

Chemistry A

Advanced Subsidiary GCE

Unit **F322**: Chains, Energy and Resources

Mark Scheme for June 2013

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

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.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

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Annotations

Annotations available in Scoris.

Annotation	Meaning
	Benefit of doubt given
	Contradiction
	Incorrect response
	Error carried forward
	Ignore
	Not answered question
	Benefit of doubt not given
	Power of 10 error
	Omission mark
	Rounding error
	Error in number of significant figures
	Correct response
	Noted but no credit given
	Repeat

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

All questions should be annotated with ticks to show where marks have been awarded in the body of the text.

All questions where an ECF has been applied should also be annotated with the ECF annotation.

Use the omission mark where the answer is not sufficient to be awarded a mark.

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

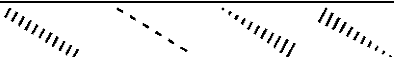
For an OH group shown within a structure,

- **DO NOT ALLOW** formula with horizontal —HO **OR** —HO
- **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

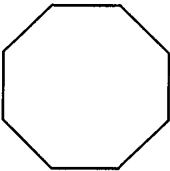
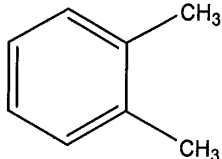
van der Waal's forces

ALLOW vdw forces **OR** VDW forces (and any combination of upper and lower cases)

Question			Answer	Marks	Guidance
1	(a)	(i)	$C_{10}H_{22}$ ✓	1	IGNORE the name decane
		(ii)	Correct skeletal formula ✓ Correct name for structure drawn providing the structure is a branched chain isomer of $C_{10}H_{22}$ ✓	2	DO NOT ALLOW structural formula OR displayed formula Examples of skeletal formulae:  2-methylnonane 3-methylnonane ALLOW name even if structural or displayed formula drawn DO NOT ALLOW incorrect nomenclature eg 2-ethyloctane, 6-methylnonane, 2-methnonane, 2-methylnonan, 2-methynonane There are many more isomers that can be drawn

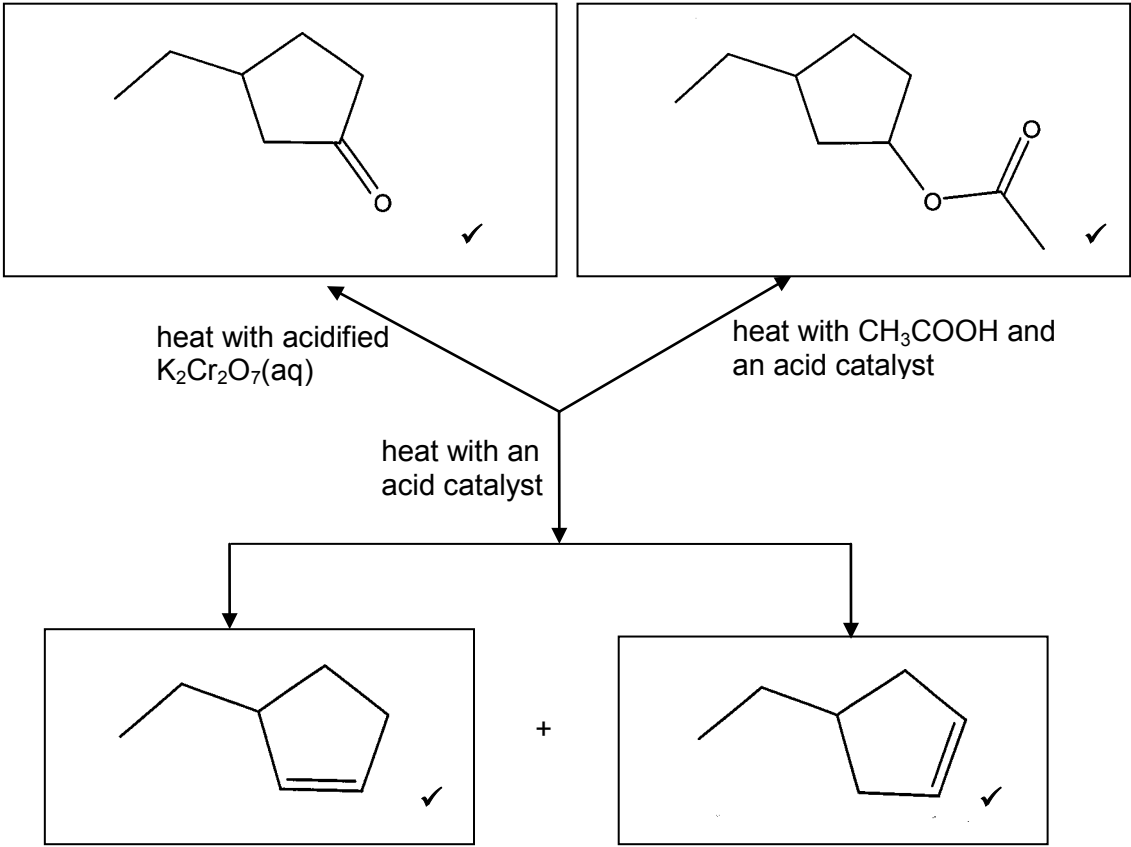
Question			Answer	Marks	Guidance
1	(a)	(iii)	B has less surface (area of) contact OR ORA AND B has fewer van der Waals' forces OR B has weaker van der Waals' forces OR ORA ✓ So less energy needed to break the intermolecular forces in B OR ORA ✓	2	Both answers need to be comparisons Assume 'it' refers to B ALLOW B has less points of contact AND fewer VDW DO NOT ALLOW less points of contact between atoms Reference to just surface area or closeness of molecules is not sufficient. IGNORE if not qualified IGNORE B more compact OR B has a shorter chain DO NOT ALLOW B is a smaller molecule DO NOT ALLOW B has fewer electrons Intermolecular forces is not sufficient for the first marking point must refer to van der Waals' ALLOW ORA throughout in terms of A if specified ALLOW in B it takes less energy to overcome the intermolecular forces ALLOW it is easier to overcome the intermolecular forces DO NOT ALLOW so less energy is needed to break bonds DO NOT ALLOW intermolecular bonds

Question			Answer	Marks	Guidance
1	(b)	(i)	Correct equation for the cracking of $C_{15}H_{32}$ ✓ eg $C_{15}H_{32} \rightarrow C_{13}H_{28} + C_2H_4$	1	ALLOW molecular formula OR correct structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous) ALLOW any correct equation that has an alkane and alkene(s) (and hydrogen) as products OR has alkenes and hydrogen as products e.g. $C_{15}H_{32} \rightarrow C_{11}H_{24} + 2C_2H_4$ $C_{15}H_{32} \rightarrow C_6H_{12} + C_9H_{18} + H_2$ IGNORE state symbols
		(ii)	(idea that) any carbon–carbon bond (in the chain) can break ✓	1	ALLOW carbon chain can break in many different places ALLOW the position of breakdown of the carbon chain is random ALLOW the carbon chain can break in many different places ALLOW carbon chain can split in many different places Carbon chain is cracked in many places is not sufficient Molecule can break anywhere is not sufficient / cannot control where the molecule breaks is not sufficient Molecule can form many different chain lengths is not sufficient

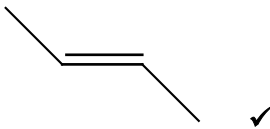
Question			Answer	Marks	Guidance
1	(c)	(i)	Any cyclic hydrocarbon with eight carbon atoms in all ✓ eg  	1	ALLOW correct structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous) ALLOW equation with the correct product DO NOT ALLOW if any other extra structure is included which is incorrect DO NOT ALLOW 'aromatic cyclooctatetraene' but ALLOW this as a normal structural formula IGNORE hydrogen as an extra product IGNORE any name given

Question			Answer	Marks	Guidance
1	(c)	(ii)	Cyclic hydrocarbons promote efficient combustion ✓	1	The answer must relate to combustion or burning ALLOW cyclic hydrocarbons allow smoother burning OR cyclic hydrocarbons increase octane number OR cyclic hydrocarbons reduce knocking OR cyclic hydrocarbons are less likely to produce pre-ignition OR cyclic hydrocarbons are more efficient fuels OR cyclic hydrocarbons burn better OR easier to burn OR cyclic hydrocarbon combust more easily OR improves combustion DO NOT ALLOW cyclic hydrocarbons ignite more easily ALLOW ora for straight chain hydrocarbons IGNORE cyclic hydrocarbons increase volatility of fuel IGNORE cyclic hydrocarbons have a lower boiling point Cyclic hydrocarbons are a better fuel on their own is NOT sufficient Cyclic hydrocarbons burn more cleanly on their own is NOT sufficient
			Total	9	

Question			Answer	Marks	Guidance
2	(a)	(i)	E and H ✓	1	ALLOW pentan-2-ol and 2-methylbutan-2-ol
		(ii)	H ✓	1	ALLOW 2-methylbutan-2-ol
		(iii)	F ✓	1	ALLOW propan-1-ol
	(b)	(i)	C ₅ H ₁₀ O ✓	1	ALLOW any order of atoms DO NOT ALLOW C ₅ H ₉ OH
		(ii)	2-methylpentan-3-ol ✓	1	ALLOW 2-methylpentane-3-ol ALLOW absence of hyphens or use of commas ALLOW space between methyl and pentan DO NOT ALLOW 2-methylpent-3-ol OR 2-methylpentan-3-ol OR 2-metpentan-3-ol, 4-methylpentan-3-ol etc
	(c)		(series of compound) with same functional group ✓ and each successive member differing by CH ₂ ✓	2	IGNORE with same or similar chemical properties OR same or similar chemical reactions IGNORE references to physical properties or named physical properties vary with an observable trend. IGNORE have similar or the same physical properties IGNORE has same general formula ALLOW each subsequent member varying by CH ₂ DO NOT ALLOW have the same empirical formula OR have the same molecular formula

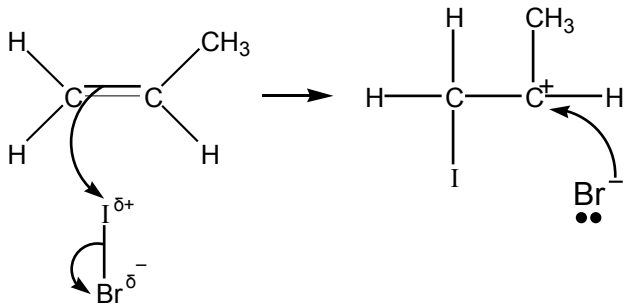
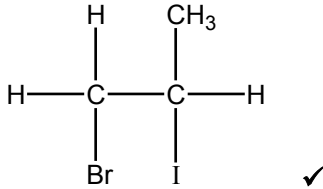
Question	Answer	Marks	Guidance
2 (d)		4	ALLOW correct structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous) IGNORE inorganic products if written in, eg H₂O for the elimination reactions IGNORE names of compounds ALLOW in either order
	Total	11	

Question			Answer	Marks	Guidance
3	(a)		alkene ✓ ester ✓	2	ALLOW carbon–carbon double bond OR a C-C <u>double</u> bond A double bonded carbon is not sufficient C=C is not sufficient Carbon-carbon multiple bond is not sufficient Ketone / carbonyl / aldehyde / carboxylic acid contradicts the ester mark
	(b)		contains a C=C bond ✓	1	Contains a double bond is not sufficient Carbon-carbon multiple bond is not sufficient DO NOT ALLOW contains a C=O bond
	(c)		(from) orange (to) colourless ✓	1	ALLOW shades of orange OR yellow OR brown ALLOW orange to decolourised DO NOT ALLOW red alone DO NOT ALLOW any response that includes precipitate OR solid, irrespective of colour DO NOT ALLOW clear for colourless
	(d)	(i)	Same structural formula AND different arrangement (of atoms) in space OR different spatial arrangement ✓	1	ALLOW have the same structure/displayed formula/skeletal formula DO NOT ALLOW same empirical formula OR same general formula Stereoisomers have the same formula or molecular formula is not sufficient Different three dimensional arrangement is not sufficient Reference to <i>E/Z</i> isomerism or optical isomerism is not sufficient

Question			Answer	Marks	Guidance
3	(d)	(ii)		1	Any writing must not contradict the diagram IGNORE any other feature of the structure drawn ALLOW the J will be the <i>E</i> isomer and I is the <i>Z</i> isomer ALLOW the J will be the <i>trans</i> isomer and I is the <i>cis</i> isomer ALLOW a description, eg the other isomer will have (carbon) chains diagonally arranged across the C=C or the other isomer will have hydrogen atoms diagonally arranged across the C=C bond DO NOT ALLOW draw <i>trans</i> but label as <i>cis</i>
	(e)	(i)	(Enthalpy change that occurs) when one mole of a substance ✓ completely combusts OR reacts fully with oxygen ✓	2	ALLOW energy required OR energy released ALLOW (energy change) when one mole of an element / compound / molecule / reactant DO NOT ALLOW one mole of reactants / product / substances / fuel / atoms ALLOW combusts in excess oxygen ALLOW burns in excess oxygen DO NOT ALLOW combust in excess air IGNORE fully oxidised IGNORE any conditions stated

Question			Answer	Marks	Guidance
3	(e)	(ii)	FIRST, CHECK THE ANSWER ON ANSWER LINE IF answer = 7.06(42), award 2 marks. IF answer = 7.1, award 1 mark. $q = 50.0 \times 4.18 \times 33.8$ OR 7064.2 (J) ✓ = 7.06(42) (kJ) ✓	2	ALLOW 7.06 up to calculator value of 7.0642 correctly rounded DO NOT ALLOW ECF from marking point 1 IGNORE negative sign in answer
		(iii)	FIRST, CHECK THE ANSWER ON ANSWER LINE IF answer = 0.005(00), award 2 marks. $M_r = 268.0$ ✓ amount used = 0.005(00) (mol) ✓	2	IF there is an alternative answer, check to see if there is any ECF credit possible using working below ALLOW 268 ALLOW 5×10^{-3} ALLOW ECF from incorrect M_r IGNORE trailing zeros
		(iv)	FIRST, CHECK THE ANSWER ON ANSWER LINE IF answer = -1413, award 3 marks. IF answer = 1413, award 2 marks. $\Delta H = \frac{\text{answer to (ii)}}{\text{answer to (iii)}}$ OR $\frac{7.0642}{0.005}$ ✓ 1413 ✓ minus sign (this is an independent mark) ✓	3	IF there is an alternative answer, check to see if there is any ECF credit possible using working below ALLOW ECF from (ii) and (iii) ALLOW 1410 up to calculator value of 1412.84 correctly rounded ALLOW answers in standard form 1.41×10^3 up to calculator value of 1.41284×10^3 correctly rounded Answer must be at least three significant figures ALLOW 1412 if answer to (ii) is 7.06 ALLOW 1420 if answer to (ii) is 7.1

Question			Answer	Marks	Guidance
3	(e)	(v)	incomplete combustion OR not sufficient oxygen available AND carbon is formed ✓	1	IGNORE soot is formed, carbon monoxide is formed or carbon dioxide is formed
	(f)		$\text{C}_6\text{H}_{12}\text{O}_6 \rightarrow 2\text{CO}_2 + 2\text{C}_2\text{H}_5\text{OH} \checkmark$ use of yeast OR zymase ✓ anaerobic OR absence of oxygen OR any temperature between 20 and 45 °C OR water OR aqueous ✓	3	ALLOW correct molecular OR structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous) IGNORE state symbols Enzyme is not sufficient DO NOT ALLOW acid catalyst If there is a contradiction or an incorrect answer in any condition given then do not award this mark. ALLOW room temperature Temperature quoted must include unit ALLOW conditions shown in the equation IGNORE warm temperature IGNORE heat / warm Body temperature is not sufficient A limited supply of oxygen is not sufficient IGNORE low pressure OR atmospheric pressure DO NOT ALLOW high pressure OR a pressure above 2 atmospheres
			Total	19	

Question	Answer	Marks	Guidance
4 (a) (i)	correct curly arrow from double bond to iodine atom and curly arrow from the I–Br bond to the bromine atom ✓ correct carbonium ion OR correct carbocation ✓ correct curly arrow from bromide ion to the (positive) carbon ✓ 	3	Curly arrow must start from bond and go to correct atom DO NOT ALLOW partial charges on carbon–carbon double bond DO NOT ALLOW $\delta+$ on carbon atom The positive charge must be associated with the carbon atom and not with a bond Make certain the carbonium ion includes the iodine atom Curly arrow must come from any lone pair or the negative sign of the bromide ion The lone pair on the bromide ion does not need to be shown
	(ii) Electrophilic addition ✓	1	
	(iii)  ✓	1	ALLOW correct structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous) eg <chem>CH2BrCHICH3</chem> IGNORE any name given

Question			Answer	Marks	Guidance
	(b)	(i)	Ultraviolet OR UV ✓	1	ALLOW high temperature OR 300 °C IGNORE light/radiation DO NOT ALLOW any catalyst
		(ii)	(free) radical substitution ✓ (Initiation step) $\text{IBr} \rightarrow \text{Br} + \text{I}$ ✓ homolytic fission ✓ (Propagation steps) $\text{Br} + \text{CH}_4 \rightarrow \text{HBr} + \text{CH}_3$ ✓ $\text{CH}_3 + \text{IBr} \rightarrow \text{CH}_3\text{I} + \text{Br}$ ✓ (Termination steps) $\text{I} + \text{CH}_3 \rightarrow \text{CH}_3\text{I}$ OR $\text{Br} + \text{Br} \rightarrow \text{Br}_2$ OR $\text{I} + \text{I} \rightarrow \text{I}_2$ OR $\text{Br} + \text{CH}_3 \rightarrow \text{CH}_3\text{Br}$ OR $\text{CH}_3 + \text{CH}_3 \rightarrow \text{C}_2\text{H}_6$ OR $\text{I} + \text{Br} \rightarrow \text{IBr}$ ✓ QWC propagation linked to correct equations $\text{Br} + \text{CH}_4 \rightarrow \text{HBr} + \text{CH}_3$ $\text{CH}_3 + \text{IBr} \rightarrow \text{CH}_3\text{I} + \text{Br}$ AND initiation linked to correct equation $\text{IBr} \rightarrow \text{Br} + \text{I}$ ✓	7	Use the SEEN annotation on page 11 if blank or no credit can be given IGNORE any state symbols in equations Radicals do NOT need a single dot IGNORE dots DO NOT ALLOW homolytical fission Heterolytic anywhere in the answer contradicts this mark IGNORE $\text{I} + \text{CH}_4 \rightarrow \text{HI} + \text{CH}_3$ IGNORE $\text{CH}_3 + \text{IBr} \rightarrow \text{CH}_3\text{Br} + \text{I}$ DO NOT ALLOW equations with H OR any other incorrect equation (i.e. not one of the four propagation steps shown) ALLOW any other suitable termination steps DO NOT ALLOW termination steps with H QWC can only be given if marking points 2, 4 and 5 have been awarded
			Total	13	

Question	Answer	Marks	Guidance
5 (a)	FIRST, CHECK THE ANSWER ON ANSWER LINE IF answer = -4596, award 3 marks. IF answer = $+4596$ award 2 marks. (-116) ✓ (-4480) ✓ -4596 ✓	3	IF there is an alternative answer, check to see if there is any ECF credit possible using working below ALLOW 116 OR $-4(+54) - 5(-20)$ OR $-216 + 100$ ALLOW 4480 OR $4(-394) + 12(-242)$ OR $-1576 - 2904$ ALLOW ecf from $\Delta H_{\text{products}} - \Delta H_{\text{reactants}}$ ALLOW for 2 marks $(+4596)$ (cycle the wrong way round) OR -4364 ($\Delta H_{\text{reactants}}$ the incorrect sign) OR $(+4364)$ ($\Delta H_{\text{products}}$ the incorrect sign) OR -752 (moles not used for products) OR -4514 (moles not used for reactants) ALLOW for 1 mark $(+752)$ (moles not used for products and the cycle the wrong way round) OR $(+4514)$ (moles not used for reactants and the cycle the wrong way round) OR -670 (moles not used for reactants and products) Note: There may be other possibilities

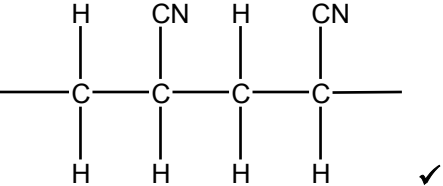
Question			Answer	Marks	Guidance
5	(b)	(i)	FIRST, CHECK THE ANSWER ON ANSWER LINE IF answer = +820, award 2 marks . IF answer = -820 or +1640 award 1 mark . amount of N ₂ O = 10 (mol) ✓ enthalpy change = (+)820 ✓	2	IF there is an alternative answer, check to see if there is any ECF credit possible using working below ALLOW ECF, ie moles of N ₂ O x enthalpy of formation
		(ii)	(+)82 ✓	1	
		(iii)	(+)283 ✓	1	
	(c)		$O_3 \rightarrow O_2 + O$ AND $O + O_2 \rightarrow O_3$ ✓ rate of ozone decomposition (almost) equals rate of ozone formation ✓	2	ALLOW $O_3 \rightleftharpoons O_2 + O$ ALLOW $O_3 \rightarrow O_2 + O$ is reversible ALLOW $O + O_2 \rightarrow O_3$ is reversible IGNORE dots IGNORE other equations involving ozone, eg $O + O_3 \rightarrow 2O_2$ IGNORE comments about an equilibrium ALLOW rate of forward reaction is similar to the rate of the backward reaction if marking point 1 is awarded
	(d)		$NO + O_3 \rightarrow NO_2 + O_2$ ✓ $NO_2 + O \rightarrow NO + O_2$ ✓	2	ALLOW $NO_2 + O_3 \rightarrow NO + 2O_2$ ✓ IGNORE dots IGNORE $O + O_3 \rightarrow 2O_2$ IGNORE $2O_3 \rightarrow 3O_2$
			Total	11	

Question			Answer	Marks	Guidance
6	(a)	(i)	256 ✓	1	
		(ii)	S ₈ ✓	1	ALLOW ³² S ₈ OR ³² ₁₆ S ₈ DO NOT ALLOW ³³ S ₈ OR ³⁰ ₁₆ S ₈ etc
		(iii)	S ₄ ⁺ ✓	1	Positive ion must be present ALLOW ³² S ₄ ⁺ OR ³² ₁₆ S ₄ ⁺ DO NOT ALLOW ³³ S ₄ ⁺ OR ³⁰ ₁₆ S ₄ ⁺ etc
	(b)		FIRST, CHECK THE ANSWER ON ANSWER LINE IF answer = 195.2, award 2 marks . IF answer = 195.16 award 1 marks . = $\frac{(194 \times 33) + (195 \times 34) + (196 \times 25) + (198 \times 8)}{100}$ ✓ 195.2 ✓	2	195 on its own with no working scores 0 marks
	(c)		Monitor air pollution OR breathalysers ✓	1	ALLOW measure the concentration or abundance of atmospheric pollutants ALLOW measure concentration of named atmospheric pollutant ALLOW monitoring of gases in car exhaust fumes ALLOW drug detection or drug identification IGNORE night vision goggles, identifying gases on distant planets / ice samples

Question	Answer	Marks	Guidance
6 (d)	mole ratio C : H : O $\frac{66.7}{12.0} : \frac{11.1}{1.0} : \frac{22.2}{16.0}$ OR 5.56 : 11.1 : 1.39 ✓ 4 : 8 : 1 OR C₄H₈O ✓ contains a C=O or carbonyl because of absorbance at about 1710 cm⁻¹ ✓ Any two from: $\begin{array}{c} \text{CH}_3 - \text{CH}_2 - \text{CH}_2 - \text{C} - \text{H} \\ \quad \quad \quad \quad \quad \parallel \\ \quad \quad \quad \quad \quad \text{O} \end{array}$ $\begin{array}{c} \text{CH}_3 \\ \\ \text{CH}_3 - \text{CH} - \text{C} - \text{H} \\ \quad \quad \quad \parallel \\ \quad \quad \quad \text{O} \end{array}$ $\begin{array}{c} \text{CH}_3 - \text{CH}_2 - \text{C} - \text{CH}_3 \\ \quad \quad \quad \parallel \\ \quad \quad \quad \text{O} \end{array} \quad \checkmark \checkmark$	5	PLEASE LOOK AT THE SPECTRA AND ABOVE THE SPECTRA FOR POSSIBLE ANSWERS ALLOW two marks for 72 x 66.7/100 = 48/12 = 4 (C) 72 x 11.1/100 = 8 = 8 (H) 72 x 22.2/100 = 16 = 1 (O) ALLOW C=O or carbonyl since has absorbance within the range 1640 to 1750 cm⁻¹ ALLOW ketone OR aldehyde linked to correct absorbance ALLOW 'could be aldehyde, ketone, carboxylic acid, ester (or amide) because of absorbance between range 1640 to 1750 cm⁻¹' (ie direct quote from the data book) DO NOT ALLOW reference to M being a carboxylic acid, ester or amide unless they are included in a list with aldehyde/ketone in which case IGNORE carboxylic acid/ester/amide IGNORE reference to C—O / absence of O—H DO NOT ALLOW has O—H ALLOW correct structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous) eg CH₃CH₂CH₂CHO, CH₃COCH₂CH₃ OR (CH₃)₂CHCHO DO NOT ALLOW C₃H₇CHO IGNORE incorrect name correct name on its own is not sufficient
	Total	11	

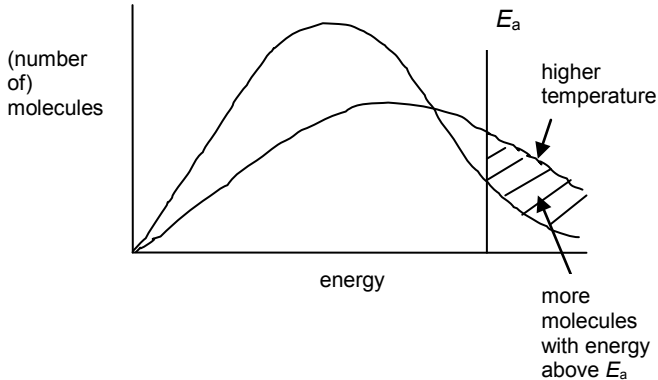
Question			Answer	Marks	Guidance
7	(a)		N ✓	1	ALLOW CF_3CFCI_2
	(b)	(i)	S ✓	1	ALLOW $\text{CH}_3\text{CHBrCH}_2\text{CHICH}_3$
		(ii)	curly arrow from HO^- to carbon atom of C–Br bond ✓ Dipole shown on C–Br bond, $\text{C}^{\delta+}$ and $\text{Br}^{\delta-}$, and curly arrow from C–Br bond to the halogen atom – arrow must be very close to the bond ✓ correct products of the reaction – not ambiguous with the C_3H_7 ✓ $\text{CH}_3\text{CH}_2\text{CH}_2-\text{C}(\text{H})_2-\text{OH} + \text{Br}^-$ nucleophilic substitution ✓	4	The curly arrow must start from the oxygen atom of the OH^-, and must start either from a lone pair or from the negative charge. No need to show lone pair if curly arrow came from negative charge DO NOT ALLOW attack by KOH or K^+OH^- ALLOW $\text{S}_{\text{N}}1$ Dipole shown on C–Br bond, $\text{C}^{\delta+}$ and $\text{Br}^{\delta-}$, and curly arrow from C–Br bond to the halogen atom – arrow must be very close to the bond ✓ Correct carbocation drawn AND curly arrow from HO^- to the carbocation (the curly arrow must start from the oxygen atom of the OH^-, and must start either from a lone pair or from the negative charge. No need to show lone pair if curly arrow came from negative charge) ✓ Correct products of the reaction – not ambiguous with the C_3H_7 ✓ nucleophilic substitution ✓

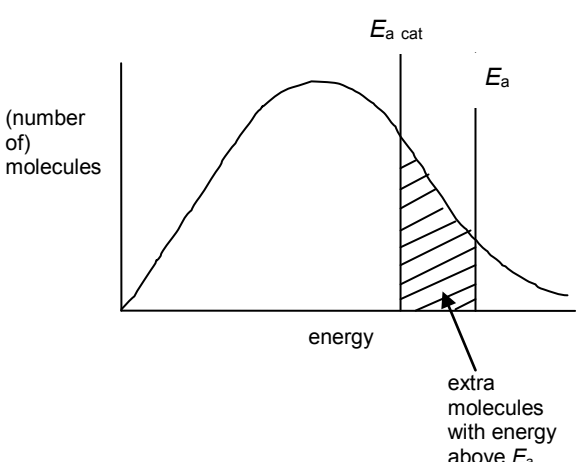
Question			Answer	Marks	Guidance
7	(b)	(iii)	C–I bond is weaker than C–Br bond OR C–I has a lower bond enthalpy than C–Br bond OR C–I bond is longer than C–Br bond AND C–I bond is easier to break than C–Br bond OR less energy is needed to break the C–I bond ✓	1	Answer must refer to the correct bond ALLOW ora IGNORE references to electronegativity
	(c)		HC/ + CH₃CHCHCH₃ → CH₃CH₂CHC/CH₃ Correct structural formula of product ✓ Equation with structural formulae ✓	2	Must use structural formulae for both organic compounds in the equation ALLOW CH₃CH=CHCH₃ for but-2-ene ALLOW two marks for correct equation with structural formulae ALLOW one mark for correct equation with displayed formulae IGNORE any mechanisms
	(d)		HCFCs OR hydrocarbons OR HFCs ✓	1	ALLOW alkanes DO NOT ALLOW specific alkanes
			Total	10	

Question	Answer	Marks	Guidance
8 (a)		1	ALLOW correct structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous) ALLOW two or more repeat units but has to be a whole number of repeat units ALLOW vertical bond to CN to any part of the CN End bonds MUST be shown as either dotted or normal line IGNORE brackets IGNORE <i>n</i>
(b)	All the reactants are made into the desired product OR it is an addition reaction ✓	1	ALLOW there are no waste (products) OR there are no by-products OR only one product is made ALLOW an addition polymer is made DO NOT ALLOW all the products are useful IGNORE additional reaction

Question		Answer	Marks	Guidance
8	(c)	QWC – Linking effect with explanation (as temperature rises) position of equilibrium changes to minimise effect of temperature rise by absorbing energy OR (as pressure rises) position of equilibrium changes to minimise the pressure increase by reducing the pressure and making fewer gas molecules ✓ as temperature rises the position of equilibrium shifts to the left AND increase in pressure shifts the equilibrium to the left ✓ relates change with temperature to the (forward) reaction being exothermic OR reaction releases energy or heat OR reverse reaction is endothermic OR reverse reaction takes in heat or energy ✓ change with pressure because there are fewer moles of reactants OR more moles of products ✓ removing the catalyst does not change the position of equilibrium ✓	5	ALLOW suitable alternatives for ‘to the left’ eg moves to the reactant side OR towards $C_3H_6(g)$ or $NH_3(g)$ or O_2 OR moves in reverse direction IGNORE responses in terms of rate This mark is dependent on correct change in position of equilibrium Moves towards the endothermic direction is not sufficient ALLOW fewer molecules of reactant This mark is dependent on correct change in position of equilibrium ALLOW equilibrium does not move OR catalyst has no effect on the equilibrium

Question		Answer	Marks	Guidance
8	(d)	FIRST, CHECK THE ANSWER ON ANSWER LINE IF answer = 95.5, award 2 marks. actual amount propenenitrile is 210 (mol) ✓ % yield = 95.454545 ✓	2	IF there is an alternative answer, check to see if there is any ECF credit possible using working below ALLOW theoretical mass of propenenitrile = 11660 g OR 11.66 kg ALLOW 11700 OR 11.7kg ALLOW 95 up to calculator value of 95.454545 correctly rounded up ALLOW 95 up to calculator value of 95.128205 correctly rounded up if 11.7kg is used' ALLOW ecf from wrong actual mass or actual amount DO NOT ALLOW ecf if percentage yield is above 100%

Question	Answer	Marks	Guidance
(e)	Boltzmann distribution Correct drawing of one Boltzmann distribution (could be temperature or catalyst) ✓ axes labelled (number of) molecules and energy ✓ Increasing the temperature Correct drawing of Boltzmann distribution at two different temperatures with higher and lower temperature clearly identified ✓ 	7	Look at the first Boltzmann distribution on the paper: If it is the temperature one then both curves will have to be correct Boltzmann distribution – must start at origin and must not end up at 0 on y-axis ie must not touch x-axis ALLOW a slight inflexion in the Boltzmann curve ALLOW particles instead of molecules DO NOT ALLOW atoms instead of particles or molecules DO NOT ALLOW number of particles at activation energy DO NOT ALLOW enthalpy ONLY penalise the incorrect use of atoms (instead of molecules or particles) the first time it is seen Maximum of curve for higher temperature to right AND lower than maximum of lower temperature curve AND above lower temp line at higher energy as shown in diagram below Higher temperature line should intersect the lower temperature only once

Question	Answer	Marks	Guidance
	Adding a catalyst  idea that activation energy is lowered with a catalyst ✓		ALLOW E_c OR E_{cat} for activation energy of catalysed reaction ALLOW activation lowered shown on Boltzmann distribution diagram
	Collision theory reaction is faster with catalyst AND when temperature is increased ✓ Greater proportion of molecules with energy above activation energy (with increased temperature or when catalyst is used) ✓ more effective collisions OR more successful collisions (with increased temperature or when catalyst is used) ✓		ALLOW more molecules with energy above activation energy OR more molecules that overcome the activation energy OR more molecules have enough energy to react ALLOW this marking point once either in terms of using a catalyst or increasing the temperature ALLOW this marking point once either in terms of using a catalyst or increasing the temperature ALLOW more collisions involving particles with energy above the activation energy More collisions per second is not sufficient
	Total	16	

OCR (Oxford Cambridge and RSA Examinations)
1 Hills Road
Cambridge
CB1 2EU

OCR Customer Contact Centre

Education and Learning

Telephone: 01223 553998

Facsimile: 01223 552627

Email: general.qualifications@ocr.org.uk

www.ocr.org.uk

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Head office
Telephone: 01223 552552
Facsimile: 01223 552553

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