OCR
Oxford Cambridge and RSA

GCE

Chemistry A

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

Advanced Subsidiary GCE

Mark Scheme for June 2015

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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.

1. **Annotations**

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
	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

12 **Subject-specific Marking Instructions**

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

3(c)(i), 3(d), 4(c)(ii) 5(d)(i), 5(e)(i), 5(f)(ii), 6(a)(i), 6(b)(ii), 6(c) and 7(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)** 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, ^, or the BP annotation
- Scroll down to page 24 and annotate with a ^ if the page is blank.
- If pages 22, 23 or 24 are not blank then use the paper clip icon to link the pages to the correct questions.
- You may need to contact your Team Leader if you do not know how to do this.

Generic comments

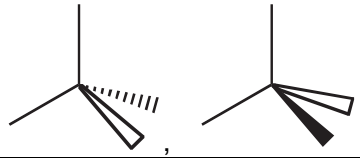
ORGANIC STRUCTURES
For a 'structure' or 'structural formula',
- **ALLOW** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above (as long as unambiguous)

For an alkyl group shown within a structure,
- **ALLOW** bond drawn to C or H,
  e.g. **ALLOW** CH_3–,CH_2–, C_3H_7–, 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.:	

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)

Question			Answer	Mark	Guidance
1	(a)	(i)	(compounds or molecules having the) same molecular formula but different structural formulae ✓	1	**ALLOW** different structure **OR** different displayed formula **OR** different skeletal formula for structure **DO NOT ALLOW** any reference to spatial/space Same formula is **not** sufficient *(no reference to molecular)* Different arrangement of atoms is **not** sufficient (*no reference to structure/structural)*
		(ii)	2,2,3-trimethylbutane ✓	1	**ALLOW** trimethylbutane as the **ONLY** alternative response
	(b)		 ✓	1	**DO NOT ALLOW** molecular formulae **OR** structural formula **OR** displayed formula **OR** mixture of the above
	(c)		$C_{12}H_{25}$ ✓	1	**IGNORE** $C_{24}H_{50}$
	(d)	(i)	$C_8H_{18} + 12½O_2 \longrightarrow 8CO_2 + 9H_2O$ ✓	1	**ALLOW** multiples e.g. $2C_8H_{18} + 25O_2 \longrightarrow 16CO_2 + 18H_2O$ **IGNORE** state symbols

Question			Answer	Mark	Guidance
	(ii)		(n(C_8H_{18}) burned) = 0.32 (mol) ✓ (n(CO_2) from complete combustion) = 2.56 **or** 2.6 mol **OR** (ratio $n CO_2 / n C_8H_{18}$) = 7.8(125) **OR** (n C_8H_{18} produce 2.5 mol CO_2) = 0.31(25) ✓	**2**	**DO NOT ALLOW ECF** from an incorrect moles of octane **DO NOT ALLOW ECF** from incorrect ratio from equation in **(i)** **ALLOW** the following alternate methods --- **Method 1** (mass CO_2 produced) = 110 g ✓ (mass CO_2 from complete combustion) = 8 × 0.32 × 44 = 112.64 **or** 112.6 **or** 113 g✓ --- **Method 2** (n C_8H_{18} to produce 2.5 mol CO_2) = 0.31(25) ✓ (mass of octane required to produce 2.50 mol CO_2) = 35.6 **OR** 35.63 **OR** 35.625 g ✓

Question			Answer	Mark	Guidance
	(e)	(i)	Fractional distillation **AND** cracking ✓	1	**ALLOW** either order
		(ii)	Correct equation showing cracking of an alkane to form ethene ✓	1	**ALLOW** any correct equation with correct formulae to show cracking forming C_2H_4 of the type: alkane ⟶ shorter alkane(s) + alkene, e.g. $C_{10}H_{22} \longrightarrow C_8H_{18} + C_2H_4$ $C_{10}H_{22} \longrightarrow C_6H_{14} + 2C_2H_4$ **ALLOW** $C_2H_6 \longrightarrow C_2H_4 + H_2$ **ALLOW** correct molecular formulae **OR** structural **OR** displayed **OR** skeletal **OR** mixture of the above. **IGNORE** state symbols
			Total	9	

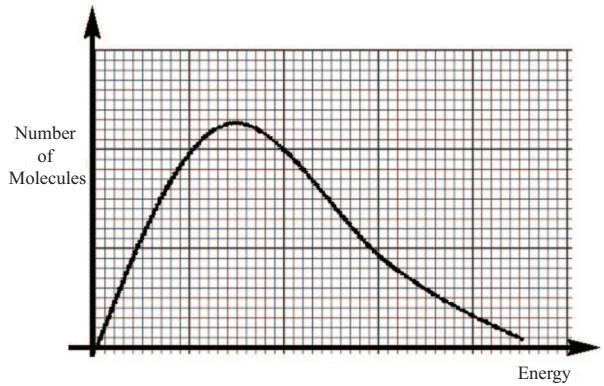
Question			Answer	Mark	Guidance
2	(a)		Method 1: 100% **OR** (only) one product **OR** no waste product **OR** addition (reaction) ✓ Method 2: < 100% **AND** two products **OR** (also) produces NaBr **OR** (There is a) waste product **OR** substitution (reaction) ✓	2	**ALLOW** co-product or by-product for waste product For '< 100%' **ALLOW** not 100% **OR** method 2 has a low(er) atom economy (compared to method 1) **IGNORE** produces Br^-/ Na^+ **DO NOT ALLOW** incorrect waste products e.g. Br_2, HBr, Br, Na **ALLOW** correctly calculated value of 42 or 41.8 up to calculator value of 41.83154324 correctly rounded for second mark **DO NOT ALLOW** incorrect values for the atom economy of method 2. **ALLOW ONLY** 1 mark for a statement that both methods have 100% atom economy.
	(b)		Acid ✓	1	**ALLOW** H^+ / named mineral acid / H_2SO_4 / H_3PO_4 **DO NOT ALLOW** 'weak acid' e.g. ethanoic acid **IGNORE** pressure **IGNORE** temperature

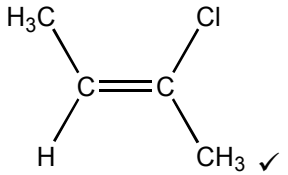
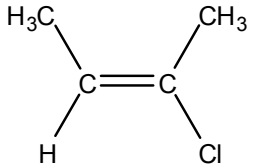
Question			Answer	Mark	Guidance
	(c)	(i)	(Average enthalpy change) when one mole of bonds ✓ of (gaseous covalent) bonds is broken ✓	2	**IGNORE** energy required **OR** energy released **DO NOT ALLOW** bonds formed
		(ii)	**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF enthalpy change = –42 (kJ mol^{-1}) award 3 marks** **IF enthalpy change = +42 (kJ mol^{-1}) award 2 marks** (Energy for bonds broken) = 5538 (kJ) ✓ (Energy for bonds made) = 5580 (kJ) ✓ ΔH_r = –42 (kJ mol^{-1}) ✓	3	**IF there is an alternative answer, check to see if there is any ECF credit possible.** two common incorrect answers are: –970 (kJ mol^{-1}) award 2 marks +970 (kJ mol^{-1}) award 1 mark **IGNORE** signs **ALLOW** 1076 (bonds broken); 1118 (bonds made) Correct sign required **ALLOW ECF** for bonds broken – bonds made **IF** at least one molar ratio is used e.g. 8 x C–H

Question	Answer	Mark	Guidance
(d)	**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF mass = 8.21 (g) award 3 marks** **Actual** $n(C_4H_9OH)$ produced = $\frac{3.552}{74}$ = 0.048 (mol) ✓ **theoretical** $n(C_4H_9OH) = n(C_4H_9Br) = 0.048 \times \frac{100}{80}$ = 0.06 (mol) ✓ Mass of C_4H_9Br = 0.06 × 136.9 = 8.21 (g) ✓ ***3 SF required***	3	**ALLOW ECF** at each stage **ALLOW** expected mass $C_4H_9OH = 3.552 \times \frac{100}{80}$ = 4.44 (g) **ALLOW** Mass C_4H_9Br reacted = 0.048 × 136.9 = 6.5712 (g) **ALLOW** Mass of C_4H_9Br used $= 6.5712 \times \frac{100}{80}$ = 8.21 (g) **DO NOT ALLOW** 8.22 (*from use of 137 as M_r of C_4H_9Br*)
	Total	**11**	

Question			Answer	Mark	Guidance
3	(a)		Increased rate **AND** greater concentration of molecules / more molecules per (unit) volume ✓ More collisions per second **/** more frequent collisions ✓	2	**ALLOW** particles for molecules **IGNORE** atoms **Response must imply a volume and not area** **ALLOW** more molecules in the **same space** **OR** more molecules in the **same volume** **OR** same number of molecules in a **smaller volume** **IGNORE** molecules are closer together *(no idea of volume)* **ALLOW** collisions more often **OR** increased rate of collision **IGNORE** more chance of collisions 'more collisions' alone is **not** sufficient *(no rate)* **IGNORE** 'successful'
3	(b)		The (position of a dynamic) equilibrium shifts to minimise (the effect of) any change ✓	1	**ALLOW** suitable alternatives for 'shifts' and 'minimises' **IGNORE '**reaction shifts'

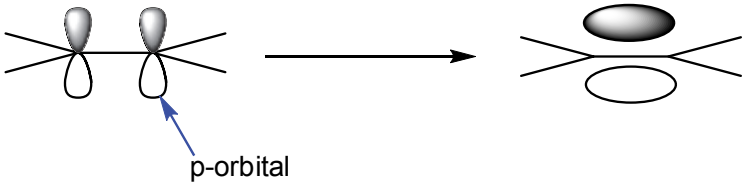
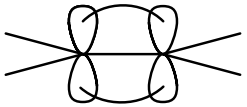
Question			Answer	Mark	Guidance
	(c)	(i)	**Pressure**: Right-hand side has fewer (gaseous) moles/molecules **OR** left-hand side has more (gaseous) moles/molecules ✓ **Temperature**: Statement that: (Forward) reaction is exothermic **OR** (forward) reaction gives out heat **OR** reverse reaction is endothermic **OR** reverse reaction takes in heat ✓ **Equilibrium** Lower temperature/cooling **AND** increasing pressure shifts (equilibrium position) to the right ✓	3	ANNOTATE ANSWER WITH TICKS AND CROSSES ETC **DO NOT ALLOW** fewer atoms on right-hand side **OR** more atoms on left-hand side. **IGNORE** comments about the 'exothermic side' or 'endothermic side' **Equilibrium mark** is for stating that **BOTH** low temperature and high pressure shift equilibrium to the right (Could be separate statements) **Note: ALLOW** suitable alternatives for 'to right', e.g.: towards products **OR** towards CH_3OH / H_2O **OR** in forward direction **OR** favours the right **IGNORE** Increases yield of CH_3OH/products *(in question)* **IGNORE** responses in terms of rate
	(ii)		Low temperature gives a slow rate **OR** high temperatures needed to increase rate ✓ High pressure is expensive (to generate) **OR** high pressure provides a safety risk ✓	2	**ALLOW** high pressure is dangerous **IGNORE** high pressure is explosive

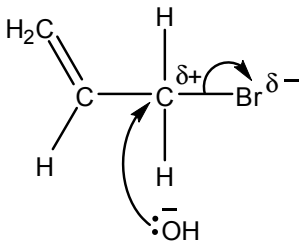
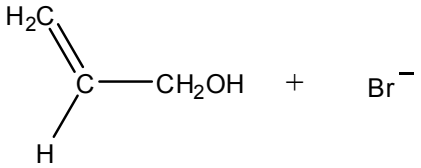
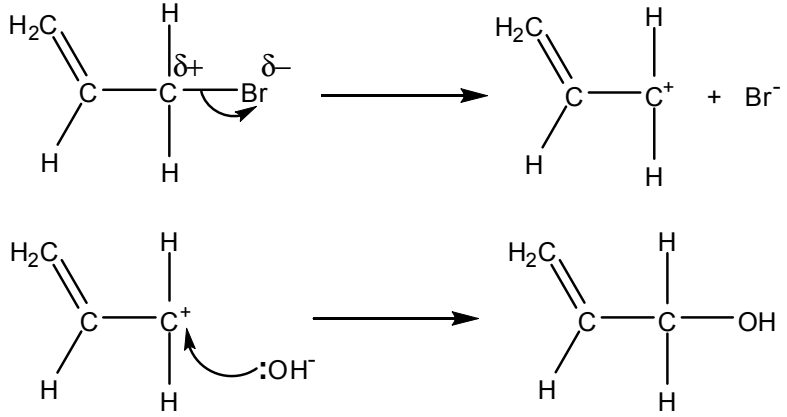
Question	Answer	Mark	Guidance
(d)	 Correct drawing of Boltzmann distribution curve ✓ Axes labelled: y axis: (number of) molecules **AND** x axis: energy ✓ Catalyst lowers the activation energy (by providing an alternative route) ✓ (With a catalyst a) greater proportion of molecules with energy greater than activation energy **OR** (With a catalyst a) greater proportion of molecules with energy equal to the activation energy ✓	4	ANNOTATE ANSWER WITH TICKS AND CROSSES ETC Curve must start at origin. The limit of acceptability is that the curve must start within the first small square nearest the origin. Curve must not touch the x-axis at higher energy **IGNORE** a slight inflexion on the curve **DO NOT ALLOW** two curves **DO NOT ALLOW** a curve that bends up at the end by more than one small square **ALLOW** particles instead of molecules on y axis **DO NOT ALLOW** enthalpy for x-axis label **DO NOT ALLOW** atoms instead of particles or molecules **ALLOW ECF** for the subsequent use of atoms (instead of molecules or particles) **ALLOW** annotations on Boltzmann distribution diagram **ALLOW** (with a catalyst) more molecules have sufficient energy to react **IGNORE** (more) successful collisions
(e)	Allows reactions to take place at lower temperatures ✓	1	**ALLOW** less heat (required) **IGNORE** references to pressure **IGNORE** references to less energy (*in question)* e.g. lowers E_a
	Total	13	

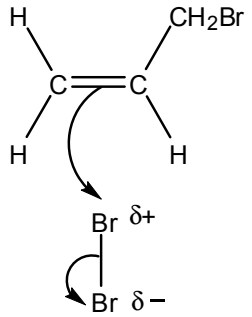
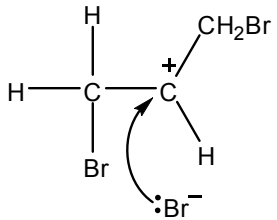
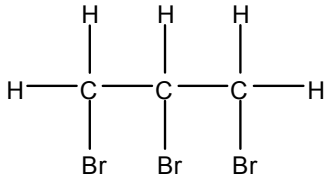
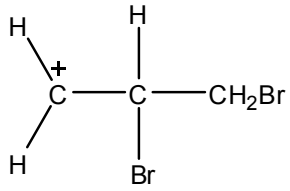
Question			Answer	Mark	Guidance
4	(a)		**B** ✓	1	**ALLOW** CF_2CF_2 O**R** C_2F_4 **OR** tetrafluoroethene
	(b)	(i)	 ✓	1	**ALLOW** correct structural **OR** displayed **OR** skeletal **OR** mixture of the above **ALLOW** *E* isomer 
		(ii)	HCl ✓	1	**DO NOT ALLOW** Cl_2 **IGNORE** names **IGNORE** nitrogen oxides / NO_x
	(c)	(i)	**ANY TWO FROM THE FOLLOWING** ✓ Low reactivity **OR** will not burn/non-flammable Volatile **OR** low boiling point non-poisonous **OR** non-toxic	1	 **ALLOW** inert **OR** stable **DO NOT ALLOW** inflammable **ALLOW** it is a gas **IGNORE** easily compressed **IGNORE** not harmful **IGNORE** references to solubility

Question	Answer	Mark	Guidance
(ii)	*Benefit of ozone layer to life (1 mark)* Ozone absorbs **UV** (radiation) **UV** at Earth's surface is reduced ✓ **OR** *Maintenance of O_3 concentration* (1 mark) $_3 \rightleftharpoons O_2 + O$ ✓ O *Production of radicals from **G** (1 mark)* $_2Cl_2 \longrightarrow C\ l + CF_2Cl$ ✓ CF *Breakdown of O_3 (2 marks)* $l + O_3 \longrightarrow C\ lO + O_2$ ✓ $lO + O \longrightarrow Cl + O_2$ C **OR** $ClO + O_3 \longrightarrow Cl + 2O_2$ ✓ C	5	**ANNOTATE ANSWER WITH TICKS AND CROSSES ETC** For all equations, **IGNORE** dots on radicals --- Essential idea for first mark is that **UV** is removed in some way. **ALLOW** Prevents **UV** damaging life or stated type of damage, e.g. cataracts, skin cancer, mutation, crop damage **DO NOT ALLOW** ozone absorbs IR --- **ALLOW** $_3 \longrightarrow O_2 + O$ $_2 + O \longrightarrow O_3$ O **AND** O **DO NOT ALLOW** $2O_3 \rightleftharpoons 3O_2$ **OR** $O_3 + O \longrightarrow 2O_2$ for this mark --- **DO NOT ALLOW** equations with other CFCs **DO NOT ALLOW** $CF_2Cl_2 \longrightarrow 2C\ l + CF_2$ --- These are the only acceptable equations **IGNORE** overall equation *(does not show role of catalyst)* e.g. $O_3 + O \longrightarrow 2O_2$

Question			Answer	Mark	Guidance
	(iii)		**D** ✓	1	**ALLOW** CHF_2Cl **ALLOW B OR** C_2F_4 **OR** CF_2CF_2
	(d)	(i)	**bond** vibrates (more) **OR bond** bends (more) **OR bond** stretches (more) ✓	1	**BOND essential** **IGNORE** molecule vibrates/rotates Assume "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 **C** and **F** e.g. C–O, C–H not present
	(ii)		Cl_3C^+ ✓ $CF_2\ Cl^+$ ✓	2	**ALLOW** 1 mark for Cl_3C **AND** $CF_2\ Cl$ *i.e. no + charge used* **ALLOW** 1 mark for Cl_3C^- **AND** $CF_2\ Cl^-$ *i.e. – charge used on both*
			Total	13	

			Answer	Mark	Guidance
5	(a)		 **First mark** diagram on left with p-orbitals labelled **OR** unlabelled diagram **AND** the statement: (sideways) overlap of p orbitals ✓ **Second mark** (labelled) diagram on right showing π-bond ✓	**2**	**Note:** A diagram is required for **each** mark **DO NOT ALLOW** C=C in one diagram but **ALLOW ECF** for subsequent use in another diagram. The bonds shown in the diagram are **required** **ALLOW ECF** for missing bonds in second diagram **IGNORE** any atoms joined to the bonds **ALLOW** a diagram where the p-orbitals are linked for second mark. e.g. 
	(b)	**(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** reference to physical properties **IGNORE** same general formula *(in question)* Differs by CH_2 is **not** sufficient (*no successive*) **DO NOT ALLOW** same empirical **OR** have the same molecular formula
		(ii)	$C_nH_{2n-1}Br$ ✓	**1**	**ALLOW** $\mathbf{C_nH_{2n-1}X}$ **ONLY** if X is specified as Br (*question asks for bromide)*
		(iii)	3-bromoprop(-1-)ene ✓	**1**	**ALLOW** 1-bromoprop-2-ene
	(c)	**(i)**	Movement of an electron pair ✓	**1**	**ALLOW** movement of a lone pair **OR** movement of a bond
		(ii)	Electron pair donor ✓	**1**	**ALLOW** can donate a lone pair

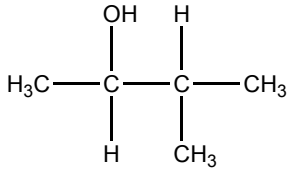
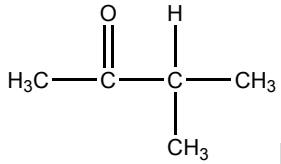
			Answer	Mark	Guidance
	(d)	(i)	 curly arrow from HO^- to carbon atom of C−Br bond ✓ Dipole shown on C–Br bond, $C^{\delta+}$ and $Br^{\delta-}$, **AND** curly arrow from C−Br bond to Br atom ✓ ---  correct organic product **AND** Br^- ✓	3	**ANNOTATE ANSWER WITH TICKS AND CROSSES ETC** Curly arrow must come from lone pair on O of HO^- **OR** OH^- **OR** from minus sign on HO^- ion (No need to show lone pair if curly arrow came from negative charge on O) --- **ALLOW** S_N1 mechanism: Dipole shown on C–Br bond, $C^{\delta+}$ and $Br^{\delta-}$, **AND** curly arrow from C−Br bond to Br atom ✓ Correct carbocation **AND** curly arrow from HO^- to carbocation Curly arrow must come from lone pair on O of HO^- **OR** OH^- **OR** from minus sign on HO^- ion (No need to show lone pair if curly arrow came from negative charge on O) ✓ correct organic product **AND** Br^- ✓  ---
		(ii)	Nucleophilic substitution ✓	1	

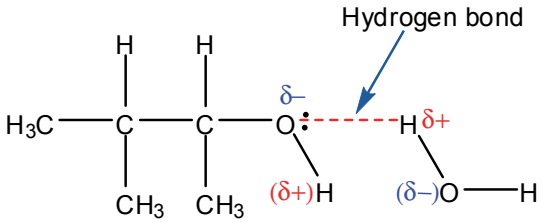
			Answer	Mark	Guidance
(e)		(i)	Curly arrow from double bond to Br of Br–Br ✓ Correct dipole shown on Br–Br **AND** curly arrow showing breaking of Br–Br bond ✓  --- Correct carbocation with + charge on C with 3 bonds **AND** curly arrow from Br^- to C^+ of carbocation ✓  --- Correct product: ✓ 	4	**ANNOTATE ANSWER WITH TICKS AND CROSSES ETC** Curly arrow **must** start from bond and go to correct atom **DO NOT ALLOW** any other partial charges e.g. shown on double bond **ALLOW** carbocation on terminal CH_2  **DO NOT ALLOW** δ+ on C of carbocation. Curly arrow must come from a lone pair on Br^- **OR** from the negative sign of Br^- ion (then lone pair on Br^- ion does not need to be shown)
		(ii)	Electrophilic addition ✓	1	

			Answer	Mark	Guidance
	(f)	(i)	H_2 **AND** Ni (catalyst) ✓	1	**ALLOW** name or formula for each **IGNORE** any stated temperature and pressure
		(ii)	(Initiation) $Cl_2 \longrightarrow 2Cl$ **AND** UV ✓ (Propagation) $C_3H_7Br + Cl \longrightarrow C_3H_6Br + HCl$ ✓ $C_3H_6Br + Cl_2 \longrightarrow C_3H_6BrCl + Cl$ ✓ (Termination) Two from the three termination equations below ✓ $2Cl \longrightarrow Cl_2$ $C_3H_6Br + Cl \longrightarrow C_3H_6BrCl$ $2C_3H_6Br \longrightarrow C_6H_{12}Br_2$ names of steps initiation, propagation and termination linked to one correct equation for each step in this mechanism✓	5	**ANNOTATE ANSWER WITH TICKS AND CROSSES ETC** **DO NOT ALLOW** any ECF in this question **IGNORE** references to temperature **THROUGHOUT, ALLOW** correct molecular formulae **OR** structural **OR** displayed **OR** skeletal **OR** mixture of the above **IGNORE** dots **IGNORE** state symbols **IGNORE** one incorrect termination equation
		(iii)	further substitution **OR** produces different termination products **OR** More than one termination step✓ substitution at different positions along chain ✓	2	**IGNORE** mixture of organic products (*in question*) **ALLOW** dichloro/multichloro/dibromo/multibromo compounds formed **OR** an example of a further substitution product **OR** an example of a different termination product **ALLOW** more than one hydrogen (atom) can be replaced **ALLOW** radicals react with each other to form other product**s** **ALLOW** forms different structural isomers **ALLOW** a hydrogen (atom) on a different carbon (atom) can be replaced
			Total	25	

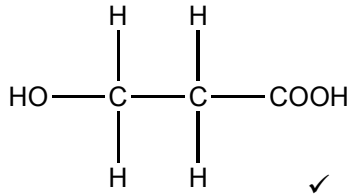
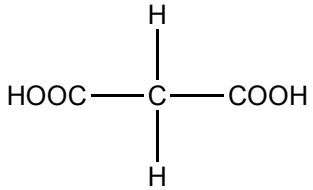
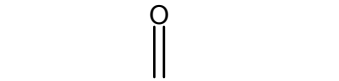
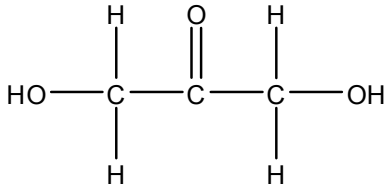
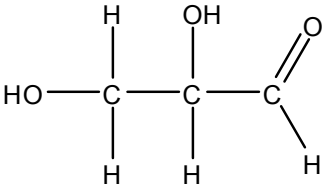
Question			Answer	Mark	Guidance
6	(a)	(i)	**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF ΔH_c = –2260 (kJ mol $^{-1}$) award 4 marks** **IF ΔH_c = (+)2260 (kJ mol $^{-1}$) award 3 marks (incorrect sign)** **IF ΔH_c = (±)2257(.2) (kJ mol $^{-1}$) award 3 marks (not 3 sf)** **Moles** Amount, *n*, $C_5H_{12}O$ calculated correctly = 0.0175 (mol) ✓ **Energy** *q* calculated correctly = 39501 (J) **OR** 39.5(01) (kJ) ✓ **Calculating ΔH** correctly calculates ΔH in kJ mol^{-1} to 3 or more sig figs ✓ **Rounding and Sign** calculated value of ΔH rounded to 3 sig. fig. with minus sign✓	4	**ANNOTATE ANSWER WITH TICKS AND CROSSES ETC** **Note:** *q* = 180 × 4.18 × 52.5 **ALLOW** 39501 **OR** correctly rounded to 3 sig. fig. (J) **IGNORE** sign **IGNORE** working **Note:** from 39501 J and 0.0175 mol ΔH = (-)2257.2 kJ mol^{-1} **IGNORE** sign at this intermediate stage **ALLOW** ECF from incorrect q and/or incorrect n Final answer must have **correct sign** and **three sig figs**
		(ii)	**ANY TWO FROM THE FOLLOWING** ✓✓ incomplete combustion non-standard conditions evaporation of alcohol/water specific heat capacity of beaker/apparatus	2	**IGNORE** heat loss (*in question*) **ALLOW** burns incompletely **IGNORE** incomplete reaction

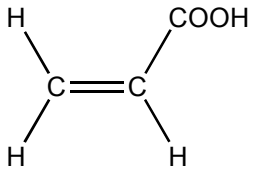
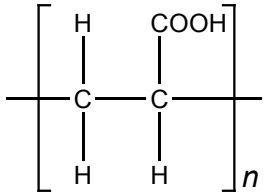
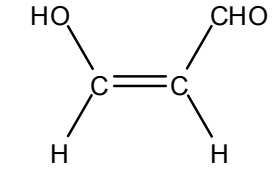
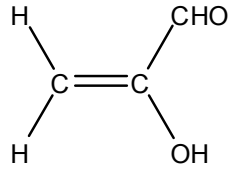
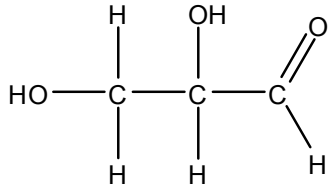
Question			Answer	Mark	Guidance
	(b)	(i)	$5C(s) + 6H_2(g) + \frac{1}{2}O_2(g) \longrightarrow C_5H_{12}O(l)$ ✓	1	Balancing numbers **AND** species **AND** states all required **DO NOT ALLOW** multiples of this equation
		(ii)	**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF enthalpy change = –3320 (kJ mol^{-1}) award 3 marks** **IF enthalpy change = (+)3320 (kJ mol^{-1}) award 2 marks** --- Working for CO_2 **AND** H_2O seen anywhere 5 × (–)394 **AND** 6 × (–)286 **OR** (–)1970 **AND** **OR** (–)3686 ✓ (–)1716 Calculates ΔH_c **A further 2 marks** for correct answer **AND** correct sign = 5 × –394 + 6 × –286 – –366 = –3320 (kJ mol^{-1}) ✓✓ **A further 1 mark** for correct answer **AND** incorrect or no sign = (+)3320 (kJ mol^{-1}) ✓ *Cycle wrong way around:* *–366 – (5 × –394 + 6 × –286)*	3	**ANNOTATE ANSWER WITH TICKS AND CROSSES ETC** **IF there is an alternative answer, check to see if there is any ECF credit possible** **Common incorrect answers are shown below** **Award 2 marks for** –1744 **OR** –1890 **OR** –314 **OR** –4052 **Award 1 mark for** 1744 **OR** 1890 **OR** 314 **OR** 4052

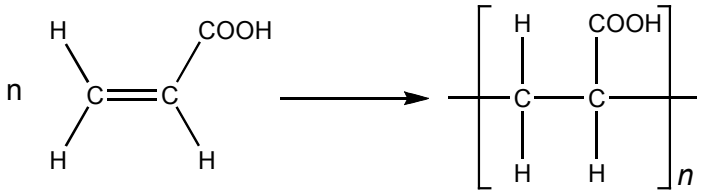
Question	Answer	Mark	Guidance
(c)		6	**ANNOTATE ANSWER WITH TICKS AND CROSSES ETC**
	QWC: Evidence of the **IR** absorption at 1720 (cm^{-1}) for presence of C=O/carbonyl group ✓		**LOOK ON THE SPECTRUM** for labelled peaks which can be given credit **BOTH IR** at ~1720 (cm^{-1}) **AND** C=O required **ALLOW** ranges from *Data Sheet*, i.e. C=O within range 1640–1750 cm^{-1};
	QWC: No carboxylic acid OH absorption in IR **OR** no peak between 2500–3300 cm^{-1} **AND** so **J** is a secondary alcohol **OR** so **K** is a ketone ✓		**IGNORE** any reference to C-O absorption For structures of **J** and **K**, **ALLOW** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above **IGNORE** any names given for **J** and **K**
	Alcohol J  ✓✓		**ALLOW** 1 mark for the structure of an alcohol with the molecular formula $C_5H_{12}O$ **DO NOT ALLOW** pentan-1-ol (*primary and unbranched*) or 2-methylbutan-2-ol (*branched but tertiary*)
	Compound K Structure of a carbonyl compound that could be obtained from alcohol **J** ✓		**DO NOT ALLOW** any marks for **J** and **K** if more than one structure is given for **J** **Note:** 'sticks' in either **J** and/or **K** will lose only 1 mark **ALLOW** 1 mark for:  **IF** a structure is not given for **J**
	Equation Balanced equation for conversion of **J** to **K** ✓ e.g. $CH_3CHOHCH(CH_3)_2 + [O] \longrightarrow CH_3COCH(CH_3)_2 + H_2O$		**NOTE:** structures for **J** and **K** could be awarded from the equation, even if not labelled. **ALLOW** molecular formulae in equation i.e. $C_5H_{12}O + [O] \longrightarrow C_5H_{10}O + H_2O$ **DO NOT ALLOW** equations that form a carboxylic acid

Question			Answer	Mark	Guidance
	(d)		**Labelled** diagram showing at least one H-bond between alcohol molecule and water ✓ e.g.  	1	**IF** diagram is not labelled **ALLOW** Hydrogen bonds / H bonds from text Diagram should include role of an O lone pair and dipole charges on each end of H bond. **IGNORE** alcohol R group, even if wrong **ALLOW** structural **OR** displayed **OR** skeletal formula **OR** mixture of the above
			Total	**17**	

Question			Answer	Mark	Guidance
7	(a)		Mole ratio C : H : O is 3.33 : 6.67 : 3.33 ✓ Empirical formula is CH_2O ✓ Molecular formula is $C_3H_6O_3$ **AND** use of 90 **OR** 3 × 30 ✓	**3**	**ALLOW** $\frac{40.00}{12.0} : \frac{6.67}{1.0} : \frac{53.33}{16.0}$ **ALLOW** mass of C = 0.400 x 90 **or** 36 **AND** mass of H = 0.06677 x 90 **or** 6 **AND** mass of O = 0.5333 x 90 **or** 48

Question	Answer	Mark	Guidance
(b)	**Evidence of carboxylic acid (1 mark)** **IR:** 1550–1800 cm^{-1} **AND** C=O/carbonyl **AND** 2300–3700 cm^{-1} **AND** O–H in carboxylic acid ✓ **Evidence of alcohol (1 mark)** (broad) 3200–3700 cm^{-1} linked to O–H in alcohol **OR** (is a primary) alcohol as oxidised (to a COOH) **OR** is an alcohol as it forms a carboxylic acid **OR** is an alcohol as water is eliminated. ✓ **Identifications (2 marks)** **L**:  ✓ **M**:  ✓ **Equation (1 mark)** $C_3H_6O_3 + 2[O] \longrightarrow C_3H_4O_4 + H_2O$ ✓	5	**ANNOTATE ANSWER WITH TICKS AND CROSSES ETC** **LOOK ON THE SPECTRUM** for labelled peaks which can be given credit **ALLOW** ranges from *Data Sheet*: C=O within range 1640–1750 cm^{-1}; (broad) O–H within range 2500–3300 cm^{-1} (broad) O–H within range 3200–3550 cm^{-1} **For ALL structures:** **ALLOW** correct structural **OR** skeletal **OR** displayed formula **OR** mixture of the above **IGNORE** names --- **FOR M: ALLOW 1 mark for**  ✓ **AS ECF from L as either**  **OR**  **Equation:** $C_3H_6O_3 + 4[O] \longrightarrow C_3H_2O_5 + 2H_2O$ ✓ --- **ALLOW** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above in equation

Question	Answer	Mark	Guidance
(c)	**Monomer N: (1 mark)**  ✓ **Polymer P: (1 mark)** Section showing at least one repeat unit of a polymer formed from **N** with side links ✓ e.g. 	4	**For ALL structures:** **ALLOW** correct structural **OR** skeletal **OR** displayed formula **OR** mixture of the above **IGNORE** names **ALLOW 1 mark for either**  **OR**  **AS ECF** from **L:**  --- **For P: ALLOW ECF** from an alkene with molecular formula $C_3H_4O_2$ **ALLOW** one or more repeat units but has to have a whole number of repeat units **ALLOW** repeat unit with no brackets and absence of *n*

Question	Answer	Mark	Guidance
	Repeat units (1 mark) n = 10000/72 = 139 ✓		**MUST** be a whole number. **ALLOW** 138 **OR**140
	Equation (1 mark) Balanced equation for formation of P from N✓ e.g.  		**For equation, ALLOW** molecular **OR** structural **OR** skeletal **OR** displayed formulae **OR** mixture of the above e.g. **ALLOW** $n C_3H_4O_2 \longrightarrow (C_3H_4O_2)_n$ 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 if displayed/skeletal formula is used) **ALLOW** use of calculated value for n in equation e.g. $139 C_3H_4O_2 \longrightarrow (C_3H_4O_2)_{139}$
	Total	**12**	

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