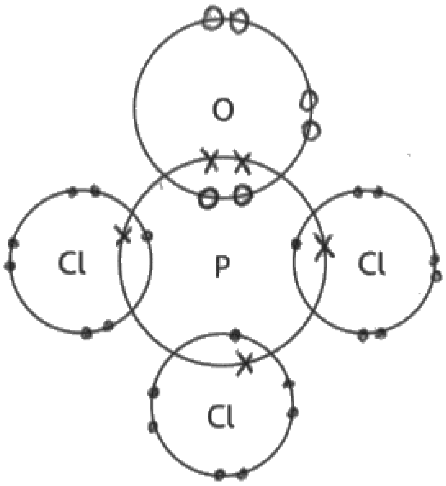
Count the number of electrons for each element to check your dot and cross diagrams

(c) The compound $POCl_3$ has a simple molecular structure.

(i) Complete the dot-and-cross diagram for the $POCl_3$ molecule.

Use crosses (×) for the phosphorus electrons, dots (•) for the chlorine electrons and circles (o) for the oxygen electrons.

(2)



(ii) Explain the shape of this molecule using the electron-pair repulsion theory.

(3)

Phosphorus has ~~5 bond~~ 4 bond Pairs 3 with Cl atoms and 2 with O but it is considered as one. So to minimize repulsion between ~~atoms~~ electron pairs they are arranged in a tetrahedral shape with a bond angle of 109.5°.

ResultsPlus
Examiner Comments

This response scores 2 for the bonding diagram and three for the explanation. The description as the double bond to the oxygen behaving as one bonding pair illustrates the candidate's understanding.

The explanation does not need to be long to gain credit.

ResultsPlus
Examiner Tip

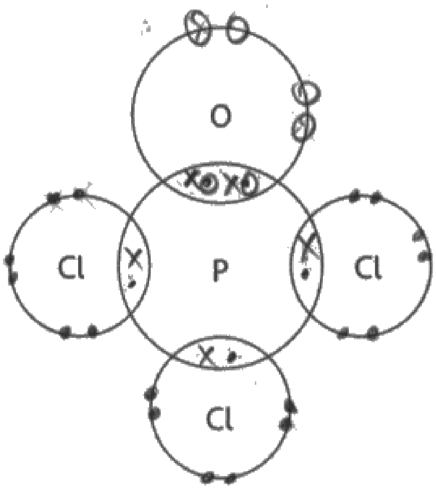
Clearly explain your reasoning in your answers.

(i) Complete the dot-and-cross diagram for the $POCl_3$ molecule.

Use crosses (×) for the phosphorus electrons, dots (•) for the chlorine electrons and circles (o) for the oxygen electrons.

(2)

2,8,5



(ii) Explain the shape of this molecule using the electron-pair repulsion theory.

(3)

There are 4 regions of electron density in this molecule and 5 pairs of bonded electrons. It is a tetrahedral shaped molecule. The electron pairs are arranged in such a way that separation is minimum and repulsion is maximum.

ResultsPlus

Examiner Comments

This response to Q23(c)(ii) begins well and scores marks for the 4 regions of electron density and the tetrahedral molecule. The candidate then becomes confused between the relationship of maximum separation and minimum repulsion, so is not awarded the third mark.

ResultsPlus

Examiner Tip

Re-read your answers to check them.

Question 23 (d) (i)

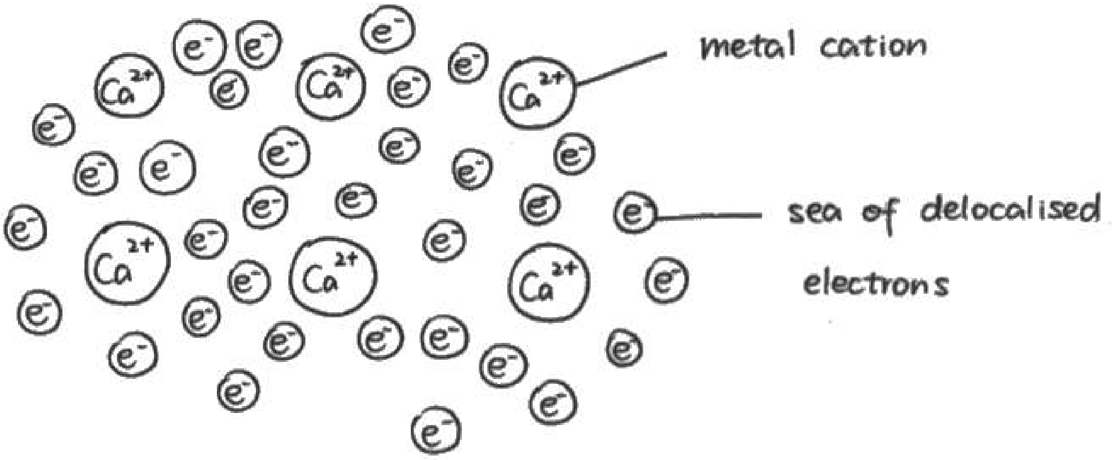
A plethora of different structures were seen here. The first mark was for the regular arrangement of cations. Most candidates achieved the first mark, only losing it when they forgot to put a charge on their calcium ions. This could be as a label to the diagram or written within the ions.

The second mark was for a number of irregularly arranged electrons to balance the positive charge. Examiners did not count electrons - they did not need to be exactly equal - but approximately twice the number of electrons was needed for calcium ions with a 2+ charge. The second mark was also lost when candidates drew structures that looked ionic, failing to label their electrons and just drawing them as regularly arranged particles with a negative charge.

(d) The properties of metals depend on their structure and bonding.

(i) Draw a labelled diagram to show the metallic bonding in calcium.

(2)



ResultsPlus
Examiner Comments

The candidate here scores 1 for the regular arrangement of calcium cations. There are far too many electrons to balance the charges of the positive ions, so the second mark is not awarded.

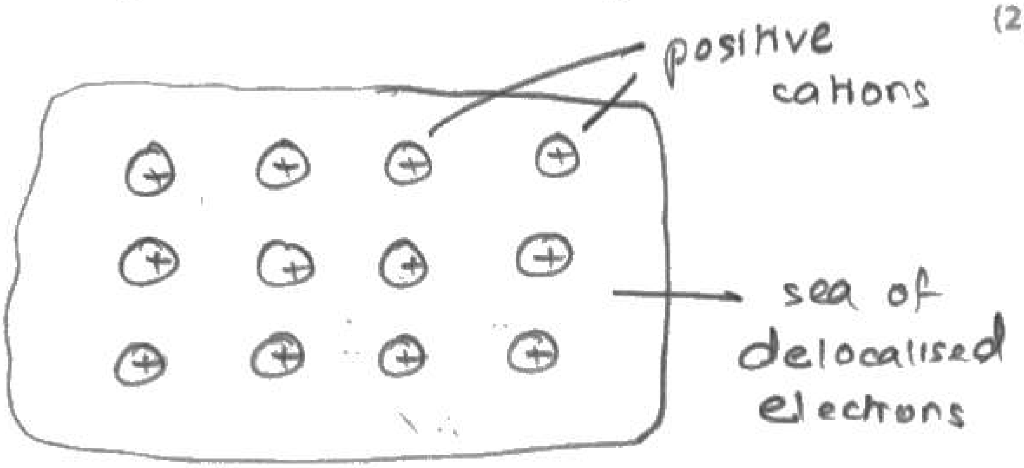
ResultsPlus
Examiner Tip

Be precise in your drawing of diagrams and check that charges are balanced.

(d) The properties of metals depend on their structure and bonding.

(i) Draw a labelled diagram to show the metallic bonding in calcium.

(2)



ResultsPlus
Examiner Comments

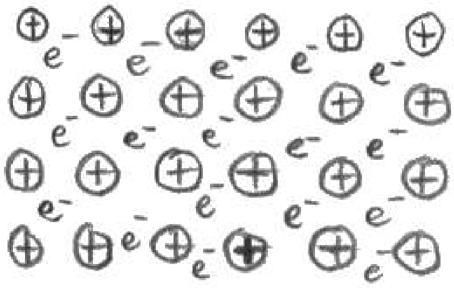
This response scores 1 for the arrangement of calcium cations. Singly charged positive ions are acceptable as the delocalised electrons may be near any cation at any time. The electrons are expected to be shown, even if only as dots.

ResultsPlus
Examiner Tip

Show all electrons on diagrams.

(i) Draw a labelled diagram to show the metallic bonding in calcium.

(2)



ResultsPlus
Examiner Comments

This response scores 2 marks as the cations show a regular arrangement and the charges of the electrons approximately balance the positive ions. The electrons show a slight irregular arrangement; this is important as if structures appeared to be regular and ionic, they lost the second mark.

ResultsPlus
Examiner Tip

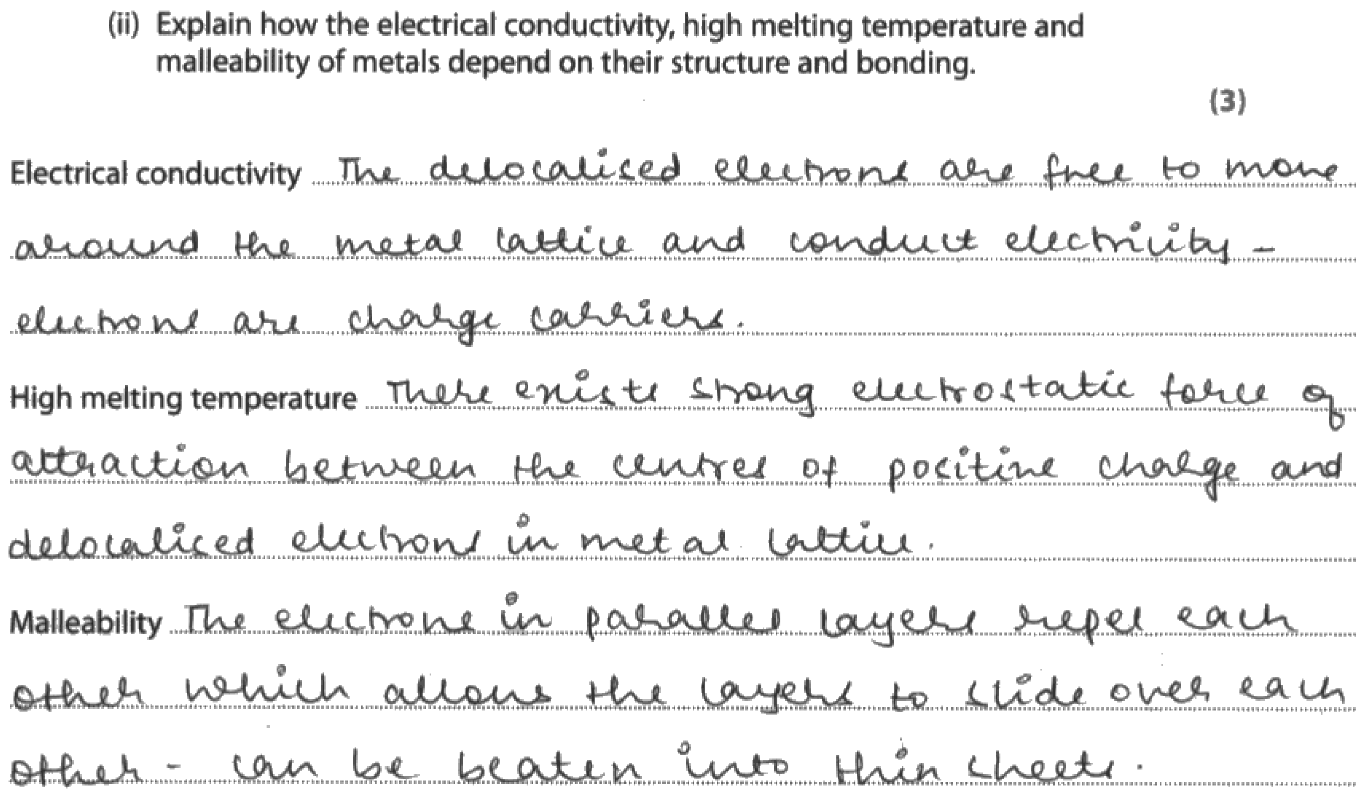
Remember that delocalised electrons will not show too regular a pattern.

Question 23 (d) (ii)

The average mark here was 2 of the three.

Most candidates explained the strong electrostatic forces between the cations and electrons well. Explanations of malleability was often credited as ions were not necessary for this answer, having been tested in Q23(d)(i).

The mark most frequently lost was due to the candidates' explanations of the movement of electrons to carry charge. They often just wrote that "electrons are delocalised" and this did not gain credit. References to strong forces between positive and negative ions negated the second mark.



(ii) Explain how the electrical conductivity, high melting temperature and malleability of metals depend on their structure and bonding.

(3)

Electrical conductivity The delocalised electrons are free to move around the metal lattice and conduct electricity – electrons are charge carriers.

High melting temperature There exists strong electrostatic force of attraction between the centres of positive charge and delocalised electrons in metal lattice.

Malleability The electrons in parallel layers repel each other which allows the layers to slide over each other – can be beaten into thin sheets.

ResultsPlus

Examiner Comments

This answer scores 3. There is a clear description of the electrons as the charge carriers, the strong forces in the lattice and the layers sliding (to give malleability).

ResultsPlus
Examiner Tip

Use any structure given in the answer lines to help phrase your answer.

(ii) Explain how the electrical conductivity, high melting temperature and malleability of metals depend on their structure and bonding.

(3)

Electrical conductivity Metals conduct electricity ~~dot~~ due to the sea of delocolise electrons.

High melting temperature Metals are bonded with high electrostatic force of attraction between ~~Posi~~ pussative ion and delocolised electron. So the melting temperature is high.

Malleability Delocolised electron can be shifted from its positon by a externel force. So the metal are malleable.

ResultsPlus
Examiner Comments

This response only gains one mark, for the melting temperature. "Delocalised electrons" is insufficient for the conductivity mark. When discussing malleability this response implies it is the electrons that move, rather than the layers of cations.

ResultsPlus
Examiner Tip

Revise the properties of different structures and how the structure confers these properties.

Question 23 (e) (i)

This question proved challenging for candidates with few candidates achieving all four marks.

Frequently candidates referred to melting temperature as a difference in the properties of diamond and graphite, which was not allowed, due to the small difference at very high temperatures (and candidates usually had the melting points the wrong way around).

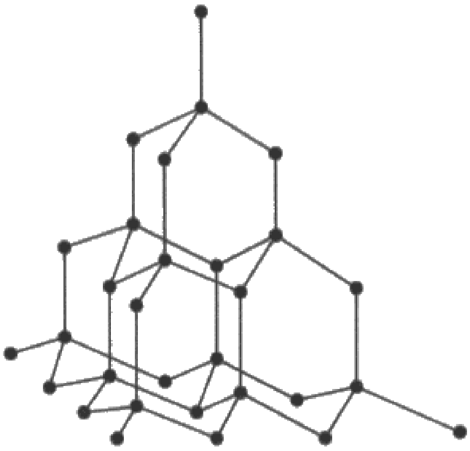
The bonding marks were independent of the comparison marks, so some candidates achieved these without referring to differences in properties at all.

Most commonly a mark was awarded for delocalised electrons in graphite or weak forces between the layers in graphite, rather than referring to the structure of diamond.

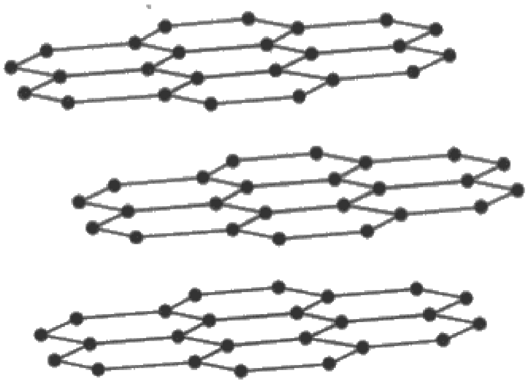
(e) Diamond, graphite and graphene are all forms of carbon.

(i) Explain **two** ways in which the physical properties of diamond and graphite differ. Refer to their structure and bonding in your answer.

(4)



diamond



graphite

Diamond

- It has a giant lattice structure.
- The covalent bonds are very strong
- It has high melting point.

Graphite

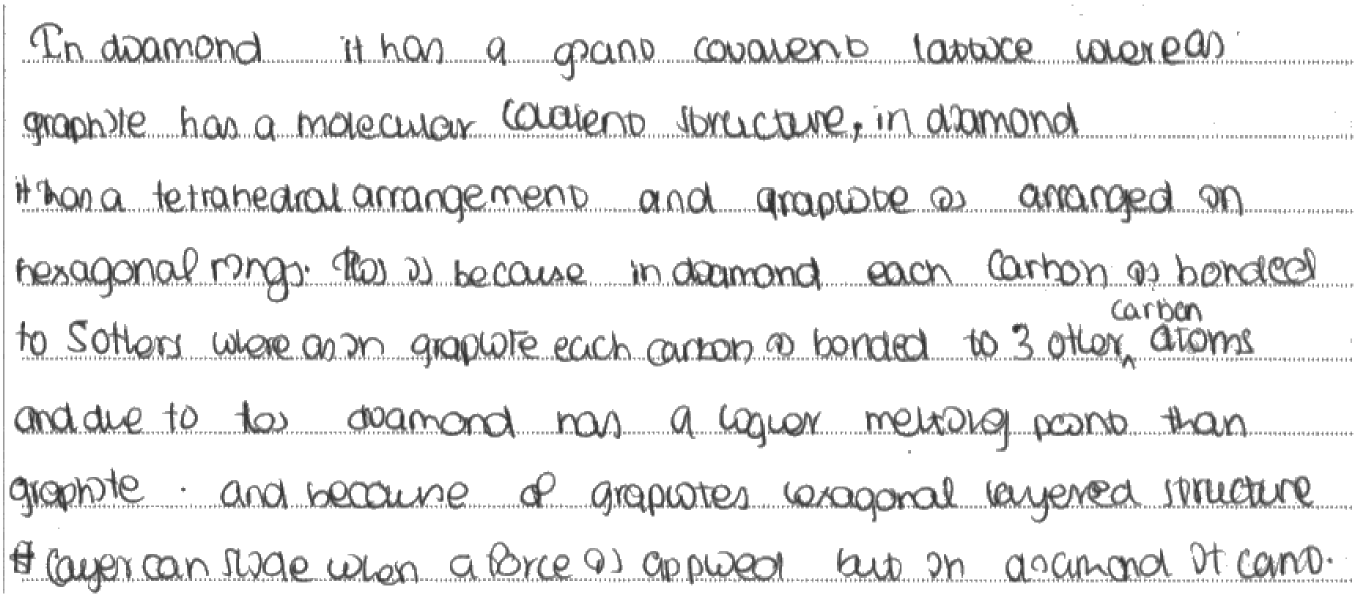
- The structure is layered.
- Weak electrostatic forces of attraction between the layers
- The melting is is not as high as the diamond.

ResultsPlus
Examiner Comments

The candidate here has written separately about diamond and graphite, rather than comparing or contrasting the properties as asked for in the question. The candidate scores 1 for the weak forces between the layers of graphite as these were independent marks, unconnected to the properties.

ResultsPlus
Examiner Tip

If asked for difference then you must compare both structures, rather than write about each individually.



In diamond it has a giant covalent lattice whereas graphite has a molecular covalent structure, in diamond it has a tetrahedral arrangement and graphite is arranged in hexagonal rings. This is because in diamond each carbon is bonded to 5 others whereas in graphite each carbon is bonded to 3 other carbon atoms and due to this diamond has a higher melting point than graphite. and because of graphites hexagonal layered structure layer can slide when a force is applied but in diamond it cant.

ResultsPlus
Examiner Comments

This candidate unfortunately failed to gain any marks for this response. Their answer centres on describing the diagram given rather than comparing the properties and they discuss the bonding within the layers of graphite rather than between. The property of "melting point" was a frequently seen incorrect answer along with describing graphite as molecular, instead of giant.

ResultsPlus
Examiner Tip

Revise the properties of the structures on the specification.

Diamond can not conduct electricity white graphite ~~eas~~ can as all the 4 electrons in ~~diamond~~ carbon form covalent bond with othere carbon while graphite has 1 free electron that can ~~eary~~ carry electricity throughout the ~~whoe~~ whole structure. Diamond has high melting temperature than graphite as ~~#~~ it has strong covalent bond where as graphite has London forces between the layers that are weak so less energy is required to break the bond.

ResultsPlus
Examiner Comments

This is an example of a candidate scoring three marks, for one correct comparison of properties and two correct descriptions of bonding within the structures. The mark for weak forces between the layers is allowed even though the correct difference in properties has not been identified.

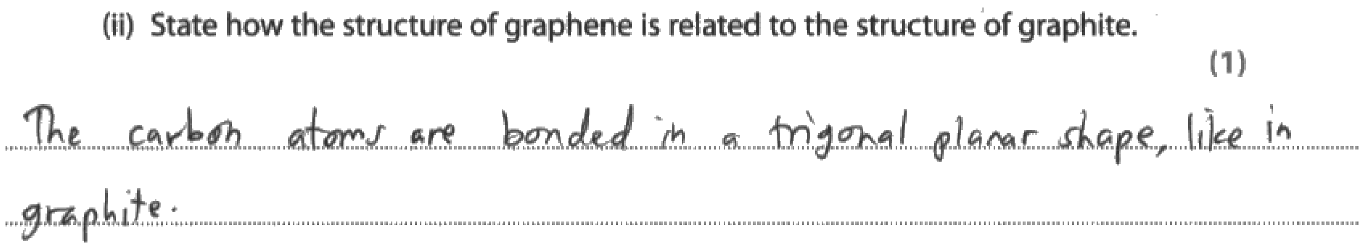
Diamond cannot conduct electricity but graphite can. In diamond ~~four ca~~ one carbon atom is bonded to other four carbon atoms and so there are no free electrons. But in graphite, one carbon atom bonds with three other carbon atoms and as a result there is one eletron in each carbon atom which is free to conduct electricity. Diamond is hard because of the strong carbon-carbon covalent bonds ~~throught~~ throughout the structure. But graphite is soft with slimmy feel because it has layered structure and forces of attractions between the layes are weak.

ResultsPlus
Examiner Comments

This is an example of an excellent response. The candidate clearly identifies two differences and describes the reason for each in terms of bonding. This response states the reason for each difference in terms of the bonding within both graphite and diamond, which is more than was required for full marks to be awarded.

Question 23 (e) (ii)

Candidates found this question difficult. Many discussed the bonding in graphite and graphene rather than relating the structures to each other. Fewer than 30% of candidates achieved a mark here.



(ii) State how the structure of graphene is related to the structure of graphite.

(1)

The carbon atoms are bonded in a trigonal planar shape, like in graphite.

ResultsPlus
Examiner Comments

This answer does not relate the two structures to each other, just giving a similarity. No mark was awarded here.

ResultsPlus
Examiner Tip

Read questions carefully.

It is a single, one atom thick, layer of graphite.

ResultsPlus
Examiner Comments

This was the expected response and scores 1 mark. "It" is taken as referring to graphene.

ResultsPlus
Examiner Tip

'State' as a command word implies that the answer will be short.

Graphite is made of multiple layers of bonded carbon atoms and one layer on its own is called graphene.

ResultsPlus
Examiner Comments

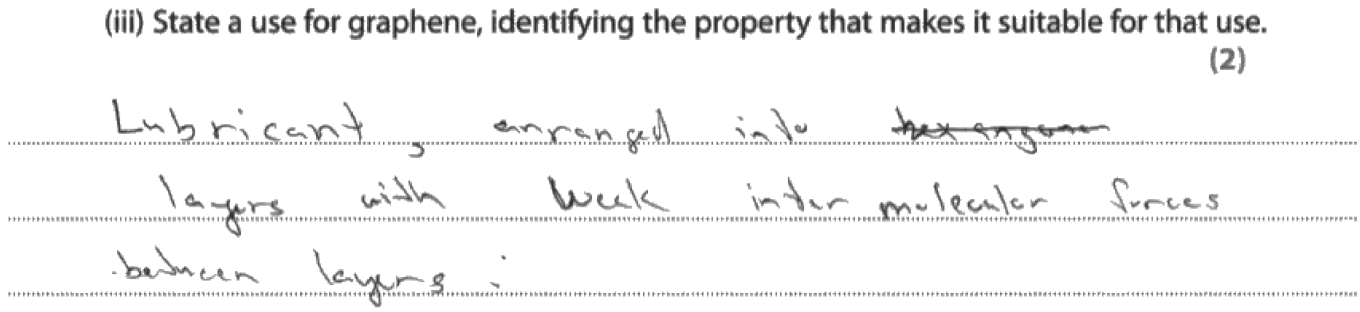
This response scores 1 and is a good example of how the two structures can be related but not compared.

Question 23 (e) (iii)

This question was poorly answered. Over half of candidates did not gain any credit here.

The uses and potential uses of graphene are numerous and examiners were encouraged to research any specific uses that candidates came up with as well as using the list provided.

Frequent errors included the implication that graphene was used alone for a certain function, rather than being added to other materials to change their properties, e.g. cutting tools or car bodies, or confusion with the uses (and properties) of graphite.



(iii) State a use for graphene, identifying the property that makes it suitable for that use.
(2)

Lubricant, arranged into ~~hexagon~~
layers with weak inter molecular forces
between layers ;

ResultsPlus
Examiner Comments

This was a frequent response that gained no marks. Lubricants can contain graphene, but the reference to weak forces between the layers shows a confusion with graphite. For this reason, "lubricant" alone was not awarded as a use for graphene.

ResultsPlus
Examiner Tip

The uses of graphene and its properties would make an excellent research homework.

Graphene is used in road making as it has a high thermal stability.

ResultsPlus
Examiner Comments

This is an example of a use of graphene and a property of graphene that are not clearly linked, but can both gain credit. This response scored two marks.

ResultsPlus
Examiner Tip

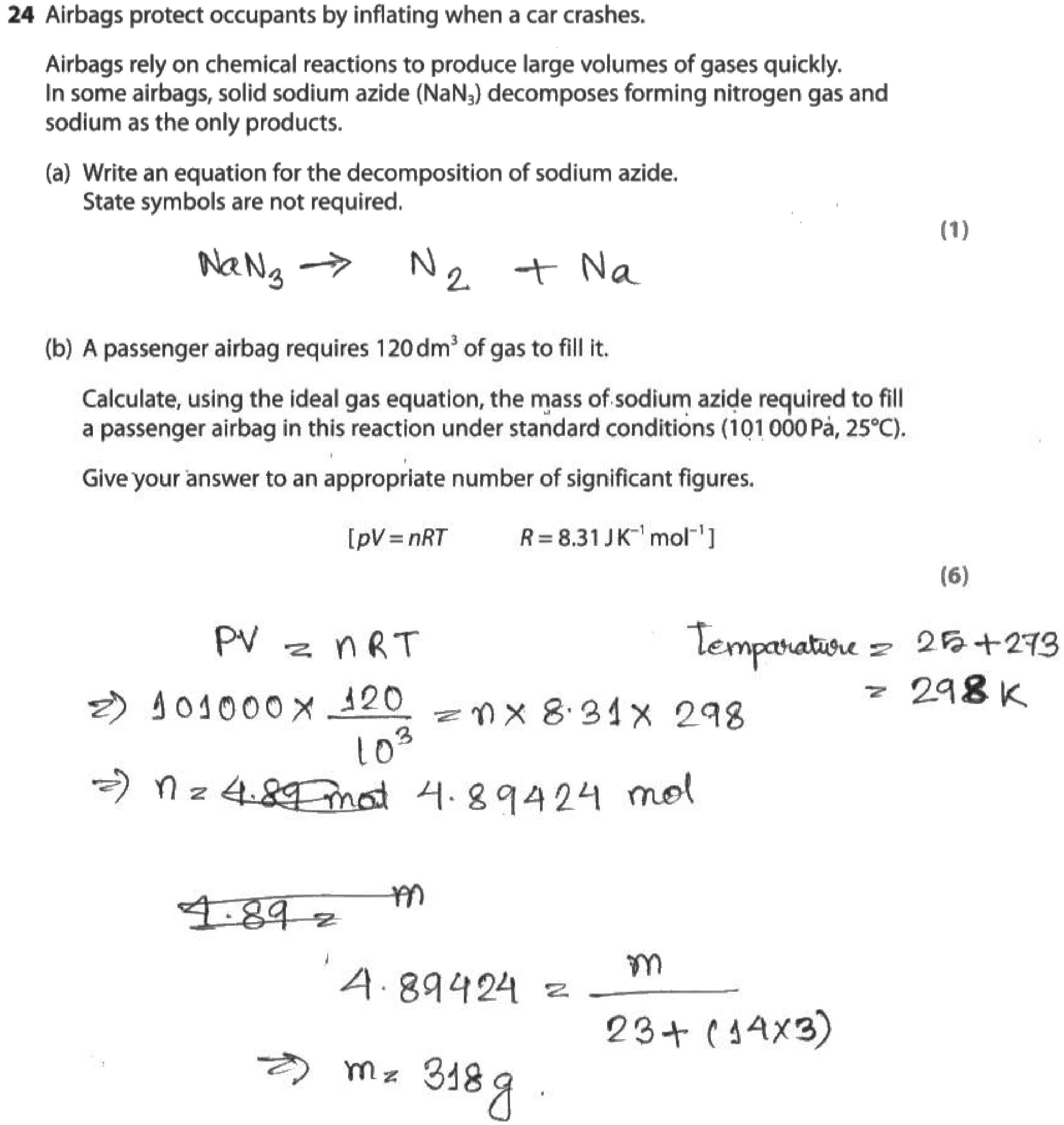
Learn a potential use of graphene and the property that makes it suitable for that purpose.

Question 24 (a) (b)

Candidates answered part Q24(a) well, with only occasional responses forgetting that nitrogen exists as a molecule or writing sodium as a molecule.

Q24(b) allowed transfer errors throughout, so candidates regularly scored 3 or 4 marks even whilst making errors.

The most common slips were forgetting the ratio from the equation or to use 2 or 3 significant figures for their final answer. Some candidates made errors in their conversion of volume - or incorrectly converted the pressure - but carried these errors through to their final answer and gained credit for the later steps. In general, candidates were adept at manipulating the universal gas equation and substituting in their values.



24 Airbags protect occupants by inflating when a car crashes.

Airbags rely on chemical reactions to produce large volumes of gases quickly. In some airbags, solid sodium azide (NaN_3) decomposes forming nitrogen gas and sodium as the only products.

(a) Write an equation for the decomposition of sodium azide. State symbols are not required.

(1)

$NaN_3 \rightarrow N_2 + Na$

(b) A passenger airbag requires 120 dm^3 of gas to fill it.

Calculate, using the ideal gas equation, the mass of sodium azide required to fill a passenger airbag in this reaction under standard conditions (101 000 Pa, 25°C).

Give your answer to an appropriate number of significant figures.

[$pV = nRT$ $R = 8.31\ J\ K^{-1}\ mol^{-1}$]

(6)

$PV = nRT$

Temparature = 25 + 273
= 298 K

$\Rightarrow 101000 \times \frac{120}{10^3} = n \times 8.31 \times 298$

$\Rightarrow$ n = ~~4.89 mol~~ 4.89424 mol

~~4.89 =~~ m

$4.89424 = \frac{m}{23 + (14 \times 3)}$

$\Rightarrow$ m = 318 g.

ResultsPlus
Examiner Comments

This candidate does not gain a mark for part Q24(a) as they have not balanced the equation. If they had made reference to this ratio in Q24(b), they could have gained another TE mark. Their answer to part Q24(b) therefore gains 5 marks as no ratio is used or stated for M5.

ResultsPlus
Examiner Tip

Don't forget to use ratios from equations in your calculations.

(a) Write an equation for the decomposition of sodium azide.
State symbols are not required.

(1)

$2NaN_3 \longrightarrow 3N_{2(g)} + 2Na_{(s)}$

(b) A passenger airbag requires 120 dm³ of gas to fill it.

Calculate, using the ideal gas equation, the mass of sodium azide required to fill a passenger airbag in this reaction under standard conditions (101 000 Pa, 25°C).

Give your answer to an appropriate number of significant figures.

$[pV = nRT \qquad R = 8.31\,J\,K^{-1}\,mol^{-1}]$

(6)

$V = 120\ dm^3 \rightarrow 0.12\ m^3$

$P = 101\ 000\ Pa$

$t = 25°C \rightarrow 298K$

① $PV = nRT$

$n = \frac{PV}{RT}$

$n = \frac{101\ 000 \times 0.12}{8.31 \times 298}$

$n = 4.89424\ mol$

② $n = \frac{m}{mr}$

$4.89424 = \frac{m}{65}$

$\boxed{m = 318g}$

ResultsPlus
Examiner Comments

This candidate gains 1 for Q24(a) and 5 marks for Q24(b), as the ratio has not been used to gain the final answer. A clear presentation of the conversion of units is shown here and the final answer is circled to bring it to the attention of the examiner. The candidate has included the correct units, though these were not required for the final mark to be credited.

ResultsPlus
Examiner Tip

Present your workings clearly.

Underlining or circling final answers to multi-step calculations is an example of good practice.

(a) Write an equation for the decomposition of sodium azide.
State symbols are not required.

(1)

$$2\,NaN_3 \longrightarrow 3N_2 + 2Na$$

(b) A passenger airbag requires 120 dm^3 of gas to fill it.

Calculate, using the ideal gas equation, the mass of sodium azide required to fill a passenger airbag in this reaction under standard conditions (101 000 Pa, 25°C).

Give your answer to an appropriate number of significant figures.

$$[pV = nRT \qquad R = 8.31\,J\,K^{-1}\,mol^{-1}]$$

(6)

$V = 120 \times 10^{-3}$ m^3

$T = 25 + 273 = 298$ K

$nRT = pV$

$\Rightarrow n = \frac{pV}{RT}$

$= \frac{101\,000 \times 120 \times 10^{-3}}{8.31 \times 298}$

$= 4.8942$ mol

∴ Mole no. of NaN_3 $= \frac{2}{3} \times 4.8942$

$= 3.2628$ mol.

∴ Mass of NaN_3 $= 3.2628 \times [23 + 3(14)]$

$= 212.082$

$\simeq 212$ g

ResultsPlus
Examiner Comments

This response is clearly laid out and gains full credit. The candidate has shown their full workings and their final answer is given to 3 significant figures.

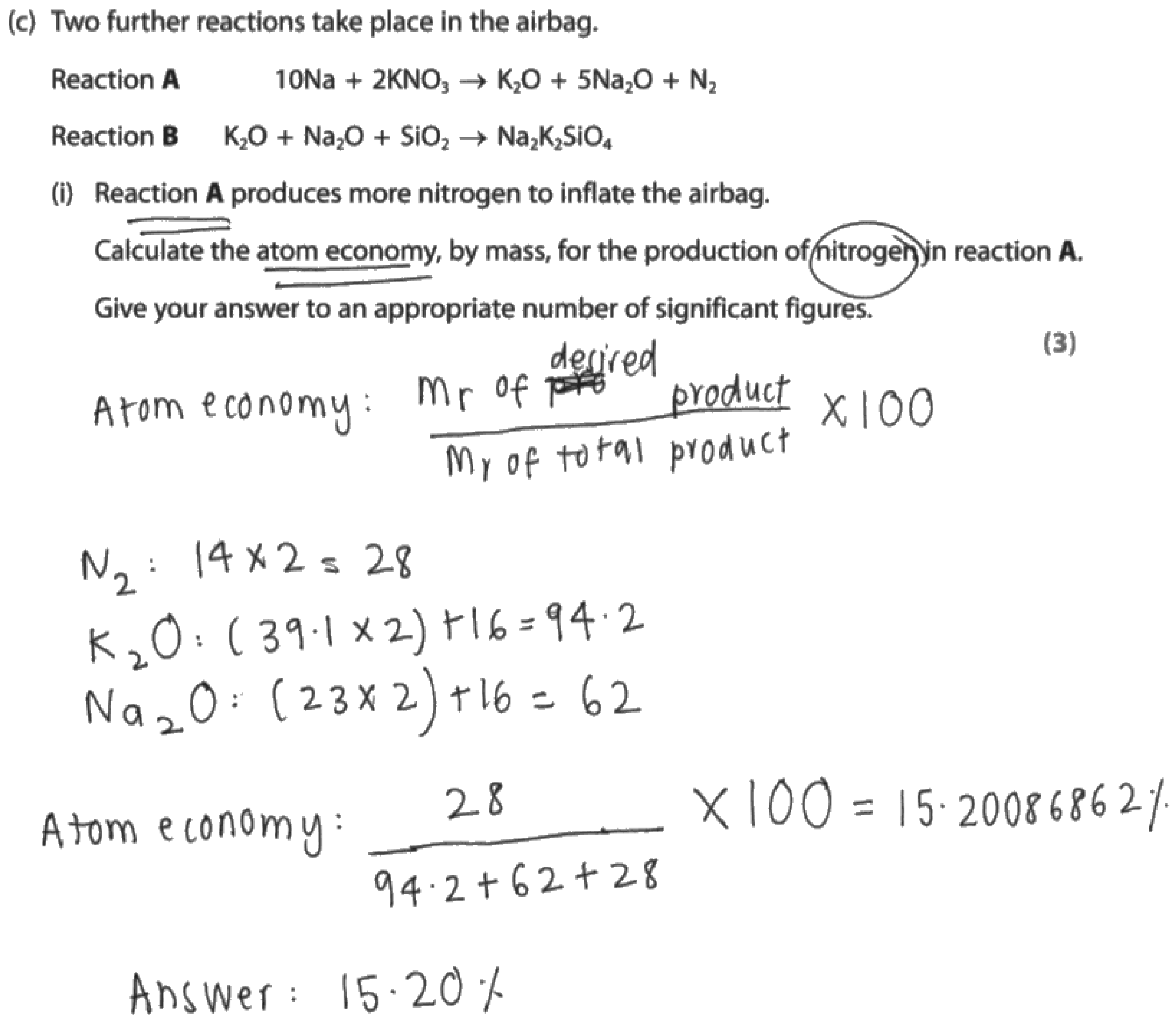
ResultsPlus
Examiner Tip

Practise giving your answers to suitable numbers of significant figures - use numbers from the question to help you.

Question 24 (c) (i)

Candidates could score full marks for a correct answer here, but candidates should be encouraged to state the formula for atom economy in case they make a mistake in their workings.

The modal mark here was 3, but candidates frequently lost a mark for a variety of reasons.



(c) Two further reactions take place in the airbag.

Reaction A $10Na + 2KNO_3 \rightarrow K_2O + 5Na_2O + N_2$

Reaction B $K_2O + Na_2O + SiO_2 \rightarrow Na_2K_2SiO_4$

(i) Reaction **A** produces more nitrogen to inflate the airbag.

Calculate the atom economy, by mass, for the production of nitrogen in reaction **A**.

Give your answer to an appropriate number of significant figures.

(3)

Atom economy: $\frac{\text{Mr of } \cancel{\text{pro}} \text{ desired product}}{\text{Mr of total product}} \times 100$

N_2 : $14 \times 2 = 28$

K_2O : $(39.1 \times 2) + 16 = 94.2$

Na_2O : $(23 \times 2) + 16 = 62$

Atom economy: $\frac{28}{94.2 + 62 + 28} \times 100 = 15.20086862\%$

Answer: 15.20%

ResultsPlus
Examiner Comments

This response scores 2 marks. The initial equation is stated correctly and a TE is given on the total molar mass of the products. One mole of sodium oxide has been used instead of the five moles in the equation, but all elements have been used to calculate the total molar mass. If any number other than zero was on the end of the answer, another mark would have been lost for inappropriate significant figures.

ResultsPlus
Examiner Tip

Check that calculations of atom economy match the stoichiometry given in the equation.

432. ✓

(c) Two further reactions take place in the airbag.

Reaction A $10Na + 2KNO_3 \rightarrow K_2O + 5Na_2O + N_2$

Reaction B $K_2O + Na_2O + SiO_2 \rightarrow Na_2K_2SiO_4$

(i) Reaction **A** produces more nitrogen to inflate the airbag.

Calculate the atom economy, by mass, for the production of nitrogen in reaction **A**.

Give your answer to an appropriate number of significant figures.

(3)

$$\text{Atom economy} = \frac{(14 \times 2)}{(14 \times 2) + (2 \times 39.1 + 16) + (10 \times 23 + 5 \times 16)}$$

$$= \frac{28}{432.2}$$

$$= 0.0648 /\!/$$

ResultsPlus
Examiner Comments

This response scores 2. The absence of the 100% was only penalised once so the other marks were available to the candidate for correct chemistry and arithmetic.

ResultsPlus
Examiner Tip

Learn the equation for atom economy and state it at the beginning of your answer

K = 39.1
Na = 23
N = 14

(c) Two further reactions take place in the airbag.

Reaction A $10Na + 2KNO_3 \rightarrow K_2O + 5Na_2O + N_2$

Reaction B $\underset{2-}{K_2O} + \underset{2-}{Na_2O} + \underset{2-}{SiO_2} \rightarrow Na_2K_2SiO_4$

(i) Reaction **A** produces more nitrogen to inflate the airbag.

Calculate the atom economy, by mass, for the production of nitrogen in reaction **A**.

Give your answer to an appropriate number of significant figures.

(3)

Atom economy :

mass of all products = ((39.1×2)+16) + (5((23×2)+16)) + (2×14)

= 94.2 + 310 + 28

= 432.2

mass of N_2 = 14×2 = 28

Atom economy = $\frac{28}{432.2}$ × 100 = 6.478 %

ResultsPlus
Examiner Comments

This candidate has made an excellent start to the calculation but loses the final mark for stating too many significant figures. Two marks were awarded.

ResultsPlus
Examiner Tip

The relative atomic masses used here give a hint about the maximum number of significant figures can be stated.

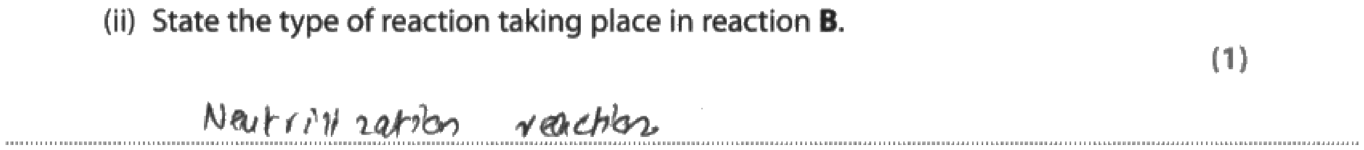
Question 24 (c) (ii)

This was a challenging question for the end of the paper and though the vast majority of candidates gave an answer, indicating that they had not run out of time, few gained credit here.

Candidates were expected to elucidate that basic oxides and acidic oxides were reacting to form a product in a neutralisation reaction, but the most frequent answer seen was addition.

This is applied knowledge from GCSE and patterns in the periodic table, namely that metals form basic oxides and non-metals form acidic oxides.

An example of a correct answer - the spelling is ignored here as the meaning is clear.



(ii) State the type of reaction taking place in reaction **B**.

(1)

Neutrili zation reaction

ResultsPlus
Examiner Comments

Spelling is less important in questions where your clear expression of English is not being tested (these questions are marked with an asterisk *).

Paper Summary

Based on their performance on this paper, candidates are offered the following advice:

- Practise writing the different types of formulae and equations, including state symbols.

- Read the question carefully, underlining or highlighting key words and using this to structure their answers.

- Revise the Core practicals for all exams, along with chemical tests from the specification.

- Learn formulae (such as for atom economy) and definitions for concepts (such as carbon neutrality) to apply to questions.

- Practise recording their answers for calculations to appropriate numbers of significant figures, using values stated in questions as a guide.

Grade Boundaries

Grade boundaries for this, and all other papers, can be found on the website on this link:

http://www.edexcel.com/iwantto/Pages/grade-boundaries.aspx

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