OCR
RECOGNISING ACHIEVEMENT

GCE

Chemistry A

Advanced Subsidiary GCE

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

Mark Scheme for June 2012

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

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

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Annotations

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

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

Annotations should be placed to clearly show where they apply within the body of the text (ie not in margins)

Question 1 (c)(ii), (d)
Question 3 (c)(ii)
Question 4 (a)(i)
Question 5 (c)(i)
Question 6 (b)(iii)

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.

The only additional page is part of the last question, **6(b)(iii)**.

You must annotate page 20 with an omission mark ^ if the page is blank to show that you have checked this page.

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** CH_3–,CH_2–, C_3H_7–, etc
- **ALLOW** vertical 'bond' to any part of an alkyl group

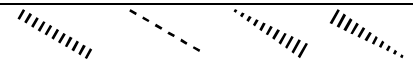
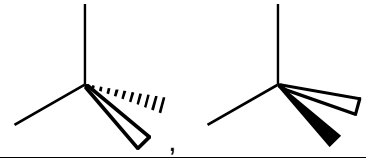
For an OH group shown within a structure,

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

For a CHO group shown within a structure,

- **DO NOT ALLOW** COH

For a 3-D 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

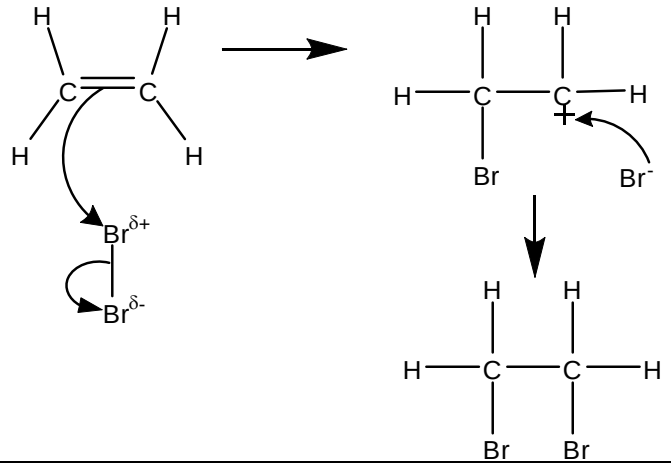
van der Waals' forces

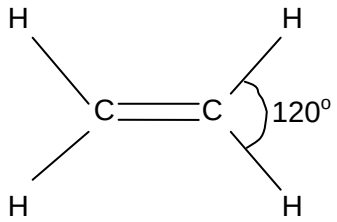
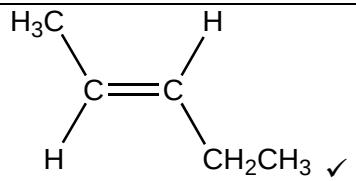
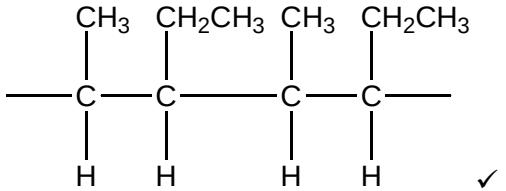
- **ALLOW** vdw forces **OR** VDW forces (and any combination of upper and lower cases)

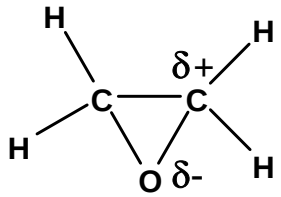
Question			Answer	Marks	Guidance
1	(a)		Because hydrocarbons have different boiling points ✓	1	**ALLOW** each fraction / component / substance / molecule / compound / fuel has a different boiling temperatures **ALLOW** condense at different temperatures **ALLOW** because van der Waals' forces differ with molecular size **IGNORE** references to volatility different strength of intermolecular forces is **not** sufficient
	(b)		***Any one from:*** Bio-fuels produce less carbon dioxide (overall) **OR** petrol or diesel produce more carbon dioxide (overall) ✓ Bio-fuels are renewable **OR** petrol and diesel are non-renewable ✓ Allows crude oil to be used to make other products **OR** petrochemicals (rather than petrol) **OR** Save crude oil **OR** no risk of large scale pollution from exploitation of crude oil ✓	1	**ASSUME** 'they' or 'it' refers to biofuels **ALLOW** bio-fuels are (more) carbon-neutral **OR** plants take up the carbon dioxide released during combustion **ALLOW** lower carbon footprint **ALLOW** plants are a renewable resource / crude oil non-renewable resource / bio-diesel is more sustainable / diesel is not sustainable / petrol and diesel are made from a finite resource / petrol and diesel will run out / bio-fuels will not run out **ALLOW** decrease the need for fossil fuels **IGNORE** can be used by diesel powered cars with or without any conversion
	(c)	(i)	Idea that **carbon–carbon** bonds can break anywhere ✓	1	The answer must refer to carbon–carbon bonds or the carbon chain **ALLOW** (carbon) **chain** can break anywhere Bonds can break anywhere is not sufficient

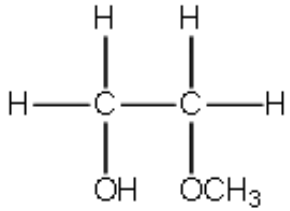
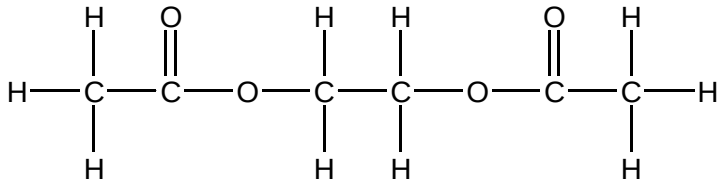
Question			Answer	Marks	Guidance
1	(c)	(ii)		4	**ANNOTATE ANSWER WITH TICKS AND CROSSES ETC**
			Correct identification of $C_2H_3^+$ for $m/z = 27$ ✓		**ALLOW** $CHCH_2^+$ **DO NOT ALLOW** C_2H_3 (the positive charge is essential) **OR** CCH_3^+
			Some indication to explain how the identity of propene was deduced **OR** further analysis of the mass spectrum ✓		**ALLOW** Molecular ion/M^+/M is $m/z = 42$ **OR** $m/z = 15$ is CH_3 **ALLOW** mass spectrum shows $M_r = 42$ **ALLOW** idea that alkane $C_{12}H_{26} – C_3H_8$ can only give $3C_3H_6$
			Correct identification of the alkene as C_3H_6 **OR** propene ✓		**ALLOW** prop-1-ene An incorrect formula for the alkene in the equation will not contradict this answer
			$C_{12}H_{26} \rightarrow C_3H_8 + 3C_3H_6$ ✓		**ALLOW** C_3H_6 from its use in an equation even if the equation is wrong providing there has not been an attempt elsewhere to identify the alkene **ALLOW** correct displayed **OR** structural **OR** skeletal **OR** molecular formulae in the equation

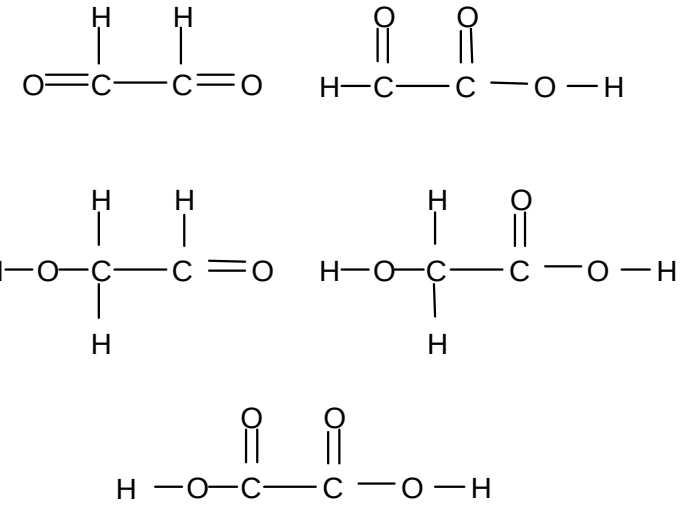
Question			Answer	Marks	Guidance
1	(d)			9	**ANNOTATE ANSWER WITH TICKS AND CROSSES ETC** **ALLOW** reactants even from incorrect equations **ALLOW** reactants or conditions over the arrow
			React with bromine **OR** $C_2H_4 + Br_2 \rightarrow C_2H_4Br_2$ ✓		**ALLOW** Br_2 mark from the mechanism even if the mechanism is incorrect **IGNORE** conditions unless they would lead to a different reaction with ethene
			React with hydrogen bromide **OR** $C_2H_4 + HBr \rightarrow C_2H_5Br$ ✓		**IGNORE** conditions unless they would lead to a different reaction with ethene
			React with steam **OR** heat with water **OR** $C_2H_4 + H_2O(g) \rightarrow C_2H_5OH$ ✓		**ALLOW** temperature range between 100–400 ^oC if quoted **IGNORE** reference to pressure **IGNORE** hydrolysis Hydration is not sufficient but **DO NOT ALLOW** hydrogenation
			acid (catalyst) ✓		**ALLOW** H_2SO_4 **OR** H_3PO_4 **OR** H^+ **DO NOT ALLOW** HC*l*, HBr etc. **ALLOW** two stage process e.g. react with HBr one mark followed by KOH(aq) one mark

Question	Answer	Marks	Guidance
	Electrophilic addition ✓		
	Curly arrow from double bond to attack $Br^{\delta+}$ of Br–Br and breaking of Br–Br bond ✓		Curly arrow must start from the double bond and not a carbon atom and go the $Br^{\delta+}$; other curly arrow must start from Br–Br bond. **ALLOW** attack of Br–Br if dipoles not shown **DO NOT ALLOW** attack of $Br^{\delta-}$
	Correct dipoles shown on $Br^{\delta+}$–$Br^{\delta-}$ ✓		Dipole must be partial charge and not full charge **DO NOT ALLOW** any other partial charges eg on the double bond
	Correct carbonium / carbocation ion drawn ✓		Carbocation needs a full charge and not a partial charge (charges do not need to be surrounded by a circle) All atoms in the carbocation must be shown
	Curly arrow from Br^- to the carbonium ion **and** correct product shown ✓		Br^- curly arrow must come from one lone pair on Br^- ion **OR** from minus sign on Br^- ion Lone pair does not need to be shown on Br^- ion
			**ALLOW** mechanism which goes via a cyclic bromonium ion instead of the carbocation **SEE EXTRA ADVICE ABOUT CURLY ARROWS ON PAGE 30**

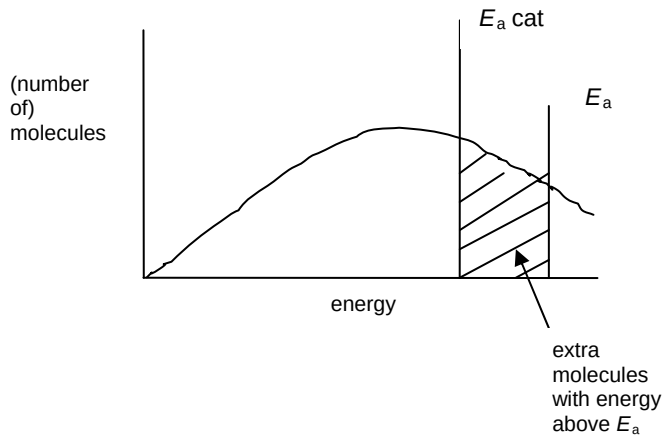
Question			Answer	Marks	Guidance
1	(e)		Correct shape ✓  120° ✓ Three areas of electron density repel each other ✓	3	**IGNORE** any name of shape given **ALLOW** 115–125° **ALLOW** even if it is the C–C–H shown on a diagram. **ALLOW** three or four electron pairs repel **OR** three or four bonds repel **IGNORE** does not have any lone pairs **DO NOT ALLOW** atoms repel / electrons repel **DO NOT ALLOW** has lone pair which repels more
	(f)	(i)	 ✓	1	**ALLOW** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above (as long as unambiguous)
		(ii)	 ✓	1	**ALLOW** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above (as long as unambiguous) **ALLOW** CH_3 and C_2H_5 groups above or below chain **ALLOW** bond to ethyl and methyl group to any part of ethyl or methyl group **IGNORE** any brackets drawn **ALLOW two** or more repeat units but has to have a whole number of repeat units (*ie* does not have to be two) 'End bonds' **MUST** be shown and can be dotted **IGNORE** *n*
			Total	**21**	

Question			Answer	Marks	Guidance
2	(a)	(i)	$2C_2H_4 + O_2 \rightarrow 2C_2H_4O$ ✓	1	**ALLOW** molecular formulae **OR** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above (as long as unambiguous) **ALLOW** correct multiples, including fractions, of this equation **IGNORE** state symbols **DO NOT ALLOW** [O]
		(ii)	$C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$ ✓	1	**ALLOW** molecular formulae **OR** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above (as long as unambiguous) **ALLOW** correct multiples of this equation **IGNORE** state **symbols** **DO NOT ALLOW** [O]
	(b)	(i)	✓  	1	Only one carbon atom needs to have the correct partial charge **DO NOT ALLOW** partial charges on hydrogen atoms
		(ii)	Movement of an electron pair ✓	1	**ALLOW** movement of a lone pair **OR** movement of a bond **ALLOW** movement of two electrons
		(iii)	Heterolytic ✓ Both electrons (in the bond) go to the same atom **OR** (bond breaks) to make a cation and (a lone pair on the oxygen atom) **OR** bond pair becomes a lone pair on oxygen ✓	2	**MARK INDEPENDENTLY** **ALLOW** one atom gets none of the bonded electrons **DO NOT ALLOW** both electrons go to a molecule **DO NOT ALLOW** makes a positive and a negative ion because in this example this is **not** true
		(iv)	It donates a **pair** of electrons ✓	1	**ALLOW** donates a lone pair **DO NOT ALLOW** it donates electrons
		(v)	idea that H^+ ion is used in **step 1 AND** made in **step 4** ✓	1	**ALLOW** H^+ ion is used at the **start AND** made at the **end** **IGNORE** overall H^+ is not used up in the mechanism

Question			Answer	Marks	Guidance
2	(b)	(vi)	 ✓	1	**ALLOW** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above (as long as unambiguous) eg $CH_2OHCH_2OCH_3$ **ALLOW** vertical 'bond' to any part of the OH or OCH_3 group **DO NOT ALLOW** formula with horizontal –HO **OR** OH– **DO NOT ALLOW** formula with horizontal $–CH_3O$ **OR** $OCH_3–$
	(c)		Ethane-1,2-diol has more OH groups (than ethanol) ✓ Stronger hydrogen bonding (between ethane-1,2-diol molecules) ✓	2	**ALLOW** has more hydroxyl groups **OR** has more hydroxy groups **OR** has more alcohol groups Ethane-1,2-diol has two OH groups is **NOT** sufficient but **ALLOW** ethane-1,2-diol has two OH groups and ethanol has one **DO NOT ALLOW** it has hydroxide (ions) **ALLOW** more hydrogen bonds (between ethane-1,2-diol molecules) **IGNORE** hydrogen bonds with water
	(d)		One ester linkage drawn despite the rest of the structure ✓ Correct structure for example $CH_3COOCH_2CH_2OOCCH_3$ **OR**  ✓	2	**ALLOW** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above (as long as unambiguous) **ALLOW** ester shown as all the atoms **OR** as –COOC– **OR** $–CH_2OOC–$ **OR** $–CH_2OCOC–$ **IGNORE** molecular formula

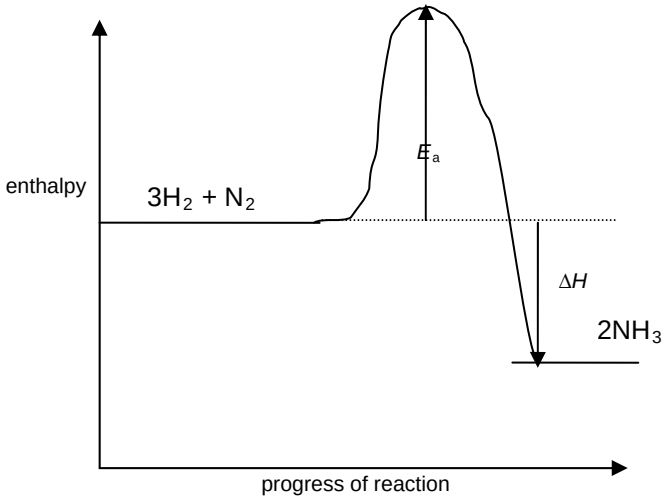
Question			Answer	Marks	Guidance
2	(e)		***Any two from:***  ✓✓	2	Mark incorrect answers first • If one incorrect answer maximum of 1 mark • If two incorrect answers award 0 marks **ALLOW** OH instead of –O—H **ALLOW** vertical 'bond' to any part of the OH **DO NOT ALLOW** formula with horizontal —HO **OR** OH— but **ALLOW ECF** if both displayed formulae are drawn this way **ALLOW one mark if two correct** structural **OR** skeletal formula **OR** mixture of the above (as long as unambiguous) are drawn
			Total	**15**	

Question			Answer	Marks	Guidance
3	(a)		(equilibrium position shifts) to the left ✓ (because there are) fewer moles (of gas) on the reactant side **OR** (there are) more moles (of gas) on product side ✓ This explanation mark is dependent on the correct shift of the equilibrium	2	**Note: ALLOW** suitable alternatives for 'to left', eg: towards CH_4 or H_2O / towards reactants **OR** in backward direction **OR** in reverse direction **OR** decreases yield of CO or H_2/products **ALLOW** 'favours the left', as alternative for 'shifts equilibrium to left' **ALLOW** fewer molecules on reactant side **OR** smaller volume on the left hand side **ALLOW ORA** if specified **IGNORE** responses in terms of rate
	(b)		(equilibrium position shifts) to the right ✓ (because forward) reaction is endothermic **OR** **reverse** reaction is exothermic ✓ This explanation mark is dependent on the correct shift of the equilibrium	2	**Note: ALLOW** suitable alternatives for 'to right', eg: towards CO or H_2 / towards products **OR** in forward direction **OR** increases yield of CO or H_2/products **OR** decreases amount of CH_4 or H_2O/reactants **ALLOW** 'favours the right', as alternative for 'shifts equilibrium to right' **ALLOW** reaction takes in heat **ALLOW reverse** reaction gives out heat **ALLOW ORA** if specified **IGNORE** responses in terms of rate
	(c)	(i)	Gives a high rate of reaction **OR** reaction is fast **OR** reasonable rate of reaction without shifting equilibrium too much to the left ✓	1	**ALLOW** if greater pressure used it increases safety risk **ALLOW** if greater pressure used it is more expensive **ALLOW** higher pressure will shift equilibrium position even more to the left It is a compromise on its own is **not** sufficient but **ALLOW** compromise between rate and yield **OR** between rate and safety

Question			Answer	Marks	Guidance
3	(c)	(ii)		3	**ANNOTATE ANSWER WITH TICKS AND CROSSES ETC**
			y-axis label is '(fraction of or number of) molecules' **AND** *x*-axis label is 'energy' **AND** correct curve ✓		Boltzmann distribution - must start at origin and must not end up at 0 on *y*-axis ie must not touch *x*-axis **ALLOW** particles **OR** moles as *y*-axis label **IGNORE** minor point of inflexion in the curve **DO NOT ALLOW** two curves **DO NOT ALLOW** atoms but credit atoms if used in a second marking point **DO NOT ALLOW** enthalpy for *x*-axis label
			Lowers activation energy ✓		**ALLOW** this mark from a labelled diagram
			More molecules with energy above activation energy with a catalyst **OR** more **effective** collisions **OR** more **successful** collisions ✓		more collisions per second is not sufficient
					

Question			Answer	Marks	Guidance
3	(d)		**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF answer = 91.2 (%) award 3 marks** theoretical amount of hydrogen = 3.75×10^7 (mol) ✓ actual amount of hydrogen made = 3.42×10^7 (mol) ✓ % = 91.2 ✓	3	**IF** there is an alternative answer, check to see if there is any **ECF** credit possible using working below IF ECF, **ANNOTATE WITH TICKS AND CROSSES, etc** Answer must have **three** significant figures **ALLOW** ECF from incorrect theoretical and actual amounts of hydrogen **ALLOW** answer that uses grams rather than tonnes where theoretical amount of hydrogen = 37.5 (mol) and actual amount of hydrogen = 34.2 (mol) **ALLOW** alternative approach based on the mass of hydrogen rather than the amount of hydrogen Theoretical amount of hydrogen = 3.75×10^7 (mol) ✓ Theoretical mass of hydrogen made = 75 (tonnes) ✓ Percentage = 91.2 ✓
	(e)	(i)	$CO + 2H_2 \rightarrow CH_3OH$ ✓	1	**ALLOW** correct multiples **ALLOW** CH_4O **IGNORE** state symbols
		(ii)	***Any two from:*** Carbon monoxide is toxic **OR** poisonous ✓ Increases atom economy of the process **OR** gives 100% atom economy ✓ Methanol is a fuel ✓	2	 **IGNORE** harmful or dangerous **ALLOW** uses a waste product **OR** CO is then a desired product **OR** CO is no longer a waste product **OR** reduces amount of waste product **ALLOW** other uses of methanol eg petrol additive, solvent or organic feedstock

Question			Answer	Marks	Guidance
3	(f)		Unsaturated (vegetable) oils **OR** oils containing C=C bonds ✓ (reacted with hydrogen) in the presence of a nickel catalyst ✓	2	**ALLOW** unsaturated fats **OR** unsaturated lipids **OR** unsaturated ester **ALLOW** oils become more saturated **IGNORE** unsaturated compound **DO NOT ALLOW** unsaturated hydrocarbon **ALLOW** Pt **OR** Pd
			Total	**16**	

Question			Answer	Marks	Guidance
4	(a)	(i)		3	**ANNOTATE ANSWER WITH TICKS AND CROSSES ETC**
			$2NH_3$ added as product ✓		**IGNORE** state symbol **ALLOW** product mark even if product line above the reactant line
			Δ*H* labelled with product below reactant **AND** arrow downwards ✓		**ALLOW** –92 as a label for Δ*H* **ALLOW** this line even if it has a small gap at the top and bottom ie does not quite reach reactant or product line
			E_a labelled correctly **AND** above reactants ✓		The curve must be drawn for this marking point
					**IGNORE** arrows at both ends of activation energy line but **DO NOT ALLOW** arrow pointing down The E_a line must go to maximum (or near to the maximum) on the curve **ALLOW** if the line clearly shows an activation energy and is not an enthalpy change **ALLOW** this line even if it has a small gap at the top and bottom ie does not quite reach the maximum or reactant line

Question			Answer	Marks	Guidance
4	(a)	(ii)	–46 (kJ mol^{-1}) ✓	1	**DO NOT ALLOW** 46 with no sign
		(iii)	Any value between +1 to +249 (kJ mol^{-1}) ✓	1	+ sign is not needed
		(iv)	+342 (kJ mol^{-1}) ✓	1	+ sign is not needed
	(b)	(i)	$2CO + 2NO \rightarrow 2CO_2 + N_2$ ✓	1	**ALLOW** correct multiples

Question			Answer	Marks	Guidance
4	(b)	(ii)	CO and NO are adsorbed (onto surface) **OR** reactants are adsorbed (onto surface) ✓	3	**ALLOW** CO and NO stick onto surface **OR** CO and NO form weak attractions to the surface **OR** gases are adsorbed onto surface **OR** gases bond to surface **NOT** absorb but **allow** ecf for deabsorb later on
			weakening of bonds **OR** chemical reaction **OR** new bonds are made **OR** carbon dioxide and nitrogen are made ✓		**ALLOW** lowers activation energy **IGNORE** alternative pathway Requires less energy is not sufficient
			CO_2 and N_2 desorbs (from the surface) **OR** products desorbs (from the surface) ✓		**ALLOW** products leave (the surface) **OR** products diffuse away (from surface) **OR** weak attraction to surface is broken **ALLOW** deadsorb

Question			Answer	Marks	Guidance
4	(c)	(i)	***Any two from:*** IR (spectroscopy) ✓ Mass spectrometry ✓ UV (spectroscopy) ✓ NMR ✓ GC ✓	2	 **ALLOW** mass spec / MS / mass spectroscopy **ALLOW** atomic absorption / AAS **IGNORE** satellite imaging or thermal imaging
		(ii)	***Any one from:*** Idea that pollution travels (across country) borders **OR** idea that all countries contribute towards pollution **OR** Cooperation means that scientists can share ideas **OR** scientists can warn governments of risk **OR** world-wide legislation can be introduced **OR** allows monitoring of pollution in different countries **OR** richer countries can help poorer countries introduce pollution controls **OR** One country cannot control pollution unless all countries do ✓	1	 **ALLOW** some countries produce more pollution than others **ALLOW** so protocols can be developed
	(d)		**Step 1** $NO + O_3 \rightarrow NO_2 + O_2$ ✓ **Step 2** $NO_2 + O \rightarrow NO + O_2$ ✓ **overall** $O_3 + O \rightarrow 2O_2$ ✓	3	

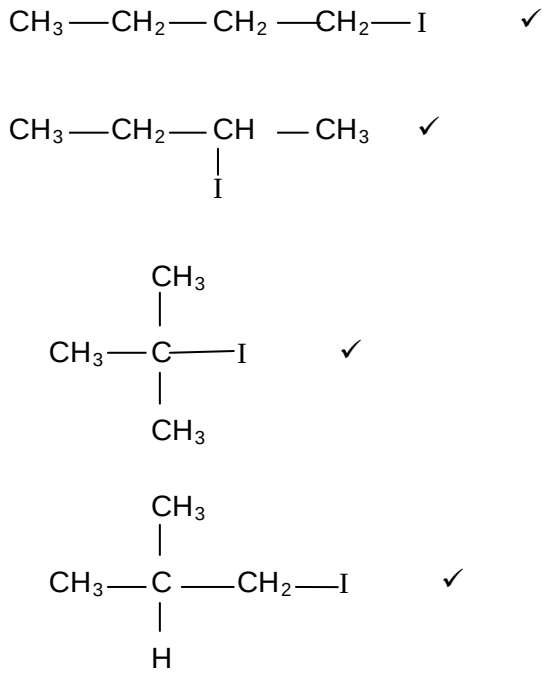
Question			Answer	Marks	Guidance
4	(e)	(i)	Reaction gives NO **OR** reaction gives NO_2 **OR** reaction gives a mixture of oxides **OR** activation energy too high **OR** rate of reaction is too slow ✓	1	**ALLOW** makes a mixture of oxides/products **ALLOW** reaction cannot be carried out experimentally **ALLOW** reaction does not take place nitrogen and oxygen do not react together is **not** sufficient **IGNORE** heat loss to surroundings **IGNORE** reference to bond enthalpy being a mean value
		(ii)	**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF answer = +82 (kJ mol^{-1}) award 2 marks** **IF answer = –82 (kJ mol^{-1}) award 1 mark** ΔH = 193 – 111 ✓ = +82 ✓	2	 **ALLOW** 82 **ALLOW** one mark for –82 **ALLOW** one mark for +304 / –304
			Total	**19**	

Question			Answer	Marks	Guidance
5	(a)		**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF answer = –162 (kJ mol^{-1}) award 3 marks** Energy associated with bond breaking = 3354 **OR** (2 × 805) + (4 × 436) ✓ Energy associated with bond making = 3516 **OR** (4 × 415) + (4 × 464) ✓ Enthalpy change = –162 ✓	3	**IF** there is an alternative answer, check to see if there is any **ECF** credit possible using working below. IF ECF, **ANNOTATE WITH TICKS AND CROSSES, etc** **IGNORE** sign **IGNORE** sign **ALLOW** ECF from wrong additions of energy associated with bond breaking and/or from bond making **ALLOW** two marks for (+)162, (+)6870, –6870 or (+)766 **ALLOW** one mark for –766
	(b)	(i)	Absorbs IR radiation ✓ Bonds vibrate ✓	2	**IGNORE absorbs heat** **ALLOW** IR re-radiated **DO NOT ALLOW** absorbs UV radiation **DO NOT ALLOW** blocks IR radiation **ALLOW** bonds stretch **OR** bonds bend **IGNORE** molecule vibrates/rotates **DO NOT ALLOW** bonds break

Question			Answer	Marks	Guidance
5	(b)	(ii)	***Any two from:***	2	
					DO NOT ALLOW reference to carbon being stored – the answer must either refer to carbon dioxide or not mention the name of the stored substance
			(liquid) injected deep into the oceans ✓		**ALLOW store deep** in the oceans **OR** on the **sea-bed** ✓ **ALLOW** stored deep under the sea **DO NOT ALLOW** dissolve CO_2 in the sea **OR** stored in ocean
			Stored in (old) geological formations **OR** stored underground in rocks **OR** stored in (old) mines **OR** stored in (old) oil wells ✓		**ALLOW** stored under the sea bed **ALLOW** pumped into oil wells to force last bit of oil out
			Stored by reaction with metal <u>oxides</u> **OR** reaction to form (solid) <u>carbonates</u> **OR** stored as a <u>carbonate</u> **OR** equation to show formation of metal carbonate ✓		**IGNORE** mineral storage

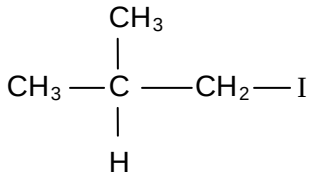
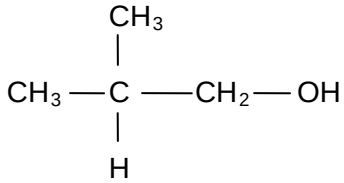
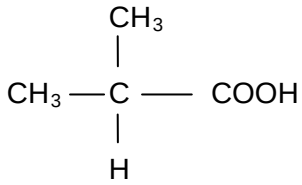
Question			Answer	Marks	Guidance
5	(c)	(i)		7	**ANNOTATE ANSWER WITH TICKS AND CROSSES ETC** **IGNORE** dot for radical and any state symbols for all equations
			Homolytic ✓		
			$Br_2 \longrightarrow 2Br$ ✓		
			$Br + C_2H_6 \longrightarrow HBr + C_2H_5$ ✓ $C_2H_5 + Br_2 \longrightarrow C_2H_5Br + Br$ ✓		If more than one termination step is written they must all be correct to be awarded the mark **DO NOT ALLOW** termination steps with H
			$Br + C_2H_5 \longrightarrow C_2H_5Br$ **OR** $Br + Br \longrightarrow Br_2$ **OR** $C_2H_5 + C_2H_5 \longrightarrow C_4H_{10}$ ✓		
			Two names of steps linked to appropriate equations ✓ **OR** **three** names of steps linked to appropriate equations ✓✓		initiation step linked to correct equation propagation step linked to one equation in which there is a radical on the left and a radical on the right termination step linked to equation involving two radicals: If no equations are given to link the names of the step then award one mark for mention of all three steps If halogen other than bromine do not give equation mark for initiation and only give one mark for all three terms linked to appropriate equations If hydrocarbons other than ethane are used **DO NOT ALLOW** any marks for the equations in the propagation steps

Question			Answer	Marks	Guidance
5	(c)	(ii)	***Any two from:***	2	
			More than one C–H bond can be substituted **OR** multi-substitution can occur **OR** more than one substitution can happen ✓		**ALLOW** equations or examples of multi substitution
			Lots of termination steps ✓		**ALLOW** an equation to illustrate formation of other products eg butane **ALLOW** examples of other products that can be formed in termination steps eg bromobutane
			termination steps can give products that will also react with (bromine) radicals ✓		**ALLOW** examples of products eg butane reacting with bromine radicals to give bromobutane
			Total	**16**	

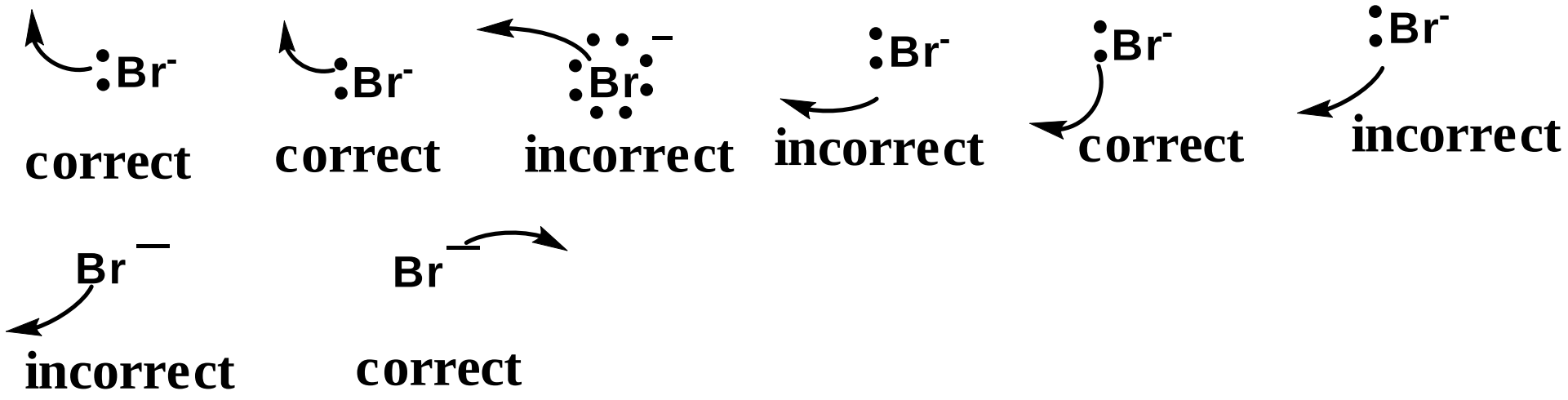
Question			Answer	Marks	Guidance
6	(a)		1-bromopentane reacts faster **OR** 1-chloropentane reacts slower ✓ C–C*l* stronger bond (than C–Br bond) **OR** C–C*l* shorter bond (than C–Br bond) **OR** C–C*l* bond is harder to break **OR** needs more energy to break C–C*l* bond **OR** bond enthalpy of C–C*l* greater (than C–Br bond) ✓	2	**ALLOW** takes more time to react **ALLOW** chloro compound reacts slower than bromine compound **DO NOT ALLOW** bromine reacts faster than chlorine **ALLOW** ORA Answer must refer to the C–C*l* bond or C–Br bonds
	(b)	(i)	 ✓ ✓ ✓ ✓	4	**ALLOW** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above (as long as unambiguous) n.b. C_2H_5 is unambiguous but C_3H_7 is ambiguous **IGNORE** incorrect name Mark incorrect answers first of all. • One incorrect answers maximum 3 marks • Two incorrect answers maximum 2 marks • Three incorrect answers maximum 1 mark • Four incorrect answers scores 0 mark **ALLOW** as a slip one stick with no H on in a displayed formula

Question			Answer	Marks	Guidance
6	(b)	(ii)	$C_4H_{10}O$ ✓	1	**IGNORE** any structures drawn **DO NOT ALLOW** C_4H_9OH

Question			Answer	Marks	Guidance
6	(b)	(iii)	**infrared** 1700–1730 cm^{-1} indicates carbonyl group ✓ broad 2900 cm^{-1} indicates O–H bond **AND** it is a **carboxylic acid** ✓ **explanation mark** **B** has a branched structure because of relationship to methylpropene **OR** **C** has a branched structure because of relationship to methylpropene **OR** **C** must be a primary alcohol because it is oxidised to a carboxylic acid **OR** a primary alcohol because it reacts with acidified dichromate to make a carboxylic acid **OR** **C** cannot be a tertiary alcohol because it is oxidised **OR** cannot be a tertiary alcohol because it does react with acidified dichromate ✓	6	**ANNOTATE ANSWER WITH TICKS AND CROSSES ETC** **LOOK ON THE SPECTRUM** for labeled absorbances which can be given credit **ALLOW** has a C=O bond because it has absorbance within range 1640–1750 cm^{-1} **ALLOW** 2900 cm^{-1} indicates O–H in carboxylic acid **ALLOW** has O–H bond in carboxylic aid because it has absorbance within range 2500–3300 cm^{-1} The presence of carboxylic acid can be anywhere in the text including the structure for **D** If two marking points from the explanation mark are given both must be correct

Question			Answer	Marks	Guidance
			B is  ✓ **C** is  ✓ **D** is  ✓		**ALLOW** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above (as long as unambiguous) **IGNORE** incorrect names for **B**, **C** and **D** Mark correct branched structures first of all. If there are no correct branched structures and **C** is $CH_3CH_2CH_2CH_2OH$ then **ALLOW** one mark for $CH_3CH_2CH_2COOH$ and one mark for $CH_3CH_2CH_2CH_2I$
			Total	**13**	

APPENDIX 1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