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Examiners' Report
June 2015

GCE Chemistry 6CH01 01

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June 2015

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Introduction

It is evident from the wide range of responses on this paper that it was accessible for the whole ability range, and provided opportunities for knowledge and understanding of key concepts from Unit 1 to be demonstrated. There was little evidence that candidates had insufficient time to complete the paper.

The more successful candidate was able to:

- recall key principles and concepts and apply them to similar situations to those already studied
- understand how practical equipment works and why procedures are carried out, and then to explain or draw these
- apply their knowledge and understanding to real-life situations.
- The less successful candidate was unable to:
- recall straightforward definitions and ideas from GCSE that are still needed for A level
- answer the questions asked rather than give information that was not required.

Question 17 (a)

The vast majority of candidates were able to make the correct statements about protons and neutrons to gain the mark. Those candidates who failed to score either missed the reference to 'sub-atomic particles' in the question and so gave responses in terms of atomic and mass numbers, or only commented on the different number of neutrons without mention of 'the same number of protons'.

In view of the fact that only one mark was available for the answer to this question, those responses that referred to elements or isotopes were allowed but obviously reference should have been made to 'atoms'.

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

17 This question is about the use of mass spectrometers.

(a) Bromine has two isotopes, ^{79}Br and ^{81}Br. Explain the term **isotopes**, by reference to sub-atomic particles.

(1)

Isotopes are atoms of the same element with different number of neutrons but same number of electrons.

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Examiner Comments

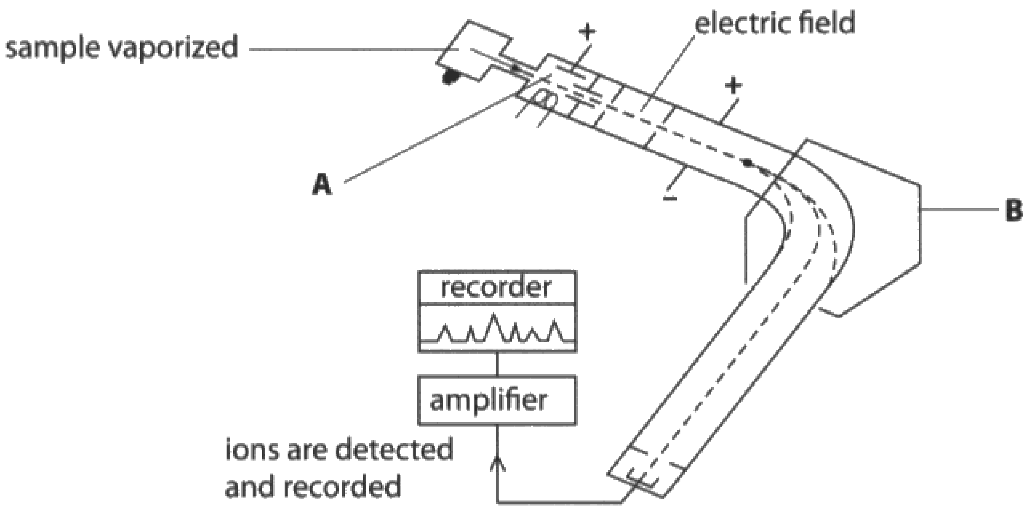
The candidate correctly referred to isotopes having different numbers of neutrons but incorrectly referred to isotopes having the same number of electrons instead of protons. Hence this response did not score.

Question 17 (b) (i)

The ionisation area of the mass spectrometer was generally well known with many high scoring responses. The failure to gain both marks commonly resulted from a lack of depth of the response and may have not been due to lack of understanding. Candidates need to make sure that they are giving fulsome answers if they want to gain all the available marks.

On rare occasions a candidate did negate a valid statement for the second mark for loss of electrons, by the comment that a negative ion or anion was formed. This would be the gain not the loss of an electron, and so clearly counteracts the statement of loss of electrons. However, this was not commonly seen. An alternative way of expressing 'electron loss' is via an equation and this was seen, although infrequently.

(b) The presence and abundance of these isotopes can be determined by using a mass spectrometer such as that shown in the diagram below.



(i) Explain how ions are produced in the area labelled **A**.

(2)

High energy electrons are collided with the gaseous sample via an electron gun.

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Examiner Comments

The use of high energy electrons via an electron 'gun', scored the first mark in this example but there was no mention of the effect of this and so the second mark was not awarded.

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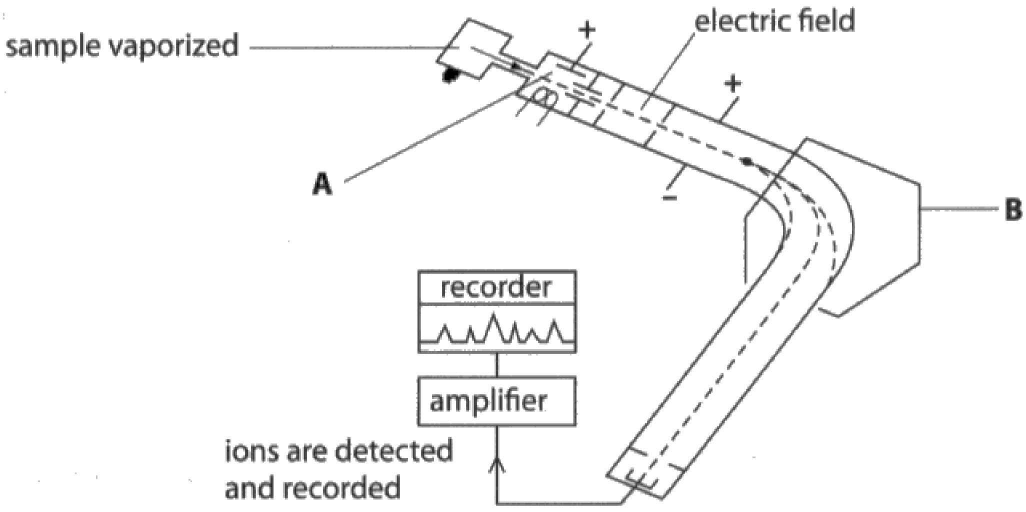
Examiner Tip

The marking point allocation and the space provided for the response to each question are always important considerations when considering a response. In this example only one point is being made and only just over one line out of three possible lines. This suggests that there may not be sufficient space here for all the marks to be awarded and it proved correct.

(b) The presence and abundance of these isotopes can be determined by using a mass spectrometer such as that shown in the diagram below.



(i) Explain how ions are produced in the area labelled **A**.

(2)

high speed electrons hit the gas particles removing one of its electrons to form positive ~~the~~ ions.

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Examiner Comments

There was clear mention of high energy electrons 'hitting' the sample for the first marking point; and then the effect of this in that an electron was lost, meant that both marking points were awarded.

Question 17 (b) (ii)

The workings of the mass spectrometer were very well known, as over 90% of candidates knew that a magnetic field is used to deflect the moving ions.

(ii) State what is used to deflect the ions moving through the mass spectrometer in the area labelled **B**.

(1)

A Magnetic Shield

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Examiner Comments

The use of the word 'shield' completely gives the wrong impression, as it means some sort of barrier rather, than a deflector. Hence, this response was not credited.

(ii) State what is used to deflect the ions moving through the mass spectrometer in the area labelled **B**.

(1)

magnitude field

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Examiner Comments

The term 'magnitude' means size or scope of something and has nothing to do with a magnetic field. Hence, this response did not score.

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Examiner Tip

A general principle is that if the word is misspelt and could mean something other than that intended, then no credit is given.

Question 17 (b) (iii)

Many candidates seemed unaware of the true purpose of the vacuum in the mass spectrometer. A significant number thought that the vacuum was to remove ions or electrons, and it was also common to see reference to the need to prevent reactions occurring. In addition, vague answers that simply referred to 'interference' were insufficient to score.

The particles in the air are removed by the vacuum in order to prevent any hindrance to the path of the ions as they flow through the mass spectrometer to the detector. Only the more able either knew this, or were able to deduce it from their understanding of the workings of the mass spectrometer.

(iii) Explain why there is a vacuum in a mass spectrometer.

(1)

so that there aren't any components of air such as nitrogen or oxygen that would affect the results in the mass spectrometer with the sample.

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Examiner Comments

This response had the beginnings of the correct idea, in that air particles are the issue but simply to 'interfere' was insufficient and did not score.

(iii) Explain why there is a vacuum in a mass spectrometer.

(1)

This is to ensure that the sample moves through the mass spectrometer unhindered, so it doesn't collide with any other atom, e.g. other molecules in the air, and therefore doesn't interfere with the result.

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Examiner Comments

The idea expressed in this response was the correct one, namely that the air particles could hinder the pathway or movement of the ions through the mass spectrometer. However, it failed to refer to ions and only mentioned the sample. Both question parts (i) and (ii) mentioned "ions", and so since this information which provided the reference to just a sample, was insufficient to score.

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Examiner Tip

Make sure that information provided in the question is used when answering.

Question 17 (c)

This question was a very effective discriminator and provided the full spread of marks across the whole ability range.

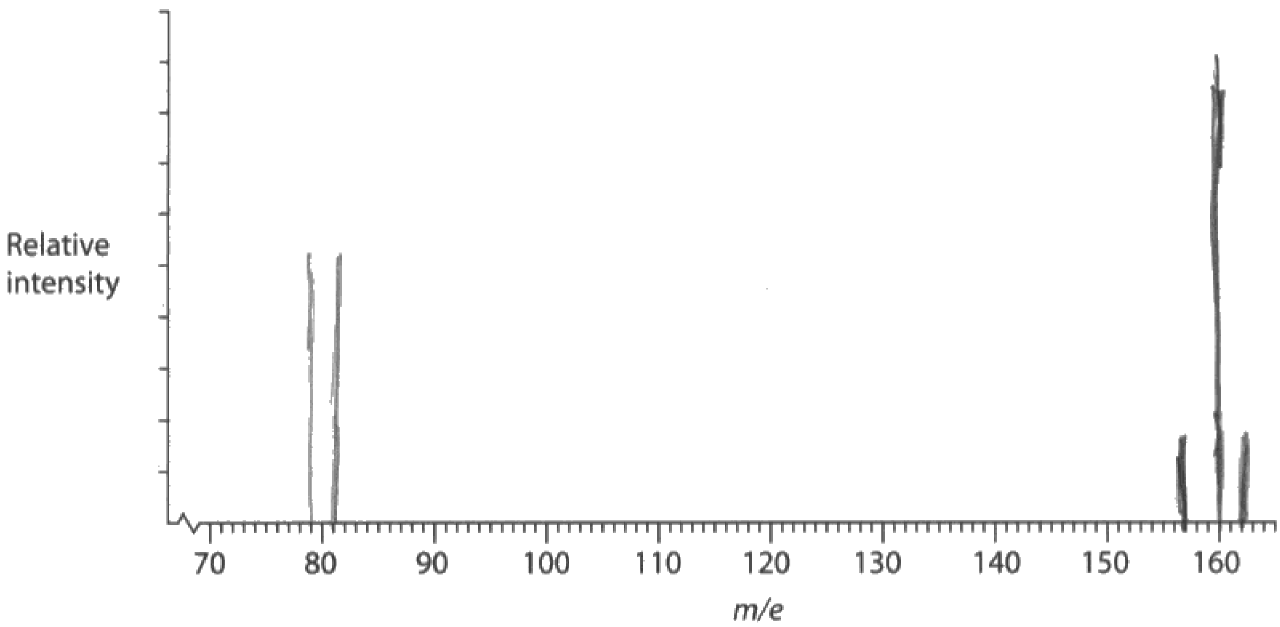
The mark most frequently awarded was for the two peaks at values 79 and 81. However these needed to be approximately equal in height because this information was given in the question and occasionally this was missing. Also the placement of the vertical lines exactly at 79 and 81 was required and, for the most part, this was seen, although candidates should be reminded to take care with this aspect of their drawing.

The second most common mark awarded was for a peak at 160 for the bromine molecular ion made up of one of each isotope. The more able candidate noted the presence of peaks at 158 and 162 for the third mark. These peaks needed to be of approximately the same height for the same reason as stated earlier. Care was also needed for their placement because these were at two small divisions either side of 160, as opposed to one small division either side of 80 for the first marking point.

The mark least awarded, although not always the case, was for the peak at 160 to be approximately double the height of the peaks at 158 and 162. This obviously arises from the probability of the two isotopes combining to form the molecule. This mark was most commonly awarded to the more able candidates, but sometimes candidates appeared to focus all of their attention on the molecular ions peaks and failed to draw the atomic peaks at 79 and 81. The mass spectrum started at 70 m/e on the x axis, so it should have seemed odd that the vast majority of the spectrum was left blank.

(c) Complete the mass spectrum below for a sample of bromine **gas** that contains approximately half ^{79}Br isotope and half ^{81}Br isotope.

(4)



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Examiner Comments

This response was only awarded 2 marks out of the possible 4 available. The peaks at 79 and 81 scored 1 mark. However, the next peak was not at 158 but clearly at 157 so one mark was lost. There is a peak at 160 for a second mark but this peak was clearly much more than double and so the fourth mark was not awarded.

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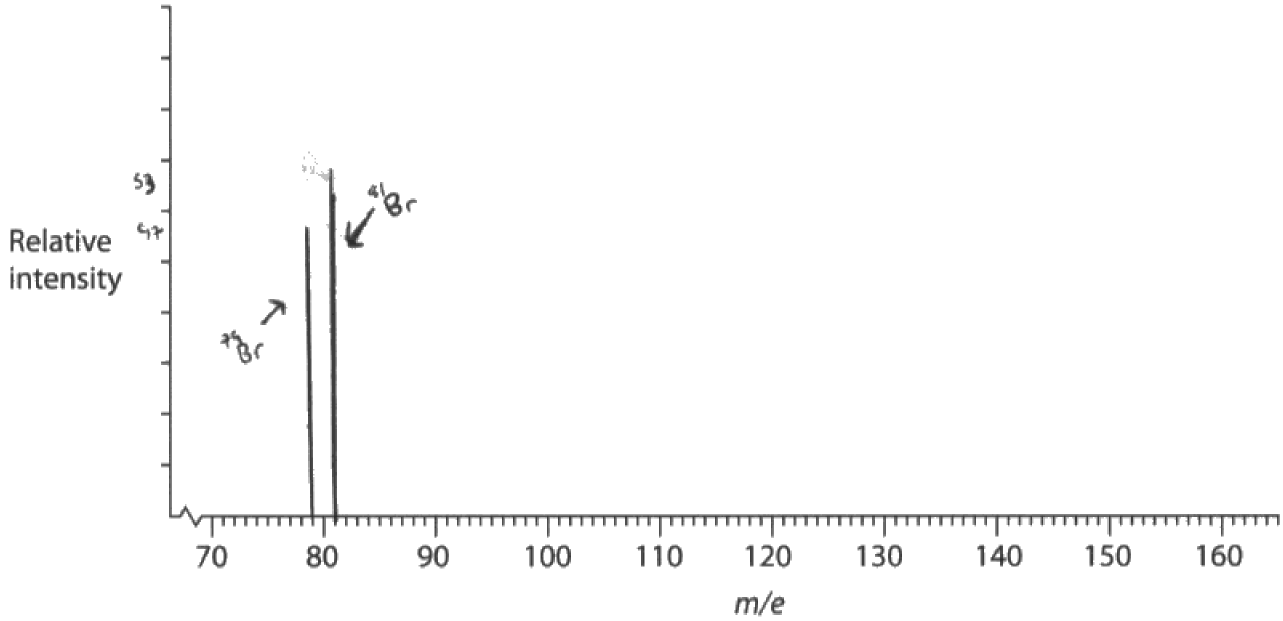
Examiner Tip

The divisions on both the x and y axes are there for guidance and assistance, hence close attention and care needs to be taken when using them in any drawings.



ResultsPlus
Examiner Comments

This response did not score. There are no molecular ion peaks, and those at 79 and 81 are not approximately equal as stated in the question introduction, but are one whole division different.

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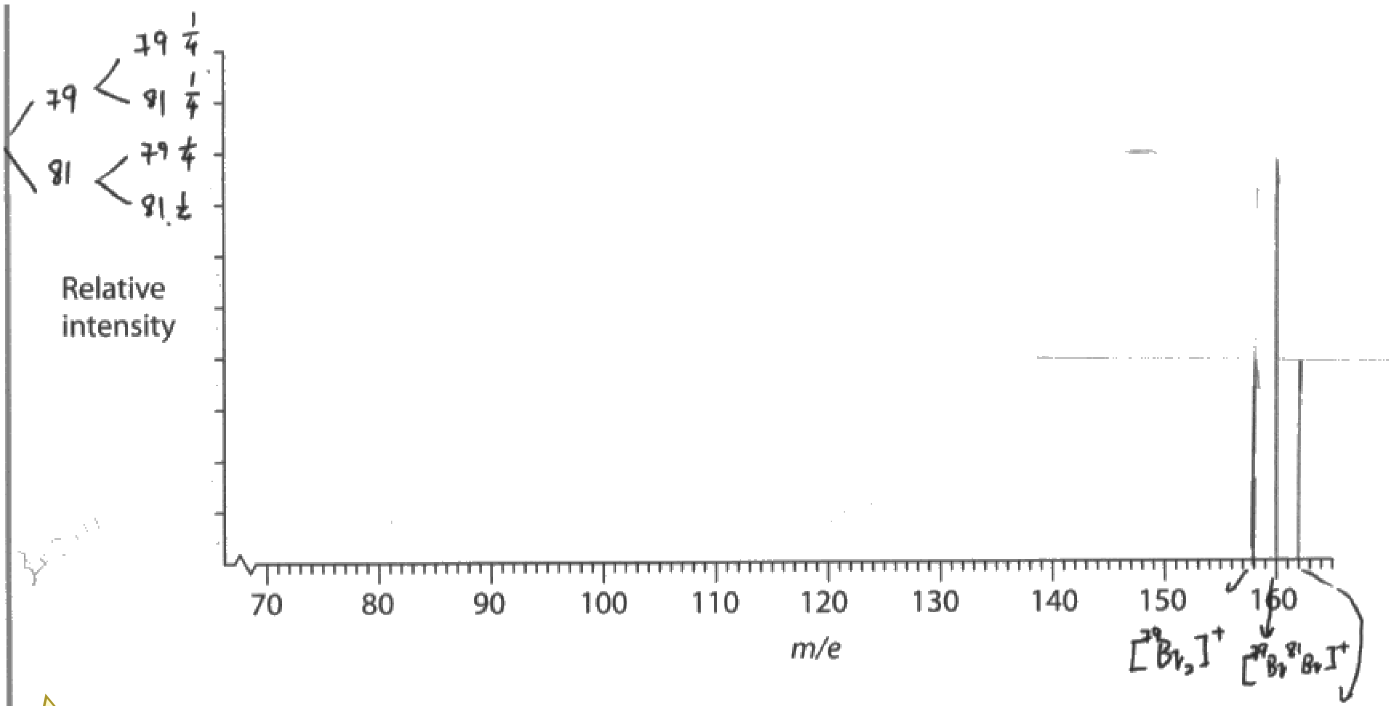
Examiner Tip

Remember to make any drawing reflect the information given in the question.



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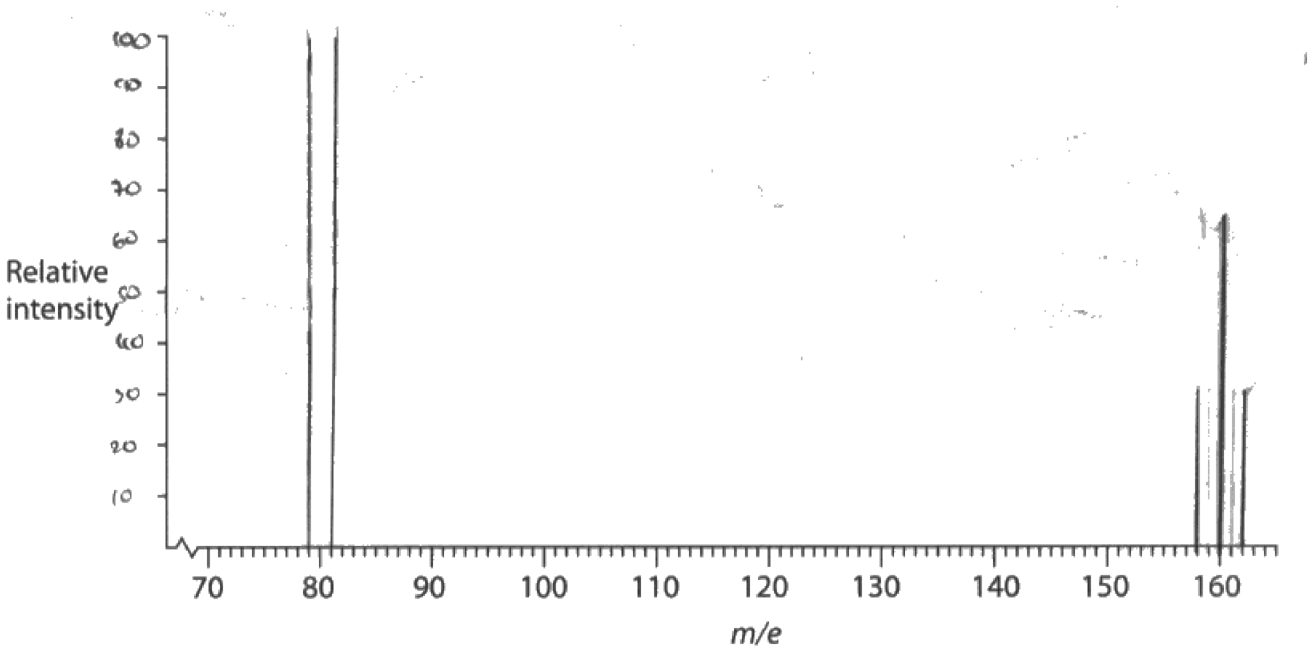
Examiner Comments

This was an example of how the candidate had used the divisions on the y axis, shown by the faint horizontal lines, to ensure that the peak at 160 was double the height of those peaks at 158 and 162. Working can be seen on the left hand side to deduce the relative heights of the peaks.

Unfortunately there were no peaks at 79 and 81 for the atoms and so a total of 3 marks was awarded.



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Examiner Comments

This was an example of a response which scored full marks. The relative height of the 'sets of peaks' at 79/81 and at 158/160/162 was not compared and so although the atomic peaks at 79 and 81 would not be higher than the molecular ion peaks, this was not penalised.

Question 17 (d)

This was generally a high scoring question with the majority of candidates scoring both marks. Relative atomic mass does not have units and so should not be given any, however one mark was occasionally lost by the inclusion of incorrect units. The correct answer of 80.1 was awarded both marks and some candidates simply wrote down their answer without any working which was fine, but if an error had been made then both marks would have been lost. For example, the answer of 81.0 was seen which could have been a simple, and incorrect, division of the sum of 79 and 81, or it could have been a transcription error from the correct answer of 80.1 from a calculator. However, without evidence of working this cannot be discerned. Hence, no marks awarded. This emphasises the need to give workings even for very straight-forward calculations.

(d) Calculate the relative atomic mass of bromine for a sample which was found to contain 47.0% ^{79}Br and 53.0% ^{81}Br.

Give your answer to **three** significant figures.

(2)

$$\frac{47 \times 79 + 53 \times 81}{100} = \underline{80.06}$$

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Examiner Comments

The response seen here failed to quote the final answer to 3 significant figures, which was emboldened in the question, and so only scored 1 mark.

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Examiner Tip

Always re-read the question to ensure that the response given meets the requirements of the question, otherwise marks will be lost.

(d) Calculate the relative atomic mass of bromine for a sample which was found to contain 47.0% ^{79}Br and 53.0% ^{81}Br.

Give your answer to **three** significant figures.

(2)

$$\frac{(47.0 \times 79) + (53.0 \times 81)}{100}$$

~~80.06%~~

80.1%

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Examiner Comments

The inclusion of '%' units resulted in one mark being lost for this response.

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Examiner Tip

Double-check your answers so that any simple errors can be corrected.

Question 17 (e)

Candidates would do well to remember to read the question twice, i.e. read the question twice because there were some chemically correct comments seen about the increased deflection of ions with a 2+ charge, but this was not what the question asked.

A significant number of candidates thought that there would be no difference because of the negligible mass difference as a result of the loss of a second electron, and so they ignored the charge difference and the meaning of the x axis label, m/e.

Only some of the more able candidates realised that the m/e value would halve if a second electron was lost.

(e) What would be the effect, if any, on the *m/e* value of the peak if the ion detected had lost two electrons rather than one electron?

(1)

m/e value will be smaller.

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Examiner Comments

This was an example of a very common response which failed to score because it did not qualify how much smaller the m/e value will be.

Question 17 (f) (i)

This question was designed to test candidates' knowledge and understanding of validity in experimental evidence, and their wider knowledge of the application of science using an example of something which is regularly in the news. All candidates could comment on what could go wrong but frequently failed to comment on necessary precautions that would need to be taken to avoid this. Precautions are actions or activities that are carried out and not just statements that something must or must not happen. Reference to 'how' this is ensured or prevented was required. However many candidates scored at least one mark with reference to 'repeated testing' being by far the most common correct response.

Reference to avoid eating before the test or to check the competitors medication were not creditworthy, and were not suitable excuses from sports competitors whom have been found guilty of taking anabolic steroids.

*(f) One of the uses of mass spectrometers is for the detection of banned substances, such as anabolic steroids, in a blood or urine sample taken from competitors in sports events.

(i) Suggest **two** precautions that are necessary to ensure that the result of any analysis would be valid.

(2)

~~The mass spectrometer~~ Make sure no equipment is contaminated so that no external substances can affect the results and make sure prior results of the identification of banned substances corresponds to the results of mass spectrometer. Also make sure its in a vacuum

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Examiner Comments

The beginning of this response illustrated a common failing by simply stating to 'make sure that' there was no contamination but without stating how this might be done or achieved. The latter part of the response did go on to give a valid comment about providing a mass spectrum of a banned substance for comparison. Hence, this response scored 1 mark.

Question 17 (f) (ii)

Any suitable expression of health concerns was credited with the mark for this question but it needed to be clear that the issue was harmful or suchlike. It was not enough to state that there would be side effects without qualifying that these are harmful.

A significant number of candidates focussed their response on the fear of being banned or being sent to prison if found out but this was not credited.

(ii) These substances can give competitors an unfair advantage. Suggest why the use of these substances may be of concern to the user.

(1)

they speed up reactions inside of the body, and this can effect internal organs

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Examiner Comments
This was an example of the kind of vague responses seen which did not score. It was not clearly stated whether the 'effect' on internal organs was detrimental or harmful.

Question 17 (g)

The most common correct responses were 'radiocarbon dating' and 'for space research' but a wide range of other acceptable answers were considered and awarded the mark. This was a high-scoring question with over 80% of candidates gaining the mark.

(g) Suggest **one** other use for mass spectrometers.

(1)

Determining the chemical compisition of unknown substances such as those found in space research.

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Examiner Comments
This was one example of an acceptable answer for a use of a mass spectrometer.

Question 18 (a)

The vast majority of candidates correctly gave C_nH_{2n}, thus demonstrating that they understood the meaning of the term 'general formula'.

18 Alkenes and cycloalkanes have the same general formula, but react very differently with halogens.

(a) Give the general formula that applies to both alkenes and cycloalkanes.

(1)

C_nH_{2n+2}

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Examiner Comments

This was a general formula, but for alkanes, and not either alkenes or cycloalkanes as asked in this question. Hence, this did not score.

Question 18 (b)

Almost all candidates correctly identified either ethene or propene for marking point 1. The question clearly requested structural formulae, but despite this a significant number of candidates gave a molecular formula for the product which meant that the second marking point was not then awarded. Marking point 3 was awarded for the correct name from the number of carbon atoms in the reactant alkene. This prevented an incorrect molecular formula from also resulting in a loss of a further marking point. However, a somewhat careless approach thwarted a sizeable number of candidates from gaining this third marking point due to omission of either '1, 2' or 'di' in the name of the product.

(b) Using structural formulae, complete the overall equation for the reaction of an alkene of your own choice, containing fewer than four carbon atoms, with liquid bromine.

Name the product.

(3)

$CH_2{=}CH_2 \quad + \quad Br_2 \quad \rightarrow \quad CHBrCHBr$

Name: 1,2-dibromoethane

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Examiner Comments

A suitable alkene was given and the name of the product from this alkene was correctly stated for 2 marks.

The formula of the product was incorrect, as a hydrogen was missing from each of the carbon atoms. It could be construed that the reaction was one of substitution rather than addition from what is written, but then the question is, where have the two hydrogen atoms gone? The writing did not look to have been done in haste so it would appear to be just a careless mistake to omit the subscript '2' from each hydrogen.

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Examiner Tip

Equations should always balance for atoms and charge, so make time at the end of the exam to double-check that all equations are thus balanced.

Question 18 (c) (i)

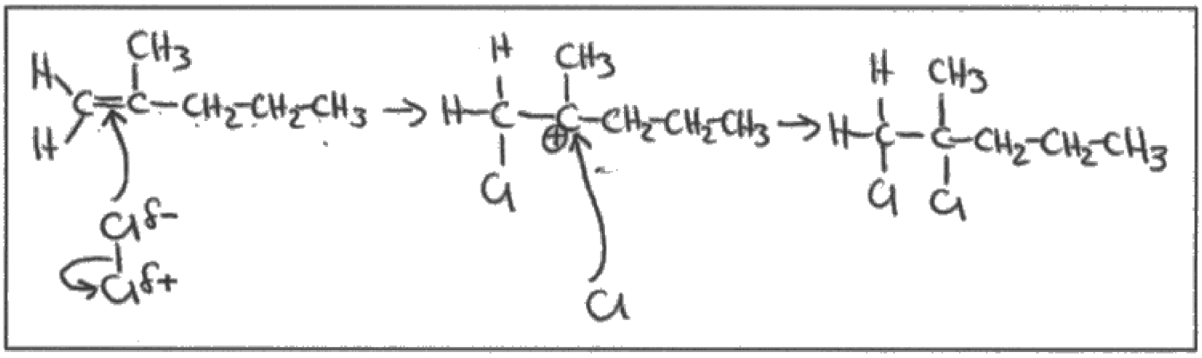
Many candidates had clearly been well-prepared for this type of question, being of a similar style to that in a question from 6CH02 June 2014. Any failure to gain all three marks generally stemmed from a lack of precision in the candidates answer.

One of the errors was that the dipole on the chlorine molecule was the wrong way round. A statement that the uppermost chlorine atom 'shouldn't be delta negative' doesn't indicate what it should be and so does not score. If however the statement was made that the uppermost chlorine atom should be delta positive or that the dipole charges should be switched then the mark could be awarded.

Likewise the description of another error in the first step required clarity. It was not enough to state that the curly arrow was drawn incorrectly, but to identify what was incorrect about it, namely that the direction of the arrow should be reversed.

The final error was the lack of negative charge on the chlorine in the second step of the mechanism. Unfortunately it was not uncommon to see a response stating that the chlorine was lacking a charge, but then to fail to state what that charge was. This lack of detail meant that the mark was not awarded.

*(c) An example of an alkene with six carbon atoms is 2-methylpent-1-ene. It reacts with chlorine by means of an electrophilic addition reaction. The diagram below shows a student's attempt at drawing the mechanism for this reaction.



(i) Identify the three errors in this student's drawing of the mechanism.

(3)

Error 1 ~~The Cl radical must have a negative~~ The arrows must be coming from the double bond to the $Cl^{\delta-}$ and then through the Cl–Cl bo[nd]

Error 2 The Cl radical must have two electrons and a negative charge i.e. Cl:⁻

Error 3 The arrows must be half-headed.

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Examiner Comments

The identification of the first error was aided by the diagram to the right-hand side. If the dipoles had been correctly drawn then this could have been an additional mark but in the drawing the uppermost chlorine atom appeared to have a full positive charge.

The identification of the second error looked all fine until the wording was read carefully. The chlorine is not a radical, but an ion, and so this reference to radical negates the awarding of a mark.

The third error suggested was clearly incorrect.

Hence, this response scored 1 mark.

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Examiner Tip

Be careful with the use of specialist terminology.

Error 1 The arrow should come from the C = C bond to the chlorine atom (1)

Error 2 The electrons move from the Cl - Cl bond to ~~the~~ the $Cl^{\delta-}$ not $Cl^{\delta+}$ (2)

Error 3 The Cl should have a negative charge / lone pair (3) when attacking the carbocation

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Examiner Comments

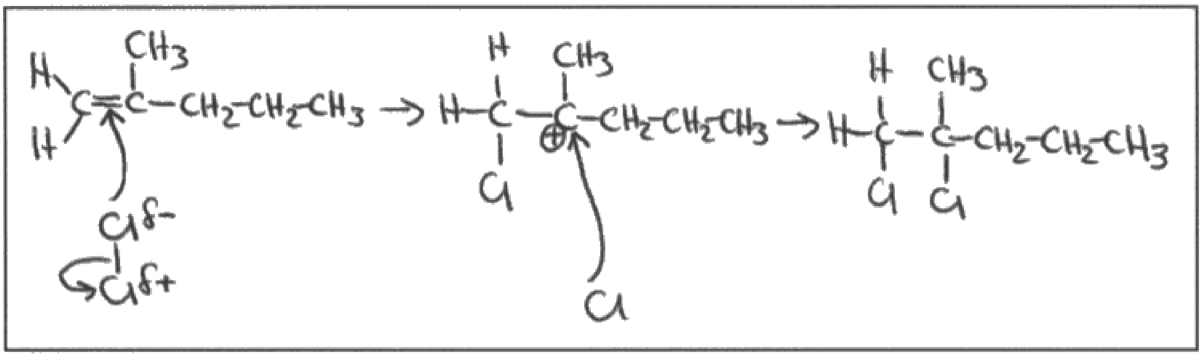
It is important in this type of question for there to be a logical progression through the response. The first error was correctly stated as being the need for the arrow to go from the carbon-carbon double bond to the uppermost chlorine atom. This being so, the next error identified as the curly arrow for the fission of the chlorine-chlorine bond being also to the uppermost chlorine atom, can't possibly be correct. It did not follow from the correct identification of the first error. Hence, this comment did not score.

The third error identified correctly the lack of negative charge on the chlorine in the second step and so this response scored a total of 2 marks.

Question 18 (c) (ii)

Unfortunately a significant number of candidate misread the question and put their focus on why the carbon has a positive charge. However, the question was concerning why the particular carbon atom shown has the positive charge. There were some fine answers describing the positive inductive effect or the electron-releasing effect of the three alkyl groups and this was credited. Some candidates simply stated it was due to Markovnikov's rule rather than giving an explanation as asked in the question.

*(c) An example of an alkene with six carbon atoms is 2-methylpent-1-ene. It reacts with chlorine by means of an electrophilic addition reaction. The diagram below shows a student's attempt at drawing the mechanism for this reaction.



(i) Identify the three errors in this student's drawing of the mechanism.

(3)

Error 1 The arrow should go from C=C double bond to the space between Bond and Cl. in the start. (not from Cl to C=C)

Error 2 ~~That~~ Should be $Cl^{\delta+}$ ~~to~~ instead of $Cl^{\delta-}$ that first approaches the C=C.

Error 3 The Cl in the intermediate should have a negative charge when attracted to the carbocation.

(ii) The structure of the carbocation intermediate is correctly drawn. Explain why the positive charge is on the carbon atom shown.

(1)

The reaction goes via the more stable ~~carb~~ secondary carbocation intermediate.

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Examiner Comments

The carbocation in the mechanism is the most stable but it is a tertiary carbocation and not a secondary one. Hence, this response did not score.

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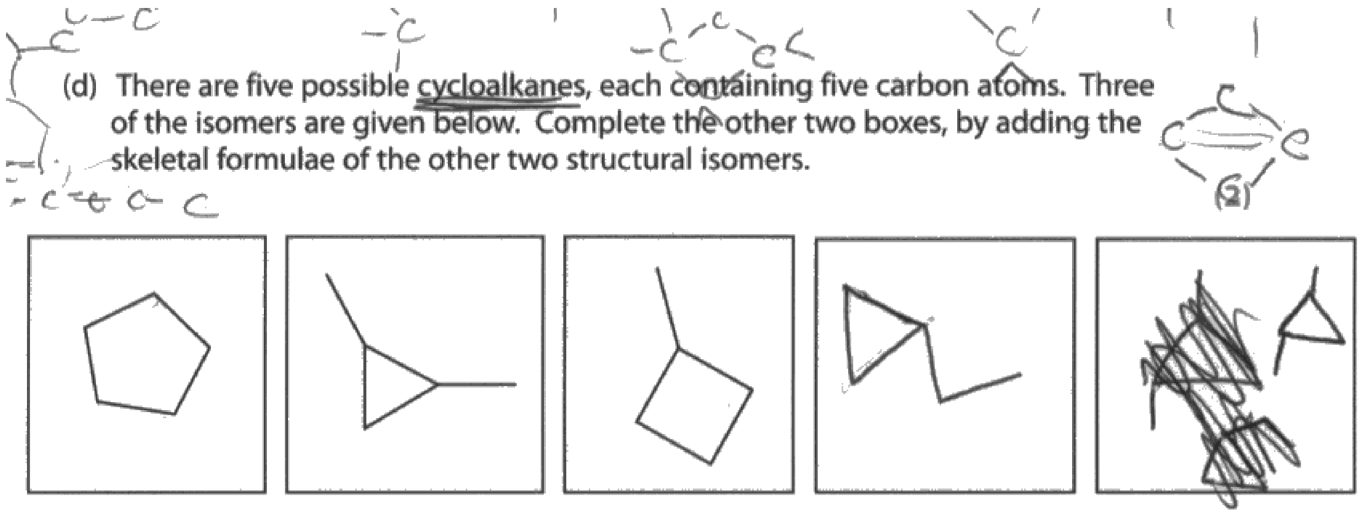
Examiner Tip

Double-check your classifications so that errors or misunderstandings do not arise.

Question 18 (d)

The majority of candidates were at least able to draw one cyclolalkane skeletal isomer. Duplication of those already drawn or of the candidates own first isomer, were commonly seen.


(d) There are five possible cycloalkanes, each containing five carbon atoms. Three of the isomers are given below. Complete the other two boxes, by adding the skeletal formulae of the other two structural isomers.

(2)

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Examiner Comments

There was clearly some working-out here which was fine. However, the second skeletal isomer drawn here was the same as the isomer in the second box from the left (1, 2-dimethylcyclopropane). Hence, this response only scored 1 mark.

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Examiner Tip

When drawing skeletal isomers, try and mentally rotate the molecule to avoid duplicating structures already drawn.

Question 18 (e)

It was surprising and disappointing to see so many poor responses to what is a standard definition. A small number of candidate simply wrote that structural isomers have the same number of atoms without qualifying that it is the same number of atoms of each element . However, it is much easier and simpler to state 'the same molecular formula' which is what the candidates should know. This would obviously need to be followed with 'but different arrangement of the atoms / different structural formula', in order for the 1 mark to be awarded.

(e) Define the term **structural isomerism.**

(1)

A structural isomer is one with the same molecular formula but different arrangement in space

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Examiner Comments

A significant number of candidates answered in similar terms to that seen here and referred to the arrangement 'in space'. However, this is how stereoisomerism would be described and so this type of response did not score.

Question 18 (f) (i)

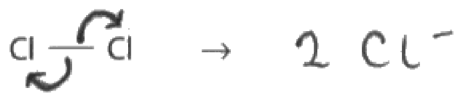
Approximately 90% of responses were correct showing that the condition of ultraviolet radiation needed for free radical substitution is very well-known.

Question 18 (f) (ii)

This was a high-scoring question with over 80% of candidates scoring both points. Occasionally, candidates appeared to miss the instructions for curly arrows and just wrote the initiation equation which only scored one mark. At other times double-headed curly arrows were seen and not awarded the first mark.

(ii) Using the appropriate arrows, complete the equation for the initiation step of the reaction mechanism for the reaction of chlorine with cyclobutane.

(2)



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Examiner Tip

Make sure that if a 'dot' is meant then it clearly looks like one and cannot be confused with a dash or a negative charge.

Think too about the balancing of the equation, how can the left-hand side of the equation have no charge but the right-hand side have an overall charge of -2? This is an example where a simple check of the equation would have highlighted an error that should be corrected.

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Examiner Comments

The two marking points was standalone but unfortunately in this example neither could be awarded.

The curly arrows were clearly double-headed and so the first marking point was not awarded.

The products were also clearly given a negative charge rather than a 'dot' and so the second marking point was likewise not awarded.

(ii) Using the appropriate arrows, complete the equation for the initiation step of the reaction mechanism for the reaction of chlorine with cyclobutane.

(2)

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Examiner Comments

The half-headed curly arrows could be drawn as here, going from opposite sides of the covalent bond or from the same side for the first mark.

The chlorine free radicals produced could be drawn together as here, or separately for the second mark.

Question 18 (f) (iii)

Most candidates were able to apply their knowledge and understanding of the reaction of chlorine and methane to the more unusual example of cyclobutane and that was good to see. Generally candidates used molecular formulae as required in the question, but if alternative formulae were given then marks were awarded as long as the formulae given were correct. In addition most candidates made sure that the free radical species clearly had the necessary 'dot' to indicate the unpaired electron. Omission of this would have been penalised once only, but this omission was very rare so teachers have clearly emphasized this to their students in an effective way.

The wording of this question meant that the order of the propagation steps was important but there was little evidence of candidates writing them in reverse order.

The error most commonly seen was the formation of a hydrogen free radical which was incorrect and if seen in step 1, resulted in zero marks.

(iii) Using molecular formulae, write equations for the **two** propagation steps of this mechanism.

(2)

First propagation step: $Cl^{\bullet} + C_4H_8 \rightarrow C_4H_7Cl + H^{\bullet}$

Second propagation step: $H^{\bullet} + Cl_2 \rightarrow HCl + Cl^{\bullet}$

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Examiner Comments

This was an example of a response that was given zero marks because of the formation of a hydrogen free radical in the first propagation step.

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Examiner Tip

Think about the structure of the molecule and what atom would the chlorine free radical approach first? It would be a hydrogen as they are on the 'outside' of the molecule, and so hydrogen would be broken off to combine with the chlorine free radical to make hydrogen chloride. This would then leave behind the remainder as an alkyl free radical.

(iii) Using molecular formulae, write equations for the **two** propagation steps of this mechanism.

(2)

First propagation step: $C_4H_8 + Cl\cdot \rightarrow C_4H_7\cdot + HCl$

Second propagation step: $C_4H_7\bullet + Cl_2 \rightarrow C_4H_7Cl + H\cdot$

ResultsPlus

Examiner Comments

The first propagation step equation was correct for 1 mark. The second equation was incorrect because a hydrogen free radical was produced and the equation was not balanced for chlorine atoms or hydrogen atoms. Hence, the second mark was not awarded.

ResultsPlus

Examiner Tip

Equations should always be double-checked and even triple-checked for balancing, both for atoms and charge. In this example both the number of chlorine and hydrogen atoms are not the same either side of the equation.

Question 18 (f) (iv)

The type of bond fission was not as well-known as was expected with only just over 50% of candidates correctly stating homolytic fission. Some candidates appeared to miss the phrase 'type of fission' in the question and stated the name of the reaction mechanism which did not score. Occasionally, answers referring to 'binary fission' were seen which may originate from a study of biology and asexual reproduction but is obviously completely incorrect here.

Question 18 (f) (v)

The first marking point required the clear statement that TWO free radicals combine or react together in the termination step. This could be expressed by an equation. The importance of this was evident from a number of responses which stated that more than two free radical combined. Hence although this point may have seemed to be obvious it was necessary for the first marking point.

The second marking point was for a description of the effect of this termination step, namely that there are no free radicals made or that the product is stable and either of these was acceptable for this mark to be awarded. Since the question asked for a description a simple equation was not sufficient to score this mark.

(v) There are also termination steps in this mechanism. Explain how these differ from the other steps in the mechanism and why these result in the reaction ending.

(2)

Termination steps is the steps which produce the products and joins free radicals together to form stable products. ~~The~~ the ~~sw~~ removal of free radicals from the system ~~the~~ prevent the chain reaction continuing so the reaction stops as no free radicals available to attack the stable molecules.

ResultsPlus

Examiner Comments

This was an example where the response failed to clearly state that two free radicals combine in the termination step. The second marking point concerning the product being stable and that free radicals are no longer made could be seen for 1 mark.

ResultsPlus

Examiner Tip

Examiners must not infer what is being meant in an answer and so even if it is felt that the meaning is obvious, it must be clearly stated if the mark is to be awarded.

Question 18 (g)

This was an effective discriminator and only the more able candidates appreciated that the use of excess chlorine would result in further substitution of the hydrogens in cyclobutane by chlorine atoms. It was common to see responses referring to the yield of chlorocyclobutane or that more HCl was formed. Reference to more chlorine free radicals was also frequently seen but the question was about the effect on the products and so this did not score.

(g) If the reaction with cyclobutane is carried out with an excess of chlorine, how are the products of the reaction affected?

(1)

More ~~bigger~~ chloroalkanes are produced, with traces of dichlorobutane, trichlorobutane etc.

ResultsPlus

Examiner Comments

Unfortunately the correct mention of dichloro/trichloro seen here was given in reference to a non-cyclic alkane and so did not score. This illustrated the need for care when writing chemical names.

(g) If the reaction with cyclobutane is carried out with an excess of chlorine, how are the products of the reaction affected?

(1)

There will be a combination of products other than HCl and C_4H_7Cl ie. $C_4H_6Cl_2$, $C_4H_5Cl_3$ $C_4H_4Cl_4$ etc.

ResultsPlus

Examiner Comments

This response stated some of the polychlorinated products that can be produced and so gained the mark.

ResultsPlus

Examiner Tip

Avoid giving multiple answers to a question when only one is required because all answers given have to be correct and an incorrect answer can negate a correct one.

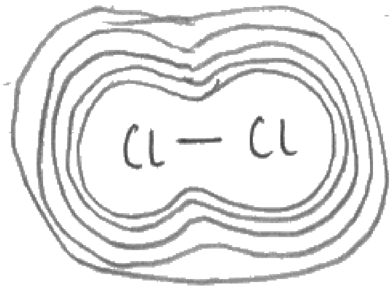
Question 19 (a)

A significant number of less successful candidates drew dot and cross diagrams revealing that they didn't understand what electron density maps were.

19 Sodium and chlorine react together to produce sodium chloride. The bonding in the product is different from that in both of the reactants. Evidence for the type of bonding present can be obtained in a number of different ways.

(a) Draw the electron density map for a chlorine molecule to show covalent bonding.

(1)



ResultsPlus

Examiner Comments

This was an example of the type of response that failed to score because there were no contour rings of electron density around the chlorine atoms.

Question 19 (b)

This was another very straight-forward question that candidates should be very comfortable with but resulted in many poor responses. There were a significant number of candidates that described how an ionic bond is made instead of what one is. Other responses referred to attraction but did not state that it is between oppositely-charged ions. Definitions are often the foundation of understanding and should be known and understood by candidates of all ability.

(b) Sodium chloride is ionically bonded. What is meant by the term **ionic bond**?

(1)

An ionic bond is a bond between a positive cation metal ion and a negative anion non-metal ion

ResultsPlus

Examiner Comments

There was no mention of 'attraction' between the cation and anion here. The word 'bond' was given in the question and so this response did not score.

Question 19 (c)

This proved to be one of the more challenging questions to mark, with candidates doing lots of crossings-out and generally being very unclear. There were a lot of poorly-drawn diagrams and it was not uncommon to see reference to the wrong electrolyte, copper(II) chromate.

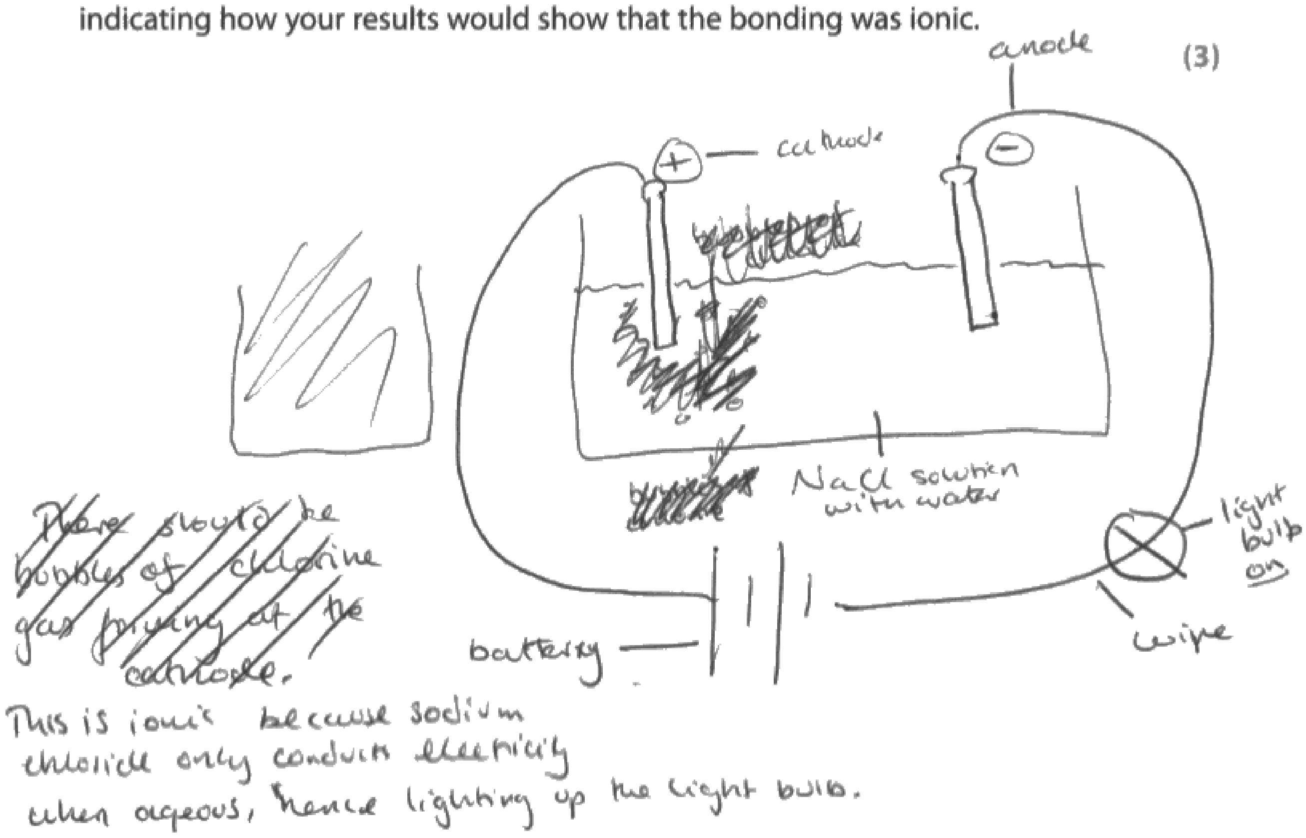
This question could have been answered by the use of a U-tube or a microscope slide. Those who chose the microscope slide frequently forgot to attach paper or failed to dampen it or only put a drop of the sodium chloride solution on it. Both diagrams often failed to draw a complete circuit and so were penalised for a system that would not work as drawn. The question required a means of proving that conduction was taking place and the more successful candidates incorporated a light bulb in the circuit, although the presence of chlorine gaseous bubbles was credited.

The electrolysis of brine is on a lot of GCSE specifications and even if not previously studied it should be obvious to candidates that sodium metal will never be produced in an aqueous environment. This point was frequently ignored and was penalised.

(c) Electrolysis is an experiment which you could carry out in a school or college laboratory on an aqueous solution of sodium chloride, to provide evidence for the presence of ionic bonding.

Draw a labelled diagram of the apparatus that you would use for this experiment, indicating how your results would show that the bonding was ionic.

(3)



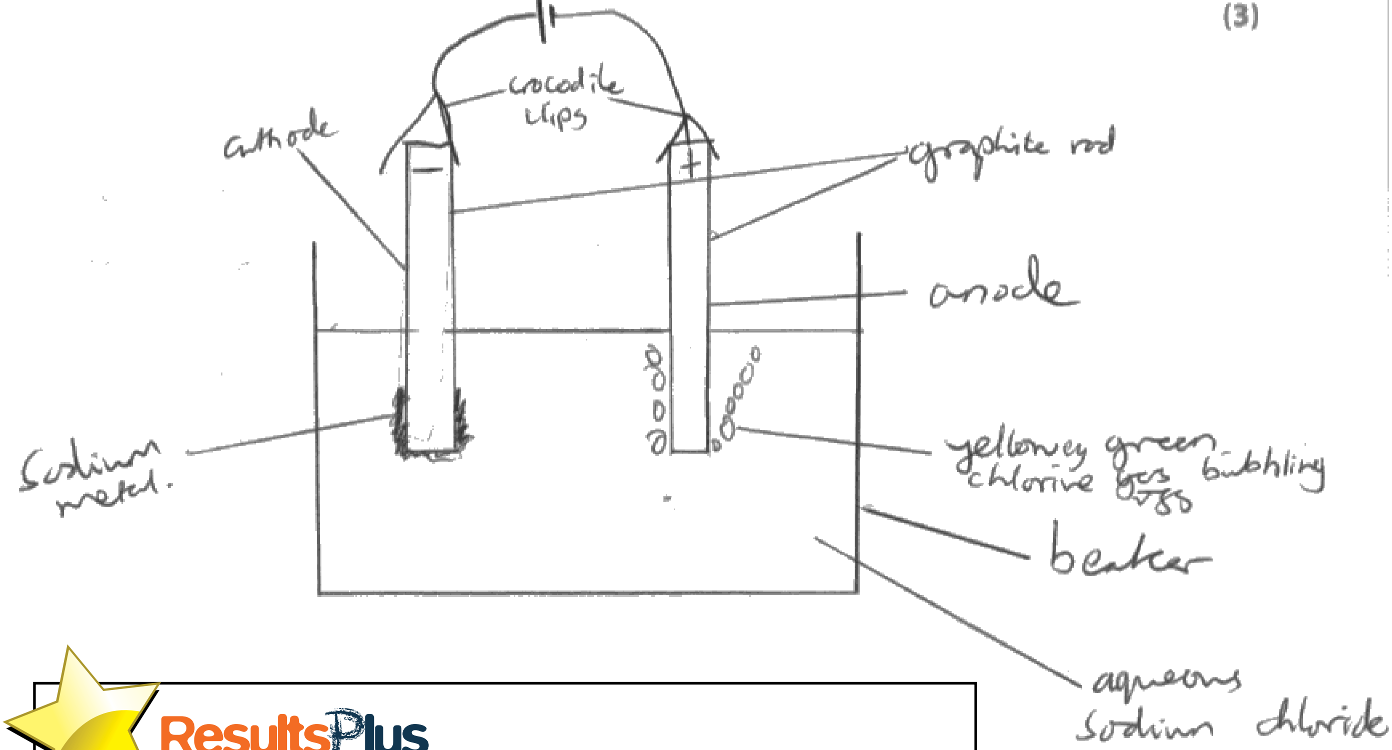
ResultsPlus
Examiner Comments

This was an example of one of the better responses with a clear diagram and the use of a bulb to demonstrate conductivity. However 1 mark was lost because of the use of the wrong terms for the electrodes. The cathode is the negatively-charged electrode and the anode is positive.

(c) Electrolysis is an experiment which you could carry out in a school or college laboratory on an aqueous solution of sodium chloride, to provide evidence for the presence of ionic bonding.

Draw a labelled diagram of the apparatus that you would use for this experiment, indicating how your results would show that the bonding was ionic.

(3)

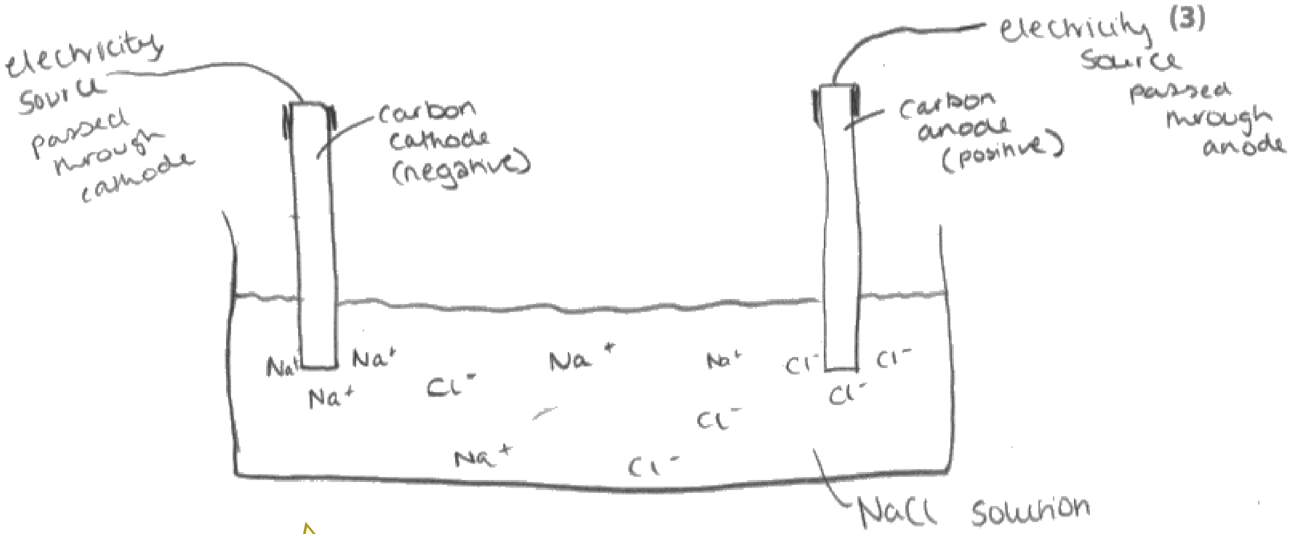


ResultsPlus

Examiner Comments

Evidence of conductivity was here described by the formation of gaseous bubbles of chlorine which was fine except that the colour was incorrect. Candidates are expected to know that chlorine is a PALE yellowish-green gas and also in this context much of the gas would likely dissolve. Furthermore, the candidate had clearly drawn the plating of sodium metal on the cathode, which was incorrect.

(3)



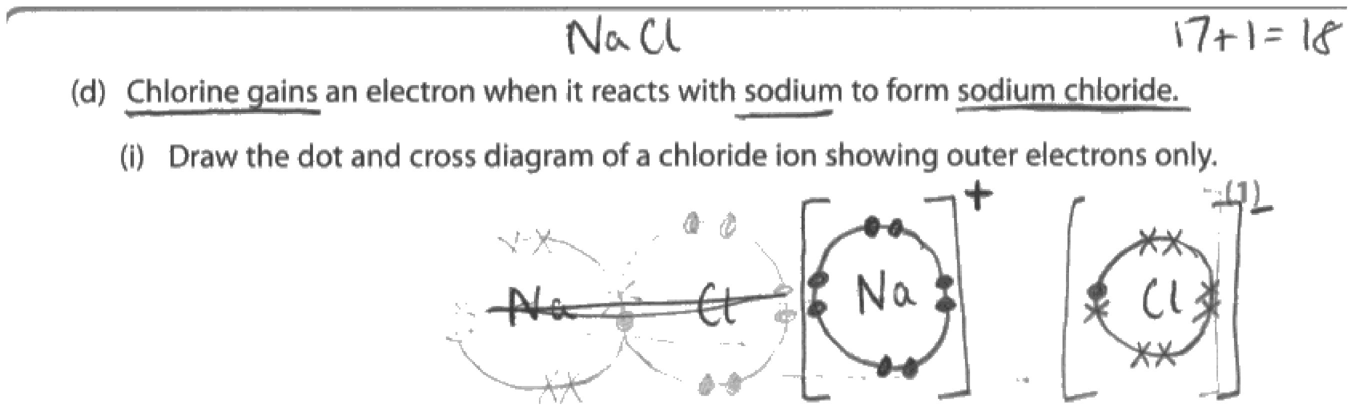
ResultsPlus

Examiner Comments

This response illustrated a very common error, namely that the electrodes were not drawn to complete a circuit. Hence this response only scored 1 mark.

Question 19 (d) (i)

The dot and cross diagram for the chloride ion was mostly done correctly but occasionally the negative charge was missing.


NaCl 17+1=18

(d) Chlorine gains an electron when it reacts with sodium to form sodium chloride.

(i) Draw the dot and cross diagram of a chloride ion showing outer electrons only.

(1)

ResultsPlus

Examiner Comments

This response unnecessarily gave the sodium ion dot and cross diagram. This was ignored. The mark was awarded for the correct chloride ion diagram.

ResultsPlus

Examiner Tip

Only give the answer to the question asked. This saves time and effort.

Question 19 (d) (ii)

This question again illustrated the need for candidates to read the question twice. There were lots of answers which gave the formulae of ions from the wrong period or that gave atoms instead of ions. The meaning of the term 'isoelectronic' seemed to be correctly understood.

Question 19 (e)

A sizeable number of candidates failed to clearly state for the first marking point that sodium in its solid state is an electrical conductor, and simply wrote about its good conductivity. Earlier in the question the candidates had been told that aqueous sodium chloride conducts electricity and so no credit was given for repeating this,. Rather, it was necessary to clearly state that the molten or liquid state was necessary for sodium chloride to electrically conduct for the second marking point. The question required a comparison of the method of electrical conductivity for the third marking point and a lack of precision or understanding was occasionally seen here. The reference to a metal having delocalised electrons was insufficient in itself, it needed to be clearly stated that these electrons are mobile. In addition it needed to be stated that the charge carrier in sodium chloride are the ions which are able to move in the molten state. Less successful candidates tended to state that sodium chloride was similar to sodium in having electrons that can move, but this is obviously incorrect.

(e) Sodium and sodium chloride can both be good conductors of electricity.

Under what conditions do these substances conduct electricity?

Compare the method of conductivity in each case.

(3)

Sodium is a metals and so have a sea of delocalise electrons around cations, this means sodium can conduct electricity when solid as electrons are free to move. However sodium chloride has localised electrons in its lattice, but when sodium chloride is molten the ions ~~in~~ and electrons ~~are~~ in the lattice are more free to move and thus conduct electricity.

(Total for Question 19 = 10 marks)

ResultsPlus
Examiner Comments

This response stated that molten sodium chloride has mobile ions and electrons when discussing electrical conductivity. This was incorrect and so lost the third marking point. The other 2 points were awarded.

Question 20 (a) (b)

Part (a) was correctly carried out by most candidates. However a high proportion of candidates calculated the number of moles of hydrochloric acid for use in the enthalpy change calculation but this reagent was clearly stated to be in excess. Hence this type of response only scored one mark out of the two available. It was pleasing to see that the vast majority of candidates gave the correct sign and units for the enthalpy change, but there were a few who were still making this mistake.

20 The reaction of calcium oxide with hydrochloric acid is an exothermic reaction.

$$CaO(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l)$$

In an experiment to investigate this reaction, the following procedure was carried out.

1. 50.0 cm^3 of hydrochloric acid, concentration 2.0 mol dm^{-3} (an excess), was pipetted into a polystyrene cup and the initial temperature measured using a thermometer with 0.5 °C graduations.

2. 1.46 g of calcium oxide powder was weighed out and added to the acid. The mixture was stirred and the maximum temperature measured.

Maximum temperature / °C	35.0
Initial temperature / °C	19.5

(a) Calculate the enthalpy change, in joules, for the quantities in this experiment. Assume that the specific heat capacity of the solution is 4.18 J g^{-1} C^{-1}.

Use the expression:

energy transferred in joules = 50.0 × specific heat capacity × temperature change

(1)

E = 50 × 4.18 × (35 − 19.5) = 3239.5 J

(b) Using your answer from (a), calculate the molar enthalpy change for the reaction between calcium oxide and hydrochloric acid. Include a sign and units in your answer.

(2)

~~[illegible]~~ $\frac{1.46}{16 + 40.1}$ = 0.0260 mol

0.0260 × 2 = 0.0520 mol

$\frac{3239.5}{1000}$ = 3.2395 $\frac{-3.2395}{0.0520}$ = ~~62.216~~

ResultsPlus

Examiner Comments

This candidate incorrectly doubled the number of moles of calcium oxide and so only scored 1 mark in part (b).

ResultsPlus

Examiner Tip

The limiting reagent that results in the reaction should always be used for molar calculations.

20 The reaction of calcium oxide with hydrochloric acid is an exothermic reaction.

$$CaO(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l)$$

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Maximum temperature / °C	35.0
Initial temperature / °C	19.5

(a) Calculate the enthalpy change, in joules, for the quantities in this experiment. Assume that the specific heat capacity of the solution is 4.18 J g^{-1} C^{-1}.

Use the expression:

energy transferred in joules = 50.0 × specific heat capacity × temperature change

(1)

50 × 4.18 × (19 − 35) = −3344 joules

(b) Using your answer from (a), calculate the molar enthalpy change for the reaction between calcium oxide and hydrochloric acid. Include a sign and units in your answer.

(2)

$\frac{1.46}{56.1}$ = 0.026 moles of CaO

$\frac{-3344}{0.0260}$ = $\frac{-128263.0137}{1000}$

= −128.6 kJmol^{-1}

ResultsPlus

Examiner Comments

This response illustrated the meaning of TE or transferred error. The temperature change in (a) was incorrect because 19 and not 19.5 had been used and so this did not score. However if this value was transferred to (b) and the correct calculation carried out then both marks could be, and in this case were, awarded.

It can be noted that this candidate had written an incorrect number (128**2**6...) in their working but since the correct final answer was written for this candidates figures, this transcription error was over-looked.

Question 20 (c) (i)

Full marks on this question were rarely awarded.

Frequent reference to non-standard conditions, incomplete reaction and to CaO lost on transfer were made, but none of these were valid responses to this particular question. For example the answer from (b) was over 70 kJ mol-1 less exothermic than the quoted value and the small temperature difference from standard conditions would not result in this significant difference of enthalpy change.

A significant number of responses made effectively the same point twice and so were only awarded one mark. For example, one mark was given for reference to heat loss. Reference to heat loss to the apparatus or that the specific heat capacity of the apparatus is not zero, both amount to the same marking point and so did not warrant a second mark.

Only the more successful candidates referred to the inaccuracy of the thermometer readings or the possible impurity of calcium oxide powder.

(c) The standard molar enthalpy change for the reaction between calcium oxide and hydrochloric acid is -196.8 kJ mol^{-1}.

(i) Suggest **three** reasons why the calculated value in part (b) is different from this value.

(3)

Reason 1 ~~As it is an average.~~ Some of the heat may have been lost to the surroundings.

Reason 2 ~~Flame may~~ We ~~take~~ assume the acid has the same density as water.

Reason 3 We assume the acid has the same specific heat capacity as water ($4.18\,J\,g^{-1}\,C^{-1}$)

ResultsPlus
Examiner Comments

This candidate illustrated another example of essentially making the same point twice. The use of the specific heat capacity and density of water for hydrochloric acid were basically the same point and so only 1 mark was awarded for either of these.

ResultsPlus
Examiner Tip

Make sure that any information given, either at the start of the question or earlier on in the question, is taken into account when responding to such questions about the efficacy of the method used.

Question 20 (c) (ii)

This question required the candidates to in effect 'work in reverse' and to calculate the minimum mass of calcium oxide required to produce a temperature change. Less successful candidates either failed to correctly answer the question at all or only used Q=m x c x T to calculate 26125 J and then stopped there. Candidates of middle-ability could work out the number of moles from this value of Q but then incorrectly divided it by two or some such so that the final mass was incorrect. Only the more able candidates could correctly complete the calculation all the way through to arrive at 7.45g.

(ii) Using the standard enthalpy change of –196.8 kJ mol^{-1}, calculate the minimum mass of calcium oxide that would be needed to raise the temperature of 250 cm^3 of hydrochloric acid (an excess) by 25.0°C.

(3)

$\frac{250}{1000} \times 2 = 0.5$ moles of HCl

∴ 0.25 moles of CaO

CaO → 40 + 16 = 56

56 x 0.25 = 14g

Minimum of ~~14g~~ 14g of CaO needed to raise temprature by 25°C.

ResultsPlus

Examiner Comments

This candidate ignored the opening instruction to use the standard enthalpy change of -196.8 kJ mol^{-1} and just used the number of moles of the excess reagent for the basis of a calculation. This was not uncommon and was given 1 mark only for the correct calculation of the mass from the number of moles.

ResultsPlus

Examiner Tip

Follow the instructions in the question when writing a response. Any reagent in excess will not be used as the basis for a molar calculation.

(ii) Using the standard enthalpy change of −196.8 kJ mol⁻¹, calculate the minimum mass of calcium oxide that would be needed to raise the temperature of 250 cm³ of hydrochloric acid (an excess) by 25.0 °C.

(3)

$250 \times 4.18 \times 25 = 26125\ J$

$= -26.125\ kJ$

$\frac{26.125}{196.8} = 0.1327...\ moles$

$0.1327... = \frac{x}{40.1+16}$

$x = (40.1+16)(0.1327...)$

$= 7.4472...$

$= 7.5\ g$

(round up to ensure ΔH = 26.125 kJ)

ResultsPlus

Examiner Comments

This was obviously a very able candidate and the calculation workings were clearly laid out. However this candidate had only underlined the word 'mass' in the question but on closer examination it is noted that the MINIMUM mass was required. Hence the rounding-up to 7.5g was an error and resulted in the loss of 1 mark which is unfortunate.

ResultsPlus

Examiner Tip

Underlining key parts of the question is very good practice and helps to focus on the precise requirements of the question. However, do make sure that all the relevant parts are underlined.

Question 20 (d) (i)

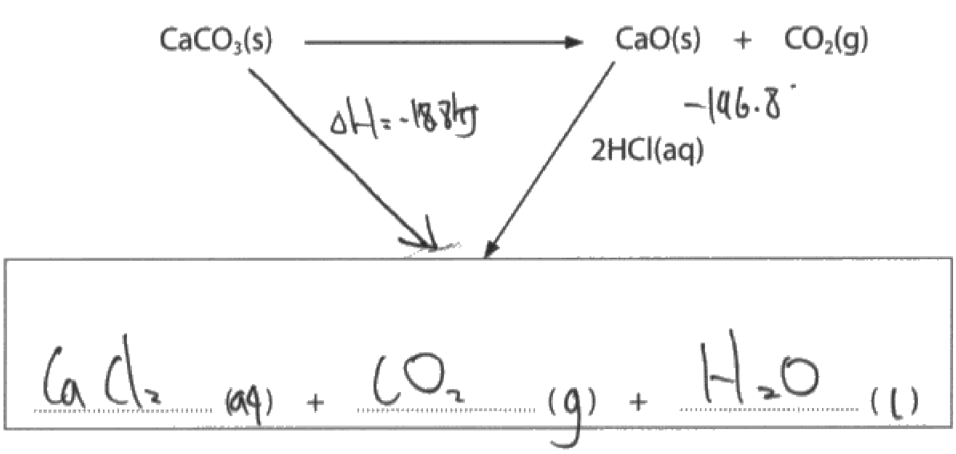
This question produced the full spectrum of marks but at times the marks awarded were not always likely commensurate with the candidates seeming ability because of rather careless errors. For example, it was not uncommon to see calcium chloride given as the state symbol for a solid but at the very beginning of the question on page 20 the state symbol was given as aqueous and in any case candidates should know that calcium chloride is soluble from GCSE studies. Another common error was the omission of 2HCl(aq) by the side of the downward arrow that was to be added to the incomplete diagram.

Hess' law continues to prove challenging for many candidates and frequently the known enthalpy changes were doubled, which presumably arose from the two moles of hydrochloric acid.

(i) Complete the Hess energy cycle below by adding the missing arrow and entities.

Use the cycle, and the standard enthalpy change for the reaction of calcium oxide and hydrochloric acid (–196.8 kJ mol⁻¹), to determine the standard enthalpy change for the decomposition of calcium carbonate.

(4)



$\Delta H = -188 \times 10^3 - (-196.8 \times 10^3)$

$= +178 \text{ kJ mol}^{-1}$

ResultsPlus
Examiner Comments

This was clearly the work of an able candidate, but at times the more elementary aspects can be missed by such learners. The enthalpy change was correctly calculated and the entities, with their correct state symbols, have been written in the box provided for 3 marks. The fourth mark was awarded for the completion of the Hess' cycle with a downward arrow AND for the inclusion of 2HCl(aq) by this arrow. The acid was clearly included for the other downward arrow and the candidate should have taken note of this because it ensured that the cycle balanced in all directions. Unfortunately, this candidate missed this substance out and so was not awarded this fourth mark.

ResultsPlus
Examiner Tip

Look carefully at the way an incomplete diagram has been drawn so that any key features that are either missing or that need to be included are noted and addressed.

Question 20 (d) (ii)

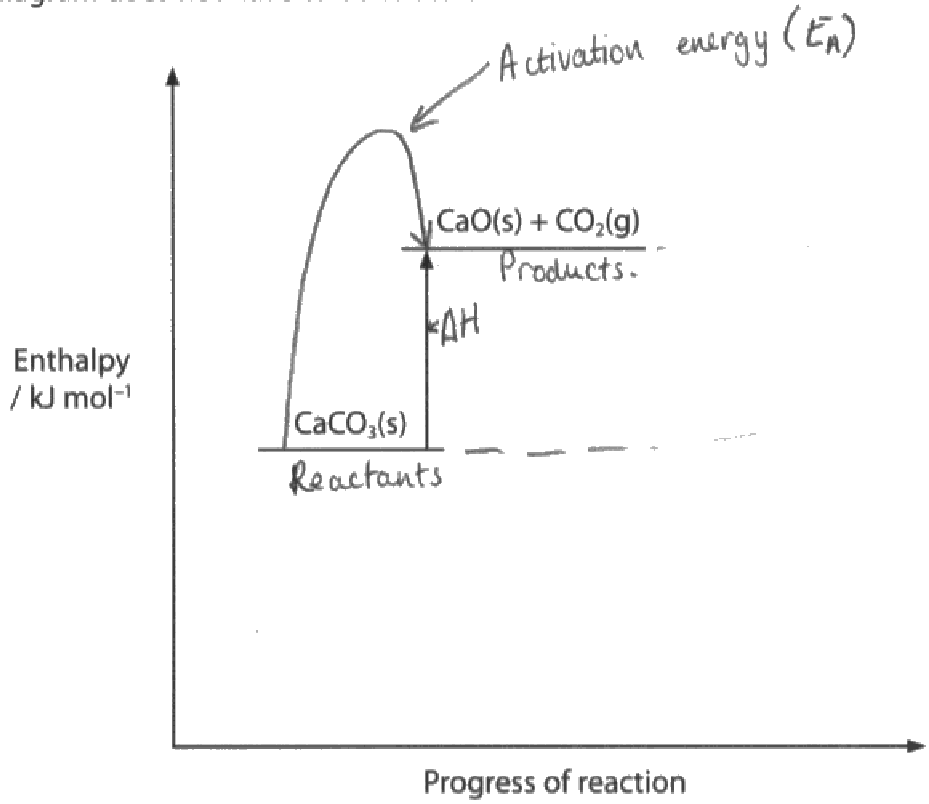
This was a very poorly answered question and may be a reflection of its position at the end of the paper because such enthalpy level diagrams have been asked on exams numerous times in the past but rarely have they been so badly done.

The question asked for 'the series' of reactions from (d)(i) to be added to the diagram, was incomplete. The vast majority of candidates did not appear to understand what this meant. At times a simple label of enthalpy change was added which may have arisen from the mark allocation of just one mark. However it is worth candidates appreciating that questions towards the end of each individual question tend to be of higher demand and so the amount required for the mark, or marks, can be increased. This was the case here with candidates required to add a new enthalpy level below that of calcium carbonate, to write on that level, calcium chloride, water and carbon dioxide, and then finally to link this enthalpy level to the others by means of downward arrows. Only the very able were able to reproduce these requirements.

(ii) Complete and label the enthalpy level diagram below, for the series of reactions in (d)(i).

Your diagram does not have to be to scale.

(1)



ResultsPlus
Examiner Comments

This candidate misread the question and simply added an enthalpy change sign and a curve which was labelled activation energy. The activation energy was not required but if it was this would not be suitable as it does not point to the enthalpy change and it doesn't even point to the peak of the curve.

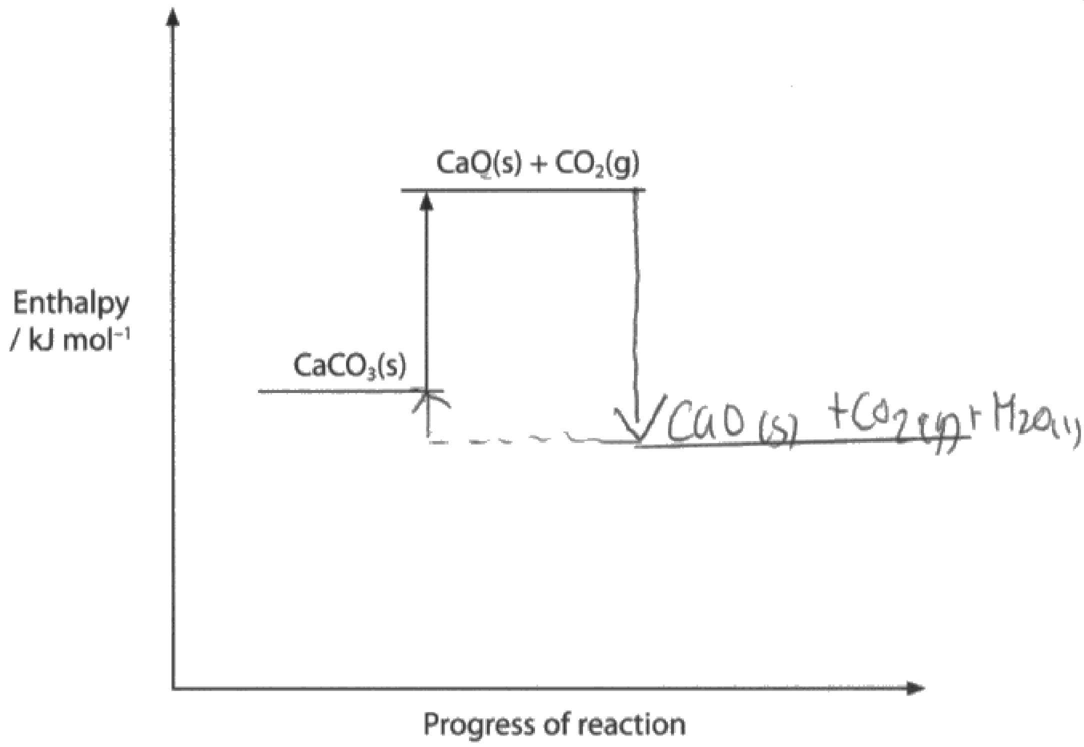
ResultsPlus
Examiner Tip

At the end of the exam paper there can be a tendency to rush but this needs to be avoided otherwise simple errors can result as seen here.

(ii) Complete and label the enthalpy level diagram below, for the series of reactions in (d)(i).

Your diagram does not have to be to scale.

(1)



ResultsPlus

Examiner Comments

Note that the candidate added calcium oxide instead of calcium chloride to the enthalpy level that they have added. In addition the enthalpy change arrow goes upwards from this enthalpy level to the calcium carbonate. Either of these errors would have lost the mark available here.

Paper Summary

On the basis of responses to questions in this paper the following advice is offered to candidates:

- read the question twice to ensure that the precise requirements of the question are correctly addressed
- study carefully practical equipment and experimental procedures to understand why and how things are done
- be able to apply knowledge and understanding to similar molecules or situations to those normally studied
- look for how chemical concepts and principles can be applied to 'real world' situations
- make sure that 'simple' definitions such as structural isomerism and ionic bonding are well-known
- follow the question guidance on number of significant figures, units and sign.

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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