

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** 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**
- **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

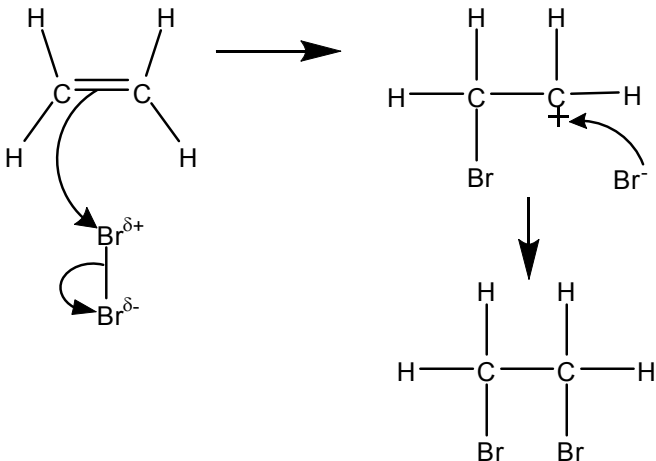
van der Waals' forces

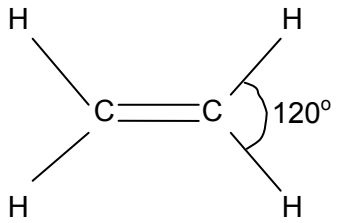
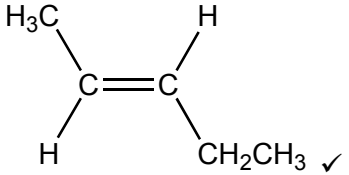
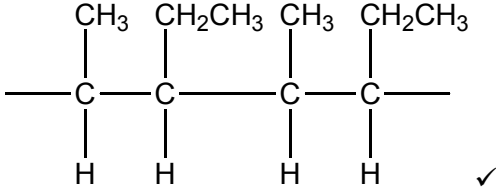
- **ALLOW** vdw forces **OR** VDW forces (and any combination of upper and lower cases)

Question		Answer	Marks	Guidance
1	(a)	Because hydrocarbons have different boiling points ✓	1	<p>ALLOW each fraction / component / substance / molecule / compound / fuel has a different boiling temperatures</p> <p>ALLOW condense at different temperatures</p> <p>ALLOW because van der Waals' forces differ with molecular size</p> <p>IGNORE references to volatility</p> <p>different strength of intermolecular forces is not sufficient</p>
	(b)	<p>Any one from:</p> <p>Bio-fuels produce less carbon dioxide (overall) OR petrol or diesel produce more carbon dioxide (overall) ✓</p> <p>Bio-fuels are renewable OR petrol and diesel are non-renewable ✓</p> <p>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 ✓</p>	1	<p>ASSUME 'they' or 'it' refers to biofuels</p> <p>ALLOW bio-fuels are (more) carbon-neutral OR plants take up the carbon dioxide released during combustion</p> <p>ALLOW lower carbon footprint</p> <p>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</p> <p>ALLOW decrease the need for fossil fuels</p> <p>IGNORE can be used by diesel powered cars with or without any conversion</p>
	(c) (i)	Idea that carbon-carbon bonds can break anywhere ✓	1	<p>The answer must refer to carbon-carbon bonds or the carbon chain</p> <p>ALLOW (carbon) chain can break anywhere</p> <p>Bonds can break anywhere is not sufficient</p>

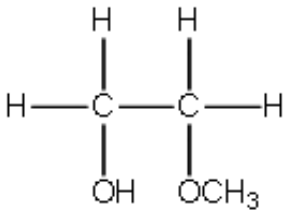
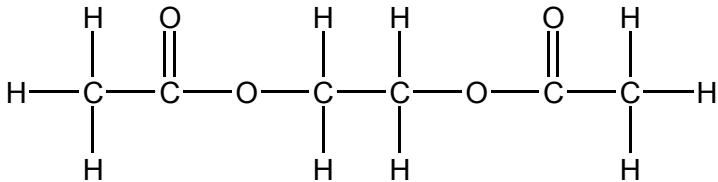
Question			Answer	Marks	Guidance
1	(c)	(ii)	<p>Correct identification of $C_2H_3^+$ for $m/z = 27$ ✓</p> <p>Some indication to explain how the identity of propene was deduced OR further analysis of the mass spectrum ✓</p> <p>Correct identification of the alkene as C_3H_6 OR propene ✓</p> <p>$C_{12}H_{26} \rightarrow C_3H_8 + 3C_3H_6$ ✓</p>	4	<p>ANNOTATE ANSWER WITH TICKS AND CROSSES ETC</p> <p>ALLOW $CHCH_2^+$ DO NOT ALLOW C_2H_3 (the positive charge is essential) OR CCH_3^+</p> <p>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 $3C_3H_6$</p> <p>ALLOW prop-1-ene An incorrect formula for the alkene in the equation will not contradict this answer</p> <p>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</p> <p>ALLOW correct displayed OR structural OR skeletal OR molecular formulae in the equation</p>

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

Question	Answer	Marks	Guidance
	<p>Electrophilic addition ✓</p> <p>Curly arrow from double bond to attack $\text{Br}^{\delta+}$ of $\text{Br}-\text{Br}$ and breaking of $\text{Br}-\text{Br}$ bond ✓</p> <p>Correct dipoles shown on $\text{Br}^{\delta+}-\text{Br}^{\delta-}$ ✓</p> <p>Correct carbonium / carbocation ion drawn ✓</p> <p>Curly arrow from Br^- to the carbonium ion and correct product shown ✓</p> 		<p>Curly arrow must start from the double bond and not a carbon atom and go to the $\text{Br}^{\delta+}$; other curly arrow must start from $\text{Br}-\text{Br}$ bond.</p> <p>ALLOW attack of $\text{Br}-\text{Br}$ if dipoles not shown DO NOT ALLOW attack of $\text{Br}^{\delta-}$</p> <p>Dipole must be partial charge and not full charge DO NOT ALLOW any other partial charges eg on the double bond</p> <p>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</p> <p>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</p> <p>ALLOW mechanism which goes via a cyclic bromonium ion instead of the carbocation</p> <p>SEE EXTRA ADVICE ABOUT CURLY ARROWS ON PAGE 30</p>

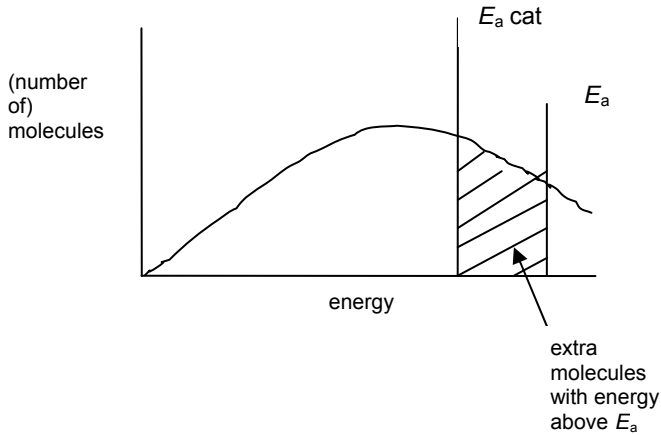
Question		Answer	Marks	Guidance
1	(e)	Correct shape ✓  120° ✓ Three areas of electron density repel each other ✓	3	IGNORE any name of shape given ALLOW 115–125° ALLOW even if it is the C–C–H shown on a diagram. ALLOW three or four electron pairs repel OR three or four bonds repel IGNORE does not have 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 ₂ H 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 (<i>ie</i> does not have to be two) 'End bonds' MUST be shown and can be dotted IGNORE <i>n</i>
Total			21	

Question		Answer	Marks	Guidance
2	(a) (i)	$2\text{C}_2\text{H}_4 + \text{O}_2 \rightarrow 2\text{C}_2\text{H}_4\text{O}$ ✓	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)	$\text{C}_2\text{H}_4 + 3\text{O}_2 \rightarrow 2\text{CO}_2 + 2\text{H}_2\text{O}$ ✓	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	<p>ALLOW correct structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous) eg $\text{CH}_2\text{OHCH}_2\text{OCH}_3$</p> <p>ALLOW vertical 'bond' to any part of the OH or OCH_3 group DO NOT ALLOW formula with horizontal $-\text{HO}$ OR $\text{OH}-$ DO NOT ALLOW formula with horizontal $-\text{CH}_3\text{O}$ OR OCH_3-</p>
	(c)		<p>Ethane-1,2-diol has more OH groups (than ethanol) ✓</p> <p>Stronger hydrogen bonding (between ethane-1,2-diol molecules) ✓</p>	2	<p>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)</p> <p>ALLOW more hydrogen bonds (between ethane-1,2-diol molecules) IGNORE hydrogen bonds with water</p>
	(d)		<p>One ester linkage drawn despite the rest of the structure ✓</p> <p>Correct structure for example $\text{CH}_3\text{COOCH}_2\text{CH}_2\text{OOCCH}_3$ OR</p> 	2	<p>ALLOW correct structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous)</p> <p>ALLOW ester shown as all the atoms OR as $-\text{COOC}-$ OR $-\text{CH}_2\text{OOC}-$ OR $-\text{CH}_2\text{OCOC}-$</p> <p>IGNORE molecular formula</p>

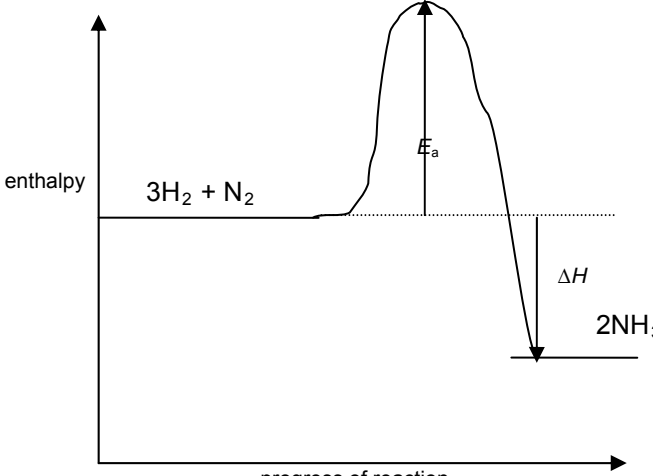
Question	Answer	Marks	Guidance
2 (e)	<p><i>Any two from:</i></p> $\begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{O}=\text{C}-\text{C}=\text{O} \end{array} \quad \begin{array}{c} \text{O} \quad \text{O} \\ \quad \\ \text{H}-\text{C}-\text{C}-\text{O}-\text{H} \end{array}$ $\begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{H}-\text{O}-\text{C}-\text{C}=\text{O} \\ \\ \text{H} \end{array} \quad \begin{array}{c} \text{H} \quad \text{O} \\ \quad \\ \text{H}-\text{O}-\text{C}-\text{C}-\text{O}-\text{H} \\ \\ \text{H} \end{array}$ $\text{H}-\text{O}-\overset{\text{O}}{\parallel}{\text{C}}-\overset{\text{O}}{\parallel}{\text{C}}-\text{O}-\text{H}$ <p>✓✓</p>	2	<p>Mark incorrect answers first</p> <ul style="list-style-type: none"> • If one incorrect answer maximum of 1 mark • If two incorrect answers award 0 marks <p>ALLOW OH instead of $-\text{O}-\text{H}$</p> <p>ALLOW vertical 'bond' to any part of the OH DO NOT ALLOW formula with horizontal $-\text{HO}$ OR $\text{OH}-$ but ALLOW ECF if both displayed formulae are drawn this way</p> <p>ALLOW one mark if two correct structural OR skeletal formula OR mixture of the above (as long as unambiguous) are drawn</p>
	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 ₂ O / 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 ₂ O/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)	<p>y-axis label is '(fraction of or number of) molecules' AND x-axis label is 'energy' AND correct curve ✓</p> <p>Lowers activation energy ✓</p> <p>More molecules with energy above activation energy with a catalyst OR more effective collisions OR more successful collisions ✓</p> 	3	<p>ANNOTATE ANSWER WITH TICKS AND CROSSES ETC</p> <p>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</p> <p>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</p> <p>ALLOW this mark from a labelled diagram</p> <p>more collisions per second is not sufficient</p>

Question		Answer	Marks	Guidance	
3	(d)	<p>FIRST, CHECK THE ANSWER ON ANSWER LINE IF answer = 91.2 (%) award 3 marks</p> <p>theoretical amount of hydrogen = 3.75×10^7 (mol) ✓</p> <p>actual amount of hydrogen made = 3.42×10^7 (mol) ✓</p> <p>% = 91.2 ✓</p>	3	<p>IF there is an alternative answer, check to see if there is any ECF credit possible using working below</p> <p>IF ECF, ANNOTATE WITH TICKS AND CROSSES, etc</p> <p>Answer must have three significant figures ALLOW ECF from incorrect theoretical and actual amounts of hydrogen</p> <p>ALLOW answer that uses grams rather than tonnes where theoretical amount of hydrogen = 37.5 (mol) and actual amount of hydrogen = 34.2 (mol)</p> <p>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 ✓</p>	
	(e)	(i)	<p>$\text{CO} + 2\text{H}_2 \rightarrow \text{CH}_3\text{OH}$ ✓</p>	1	<p>ALLOW correct multiples ALLOW CH_4O IGNORE state symbols</p>
		(ii)	<p>Any two from:</p> <p>Carbon monoxide is toxic OR poisonous ✓</p> <p>Increases atom economy of the process OR gives 100% atom economy ✓</p> <p>Methanol is a fuel ✓</p>	2	<p>IGNORE harmful or dangerous</p> <p>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</p> <p>ALLOW other uses of methanol eg petrol additive, solvent or organic feedstock</p>

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)	<p>2NH₃ added as product ✓</p> <p>ΔH labelled with product below reactant AND arrow downwards ✓</p> <p>E_a labelled correctly AND above reactants ✓</p> 	3	<p>ANNOTATE ANSWER WITH TICKS AND CROSSES ETC</p> <p>IGNORE state symbol ALLOW product mark even if product line above the reactant line</p> <p>ALLOW -92 as a label for ΔH ALLOW this line even if it has a small gap at the top and bottom ie does not quite reach reactant or product line</p> <p>The curve must be drawn for this marking point</p> <p>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</p>

Question			Answer	Marks	Guidance
4	(a)	(ii)	$-46 \text{ (kJ mol}^{-1}\text{)} \checkmark$	1	DO NOT ALLOW 46 with no sign
		(iii)	Any value between +1 to +249 (kJ mol ⁻¹) ✓	1	+ sign is not needed
		(iv)	$+342 \text{ (kJ mol}^{-1}\text{)} \checkmark$	1	+ sign is not needed
	(b)	(i)	$2\text{CO} + 2\text{NO} \rightarrow 2\text{CO}_2 + \text{N}_2 \checkmark$	1	ALLOW correct multiples

Question			Answer	Marks	Guidance
4	(b)	(ii)	<p>CO and NO are adsorbed (onto surface) OR reactants are adsorbed (onto surface) ✓</p> <p>weakening of bonds OR chemical reaction OR new bonds are made OR carbon dioxide and nitrogen are made ✓</p> <p>CO₂ and N₂ desorbs (from the surface) OR products desorbs (from the surface) ✓</p>	3	<p>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</p> <p>NOT absorb but allow ecf for deabsorb later on</p> <p>ALLOW lowers activation energy</p> <p>IGNORE alternative pathway</p> <p>Requires less energy is not sufficient</p> <p>ALLOW products leave (the surface) OR products diffuse away (from surface) OR weak attraction to surface is broken</p> <p>ALLOW deadsorb</p>

Question			Answer	Marks	Guidance
4	(c)	(i)	<p>Any two from:</p> <p>IR (spectroscopy) ✓</p> <p>Mass spectrometry ✓</p> <p>UV (spectroscopy) ✓</p> <p>NMR ✓</p> <p>GC ✓</p>	2	<p>ALLOW mass spec / MS / mass spectroscopy</p> <p>ALLOW atomic absorption / AAS</p> <p>IGNORE satellite imaging or thermal imaging</p>
		(ii)	<p>Any one from:</p> <p>Idea that pollution travels (across country) borders</p> <p>OR idea that all countries contribute towards pollution</p> <p>OR Cooperation means that scientists can share ideas</p> <p>OR scientists can warn governments of risk</p> <p>OR world-wide legislation can be introduced</p> <p>OR allows monitoring of pollution in different countries</p> <p>OR richer countries can help poorer countries introduce pollution controls</p> <p>OR One country cannot control pollution unless all countries do ✓</p>	1	<p>ALLOW some countries produce more pollution than others</p> <p>ALLOW so protocols can be developed</p>
	(d)		<p>Step 1 $\text{NO} + \text{O}_3 \rightarrow \text{NO}_2 + \text{O}_2$ ✓</p> <p>Step 2 $\text{NO}_2 + \text{O} \rightarrow \text{NO} + \text{O}_2$ ✓</p> <p>overall $\text{O}_3 + \text{O} \rightarrow 2\text{O}_2$ ✓</p>	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 $\Delta H = 193 - 111$ ✓ $= +82$ ✓	2	ALLOW 82 ALLOW one mark for -82 ALLOW one mark for +304 / -304
			Total	19	

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

Question			Answer	Marks	Guidance
5	(b)	(ii)	<p><i>Any two from:</i></p> <p>(liquid) injected deep into the oceans ✓</p> <p>Stored in (old) geological formations OR stored underground in rocks OR stored in (old) mines OR stored in (old) oil wells ✓</p> <p>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 ✓</p>	2	<p>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</p> <p>ALLOW store deep in the oceans OR on the sea-bed ✓ ALLOW stored deep under the sea DO NOT ALLOW dissolve CO₂ in the sea OR stored in ocean</p> <p>ALLOW stored under the sea bed ALLOW pumped into oil wells to force last bit of oil out</p> <p>IGNORE mineral storage</p>

Question			Answer	Marks	Guidance
5	(c)	(i)	<p>Homolytic ✓</p> <p>$\text{Br}_2 \longrightarrow 2\text{Br}$ ✓</p> <p>$\text{Br} + \text{C}_2\text{H}_6 \longrightarrow \text{HBr} + \text{C}_2\text{H}_5$ ✓</p> <p>$\text{C}_2\text{H}_5 + \text{Br}_2 \longrightarrow \text{C}_2\text{H}_5\text{Br} + \text{Br}$ ✓</p> <p>$\text{Br} + \text{C}_2\text{H}_5 \longrightarrow \text{C}_2\text{H}_5\text{Br}$</p> <p>OR $\text{Br} + \text{Br} \longrightarrow \text{Br}_2$</p> <p>OR $\text{C}_2\text{H}_5 + \text{C}_2\text{H}_5 \longrightarrow \text{C}_4\text{H}_{10}$ ✓</p> <p>Two names of steps linked to appropriate equations ✓</p> <p>OR</p> <p>three names of steps linked to appropriate equations ✓✓</p>	7	<p>ANNOTATE ANSWER WITH TICKS AND CROSSES ETC</p> <p>IGNORE dot for radical and any state symbols for all equations</p> <p>If more than one termination step is written they must all be correct to be awarded the mark</p> <p>DO NOT ALLOW termination steps with H</p> <p>initiation step linked to correct equation</p> <p>propagation step linked to one equation in which there is a radical on the left and a radical on the right</p> <p>termination step linked to equation involving two radicals:</p> <p>If no equations are given to link the names of the step then award one mark for mention of all three steps</p> <p>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</p> <p>If hydrocarbons other than ethane are used DO NOT ALLOW any marks for the equations in the propagation steps</p>

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

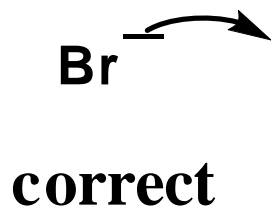
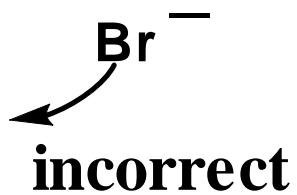
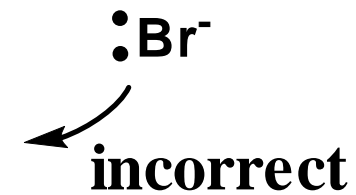
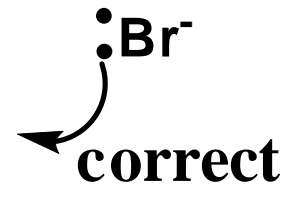
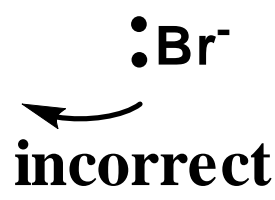
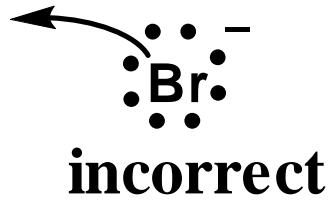
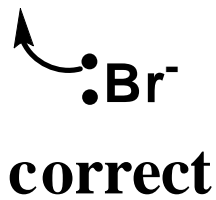
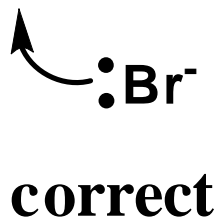
Question	Answer	Marks	Guidance
6 (a)	1-bromopentane reacts faster OR 1-chloropentane reacts slower ✓ C–C/ stronger bond (than C–Br bond) OR C–C/ shorter bond (than C–Br bond) OR C–C/ bond is harder to break OR needs more energy to break C–C/ bond OR bond enthalpy of C–C/ greater (than C–Br bond) ✓	2	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/ bond or C–Br bonds
(b) (i)	$\text{CH}_3\text{—CH}_2\text{—CH}_2\text{—CH}_2\text{—I} \quad \checkmark$ $\begin{array}{c} \text{CH}_3\text{—CH}_2\text{—CH—CH}_3 \\ \\ \text{I} \end{array} \quad \checkmark$ $\begin{array}{c} \text{CH}_3 \\ \\ \text{CH}_3\text{—C—I} \\ \\ \text{CH}_3 \end{array} \quad \checkmark$ $\begin{array}{c} \text{CH}_3 \\ \\ \text{CH}_3\text{—C—CH}_2\text{—I} \\ \\ \text{H} \end{array} \quad \checkmark$	4	ALLOW correct structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous) n.b. C ₂ H ₅ is unambiguous but C ₃ H ₇ is ambiguous IGNORE incorrect name Mark incorrect answers first of all. <ul style="list-style-type: none"> • 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)	<p>infrared</p> <p>1700–1730 cm^{-1} indicates carbonyl group ✓</p> <p>broad 2900 cm^{-1} indicates O–H bond AND it is a carboxylic acid ✓</p> <p>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 ✓</p>	6	<p>ANNOTATE ANSWER WITH TICKS AND CROSSES ETC</p> <p>LOOK ON THE SPECTRUM for labeled absorbances which can be given credit</p> <p>ALLOW has a C=O bond because it has absorbance within range 1640–1750 cm^{-1}</p> <p>ALLOW 2900 cm^{-1} indicates O–H in carboxylic acid ALLOW has O–H bond in carboxylic acid 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</p> <p>If two marking points from the explanation mark are given both must be correct</p>

Question	Answer	Marks	Guidance
	<p>B is $\begin{array}{c} \text{CH}_3 \\ \\ \text{CH}_3 - \text{C} - \text{CH}_2 - \text{I} \\ \\ \text{H} \end{array}$ ✓</p> <p>C is $\begin{array}{c} \text{CH}_3 \\ \\ \text{CH}_3 - \text{C} - \text{CH}_2 - \text{OH} \\ \\ \text{H} \end{array}$ ✓</p> <p>D is $\begin{array}{c} \text{CH}_3 \\ \\ \text{CH}_3 - \text{C} - \text{COOH} \\ \\ \text{H} \end{array}$ ✓</p>		<p>ALLOW correct structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous)</p> <p>IGNORE incorrect names for B, C and D</p> <p>Mark correct branched structures first of all.</p> <p>If there are no correct branched structures and C is $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$ then ALLOW one mark for $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$ and one mark for $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{I}$</p>
	Total	13	

APPENDIX 1



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