



Mark Scheme (Results)

October 2023

Pearson Edexcel International Advanced
Subsidiary Level in Chemistry (WCH11)

Paper 01

Unit 1: Structure, Bonding and
Introduction to Organic Chemistry

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November 2023

Question Paper Log Number P75070A

Publications Code WCH11_01_MS_2310


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Section A (multiple choice)

Question Number	Answer	Mark
1	<p>The only correct answer is D (13, 10, 14)</p> <p><i>A is incorrect because this is the number of particles present in a $^{27}_{13}\text{Al}$ atom</i></p> <p><i>B is incorrect because the number of protons and electrons are reversed</i></p> <p><i>C is incorrect because the number of protons and neutrons are reversed</i></p>	(1)

(Total for Question 1 = 1 mark)

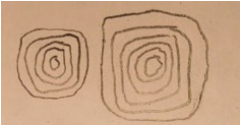
Question Number	Answer	Mark
2	<p>The only correct answer is C ( , 2)</p> <p><i>A is incorrect because the shape is that of an s orbital</i></p> <p><i>B is incorrect because the shape represents an s orbital and the maximum number of electrons in any orbital is 2</i></p> <p><i>D is incorrect because the maximum number of electrons in any orbital is 2</i></p>	(1)

(Total for Question 2 = 1 mark)

Question Number	Answer	Mark
3(a)	<p>The only correct answer is C (C_2^{2-})</p> <p><i>A is incorrect because C_2^- would result in an overall charge of +1 for CaC_2</i></p> <p><i>B is incorrect because C_2^+ would result in an overall charge of +3 for CaC_2</i></p> <p><i>D is incorrect because C_2^{2+} would result in an overall charge of +4 for CaC_2</i></p>	(1)

Question Number	Answer	Mark
3(b)	<p>The only correct answer is A (7.22 g)</p> <p><i>B is incorrect because the molar ratio used is 1:1</i></p> <p><i>C is incorrect because the expression for moles of water is inverted</i></p> <p><i>D is incorrect because the molar ratio used is $2\text{CaC}_2:1\text{H}_2\text{O}$</i></p>	(1)

(Total for Question 3 = 2 marks)

Question Number	Answer	Mark
4	<p>The only correct answer is A ()</p> <p><i>B is incorrect because both ions are the same size</i></p> <p><i>C is incorrect because sodium chloride is not covalent</i></p> <p><i>D is incorrect because sodium chloride is not covalent</i></p>	(1)

(Total for Question 4 = 1 mark)

Question Number	Answer	Mark
5	<p>The only correct answer is D (ionic, covalent, dative covalent)</p> <p><i>A is incorrect because there are covalent bonds within the ammonium ion</i></p> <p><i>B is incorrect because there are ionic bonds between the ions and a dative covalent bond within the ammonium ion</i></p> <p><i>C is incorrect because there is a dative covalent bond within the ammonium ions</i></p>	(1)

(Total for Question 5 = 1 mark)

Question Number	Answer	Mark
6	<p>The only correct answer is B ($1s^22s^22p^63s^23p^1$)</p> <p><i>A is incorrect because the outermost electron is in an orbital closer to the nucleus (than B)</i></p> <p><i>C is incorrect as the nuclear charge is greater (than B), but the outermost electron is in the same sub-shell</i></p> <p><i>D is incorrect because the nuclear charge is greater (than B), but the outermost electron is in the same sub-shell</i></p>	(1)

(Total for Question 6 = 1 mark)

Question Number	Answer	Mark
7	<p>The only correct answer is C (blue, yellow)</p> <p><i>A is incorrect because the chromate(VI) ion is yellow</i></p> <p><i>B is incorrect because the copper(II) ion is blue</i></p> <p><i>D is incorrect because the colours are reversed</i></p>	(1)

(Total for Question 7 = 1 mark)

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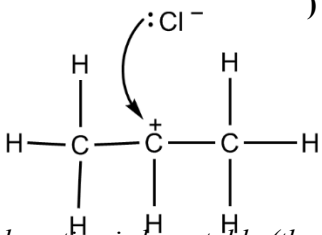


Question Number	Answer	Mark
8	<p>The only correct answer is B (region Q)</p> <p><i>A is incorrect because this is the region where particles are vaporised</i></p> <p><i>C is incorrect because this is the region where particles are accelerated</i></p> <p><i>D is incorrect because this is the region where particles are detected</i></p>	(1)

(Total for Question 8 = 1 mark)

Question Number	Answer	Mark
9	<p>The only correct answer is C (five)</p> <p><i>A is incorrect because the molecular ions have been omitted</i></p> <p><i>B is incorrect because the possibility of molecular ions with m/z ratio of 72 is not considered</i></p> <p><i>D is incorrect because molecular ions consisting of $^{35}\text{Cl} - ^{37}\text{Cl}$ and $^{37}\text{Cl} - ^{35}\text{Cl}$ are considered as distinct particles</i></p>	(1)

(Total for Question 9 = 1 mark)

Question Number	Answer	Mark
10(a)	<p>The only correct answer is C ()</p> <p><i>A is incorrect because the primary carbocation is less stable (than the secondary carbocation)</i></p> <p><i>B is incorrect because the primary carbocation is less stable (than the secondary carbocation) and the arrow should start from a lone pair of electrons</i></p> <p><i>D is incorrect because the arrow should start from a lone pair of electrons</i></p>	(1)

Question Number	Answer	Mark
10(b)	<p>The only correct answer is D (electrophilic addition)</p> <p><i>A is incorrect because the attacking particle is not a free radical and the reaction is not substitution</i></p> <p><i>B is incorrect because the attacking particle is not a free radical</i></p> <p><i>C is incorrect because the reaction is not substitution</i></p>	(1)

(Total for Question 10 = 2 marks)

Question Number	Answer	Mark
11	<p>The only correct answer is B (two)</p> <p><i>A is incorrect because only the second and fourth statements are correct</i></p> <p><i>C is incorrect because only the second and fourth statements are correct</i></p> <p><i>D is incorrect because only the second and fourth statements are correct</i></p>	(1)

(Total for Question 11 = 1 mark)

Question Number	Answer	Mark
12(a)	<p>The only correct answer is B (2.19×10^4)</p> <p><i>A is incorrect because the % has been multiplied by 10^6</i></p> <p><i>C is incorrect because the % has been divided by 10^4</i></p> <p><i>D is incorrect because the % has been divided by 10^6</i></p>	(1)

Question Number	Answer	Mark
12(b)	<p>The only correct answer is A (6.00×10^{-3} g)</p> <p><i>B is incorrect because this is the mass in 400 mg of the solution</i></p> <p><i>C is incorrect because this is the mass in 400 kg of the solution</i></p> <p><i>D is incorrect because this is the mass in 400 tonnes of the solution</i></p>	(1)

(Total for Question 12 = 2 marks)

Question Number	Answer	Mark
13	<p>The only correct answer is B (calcium chloride, 1.39 g, 500 cm³)</p> <p><i>A is incorrect because the concentration of chloride ions is 0.100 mol dm⁻³</i></p> <p><i>C is incorrect because the concentration of chloride ions is 0.100 mol dm⁻³</i></p> <p><i>D is incorrect because the concentration of chloride ions is 0.025 mol dm⁻³</i></p>	(1)

(Total for Question 13 = 1 mark)

Question Number	Answer	Mark
14	<p>The only correct answer is D (2.41×10^{23})</p> <p><i>A is incorrect because the amount of phosgene molecules used in the calculation has been divided by 4</i></p> <p><i>B is incorrect because the amount of phosgene molecules is used in the calculation</i></p> <p><i>C is incorrect because the number of types of atoms is used in the calculation</i></p>	(1)

(Total for Question 14 = 1 mark)

Question Number	Answer	Mark
15	<p>The only correct answer is D (three)</p> <p><i>A is incorrect because there are only three structural isomers</i></p> <p><i>B is incorrect because there are only three structural isomers</i></p> <p><i>C is incorrect because there are only three structural isomers</i></p>	(1)

(Total for Question 15 = 1 mark)

Question Number	Answer	Mark
16	<p>The only correct answer is A (2,11)</p> <p><i>B is incorrect because it does not take into account C-H bonds</i></p> <p><i>C is incorrect because it does not take into account C-H bonds and assumes both parts of the C=C bond are pi bonds</i></p> <p><i>D is incorrect because it assumes both parts of the C=C bond are pi bonds and that each carbon has only 1 C-H bond</i></p>	(1)

(Total for Question 16 = 1 mark)

Question Number	Answer	Mark
17	<p>The only correct answer is C (W and X)</p> <p><i>A is incorrect because only W and X will always pose a risk when stored together</i></p> <p><i>B is incorrect because only W and X will always pose a risk when stored together</i></p> <p><i>D is incorrect because only W and X will always pose a risk when stored together</i></p>	(1)

(Total for Question 17 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

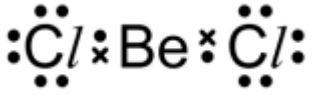
Section B

Question Number	Answer	Additional Guidance	Mark
18(a)(i)	an explanation that makes reference to the following points: <ul style="list-style-type: none">• (there is) an (overall) increase (in first ionisation energy) as the nuclear charge / number of protons increases (across the period) (1)• but the electron removed comes from the same (main quantum) shell / level of shielding is unchanged (1)	Ignore just 'charge increases' Allow same (main) energy level / number of (quantum) shells stays the same / number of electron shells stays the same Allow subshell for shell Ignore references to atomic radius and distance from the nucleus	(2)

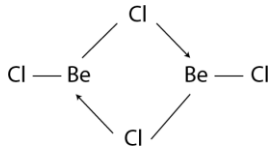
Question Number	Answer	Additional Guidance	Mark
18(a)(ii)	<p>an answer that makes reference to the following points:</p> <ul style="list-style-type: none"> • 1314 (kJ mol⁻¹) (1) • as electrons pair up (in p orbital) / has a full p orbital (1) • which leads to repulsion (causes a lower ionisation energy for oxygen) (1) <p>Alternative for M2 and M3</p> <ul style="list-style-type: none"> • Allow (2p3) half-filled subshell is stable (1) • So oxygen loses an electron more readily to reach this configuration (1) 	<p>Allow any value or range or values between 1200 and 1350 (kJ mol⁻¹)</p> <p>Allow reverse argument for M2 and M3 e.g. nitrogen has unpaired electrons / half filled subshell so less repulsion</p> <p>Comment : pairing of electrons in M2 could be shown via 'electrons in boxes' diagram Ignore any references to shielding</p>	(3)

Question Number	Answer	Additional Guidance	Mark
18(b)(i)	<ul style="list-style-type: none"> • correct species in equation (1) • state symbols (1) 	$\text{Li}^+(\text{g}) \rightarrow \text{Li}^{2+}(\text{g}) + \text{e}^{(-)}$ <p>Accept $\text{Li}^+(\text{g}) - \text{e}^{(-)} \rightarrow \text{Li}^{2+}(\text{g})$</p> <p>Allow $\text{Li}^+(\text{g}) + \text{e}^{(-)} \rightarrow \text{Li}^{2+}(\text{g}) + 2\text{e}^{(-)}$</p> <p>Ignore any state symbols on $\text{e}^{(-)}$</p> <p>Accept '=' instead of '→'</p> <p>Allow state symbols mark on any correct ionisation energy equations removing 1 electron</p>	(2)

Question Number	Answer	Additional Guidance	Mark
18(b)(ii)	<p>an explanation that makes reference to the following points:</p> <p>(2nd ionisation is greater because)</p> <ul style="list-style-type: none"> • (second) electron removed is in a lower (main) energy level / from the inner (main) energy level (1) • removal of an electron reduces electron-electron repulsion causing the ion to contract <p>OR</p> <p>electron removed is closer to the nucleus (1)</p>	<p>Allow shell for energy level Allow second electron removed is from the 1s (orbital / shell / subshell) Allow 'first electron is removed from 2nd shell, 2nd electron is removed from first' Ignore 'new shell'</p> <p>Allow needs more energy to remove an electron from a positive ion / stronger (forces of) attraction to a positive ion / needs more energy to remove an electron as there are now more protons than electrons</p> <p>Allow net charge is greater / effective nuclear charge is greater / nuclear charge is greater as there are more protons than electrons</p> <p>Allow lower / less / low shielding</p> <p>Ignore just 'nuclear charge is greater'</p>	(2)

Question Number	Answer	Additional Guidance	Mark
18(c)(i)	an answer that makes reference to the following point: <ul style="list-style-type: none"> • dot-and-cross diagram 	 <p>Allow all dots or all crosses Allow bonding electrons / electron pairs shown horizontally Do not award ions / ionic bonds</p>	(1)

Question Number	Answer	Additional Guidance	Mark
18(c)(ii)	<p>an answer that makes reference to the following points:</p> <ul style="list-style-type: none"> • linear (1) • 180° (1) • 2 bond pairs / pairs of electrons (around central atom) (1) • (linear shape adopted to) minimise repulsion (between electron pairs) (1) <p>mark independently</p>	<p>Allow TE from (c)(i)</p> <p>Allow TE from (c)(i) e.g. 2bp, 1lp allow 118-120, e.g. 2bp, 2lp 103 - 106</p> <p>Allow two regions of electron density Allow TE from (c)(i)</p> <p>Allow maximise separation (between electron pairs) Allow 'minimise repulsion / maximise separation between bonds'</p>	(4)

Question Number	Answer	Additional Guidance	Mark
18(c)(iii)	<p>an answer that makes reference to the following points:</p> <ul style="list-style-type: none"> <li data-bbox="504 368 1115 400">• diagram of dimer including two arrows (1) <li data-bbox="504 775 1115 807">• dative (covalent bond) (1) 	<div style="text-align: center;">  </div> <p>Arrow heads in correct direction needed for M1</p> <p>Ignore bond angles / shapes in diagram Accept correct dot-and-cross diagram with correct arrows</p> <p>Ignore just covalent (bond) / sigma bond Do not award ionic (bond)</p>	(2)

(Total for Question 18 = 16 marks)

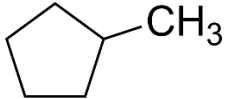
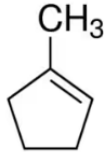
Question Number	Answer	Additional Guidance	Mark
19(a)(i)	<ul style="list-style-type: none"> Expression for weighted mean for energy density (1) calculation of energy density of sample to 2 or 3 SF (1) 	<p><u>example of calculation</u></p> $\frac{(92.2 \times 46.5) + (29.7 \times 7.80)}{100}$ <p>OR</p> $(92.2\% \times 46.5) + (7.8\% \times 29.7)$ <p>= 45.190 = 45 / 45.2 (MJ kg⁻¹)</p> <p>Allow 45000 kJ kg⁻¹ / 45200 kJ kg⁻¹</p> <p>Correct answer with or without working scores 2 marks</p>	(2)

Question Number	Answer	Additional Guidance	Mark
19(a)(ii)	<ul style="list-style-type: none"> calculation of mass of sample 	<p><u>example of calculation</u></p> $0.729 \times 1500 = 1093.5 / 1094 / 1090 / 1100 \text{ (g)}$ <p>Do not award 1093 (g)</p>	(1)

Question Number	Answer	Additional Guidance	Mark
19(a)(iii)	<ul style="list-style-type: none"> calculation of energy released and correct units 	<p><u>example of calculation</u></p> <p>$1093.5 \div 1000 = 1.0935$ $45.190 \times 1.0935 = 49.415 \text{ MJ}$ Accept 49415 kJ Accept $4.9415 \times 10^7 \text{ J}$</p> <p>OR</p> <p>$1093.5 \div 1000 = 1.0935$ $38.1 \times 1.0935 = 41.662 \text{ MJ}$ Accept 41662 kJ Accept $4.1662 \times 10^7 \text{ J}$</p> <p>Allow TE from (i) and (ii) Allow use of rounded values from (i) and (ii) Ignore SF except 1 SF Ignore negative signs Correct answer with no working scores the mark</p> <p>Comment – if a value is given in (a)(i), candidates can still use 38.1 to access the mark here</p>	(1)

Question Number	Answer	Additional Guidance	Mark
19(b)	<p>An answer that makes reference to three of the following points:</p> <ul style="list-style-type: none"> • (increased amount of) ethanol used could be bioethanol / ethanol sourced from plants (1) • from fermentation (of sugars / glucose using yeast) (1) • reducing CO₂ emissions (overall) / (some) CO₂ released in combustion offset by CO₂ used in photosynthesis (1) • less impact on global warming / climate change (1) • uses less of a finite resource (which can then be used in other processes e.g. manufacture of pharmaceuticals) (1) • less pollution from sulfur impurities / less SO₂ emissions (1) 	<p>Allow ethanol can be made from a renewable resource Ignore esterification of vegetable oils (biodiesel)</p> <p>Allow fermentation is a low energy process</p> <p>Allow bioethanol is (nearly) carbon neutral / has a lower carbon footprint</p> <p>Ignore 'crude oil is non-renewable'</p> <p>Comment – allow reverse arguments in context of E5</p>	(3)

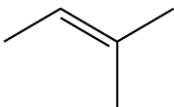
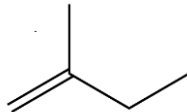

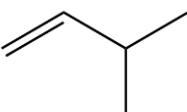
Question Number	Answer	Additional Guidance	Mark
19(c)(i)	An answer that makes reference to the following point: $\text{C}_6\text{H}_{14} \rightarrow \text{C}_6\text{H}_{12} + \text{H}_2$	Allow other types of correct formulae Allow $\text{C}_6\text{H}_{14} \rightarrow \text{C}_6\text{H}_{10} + 2\text{H}_2$ Allow multiples Ignore state symbols even if incorrect	(1)

Question Number	Answer	Additional Guidance	Mark
19(c)(ii)		Allow skeletal, displayed or hybrid formulae mark for (c)(ii) could be evident in c(i) Allow methylcyclopentenes if C_6H_{10} is given in (c)(i) e.g. 	(1)
		No TE from (c)(i)	

Question Number	Answer	Additional Guidance	Mark
19(d)(i)	<p>An explanation that makes reference to the following points:</p> <ul style="list-style-type: none"> (to provide enough energy) to break Cl-Cl bond(s) / for homolytic fission of chlorine (1) to form chlorine radicals / to form Cl• (1) 	<p>Allow Cl₂ → 2Cl• for M2</p> <p>Accept (to form chlorine radicals) without breaking the C-H bonds (in hexane)</p> <p>Do not award ions Do not award chloride radicals</p> <p>Comment</p> $\text{Cl} \begin{array}{c} \curvearrowright \\ \text{---} \\ \curvearrowleft \end{array} \text{Cl} \longrightarrow 2\text{Cl}^\bullet$ <p>Scores M1 for LHS and M2 for RHS</p>	(2)

Question Number	Answer	Additional Guidance	Mark
19(d)(ii)	<p>An answer that makes reference to the following points:</p> <ul style="list-style-type: none"> • equation for propagation step (1) • equation for termination step (1) 	$\text{Cl}^\bullet + \text{C}_6\text{H}_{14} \rightarrow \cdot\text{C}_6\text{H}_{13} + \text{HCl}$ $(\cdot\text{C}_6\text{H}_{13} + \text{Cl}_2 \rightarrow \text{Cl}^\bullet + \text{C}_6\text{H}_{13}\text{Cl})$ $2\cdot\text{C}_6\text{H}_{13} \rightarrow \text{C}_{12}\text{H}_{26}$ <p>Allow $\text{C}_6\text{H}_{13}^\bullet$ for hexyl radical</p> <p>Do not award if additional termination equations are shown</p> <p>Penalise omission of unpaired electron once only</p> <p>Comment – if $\text{C}_{12}\text{H}_{26}$ used as the reactant alkane allow TE for M2</p> $2\text{C}_{12}\text{H}_{25}^\bullet \rightarrow \text{C}_{24}\text{H}_{50}$	(2)

(Total for Question 19 = 13 marks)

Question Number	Answer	Additional Guidance	Mark
20(a)(i)	<p>An answer that makes reference to the following points:</p> <ul style="list-style-type: none"> <li data-bbox="533 395 1077 512">•  (1) <li data-bbox="533 550 1077 694">•  (1) <li data-bbox="533 790 1077 917">•  (1) <li data-bbox="533 981 1077 1109">•  (1) 	<p>Allow displayed, structural or hybrid formulae</p> <p>Ignore any working e.g. additional partially complete displayed formulae with a carbon chain only</p> <p>Ignore any names, even if incorrect</p>	(4)

Question Number	Answer	Additional Guidance	Mark
20(a)(ii)	<p>An explanation that makes reference to the following points:</p> <ul style="list-style-type: none"> There are two different groups on each of the carbon atoms in the C=C bond / double bond (1) The C=C bond has restricted rotation / cannot rotate (so the groups are locked in position) (1) 	<p>Allow there are two different groups on either side of the C=C bond / double bond Allow there are two different groups on opposite sides of the C=C bond / double bond Allow 'each carbon atom in the C=C bond / double bond has only 1 hydrogen' Ignore 'there are two different groups beside the C=C bond' Allow 'The C=C bond has restricted rotate'</p>	(2)

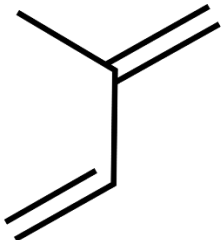
Question Number	Answer	Additional Guidance	Mark
20(b)(i)	<ul style="list-style-type: none"> <i>E</i>-2,3-dichlorobut-2-ene 	Allow trans-2,3-dichlorobut-2-ene Ignore punctuation errors e.g. additional commas, spaces, missing hyphens etc	(1)

Question Number	Answer	Additional Guidance	Mark
20(b)(ii)	an answer that makes reference to the following points: <ul style="list-style-type: none"> (the student is correct that the alkene has polar bonds, as) the C-Cl bonds are polar (1) As Cl is more electronegative (than C) (1) but the molecule is not polar as it is symmetrical / has no net dipole (moment) / has an even distribution of charge (1) 	Allow dipole shown on structure in stem Allow 'there is a difference in electronegativity (between C and Cl)' Allow 'the molecule is not polar as it is symmetric' Allow molecule has no overall dipole Allow 'dipoles / charges cancel'	(3)

Question Number	Answer	Additional Guidance	Mark
20(c)(i)	<ul style="list-style-type: none"> calculation of number of moles 	<u>Example of calculation</u> $5.51 \div 204 = 0.027010$ (mol) Correct answer with no working scores 1 Ignore SF except 1SF Ignore incorrect units	(1)

Question Number	Answer	Additional Guidance	Mark
20(c)(ii)	<ul style="list-style-type: none"> rearrangement of ideal gas equation (1) conversion of temperature and volume to appropriate units (1) calculation of moles of hydrogen (1) 	<u>Example of calculation</u> $n = pV \div RT$ M1 may be subsumed in M3 423 (K), 1873×10^{-6} (m ³) Allow 423 (K), 1873×10^{-3} (dm ³), 152 (kPa) Allow 423.15K (which gives final answer of 0.080963) $= \frac{(152 \times 10^3) \times (1873 \times 10^{-6})}{8.31 \times 423}$ $= 0.080992 / 0.08099 / 0.0810 / 0.081$ (mol) Correct answer with no working scores 1 Allow TE from M2 to M3 Ignore SF except 1SF Penalise use of 1 SF once only in (c)(i) and (c)(ii)	(3)

Question Number	Answer	Additional Guidance	Mark
20(c)(iii)	<ul style="list-style-type: none"> determination of ratio between moles of α-bisabolene : moles of hydrogen and hence number of C=C bonds 	<p><u>Example of calculation</u></p> <p>$0.080992 \div 0.02701 = 2.9986$, so 3 C=C bonds</p> <p>Allow TE from c(i) and c(ii) but must be nearest whole number</p> <p>Do not award non integer answers</p>	(1)

Question Number	Answer	Additional Guidance	Mark
20(d)(i)		Allow displayed, structural or hybrid formulae	(1)

Question Number	Answer	Additional Guidance	Mark
20(d)(ii)	<ul style="list-style-type: none"> <li data-bbox="562 810 1178 839">• calculation of molar mass of repeat unit (1) <li data-bbox="562 1018 1252 1078">• calculation of number of repeat units as whole number (1) 	<p data-bbox="1335 740 1608 769"><u>example of calculation</u></p> <p data-bbox="1335 807 1368 836">68</p> <p data-bbox="1335 874 1823 935">Comment – no TE from (i) as repeat unit given in stem in order to find molar mass</p> <p data-bbox="1335 1011 1592 1072">$50250 \div 68 = 738.97$ = 739 repeat units</p> <p data-bbox="1335 1114 1778 1238">Allow 738 units Allow TE from M1 to M2 for correct integer value either side of calculated value</p>	(2)

Question Number	Answer	Additional Guidance	Mark
20(e)	<p>An answer that makes reference to the following points:</p> <p>use of Ca(OH)₂</p> <ul style="list-style-type: none"> • (basic so) will neutralise HCl / SO₂ / NO_x / CO₂ (in waste gases) (1) <p>use of fine powder</p> <ul style="list-style-type: none"> • large surface area and to ensure fast reaction / increase rate of reaction (1) 	<p>(Allow basic) so will neutralise acids (in waste gases) Allow 'react with', 'absorb', 'capture' for neutralise in M1 Do not award CO / NO / any non-acidic gases Ignore 'prevent CO₂ from going in to the atmosphere'</p> <p>Ignore absorb</p>	(2)

(Total for Question 20 = 20 marks)

Question Number	Answer	Additional Guidance	Mark
21(a)(i)	<ul style="list-style-type: none"> calculation of relative formula mass 	<p><u>Example of calculation</u> $[(3 \times 58.7) + 12 + (3 \times 16) + (4 \times 17) + (4 \times 18)]$</p> <p>(=) 376.1</p> <p>Ignore any units</p>	(1)

Question Number	Answer	Additional Guidance	Mark
21(a)(ii)	<ul style="list-style-type: none"> calculation of relative formula masses of all products / reactants (1) <p>Comment M1 can be awarded for expression $376.1 + (3 \times 142.1)$ or $(3 \times 154.8) + 106 + (4 \times 40) + (4 \times 18)$ if 802.4 not shown</p> <ul style="list-style-type: none"> calculation of atom economy (1) 	<p><u>Example of calculation</u> $376.1 + (3 \times 142.1) = 802.4$ Allow 802.1 (use of 32 for S) Allow TE from (a)(i) OR $(3 \times 154.8) + 106 + (4 \times 40) + (4 \times 18) = 802.4$ Allow 802.1 (use of 32 for S)</p> <p>$(376.1 \div 802.4) \times 100 = 46.872 \%$ Allow TE from M1 Allow $(376.1 \div 802.1) \times 100 = 46.889 \%$ Ignore SF except 1 SF</p> <p>Correct answer with some / no working scores (2) Comment – M2 awarded for a percentage not for the raw value e.g. 0.46889 scores M1 but not M2</p>	(2)

Question Number	Answer	Additional Guidance	Mark
21(a)(iii)	An answer that makes reference to the following point: <ul style="list-style-type: none"> because basic nickel(II) carbonate has a giant structure / lattice structure 	Allow has an ionic lattice / ionic (compound) / consists of ions Allow does not consist of individual molecules / it is not molecular / it is not a (simple) molecule	(1)

Question Number	Answer	Additional Guidance	Mark
21(b)(i)	An answer that makes reference to the following point: <ul style="list-style-type: none"> electronic configuration of Ni²⁺ 	1s ² 2s ² 2p ⁶ 3s ² 3p ⁶ 3d ⁸ Allow [Ar] 3d ⁸ Ignore 4s ⁰	(1)

Question Number	Answer	Additional Guidance	Mark
21(b)(ii)	An answer that makes reference to the following point: <ul style="list-style-type: none"> $3\text{Ni}^{2+} + \text{CO}_3^{2-} + 4\text{OH}^- + 4\text{H}_2\text{O} \rightarrow \text{Ni}_3\text{CO}_3(\text{OH})_4 \cdot 4\text{H}_2\text{O}$ 	Ignore missing / incorrect state symbols	(1)

Question Number	Answer	Additional Guidance	Mark
21(c)(i)	<ul style="list-style-type: none"> • conversion of volume of CO₂ into dm³ (1) • calculation of moles of CO₂ (1) • calculation of moles of XSO₄ using ratio from equation (1) • calculation of the relative formula mass of XSO₄ (1) <p>Comment Allow conversion of molar gas volume to 24000 cm³ mol⁻¹ and use of 150 cm³ for M1 and M2</p>	<p><u>Example of calculation</u></p> <p>150 ÷ 1000 = 0.15 (dm³)</p> <p>0.15 ÷ 24 = 6.25 × 10⁻³ (mol)</p> <p>6.25 × 10⁻³ × 2 = 0.0125 (mol)</p> <p>1.995 ÷ 0.0125 = 159.6</p> <p>Ignore units for RFM Allow TE throughout Ignore SF except 1 SF</p> <p>Correct answer with some working scores (4)</p> <p>Correct answer with no working scores M4 only</p>	(4)

Question Number	Answer	Additional Guidance	Mark
21(c)(ii)	<ul style="list-style-type: none"> <li data-bbox="633 325 996 352">Deduction of identity of X 	<p data-bbox="1335 288 1608 316"><u>Example of calculation</u></p> <p data-bbox="1335 352 1798 379">$159.6 - (32.1 + 64) = 63.5$ so Cu / Cu²⁺</p> <p data-bbox="1335 421 1823 480">If 159.6 given in (c)(i) then allow just Cu / Cu²⁺</p> <p data-bbox="1335 523 1787 582">Allow TE from (c)(i) for any element consistent with calculated RFM – 96.1</p> <p data-bbox="1335 625 1823 722">e.g. failure to multiply by 2 in (i) leads to a RFM of 319.2, which is consistent with Fr in (ii)</p>	(1)

(Total for Question 21 = 11 marks)

(Total for Section B = 60 marks)

Total for Paper = 80 marks

