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	**The only correct answer is D** (13, 10, 14) *A is incorrect because this is the number of particles present in a* ${}^{27}_{13}Al$ *atom* *B is incorrect because the number of protons and electrons are reversed* *C is incorrect because the number of protons and neutrons are reversed*	**(1)**

(Total for Question 1 = 1 mark)

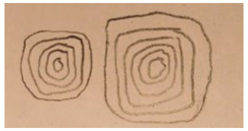
Question Number	Answer	Mark
2	**The only correct answer is C** ( , 2) *A is incorrect because the shape is that of an s orbital* *B is incorrect because the shape represents an s orbital and the maximum number of electrons in any orbital is 2* *D is incorrect because the maximum number of electrons in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

(Total for Question 2 = 1 mark)

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

Question Number	Answer	Mark
3(b)	**The only correct answer is A** (7.22 g) *B is incorrect because the molar ratio used is 1:1* *C is incorrect because the expression for moles of water is inverted* *D is incorrect because the molar ratio used is* $2CaC_2:1H_2O$	**(1)**

(Total for Question 3 = 2 marks)

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

(Total for Question 4 = 1 mark)

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

(Total for Question 5 = 1 mark)

Question Number	Answer	Mark
6	**The only correct answer is B** ($1s^2 2s^2 2p^6 3s^2 3p^1$) *A is incorrect because the outermost electron is in an orbital closer to the nucleus (than B)* *C is incorrect as the nuclear charge is greater (than B), but the outermost electron is in the same sub-shell* *D is incorrect because the nuclear charge is greater (than B), but the outermost electron is in the same sub-shell*	**(1)**

(Total for Question 6 = 1 mark)

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

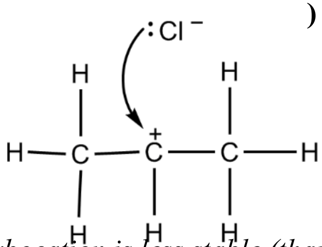
(Total for Question 7 = 1 mark)

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

(Total for Question 8 = 1 mark)

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

(Total for Question 9 = 1 mark)

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

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

(Total for Question 10 = 2 marks)

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

(Total for Question 11 = 1 mark)

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

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

(Total for Question 12 = 2 marks)

Question Number	Answer	Mark
13	**The only correct answer is B** (calcium chloride, 1.39 g, 500 cm^3) *A is incorrect because the concentration of chloride ions is 0.100 mol dm^{-3}* *C is incorrect because the concentration of chloride ions is 0.100 mol dm^{-3}* *D is incorrect because the concentration of chloride ions is 0.025 mol dm^{-3}*	**(1)**

(Total for Question 13 = 1 mark)

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

(Total for Question 14 = 1 mark)

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

(Total for Question 15 = 1 mark)

Question Number	Answer	Mark
16	**The only correct answer is A** (2,11) *B is incorrect because it does not take into account C-H bonds* *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* *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*	**(1)**

(Total for Question 16 = 1 mark)

Question Number	Answer	Mark
17	**The only correct answer is C** (W and X) *A is incorrect because only W and X will always pose a risk when stored together* *B is incorrect because only W and X will always pose a risk when stored together* *D is incorrect because only W and X will always pose a risk when stored together*	**(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: • (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)**

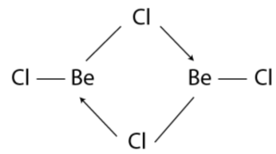
Question Number	Answer	Additional Guidance	Mark
18(a)(ii)	an answer that makes reference to the following points: • 1314 (kJ mol^{-1}) **(1)** • as electrons pair up (in p orbital) / has a full p orbital **(1)** • which leads to repulsion (causes a lower ionisation energy for oxygen) **(1)** Alternative for M2 and M3 • Allow (2p3) half-filled subshell is stable **(1)** • So oxygen loses an electron more readily to reach this configuration **(1)**	Allow any value or range or values between 1200 and 1350 (kJ mol^{-1}) Allow reverse argument for M2 and M3 e.g. nitrogen has unpaired electrons / half filled subshell so less repulsion Comment : pairing of electrons in M2 could be shown via 'electrons in boxes' diagram Ignore any references to shielding	**(3)**

Question Number	Answer	Additional Guidance	Mark
18(b)(i)	• correct species in equation **(1)** • state symbols **(1)**	$Li^{+}(g) \rightarrow Li^{2+}(g) + e^{(-)}$ Accept $Li^{+}(g) - e^{(-)} \rightarrow Li^{2+}(g)$ Allow $Li^{+}(g) + e^{(-)} \rightarrow Li^{2+}(g) + 2e^{(-)}$ Ignore **any** state symbols on $e^{(-)}$ Accept '=' instead of '→' Allow state symbols mark on any correct ionisation energy equations removing 1 electron	**(2)**

Question Number	Answer	Additional Guidance	Mark
18(b)(ii)	an explanation that makes reference to the following points: (2^{nd} ionisation is greater because) • (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 OR electron removed is closer to the nucleus **(1)**	Allow shell for energy level Allow second electron removed is from the 1s (orbital / shell / subshell) Allow 'first electron is removed from 2^{nd} shell, 2^{nd} electron is removed from first' Ignore 'new shell' 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 Allow net charge is greater / effective nuclear charge is greater / nuclear charge is greater as there are more protons than electrons Allow lower / less / low shielding Ignore just 'nuclear charge is greater'	**(2)**

Question Number	Answer	Additional Guidance	Mark
18(c)(i)	an answer that makes reference to the following point: • dot-and-cross diagram	 Allow all dots or all crosses Allow bonding electrons / electron pairs shown horizontally Do not award ions / ionic bonds	**(1)**

Question Number	Answer	Additional Guidance	Mark
18(c)(ii)	an answer that makes reference to the following points: • linear **(1)** • 180° **(1)** • 2 bond pairs / pairs of electrons (around central atom) **(1)** • (linear shape adopted to) minimise repulsion (between electron pairs) **(1)** mark independently	Allow TE from (c)(i) Allow TE from (c)(i) e.g. 2bp, 1lp allow 118-120, e.g. 2bp, 2lp 103 - 106 Allow two regions of electron density Allow TE from (c)(i) Allow maximise separation (between electron pairs) Allow 'minimise repulsion / maximise separation between bonds'	**(4)**

Question Number	Answer	Additional Guidance	Mark
18(c)(iii)	an answer that makes reference to the following points: • diagram of dimer including two arrows **(1)** • dative (covalent bond) **(1)**	 Arrow heads in correct direction needed for M1 Ignore bond angles / shapes in diagram Accept correct dot-and-cross diagram with correct arrows Ignore just covalent (bond) / sigma bond Do not award ionic (bond)	**(2)**

(Total for Question 18 = 16 marks)

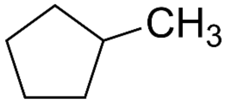
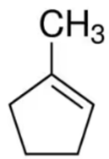
Question Number	Answer	Additional Guidance	Mark
19(a)(i)	• Expression for weighted mean for energy density **(1)** • calculation of energy density of sample to 2 or 3 SF **(1)**	<u>example of calculation</u> $\dfrac{(92.2 \times 46.5) + (29.7 \times 7.80)}{100}$ OR (92.2% × 46.5) + (7.8% × 29.7) = 45.190 = 45 / 45.2 (MJ kg^{-1}) Allow 45000 kJ kg^{-1} / 45200 kJ kg^{-1} Correct answer with or without working scores 2 marks	**(2)**

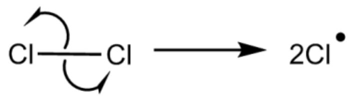
Question Number	Answer	Additional Guidance	Mark
19(a)(ii)	• calculation of mass of sample	<u>example of calculation</u> 0.729 × 1500 = 1093.5 / 1094 / 1090 / 1100 (g) Do not award 1093 (g)	**(1)**

Question Number	Answer	Additional Guidance	Mark
19(a)(iii)	• calculation of energy released **and** correct units	<u>example of calculation</u> 1093.5 ÷ 1000 = 1.0935 45.190 × 1.0935 = 49.415 MJ Accept 49415 kJ Accept 4.9415× 10^7 J OR 1093.5 ÷ 1000 = 1.0935 38.1 × 1.0935 = 41.662 MJ Accept 41662 kJ Accept 4.1662 × 10^7 J 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 Comment – if a value is given in (a)(i), candidates can still use 38.1 to access the mark here	**(1)**

Question Number	Answer	Additional Guidance	Mark
19(b)	An answer that makes reference to three of the following points: • (increased amount of) ethanol used could be bioethanol / ethanol sourced from plants **(1)** • from fermentation (of sugars / glucose using yeast) **(1)** • reducing CO_2 emissions (overall) / (some) CO_2 released in combustion offset by CO_2 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 SO_2 emissions **(1)**	Allow ethanol can be made from a renewable resource Ignore esterification of vegetable oils (biodiesel) Allow fermentation is a low energy process Allow bioethanol is (nearly) carbon neutral / has a lower carbon footprint Ignore 'crude oil is non-renewable' Comment – allow reverse arguments in context of E5	**(3)**

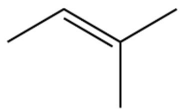
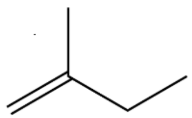
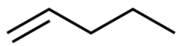
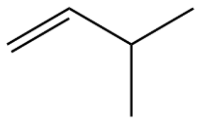
Question Number	Answer	Additional Guidance	Mark
19(c)(i)	An answer that makes reference to the following point: $C_6H_{14} \rightarrow C_6H_{12} + H_2$	Allow other types of correct formulae Allow $C_6H_{14} \rightarrow C_6H_{10} + 2H_2$ Allow multiples Ignore state symbols even if incorrect	**(1)**

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.  No TE from (c)(i)	**(1)**

Question Number	Answer	Additional Guidance	Mark
19(d)(i)	An explanation that makes reference to the following points: • (to provide enough energy) to break Cl-Cl **bond(s)** / for homolytic fission of chlorine **(1)** • to form chlorine radicals / to form $Cl^{\bullet}$ **(1)**	Allow $Cl_2 \rightarrow 2Cl^{\bullet}$ for M2 Accept (to form chlorine radicals) without breaking the C-H bonds (in hexane) Do not award ions Do not award chloride radicals Comment  Scores M1 for LHS and M2 for RHS	**(2)**

Question Number	Answer	Additional Guidance	Mark
19(d)(ii)	An answer that makes reference to the following points: • equation for propagation step **(1)** • equation for termination step **(1)**	$Cl^{\bullet} + C_6H_{14} \rightarrow {}^{\bullet}C_6H_{13} + HCl$ $({}^{\bullet}C_6H_{13} + Cl_2 \rightarrow Cl^{\bullet} + C_6H_{13}Cl)$ $2{}^{\bullet}C_6H_{13} \rightarrow C_{12}H_{26}$ Allow $C_6H_{13}^{\bullet}$ for hexyl radical Do not award if additional termination equations are shown Penalise omission of unpaired electron once only Comment – if $C_{12}H_{26}$ used as the reactant alkane allow TE for M2 $2C_{12}H_{25}^{\bullet} \rightarrow C_{24}H_{50}$	**(2)**

(Total for Question 19 = 13 marks)

Question Number	Answer	Additional Guidance	Mark
20(a)(i)	An answer that makes reference to the following points: •  **(1)** •  **(1)** •  **(1)** •  **(1)**	Allow displayed, structural or hybrid formulae Ignore any working e.g. additional partially complete displayed formulae with a carbon chain only Ignore any names, even if incorrect	**(4)**

Question Number	Answer	Additional Guidance	Mark
20(a)(ii)	An explanation that makes reference to the following points: • 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)**	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'	**(2)**

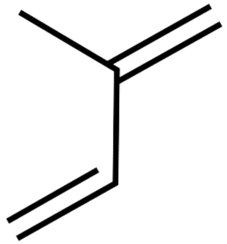
Question Number	Answer	Additional Guidance	Mark
20(b)(i)	• *E*-2,3-dichlorobut-2-ene	Allow trans-2,3-dichlorobut-2-ene Ignore punctuation errors e.g. additional commas, spaces, missing hyphens etc	**(1)**

Question Number	Answer	Additional Guidance	Mark
20(b)(ii)	an answer that makes reference to the following points: • (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)	• calculation of number of moles	Example of calculation $5.51 \div 204 = 0.027010$ (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)	• rearrangement of ideal gas equation **(1)** • conversion of temperature and volume to appropriate units **(1)** • calculation of moles of hydrogen **(1)**	Example of calculation $n = pV \div RT$ 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) $= \dfrac{(152 \times 10^3) \times (1873 \times 10^{-6})}{8.31 \times 423}$ = 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)	• determination of ratio between moles of α-bisabolene : moles of hydrogen and hence number of C=C bonds	<u>Example of calculation</u> $0.080992 \div 0.02701 = 2.9986$, so 3 C=C bonds Allow TE from c(i) and c(ii) but must be nearest whole number Do not award non integer answers	**(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)	• calculation of molar mass of repeat unit **(1)** • calculation of number of repeat units as whole number **(1)**	<u>example of calculation</u> 68 Comment – no TE from (i) as repeat unit given in stem in order to find molar mass 50250 ÷ 68 = 738.97 = 739 repeat units Allow 738 units Allow TE from M1 to M2 for correct integer value either side of calculated value	**(2)**

Question Number	Answer	Additional Guidance	Mark
20(e)	An answer that makes reference to the following points: use of $Ca(OH)_2$ • (basic so) will neutralise HCl / SO_2 / NO_x / CO_2 (in waste gases) **(1)** use of fine powder • large surface area **and** to ensure fast **reaction** / increase rate of **reaction** **(1)**	(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' Ignore absorb	**(2)**

(Total for Question 20 = 20 marks)

Question Number	Answer	Additional Guidance	Mark
21(a)(i)	• calculation of relative formula mass	<u>Example of calculation</u> [(3 × 58.7) + 12 + (3 × 16) + (4 × 17) + (4 × 18)] (=) 376.1 Ignore any units	**(1)**

Question Number	Answer	Additional Guidance	Mark
21(a)(ii)	• calculation of relative formula masses of all products / reactants **(1)** Comment M1 can be awarded for expression 376.1 + (3 x 142.1) or (3 x 154.8) + 106 + (4 x 40) + (4 x 18) if 802.4 not shown • calculation of atom economy **(1)**	<u>Example of calculation</u> 376.1 + (3 x 142.1) = 802.4 Allow 802.1 (use of 32 for S) Allow TE from (a)(i) **OR** (3 x 154.8) + 106 + (4 x 40) + (4 x 18) = 802.4 Allow 802.1 (use of 32 for S) (376.1 ÷ 802.4) × 100 = 46.872 % Allow TE from M1 Allow (376.1 ÷ 802.1) × 100 = 46.889 % Ignore SF except 1 SF 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	**(2)**

Question Number	Answer	Additional Guidance	Mark
21(a)(iii)	An answer that makes reference to the following point: • 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: • electronic configuration of Ni^{2+}	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^8$ 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: • $3Ni^{2+} + CO_3^{2-} + 4OH^- + 4H_2O \rightarrow Ni_3CO_3(OH)_4 \cdot 4H_2O$	Ignore missing / incorrect state symbols	**(1)**

Question Number	Answer	Additional Guidance	Mark
21(c)(i)	• conversion of volume of CO_2 into dm^3 **(1)** • calculation of moles of CO_2 **(1)** • calculation of moles of XSO_4 using ratio from equation **(1)** • calculation of the relative formula mass of XSO_4 **(1)** Comment Allow conversion of molar gas volume to 24000 $cm^3\ mol^{-1}$ and use of 150 cm^3 for M1 and M2	<u>Example of calculation</u> $150 \div 1000 = 0.15\ (dm^3)$ $0.15 \div 24 = 6.25 \times 10^{-3}$ (mol) $6.25 \times 10^{-3} \times 2 = 0.0125$ (mol) $1.995 \div 0.0125 = 159.6$ Ignore units for RFM Allow TE throughout Ignore SF except 1 SF Correct answer with some working scores (4) Correct answer with **no** working scores M4 only	**(4)**

Question Number	Answer	Additional Guidance	Mark
21(c)(ii)	• Deduction of identity of **X**	<u>Example of calculation</u> 159.6 – (32.1 + 64) = 63.5 so Cu / Cu^{2+} If 159.6 given in (c)(i) then allow just Cu / Cu^{2+} Allow TE from (c)(i) for any element consistent with calculated RFM – 96.1 e.g. failure to multiply by 2 in (i) leads to a RFM of 319.2, which is consistent with Fr in (ii)	**(1)**

(Total for Question 21 = 11 marks)

(Total for Section B = 60 marks)

Total for Paper = 80 marks

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