



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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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)

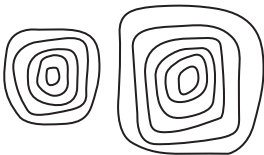
Question Number	Answer	Mark
2	<p>The only correct answer is C ( , 2)</p> <p><i>A is incorrect because the shape is that of an s orbital</i></p> <p><i>B is incorrect because the shape represents an s orbital and the maximum number of electrons in any orbital is 2</i></p> <p><i>D is incorrect because the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

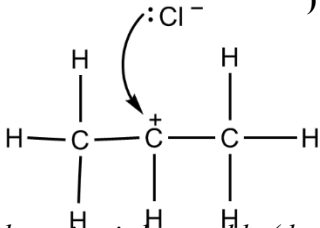
(Total for Question 7 = 1 mark)

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

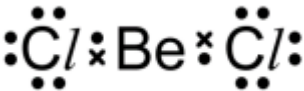
Section B

Question Number	Answer	Additional Guidance	Mark
18(a)(i)	<p>an explanation that makes reference to the following points:</p> <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) 	<p>Ignore just ‘charge increases’</p> <p>Allow same (main) energy level / number of (quantum) shells stays the same / number of electron shells stays the same</p> <p>Allow subshell for shell</p> <p>Ignore references to atomic radius and distance from the nucleus</p>	(2)

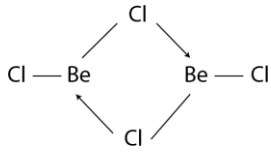
Question Number	Answer	Additional Guidance	Mark
18(a)(ii)	<p>an answer that makes reference to the following points:</p> <ul style="list-style-type: none"> 1314 (kJ mol⁻¹) (1) as electrons pair up (in p orbital) / has a full p orbital (1) which leads to repulsion (causes a lower ionisation energy for 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"> • diagram of dimer including two arrows (1) • dative (covalent bond) (1) 	 <p>Arrow heads in correct direction needed for M1</p> <p>Ignore bond angles / shapes in diagram</p> <p>Accept correct dot-and-cross diagram with correct arrows</p> <p>Ignore just covalent (bond) / sigma bond</p> <p>Do not award ionic (bond)</p>	(2)

(Total for Question 18 = 16 marks)

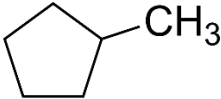
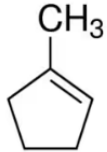
Question Number	Answer	Additional Guidance	Mark
19(a)(i)	<ul style="list-style-type: none"> Expression for weighted mean for energy density (1) calculation of energy density of sample to 2 or 3 SF (1) 	<u>example of calculation</u> $\frac{(92.2 \times 46.5) + (29.7 \times 7.80)}{100}$ OR $(92.2\% \times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

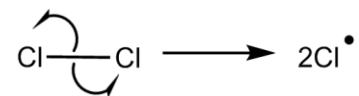
Question Number	Answer	Additional Guidance	Mark
19(a)(ii)	<ul style="list-style-type: none"> calculation of mass of sample 	<u>example of calculation</u> $0.729 \times 1500 = 1093.5 / 1094 / 1090 / 1100 \text{ (g)}$ Do not award 1093 (g)	(1)

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)	<p>An answer that makes reference to the following point:</p> $\text{C}_6\text{H}_{14} \rightarrow \text{C}_6\text{H}_{12} + \text{H}_2$	<p>Allow other types of correct formulae</p> <p>Allow $\text{C}_6\text{H}_{14} \rightarrow \text{C}_6\text{H}_{10} + 2\text{H}_2$</p> <p>Allow multiples</p> <p>Ignore state symbols even if incorrect</p>	(1)

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

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 $\text{Cl}_2 \rightarrow 2\text{Cl}^\bullet$ 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>  <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) 	$\text{Cl}^\bullet + \text{C}_6\text{H}_{14} \rightarrow \text{C}_6\text{H}_{13}^\bullet + \text{HCl}$ $(\text{C}_6\text{H}_{13}^\bullet + \text{Cl}_2 \rightarrow \text{Cl}^\bullet + \text{C}_6\text{H}_{13}\text{Cl})$ $2\text{C}_6\text{H}_{13}^\bullet \rightarrow \text{C}_{12}\text{H}_{26}$ <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"> <div data-bbox="593 399 766 502"> </div> <div data-bbox="1039 480 1075 515">(1)</div> <div data-bbox="593 550 781 662"> </div> <div data-bbox="1039 659 1075 694">(1)</div> <div data-bbox="593 790 761 837"> </div> <div data-bbox="1039 887 1075 922">(1)</div> <div data-bbox="593 981 781 1101"> </div> <div data-bbox="1039 1080 1075 1115">(1)</div> 	<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)

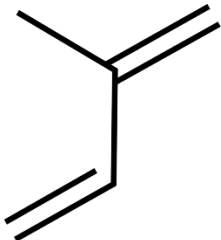
Question Number	Answer	Additional Guidance	Mark
20(b)(i)	<ul style="list-style-type: none"> <i>E</i>-2,3-dichlorobut-2-ene 	Allow trans-2,3-dichlorobut-2-ene Ignore punctuation errors e.g. additional commas, spaces, missing hyphens etc	(1)

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> $5.51 \div 204 = 0.027010 \text{ (mol)}$ 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), $1873 \times 10^{-6} \text{ (m}^3\text{)}$ Allow 423 (K), $1873 \times 10^{-3} \text{ (dm}^3\text{)}$, 152 (kPa) Allow 423.15K (which gives final answer of 0.080963) $= \frac{(152 \times 10^3) \times (1873 \times 10^{-6})}{8.31 \times 423}$ $= 0.080992 / 0.08099 / 0.0810 / 0.081 \text{ (mol)}$ 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"> calculation of molar mass of repeat unit (1) calculation of number of repeat units as whole number (1) 	<p><u>example of calculation</u></p> <p>68</p> <p>Comment – no TE from (i) as repeat unit given in stem in order to find molar mass</p> <p>$50250 \div 68 = 738.97$ = 739 repeat units</p> <p>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 $\text{Ca}(\text{OH})_2$</p> <ul style="list-style-type: none"> (basic so) will neutralise HCl / SO_2 / NO_x / CO_2 (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 CO_2 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 	<u>Example of calculation</u> $[(3 \times 58.7) + 12 + (3 \times 16) + (4 \times 17) + (4 \times 18)]$ $(=) 376.1$ Ignore any units	(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)	<p>An answer that makes reference to the following point:</p> <ul style="list-style-type: none"> because basic nickel(II) carbonate has a giant structure / lattice structure 	<p>Allow has an ionic lattice / ionic (compound) / consists of ions</p> <p>Allow does not consist of individual molecules / it is not molecular / it is not a (simple) molecule</p>	(1)

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

Question Number	Answer	Additional Guidance	Mark
21(b)(ii)	<p>An answer that makes reference to the following point:</p> <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>$150 \div 1000 = 0.15 \text{ (dm}^3\text{)}$</p> <p>$0.15 \div 24 = 6.25 \times 10^{-3} \text{ (mol)}$</p> <p>$6.25 \times 10^{-3} \times 2 = 0.0125 \text{ (mol)}$</p> <p>$1.995 \div 0.0125 = 159.6$ 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"> Deduction of identity of X 	<p><u>Example of calculation</u></p> <p>$159.6 - (32.1 + 64) = 63.5$ so Cu / Cu²⁺</p> <p>If 159.6 given in (c)(i) then allow just Cu / Cu²⁺</p> <p>Allow TE from (c)(i) for any element consistent with calculated RFM – 96.1</p> <p>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

