
CHEMISTRY

9701/21

Paper 2 AS Level Structured Questions

May/June 2018

MARK SCHEME

Maximum Mark: 60

Published

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GENERIC MARKING PRINCIPLE 1:

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- the standard of response required by a candidate as exemplified by the standardisation scripts.

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Marks awarded are always **whole marks** (not half marks, or other fractions).

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Rules must be applied consistently e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors.

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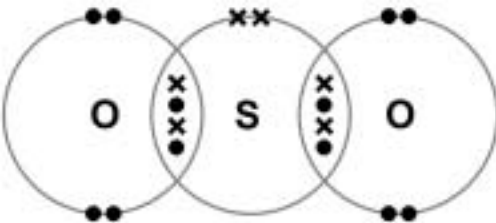
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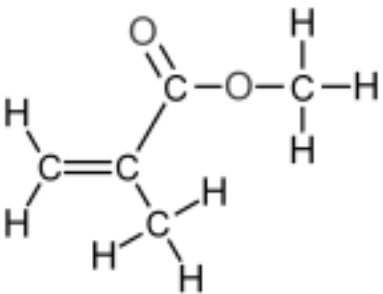
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Question	Answer	Marks
1(a)(i)	(It is a substance that) speeds up a reaction	1
	(by creating an alternative pathway / mechanism with) lower E_a	1
1(a)(ii)	(a heterogeneous catalyst is in a) different state / phase (to the reactants)	1
1(b)	$-196 + 6S=O = (4 \times 534) + 496$	1
	$S=O = 2828 / 6 = 471(.3)$	1
1(c)	1 = B	1
	2 = A	1
	3 = D	1
1(d)(i)	Increases rate AND explanation re collisions	1
	By increasing number / proportion of / more molecules / particles / species with $E \geq E_a$	1
	(So) increases frequency of successful collisions / more successful collisions per unit time / higher chance of successful collisions per unit time / higher proportion of successful collisions per unit time	1
1(d)(ii)	(Increasing T) decreases yield (of SO_3)	1
	(Forward) reaction is exothermic (or reverse argument)	1
	So increasing T shifts (equilibrium) reaction to left / towards reactants / in endothermic direction (to oppose the change in T)	1
1(e)	$H_2S_2O_7 + H_2O \rightarrow 2H_2SO_4$	1

Question	Answer	Marks
1(f)(i)		1
1(f)(ii)	fully ionises/dissociates	1
	(Brønsted-Lowry acid is a) proton / H ⁺ donor	1
1(f)(iii)	$\text{H}_2\text{SO}_4(\text{l})/(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{HSO}_4^-(\text{aq}) + \text{H}_3\text{O}^+(\text{aq})$	
	species and balancing	1
	correct state symbols on left hand side; all products aqueous	1

Question	Answer	Marks
2(a)	Different (hydrocarbon) molecules have different numbers of electrons	1
	so different strengths / numbers / amount of VdW / IMFs / id-id	1
2(b)	Produces more useful / more valuable / higher demand substances / alkanes / alkenes	1
2(c)(i)	$\text{C}_{12}\text{H}_{26} \rightarrow 2\text{C}_2\text{H}_4 + \text{C}_8\text{H}_{18}$	1
2(c)(ii)	addition polymerisation	1

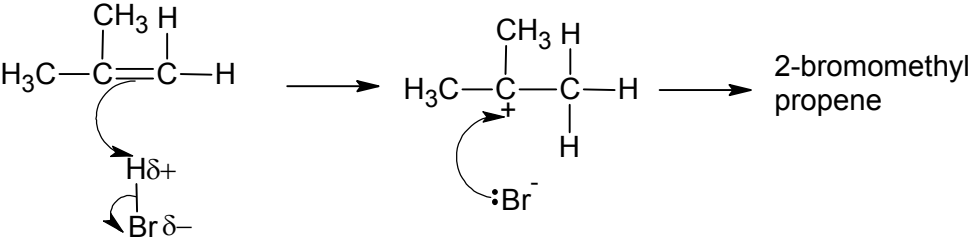
Question	Answer	Marks
2(c)(iii)	<i>two from</i> save space in landfill avoid litter prevent eyesore non-biodegradable conserves non-renewable resources harmful incineration products harmful to wildlife	2
2(c)(iv)		
	correct monomer	1
	fully displayed	1

Question	Answer	Marks
3(a)(i)	increasing attraction between nucleus and (outer) electrons	1
	increasing nuclear charge with similar shielding / (electrons in) same (outer) shell	1
3(a)(ii)	(ions of Na to Si have) lost outer shell / outer electrons OR atoms have one more shell than (corresponding) ions OR effective nuclear charge is greater for the ion	1

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Question	Answer	Marks									
3(a)(iii)	(P to Cl form ions by) gaining electrons (to the same outer shell / p sub-shell)	1									
	Increased repulsion between electrons in same / outer shell / p sub-shell	1									
3(b)(i)	(outer) electron removed from <u>3p</u> subshell / orbital	1									
	(3p) higher in energy / more shielded / further from the nucleus	1									
3(b)(ii)	(outer) electron for S is paired in a <u>p orbital</u> / S has a full <u>p orbital</u>	1									
	causing (spin / electron) pair repulsion (which reduces attraction)	1									
3(c)(i)	oxidation numbers / states of elements (Na-Si) increase from +1 to +4 / by 1 every time	1									
	increasing number of valence electrons / NaCl, MgCl ₂ , AlCl ₃ , SiCl ₄ / number of chlorines matches group number	1									
	chlorine oxidation number / state –1 in all / stays the same	1									
3(c)(ii)	$\text{NaCl} \rightarrow \text{Na}^+ + \text{Cl}^-$	1									
	$\text{SiCl}_4 + 2\text{H}_2\text{O} \rightarrow \text{SiO}_2 + 4\text{HCl}$	1									
3(c)(iii)	<table border="1"> <tr> <td></td><td>structure</td><td>bonding</td></tr> <tr> <td>sodium chloride</td><td>giant / ionic</td><td>ionic</td></tr> <tr> <td>silicon(IV) chloride</td><td>simple / molecular</td><td>covalent</td></tr> </table>		structure	bonding	sodium chloride	giant / ionic	ionic	silicon(IV) chloride	simple / molecular	covalent	2
	structure	bonding									
sodium chloride	giant / ionic	ionic									
silicon(IV) chloride	simple / molecular	covalent									

Question	Answer	Marks
4(a)(i)	Iodoform / triiodomethane	1
4(a)(ii)	butan-2-ol	1
4(b)	CH ₃ CH ₂ CH ₂ CH ₂ OH (CH ₃) ₃ COH (CH ₃) ₂ CHCH ₂ OH	2
4(c)(i)	oxidation / redox	1
4(c)(ii)	acidified / H ⁺ AND potassium / sodium dichromate((VI)) or formulae	1
4(c)(iii)	<i>In any order:</i>	
	but-1-ene	1
	but-2-ene	1
	<i>cis / Z- AND trans / E-</i>	1

4(d)(i)		
	curly arrow from C=C to H	1
	correct dipole on HBr and curly arrow from bond of HBr to Br	1
	tertiary intermediate cation	1
	Br ⁻ with curly arrow from lone pair	1
4(d)(ii)	(carbo)cation / tertiary ion / tertiary intermediate (more) stable (than primary)	1
	due to electron-releasing / (positive) inductive effect of more alkyl / methyl groups	1

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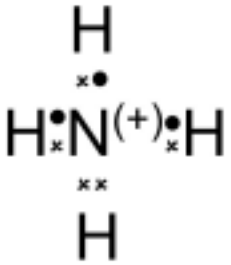
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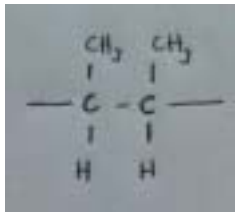
Question	Answer	Marks
1(a)(i)	$\text{Mg} + 2\text{H}_2\text{O} \rightarrow \text{Mg}(\text{OH})_2 + \text{H}_2$	1
1(a)(ii)	the product / $\text{Mg}(\text{OH})_2$ sparingly soluble / slightly soluble / less soluble (than NaOH)	1
1(b)(i)	<i>any two from:</i> (from Mg to Ba) larger (atomic) radius / more shells / more shielding - electron(s) are less tightly held (by nucleus) / less attracted (to nucleus) - ionisation energy / ies decrease(s) / electron(s) lost (more) easily (down the group) - lower activation energy (for the reactions down the group)	2
1(b)(ii)	<u>white</u> light / <u>white</u> flame	1
	<u>white</u> smoke / white solid	1
	$2\text{Mg}(\text{s}) + \text{O}_2(\text{g}) \rightarrow 2\text{MgO}(\text{s})$	1
1(b)(iii)	$\text{Mg} + \text{H}_2\text{SO}_4 \rightarrow \text{MgSO}_4 + \text{H}_2$	1
1(b)(iv)	<i>any two from:</i> - increasing (cation) size / (cat)ionic radius increases / increasing size of atoms - overall charge on (cation) is constant / (+)2 / decreasing charge density of (+2 charged cation) - number of delocalised / outer / valence electrons (per atom) remains the same / 2 - increased shielding	2
	decreasing (strength of) attraction between (cat)ion / nucleus / nuclear charge AND delocalised electron(s)	1

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Question	Answer	Marks
2(a)	<i>option 1:</i> the mass of (all the atoms/ions in) a formula (unit) / molecule OR the (weighted) average / (weighted) mean mass of (all the atoms / ions in) the formula (unit) / molecule [1] relative / compared to 1 / 12 (the mass of an atom) of carbon–12 OR on a scale in which a carbon–12 (atom / isotope) has a (mass) of (exactly) 12 (units) [1] <i>option 2:</i> mass of one mol of a compound / formula (unit) / molecule [1] relative / compared to 1 / 12 (the mass) of 1 mol of C-12 OR in which one mol C-12 (atom / isotope) is (a mass of exactly) 12 g [1]	2
2(b)(i)		
	4 shared pairs only (any symbols) (in NH ₄)	1
	3 × dot-and-cross bonds AND 1 × 2 crosses (in NH ₄)	1
2(b)(ii)	tetrahedral	1
	109–109.5° (inclusive)	1

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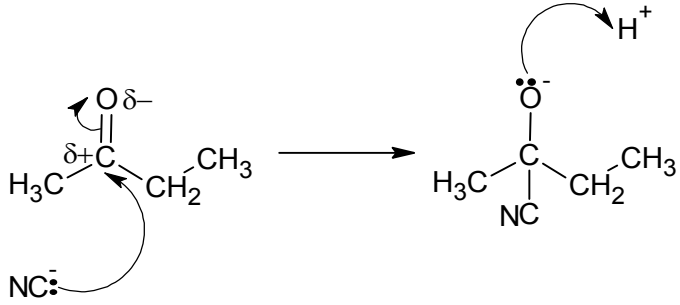
Question	Answer	Marks
2c(i)	<i>in any order explain meaning of:</i> <i>weak</i> partially ionises / incompletely dissociates (into ions) <i>Bronsted-Lowry acid</i> is a proton donor / H^+ (ion) donor / hydrogen ion donor	2
2c(ii)	$\text{NH}_4^+(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{NH}_3(\text{aq or g}) + \text{H}_3\text{O}^+(\text{aq})$	
	all correct species and balancing	1
	correct state symbols	1
2(d)(i)	$\text{MnO}_4^- + 5\text{Fe}^{2+} + 8\text{H}^+ \rightarrow \text{Mn}^{2+} + 5\text{Fe}^{3+} + 4\text{H}_2\text{O}$	1
2(d)(ii)	(Fe^{2+} is a) reducing agent / reductant provides/donates electron(s) / loses electron(s) / increases its oxidation number / (Fe^{2+}) becomes Fe^{3+}	2
2(d)(iii)	$4 \times 10^{-4} / 0.0004$	1
2(d)(iv)	$2 \times 10^{-3} / 0.002$	1
2(d)(v)	392	1
2(d)(vi)	6	1

Question	Answer	Marks
3(a)(i)	combustion	1
3(a)(ii)	$\text{C}_8\text{H}_{18} + 12\frac{1}{2}\text{O}_2 \rightarrow 8\text{CO}_2 + 9\text{H}_2\text{O}$	
	correct species	1
	correct balancing	1
3(b)(i)	cracking	1
3(b)(ii)	$-\text{CH}(\text{CH}_3)\text{CH}(\text{CH}_3)-$ OR 	
	even number of C's in correct backbone with 'end bonds' AND no C=C	1
	CH_3 and H on each of two C drawn for 1 repeat unit only AND all the carbons must be tetravalent	1
3(b)(iii)	addition	1
3c(i)	catalytic converter / catalyst	1
3c(ii)	$2\text{CO} + \text{NO}_2 \rightarrow 2\text{CO}_2 + \frac{1}{2}\text{N}_2$	1

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Question	Answer	Marks
3c(iii)	(photochemical) smog / fog / haze OR global dimming	1
3(d)(i)	<i>any 2 from:</i> lowers pH / increases acidity of rivers / lakes / oceans / seas / soil kills/harms fish OR harms / kills coral / plants / crops / trees leaches (toxic) aluminium (ions / salts) from soil (into rivers / lakes) leaches away soil nutrients damages / weathers / erodes buildings / statues	2
3(d)(ii)	$\text{NO}_2 + \text{SO}_2 \rightarrow \text{NO} + \text{SO}_3$	1
	$\text{SO}_3 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_4$	1
3(d)(iii)	(it is) regenerated / not used up / undergoes temporary chemical change / recovered unchanged	1
	$\text{NO} + \frac{1}{2}\text{O}_2 \rightarrow \text{NO}_2$	1

Question	Answer	Marks
4(a)(i)	iodoform / tri-iodomethane	1
4(a)(ii)	butanone	1

Question	Answer	Marks
4(b)	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO}$	1
	$(\text{CH}_3)_2\text{CHCHO}$	1
4(c)(i)	reduction	1
4(c)(ii)	NaBH_4 / sodium borohydride	1
	OR LiAlH_4 / lithium aluminium hydride	
4(d)(i)		
	lone pair on C of CN^- and curly arrow to C of $\text{C}=\text{O}$	1
	correct dipole on $\text{C}=\text{O}$ and curly arrow from = to O	1
	correct intermediate anion	1
	curly arrow from lone pair on O to H^+	1

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Question	Answer	Marks																							
4(d)(ii)	optical	1																							
4(d)(iii)	(X has a) chiral centre / asymmetric carbon atom OR (X has a) C atom attached to four different groups / atoms / chains	1																							
	non-super(im)posable mirror images	1																							
4(e)(i)	<i>M1 is for the process of taking the % of each element and dividing by its relative atomic mass.</i> <table><tr><td>C</td><td>H</td><td>N</td><td>O</td></tr><tr><td>$\frac{51.3}{12}$</td><td>$\frac{9.40}{1}$</td><td>$\frac{12.0}{14}$</td><td>$\frac{27.3}{16}$</td></tr></table> OR <table><tr><td>4.28</td><td>9.40</td><td>0.857</td><td>1.71</td></tr></table> <i>M2 is for dividing the smallest %/A_r into each of the remaining values to produce the correct ratio.</i> <table><tr><td>$\frac{4.28}{0.857}$</td><td>$\frac{9.40}{0.857}$</td><td>$\frac{0.857}{0.857}$</td><td>$\frac{1.71}{0.857}$</td></tr></table> OR <table><tr><td>4.9942</td><td>:</td><td>10.9685</td><td>:</td><td>1</td><td>:</td><td>1.9953</td></tr></table>	C	H	N	O	$\frac{51.3}{12}$	$\frac{9.40}{1}$	$\frac{12.0}{14}$	$\frac{27.3}{16}$	4.28	9.40	0.857	1.71	$\frac{4.28}{0.857}$	$\frac{9.40}{0.857}$	$\frac{0.857}{0.857}$	$\frac{1.71}{0.857}$	4.9942	:	10.9685	:	1	:	1.9953	2
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4.9942	:	10.9685	:	1	:	1.9953																			
4(e)(ii)	C ₅ H ₁₁ NO ₂ AND because the EFM = RFM	1																							

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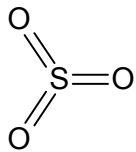
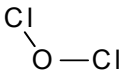
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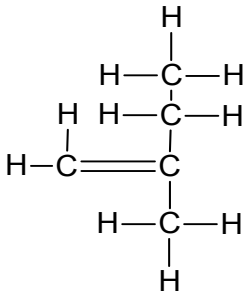
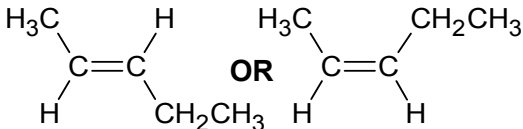
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1(a)	  trigonal planar non-linear/bent/V-shaped/angular	4
1(b)(i)	stronger attraction for O ²⁻ / stronger ionic bonding / more energy needed to overcome ionic bonding / separate ions	1
	charge density of magnesium (ion) is greater (than sodium ion) ora	1
1(b)(ii)	Either: M1 SiO ₂ has a giant (covalent) structure / giant molecular M2 Covalent bonds (much) stronger than VdW / id-id / IMFs in SO ₃ OR M1 SO ₃ has a (simple) molecular structure / (simple) molecule. M2 VdW / id-id / IMFs M2 IMF's are (much) weaker than covalent bonds (broken in SiO ₂) OR M1 Covalent bonds are broken in SiO ₂ AND VdW / id-id / IMFs in SO ₃ M2 Covalent bonds are stronger (than VdW / id-id / IMFs)	2
1(c)(i)	molecules / particles / reacting species are closer together	1
	so frequency of collisions increases	1
	few(er) moles on right	1
	so (equilibrium) reaction shifts right / towards products / (as pressure increases to oppose the change)	1

Question	Answer	Marks
1(c)(ii)	Decreasing reactant concentrations (at different time intervals / as reaction progresses)	1
	So rate decreases OR change in concentration ÷ time taken decreases	1
1(c)(iii)	(line becomes horizontal when) forward and reverse rates equal / equilibrium established	1
1(c)(iv)	2:1 ratio in equation / SO ₂ used up more quickly (than O ₂) / 2 × SO ₂ react for every 1 × O ₂	1
1(d)(i)	$K_c = \frac{[\text{SO}_3]^2}{[\text{SO}_2]^2 \times [\text{O}_2]}$	1
1(d)(ii)	SO ₂ = 0.02 (mol)	1
	O ₂ = 1.01 (mol)	1
1(d)(iii)	$K_c = \frac{(1.98 / 40)^2}{(0.02 / 40)^2 (1.01 / 40)}$ = 3.88 / 3.882 × 10 ⁵ Units = dm ³ mol ⁻¹ / mol ⁻¹ dm ³	3 M1 M2 M3

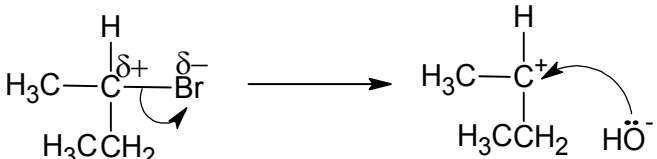
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Question	Answer	Marks
2(a)(i)	(molecules / isomers with) the same molecular formula / same number of atoms of each element	1
	different structural formulae / different structures	1
2(a)(ii)	(Molecules / isomers) with the same (molecular and) structural formula	1
	different arrangement of atoms in space / different spatial arrangement of atoms.	1
2(b)(i)	two Hs on one of the C=C carbons / terminal C / C-1	1
	no chiral C / no C with 4 different groups / atoms / chains attached has a super(im)posable mirror image	1
2(b)(ii)		1
	2-methylbut-1-ene	1
2(b)(iii)	structure 	1
	trans-pent-2-ene or <i>E</i> - cis-pent-2-ene or <i>Z</i> -	1

Question	Answer			Marks												
3(a)(i)	(volatility) decreases			1												
3(a)(ii)	increasing numbers / more of electrons (in molecules)			1												
	increased strength of id-id / VdW / IMFs			1												
3(b)	$\text{Cl}_2 + 2\text{NaI} \rightarrow 2\text{NaCl} + \text{I}_2$			1												
3(c)(i)	<table><tr><td></td><td>$\text{NaI(aq)} + \text{AgNO}_3\text{(aq)}$</td><td>$\text{NaCl(aq)} + \text{AgNO}_3\text{(aq)}$</td></tr><tr><td>colour of ppt</td><td>yellow</td><td>white</td></tr><tr><td>name of ppt</td><td>silver iodide</td><td>silver chloride</td></tr><tr><td>effect of addition of aqueous ammonia to the precipitate</td><td>No (visible) change</td><td>dissolves / soluble</td></tr></table>				$\text{NaI(aq)} + \text{AgNO}_3\text{(aq)}$	$\text{NaCl(aq)} + \text{AgNO}_3\text{(aq)}$	colour of ppt	yellow	white	name of ppt	silver iodide	silver chloride	effect of addition of aqueous ammonia to the precipitate	No (visible) change	dissolves / soluble	3
	$\text{NaI(aq)} + \text{AgNO}_3\text{(aq)}$	$\text{NaCl(aq)} + \text{AgNO}_3\text{(aq)}$														
colour of ppt	yellow	white														
name of ppt	silver iodide	silver chloride														
effect of addition of aqueous ammonia to the precipitate	No (visible) change	dissolves / soluble														
3(c)(ii)	$\text{Ag}^+\text{(aq)} + \text{I}^-\text{(aq)} \rightarrow \text{AgI(s)}$			1												

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Question	Answer	Marks
3(d)	M1 sulfuric acid acts as an acid with NaCl (and NaBr) OR $\text{NaCl} + \text{H}_2\text{SO}_4 \rightarrow \text{NaHSO}_4 + \text{HCl}$ OR $2\text{NaCl} + \text{H}_2\text{SO}_4 \rightarrow \text{Na}_2\text{SO}_4 + 2\text{HCl}$	1
	sulfuric acid acts as an oxidising agent with NaI / I OR NaI is a reducing agent	1
	I^- more powerful reducing agent than Cl^- OR sulfuric acid can oxidise I^- but not Cl^- OR sulfuric acid is a stronger oxidising agent than iodide ions OR sulfuric acid is not as strong an oxidising agent than chloride ions	1
3(e)(i)	(Species that) gains <u>electrons</u> / <u>electron</u> acceptor	1
3(e)(ii)	$\text{Cl}_2 + \text{H}_2\text{O} \rightarrow \text{HCl} + \text{HClO}$	1
3(e)(iii)	$3\text{Cl}_2 + 6\text{NaOH} \rightarrow 5\text{NaCl} + \text{NaClO}_3 + 3\text{H}_2\text{O}$	1
	0 to –1 (+)5 AND chlorine has been oxidised and reduced.	1

Question	Answer	Marks
4(a)(i)	2-bromobutane	1
4(a)(ii)	ketone	1
4(b)	$(\text{CH}_3)_3\text{CBr}$ $(\text{CH}_3)_2\text{CHCH}_2\text{Br}$ $\text{CH}_2\text{BrCH}_2\text{CH}_2\text{CH}_3$ 3 correct = 2 marks 2 correct = 1 mark	2
4(c)(i)	S = substitution N = nucleophilic	1
4(c)(ii)	 M1 = dipole and curly arrow M2 = intermediate carbocation IGNORE CH_2CH_3 shown as C_2H_5 M3 = OH^- with lone pair and curly arrow from lone pair to the 'C'	3
4(d)	$\text{C}_4\text{H}_9\text{Cl}$ slower (than $\text{C}_4\text{H}_9\text{Br}$) $\text{C}_4\text{H}_9\text{I}$ faster (than $\text{C}_4\text{H}_9\text{Br}$) $\text{C}-\text{Cl}$ bond stronger than $\text{C}-\text{Br}$ OR $\text{C}-\text{Cl}$ 340 $\text{C}-\text{Br}$ 280 $\text{C}-\text{I}$ bond weaker than $\text{C}-\text{Br}$ OR $\text{C}-\text{Br}$ 280 $\text{C}-\text{I}$ 240 1 mark for each point, max 3	3

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Question	Answer	Marks
4(e)	ethanolic (instead of aqueous)	1
	hotter/higher temperature (heat under) reflux	1