



GCE

Chemistry A

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

Advanced Subsidiary GCE

Mark Scheme for June 2014

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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.














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Annotation	Meaning
	Blank Page – this annotation must be used on all blank pages within an answer booklet (structured or unstructured) and on each page of an additional object where there is no candidate response.
	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

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

Subject-specific Marking Instructions

The following questions should be annotated with ticks to show where marks have been awarded in the body of the text:

2(b), 3(a), 4(a), 4(b)(iii), 6(a)(i), 7(d), 8(a), 8(b)

All questions where an ECF has been applied.

Checking additional pages

All the Additional Pages in the examination script must be checked to see if any candidates include any answers.

- When you open question **1(a)(i)** you will see a view of page 22 one of the Additional Pages.
- If the page is blank then, using the marking mode, annotate the page with an omission mark, ^.
- Scroll down to page 24 and annotate with a ^ if the page is blank.
- If pages 23 or 24 are not blank then use the paper clip icon to link the pages to the correct questions.

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- You may need to contact your Team Leader if you do not know how to do this.

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,
e.g. **ALLOW** CH₃–, CH₂–, C₃H₇–, etc.
- ALLOW** vertical 'bond' to any part of an alkyl group

For an OH group shown within a structure,

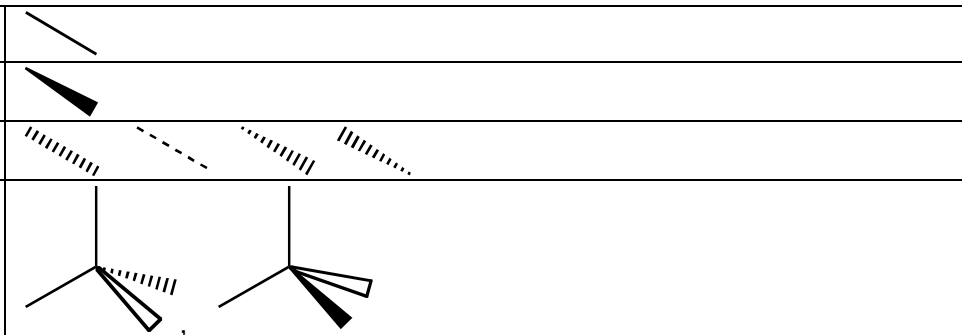
- DO NOT ALLOW** formula with horizontal —HO **OR** OH –
- ALLOW** vertical 'bond' to any part of the OH group

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 e.g.:



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NAMES

Names including alkyl groups:

- **ALLOW** alkanyl, e.g. ethanyl (i.e. **IGNORE** 'an')
- **DO NOT ALLOW** alkol, e.g. ethol (ie 'an' is essential)

Names of esters:

- Two words are expected, e.g. ethyl ethanoate
- **ALLOW** one word, e.g. ethylethanoate

Names with multiple numbers and hyphens:

Use of 'e'

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

Hyphens separate name from numbers:

- **ALLOW** absence of hyphens, e.g. propane 1,2 diol

Multiple locant numbers must be clearly separated:

- **ALLOW** full stops: e.g. 1.2 OR spaces: 1 2
- **DO NOT ALLOW** e.g. 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), e.g. 2-chloro-3-bromobutane

ABBREVIATIONS

van der Waal's forces

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

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Question			Answer	Mark	Guidance
1	(a)	(i)	(series of compounds with the) same functional group OR same/similar chemical properties OR same/similar chemical reactions ✓ each successive/subsequent member differing by CH ₂ ✓	2	IGNORE references to physical properties IGNORE has same general formula (in question) DO NOT ALLOW have the same empirical formula OR have the same molecular formula
		(ii)	C _n H _{2n} ✓	1	
		(iii)	More carbons (in ring) OR more (surface area of) contact AND more van der Waals forces OR stronger van der Waals forces ✓ More energy needed to break the intermolecular forces ✓	2	Both answers need to be comparisons ALLOW ORA throughout ALLOW has more electrons OR larger (carbon) ring OR higher molecular mass IGNORE bigger molecule IGNORE chain instead of ring DO NOT ALLOW 'more contact between atoms' ALLOW 'VDW' for van der Waals 'More intermolecular forces' is not sufficient ALLOW it is harder to overcome the intermolecular forces ALLOW intermolecular bonds / van der Waals bonds ALLOW more energy is needed to separate molecules IGNORE more energy is needed to break bonds

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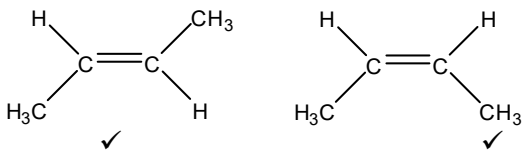
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Question		Answer	Mark	Guidance
	(b)	tetrahedral ✓ four bonding pairs repel OR four bonds repel ✓	2	Mark each point independently IGNORE surrounded by four atoms IGNORE four areas of electron charge repel IGNORE four electron pairs repel (<i>one could be lp</i>) DO NOT ALLOW atoms repel
	(c)	$ \begin{array}{ccccccc} & \text{H} & & \text{H} & & \text{H} & \\ & & & & & & \\ \text{Br} & - \text{C} & - & \text{C} & - & \text{C} & - \text{Br} \\ & & & & & & \\ & \text{H} & & \text{H} & & \text{H} & \end{array} $ ✓	1	ALLOW correct structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous) ALLOW structure of 1,2-isomer $ \begin{array}{ccccccc} & \text{H} & & \text{H} & & \text{H} & \\ & & & & & & \\ \text{Br} & - \text{C} & - & \text{C} & - & \text{C} & - \text{H} \\ & & & & & & \\ & \text{H} & & \text{Br} & & \text{H} & \end{array} $ IGNORE molecular formula DO NOT ALLOW , structure of 1,1-isomer OR 2,2-isomer $ \begin{array}{ccccccc} & \text{H} & & \text{H} & & \text{H} & & & \text{H} & & \text{Br} & & \text{H} \\ & & & & & & & & & & & & \\ \text{Br} & - \text{C} & - & \text{C} & - & \text{C} & - \text{H} & \text{H} & - & \text{C} & - & \text{C} & - & \text{C} & - \text{H} \\ & & & & & & & & & & & & & \\ & \text{Br} & & \text{H} & & \text{H} & & & & \text{H} & & \text{Br} & & \text{H} \end{array} $
(d)	(i)	$\text{C}_6\text{H}_{14} \rightarrow \text{C}_6\text{H}_{12} + \text{H}_2$ ✓	1	ALLOW correct structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous) ALLOW any correct multiple IGNORE state symbols

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Question		Answer	Mark	Guidance
	(ii)	Cyclohexane will burn more efficiently ✓	1	<p>KEY IDEA IS COMBUSTION OR BURNING</p> <p>Assume 'it' refers to cyclohexane ALLOW ORA for hexane</p> <p>ALLOW cyclohexane allows smoother burning OR promotes more efficient combustion OR increases octane number OR reduces knocking OR less likely to produce pre-ignition OR burns better OR easier to burn OR combusts more easily OR improves combustion OR burns more cleanly DO NOT ALLOW cyclohexane ignites more easily IGNORE cyclohexane increase volatility of fuel IGNORE reference to boiling points IGNORE cyclohexane gives a better fuel</p>
(e)	(i)	(Compounds with the) same structural formula but a different arrangement (of atoms) in space ✓	1	<p>ALLOW different spatial arrangement of atoms. DO NOT ALLOW different displayed formula.</p>
	(ii)		2	<p>ALLOW displayed OR skeletal formula OR mixture of the above. ALLOW structures in either order IGNORE molecular formula IGNORE structural formula IGNORE names IGNORE E/Z and cis/trans labels ALLOW 1 mark for a pair of E/Z isomers of an incorrect hydrocarbon structure with four C atoms e.g. C, or CH or CH₂ instead of CH₃ groups.</p>

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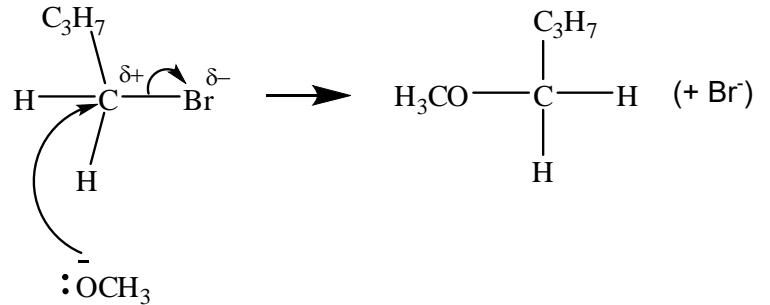
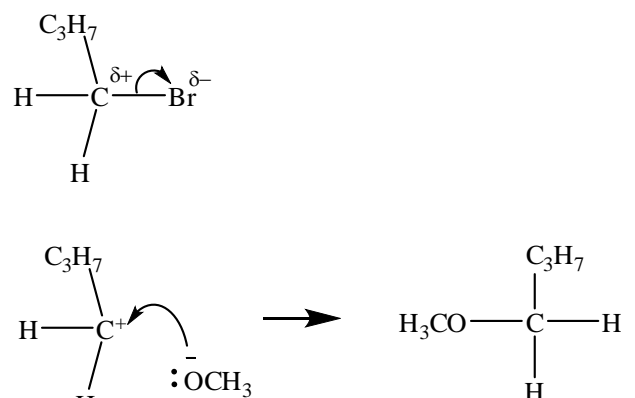
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Question		Answer	Mark	Guidance																																	
	(f)	(i)	5	<p>IGNORE state symbols</p> <p>IGNORE dots</p> <p>If an incorrect hydrocarbon with six C atoms is used: DO NOT ALLOW any marks for the propagation steps but ALLOW ECF for termination steps (<i>i.e.</i> 3 max)</p>																																	
		<table border="1"> <thead> <tr> <th>Step</th> <th>Equation</th> </tr> </thead> <tbody> <tr> <td>Initiation (1 mark)</td> <td>$\text{Br}_2 \rightarrow 2\text{Br}\cdot \checkmark$</td> </tr> <tr> <td rowspan="2">Propagation (2 marks)</td> <td>$\text{C}_6\text{H}_{12} + \text{Br}\cdot \rightarrow \text{C}_6\text{H}_{11}\cdot + \text{HBr} \checkmark$</td> </tr> <tr> <td>$\text{C}_6\text{H}_{11}\cdot + \text{Br}_2 \rightarrow \text{C}_6\text{H}_{11}\text{Br} + \text{Br}\cdot \checkmark$</td> </tr> <tr> <td rowspan="3">Termination (2 marks)</td> <td>$\text{C}_6\text{H}_{11}\cdot + \text{Br}\cdot \rightarrow \text{C}_6\text{H}_{11}\text{Br}$</td> </tr> <tr> <td>$\text{C}_6\text{H}_{11}\cdot + \text{C}_6\text{H}_{11}\cdot \rightarrow \text{C}_{12}\text{H}_{22}$</td> </tr> <tr> <td>$\text{Br}\cdot + \text{Br}\cdot \rightarrow \text{Br}_2$</td> </tr> <tr> <td colspan="2"></td> <td> <p>Two correct \checkmark</p> <p>All three correct $\checkmark\checkmark$</p> </td> <td></td> <td></td> </tr> <tr> <td></td> <td></td> <td>(ii)</td> <td>1</td> <td> <p>ALLOW 'the breaking of a covalent bond'</p> <p>ALLOW the splitting of the bond in bromine</p> <p>ALLOW the breaking of a covalent bond where each atom keeps one of the bonding electrons</p> <p>IGNORE particle for atom</p> <p>ALLOW one electron goes to each product / species</p> <p>DO NOT ALLOW molecule or compound for atom</p> <p>IGNORE homolytic fission equations</p> </td> </tr> <tr> <td></td> <td>(g)</td> <td>(i)</td> <td>1</td> <td>ALLOW molecular formula only.</td> </tr> <tr> <td></td> <td></td> <td>(ii)</td> <td>1</td> <td> <p>Locant numbers MUST lowest possible e.g. DO NOT ALLOW 2,4-dibromocyclohexane etc.</p> <p>IGNORE structures</p> </td> </tr> <tr> <td colspan="2"></td> <td>Total</td> <td>21</td> <td></td> </tr> </tbody> </table>			Step	Equation	Initiation (1 mark)	$\text{Br}_2 \rightarrow 2\text{Br}\cdot \checkmark$	Propagation (2 marks)	$\text{C}_6\text{H}_{12} + \text{Br}\cdot \rightarrow \text{C}_6\text{H}_{11}\cdot + \text{HBr} \checkmark$	$\text{C}_6\text{H}_{11}\cdot + \text{Br}_2 \rightarrow \text{C}_6\text{H}_{11}\text{Br} + \text{Br}\cdot \checkmark$	Termination (2 marks)	$\text{C}_6\text{H}_{11}\cdot + \text{Br}\cdot \rightarrow \text{C}_6\text{H}_{11}\text{Br}$	$\text{C}_6\text{H}_{11}\cdot + \text{C}_6\text{H}_{11}\cdot \rightarrow \text{C}_{12}\text{H}_{22}$	$\text{Br}\cdot + \text{Br}\cdot \rightarrow \text{Br}_2$			<p>Two correct \checkmark</p> <p>All three correct $\checkmark\checkmark$</p>					(ii)	1	<p>ALLOW 'the breaking of a covalent bond'</p> <p>ALLOW the splitting of the bond in bromine</p> <p>ALLOW the breaking of a covalent bond where each atom keeps one of the bonding electrons</p> <p>IGNORE particle for atom</p> <p>ALLOW one electron goes to each product / species</p> <p>DO NOT ALLOW molecule or compound for atom</p> <p>IGNORE homolytic fission equations</p>		(g)	(i)	1	ALLOW molecular formula only.			(ii)	1	<p>Locant numbers MUST lowest possible e.g. DO NOT ALLOW 2,4-dibromocyclohexane etc.</p> <p>IGNORE structures</p>		
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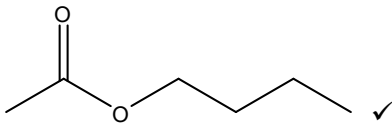
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Question	Answer	Mark	Guidance
2 (a)	It is an electron pair donor OR can donate a lone pair ✓	1	
2 (b)	 <p>Dipole shown on the C-Br bond, C^{δ+} and Br^{δ-} and curly arrow from the C-Br bond to the Br atom ✓</p> <p>Curly arrow from :$\bar{\text{O}}\text{CH}_3$ to carbon atom in the C-Br bond ✓</p> <p>Correct organic product ✓</p> <p>S_N1 mechanism</p> 	3	<p>ANNOTATE ANSWER WITH TICKS AND CROSSES ETC</p> <p>IGNORE connectivity to C₃H₇ throughout</p> <p>IGNORE alkyl group in first marking point. Curly arrow must start from C-Br bond and not from C atom. Dipole must be partial charge and not full charge</p> <p>CH₃O⁻ curly arrow must come from one lone pair on O of CH₃O⁻ ion OR from negative sign on O of the CH₃O⁻ ion ALLOW arrow from lone pair on O in OCH₃⁻ Lone pair not required DO NOT ALLOW CH₃O^{δ-} DO NOT ALLOW incorrect connectivity of CH₃O group in the final product -CH₃O IGNORE Br^{δ-} as a product</p> <p>ALLOW S_N1 mechanism Dipole shown on the C-Br bond, C^{δ+} and Br^{δ-} and curly arrow from C-Br bond to the Br atom ✓ curly arrow from CH₃O⁻ to carbonium ion ✓ correct organic product ✓</p>

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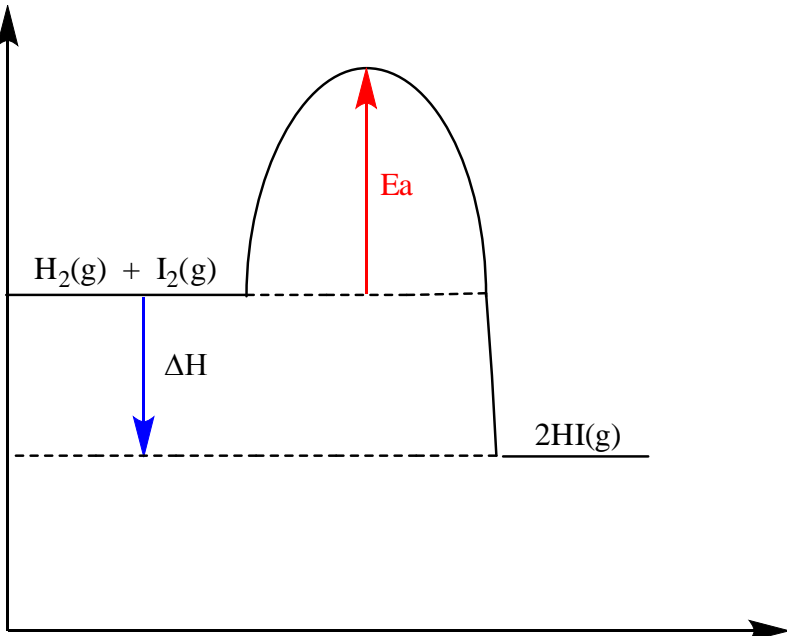
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Question	Answer	Mark	Guidance
(c)	1-Iodobutane increases the rate <input checked="" type="checkbox"/> AND C—I bonds are weaker (than C—Br) OR C—I bond has a lower bond enthalpy OR C—I bond needs a smaller amount of energy to break OR C—I bond is easier to break ✓	1	All statements must be comparative ALLOW ORA IGNORE C—I bond is longer IGNORE polarity and references to electronegativity
(d)	 butyl ethanoate ✓	2	ALLOW only skeletal formula DO NOT ALLOW ECF from incorrect structure. ALLOW butylethanoate ALLOW butanyl for butyl DO NOT ALLOW butly
(e) (i)	$\left(\frac{136.9}{291.1} \times 100 \right) = 47\%$	1	ALLOW 47 up to calculator value correctly rounded. 47.0 or 47.03 or 47.029 will be correct common answers IGNORE any working shown.
(e) (ii)	NaBr OR LiBr ✓	1	ALLOW correct name or formula DO NOT ALLOW HBr (it is an acid)
(e) (iii)	Look at answer if 88.8% AWARD 3 marks if 88.75% AWARD 2 marks (not 3 sig. fig.) Moles of butan-1-ol = 0.08(00) ✓ Moles of 1-bromobutane = 0.071(0) ✓ % yield = 88.8% ✓	3	Answer MUST be to 3 significant figures. ALLOW ECF but do not allow a yield >100% ALLOW Mass of 1-bromobutane expected = 10.952 g
Total		12	

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Question	Answer	Mark	Guidance
3 (a)	<p>There are 3 marking points required for 2 marks</p>  <p>H₂ and I₂ on LHS AND 2HI on RHS AND correctly labelled E_a ✓</p> <p>ΔH labelled with product below reactant AND arrow downwards ✓</p>	2	<p>ANNOTATE ANSWER WITH TICKS AND CROSSES ETC</p> <p>IGNORE state symbols.</p> <p>E_a:</p> <p>ALLOW (+)173 only as an alternative label for E_a ALLOW no arrowhead or arrowheads at both ends of activation energy line The E_a line must point to maximum (or near to the maximum) on the curve OR span approximately 80% of the distance between reactants and maximum regardless of position ALLOW A_E or A_E for E_a</p> <p>ΔH:</p> <p>IF there is no ΔH labelled ALLOW -9 as an alternative label for ΔH. IF ΔH is labelled IGNORE any numerical value.</p> <p>DO NOT ALLOW -ΔH. ALLOW this arrow even if it has a small gap at the top and bottom i.e. does not quite reach reactant or product line</p>
(b)	(+)182 ✓	1	This is the ONLY acceptable answer

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Question		Answer	Mark	Guidance
	(c)	<p>Look at answer if +63 kJ AWARD 2 marks If 63 (no sign) OR-63 (incorrect sign) AWARD 1 mark</p> <p>No of moles of HI = 14 moles ✓</p> <p>Enthalpy Change = +63 kJ ✓</p>	2	<p>ALLOW one mark for +126 kJ</p> <p>Sign and value required. ALLOW ECF from incorrect number of moles of HI</p>
	(d) (i)	<p>Rate of the forward reaction is equal to the rate of the reverse reaction ✓</p> <p>OR</p> <p>concentrations do not change ✓</p>	1	<p>ALLOW both reactions occur at same rate</p> <p>IGNORE conc. of reactants = conc. of products</p>
	(ii)	<p>More H₂ and I₂ OR less HI ✓</p> <p>(equilibrium position shifts) to the left AND (Forward) reaction is exothermic OR reverse reaction is endothermic OR in the endothermic direction ✓</p>	2	<p>Mark each point independently</p> <p>ALLOW more reactants OR less products</p> <p>Note: ALLOW suitable alternatives for to the left e.g. towards reactants OR towards H₂ / I₂ OR in reverse direction OR favours the left.</p> <p>ALLOW gives out heat for exothermic ALLOW takes in heat for endothermic</p> <p>IGNORE responses in terms of rate</p>
	(iii)	<p>No effect AND Same number of (gaseous) moles on both sides ✓</p>	1	<p>ALLOW same number of molecules on each side</p>

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Question		Answer	Mark	Guidance
	(e)	<p>Look at answer if (+)298 AWARD 2 marks If answer is -298 AWARD 1 mark (incorrect sign)</p> <p>2 x H-I bond enthalpy correctly calculated (436 +151-(-9) =) (+)596 ✓</p> <p>H-I bond enthalpy correctly calculated (Bond energy for H-I $\frac{(+596)}{2}$ =) (+)298 kJ mol⁻¹ ✓</p>	2	<p>ALLOW 1 mark for (+)293.5 kJ mol⁻¹ (bonds broken divided by 2) ALLOW 1 mark for (+)289 kJ mol⁻¹ (incorrect expression i.e. $\frac{[436 +151+(-9)]}{2}$)</p>
Total			11	

Question		Answer	Mark	Guidance
4	(a)	<p>FIRST, CHECK THE ANSWER ON ANSWER LINE IF answer = -38.3 (kJ mol^{-1}) award 4 marks IF answer = $(+)$$38.3$ (kJ mol^{-1}) award 3 marks (incorrect sign) IF answer = $-38,300$ (kJ mol^{-1}) award 3 marks (used J instead of kJ).</p> <p>Energy q calculated correctly = $1149.5(\text{J})$ ✓ OR 1.1495 (kJ) ✓</p> <p>Moles Amount, n, of Na_2CO_3 calculated correctly = $0.03(00)$ ✓</p> <p>Calculating ΔH correctly calculates ΔH in kJ mol^{-1} to 3 or more sig figs ✓</p> <p>Rounding and Sign calculated value of ΔH rounded to 3 sig. fig. with minus sign ✓</p>	4	<p>ANNOTATE ANSWER WITH TICKS AND CROSSES ETC</p> <p>Note: $q = 50.0 \times 4.18 \times 5.5$ ALLOW 1149.5 OR correctly rounded to 3 sig figs (J) IGNORE sign IGNORE working ALLOW $53.18 \times 4.18 \times 5.5$ OR 1222.6082 OR 1220 OR correctly rounded to 3 or more sig figs in J or kJ</p> <p>IGNORE working IGNORE trailing zeros</p> <p>IGNORE sign at this intermediate stage ALLOW ECF from incorrect q and/or incorrect n</p> <p>Final answer must have correct sign and three sig figs</p> <p>ALLOW -40.8 kJ mol^{-1} if 53.18 used in calculation of q ALLOW -40.7 kJ mol^{-1} if q is rounded to 1220 from 53.18 earlier</p>
	(b) (i)	<p>(Enthalpy change) when one mole of a compound ✓ is formed from its elements ✓</p> <p>298 K / 25 °C AND 1 atm / 100 kPa / 101 kPa / 1 bar ✓</p>	3	<p>ALLOW energy required OR energy released ALLOW one mole of substance OR one mole of product DO NOT ALLOW one mole of element</p> <p>IGNORE reference to concentration</p>

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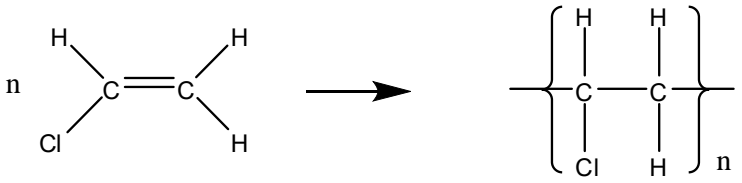
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Question	Answer	Mark	Guidance
	<p>(ii)</p> $\frac{1}{2}\text{N}_2(\text{g}) + 2\text{H}_2(\text{g}) + \frac{1}{2}\text{Cl}_2(\text{g}) + 2\text{O}_2(\text{g}) \rightarrow \text{NH}_4\text{ClO}_4(\text{s})$ <p>correct species ✓</p> <p>correct state symbols and balancing ✓</p>	2	<p>Second mark can only be awarded if all species in the equation are correct</p> <p>DO NOT ALLOW multiples of this equation</p>
	<p>(iii) FIRST, CHECK THE ANSWER ON ANSWER LINE</p> <p>IF answer = (+)90 award 3 marks</p> <p>IF answer = -90 award 2 marks</p> <p>IF answer = ±270 award 2 marks</p> <p>IF answer = ±2947 award 1 mark</p> <p>Processing ΔH_f values</p> <p>$\pm(3832 - 885) \pm 2947$ ✓</p> <p>OR</p> <p>$\pm(3832 - 885)$</p> <p>subtraction using ΔH reaction</p> <p>$\pm(2947 - 2677) = \pm 270$ ✓</p> <p>Calculation of ΔH formation NO</p> <p>$270/3 = (+)90$ ✓</p>	3	<p>ANNOTATE ANSWER WITH TICKS AND CROSSES ETC</p> <p>Note: $\pm 2947 = \pm [-1676 + (-704) + (6 \times -242)] - (3 \times -295)$</p> <p>ALLOW ECF for dividing by 3 from working that includes at least one ΔH_f and one balancing number and ΔH (-2677) for 1 mark</p>
	Total	12	

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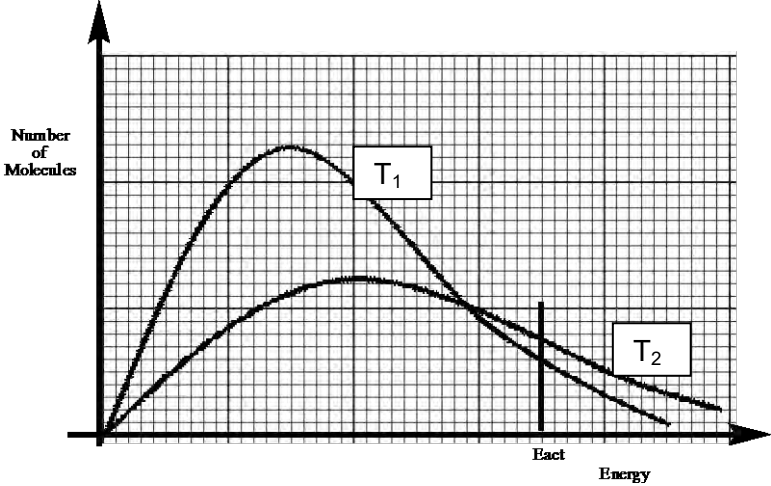
Question		Answer	Mark	Guidance
5	(a)	 <p>Correct polymer with side links ✓</p> <p>Balanced equation for formation of correct polymer - correct use of n in the equation and brackets ✓</p>	2	<p>Displayed formulae MUST be used to award each mark</p> <p>n on LHS can be at any height to the left of formula AND n on the RHS must be a subscript (essentially below the side link)</p>
	(b) (i)	$\text{CH}_2\text{CHCl} + 2\text{O}_2 \rightarrow \text{CO} + \text{CO}_2 + \text{HCl} + \text{H}_2\text{O} \checkmark$	1	<p>ALLOW any other correctly balanced equation with the same reactants and products ALLOW $\text{C}_2\text{H}_3\text{Cl}$ for CH_2CHCl</p>
	(ii)	<p>Sodium hydrogencarbonate neutralises HCl ✓</p>	1	<p>Assume that 'it' refers to sodium hydrogencarbonate but DO NOT ALLOW other chemicals e.g. sodium</p> <p>ALLOW NaHCO_3 is a base ALLOW forms a salt or sodium chloride or NaCl ALLOW equation to show formation of NaCl from NaHCO_3 and HCl even if not balanced. IGNORE reacts</p>

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Question		Answer	Mark	Guidance
	(c)	<p>ANY TWO from</p> <p>abundance (in atmosphere) OR amount (in atmosphere) OR (atmospheric) concentration OR percentage (in air) ✓</p> <p>OR</p> <p>ability to absorb infrared/IR (radiation)✓</p> <p>OR</p> <p>residence time ✓</p>	2	ALLOW absorption of infrared/IR
	(d) (i)	<p>Any balanced equation between a metal oxide and carbon dioxide to form a carbonate e.g $\text{CaO} + \text{CO}_2 \longrightarrow \text{CaCO}_3$ ✓</p>	1	ALLOW MO for metal oxide
	(ii)	<p>ANY ONE FROM</p> <p>deep in oceans OR in geological formations OR (deep) in rocks OR in mines OR in oil wells OR in gas fields ✓</p>	1	<p>Assume that 'it' refers to carbon dioxide but DO NOT ALLOW carbon</p> <p>DO NOT ALLOW reacted with oxides or stored as carbonates.</p>
Total			8	

Question	Answer	Mark	Guidance
6 (a) (i)	 <p>axes labelled (number of) molecules and (kinetic) energy ✓</p> <p>Correct drawing of a two Boltzmann distributions i.e. both curves must start within the first small square nearest to the origin AND must not touch the x axis at high energy ✓</p> <p>Drawing of Boltzmann distribution at two different temperatures with higher and lower temperature clearly identified (ie $T_2 > T_1$) ✓</p> <p>QWC - (At a higher temperature) more molecules have energy above activation energy OR greater area under the curve above the activation energy ✓</p>	4	<p>ANNOTATE ANSWER WITH TICKS AND CROSSES ETC</p> <p>Candidates do not need E_a on graph</p> <p>ALLOW particles instead of molecules on the y axis DO NOT ALLOW atoms instead of particles/molecules ALLOW ECF for the incorrect use of atoms (instead of molecules/particles) DO NOT ALLOW enthalpy on the x-axis</p> <p>DO NOT ALLOW increase of more than one small square at high energy end of curve.</p> <p>Maximum of curve for higher temperature to right AND lower than maximum of lower temperature curve AND above lower temp line at higher energy Higher temp line should intersect lower temp line once</p> <p>DO NOT ALLOW lower activation energy QWC requires more molecules have or exceed activation energy/E_a. IGNORE more molecules have enough energy to react for the QWC mark (as not linked to E_a) ORA if states the effect when the temperature is lower IGNORE (more) successful collisions</p>

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Question		Answer	Mark	Guidance
(a)	(ii)	(Decreasing the pressure) decreases the rate of reaction AND Decreased concentration of molecules OR Number of molecules remains the same but the volume increases OR Less molecules per (unit) volume ✓ Less frequent collisions ✓	2	Correct effect on rate must be linked to reason for the first marking point. ALLOW molecules are further apart IGNORE less crowded ALLOW particles or atoms for molecules ALLOW 'space' for volume DO NOT ALLOW area instead of volume ALLOW collisions occur less often OR decreased rate of collision IGNORE less chance of collisions 'less collisions' alone is not sufficient IGNORE successful
(b)	(i)	$\text{C}_6\text{H}_{12}\text{O}_6 \longrightarrow 2\text{C}_2\text{H}_5\text{OH} + 2\text{CO}_2 \checkmark$ Temperature: Between 20 °C and 45 °C inclusive AND Condition: Absence of oxygen OR anaerobic ✓	2	ALLOW correct molecular OR structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous) IGNORE state symbols DO NOT ALLOW acidic or alkaline conditions If there is a contradiction or an incorrect answer in any condition given then do not award this mark. ALLOW conditions shown in the equation A limited supply of oxygen is not sufficient IGNORE pressure IGNORE yeast (in question) ALLOW Lack of oxygen
(b)	(ii)	$2\text{NO} + 2\text{CO} \longrightarrow 2\text{CO}_2 + \text{N}_2 \checkmark$	1	ALLOW multiples IGNORE state symbols
Total			9	

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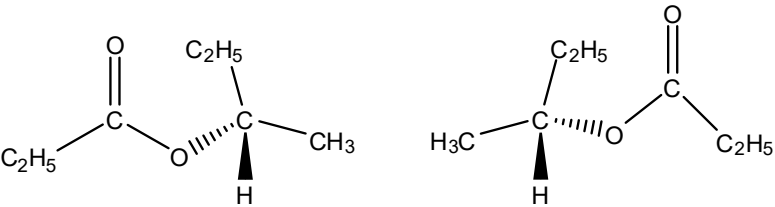
Question		Answer	Mark	Guidance
7	(a)	$ \begin{array}{c} \text{CH}_3 \quad \text{CH}_3 \\ \quad \\ \text{H}_3\text{C}-\text{C}-\text{C}-\text{H} \\ \quad \\ \text{Br} \quad \text{Br} \quad \checkmark \end{array} $	1	<p>ALLOW correct structural OR displayed OR skeletal formula OR mixture of the above</p> <p>DO NOT ALLOW molecular formula</p> <p>ALLOW dichloro or diiodo compound instead of the dibromo compound as the only alternatives.</p>
	(b)	Reagent A : correct halogen ✓ e.g. Br ₂ / bromine	1	<p>ALLOW Cl₂ if dichloro compound drawn</p> <p>ALLOW I₂ if diiodo compound drawn</p> <p>IGNORE state symbols</p> <p>Answer must match box from (a) to score</p>
	(c) (i)	Steam AND acid catalyst ✓	1	<p>ALLOW H⁺ / named acid / H₂SO₄ / H₃PO₄</p> <p>ALLOW H₂O(g)</p> <p>ALLOW water only if a temperature of 100 °C or above is quoted.</p> <p>IGNORE any temperature given with steam</p> <p>IGNORE pressure</p>
	(ii)	(compounds or molecules) having the same molecular formula but different structural formulae ✓	1	<p>ALLOW different structure OR different displayed formula OR different skeletal formula for structure</p> <p>Same formula is not sufficient</p> <p>Different arrangement of atoms is not sufficient</p>
	(iii)	$ \begin{array}{c} \text{CH}_3 \text{CH}_3 \\ \quad \\ \text{H}_3\text{C}-\text{C}-\text{C}-\text{H} \\ \quad \\ \text{OH} \quad \text{H} \quad \checkmark \end{array} \quad \begin{array}{c} \text{CH}_3 \text{CH}_3 \\ \quad \\ \text{H}_3\text{C}-\text{C}-\text{C}-\text{H} \\ \quad \\ \text{H} \quad \text{OH} \quad \checkmark \end{array} $	2	<p>ALLOW correct structural OR displayed OR skeletal formula OR mixture of the above</p> <p>ALLOW any vertical bond to OH</p> <p>DO NOT ALLOW OH-</p>
	(iv)	<p>Does not contain OH group(s)</p> <p>OR does not contain hydroxyl group(s)</p> <p>OR is not an alcohol ✓</p> <p>Does not form hydrogen bonds with water ✓</p>	2	<p>ALLOW ORA throughout</p> <p>DO NOT ALLOW OH⁻ (ions) / hydroxide (ions)</p> <p>'Does not form hydrogen bonds' is not sufficient</p>

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Question	Answer	Mark	Guidance
(d)	Reagents: Acid/H ⁺ and (potassium or sodium) dichromate/Cr ₂ O ₇ ²⁻ seen once ✓ Observations: Orange to Green OR Orange to Blue ✓ Distillation / Distil produces aldehyde/CH ₃ CH ₂ CHO: ✓ CH ₃ CH ₂ CH ₂ OH + [O] → CH ₃ CH ₂ CHO + H ₂ O ✓ Reflux (of propan-1-ol) produces carboxylic acid/CH ₃ CH ₂ COOH ✓ CH ₃ CH ₂ CH ₂ OH + 2[O] → CH ₃ CH ₂ COOH + H ₂ O ✓	6	ANNOTATE ANSWER WITH TICKS AND CROSSES ETC ALLOW H ₂ SO ₄ and K ₂ Cr ₂ O ₇ ALLOW correct displayed formula OR correct structural formula OR skeletal formula OR a mixture of the above DO NOT ALLOW molecular formulae ALLOW C ₃ H ₇ OH for propan-1-ol in equations DO NOT ALLOW CH ₃ CH ₂ COH for aldehyde IGNORE further oxidation of aldehyde ALLOW CH ₃ CH ₂ CO ₂ H for carboxylic acid
	Total	14	

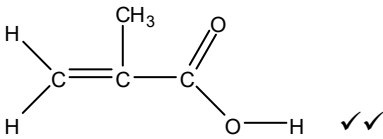
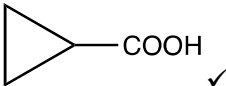
Question	Answer	Mark	Guidance
8 (a)	<p>Molar mass of B = 74 ✓</p> <p>B-F clearly identified</p> <p>B/alcohol:</p> $ \begin{array}{cccc} \text{H} & \text{H} & \text{OH} & \text{H} \\ & & & \\ \text{H}-\text{C} & -\text{C} & -\text{C} & -\text{C}-\text{H} \\ & & & \\ \text{H} & \text{H} & \text{H} & \text{H} \end{array} $ <p style="text-align: right;">✓</p> <p>C/ketone:</p> $ \begin{array}{cccc} \text{H} & \text{H} & \text{O} & \text{H} \\ & & & \\ \text{H}-\text{C} & -\text{C} & -\text{C} & -\text{C}-\text{H} \\ & & & \\ \text{H} & \text{H} & & \text{H} \end{array} $ <p style="text-align: right;">✓</p> <p>D/carboxylic acid:</p> $ \begin{array}{ccc} \text{H} & \text{H} & \text{O} \\ & & // \\ \text{H}-\text{C} & -\text{C} & -\text{C} \\ & & \backslash \\ \text{H} & \text{H} & \text{O}-\text{H} \end{array} $ <p style="text-align: right;">✓</p> <p>E and F:</p> $ \begin{array}{ccccccc} \text{H} & \text{H} & \text{O} & & \text{CH}_3 & \text{H} & \text{H} \\ & & // & & & & \\ \text{H}-\text{C} & -\text{C} & -\text{C} & -\text{O}- & \text{C} & -\text{C} & -\text{C}-\text{H} \\ & & & & & & \\ \text{H} & \text{H} & & & \text{H} & \text{H} & \text{H} \end{array} $ <p style="text-align: right;">✓</p> <p>H₂O/water ✓</p>	6	<p>ANNOTATE ANSWER WITH TICKS AND CROSSES ETC</p> <p>Check and annotate page 19 below this response</p> <p>Molar mass = $\frac{2.59}{0.035} = 74$</p> <p>For structure of B, C, D or E/F ALLOW correct displayed OR correct structural formula OR correct skeletal formula OR mixture of the above as long as unambiguous.</p> <p>DO NOT ALLOW missing H atom(s) in a displayed formula for one structure but ALLOW missing H atoms in subsequent structures.</p> <p>IGNORE names of organic compounds</p> <p>E and F can be identified either way round</p> <p>ALLOW H₂O or displayed formula for mark</p> <p>For E and F – ALLOW the two optical isomers</p> <div style="display: flex; justify-content: space-around; align-items: center;">  </div>

Question	Answer	Mark	Guidance
8 (b)	<p><u>Molecular formula for G:</u> 2 marks</p> <p>Mole ratio C : H : O = $\frac{55.8}{12.0} : \frac{7.0}{1.0} : \frac{37.2}{16.0}$</p> <p>OR 4.65 : 7.0 : 2.33/2.325 OR 2 : 3 : 1 OR C₂H₃O ✓</p> <p>Molecular formula of G C₄H₆O₂ ✓</p> <p><u>Mass spectrum for G:</u> 2 marks</p> <p>Peak X or peak 41 indicates C₃H₅⁺ ✓</p> <p>Peak Y or peak 45 indicates COOH⁺ ✓</p> <p><u>Infrared for G:</u> 1 mark</p> <p>Peak at 1640–1750 cm⁻¹ indicates presence of C=O AND Peak at 2500–3300 cm⁻¹ (indicates the presence of) –OH group linked carboxylic acid/COOH QWC ✓</p>	7	<p>ANNOTATE ANSWER WITH TICKS AND CROSSES ETC</p> <p>ALLOW mass of C = 0.558 x 86 or 48 AND mass of H = 0.07 x 86 or 6 AND mass of O = 0.372 x 86 = 32</p> <p>+ charge required for each response ALLOW one mark if both formulae are correct but with no charge/incorrect charge</p> <p>ALLOW any possible fragments that contain C, H and/or O that have the correct mass. E.g. Peak X indicates C₂OH⁺, Peak Y indicates C₂H₅O⁺ Unfeasible fragments are not allowed e.g. C₃H₉⁺ (too many H atoms)</p> <p>LOOK ON THE SPECTRUM for labelled absorbance which can be given credit Candidates must link absorbance to bond in order to gain the mark</p> <p>ALLOW 1700 cm⁻¹</p> <p>For 2500–3300 cm⁻¹, ALLOW 2900 cm⁻¹ or any stated wavenumber with range 2500–3300 cm⁻¹ ALLOW wavenumber range up to 2400–3500 cm⁻¹</p>

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Question	Answer	Mark	Guidance
	<p>Structure of G: 2 marks</p> <p>Correct structure:</p>  <p>1 mark for one of the following structures of C₄H₆O₂:</p> <p>H₂C=CH—CH₂—COOH OR H₃C—CH=CH—COOH OR</p> 		<p>ALLOW structural, skeletal or displayed formula.</p> <p>DO NOT ALLOW ECF from incorrect molecular formula</p>
	Total	13	

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