Mark Scheme (Results)

January 2019

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.

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.

Section A (Multiple Choice)

Question number	Answer	Mark
1	**The only correct answer is B** (8 neutrons and 10 electrons) ***A*** *is incorrect because in a negative ion the number of electrons should be more than the number of protons* ***C*** *is incorrect because the numbers of neutrons and electrons are incorrect* ***D*** *is incorrect because oxygen has 8 neutrons and hydrogen has 0*	**(1)**

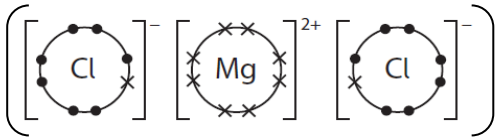
Question number	Answer	Mark
2	**The only correct answer is B** (28.2) ***A*** *is incorrect because this is the mass number of the most abundant isotope* ***C*** *is incorrect because this is the average of the mass numbers without considering their abundances* ***D*** *is incorrect because the percentages have been mixed up*	**(1)**

Question number	Answer	Mark
3	 **The only correct answer is D** ***A*** *is incorrect because the 1s and 2s electrons should be paired* ***B*** *is incorrect because the 2s electrons should be paired* ***C*** *is incorrect because the 2p electrons should not be paired*	**(1)**

Question number	Answer	Mark
4	**The only correct answer is D** (3p subshell 6, third quantum shell 18) ***A*** *is incorrect because 2 is the number of electrons in a 3p orbital and the 3d electrons have been omitted from the third quantum shell* ***B*** *is incorrect because 2 is the number of electrons in a 3p orbital* ***C*** *is incorrect because the 3d electrons have been omitted from the third quantum shell*	**(1)**

Question number	Answer	Mark
5	**The only correct answer is B** (Group 3) ***A*** *is incorrect because the biggest jump is after the third ionisation energy not after the second* ***C*** *is incorrect because the biggest jump is not after the fourth ionisation energy* ***D*** *is incorrect because the biggest jump is not after the fifth ionisation energy*	**(1)**

Question number	Answer	Mark
6	**The only correct answer is D** (1000) ***A*** *is incorrect because this is less than the first ionisation energy of sodium and phosphorus has 4 more protons* ***B*** *is incorrect because this is less than the first ionisation energy of aluminium and phosphorus has 2 more protons* ***C*** *is incorrect because this is less than the first ionisation energy of silicon and phosphorus has 1 more proton*	**(1)**

Question number	Answer	Mark
7	**The only correct answer is D**  ***A*** *is incorrect because magnesium chloride has ionic bonding* ***B*** *is incorrect because magnesium chloride has ionic bonding* ***C*** *is incorrect because the charges are incorrect*	**(1)**

Question number	Answer	Mark
8	**The only correct answer is C** (ions and delocalised electrons) ***A*** *is incorrect because this is ionic bonding* ***B*** *is incorrect because atoms do not attract delocalised electrons* ***D*** *is incorrect because this is covalent bonding*	**(1)**

Question number	Answer	Mark
9	**The only correct answer is C** (*more protons than N^{3-} but the same number of electrons as N^{3-}*) ***A*** *is incorrect because Al^{3+} has more protons and the same number of electrons as N^{3-}* ***B*** *is incorrect because Al^{3+} has the same number of electrons as N^{3-}* ***D*** *is incorrect because Al^{3+} has more protons and the same number of electrons as N^{3-}*	**(1)**

Question number	Answer	Mark
10	**The only correct answer is B** (Mg^{2+}) ***A*** *is incorrect because anions are polarised and do not cause polarisation* ***C*** *is incorrect because Na^+ has less polarising ability than Mg^{2+} as it has a larger radius and a lower charge* ***D*** *is incorrect because anions are polarised and do not cause polarisation*	**(1)**

Question number	Answer	Mark
11	**The only correct answer is C** (ICl_4^-) ***A*** *is incorrect because CCl_4 is tetrahedral* ***B*** *is incorrect because CH_4 is tetrahedral* ***D*** *is incorrect because NH_4^+ is tetrahedral*	**(1)**

Question number	Answer	Mark
12	**The only correct answer is D** (general formula) ***A*** *is incorrect because boiling temperature increases as the number of carbon atoms increases* ***B*** *is incorrect because density increases as the number of carbon atoms increases* ***C*** *is incorrect because the alkanes have different empirical formulae*	**(1)**

Question number	Answer	Mark
13	**The only correct answer is A** (accepts a pair of electrons) ***B*** *is incorrect because electrophiles never have a negative charge* ***C*** *is incorrect because not all electrophiles have a positive charge* ***D*** *is incorrect because nucleophiles donate a pair of electrons*	**(1)**

Question number	Answer	Mark
14	**The only correct answer is B** (5) ***A*** *is incorrect because there are 5 structural isomers – hexane, 2-methylpentane, 3-methylpentane, 2,2-dimethylbutane and 2,3-dimethylbutane* ***C*** *is incorrect because there are 5 structural isomers* ***D*** *is incorrect because there are 5 structural isomers*	**(1)**

Question number	Answer	Mark
15	**The only correct answer is A** (*E*-2-chlorobut-2-ene) ***B*** *is incorrect because the two highest priority groups are opposite to each other* ***C*** *is incorrect because chlorine is on the second carbon atom* ***D*** *is incorrect because chlorine is on the second carbon atom and the two highest priority groups are opposite to each other*	**(1)**

Question number	Answer	Mark
16	**The only correct answer is C** (bonds broken σ and π, bonds made σ only) ***A*** *is incorrect because a π bond also breaks in ethene and only σ bonds are made* ***B*** *is incorrect because a σ bond also breaks in hydrogen* ***D*** *is incorrect because* only σ *bonds are made*	**(1)**

Question number	Answer	Mark
17	**The only correct answer is A** ($Ca + 2HNO_3 \rightarrow Ca(NO_3)_2 + H_2$) ***B*** *is incorrect because the formulae of nitric acid and calcium nitrate are incorrect* ***C*** *is incorrect because the formula of nitric acid is incorrect* ***D*** *is incorrect because the formula of calcium nitrate is incorrect*	**(1)**

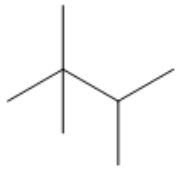
Question number	Answer	Mark
18	**The only correct answer is B** (0.424 g) **A** *is incorrect because this is the answer using a molar mass of 83 g* mol^{-1} *from* $NaCO_3$ ***C*** *is incorrect because this is the answer just using the volume and a concentration of 1 mol* dm^{-3} ***D*** *is incorrect because this is the answer just using the concentration and not the volume*	**(1)**

Question number	Answer	Mark
19	**The only correct answer is A** (6.0×10^{-2} g) ***B*** *is incorrect because* 12×10^{-6} *has been multiplied by 5 instead of 5000* ***C*** *is incorrect because* 12×10^{-6} *has been divided by 5 instead of multiplied by 5000* ***D*** *is incorrect because* 12×10^{-6} *has been divided by 5000 instead of multiplied*	**(1)**

Question number	Answer	Mark
20	**The only correct answer is A** (0.36 dm^3) ***B*** *is incorrect because the 2:1 mole ratio has not been used* ***C*** *is incorrect because the mole ratio has been used as 1:2 instead of 2:1* ***D*** *is incorrect because the mass has not been converted to moles*	**(1)**

Section B

Question number	Answer	Additional guidance	Mark
21(a)(i)	An answer that makes reference to the following: • Heptane / petrol containing heptane: burns less efficiently / smoothly (than branched chains / cycloalkanes) **or** does not combust efficiently **or** causes pre-ignition / knocking	Allow burns for combusts and vice versa Allow reverse argument e.g. petrol burns more efficiently with no / small amount of heptane Allow the octane number would be low / zero Ignore: It does not ignite / burn easily It is difficult / harder to combust Just 'less efficient' without reference to combustion Incomplete combustion Amount of CO_2 produced Causes auto-ignition References to toxicity and flammability	**(1)**

Question Number	Answer	Additional guidance	Mark
21(a)(ii)	• 	Ignore bond lengths and bond angles Ignore structural or displayed formulae as working Ignore skeletal formula with any CH_3 groups specified	**(1)**

Question number	Answer	Additional guidance	Mark
21(a)(iii)	• correct equation	Example of equation: $C_7H_{16} \rightarrow C_7H_{14} + H_2$ Allow multiples Ignore any other type of formulae	**(1)**

Question number	Answer	Additional guidance	Mark
21(a)(iv)	An explanation that makes reference to the following points: • (oxides of nitrogen / these compounds) dissolve in / react with / combine with / mix with water **(1)** • (to form nitric / nitrous) acid(s) / acidic solution / acid rain **(1)**	Ignore any reference to oxides of sulfur / sulfur dioxide / sulfuric acid in answer Allow moisture / rain / clouds for water Ignore react with air / oxygen Allow decreases pH of solution / rain	**(2)**

Question number	Answer	Additional guidance	Mark
21(b)(i)	• initiation (step / reaction)	Allow initiating (step) Ignore free radical / homolytic / chain / initial (step) Do not award heterolytic	**(1)**

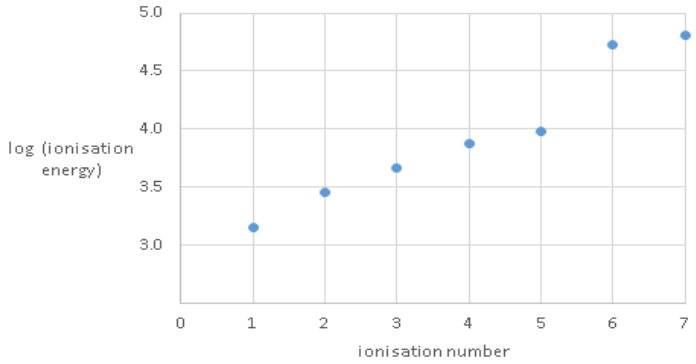
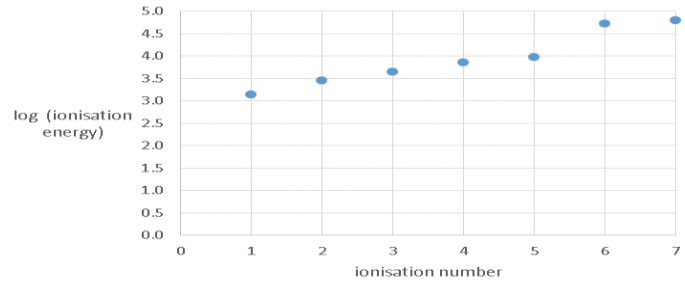
Question number	Answer	Additional guidance	Mark
21(b)(ii)	• $C_7H_{16} + Cl\bullet \rightarrow C_7H_{15}\bullet + HCl$ **(1)** • $C_7H_{15}\bullet + Cl_2 \rightarrow C_7H_{15}Cl + Cl\bullet$ **(1)**	Allow propagation steps in either order Allow • anywhere on correct species Ignore curly arrows, even if incorrect Do not award • on species that are not radicals Penalise omission of • or incorrect number of hydrogens in heptane once only in b(ii), b(iii) and b(iv)	**(2)**

Question number	Answer	Additional guidance	Mark
21(b)(iii)	• $C_7H_{15}\bullet + C_7H_{15}\bullet \rightarrow C_{14}H_{30}$	TE on alkyl radical in (b)(ii) Do not award product written as $2C_7H_{15}$ / $C_7H_{15}C_7H_{15}$	**(1)**

Question number	Answer	Additional guidance	Mark
21(b)(iv)	An explanation that makes reference to the following points: • chlorine(free) radical / atom / Cl• removes another hydrogen (atom in the product / chloroheptane) **(1)** • (this free) radical reacts with another chlorine molecule / Cl_2 (to form dichloroheptane) **or** (this free) radical reacts with a chlorine radical / atom / Cl• (to form dichloroheptane) **(1)**	TE on alkyl radical in (b)(ii) Allow $C_7H_{15}Cl + Cl• \rightarrow C_7H_{14}Cl• + HCl$ Ignore Cl• substitutes a H atom Allow $C_7H_{14}Cl• + Cl_2 \rightarrow C_7H_{14}Cl_2 + Cl•$ **or** $C_7H_{14}Cl• + Cl• \rightarrow C_7H_{14}Cl_2$ Ignore just 'further substitution' Ignore $C_7H_{16} + 2Cl_2 \rightarrow C_7H_{14}Cl_2 + 2HCl$ Any answer that shows 2Cl substituted in one step	**(2)**

(Total for Question 21 = 11 marks)

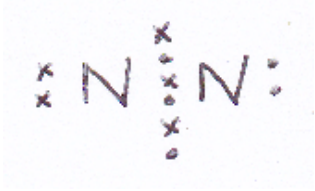
<table>
<tr><th>Question number</th><th>Answer</th><th>Additional guidance</th><th>Mark</th></tr>
<tr><td>22(a)(i)</td><td>• two correct values</td><td><table><tr><td>(6)</td><td>(53 268)</td><td>4.73</td></tr><tr><td>(7)</td><td>(64 362)</td><td>4.81</td></tr></table>
Both numbers correct and must be to 2 d.p.</td><td>(1)</td></tr>
</table>

Question number	Answer	Additional guidance	Mark
22(a)(ii)	• axes correct way round **and** linear scale **and** points covering at least half the grid horizontally **(1)** • both axes labelled **(1)** • points plotted correctly **(1)**	Example of graph:  Allow  **Labels**: Allow log(IE / kJ mol^{-1}) Do not award log(IE) / kJ mol^{-1} **Points**: TE on values in table for 6th and 7th log(IE) Allow ±1 small square Allow points joined by lines / bar chart Ignore lines drawn from x axis to each point Do not award a best fit straight line Do not award lines joined to the origin	**(3)**

Question number	Answer	Additional guidance	Mark
22(a)(iii)	An answer that makes reference to the following: • the range of numbers / 1402 to 64362 is too large (to fit on a graph / axis) **or** logarithms make it easier to plot the numbers	Allow: A (very) long y axis would be needed (Some of) the numbers are too large The difference between the ionisation energies is too large So the numbers will fit on the graph Allow logs give smaller (range of) numbers	**(1)**

Question number	Answer	Additional guidance	Mark
22(a)(iv)	An explanation that makes reference to the following points: • the (large) jump (between ionisations 5 and 6) shows the start of a new (quantum) shell **(1)** • there are two electrons that are harder to remove and they are closer to the nucleus **(1)** • there are five electrons that are easier to remove and they are further from the nucleus **(1)**	Penalise use of orbitals instead of shells once only Allow any answer relating the jump / large increase to two (quantum) shells Allow jump linked to **1s** and **2s** sub-shells Do not award jump between incorrect numbers Allow there are two electrons in the inner (quantum) shell Allow there are five electrons in the outer (quantum) shell / five valence electrons	**(3)**

Question number	Answer	Additional guidance	Mark
22(a)(v)	An explanation that makes reference to the following points: **Oxygen** • oxygen (atom) loses a paired electron (from a 2p orbital / 2p sub-shell) **or** oxygen electron is lost from a full (2p) orbital **(1)** **Nitrogen** • nitrogen (atom) loses an electron from a singly-occupied orbital **or** nitrogen loses an electron from a half-filled subshell **(1)** **Repulsion** • there is (more) repulsion between **paired** electrons (than between electrons in different orbitals so less energy is required to remove the electron in oxygen) **(1)**	Penalise mention of incorrect orbital e.g. 3p once only Ignore any reference to nuclear charge / numbers of protons / shielding / atomic radius Allow M1 and M2 from diagrams showing electrons in boxes Allow oxygen has a pair of electrons in a (2)p orbital **or** there is spin pairing in oxygen in a (2)p orbital Allow nitrogen has no paired electrons in the (2)p sub-shell / (2)p orbitals **or** nitrogen only has 1 electron in each (2)p orbital / has 3 unpaired (2)p electrons / has a half-filled (2)p sub-shell / has half-filled (2)p orbitals Do not award just 'nitrogen has a half-filled p orbital'	**(3)**

Question number	Answer	Additional guidance	Mark
22(b)(i)	• dot-and-cross diagram	Example of dot-and-cross diagram:  Allow overlapping circles Allow all dots / all crosses Allow dots and crosses in any order in the triple bond Allow the dots and crosses side-by-side in the triple bond e.g. x o x o x o Allow the non-bonded electrons on each N shown separately Ignore inner shell electrons, even if incorrect Ignore lines as bonds e.g. x x x o o o	**(1)**

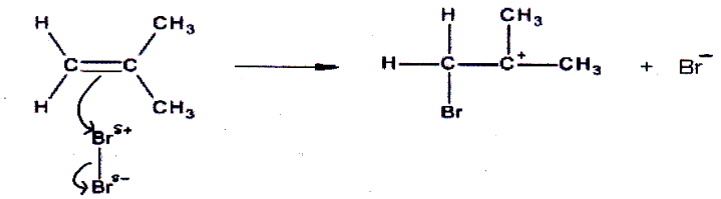
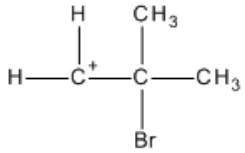
Question number	Answer	Additional guidance	Mark
22(b)(ii)	• calculation of moles of nitrogen atoms **(1)** • calculation of number of nitrogen atoms **(1)**	Example of calculation: mol N_2 = $\frac{5.60}{28}$ = 0.20 **and** mol N atoms = 0.20 x 2 = 0.40 **or** $\frac{5.60}{14}$ = 0.40 number of N atoms = 0.40 x 6.02 x 10^{23} =2.408 x 10^{23} / 2.41 x 10^{23} /2.4 x 10^{23} TE on moles of nitrogen Ignore SF except 1SF Correct answer with no working scores (2)	**(2)**

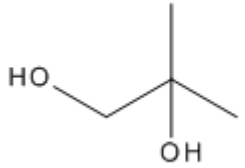
Question number	Answer		Additional guidance	Mark
22(b)(iii)			Example of calculation:	**(4)**
	• conversion of volume to m^3	**(1)**	volume of N_2 = $\frac{108}{1 \times 10^6}$ = 1.08×10^{-4} m^3	
	• conversion of temperature to K	**(1)**	temperature = 25 + 273 = 298 K	
	• rearrangement of ideal gas equation	**(1)**	$n = \frac{pV}{RT}$ **or** $n = \frac{1.36 \times 10^5 \times 1.08 \times 10^{-4}}{8.31 \times 298}$ TE on volume and temperature	
	• evaluation to give n	**(1)**	n = 5.9312×10^{-3} / 0.0059312 (mol) Conditional on correctly rearranged equation in M3 Ignore SF except 1SF Correct answer with no working scores full marks	

(Total for Question 22 = 18 marks)

Question number	Answer	Additional guidance	Mark
23(a)	• CH_2	Allow H_2C Ignore C_nH_{2n} / C_4H_8 Do not award C_3H_6	(1)

Question number	Answer	Additional guidance	Mark
23(b)	• there are two hydrogens / both hydrogens on one of the carbons (in C=C) **or** there are two / both methyl / CH_3 groups on one of the carbons (in C=C)	Allow there are two identical (functional) groups / atoms on each carbon (in C=C) Allow there is not CH_3 and H on each carbon (in C=C) Allow there are not 2 different (functional) groups / atoms on each carbon (in C=C) Do not award two identical groups on the top / bottom of the double bond Do not award molecule or radical for ((functional) groups / atoms	(1)

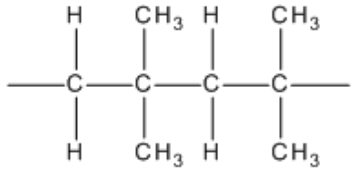
Question number	Answer	Additional guidance	Mark
23(c)	• dipole on bromine molecule **and** final product **(1)** • curly arrow from C=C to Br **and** curly arrow from Br-Br to, or just beyond, Br **(1)** • intermediate **(1)** • lone pair on Br^- **and** curly arrow from lone pair to positive charge **(1)**	Example of mechanism:   Allow intermediate with positive charge on other carbon atom  Allow full marks for using formula 2 / any combination of structural and displayed formula Penalise half arrow heads once only Do not award δ+ on intermediate in M3 Do not award δ- on Br in M4	**(4)**

Question number	Answer	Additional guidance	Mark
23(d)(i)	• skeletal formula	Example of skeletal formula:  Ignore bond lengths and bond angles Do not allow O-H-C horizontally	(1)

Question number	Answer	Additional guidance	Mark
23(d)(ii)	• (From)purple (to) colourless	Both colours needed for the mark Allow pink or violet for purple Ignore clear	(1)

Question number	Answer	Additional guidance	Mark
23(d)(iii)	• hydrogen bromide / HBr	Ignore state symbols (g) / (l) / (aq) / (s) Do not award bromine	(1)

Question number	Answer	Additional guidance	Mark
23(d)(iv)	An explanation that makes reference to the following points: • (2-bromo-2-methylpropane is formed from a) tertiary carbocation / tertiary intermediate **(1)** • (tertiary carbocation / intermediate) is more stable than primary (carbocation) **or** a tertiary carbocation is the **most** stable **(1)**	Allow a description of a tertiary carbocation Do not award secondary carbocation for M1 Allow primary carbocation is less stable than tertiary Allow secondary carbocation is more stable than primary, if secondary carbocation identified in M1 Ignore just 'tertiary carbocation is more stable' Ignore any explanation of why one cation is more stable than another Ignore any reference to Markovnikov's rule Do not award tertiary **product** is more stable (than primary)	**(2)**

Question number	Answer	Additional guidance	Mark
23(e)	• 4 carbon atoms linked by single bonds **and** both extension bonds **(1)** • rest of structure correct **(1)**	Example of repeat units:  Allow any combination of structural and displayed formulae or skeletal formulae Do not award 1, or more than 2, repeat units / 2 separate repeat units in M1 Penalise one or both extension bonds missing in M1 only M2 is conditional on M1 **or** 1 or more than 2 repeat units / 2 separate repeat units Allow both methyl groups on carbons one and three or two and three or one and four Ignore any brackets and any 'n's or numbers Ignore bond lengths and bond angles Ignore connectivity of CH_3 groups	**(2)**

Question number	Answer	Additional guidance	Mark
23(f)	• calculation / working of mol of alcohol **(1)** • calculation / working of mol of alkene if 58.2% **(1)** • calculation / working of mass of alkene **(1)** • answer given to 2 or 3 SF **(1)** **Alternative method for M2 and M3** • calculation / working of theoretical mass of alkene **(1)** • calculation / working of actual mass of alkene **(1)**	Example of calculation: mol alcohol used = $\frac{6.85}{74}$ = 0.092568 / 9.2568 x 10^{-2} mol alkene if 58.2% = 0.092568 x $\frac{58.2}{100}$ = 0.053874 / 5.3874 x 10^{-2} TE on mol alcohol mass alkene = 0.053874 x 56 = 3.017 (g) TE on mol alkene answer to 2 or 3 SF = 3.0 / 3.02 (g) Conditional on working involving 74 and 56 Correct answer to 2 or 3SF with or without working scores (4) **Alternative method for M2 and M3** mass alkene if 100% = 0.092568 x 56 = 5.1838 (g) TE on mol alcohol mass alkene if 58.2% = 5.1838 x $\frac{58.2}{100}$ = 3.017 (g) TE on theoretical mass	**(4)**

(Total for Question 23 = 17 marks)

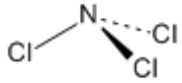
Question number	Answer	Additional guidance	Mark
24(a)	An explanation that makes reference to the following points: • (l) is incorrect because the solutions are aqueous **or** the ions are (in the) aqueous (state) **or** the state symbols should be (aq) instead of (l) **(1)** • silver ions should have one positive charge / Ag^+ **or** silver chloride is AgCl **(1)**	Allow silver nitrate and sodium chloride are aqueous Do not award if incorrect state symbol for one of the species in the equation e.g. Ag is (s) / AgCl is (aq) Ignore just the charge on the silver ion is incorrect / the formula of silver chloride is incorrect	**(2)**

Question number	Answer	Additional guidance	Mark
24(b)	• calculation of mol of C, H and Cl **(1)** • calculation of empirical formula **(1)** • calculation of molecular formula **(1)**	Example of calculation: C : H : Cl mol $\frac{3.09}{12}$: $\frac{0.26}{1}$: $\frac{9.15}{35.5}$ = 0.2575 : 0.26 : 0.2577 (ratio 1 : 1 : 1) Empirical formula is CHCl molar mass CHCl = 12 + 1 + 35.5 = 48.5 $\frac{\text{molar mass } (CHCl)_n}{\text{molar mass CHCl}} = \frac{97}{48.5} = 2$ Molecular formula is $C_2H_2Cl_2$ Allow symbols in any order Do not award 2CHCl Ignore SF in mol and ratio Correct molecular formula with some working scores (3) **Alternative method** scores (3) no. C atoms = $\frac{3.09 \times 97}{12.5 \times 12} = 2 / 1.9982$ no. H atoms = $\frac{0.26 \times 97}{12.5 \times 1} = 2(.0176)$ no. Cl atoms = $\frac{9.15 \times 97}{} = 2$	**(3)**

		12.5 x 35.5 molecular formula is $C_2H_2Cl_2$	

Question number	Answer	Additional guidance	Mark
24(c)(i)	• all 4 ion formulae **(1)** • all 4 (corresponding) *m* / *z* values **(1)**	Example of answer: ions *m* / *z* $N(^{35}Cl)_3^+$ 119 $N(^{35}Cl)_2{}^{37}Cl^+$ 121 $N^{35}Cl(^{37}Cl)_2^+$ 123 $N(^{37}Cl)_3^+$ 125 Allow any other unambiguous way of representing the formulae e.g. in words Allow (1) for any two *m* / *z* values with corresponding ion formulae Ignore missing / incorrect charge on ion Ignore mass number on N Ignore bonds or + between Cl atoms / order of atoms e.g. $N\text{-}^{35}Cl\text{-}^{35}Cl\text{-}^{35}Cl$	**(2)**

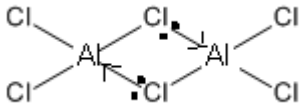
<table>
<tr><th>Question number</th><th>Answer</th><th>Additional guidance</th><th>Mark</th></tr>
<tr>
<td>24(c)(ii)</td>
<td>
• number of bonding pairs
and
number of lone pairs (1)

• shape (1)
• bond angle (1)
</td>
<td>
Example of table:
<table>
<tr><td>Number of bonding pairs of electrons on nitrogen</td><td>3</td></tr>
<tr><td>Number of lone pairs on electrons on nitrogen</td><td>1</td></tr>
<tr><td>Shape of molecule</td><td>trigonal pyramidal</td></tr>
<tr><td>Bond angle</td><td>107°</td></tr>
</table>
Shape:
Allow 3-dimensional drawing e.g.


There must be at least 1 dotted/dashed line or wedge for 3-d
Allow just ‘pyramidal’
Allow pyramid for pyramidal
Do not award tetrahedral

Bond angle:
Allow any number in the range 106-108°
Ignore missing °
</td>
<td>(3)</td>
</tr>
</table>

Question number	Answer	Additional guidance	Mark
24(d)(i)	An explanation that makes reference to one of the following pairs of points: **Polarisation route** • an aluminium ion / cation is (very) small **and** highly charged **or** Al^{3+} has a small ionic radius / is small **(1)** • so it polarises / distorts the chloride ion / Cl^- / anion **(1)** **Allow** **Electronegativity route** • there is a (relatively) small difference in electronegativity between aluminium and chlorine **(1)** • so the electrons are (partially) shared **(1)**	Marks must come from the same route – maximum 1 mark if one point from one route and one point from the other route Allow the aluminium ion has a high charge density Allow a description of polarisation Allow chlorine anion / ion Ignore the aluminium chloride is polarised Ignore size of chloride ion	**(2)**

Question number	Answer	Additional guidance	Mark
24(d)(ii)	A description including the following points: • diagram showing two $AlCl_3$ molecules joined through two chlorine atoms **(1)** • dative (covalent) bonds **or** coordinate bonds **(1)**	Example of diagram:  Allow dot-and-cross diagram Ignore missing arrow heads and lone pairs from diagram Do not award diagram with Al-Al / Cl-Cl bond(s) Allow dative covalent bonds labelled on diagram / shown as arrows from Cl to Al Allow description of dative bonds Allow M2 even if only 1 dative bond shown / mentioned Do not award M2 if dative bonds starting from aluminium Do not award M2 for any answer that mentions ions / ionic bonds	**(2)**

(Total for Question 24 = 14 marks)

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