

GCE

Chemistry A

Advanced Subsidiary GCE

Unit F322: Chains, Energy and Resources

Mark Scheme for January 2013

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All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

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Annotations

Annotations available in Scoris.

Annotation	Meaning
BOD	Benefit of doubt given
CON	Contradiction
×	Incorrect response
ECF	Error carried forward
I	Ignore
NAQ	Not answered question
NBOD	Benefit of doubt not given
POT	Power of 10 error
^	Omission mark
RE	Rounding error
SF	Error in number of significant figures
 Image: A start of the start of	Correct response

Abbreviations, annotations and conventions used in the detailed Mark Scheme (to include abbreviations and subject-specific conventions).

Annotation	Meaning
DO NOT ALLOW	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
()	Words which are not essential to gain credit
	Underlined words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

Generic comments

ORGANIC STRUCTURES

For a 'structure' or 'structural formula',

• ALLOW correct structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous)

For an alkyl group shown within a structure,

- ALLOW bond drawn to C or H, eg ALLOW CH₃-,CH₂-, C₃H₇-, etc
- ALLOW vertical 'bond' to any part of an alkyl group

For an OH group shown within a structure,

- DO NOT ALLOW formula with horizontal —HO OR OH—
- ALLOW vertical 'bond' to any part of the OH group

For a CHO group shown within a structure,

• DO NOT ALLOW COH

For a 3D structure,

•	For bond in the plane of paper, a solid line is expected:	
•	For bond out of plane of paper, a solid wedge is expected:	
•	For bond into plane of paper, ALLOW:	
•	ALLOW a hollow wedge for 'in bond' OR an 'out bond', provided it is different from the other in or out wedge eg:	

NAMES

Names including alkyl groups:

- ALLOW alkanyl, eg ethanyl (ie IGNORE 'an')
- **DO NOT ALLOW** alkol, eg ethol (ie 'an' is essential)

Names of esters:

- Two words are expected, eg ethyl ethanoate
- ALLOW one word, eg ethylethanoate

Names with multiple numbers and hyphens: Use of 'e'

- **ALLOW** superfluous 'e', eg propane-1-ol ('e' is kept if followed by consonant)
- ALLOW absence of 'e', eg propan-1,2-diol ('e' is omitted if followed by vowel)

Hyphens separate name from numbers:

• ALLOW absence of hyphens, eg propane 1,2 diol

Multiple locant numbers must be clearly separated:

- ALLOW full stops: eg 1.2 OR spaces: 1 2
- DO NOT ALLOW eg 12

Locant numbers in formula must be correct

• DO NOT ALLOW propan-3-ol

Order of substituents should be alphabetical:

• ALLOW any order (as long as unambiguous), eg 2-chloro-3-bromobutane

ABBREVIATIONS

van der Waal's forces **ALLOW** vdw forces **OR** VDW forces (and any combination of upper and lower cases)

Q	uestion	Answer	Marks	Guidance
1	(a)	C ₃ H ₇ ✓	1	ALLOW H ₇ C ₃
	(b)	Saturated Only has (carbon to carbon) single bonds ✓	2	ALLOW does not contain any (carbon to carbon) double bonds ALLOW all of the carbon atoms are bonded to four other atoms
		<i>Hydrocarbon</i> Contains (the elements) hydrogen and carbon only ✓		DO NOT ALLOW contains hydrogen and carbon DO NOT ALLOW a mixture of carbon and hydrogen only DO NOT ALLOW hydrogen and carbon molecules only
	(c)		1	
	(d)	as branching increases the boiling point decreases OR the more branched the isomers of hexane are the lower the boiling point ✓	3	ALLOW ORA throughout First marking point must compare boiling point and branching for all three isomers
		branched isomers have less surface (area) of contact OR branched fewer points of contact (than unbranched) ✓		Reference to just surface area / closeness of molecules is not sufficient
		 (the more branched the) fewer van der Waals' forces OR (the more branched) has weaker van der Waals' forces OR Less energy required to break van der Waal's forces ✓ 		ALLOW vdw forces OR VDW forces (and any combination of upper and lower cases) DO NOT ALLOW VDW mark if answer states that these are between atoms or answer implies that these are bonds
	(e)	$\begin{array}{cccc} C_{10}H_{22} \rightarrow & C_{6}H_{14} + & C_{4}H_{8} \\ \hline \mathbf{OR} \\ C_{10}H_{22} \rightarrow & C_{6}H_{14} + & 2C_{2}H_{4} \end{array} \checkmark$	1	ALLOW correct structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous) IGNORE state symbols

Question		on	Answer		Marks	Guidance
1	1 (f) (i)		$C_4H_{10} + 2Cl_2 \rightarrow C_4H_8Cl_2 + 2HCl \checkmark$		1	IGNORE state symbols
	(ii)				2	
			Isomer 1	Isomer 2		Must be a displayed formula
				1,3-dichlorobutane ✓		Must be a displayed formula
			Correct displayed formula eg:			ALLOW absence of hyphens
						1 and 3 must be clearly separated:
						ALLOW full stops: 1.3 OR spaces: 1 3
						DO NOT ALLOW 13
			н н н н 🗸			
	(g)	(i)	covalent bond breaking ✓		2	ALLOW covalent bond is split
				an ta anah atawa		ICNORE notice for store
			OR	es lo each alom		DO NOT ALLOW molecule or compound for atom
			makes (two) radicals ✓			DO NOT ALLOW to each molecule or to each reactant
						ALLOW one electron goes to each product / species
						IGNORE homolytic fission equations
		(ii)	$C_1 + C_2 H_0 C_1 \rightarrow C_2 H_0 C_1$	+ HC1 √	2	IGNORE dots even if incorrect
		(,			-	
			$C_4H_8Cl + Cl_2 \rightarrow C_4H_8Cl_2 + Cl$	\checkmark		
	(h)				1	ALLOW any correct multiples for these equations of
	(n)		$O_4 \Pi_{10} + 4/2 O_2 \rightarrow 4 O O + 5 \Pi_2 O$		I	ALLOW any correct multiples for these equations eg $2C_4H_{40} + 9O_2 \rightarrow 8CO + 10 H_2O$
			$C_4H_{10} + 2\frac{1}{2}O_2 \rightarrow 4C + 5H_2O \checkmark$			IGNORE state symbols
						ALLOW equations for incomplete combustion that give CO ₂
						with CO and/or C eg
				Total	16	

C	Question		Answer		Guidance
2	(a)		(enthalpy change for the) formation of one mole (of $P_4O_{10}) \checkmark$ from (constituent) elements OR from P_4 /phosphorus and O_2 /oxygen \checkmark	2	 ALLOW energy required OR energy released ALLOW makes one mole of product/substance/molecule/ compound ALLOW made from P and O₂ OR made from two elements IGNORE comments related to standard conditions
	(b)		FIRST, CHECK THE ANSWER ON ANSWER LINE IF answer = -368 (kJ mol ⁻¹) award 3 marks (+)2984 +(+)6 × 286 OR (+)2984 +(+)1716 OR (+)4700 ✓ (-)1267 × 4 OR (-)5068 ✓ -368 ✓	3	 IF there is an alternative answer, check to see if there is any ECF credit possible using working below. See list below for marking of answers from common errors. IGNORE sign ALLOW ECF for enthalpy change of products – enthalpy change of reactants ALLOW for 2 marks: +368 cycle wrong way around OR -1798 no × 6 OR (+)3433 no x 4 OR -3352 missing 2984 OR (+) 9768 product the wrong sign around OR (-) 9768 reactants the wrong sign ALLOW for 1 mark: (+)1798 no x 6 and cycle wrong way around and not × 4 OR (-)3352 missing 2984 and cycle wrong way around OR (-)4333 cycle wrong way around and not × 4 OR (+)3352 missing 2984 and cycle wrong way around OR (+)3352 missing 2984 and cycle wrong way around
					OR –4782 missing 2984 and x 6 Note: There may be other possibilities.

C	Question		Answer	Marks	Guidance
	(c)		P ₄ + 5O ₂ + 6H ₂ O → 4H ₃ PO ₄ \checkmark Only the desired product is made \checkmark Second marking point can only be awarded if the equation is correct.	2	ALLOW there are no waste productsOR there are no by-productsOR there is only one product.DO NOT ALLOW it is an addition reaction
			Total	7	

Question		on	Answer	Marks	Guidance
3	(a)	(i)	acid ✓	1	ALLOW named mineral acid or correct formula eg phosphoric acid, H_3PO_4 , sulfuric acid, H_2SO_4 or H^+ DO NOT ALLOW any carboxylic acids
		(ii)	$C_5H_{12}O \rightarrow C_5H_{10} + H_2O \checkmark$	1	DO NOT ALLOW use of C₅H ₁₁ OH
		(iii)	<i>structural isomerism</i> have the same molecular formula ✓ but different structural formulae ✓	4	Same formula is not sufficient ALLOW different structure OR different displayed formula OR different skeletal formula Different formula or different arrangement of atoms is not sufficient ALLOW different structural arrangement (of atoms)
			stereoisomerism have the same structural formula ✓		ALLOW have the same structure Stereoisomers have the same formula or molecular formula is not sufficient



Q	Question		Answer	Marks	Guidance
3	(a)	(v)	carbon–carbon double bond ✓ Each carbon atom in the double bond is attached to (two) different groups/atoms ✓	2	 IGNORE comments about rotation ALLOW carbon double bond ALLOW Each carbon atom of the double bond is attached to a H and an alkyl group DO NOT ALLOW functional groups for groups DO NOT ALLOW the carbon atoms are attached to different groups "Each carbon atom in the double bond" implies a carbon–carbon double bond for the first marking point
	(b)		$\begin{array}{c} \overset{OH}{\longleftarrow} & + \ [\mathrm{O}] & & & & \\ & & & & \\ & & & \\ & & & \\ & & $	2	Balancing mark can only be awarded if the equation has a correct skeletal formula for the product
	(c)		$\begin{array}{c c} CH_{3}CH_{2}CH_{2}CH_{2}OH \\ \end{array} \\ \begin{array}{c} \text{distil with } H_{2}SO_{4} \\ / K_{2}Cr_{2}O_{7} \\ \hline \\ CH_{3}CH_{2}CH_{2}CH_{2}CHO \\ \checkmark \end{array} \\ \begin{array}{c} \text{heat under reflux} \\ \text{with } H_{2}SO_{4} / K_{2}Cr_{2}O_{7} \\ \hline \\ CH_{3}CH_{2}CH_{2}CH_{2}CHO \\ \checkmark \end{array} \\ \begin{array}{c} CH_{3}CH_{2}CH_{2}CH_{2}CHO \\ \checkmark \end{array} \\ \end{array}$	2	ALLOW correct structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous) eg H = H = H = H = H = H = H = H = H = H =
			Total	15	

Question		on	Answer	Marks	Guidance
4	(a)		FIRST, CHECK THE ANSWER ON ANSWER LINE IF answer = 681 (kJ) award 3 marks	3	IF there is an alternative answer, check to see if there is any ECF credit possible using working below.
			Evidence of dividing 1000 by 24		ALLOW 41.7 up to calculator value 41.6666667 correctly rounded.
					ALLOW $\frac{1000}{24}$ for first marking point if not calculated
			Evidence of dividing by 3 and multiplying by 49 in the calculation		ALLOW energy released per mole = 16.3 ✓
			energy released = 681 (kJ) ✓		IGNORE (–) sign in the answer
			(MUST BE TO 3 SIG FIGS)		
			Alternative Working		Common Incorrect answers
			3 moles = 72 dm ³ \checkmark		0.392 scores 2 marks 392000 scores 2 marks
			So <u>1000</u> or 13.9 ✓ 72		
			Energy released = $13.9 \times 49 = 681 (kJ)$		



Question	Answer	Marks	Guidance
(c)	(+)49 ✓	1	DO NOT ALLOW -49
(d)	(+)274 ✓	1	DO NOT ALLOW –274 ALLOW answer to (c) + 225 as ECF
(e)	(equilibrium position shifts) to the left \checkmark	2	ALLOW 'favours the left', as alternative for 'shifts equilibrium to left'
	 (Forward) reaction is exothermic OR reaction gives out heat OR reverse reaction is endothermic OR reverse reaction takes in heat ✓ The explanation mark is dependent on the correct shift 		Note: ALLOW suitable alternatives for 'to left', eg: towards CO_2 / H_2 OR towards reactants OR in backward direction OR in reverse direction OR decreases yield of CH_3OH /products IGNORE responses in terms of rate
	of the equilibrium		
(f)	(equilibrium position) shifts to the left ✓	2	ALLOW 'favours the left', as alternative for 'shifts equilibrium to left' Note: ALLOW suitable alternatives for 'to left', eg: towards CO_2 / H_2 OR towards reactants OR in backward direction OR in reverse direction OR decreases yield of CH_3OH /products
			IGNORE responses in terms of rate
	Right-hand side has fewer (gaseous) moles/molecules ✓ ORA		ALLOW four moles on the left and two moles on the right ALLOW more moles of reactants or fewer moles of products
	The explanation mark is dependent on the correct shift of the equilibrium		ASSUME "goes the side with more gas molecules" implies from equation that more molecules on the left OR "goes to side with fewer gas molecules" implies from equation that fewer molecules are on the right

Question		on	Answer	Marks	Guidance
	(g)		Adsorption of reactants OR adsorption of gases OR H_2 and CO_2 attached to surface \checkmark	3	ALLOW CO ₂ and H ₂ (weakly) bonded to surface OR reactants bond to surface OR CO ₂ and H ₂ form temporary bonds with the catalyst DO NOT ALLOW absorption
			Bonds weaken in reactants OR chemical reaction OR activation energy decreases ✓		ALLOW bonds weaken in H_2 OR bonds weaken in CO_2 OR C=O bonds weaken OR bonds break and new bonds made in product OR H_2O and CH_3OH made
			Desorption of products OR desorption of H_2O and $CH_3OH \checkmark$		ALLOW products leave the surface/catalyst OR H_2O and CH_3OH no longer bonded to surface/catalyst ALLOW deadsorption OR adsorb from for desorption ALLOW diffuse away for desorption
			Total	15	

C	uestion	Answer	Marks	Guidance
5	(a)	FIRST, CHECK THE ANSWER ON ANSWER LINE IF answer = 90% award 3 marks	3	IF there is an alternative answer, check to see if there is any ECF credit possible using working below.
		amount of dichloroethane = $\frac{19800000}{99.0}$		ALLOW approach based on mass for 2nd and 3rd marks
		OR 200000 (mol) OR 2 × 10 ⁵ (mol) ✓		
		amount of chloroethene = $\frac{11250000}{62.5}$		Theoretical mass of chloroethene = 200000×62.5 OR 12500000 (g) OR 1.25×10^7 (g) \checkmark
		OR 180000 (mol) OR 1.8 × 10 ⁵ (mol) ✓		Calculates percentage yield = $\frac{11250000}{12500000} \times 100 = 90 \% \checkmark$
		Calculates percentage yield = $\frac{180000}{200000} \times 100 = 90 \%$ \checkmark		ALLOW approach based on grams rather than tonnes: $n(dichloroethane) = \frac{19.80}{99.0}$ OR 0.2 (mol) \checkmark
				n (chloroethane) = $\frac{11.25}{62.5}$ OR 0.18 (mol)
				OR theoretical mass chloroethane = 0.2×62.5 OR 12.5 g \checkmark
				% yield = $\frac{0.18}{0.20} \times 100 = 90$ % OR $\frac{11.25}{12.5} \times 100 = 90$ % \checkmark
				ALLOW ECF throughout from wrong <i>M</i> _r value(s) with final % yield to 2 or more significant figures DO NOT ALLOW final mark for an answer above 100%
				Note: If this is the only working seen award no marks ie $\frac{11.25 \times 10^6}{19.80 \times 10^6} \times 100 = 56.81\%$

C	Question		Answer	Marks	Guidance
5	(b)		FIRST, CHECK THE ANSWER ON ANSWER LINE IF answer = (+)62 award 3 marks	3	IF there is an alternative answer, check to see if there is any ECF credit possible.
			ΔH for bonds broken = 2691 (kJ mol ⁻¹) \checkmark		IGNORE sign ALLOW 1106 (C–Cl, C–C and C–H bonds)
			ΔH for bond formed = 2629 (kJ mol ⁻¹) \checkmark		IGNORE sign ALLOW 1044 (H–Cl and C=C bonds)
			$\Delta H = (+)62 (\text{kJ mol}^{-1}) \checkmark$		ECF based on bonds broken – bonds formed
					ALLOW 2 marks for –62
	(c)		Displayed formulae of monomer and polymer required for the marks.	3	Polymer must have side links (do not have to cut through bracket and can be dotted lines)
			n H_{-} $C = C_{-}$ H_{-}		ALLOW a correct section of the polymer with side links as below would score two marks as the equation is not balanced $ \begin{array}{c} & & \\ n & \\ & & \\ H & & H \end{array} \xrightarrow{CI} \\ & & \\ H & & \\ H & & \\ \end{array} \xrightarrow{H} \\ & & \\ \end{array} \xrightarrow{CI} \\ & & \\ \hline \\ & & \\ H & & \\ \end{array} \xrightarrow{CI} \\ & & \\ \hline \\ & & \\ H & & \\ \end{array} \xrightarrow{CI} \\ & & \\ \hline \\ & & \\ H & & \\ \end{array} \xrightarrow{CI} \\ & & \\ \hline \\ & & \\ H & & \\ \end{array} \xrightarrow{CI} \\ & & \\ \hline \\ & & \\ H & & \\ \end{array} \xrightarrow{CI} \\ & & \\ \hline \\ & & \\ H & & \\ \end{array} \xrightarrow{CI} \\ & & \\ \hline \\ & & \\ H & & \\ \end{array} \xrightarrow{CI} \\ & & \\ \hline \\ & & \\ H & & \\ H & & \\ \end{array} \xrightarrow{CI} \\ & & \\ \hline \\ & & \\ H & & \\ H & & \\ H & & \\ \end{array} \xrightarrow{CI} \\ & & \\ \hline \\ & & \\ H & & \\ H & & \\ H & & \\ \end{array} \xrightarrow{CI} \\ & & \\ \hline \\ & & \\ H & \\ H & & \\ H & \\ H & & \\ H & \\$
					DO NOT ALLOW ECF from wrong monomer <i>n</i> on LHS can be at any height to the left of formula AND <i>n</i> on the RHS must be a subscript (essentially below the side link)
			A correctly balanced equation using displayed formulae for any monomer and matching polymer including the correct use of $n \checkmark$		The equation below would be worth 1 mark for balancing $ \begin{array}{c} n \\ $

Que	stion	Answer	Marks	Guidance
(0	(i) (k	React with an alkali OR react with a base/carbonate OR Bubble through water (to make HCl(aq)) OR dissolve in water ✓	1	ALLOW react with a named alkali or base eg calcium carbonate, calcium hydroxide, magnesium oxide, ammonia ALLOW an appropriate chemical formula IGNORE use of gas scrubbers
	(ii)	Sort and recycle ✓ Organic feedstock OR cracked ✓	2	 ALLOW separate and recycle or sorting and remoulding ALLOW use for the production organic compounds OR synthesis gas ALLOW the production of plastics or monomers or new polymers
	(iii)	(Bio) degradable (polymers) OR compostable (polymers) OR soluble (polymers) OR photodegradable (polymers) ✓	1	IGNORE a named polymer if degradable DO NOT ALLOW any addition polymer eg PTFE
		Total	13	

	Question		Answer	Marks	Guidance
6	(a)		Bond breaking absorbs energy AND bond forming releases energy ✓ More energy released than absorbed ✓ The second marking point is dependent on the correct identification of the energy changes during bond breaking and bond making	2	 ALLOW bond breaking is endothermic AND bond forming is exothermic DO NOT ALLOW bond forming requires energy ALLOW more energy is released when the bond in the products are formed than is required to break the bonds in the reactants ALLOW exothermic change transfers more energy than endothermic change OR bond forming transfers more energy than bond breaking OR '(the sum of the) bond enthalpies in the products is greater than the (sum of the) bond enthalpies in the reactants' OR '(the sum of the) bond enthalpies of the bonds made is greater than (the sum of) the bond enthalpies of the bonds broken' OR more energy associated with bond making than with bond breaking IGNORE reference to strong and weak bonds IGNORE enthalpy of products is less than enthalpy of reactants
	(b)	(i)	(C=O) bond vibrates (more) OR bond bends (more) OR bond stretches (more) ✓	1	IGNORE molecule vibrates/rotates "It" refers to the molecule and is insufficient DO NOT ALLOW any reference to bond breaking. DO NOT ALLOW a stated bond if not present in CO ₂ eg C-O, C-H

Question	Answer	Marks	Guidance
(ii)	<pre>Any two from: (injected) deep into the oceans / sea ✓</pre>	2	DO NOT ALLOW reference to carbon being stored – the answer must either refer to carbon dioxide or not mention the name of the stored substance. Assume "it" refers to CO ₂
			DO NOT ALLOW dumping waste at the bottom of the sea
			ALLOW on the sea-bed
			DO NOT ALLOW dissolve CO_2 in the sea OR (stored) in ocean
	(Stored) in geological formations OR (stored) deep in rocks OR (stored) in old mines OR (stored) in old oil wells OR old gas fields ✓		DO NOT ALLOW geographical formations ALLOW stored under the sea (bed) ALLOW pumped into oil wells to force last bit of oil out DO NOT ALLOW buried underground
	(Stored) by reaction with metal oxides OR reaction to form (solid) carbonates OR (stored) as a carbonate OR equation to show formation of metal carbonate ✓		DO NOT ALLOW react with metals to form carbonates IGNORE mineral storage

Quest	ion	Answer	Marks	Guidance
(c)		Any two from:	2	
		Energy demand Low(er) temperature (can be used) OR reduces CO₂ emissions (from burning fossil fuels) ✓		ALLOW 'allows use of room temperature' OR 'allows use of a lower pressure' OR uses less fuel IGNORE lower energy demand OR lower activation energy IGNORE cheaper IGNORE less greenhouse gases OR reduces global warming
		Specificity enzymes have a great deal of specificity ✓		ALLOW making specific isomers / enantiomers ALLOW for making pure products ALLOW generating specified products
		Atom economy greater atom economy OR less waste ✓		ALLOW increases atom economy
		<i>Toxicity</i> can reduce use of toxic solvents OR reduces use of toxic catalysts OR reduces the use of toxic reactants ✓		ALLOW reduce use of hazardous/toxic/harmful/poisonous chemicals ALLOW enzymes are non toxic IGNORE can be reused

Quest	ion	Answer	Marks	Guidance
(d)		Catalyst lowers the activation energy (because of a different reaction pathway) ✓ Diagram of Boltzmann distribution ✓	5	Can be scored from the diagram by correctly labelling $E_{a cat}$ closer to the origin than E_a Boltzmann distribution must start at origin AND must not touch <i>x</i> -axis at high energy
		axes labelled (number of) molecules and energy \checkmark $E_{\rm a \ cat}$		DO NOT ALLOW Boltzmann distribution mark if two curves drawn
		(number of)		DO NOT ALLOW Boltzmann distribution curve bending upwards at higher energy
		molecule		ALLOW particles instead of molecules DO NOT ALLOW the first use of atoms but credit atoms if used in a subsequent marking point
		energy extra molecules with energy above <i>E</i> _a		DO NOT ALLOW enthalpy on x-axis instead of energy
		Greater proportion of molecules with energy above activation energy with catalyst \checkmark		ALLOW more molecules with energy above activation energy (with a catalyst)
		activation energy with catalyst s		OR more molecules overcome the activation energy (with a catalyst)
				OR more molecules have enough energy to react (with a catalyst)
				OR more molecules are able to react at lower energies
		more effective collisions OR more successful collisions OR increased frequency of successful collisions ✓		More collisions OR more frequent collisions are not sufficient
		Total	12	





Question	Answer	Marks	Guidance
7	Electrophilic addition	6	ANNOTATE ANSWER WITH TICKS AND CROSSES ETC
	correct equation for the reaction \checkmark		
	$CH_2CHCH_2CH_2CI + HBr \longrightarrow CH_3CHBrCH_2CH_2CI$ OR		ALLOW correct molecular OR structural OR displayed OR skeletal formula OR mixture of the above.
	$CH_2CHCH_2CH_2CI + HBr \longrightarrow CH_2BrCH_2CH_2CH_2CI$		
	Indication that there are two possible addition products \checkmark		$eg C_4H_7Cl + HBr \rightarrow C_4H_8BrCl$
	Correct product ✓		
	$ \begin{vmatrix} & & & & & \\ & H & & Br & H & H \\ & & & & & \\ & H & & & & \\ & H & & & C & C & C & C \\ & & & & & & \\ & H & & H & H & H \\ & & & H & H$		For the structure of the product ALLOW correct structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous) if seen ONCE in equation, mechanism or drawn out eg $CH_2BrCH_2CH_2CH_2Cl$ or $CH_3CHBrCH_2CH_2Cl$
	Mechanism		
	Curly arrow from C=C of correct chloroalkene to attack the H atom in HBr \checkmark		curly arrow must start from covalent bonds and not atoms Lone pair does not need to be shown on ion or used in mechanism
	Correct dipole on H–Br: $H^{\delta+}$ and $Br^{\delta-}$ AND curly arrow from H–Br bond to Br \checkmark		DO NOT ALLOW any other partial charges eg shown on double bond
	Correct carbocation / carbonium ion with the full positive charge shown: C ⁺		DO NOT ALLOW $C^{\delta+}$ for charge on carbonium ion.
	correct curly arrow from lone pair of Br ⁻ to correct carbon atom OR correct curly arrow from negative charge of Br ⁻ to correct carbon atom \checkmark		Curly arrow from Br ⁻ can start from the negative charge or the lone pair DO NOT ALLOW delta negative, i.e. $Br^{\delta-}$

Question	Answer	Marks	Guidance
7	Electrophilic addition continued		
	$H = \begin{bmatrix} H & H & H & H & H & H & H \\ H & C & C & C & C & C & C & C & C \\ H & H_2 & C & C & C & C & C & C & C & C & C & $		
	H = H = H = H = H = H = H = H = H = H =		
	$H \xrightarrow{C} C \xrightarrow{H} H \xrightarrow{H} H \xrightarrow{H} C \xrightarrow{-C} \xrightarrow{-C} C \xrightarrow{-C} \xrightarrow{-C} C \xrightarrow{-C} -C$		
	H = H = H = H = H = H = H = H = H = H =		
	heterolytic fission for both mechanisms and not contradicted ✓	1	

Question	Answer	Marks	Guidance
	 ALTERNATIVE APPROACH The Candidate who reacts with KOH followed by HBr Award all marks for the nucleophilic substitution mechanism as per the marking scheme You can award all marks for the electrophilic addition mechanism; however the product will be one of the following: 	Marks	
	$\begin{bmatrix} H & H & H & H \\ & & & \\ H & C & C & C & C & OH \\ & & & \\ H & Br & H & H \end{bmatrix} OR \begin{bmatrix} H & H & H & H \\ & & & \\ H & C & C & C & C & C & OH \\ & & & \\ Br & H & H & H \end{bmatrix}$		
	 The mechanism will be the same except the –C<i>l</i> will now be replaced by –OH at every stage 		
	Total	12	

Question	Answer	Marks	Guidance
8	IR spectrum (absorbance between) 3200–3550 cm ⁻¹ indicates –OH AND X is an alcohol ✓	1	 LOOK ON THE SPECTRUM for labelled absorbance which can be given credit ALLOW an absorbance within the range 3100 to 3700cm⁻¹ from the spectrum. Answer must give –OH and alcohol for the mark. IGNORE phenol DO NOT ALLOW carboxylic acid (there is no carbonyl group present in the spectrum)
	Formula mole ratio C : H : O $\frac{0.600}{12}$: $\frac{0.133}{1.0}$: $\frac{0.267}{16}$ OR $0.0500 : 0.133 : 0.0167 \checkmark$ $\frac{0.05}{0.0167}$: $\frac{0.133}{0.0167}$: $\frac{0.0167}{0.0167}$ OR $3 : 8 : 1$ OR C ₃ H ₈ O \checkmark Candidate links C ₃ H ₈ O to 60 such as C ₃ H ₈ O has M _r 60 OR C ₃ H ₈ O has m/z = 60 \checkmark	3	Must be a clear link between the formula and the M_r OR m/z ALLOW evidence of M_r , eg (12 x 3) + (8 x 1) + 16; 36 + 8 + 16 = 60 ALLOW alternative approach for empirical formula and evidence that 60 is equal to C ₃ H ₈ O $M_r = 60$ Carbon Hydrogen $60 \times \frac{60}{100} = 36$ $\frac{60 \times \frac{13.3}{100}}{100} = 8$ 36/12 = 3 C $8/1 = 8$ H 36 + 8 = 44 $60 - 44 = 16$ so 1 O C ₃ H ₈ O

Q	uestion	Answer	Marks	Guidance
8		Identification and equation	6	
		X is $CH_3CH_2CH_2OH$ OR $CH_3CHOHCH_3$ OR either $CH_3CH_2CH_2OH$ or $CH_3CHOHCH_3 \checkmark$		ALLOW correct structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous)
				IGNORE names
		QWC Stated in words that Y must be an ester because it is made from the reaction of a carboxylic acid AND X (propan-1-ol OR propan-2-ol OR an alcohol) ✓		ALLOW a carboxylic acid reacts with an alcohol to give an ester. IGNORE ethanoic acid (as this is stated in the question)
		Y is $CH_3COOCH_2CH_2CH_3$ OR $CH_3COOCH(CH_3)_2$ OR either $CH_3COOCH_2CH_2CH_3$ or $CH_3COOCH(CH_3)_2 \checkmark$ Must be consistent with a structure of alcohol X		ALLOW correct structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous) If no structure of X is provided one mark can be awarded for a correct structure of $CH_3COOCH_2CH_2CH_3$ OR $CH_2COOCH(CH_2)_3$
		$m/z = 31$ is $CH_2OH^+ \checkmark$		DO NOT ALLOW CH ₃ O ⁺
		QWC $m/z = 31$ or CH ₂ OH indicates that X must be CH ₃ CH ₂ CH ₂ OH OR cannot be CH ₃ CH(OH)CH ₃ OR shows that X is the primary alcohol \checkmark		QWC must link the evidence to the structure of propan-1-ol.
		$C_3H_8O + C_2H_4O_2 \rightarrow C_5H_{10}O_2 + H_2O \checkmark$		In equation ALLOW correct structural OR displayed OR skeletal formula OR mixture of the above
		Total	10	

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