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Mark Scheme (Results)

October 2021

Pearson Edexcel International Advanced Subsidiary Level
In Chemistry (WCH11)
Paper 01: Structure, Bonding and Introduction to Organic Chemistry

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

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Using the mark scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit. ( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.

Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer. ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities. Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

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Section A

Question Number	Answer	Mark
1(a)	**The only correct answer is C** (10) ***A*** *is incorrect because this is the ratio by mass* ***B*** *is incorrect because in the mass ratio the unit of kg has been ignored and this is based on 10 mg of sulfur in 1 g of fuel* ***D*** *is incorrect because this is based on 10 g of sulfur in 1 kg of fuel*	**(1)**

Question Number	Answer	Mark
1(b)	**The only correct answer is A** (0.024 dm^3) ***B*** *is incorrect because the molar mass of sulfur has not been taken into account* ***C*** *is incorrect because the mass ratio has been ignored* ***D*** *is incorrect because the units of mg have been ignored*	**(1)**

Question Number	Answer	Mark
2	**The only correct answer is D** ($Cl^+(g) \rightarrow Cl^{2+}(g) + e^-$) ***A*** *is incorrect because the equation represents an electron is added to an ion rather than being removed* ***B*** *is incorrect because the equation represents electrons being added to an atom* ***C*** *is incorrect because one electron is being removed from each of two atoms*	**(1)**

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Question Number	Answer	Mark
3(a)	**The only correct answer is B** (electrons are removed from molecules or atoms and positive ions are formed) ***A*** *is incorrect because the sample has been vaporised previously* ***C*** *is incorrect because electrons are not added to atoms (in this mass spectrometer)* ***D*** *is incorrect because acceleration occurs in region* ***S***	**(1)**

Question Number	Answer	Mark
3(b)	**The only correct answer is A** (ions with a greater mass have a smaller deflection) ***B*** *is incorrect because ions with a greater mass have a smaller deflection* ***C*** *is incorrect because ions with a greater charge have a greater deflection* ***D*** *is incorrect because ions are not speeded up in a magnetic field*	**(1)**

Question Number	Answer	Mark
4(a)	**The only correct answer is B** (0.029) ***A*** *is incorrect because this is just the number of moles of sodium* **C** *is incorrect because this assumes the number of moles of sodium is 0.1* **D** *is incorrect because this is the concentration in g* dm^{-3}	**(1)**

Question	Answer	Mark

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Number		
4(b)	**The only correct answer is A** (120) ***B*** *is incorrect because the mole ratio of 1:1 has been used* ***C*** *is incorrect because the mole ratio has been taken as 2:1 rather than 1:2* ***D*** *is incorrect because the mass of sodium has been taken as the number of moles*	**(1)**

Question Number	Answer	Mark
4(c)	**The only correct answer is A** ($H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$) ***B*** *is incorrect because the water has been ignored* ***C*** *is incorrect because the sulfuric acid has not been shown as ions* ***D*** *is incorrect because all the ions are shown but none are cancelled*	**(1)**

Question Number	Answer	Mark
4(d)	**The only correct answer is A** (29.1 %) ***B*** *is incorrect because this is the percentage ratio of magnesium hydroxide to sodium sulfate* ***C*** *is incorrect because this is the percentage ratio of magnesium hydroxide to magnesium sulfate* ***D*** *is incorrect because this is the percentage mole ratio of the product*	**(1)**

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Question Number	Answer	Mark
5	**The only correct answer is C** ($N^{3-} > O^{2-} > F^{-}$) ***A*** *is incorrect because the size of positive ions decreases across Period 3* ***B*** *is incorrect because the size of positive ions increases down Group 1* ***D*** *is incorrect because the size of negative ions increases down Group 6*	**(1)**

Question Number	Answer	Mark
6	**The only correct answer is C** (d) ***A*** *is incorrect because the s block elements don't form stable 3+ ions* ***B*** *is incorrect because the elements which form stable 3+ ions do not have 21 electrons* ***D*** *is incorrect because elements in the f block have more than 21 electrons*	**(1)**

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Question Number	Answer	Mark
7(a)	**The only correct answer is C** (392.0) ***A*** *is incorrect because the brackets have been ignored* ***B*** *is incorrect because the mass of water has been omitted* ***D*** *is incorrect because the iron has been doubled*	**(1)**

Question Number	Answer	Mark
7(b)	**The only correct answer is D** (ionic, covalent and dative covalent) ***A*** *is incorrect because there are both dative covalent and covalent bonds within the ions* ***B*** *is incorrect because there are dative covalent bonds within the ions* ***C*** *is incorrect because there are covalent bonds within the ions*	**(1)**

Question Number	Answer	Mark
7(c)	**The only correct answer is C** (3.01×10^{23}) ***A*** *is incorrect because only one ammonium, one iron and one sulfate ion have been included* ***B*** *is incorrect because the iron ions have not been included* ***D*** *is incorrect because the water molecules have been included*	**(1)**

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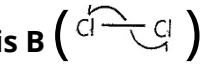
Question Number	Answer	Mark
8	**The only correct answer is B** (Li< Be< B< C) ***A*** *is incorrect because the melting temperatures of Group 7 elements increase going down the group* ***C*** *is incorrect because the melting temperatures of Group 1 elements decrease going down the group* ***D*** *is incorrect because silicon has the* ***highest*** *melting temperature in Period 3*	**(1)**

Question Number	Answer	Mark
9	**The only correct answer is B** (polar, non-polar) ***A*** *is incorrect because the* SF_6 *molecule is non-polar* ***C*** *is incorrect because the S-F bond is polar and the* SF_6 *molecule is non-polar* ***D*** *is incorrect because the S-F bond is polar*	**(1)**

Question Number	Answer	Mark
10(a)	**The only correct answer is B**  ***A*** *is incorrect because the curly arrow indicates heterolytic fission* ***C*** *is incorrect because both arrows are full arrows rather than half arrows* ***D*** *is incorrect because the arrows are in the wrong direction*	**(1)**

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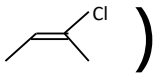
Question Number	Answer	Mark
10(b)	**The only correct answer is D** (HCl) ***A*** *is incorrect because ethane could be formed by the combination of two methyl radicals* ***B*** *is incorrect because chloromethane could be formed by the combination of a methyl radical and a chlorine radical* ***C*** *is incorrect because dichloromethane could be formed from the combination of* CH_2Cl *radical and a chlorine radical*	**(1)**

Question Number	Answer	Mark
11(a)	**The only correct answer is A** () ***B*** *is incorrect because it is Z-1-chlorobut-2-ene* ***C*** *is incorrect because it is Z-2-chlorobut-2-ene* ***D*** *is incorrect because it is E-1-chlorobut-2-ene*	**(1)**

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Question Number	Answer	Mark
11 (b)	**The only correct answer is D** (11) ***A*** *is incorrect because the C-H bonds and the sigma C-C have not been counted* ***B*** *is incorrect because some of the C-H bonds have not been counted* ***C*** *is incorrect because the C-C bond on the alkene bond has not been counted*	**(1)**

(Total for Section A = 20 marks)

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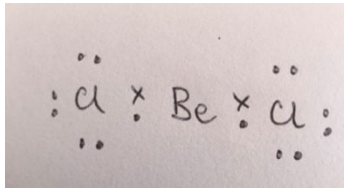
Section B

Question Number	Answer	Additional Guidance	Mark
12(a)	• $2s^2$ **(1)** • $2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2$ **(1)**	Ignore extra $1s^2$ for both Be and Ca Accept $p_x^2\ p_y^2\ p_z^2$ for p^6	**(2)**

Question Number	Answer	Additional Guidance	Mark
12(b)	Answer that shows ..... • 2 single covalent bonds **(1)** • 6 non-bonding electrons shown on chlorine **(1)**	Example of correct dot-and-cross diagram:  Allow non-bonding electrons unpaired Allow all dots or all crosses Allow shared electrons on the axis of the bond If Ca in place of Be Max 1 Ignore line showing covalent bond Ignore overlapping circles Ionic bond scores 0 overall Reject incorrect total number of electrons for M2	**(2)**

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Question Number	Answer	Additional Guidance	Mark
12(c)	• a line/covalent bond is when electron(s) come from both/each atom(s) **(1)** • arrow / dative covalent/ co-ordinate bond which is (a lone pair of) electrons donated from chlorine/ (only) one atom **(1)**	Ignore references to attraction between bonding pair and nucleus. Do not award any statement stating that the donation comes from Beryllium	**(2)**

Question Number	Answer	Additional Guidance	Mark
12(d)	• bond angle in $BeCl_2$(g)/linear is 180° **(1)** • bond angle in $BeCl_2$(s)/polymeric is 109.5^o **(1)** • electron pairs/bonds repel each other to minimise repulsion **(1)** • 4 electron pairs/bonds in solid **or** 2 bonding pairs/2 bonds (no lone pairs) in gas **(1)**	Ignore references to shape ALLOW any bond angle between 110° and 95°. [98° actual value] Ignore references to shape Allow to a maximum separation Do not award repulsion between atoms/elements or between lone pairs Ignore references to lp-lp/lp-bp repulsion	**(4)**

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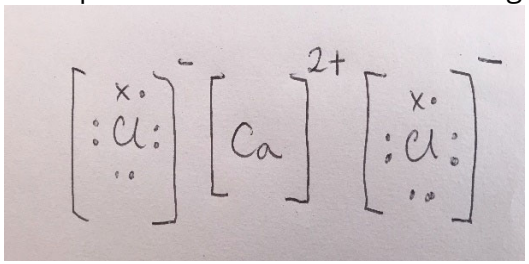
Question Number	Answer	Additional Guidance	Mark
12(e)	• correct charges shown and two chloride ions **(1)** • electronic configuration of all ions **(1)**	Example of correct dot-and-cross diagram  Accept Ca with 8 electrons Allow all dots or all crosses or any combination Ignore inner electron shells	**(2)**

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Question Number	Answer	Additional Guidance	Mark
12(f)	• Beryllium is smaller /has fewer electron shells/ has a higher charge density (than calcium) OR beryllium is more electronegative (than calcium) **(1)** • Beryllium ion/ Be^{2+} is more polarising (than calcium /ion Ca^{2+}) OR calcium loses (outer) electrons more easily (than beryllium) OR difference in electronegativity between calcium and chlorine is greater (than between beryllium and chlorine) **(1)** • beryllium-chlorine bond has a higher degree of covalency (than calcium-chlorine bond) **(1)**	Allow beryllium is more polarising than calcium Accept bonding in beryllium chloride is (more) covalent/ bonding in calcium chloride is (more) ionic. M3 is dependent on either M1 or M2 being scored Allow reverse arguments throughout	**(3)**

(Total for Question 12 = 15 marks)

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Question Number	Answer	Additional Guidance	Mark
13(a)(i)	• expression for calculation of RAM of silicon **(1)** • answer to two decimal places **(1)**	Example of calculation: $\frac{(28 \times 92.17) + (29 \times 4.71) + (30 \times 3.12)}{100}$ =28.1095 =28.11 Allow units g mol^{-1}/a.m.u only Correct answer scores 2 Allow TE from incorrect expression if answer lies between 28 and 30.	**(2)**

Question Number	Answer	Additional Guidance	Mark
13(a)(ii)	Some silicon atoms (of mass 28) lose two electrons/have a charge of 2+	Allow (formation of) Si^{2+} Do not award "atoms of mass 14"	**(1)**

Question Number	Answer	Additional Guidance	Mark
13(a)(iii)	^{28}Si 14 14 ^{29}Si 14 15 ^{30}Si 14 16		**(1)**

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Question Number	Answer	Additional Guidance	Mark
13(b)	• **all** atoms are joined together by covalent bonds/giant covalent(structure) **(1)** • these are strong / take a lot of energy to break (so melting temperature is very high) **(1)** • no electrons are free (to move)/ mobile/delocalised/ (so charge cannot be carried) **(1)**	Allow correct description of covalent bond Do not award intermolecular forces/ ionic bonds/ double covalent bonds. Ignore stoichiometry even if incorrect. Ignore high boiling temperature Ignore no free moving ions	**(3)**

Question Number	Answer	Additional Guidance	Mark
13(c)	• calculation of number of moles **(1)** • calculation of whole number mole ratio **(1)** • empirical formula **(1)**	Example of calculation $\frac{12}{40.1}$ $\frac{8.43}{28.1}$ $\frac{14.47}{16}$ OR 0.299 : 0.30 : 0.904 1 : 1 : 3 $CaSiO_3$ Correct formula with no working scores 1 mark only TE on use of atomic numbers Incorrect symbol(s) in formula loses M3	**(3)**

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Question Number	Answer		Additional Guidance	Mark
13(d)	• calculation of moles carbon dioxide	**(1)**	Example of calculation: 3÷44 = 0.06818	**(4)**
	• conversion of temperature to K	**(1)**	273 + 5 = 278	
	• rearrangement of expression	**(1)**	$V=\frac{0.06818 \times 8.31 \times 278}{1.3 \times 10^{5}}$ $(=1.2116 \times 10^{-3} m^3)$	
	• evaluation of answer in cm^3	**(1)**	=1211.6/1212/1210/1200 (cm^3) TE throughout but do not award M4 for negative volume Ignore SF except 1 SF Correct answer with no working scores 4 marks	

(Total for Question 13 = 14 marks)

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Question Number	Answer	Additional Guidance	Mark
14(a)	• there is a "jump"/much bigger increase between the third and fourth ionisation energies **(1)** • (First) 3 electrons in outer shell **(1)**	Accept fourth electron is removed from a different (quantum) **shell** (which is closer to the nucleus)	**(2)**

Question Number	Answer	Additional Guidance	Mark
14(b)(i)	• the number of protons increases /nuclear charge increases **(1)** • the additional electrons are in the same shell/same energy level/ little additional shielding from electrons **(1)**	Allow "same shielding" Ignore references to atomic radius even if incorrect Ignore electron repulsion	**(2)**

Question Number	Answer	Additional Guidance	Mark
14(b)(ii)	• the first electron is removed from a (3)p orbital/subshell in aluminium/ (3)s orbital/subshell from magnesium **(1)** • p electron(s) shielded by the s electrons (so requires less energy)/ p energy level is higher than s energy level **(1)**	Do not award 2p/2s	**(2)**

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Question Number	Answer	Additional Guidance	Mark
14(c)(i)	An answer that makes reference to • delocalised /free (to move) electrons /sea of electrons **(1)** • attracted to (a lattice of) metal/aluminium/positive **ions/cations** **(1)**	Allow charges up to 3+ Correct fully labelled diagram scores 2 marks Ignore attraction of electrons to nuclei	**(2)**

Question Number	Answer	Additional Guidance	Mark
14(c)(ii)	An answer that makes reference to **two** of the following: • (delocalised) electrons can move/carry charge **(1)** • aluminium has low density/light (weight) **(1)** • aluminium is ductile/can be drawn into wires **(1)** • aluminium forms an inert/oxide layer **(1)**	Allow good conductor of **electricity** Ignore malleable, strong, heat resistant, high melting temperature.	**(2)**

Question Number	Answer	Additional Guidance	Mark
14(d)(i)	**2** Al + **3** H_2O → **Al_2O_3** + **$3H_2$**	Allow multiples Ignore state symbols even if incorrect	**(1)**

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Question Number	Answer	Additional Guidance	Mark
14(d)(ii)	An answer that makes reference to **two** of the following: • reduces greenhouse gas emissions / carbon dioxide **and** which affects climate change / global warming **(1)** • the production of hydrogen is portable **(1)** • fossil fuels are non-renewable (unlike water) **(1)** • aluminium can be recycled **(1)**	Allow reduces sulfur dioxide emissions **and** which reduces acid rain Do not award references to ozone depletion, carbon neutral Ignore renewable Ignore landfill, atom economy, references to cost	**(2)**

(Total for Question 14 = 13 marks)

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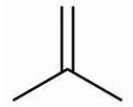
Question Number	Answer	Additional Guidance	Mark
15(a)	An answer that makes reference to: • the mixture is boiled/ vapourised/ (fractionally) distilled **(1)** • distillate condensing at a suitable temperature (range) is collected **(1)**	Do not award cracking/reforming Allow correct references to collecting fractions at different heights/temperatures (in the fractionating column) Allow simple descriptions of fractional distillation e.g. separated by boiling point/ temperature Do not award references to molecular mass or to melting temperature.	**(2)**

Question Number	Answer	Additional Guidance	Mark
15(b)(i)	($C_{18}H_{38}$ → $2C_4H_8$ +) $C_{10}H_{22}$		**(1)**

Question Number	Answer	Additional Guidance	Mark
15(b)(ii)	• cis **and** trans skeletal formulae **(1)** • 2-methylpropene **(1)**	 **and**   Allow 1 mark for three correct non-skeletal formulae Ignore bond lengths and angles	**(2)**

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<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>15(b)(iii)</td><td>
<table>
<tr><th>Product</th><th>Name</th><th>Structural formula</th></tr>
<tr><td>1</td><td>1,2-dichlorobutane</td><td>$CH_3CH_2CHClCH_2Cl$</td></tr>
<tr><td>2</td><td>butane</td><td>$CH_3CH_2CH_2CH_3$</td></tr>
<tr><td>3</td><td>butan(e)-1,2-diol</td><td>$CH_3CH_2CHOHCH_2OH$</td></tr>
<tr><td>4</td><td>butan(e)-2-ol</td><td>$CH_3CH_2CHOHCH_3$</td></tr>
</table>
(4)
</td><td>8 correct points scores 4 marks
6 or 7 correct points scores 3 marks
4 or 5 correct points scores 2 marks
2 or 3 correct points scores 1 mark

Allow displayed / skeletal formulae
If two types of formula are shown both must be correct to score the point.
Ignore punctuation errors , misplaced numbers e.g. 1,2-butan diol and connectivity of pendant -OH group.

Penalise omission of “an” in 3 and 4 once only
Penalise wrong number of carbon atoms once only
Award 1 point for butan-1-ol and correct formula in Product 4</td><td>(4)</td></tr>
</table>

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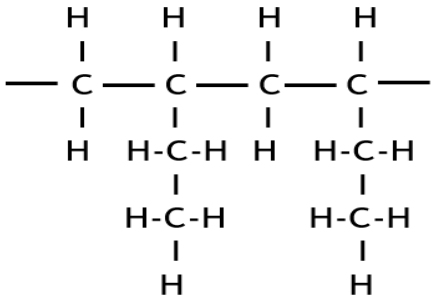
Question Number	Answer	Additional Guidance	Mark
15(c)	• correct repeat unit **(1)** • two repeat units **and** continuation bonds **(1)** ALLOW C_2H_5, CH_2CH_3 as pendant group	 Ignore brackets and n Allow ethyl groups on C2 and C3 or C1 and C4 M2 depends on M1 or near miss e.g. attachment of pendant group or use of alternative 4-carbon monomer alkene producing a valid polymer i.e. poly(but-2-ene)/poly(methylpropene). Do not award a dimer	**(2)**

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Question Number	Answer	Additional Guidance	Mark
15(d)	• energy is produced /can be used to generate electricity or heat locally Or prevents polymers going to landfill/storage/taking up space **(1)** • toxic/harmful/corrosive gases/substances may be produced Or particulates/soot may be produced **(1)**	Allow production of hydrogen Ignore non-biodegradable, non-renewable, reduces polymer waste/pollution a named gas e.g. sulfur dioxide, hydrogen cyanide, dioxin without qualification is insufficient Do not award references to climate change	**(2)**

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Question Number	Answer		Additional Guidance	Mark
15(e)(i)	• volume CO_2 produced	**(1)**	Example of calculation: 4 x 35 = 140 (cm^3)	**(3)**
	• volume of oxygen used	**(1)**	6.5 x 35 = 227.5/228 (cm^3)	
	• total volume of gas remaining	**(1)**	300-227.5 + 140 (cm^3) =212.5/213 (cm^3)	
	Alternative method • moles CO_2 produced	**(1)**	Alternative method 35 / 24000 = 1.4583 x 10^{-3} / 1.458 x 10^{-3} /1.46 x 10^{-3} 1.4583 x 10^{-3} x 4 = 5.8333 x 10^{-3} / 5.83 x 10^{-3} or 5.84 x 10^{-3} if rounded previously	
	• moles oxygen remaining	**(1)**	300/24000 = 1.25 x 10^{-2} (1.46 x 10^{-3}) x 6.5 = 9.49 x 10^{-3} moles (1.25 x 10^{-2}) – (9.49 x 10^{-3}) = 3.01 x 10^{-3} (mol)	
	• total volume remaining	**(1)**	[(5.83 x 10^{-3}) + (3.01 x 10^{-3})] x 24000 = 212.16/212 (cm^3) Allow TE throughout. Correct answer with no working scores 3 marks IGNORE SF except 1 SF	

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Question Number	Answer	Additional Guidance	Mark
15(e)(ii)	• **carbon monoxide** may be produced (incomplete combustion may occur) **(1)** • which is toxic/combines(irreversibly) with haemoglobin/ **(1)**	Do not award particulates M2 depends on clear link to gas produced by burning butane Ignore references to flammability of butane/global warming/greenhouse gases If no other mark awarded allow 1 mark for carbon dioxide causes suffocation.	**(2)**

(Total for Question 15 = 18 marks)

(Total for Section B = 60 marks)
(Total for Paper = 80 marks)

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