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Examiners' Report
January 2011

GCE Chemistry 6CH01 01

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Introduction

Section A of this paper contained questions that were found to be straightforward by the majority of candidates. The average mark for the multiple-choice component was just over 13/20. The structured questions in Section B also offered opportunities for candidates of all abilities to show their skills. All questions in Section B provided evidence for differentiation.

Calculations were generally well set out, although there remains a minority of answers that are hard to follow because candidates do not think that words are needed.

There was no evidence that candidates were unduly pressed for time in order to complete this paper.

Question 15 (a)

Most candidates picked up at least one out of the two available marks. Common omissions included a lack of reference to the word "average" or "mean" for the first mark or "carbon-12" for the second mark.

15 The relative atomic mass of an element is determined using a mass spectrometer.

(a) Define the term **relative atomic mass**.

(2)

Relative atomic mass is the mass of an atom of an element relative to the mass of 1/12 of the atom of carbon 12.

(b) The mass spectrum of rubidium is shown below.

ResultsPlus Examiner Comments

First mark is NOT awarded as no mention of average/mean. Second mark awarded as mention of carbon-12.

ResultsPlus Examiner Tip

Learn all your definitions - thoroughly!

Question 15 (b) (i)

A large majority of candidates understood that two peaks in the mass spectrum related to the fact that rubidium has two isotopes. Sometimes the word "isomers" appeared instead of "isotopes".

> Mass/charge ratio
>
> (i) Explain why there are two peaks in the spectrum.
>
> (1)
>
> Because there are to isomers with differ ent weight
> Causing to peaks of detetction
>
> (ii) Use the spectrum to calculate the relative atomic mass of rubidium.

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Examiner Comments

This response scores (0) as the word "isomer" has been used by mistake instead of "isotope".

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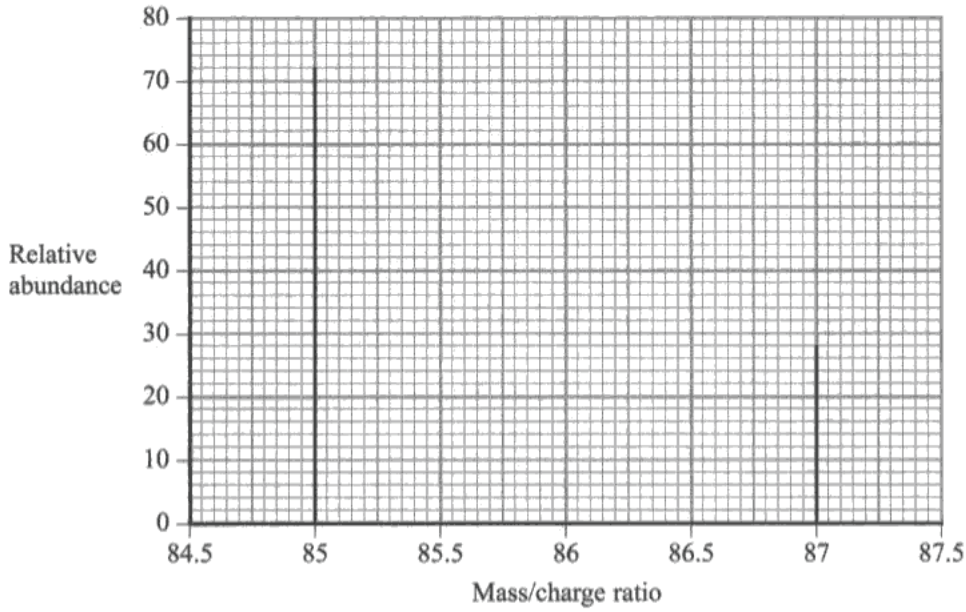
Examiner Tip

Don't muddle up key scientific words which are similar (e.g. "isomer" with "isotope").

Question 15 (b) (ii)

Most candidates calculated the relative atomic mass correctly as either 85.56 or 85.6. A small number of candidates mis-read the relative abundances from the graph and used relative abundances which did not add up to 100%. A small number of answers gave working which showed that candidates had taken the arithmetic mean of 85 and 87 to get an answer of 86.



(i) Explain why there are two peaks in the spectrum. (1)

because there are two isotopes of the element.

(ii) Use the spectrum to calculate the relative atomic mass of rubidium. (2)

$$\frac{85 + 87}{2} = 86$$

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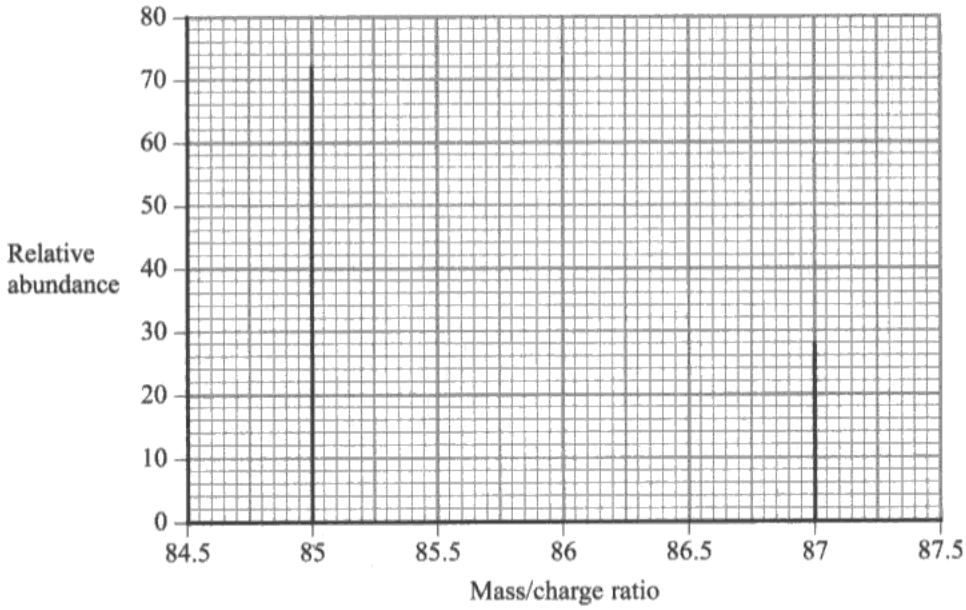
Examiner Comments

The answer of 86 is incorrect. The "simple" arithmetic mean of 85 plus 87 has been calculated. So no marks were awarded.



(i) Explain why there are two peaks in the spectrum. (1)

Different isotopes

(ii) Use the spectrum to calculate the relative atomic mass of rubidium. (2)

$(85 \times 72) + (87 \times 28) = \frac{8556}{100} = 85.56$

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Examiner Comments

Both marks were awarded for calculating the relative atomic mass correctly.

Question 16 (a)

The majority of candidates found (a)(i) more straightforward than (a)(ii).

16 (a) Coral reefs are produced by living organisms and predominantly made up of calcium carbonate. It has been suggested that coral reefs will be damaged by global warming because of the increased acidity of the oceans due to higher concentrations of carbon dioxide.

(i) Write a chemical equation to show how the presence of carbon dioxide in water results in the formation of carbonic acid. State symbols are **not** required.

(1)

$CO_2 + H_2O \rightarrow H_2CO_3$

(ii) Write the **ionic** equation to show how acids react with carbonates. State symbols are **not** required.

(2)

$HCl(aq) + CaCO_3(s) \rightarrow CaCl(s) + HCO_3(aq)$

$Cl^-(aq) + CO_3^{2-}(aq) \rightarrow Cl^-(s) + CO_3^{2-}(aq)$

ResultsPlus Examiner Comments

Equation for (a)(i) is correct, so one mark awarded.
Neither left hand side nor right hand side of equation correct in (a)(ii), so no mark awarded.

ResultsPlus Examiner Tip

Practise writing ionic equations.

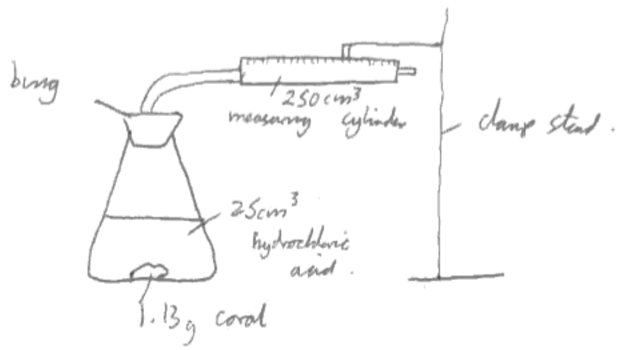
Question 16 (b) (i-ii)

A surprisingly large number of answers to (b)(i) contained poor representations of everyday laboratory apparatus. Often the carbon dioxide was shown as being collected in a gas syringe when it was clear from the question that the carbon dioxide was being collected over water in a measuring cylinder.

In (b)(ii), only a minority of candidates were able to suggest a way of mixing the reagents with the apparatus sealed, ready to collect and measure the volume of carbon dioxide released.

(i) Draw a labelled diagram of the apparatus that could be used to carry out this experiment.

(2)



(ii) Suggest how you would mix the acid and the coral to ensure that no carbon dioxide escaped from the apparatus.

(1)

Pour the acid in first and as you add the coral quickly put the bung over the top so no carbon dioxide escapes.

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Examiner Comments

In (b)(i), one mark is awarded for showing a delivery tube leaving the conical flask. There is no inverted measuring cylinder - a gas syringe has been used.
In (b)(ii) scores (0) as the reactants are mixed together before the bung is placed in the flask - so gas will be lost.

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Examiner Tip

Practise drawing everyday chemical apparatus, using a pencil and a ruler.

Question 16 (b) (iii-vi)

In (b)(iii), many candidates were able to calculate the number of moles of carbon dioxide, but a small number then lost credit for giving their answer to one significant figure.

In (b)(iv), it was rare to see all four state symbols given correctly. The HCl state symbol was often thought to be (l) and the $CaCl_2$ was given as (s) instead of (aq).

Many correct answers were seen to (b)(v) and (b)(vi), although a small minority of candidates did not do what was required which was to give their final answers to three significant figures.

(iii) Calculate the number of moles of carbon dioxide collected in the experiment.

[The molar volume of any gas is 24 000 cm^3 mol^{-1} at room temperature and pressure.]

(1)

no. of moles = 250 ÷ 24000
= 0.0104

(iv) Complete the equation below for the reaction between calcium carbonate and hydrochloric acid by inserting the missing state symbols.

(1)

$CaCO_3$(....s...) + 2HCl(....aq....) → $CaCl_2$(....aq....) + H_2O(l) + CO_2(.....g.....)

(v) Calculate the mass of 1 mol of calcium carbonate.

[Assume relative atomic masses: Ca = 40, C = 12, O = 16.]

(1)

40 + 12 + (16 × 3) = 100

(vi) Use your data and the equation in (iv) to calculate the mass of calcium carbonate in the sample and the percentage by mass of calcium carbonate in the coral. Give your final answer to **three** significant figures.

(2)

~~mass of $CaCO_3$ in coral = 1.13 ÷ 100 = 0.0113~~

0.0104 × 100 = 1.04 ← mass of $CaCO_3$ in coral

$\frac{1.04}{1.13} \times 100 = 92\%$

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Examiner Comments

In (b)(iii), answer incorrect as wrong volume of CO_2 has been used.
In (b)(iv), all state symbols correct so one mark awarded.
In (b)(v), mass of 1 mol of $CaCO_3$ is correct.
In (b)(vi), moles of $CaCO_3$ consequentially correct from moles of CO_2 in (b)(iii). So mass of $CaCO_3$ consequentially correct. One mark awarded.
No second mark as a consequentially correct % is given to 2 s.f., instead of the required 3 s.f.

(iii) Calculate the number of moles of carbon dioxide collected in the experiment.

[The molar volume of any gas is 24 000 $cm^3\ mol^{-1}$ at room temperature and pressure.]

(1)

$\frac{224\ cm^3}{24000\ cm^3}$ = 0.0093 moles

(iv) Complete the equation below for the reaction between calcium carbonate and hydrochloric acid by inserting the missing state symbols.

(1)

$CaCO_3$(.....s.....) + 2HCl(..aq.....) → $CaCl_2$(..aq....) + H_2O(l) + CO_2(...g.....)

(v) Calculate the mass of 1 mol of calcium carbonate.

[Assume relative atomic masses: Ca = 40, C = 12, O = 16.]

(1)

40g + 12g + (3 × 16 g) = 100g

(vi) Use your data and the equation in (iv) to calculate the mass of calcium carbonate in the sample and the percentage by mass of calcium carbonate in the coral. Give your final answer to **three** significant figures.

(2)

$\frac{224}{24000}$ = 0.0093 moles carbon dioxide

= 0.0093 moles $CaCO_3$.

0.0093 × 100 = 0.93 g Calcium carbonate

$\frac{0.93}{1.13}$ × 100 % = 82.3 %

↘ percentage mass of calcium carbonate in coral

(vii) When this experiment is repeated, the results are inconsistent. Suggest a reason

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Examiner Comments

(b)(iii) correct as sig figs are OK.(b)(iv) and (b)(v) correct.NOTE: (b)(vi) scores both marks as 82.3% is correct if the mass of $CaCO_3$ is given to two s.f. (i.e. 0.93 g) and this mass is used in the calculation.

Question 16 (b) (vii)

The majority of candidates understood that the proportion of calcium carbonate in different samples of coral can vary. A significant number of candidates, however, referred to procedural errors or explanations such as "the reaction did not go to completion".

(vii) When this experiment is repeated, the results are inconsistent. Suggest a reason for this other than errors in the procedure, measurements or calculations.

(1)

Different percentage by mass of calcium carbonate in ~~the coral~~ different coral.

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Examiner Comments

The idea that there can be a different proportion of $CaCO_3$ in different samples of coral has been addressed. So one mark awarded.

Question 17 (a)

The vast majority of candidates knew how to complete the electronic structure of the chlorine atom. The small number of incorrect answers included d sub-shells.

17 This question is about the element chlorine (atomic number = 17).

(a) Complete the electronic structure of chlorine.

(1)

$1s^2\ 2s^2$ $2p^6$, $3s^2$, $3p^5$

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Examiner Comments

One mark awarded.

Question 17 (b) (iii)

The quality of written communication was thoroughly tested in (b)(iii). Marks were often lost by candidates who referred to particles such as "atoms" or "molecules" being present in the ionic compounds magnesium oxide and magnesium chloride.

*(iii) Suggest why the melting temperature of magnesium oxide is higher than that of magnesium chloride, even though both are almost 100% ionic.

mg^{2+} O^{2-}

(3)

Firstly, O^{2-} is smaller than Cl^-, this means that the Mg and O ions are much more tightly packed in the ionic lattice, this means that the forces between each ion are stronger and need much more energy to break apart, compared to $MgCl_2$.

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Examiner Comments

First mark on the mark scheme is awarded as the charges on both the oxide and the chloride ion are correct.
A second mark is awarded for stating that the forces between the ions are stronger in MgO.
The third mark is awarded for realising that more energy is required to overcome the forces of attraction between the ions in MgO.

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Examiner Tip

In questions on bonding, always consider carefully the types of particle present in the substances being discussed.

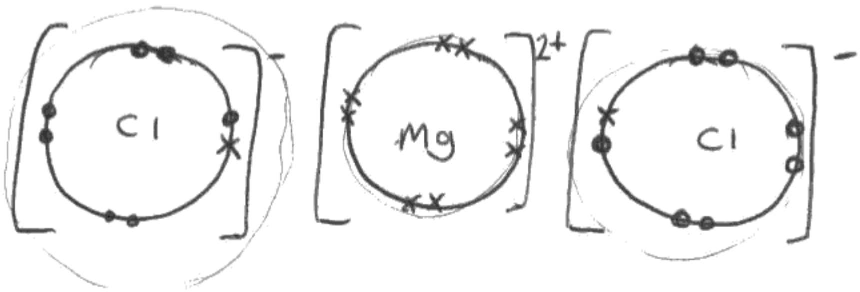
Question 17 (b) (i-ii)

Parts (b)(i) and (b)(ii) elicited many excellent answers from candidates. Occasionally, magnesium chloride was shown as being covalently bonded in (b)(i), whilst the lone pairs of electrons on the chlorine atoms in (b)(ii) were sometimes omitted.

(b) Chlorine forms compounds with magnesium and with carbon.

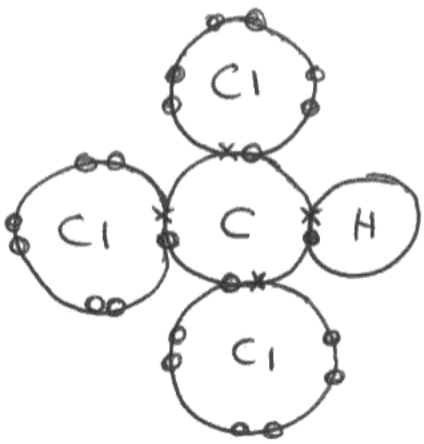
(i) Draw a dot and cross diagram to show the electronic structure of the compound magnesium chloride (only the outer electrons need be shown). Include the charges present.

(2)



(ii) Draw a dot and cross diagram to show the electronic structure of the compound tetrachloromethane (only the outer electrons need be shown).

(2)



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(b)(i) is correct and is awarded both marks.
(b)(ii) scores the first mark (for the four shared pairs of electrons around the central carbon atom).
No second mark has been given for (b)(ii) as an H atom has been included instead of the fourth Cl atom in CCl_4.

Question 17 (c)

Overall, this question was well-answered with the majority of candidates scoring at least one mark. The minority who thought that preparing magnesium chloride from hydrochloric acid was the process with the higher atom economy mistakenly did so as they reasoned that hydrogen was a useful extra by-product.

(c) Magnesium chloride may be prepared from magnesium by reaction with chlorine or with hydrochloric acid. Compare these two preparations in terms of the atom economies of the reactions. No calculation is required.

(2)

the magnesium + chlorine reaction has high atom economy because no waste products are produced whereas with magnesium + hydrochloric acid hydrogen is also released.

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Examiner Comments

Two marks were awarded.
The first mark is awarded as the answer mentions that hydrogen is also produced in the reaction between magnesium and dilute hydrochloric acid.
The higher atom economy for the direct combination of magnesium with chlorine is implied - so the second mark is also awarded.

Question 18 (a)

Most candidates understood that the accompanying product with propene, in the cracking reaction of decane described in the question, was heptane (C_7H_{16}). Marks were awarded for correct structural or displayed formulae, although molecular formulae were expected.

18 Alkenes are unsaturated hydrocarbons which, because of their reactivity, are important industrial starting materials. Alkenes for industrial use are obtained by cracking alkanes.

(a) Write the equation for the cracking of decane ($C_{10}H_{22}$) to form 1 molecule of propene as the only alkene.

(1)

$$C_{10}H_{22} \rightarrow C_2H_4 + C_8H_{18}$$

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Examiner Comments

No mark is awarded here, as ethene is given as the alkene instead of propene. Also octane has been given as the alkane instead of heptane.

18 Alkenes are unsaturated hydrocarbons which, because of their reactivity, are important industrial starting materials. Alkenes for industrial use are obtained by cracking alkanes.

(a) Write the equation for the cracking of decane ($C_{10}H_{22}$) to form 1 molecule of propene as the only alkene.

(1)

$C_{10}H_{22}(l) \rightarrow C_7H_{16}(l) + C_3H_6(g)$

Decane → Heptane + Propene

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Examiner Comments

The mark was awarded.
Note: State symbols were not essential for this equation.

Question 18 (b) (i)

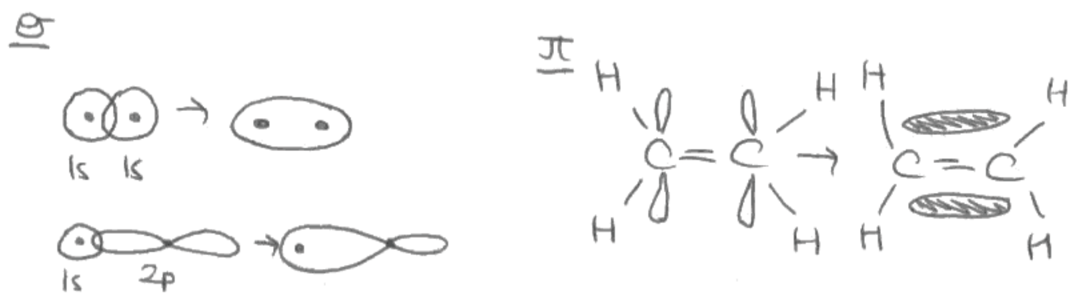
Most candidates understood the difference between sigma and pi-bonds. In such cases, candidates were able to represent these bonds using appropriately annotated diagrams. Sideways overlap of p-orbitals was correctly shown to illustrate the formation of a pi-bond. Free rotation around a sigma-bond, and restricted rotation around a pi-bond, was sometimes mentioned.

(b) The carbon–carbon double bond in alkenes consists of a σ and a π bond.

(i) Explain, using diagrams, the difference between the σ and the π bond in the carbon–carbon double bond of an alkene.

(4)

Diagrams



Explanation

A sigma bond is the direct "end-on" overlap of two 's' orbitals, an 's' and a 'p' orbital or two 'p' orbitals. A pi bond is the overlap of two 'p' orbitals in an atom, it is the bond most likely to break in a reaction.

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The diagram for sigma-bonding shows overlap as required along the line between the two nuclei. Evidence on a diagram such as that showing the electron density as a result of the overlap of the two s-orbitals is an acceptable way of showing the region of (high) electron density between the two nuclei in the sigma bond. So this scores the second mark. Ditto for the 1s and 2p resultant electron density.
Dumb-bells for p-orbitals scores third mark (diagram) and electron density shown above and below the line between the two nuclei is also evident from the diagram, hence the fourth mark is also awarded.

Question 18 (b) (ii)

Over half the candidates who sat the paper knew that alkenes underwent electrophilic addition.

Question 18 (b) (iii)

Most candidates understood that pi-bonds are weaker than sigma-bonds. The accessibility of pi-electrons to attack by electrophiles was mentioned less frequently.

*(iii) By considering the strength and structure of the π bond, explain why alkenes are more reactive than alkanes.

(2)

Alkanes just have a sigma bond, sigma bonds are stronger than pi bonds, while the alkene has a weak pi bond this is easily broken so it is less stable than an alkane so is more reactive.

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Examiner Comments

One out of the two available marks was awarded.
One mark was given for noting that the sigma-bond is stronger than a pi-bond. No second mark here as there is no mention of the accessibility of pi-bonds (to electrophiles) or any comment about the electron density in a pi-bond.

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Examiner Tip

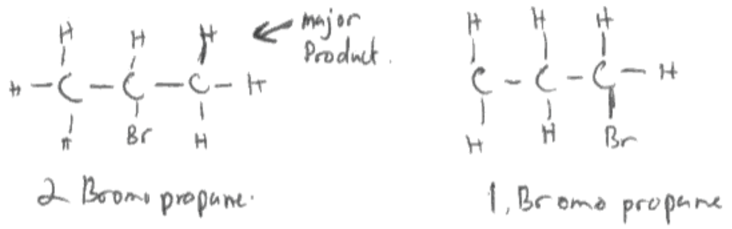
For a two mark question such as this, remember to make two separate points correctly to secure both marks.

Question 18 (c)

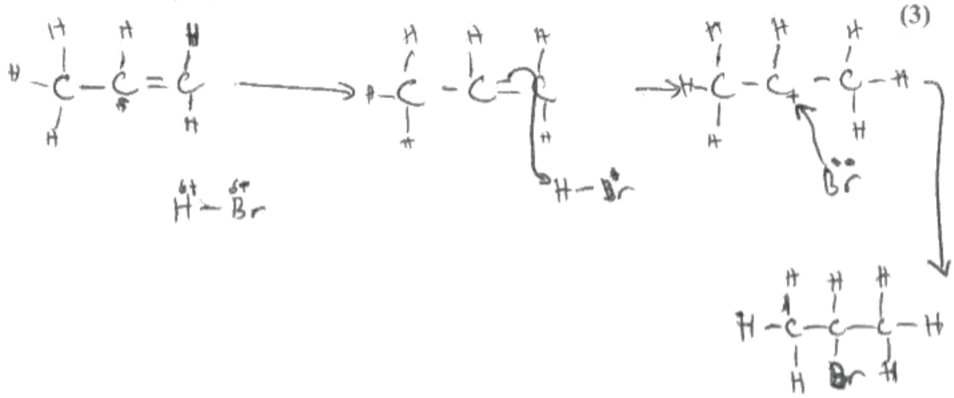
In (c)(i), a significant majority of students gave correct displayed formulae for the two isomers of bromopropane. Structural formulae, instead of displayed formulae, were given by some candidates. The mark for the major product could be awarded from the end product of the mechanism drawn in (c)(ii), if overlooked in a candidate's answer to (c)(i). Many excellent mechanisms were drawn in (c)(ii), but explanations in terms of the relative stability of the two possible carbocations were rare in (c)(iii).

(c) When propene reacts with hydrogen bromide, there are two possible products.

(i) Draw a displayed formula of each of these products and label the major product. **(2)**



(ii) Give the mechanism for the reaction of propene with hydrogen bromide which forms the major product. **(3)**



(iii) Explain, by referring to the mechanism, why the major product is formed. **(2)**

because hydrogen like to join on the carbon atom with the most hydrogens bonds. therefore in makes the bond with the last carbon atom.

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Examiner Comments

In (c)(i), the displayed formula of 1-bromopropane is incorrect (missing a hydrogen), but the major product has been correctly identified so one out of two marks awarded.
In (c)(ii), one mark is awarded for the correct carbocation structure.
In (c)(iii), neither mark is obtained.

Question 18 (d) (i)

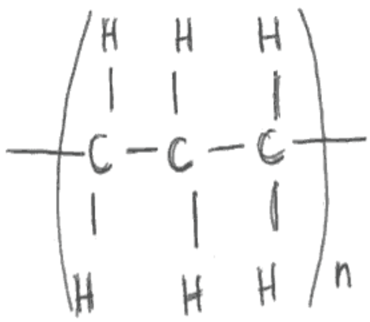
Candidates appreciated that the repeat unit of poly(propene) has continuation bonds at each end. Some candidates gave the correct repeat unit, but others gave the structure of poly(ethene) with three linear carbon atoms. The requirement to give a balanced equation for the process was often overlooked.

(d) The polymer poly(propene) is manufactured from propene.

(i) Write an equation for the polymerization, drawing the displayed formula of the repeat unit of poly(propene).

(3)

$C_3H_6 + uv \rightarrow C_3H_6^{\bullet\bullet}$



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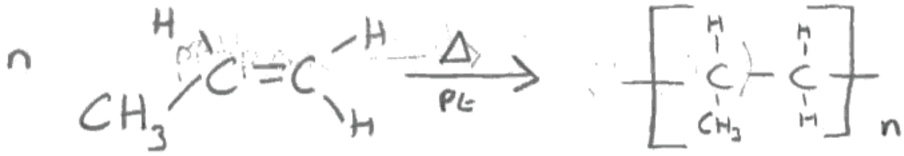
Examiner Comments

Three-carbon poly(ethene) has been drawn.
One mark, for the continuation bonds at each end of the repeat unit, has been awarded.

(d) The polymer poly(propene) is manufactured from propene.

(i) Write an equation for the polymerization, drawing the displayed formula of the repeat unit of poly(propene).

(3)



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Examiner Comments

All three marks were awarded:
"n" on each side of the arrow and the correct formula for propene (first mark). Correct repeat unit (second mark). Continuation bond at each end of the repeating unit (third mark).

Question 18 (d) (ii)

Many candidates lost marks by using terms such as "recycle" or "biodegradable" in an incorrect context. Many good answers explained that landfill sites can be saved by the polymer breaking down in sunlight. Only a minority could give correct answers to each part of the question.

(ii) UV radiation causes poly(propene) to degrade. Suggest one advantage and one disadvantage of this.

(2)

Advantage: so that it can be broken down after use and recycled

Disadvantage: it is hard to control what products it would form

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Examiner Comments

The first mark was not awarded if there is any mention of "recycle". This negates the mark that would have been awarded for "...it can be broken down after use..."

The second mark was not awarded for this response.

Question 19 (a-b (i))

In (a)(i), the majority of candidates demonstrated competence in calculating the heat energy produced.

In (a)(ii), candidates were, in general, successful at calculating the number of moles of ethanol burned. In some cases, however, answers were rounded up to 0.02 (i.e. to only one significant figure).

In (a)(iii), the correct value for the enthalpy change for the combustion of ethanol was calculated, but the negative sign was often overlooked.

Part (b)(i) was found to be challenging, with the answer from (a)(iii) divided by 1370 and multiplied by 100, instead of initially subtracting the value given in (a)(iii) from 1370 and then calculating the percentage error.

(i) Calculate the heat energy produced by the combustion of the alcohol using the equation

heat energy produced (J) = mass of water × 4.18 × temperature change

(1)

250 × 4.18 × 10.5

= 10972.5 J

(ii) Calculate the number of moles of ethanol burned in this experiment (the formula of ethanol is C_2H_5OH).

(3)

$\frac{0.74}{46} = 0.02$

(iii) Use the equation below to calculate the enthalpy change of combustion of ethanol in kJ mol^{-1}. Give the value an appropriate sign.

ΔH = heat energy produced ÷ number of moles

(2)

$\frac{10972.5}{0.02} = \frac{548625 \text{ J mol}^{-1}}{1000} = 548.6 \text{ kJ mol}^{-1}$

~~5486~~ −549 kJ mol^{-1}

(b) The data book value for the enthalpy change of combustion of ethanol is −1370 kJ mol^{-1}.

(i) Calculate the percentage error in the value calculated in (a)(iii) in comparison with the data book value.

(1)

$\frac{821}{1370} \times 100 = 60\%$

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(a)(i) is correct, so one mark is awarded. (a)(ii) scored the first two marks (for the mass of ethanol burned, by subtraction, and the molar mass of ethanol). No third mark was given as the moles of ethanol burned were rounded to one significant figure. (a)(iii) is consequentially correct, so two marks have been awarded. (b)(i) The mark is awarded as this is consequentially correct.

Question 19 (b) (ii)

Most candidates appreciated that heat loss to the surroundings is a significant factor in explaining the discrepancy between laboratory results and those from a data book. Incomplete combustion and evaporation of hot ethanol were mentioned less frequently in candidates' responses.

(ii) List **three** ways in which the design of the experiment causes the results to be so different from the data book value. (You should be specific but detailed explanations are not required.)

(3)

1 There was no lagging or lid on the beaker so some of the energy would escape into the outside environment.

2 There was no gaurd around the spirit burner to direct the heat so some of the energy might have escaped into the outside environment.

3 Ethanol is very volitile so some of it may have evapourated off and was not burnt.

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Examiner Comments

First mark was awarded for heat loss from the beaker. The second mark was awarded as not all the heat from the flame reaches the water in the beaker. Third mark was awarded for mentioning the evaporation of the alcohol.

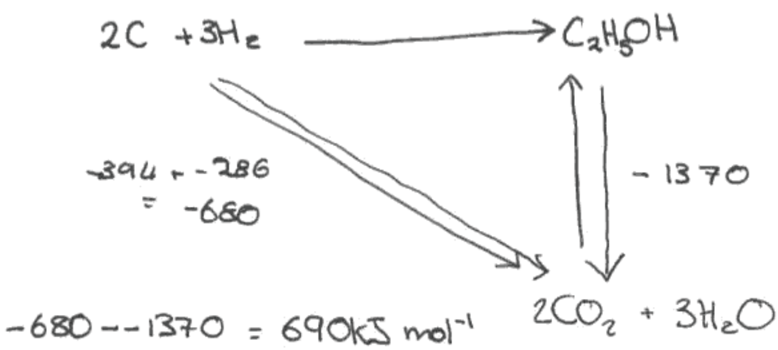
Question 19 (b) (iii)

A large majority of candidates gained some credit for their answer to this calculation question. Full marks were frequently awarded, showing that many candidates have a good understanding of Hess cycles.

(iii) Use the data book values for enthalpy changes of combustion given in the table below to calculate the enthalpy change of formation of ethanol.

(3)

Substance	Enthalpy change of combustion / kJ mol^{-1}
C(s, graphite)	–394
H_2(g)	–286
C_2H_5OH(l)	–1370



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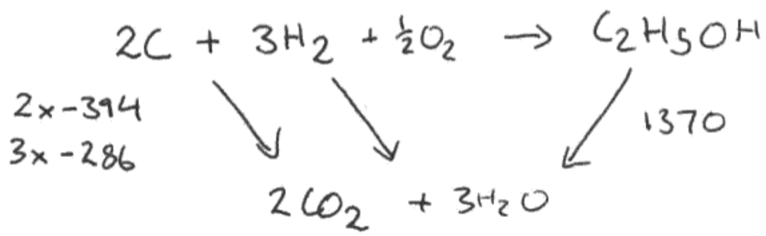
Examiner Comments

690 scores two marks. [Note: the + sign is in brackets in the mark scheme.] The total of the enthalpy changes of combustion of the reactants minus those of the products has been calculated, but without doubling the value for carbon and tripling the value for hydrogen (this counts as one error).

(iii) Use the data book values for enthalpy changes of combustion given in the table below to calculate the enthalpy change of formation of ethanol.

(3)

Substance	Enthalpy change of combustion / kJ mol^{-1}
C(s, graphite)	–394
H_2(g)	–286
C_2H_5OH(l)	–1370



((2x-394) +(3x-286)) + 1370 = -276 kJmol^{-1}

ResultsPlus
Examiner Comments

Three marks were awarded. An excellent response.

ResultsPlus
Examiner Tip

Learn all thermochemical definitions and practise more on Hess cycle questions.

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