Pearson
Edexcel

Mark Scheme (Results)

January 2020

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

Section A

Question Number	Answer	Mark
1	**The only correct answer is C** (17 protons, 20 neutrons, 18 electrons) ***A*** *is incorrect because this shows the subatomic particles in* $^{37}Cl^{+}$ *ion* ***B*** *is incorrect because this is for a chlorine-37 atom* ***D*** *is incorrect because the proton and neutron numbers are reversed*	**(1)**

Question Number	Answer	Mark
2	**The only correct answer is A** (58.760) ***B*** *is incorrect because this is the correct answer to 3 SF* ***C*** *is incorrect because a relative mass of 59 has been used for the first isotope and the answer is to 3 SF* ***D*** *is incorrect because a relative mass of 59 has been used for the first isotope*	**(1)**

Question Number	Answer	Mark
3	**The only correct answer is D** (14) ***A*** *is incorrect because 3 is the number of quantum shells* ***B*** *is incorrect because 6 is the total number of subshells* ***C*** *is incorrect because 9 is the number of orbitals in the third quantum shell*	**(1)**

Question Number	Answer	Mark
4	**The only correct answer is B** (carbon) ***A*** *is incorrect because lithium is an s-block element with one unpaired electron* ***C*** *is incorrect because fluorine is a p-block element with one unpaired electron* ***D*** *is incorrect because titanium is a d-block element with two unpaired electrons*	**(1)**

Question Number	Answer	Mark
5	**The only correct answer is C** (aluminium) ***A*** *is incorrect because there would not be a large jump between the third and fourth ionisations* ***B*** *is incorrect because there would not be a large jump between the third and fourth ionisations* ***D*** *is incorrect because there would not be a large jump between the third and fourth ionisations*	**(1)**

Question Number	Answer	Mark
6	**The only correct answer is D** (315.3) ***A*** *is incorrect because this is the relative formula mass of anhydrous barium hydroxide* ***B*** *is incorrect because the relative masses of* $8H_2$ *and O have been added instead of* $8H_2O$ ***C*** *is incorrect because an* M_r *value of 16 has been used for water*	**(1)**

Question Number	Answer	Mark
7	**The only correct answer is C** (1.1) ***A*** *is incorrect because the volume has not been converted to* dm^3 ***B*** *is incorrect because the volume has been divided by the amount of sodium sulfate* ***D*** *is incorrect because the volume has not been converted to* dm^3 *and the volume has been divided by the amount*	**(1)**

Question Number	Answer	Mark
8	**The only correct answer is B** (MgO) ***A*** *is incorrect because the ion charges are +1 and −1* ***C*** *is incorrect because the ion charges are +1 and −1 and the ionic radii are larger* ***D*** *is incorrect because the ionic radii are larger*	**(1)**

Question Number	Answer	Mark
9	**The only correct answer is B** (MgI_2) ***A*** *is incorrect because fluoride ions are not as easily polarised as iodide ions* ***C*** *is incorrect because barium ions are less polarising than magnesium and fluoride ions are not easily polarised* ***D*** *is incorrect because barium ions are less polarising than magnesium ions*	**(1)**

Question Number	Answer	Mark
10(a)	**The only correct answer is D** (white precipitate) ***A*** *is incorrect because the reactants are colourless* ***B*** *is incorrect because no gas is given off* ***C*** *is incorrect because a precipitate forms*	**(1)**

Question Number	Answer	Mark
10(b)	**The only correct answer is C** ($Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$) ***A*** *is incorrect because the ion charges are not +1 and −1* ***B*** *is incorrect because the equation does not represent the formation of a precipitate* ***D*** *is incorrect because the spectator ions have not been cancelled*	**(1)**

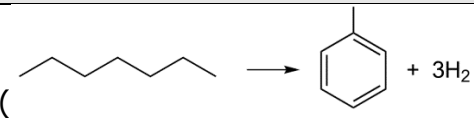
Question Number	Answer	Mark
10(c)	**The only correct answer is C** (0.560 g) ***A*** *is incorrect because the molar masses of barium chloride and barium sulfate have been reversed* ***B*** *is incorrect because the molar, and not the mass, ratio is 1:1* ***D*** *is incorrect because the M_r of Na_2SO_4 has been used instead of $BaCl_2$*	**(1)**

Question Number	Answer	Mark
10(d)	**The only correct answer is C** (66.6%) ***A*** *is incorrect because the total mass of reactants and products has been used* ***B*** *is incorrect because one mole of sodium sulfate has been used in place of two moles of sodium chloride* ***D*** *is incorrect because one mole of NaCl has been used in the equation*	**(1)**

Question Number	Answer	Mark
11	**The only correct answer is A** (diamond) ***B*** *is incorrect because* C_{60} *fullerene contains delocalised electrons* ***C*** *is incorrect because graphene contains delocalised electrons* ***D*** *is incorrect because graphite contains delocalised electrons*	**(1)**

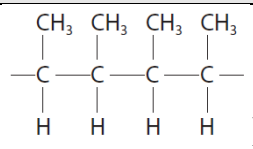
Question Number	Answer	Mark
12	**The only correct answer is A** (OF_2) ***B*** *is incorrect because* BF_3 *is trigonal planar and the bond dipoles cancel* ***C*** *is incorrect because* CF_4 *is tetrahedral and the bond dipoles cancel* ***D*** *is incorrect because* PF_5 *is trigonal bipyramidal and the bond dipoles cancel*	**(1)**

Question Number	Answer	Mark
13	**The only correct answer is A** (CH_3^+, trigonal planar, 120°) ***B*** *is incorrect because the bond angle should be 107°* ***C*** *is incorrect because the shape should be tetrahedral and the bond angle should be 109.5°* ***D*** *is incorrect because the shape should be bent and the bond angle should be 104.5°*	**(1)**

Question Number	Answer	Mark
14	**The only correct answer is D** () ***A*** *is incorrect because the equation represents a correctly balanced isomerisation* ***B*** *is incorrect because the equation is correctly balanced* ***C*** *is incorrect because the equation is correctly balanced*	**(1)**

Question Number	Answer	Mark
15	**The only correct answer is A** (H_2) ***B*** *is incorrect because H_2O is formed in the combustion of alkane fuels* ***C*** *is incorrect because CO is formed in the incomplete combustion of alkane fuels* ***D*** *is incorrect because CO_2 is formed by the combustion of alkane fuels*	**(1)**

Question Number	Answer	Mark
16	**The only correct answer is B** (39 σ bonds, 3 π bonds) ***A*** *is incorrect because 15 is the number of C–C σ bonds* ***C*** *is incorrect because 15 is the number of C–C σ bonds and 6 is twice the number of π bonds* ***D*** *is incorrect because 6 is twice the number of π bonds*	**(1)**

Question Number	Answer	Mark
17	 **The only correct answer is D** ( ) ***A*** *is incorrect because this polymer is made from propene, which does not have E/Z isomers* ***B*** *is incorrect because this polymer is made from propene, which does not have E/Z isomers* ***C*** *is incorrect because this polymer is made from 2-methylpropene, which does not have E/Z isomers*	**(1)**

(Total for Section A = 20 marks)

Section B

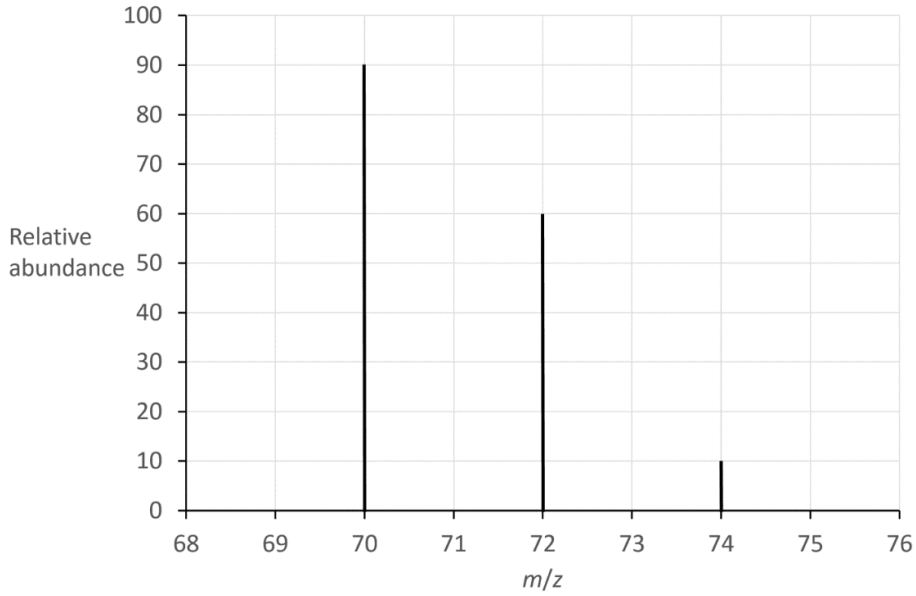
Question Number	Answer	Additional Guidance	Mark
18(a)	• $1s^2 2s^2 2p^6 3s^2 3p^5$	Accept $2p_x^2 2p_y^2 2p_z^2$ for $2p^6$ etc Ignore [Ne] for $1s^2 2s^2 2p^6$	**(1)**

Question Number	Answer		Additional Guidance	Mark
18(b)	• species and balancing	**(1)**	Example of equation: $Cl(g) \rightarrow Cl^+(g) + e(^-)$ or $Cl(g) - e(^-) \rightarrow Cl^+(g)$ Do not award multiples	
	• state symbols	**(1)**	M2 dependent on M1 or neutral Cl/Cl_2 on one side of equation and charged $Cl^+/Cl_2^+/Cl^-/Cl_2^-$ on the other Ignore state symbol on electron	**(2)**

Question Number	Answer	Additional Guidance	Mark
18(c)	An explanation that makes reference to the following points: chlorine is higher **and** any **three** of the following qualifying statements: • (although) the nuclear charge / number of protons is lower **(1)** • the (outer) electron is in a lower (principal) **energy** level / orbital of lower **energy** **(1)** • the (outer) electron is closer to the nucleus / smaller (atomic) radius **(1)** • (the outer electron experiences) less shielding **(1)**	**Accept reverse arguments throughout** This can be implied through correct reference to attraction between nucleus and (outer) electron / amount of energy required to remove (outer) electron If bromine identified as higher, or it is not implied which element has the higher ionisation energy, penalise once only Ignore effective nuclear charge Allow (outer) electron is lower in **energy** Allow 3p lower in **energy** than 4p Allow just smaller atom Do not award smaller **ionic** radius Allow just fewer shells Ignore just fewer sub-shells / electrons Accept less repulsion from inner / core electrons Ignore just less repulsion between electrons Do not award less repulsion between paired electrons within an orbital	**(3)**

Question Number	Answer	Additional Guidance	Mark
18(d)	• correct dot-and-cross diagram	Example of dot-and-cross diagram:  Allow any combination of dots, crosses or other symbols for electrons Allow indication of shells by overlapping circles Allow correctly filled inner shells	**(1)**

Question Number	Answer	Additional Guidance	Mark
18(e)	An explanation that makes reference to the following points: (chlorine is a simple molecule with) • weak forces between the molecules **(1)** • little energy required to overcome these forces **(1)**	Accept weak London / instantaneous dipole-induced dipole / van der Waals / VdW forces Allow weak intermolecular bonds / weak bonds between molecules Do not award if implied that intermolecular forces are within a chlorine molecule **M2 dependent on M1** Do not award just bond for forces unless clear that the bond is intermolecular Allow as relatively few electrons / small contact surface area	**(2)**

Question Number	Answer	Additional Guidance	Mark
18(f)(i)	• lines at 70 and 72 and 74 **only (1)** • relative abundances 90:60:10 **(1)** **respectively**	**Mark M1 and M2 independently**  Accept relative abundances 100:67:11 / 54:36:6 Allow relative abundances in ratio close to 9:6:1, eg 100:65:11 / 55:40:6 If neither M1 nor M2 awarded, **two** peaks at correct *m/z* and in correct ratio scores (1), eg peaks at 70 and 74 in 9:1 ratio	**(2)**

Question Number	Answer	Additional Guidance	Mark
18(f)(ii)	An answer that makes reference to the following points: • (peak is due to) $^{35}Cl–^{37}Cl$ (molecular ion) **(1)** • (with a charge of) 2+ **(1)**	**Mark M1 and M2 independently** Allow any indication that peak is due to combination of (chlorine-)35 and (chlorine-)37, eg (35+37)/2 = 36 Do not award chlorine-36 isotope Allow (molecular ion has) lost two electrons Just $(^{35}Cl–^{37}Cl)^{2+}$ or $(35–37)^{2+}$ scores (2)	**(2)**

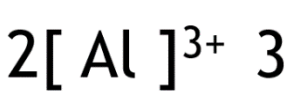
(Total for Question 18 = 13 marks)

Question Number	Answer	Additional Guidance	Mark
19(a)(i)	An answer that makes reference to the following points: • (incorrectly plotted metal is) aluminium / Al **(1)** • (incorrectly plotted non-metal is) argon / Ar **(1)**	Credit can be awarded from annotations to the graph Ignore classification of elements as metallic / non-metallic, even if incorrect	**(2)**

Question Number	Answer	Additional Guidance	Mark
19(a)(ii)	An answer that makes reference to the following points: • (silicon has a) giant (lattice/molecular structure) **and** covalent (bonds) **(1)** • (many) strong (covalent) bonds (between silicon atoms) **or** each (silicon) atom bonded to four others **(1)** • requiring a large amount of energy to break **(1)**	**Mark all points independently** Accept macromolecular Ignore large molecule Accept electrostatic attraction between nuclei and shared pair of electrons Allow strong electrostatic attraction between (silicon) atoms Do not award strong ionic/metallic bonds Do not award strong intermolecular forces Ignore three bonds between (silicon) atoms Do not award any other elements / number of bonds Allow overcome for break	**(3)**

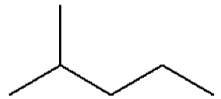
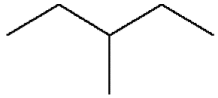
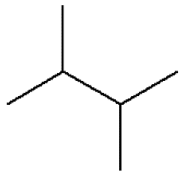
Question Number	Answer	Additional Guidance	Mark
19(b)(i)	A description that makes reference to the following points: • (metals contain) delocalised electrons **(1)** • (which can) flow / move (freely through the structure when a potential difference is applied) **(1)**	Allow delocalised electron Allow sea of electron(s) Ignore just free electrons Ignore charge carriers **M2 dependent on M1** Ignore reference to physical state	**(2)**

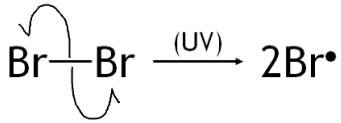
Question Number	Answer	Additional Guidance	Mark
19(b)(ii)	A description that makes reference to the following points: • Aluminium has more delocalised electrons (than sodium per atom / ion) **or** Aluminium has three delocalised electrons whereas sodium has one (per atom / ion)	Accept reverse argument Allow just more delocalised electrons Do not award incorrect numbers of delocalised electrons (per atom / ion)	**(1)**

Question Number	Answer	Additional Guidance	Mark
19(c)(i)	Dot-and-cross diagram showing the following:	Example of dot-and-cross diagram: 	
	• 0 electrons on outer shell of aluminium and 8 electrons on outer shell of oxide **(1)**	M1 dependent on some indication of ionic structure Allow 8 electrons on outer shell of Al Allow correctly filled inner shells Allow any combination of dots or crosses for electrons Allow circles to indicate outer shells	
	• two aluminium (ions) and three oxide (ions) **(1)**	Accept any unambiguous indication of the correct number of ions Allow any indication that formula is Al_2O_3, even if covalent dot-and-cross diagram shown	
	• 3+ charge on aluminium ion and 2− charge on oxide ion **(1)**	Allow +3 and –2 Ignore missing square brackets	
		If no other mark awarded, a correct dot-and-cross diagram for either an Al^{3+} ion or O^{2-} ion scores (1)	**(3)**

Question Number	Answer	Additional Guidance	Mark
19(c)(ii)	• **ions** must be mobile / free to move (to allow a current to flow)	Allow reverse argument (eg ions cannot move in the solid) Allow ions can flow Ignore just ions must be free Ignore charge carriers / charged particles Ignore reference to aqueous solutions Ignore just ions must be delocalised / dissociated Ignore reference to (lack of) delocalised electrons in the solid state Do not award reference to (presence of) delocalised electrons in the liquid/molten state	**(1)**

(Total for Question 19 = 12 marks)

Question Number	Answer	Additional Guidance	Mark
20(a)	Correct structures of: • 2-methylpentane **(1)** • 3-methylpentane **(1)** • 2,2-dimethylbutane **(1)** • 2,3-dimethylbutane **(1)**	Allow displayed, structural, skeletal formulae or any combination of these If more than one type of formula is given for an isomer all must be correct Penalise missing hydrogens from displayed formulae once only Ignore bond angles and bond lengths Ignore names even if incorrect Example of correct structures:  (2-methylpentane)  (3-methylpentane)  (2,2-dimethylbutane)  (2,3-dimethylbutane)	**(4)**

Question Number	Answer	Additional Guidance	Mark
20(b)(i)	Mechanism / equation showing: • homolytic fission of Br–Br bond with curly half-arrows **(1)** • (producing) two bromine radicals **(1)**	Example of mechanism:  Allow curly half-arrows on same side of the bond Do not award arrows that are not half-headed Do not award missing • Use of Cl for Br in otherwise fully correct equation scores (1)	**(2)**

Question Number	Answer	Additional Guidance	Mark
20(b)(ii)	• $C_6H_{14} + Br\bullet \rightarrow C_6H_{13}\bullet + HBr$ **(1)** • $C_6H_{13}\bullet + Br_2 \rightarrow C_6H_{13}Br + Br\bullet$ **(1)**	Allow equations in either order Penalise missing • in (b)(i) and (b)(ii) once only	**(2)**

Question Number	Answer	Additional Guidance	Mark
20(b)(iii)	• $C_{12}H_{26}$	Allow $H_{26}C_{12}$	**(1)**

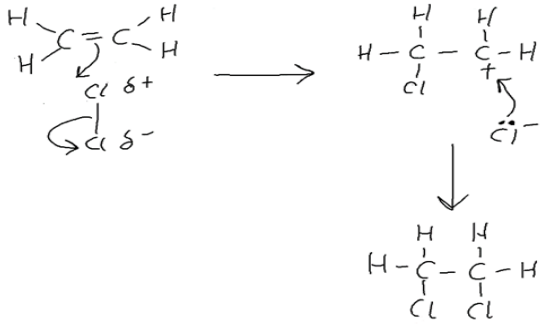
Question Number	Answer	Additional Guidance	Mark
20(b)(iv)	• evidence of C_6Br_{14} (identified as heaviest possible product) **(1)** • calculation of molar mass **(1)** • calculation of percentage by mass of bromine **(1)**	Example of calculation: $14 \times 79.9 + 6 \times 12.0$ (= 1190.6) TE on any compound of formula $C_6H_{(14-n)}Br_n$ (where $2 \leq n < 14$) or C_6Br_{12} %Br = $(14 \times 79.9) / (14 \times 79.9 + 6 \times 12.0) \times 100$ = 93.953 % = 94.0 % TE on any compound of formula $C_6H_{(14-n)}Br_n$ or $C_6H_{(12-n)}Br_n$ Allow use of 80 for relative atomic mass of bromine Ignore SF except 1 SF	**(3)**

(Total for Question 20 = 12 marks)

Question Number	Answer	Additional Guidance	Mark
21(a)	• calculation of moles of ethene **(1)** • calculation of number of ethene molecules **(1)**	Example of calculation: mols = $\frac{1.50 \times 10^{14}}{28.0} = 5.3571 \times 10^{12}$ molecules = $5.3571 \times 10^{12} \times 6.02 \times 10^{23}$ $= 3.225 \times 10^{36}$ TE on **moles** of ethene (calculated by dividing a mass by a molar mass) Ignore SF except 1 SF $(3.225 / 3.23 / 3.2) \times 10^{36}$ scores (2)	**(2)**

Question Number	Answer	Additional Guidance	Mark
21(b)		Example of calculation:	
	M1: conversion of temperature to K **(1)**	(T = 21 + 273 =) 294 (K)	
	M2: rearrangement of ideal gas equation **(1)**	$n = \frac{pV}{RT}$ or $n = \frac{1.01 \times 10^5 \times 220}{8.31 \times 294}$	
	M3: evaluation to give moles of gas **(1)**	n = 9094.9 Ignore SF except 1 SF TE on M1 No TE on incorrect volume	
	M4: use of mixing ratio to calculate moles of ethene **(1)**	moles = $\frac{100}{10^6} \times 9094.9$ = 0.90949 Ignore SF except 1 SF TE on M3	
	M5: answer to 2 or 3SF – standalone **(1)**	0.91 / 0.909 (moles) Do not award incorrect units Max (3) for calculations using 24 $dm^3\,mol^{-1}$ as the molar gas volume (ie no M1 or M2) eg 0.92 scores (3), 0.916667 scores (2)	

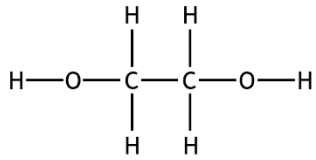
	Alternative route to **M2**, **M3** and **M4** • use of mixing ratio to calculate volume occupied by ethene **(1)** • rearrangement of ideal gas equation **(1)** • evaluation to give moles of ethene **(1)**		$V = \frac{100}{10^6} \times 220$ $= 0.022\ (m^3)$ Do not award 0.02 $n = \frac{pV}{RT}$ or $n = \frac{1.01 \times 10^5 \times 0.022}{8.31 \times 294}$ n = 0.90949 Ignore SF except 1 SF TE on M1 No TE on incorrect volume	**(5)**

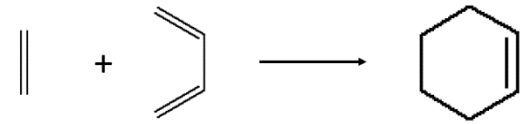
Question Number	Answer	Additional Guidance	Mark
21(c)(i)	Mechanism showing: • induced dipole on chlorine **(1)** **and** correct product • curly arrow from C=C bond to Cl(δ+) **and** curly arrow from Cl–Cl bond to Cl(δ–) **(1)** • correct carbocation intermediate **(1)** • lone pair and negative charge on chloride **and** curly arrow from lone pair to $C^{(+)}$ **(1)**	Example of mechanism:  **Mark all points independently** Penalise use of HCl / HBr / Br_2 for Cl_2 once only Penalise incorrect alkene once only Penalise missing H atom once only Penalise use of curly half-arrows once only Do not award full charges Do not award 'open bond' on C^+ Do not award $Cl^{\delta-}$ Do not award curly arrow from negative charge	**(4)**

Question Number	Answer	Additional Guidance	Mark
21(c)(ii)	An explanation that makes reference to the following points: • identification of hazard **(1)** • suitable precaution **(1)**	**Mark M1 and M2 independently** (in)flammable avoid (naked) flames / fire Ignore just take care with flames / fire Ignore fire extinguishers etc Allow use heating mantle / (electric) water bath etc Ignore keep away from heat source / do not heat Ignore Bunsen burner Allow heat in an inert atmosphere / nitrogen / argon Ignore just exclude oxygen / heat in absence of oxygen Allow use small amounts Ignore fume cupboard Ignore gloves / tie hair back / safety goggles / laboratory coat	**(2)**

Question Number	Answer		Additional Guidance	Mark
21(d)(i)	**Method 1** • calculation of mass C, H and O • calculation of moles C, H and O **and** empirical formula	**(1)** **(1)**	**Ignore SF except 1 SF for all methods** Example of calculation: mass C = $\frac{24}{28} \times 10.0 = 8.5714$ (g) mass H = $\frac{4}{28} \times 10.0 = 1.4286$ (g) mass O = 15.7–10.0 = 5.70 (g) C : H : O $\frac{8.5714}{12}$: $\frac{1.4286}{1}$: $\frac{5.7}{16}$ 0.71429 : 1.4286 : 0.36 empirical formula is C_2H_4O TE on M1 only if mass(C + H + O) = 15.7 (g)	
	Method 2 • calculation of moles C_2H_4 and O **or** calculation of moles C_2H_4 and O_2 • empirical formula	**(1)** **(1)**	(moles $C_2H_4 = \frac{10.0}{28}$ =) 0.35714 (moles O = $\frac{(15.7–10.0)}{16}$ =) 0.35625 (moles $C_2H_4 = \frac{10.0}{28}$ =) 0.35714 (moles $O_2 = \frac{(15.7–10.0)}{32}$ =) 0.17813 **M2 dependent on M1** empirical formula is C_2H_4O	

	Method 3 • calculation of moles C_2H_4 **and** M_r product **(1)** • empirical formula **and** calculation of M_r of empirical formula **(1)**	(moles C_2H_4 =) $\frac{10.0}{28}$ = 0.35714 (M_r product =) $\frac{15.7}{0.35714}$ = 43.96 **M2 dependent on M1** empirical formula is C_2H_4O 2 × 12 + 4 × 1 + 1 × 16 = 44	**(2)**

Question Number	Answer	Additional Guidance	Mark
21(d)(ii)	• displayed formula of ethane-1,2-diol	Example of displayed formula:  Ignore skeletal or structural formulae Allow non-displayed OH groups Ignore bond lengths and angles Do not award horizontal OH–C connectivity Ignore connectivity of pendant / vertical **non-displayed** OH groups Do not award missing H atoms	**(1)**

Question Number	Answer	Additional Guidance	Mark
21(e)	• correct equation and skeletal formulae	Example of equation:  Allow molecules in any orientation Ignore bond lengths and angles Allow multiples Ignore molecular, structural or displayed formulae Do not award if additional products given	**(1)**

Question Number	Answer	Additional Guidance	Mark
21(f)(i)	• addition **or** reduction **or** hydrogenation	Ignore additional Do not award electrophilic / nucleophilic addition Ignore redox Do not award hydration Do not award cracking Do not award reforming	**(1)**

Question Number	Answer		Additional Guidance	Mark
21(f)(ii)			**Mark M1 and M2 independently**	
	• steam or water **and** heat	**(1)**	Accept $H_2O(g)$ / water vapour Allow any stated temperature 100°C ≤ T ≤ 400°C Ignore stated temperatures < 100°C Ignore high temperature Do not award stated temperatures > 400°C Do not award (heat under) reflux	
	• acid catalyst	**(1)**	Accept (concentrated) phosphoric acid / H_3PO_4 Allow (concentrated) sulfuric acid / H_2SO_4 Do not award **dilute** acid catalysts Ignore reference to pressure Accept react with concentrated H_2SO_4 followed by hydrolysis (2)	**(2)**

Question Number	Answer	Additional Guidance	Mark
21(f)(iii)	An explanation that makes reference to the following points: • (angle b is) 104.5° **(1)** • four bond pairs (of electrons around C) for angle a **and** two bond pairs and two lone pairs (of electrons around O) for angle b **(1)** • lone pairs (of electrons) repel more than bond pairs **(1)**	**Mark all points independently** Allow 103° to 106° Allow four pairs of electrons (around the central atom) for both angles Ignore covalent bond for bond pair Ignore just two lone pairs for angle b and no lone pairs for angle a Allow each lone pair reduces the bond angle by 2.5° Allow lone pair-lone pair / lone pair-bond pair repulsion greater than bond pair-bond pair repulsion Allow just lone pairs repel more / lone pair repulsion greatest Ignore (electron) pairs repel to maximum separation / minimum repulsion Do not award (electron) pairs repel to minimum separation / maximum repulsion	**(3)**

(Total for Question 21 = 23 marks)
TOTAL FOR SECTION B = 60 MARKS
TOTAL FOR PAPER = 80 MARKS