

Chemistry A

Advanced Subsidiary GCE

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

Mark Scheme for January 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.

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













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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

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
<u> </u>	Underlined words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

Subject-specific Marking Instructions

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

- Q2 (b)(i)
- Q4 (c)
- Q8 (d)
- Q8 (e)

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 23 one of the Additional Pages.
- If the page is blank then, using the marking mode, annotate the page with an omission mark, ^.
- Scroll down to page 24 and annotate with a ^ if the page is blank.
- If pages 23 or 24 are not blank then use the paper clip icon to link the pages to the correct questions.
- 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




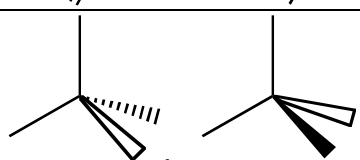
For an OH group shown within a structure,

- **DO NOT ALLOW** formula with horizontal $-\text{HO}$ **OR** $\text{OH}-$
- **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)

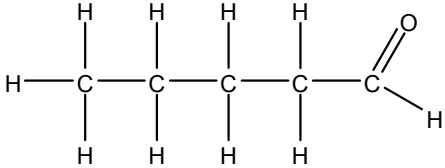
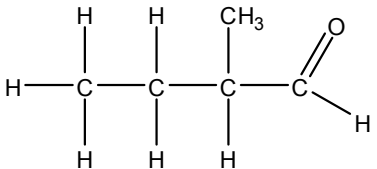
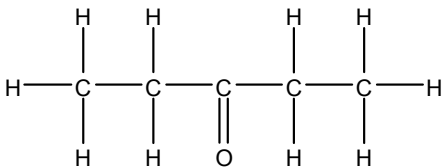
Question		Answer	Marks	Guidance
1	(a)	(a compound) with no double bond (or triple bond) ✓ containing hydrogen and carbon only ✓	2	ALLOW contains single bonds only ALLOW it contains just carbon and hydrogen DO NOT ALLOW a mixture of carbon and hydrogen OR only carbon and hydrogen molecules
	(b)	CH ₂ ✓	1	ALLOW H ₂ C
	(c)	D and I OR F and G OR F and H ✓	1	DO NOT ALLOW G and H
	(d)	(i)		Cyclic hydrocarbons have more efficient combustion ✓
			1	The answer must relate to combustion or burning Assume 'they' refers to the cyclic hydrocarbons ALLOW cyclic hydrocarbons allow smoother burning OR cyclic hydrocarbons increase octane number OR cyclic hydrocarbons reduce knocking OR cyclic hydrocarbons are less likely to produce pre-ignition OR cyclic hydrocarbons are more efficient fuels OR cyclic hydrocarbons burn better OR easier to burn OR cyclic hydrocarbon combust more easily OR improves combustion DO NOT ALLOW cyclic hydrocarbons ignite more easily ALLOW ora for straight chain hydrocarbons IGNORE cyclic hydrocarbons increase volatility of fuel IGNORE cyclic hydrocarbons have a lower boiling point cyclic hydrocarbons are a better fuel on their own is NOT sufficient cyclic hydrocarbons burn more cleanly on their own is NOT sufficient

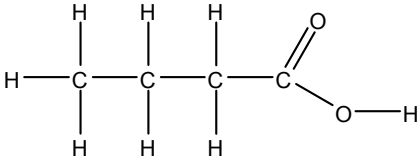
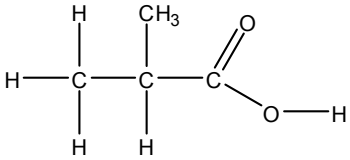
Question			Answer	Marks	Guidance
1	(d)	(ii)	$C_7H_{16} \rightarrow C_7H_{14} + H_2$ ✓	1	ALLOW molecular formulae OR correct structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous) DO NOT ALLOW cycloheptane structure in equation
	(e)		D has more surface (area of) contact OR D is a bigger molecule ✓ D has more van der Waals' forces OR C have fewer van der Waals' forces ✓	2	Both answers need to be comparisons Assume 'it' refers to D ALLOW has more electrons OR longer (carbon) chain OR higher molecular mass IGNORE surface area ALLOW ORA ALLOW D has stronger van der Waals' forces / larger VDW / greater VDW OR C has weaker van der Waals' forces OR C has smaller VDW ALLOW more VDW forces More intermolecular forces is not sufficient DO NOT ALLOW reference to bonds breaking or more bonds present unless it is clear that that the bonds are VDW
	(f)		Same structural formula ✓ Different arrangement of groups around a double bond OR different arrangement (of atoms) in space ✓	2	ALLOW have the same structure / displayed formula / skeletal formula Stereoisomers have the same formula or molecular formula is not sufficient ALLOW different three dimensional arrangement

Question		Answer	Marks	Guidance
1	(g)	$C_7H_{16} + 11O_2 \rightarrow 7CO_2 + 8H_2O$ Correct reactants and products ✓ Balancing ✓	2	ALLOW molecular formulae OR correct structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous) ALLOW any correct multiple IGNORE state symbols Balancing is dependent on correct formulae
	(h)	$C_{16}H_{34} \rightarrow C_8H_{18} + 2C_4H_8$ ✓	1	ALLOW molecular formulae OR correct structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous) ALLOW any correct multiple ALLOW structural OR displayed OR skeletal formulae in equation ALLOW but-1-ene IGNORE state symbols
	(i)	(i)	1	ALLOW the 'part' (of the molecule or compound) that reacts ALLOW the group of atoms that gives the chemical properties ALLOW group of atoms which indicates the homologous series
		(ii)	1	8 ✓
		(iii)	1	ALLOW plural i.e. unpaired electrons has a lone OR single OR free electron is not sufficient
Total			16	

Question		Answer	Marks	Guidance
2	(a)	<p>Any three from:</p> <p>Process 1 has a high atom economy OR has 100% atom economy OR a greater atom economy OR makes only the desired product ✓</p> <p>Process 1 has a very efficient conversion of reactants to products OR not much waste of starting material ✓</p> <p>Process 1 uses a lower pressure ✓</p> <p>Process 1 uses up toxic carbon monoxide ✓</p> <p>Process 1 uses methanol which can be produced from biomass ✓</p>	3	<p>Assume it refers to Process 1</p> <p>ALLOW process 1 has no waste OR process 1 has no co-products OR process 1 needs less separation OR process 1 has fewer other products OR gives only one product ALLOW ORA if process 2 is specified</p> <p>ALLOW ORA if process 2 is specified high percentage yield is not sufficient DO NOT ALLOW if percentage yield is explicitly linked to more waste (products) e.g. process 1 has a high percentage yield so makes little waste (product) scores 0 marks but process 1 makes no waste (product) and it has a high percentage yield scores 1 mark</p> <p>ALLOW ORA if process 2 is specified</p> <p>IGNORE process 2 comes from crude oil a non-renewable source ALLOW process 1 starts from a renewable source if the source is specified e.g. wood, municipal waste or sewage</p> <p>IGNORE reference to catalyst and rate of reaction</p>

Question			Answer	Marks	Guidance
2	(b)	(i)	<p>Contains C=O bond because of absorption between 1700 and 1740 cm^{-1} (from the spectrum) ✓</p> <p>does not contain an O–H bond ✓</p> <p>(So was a) ketone OR aldehyde ✓</p> <p>$M_r = 86$ ✓</p> <p>Correct structure ✓</p>	5	<p>ANNOTATE ANSWER WITH TICKS AND CROSSES ETC</p> <p>ALLOW contains a carbonyl group because of absorption within range 1640–1750 cm^{-1} OR contains an aldehyde, ketone or carboxylic acid because of absorption within range 1640–1750 cm^{-1} ✓</p> <p>Mention of only an aldehyde or a ketone is not sufficient it needs reference to the wavenumber</p> <p>LOOK FOR THIS MARK ON THE SPECTRUM</p> <p>ALLOW not a carboxylic acid ✓</p> <p>ALLOW does not have any other characteristic absorbance due to other functional groups</p> <p>ALLOW (so was a) carbonyl compound</p> <p>ALLOW this mark if a structure of an aldehyde or a ketone is given even if the structure has an incorrect number of carbon atoms</p> <p>ALLOW correct structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous)</p> <p>LOOK FOR AN ALDEHYDE or KETONE with FIVE carbon atoms OR a DIALDEHYDE, DIONE OR an OXOALDEHYDE with FOUR carbon atoms – a comprehensive list of correct structures is shown on page 34</p> <p>IGNORE incorrect name</p> <p>DO NOT ALLOW COH for an aldehyde</p>

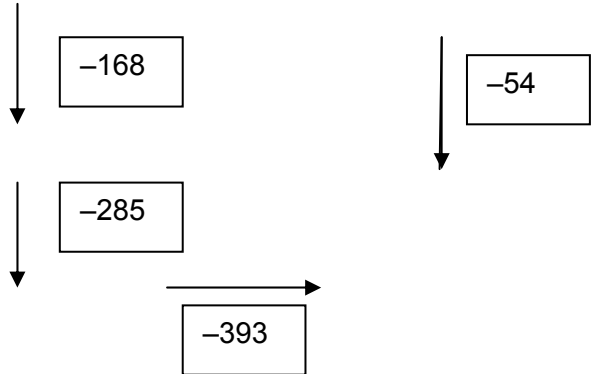
Question	Answer	Marks	Guidance
	<p data-bbox="353 231 795 399"></p> <p data-bbox="521 414 627 443">pentanal</p> <p data-bbox="353 446 398 475">OR</p> <p data-bbox="353 550 728 718"></p> <p data-bbox="443 734 638 762">2-methylbutanal</p> <p data-bbox="353 805 398 834">OR</p> <p data-bbox="353 837 795 1005"></p> <p data-bbox="499 1021 649 1050">pentan-3-one</p>		<p data-bbox="1254 327 1960 391">ALLOW as a slip one stick with no H on in a displayed formula</p>

Question			Answer	Marks	Guidance
2	(b)	(ii)	<p>Correct structure ✓</p> <p>Name of the structure drawn ✓</p>  <p>butanoic acid</p> <p>OR</p>  <p>2-methylpropanoic acid</p>	2	<p>ALLOW correct structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous)</p> <p>All bonds and all hydrogen atoms must be shown in a displayed formula within this question</p> <p>Name must correspond to the correct structure for two marks ALLOW butanoic acid or 2-methylpropanoic acid if the structure drawn is incorrect There is no ECF in this question</p> <p>ALLOW CH₃CH₂CH₂COOH</p> <p>ALLOW (CH₃)₂CHCOOH</p> <p>ALLOW methylpropanoic acid</p>

Question		Answer	Marks	Guidance
2	(c)	<p>Use of propan-1-ol ✓</p> $\text{CH}_3\text{COOH} + \text{C}_3\text{H}_7\text{OH} \rightarrow \text{CH}_3\text{COOCH}_2\text{CH}_2\text{CH}_3 + \text{H}_2\text{O}$ <p>Correct formulae for the ester ✓ Correctly balanced equation ✓</p> <p>Add H_2SO_4 OR acid catalyst OR H^+ ✓</p>	4	<p>ALLOW correct structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous) ALLOW from the equation propanol OR $\text{C}_3\text{H}_7\text{OH}$ is not sufficient</p> <p>ALLOW molecular formula OR correct structural OR displayed OR skeletal formula OR mixture of the above ALLOW propan-2-ol in the equation</p> <p>ALLOW conditions mark over the arrow in the equation</p>
Total			14	

Question			Answer	Marks	Guidance
3	(a)	(i)	<p>FIRST, CHECK THE ANSWER ON ANSWER LINE IF answer = 2.68 (kJ) award 2 marks</p> <p>$q = mc\Delta T$ OR $= 50.0 \times 4.18 \times 12.8$ ✓</p> <p>$= 2.68$ (kJ) ✓</p>	2	<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>ALLOW ecf only from using mass of 50.486</p> <p>ALLOW 2675.2 J IGNORE sign If mass used is 50.486 answer is 2701.202944</p> <p>ALLOW 2.7 OR 2.675 OR 2.6752 DO NOT ALLOW 3 IGNORE sign If mass used is 50.486 answer is 2.7, 2.70, 2.701 up to calculated value of 2.701202944 correctly rounded</p> <p>ALLOW one mark for using 4.2 and correctly calculating q in kJ to at least 2 sig figs</p>
		(ii)	amount = 0.02(00) (mol) ✓	1	<p>ALLOW $\frac{1}{50}$</p> <p>IGNORE trailing zeroes</p>

Question			Answer	Marks	Guidance
3	(a)	(iii)	<p>FIRST, CHECK THE ANSWER ON ANSWER LINE IF answer = -134 (kJ) award 3 marks IF answer = +134 (kJ) award 2 marks</p> <p>2.68 ÷ 0.02 ✓</p> <p>Correctly calculates the value to 3 sig figs ✓</p> <p>– sign ✓</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>ALLOW ECF i.e. $\frac{(i)}{(ii)}$</p> <p>This is dependant on the previous mark ALLOW ECF If 2.68, 2.675 or 2.6752 and moles of 0.02 answer is (-)134 If mass of magnesium included answer is (-)135 If 2.7 kJ and moles of 0.02 used answer is (-)135</p> <p>ALLOW only answers to three significant figures</p> <p>– sign is independent of answer</p>
	(b)	(i)	<p>(Enthalpy change) when one mole of a compound ✓</p> <p>is formed from its elements ✓</p> <p>at 25 °C/298 K AND 1 atmosphere/101 kPa ✓</p>	3	<p>ALLOW energy required OR energy released</p> <p>ALLOW (energy change) when one mole of a substance/molecule/product DO NOT ALLOW enthalpy change for one mole of products DO NOT ALLOW one mole of reactants</p> <p>ALLOW any stated temperature and 1 bar/1000mb/100kPa/100000Pa/101000Pa/101000Nm⁻² etc IGNORE reference to concentration</p>

Question			Answer	Marks	Guidance
3	(b)	(ii)	<p>Correct labelling of enthalpy cycle</p>  <p>Two or three boxes correct ✓ BUT all four boxes correct ✓✓</p> <p>$\Delta H_f -792 \text{ (kJ mol}^{-1}\text{)} \checkmark$</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>ALLOW ECF from wrong enthalpy changes in the boxes</p>
Total				12	

Question		Answer	Marks	Guidance
4	(a)	<p>FIRST, CHECK THE ANSWER ON ANSWER LINE IF answer = 431.5 (kJ mol⁻¹) award 2 marks</p> <p>Energy required to break bonds = (+)679 kJ ✓ so bond enthalpy = (+)431.5 ✓</p>	2	<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>ALLOW (+)432 ALLOW one mark in this question for -431.5 OR (+)863 ALLOW ecf for bond enthalpy = 0.5 x (-184 + energy required to break bonds)</p>
	(b)	<p>more concentrated (particles) OR more particles per (unit) volume ✓</p> <p>more collisions per second OR more frequent collisions ✓</p>	2	<p>Must state somewhere in the answer that the rate is faster for full marks ALLOW ORA if lower pressure is specified</p> <p>ALLOW particles are closer together OR more crowded particles OR more particles in the same space OR same number of particles in a smaller volume ALLOW molecules for particles but DO NOT ALLOW atoms DO NOT ALLOW 'area' instead of 'volume'</p> <p>ALLOW collisions more often OR increased rate of collision OR collisions are more likely OR there is a greater chance of collisions</p> <p>'More collisions' is not sufficient IGNORE successful</p>

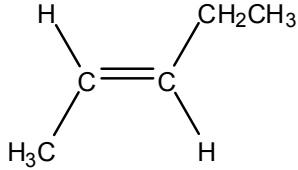
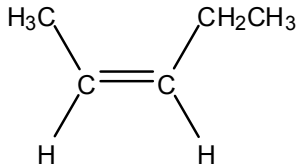
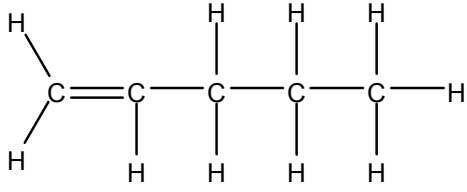
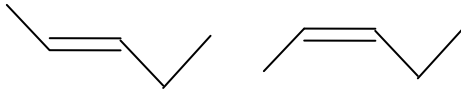
Question	Answer	Marks	Guidance
4 (c)	<p>y-axis label is '(number of) molecules' AND x-axis label is 'energy' AND one correct curve ✓</p> <p>Correct curve for lower temperature (labelled) ✓</p> <p>Activation energy does not change OR clearly labelled on diagram, e.g. E_a OR E ✓</p> <p>Fewer molecules have energy above activation energy OR fewer molecules have enough energy to react ✓</p> <p>So fewer successful collisions ✓</p>	5	<p>ANNOTATE ANSWER WITH TICKS AND CROSSES ETC</p> <p>Assume answers refer to lower temperature and rate decreases unless specified otherwise ALLOW ORA i.e. correct explanation for why higher temperatures increase rate if clearly specified ALLOW particles instead of molecules throughout question DO NOT ALLOW atoms the first time it appears in the answer</p> <p>Boltzmann distribution - must start at origin and must not end up at 0 on y-axis i.e. must not touch x-axis</p> <p>Maximum of curve to left AND higher than maximum of higher temperature curve AND below higher temp line at higher energy as shown in diagram below</p> <p>IGNORE minor point of inflexion of both curves</p> <p>ALLOW ORA for higher temperature if specified Fewer molecules have enough energy to collide successfully is worth one mark</p> <p>Fewer collisions per second is not sufficient</p>

Question			Answer	Marks	Guidance
(d)	(i)	$\text{Cl}_2 \rightarrow 2\text{Cl} \checkmark$		1	No need to show radicals with a 'dot'
	(ii)	$\text{HCl} + \text{H} \checkmark$ $\text{HCl} + \text{Cl} \checkmark$		2	No need to show radicals with a 'dot'
	(iii)	Any two from: $\text{H} + \text{H} \rightarrow \text{H}_2 \checkmark$ $\text{Cl} + \text{Cl} \rightarrow \text{Cl}_2 \checkmark$ $\text{H} + \text{Cl} \rightarrow \text{HCl} \checkmark$		2	No need to show radicals with a 'dot'
Total				14	

Question		Answer	Marks	Guidance	
5	(a)	Only one (desired) product formed ✓	1	ALLOW no waste products OR no co-product OR all atoms on left hand side are in the desired product OR sulfuric acid is the only product IGNORE it is an addition reaction	
	(b)	FIRST, CHECK THE ANSWER ON ANSWER LINE IF answer = 94% award 3 marks Moles of sulfur reacted or theoretical moles of H ₂ SO ₄ = 1.60 × 10 ⁶ ✓ Actual moles of H ₂ SO ₄ = 1.50 × 10 ⁶ ✓ % yield = 94 ✓	3	IF there is an alternative answer, check to see if there is any ECF credit possible using working below ALLOW 1.6 × 10 ⁶ to the calculator value 1.601246106 × 10 ⁶ correctly rounded ALLOW 1.60 up to calculator value 1.601246106 correctly rounded ALLOW 1.5 × 10 ⁶ to the calculator value 1.498470948 × 10 ⁶ correctly rounded ALLOW 1.5 up to calculator value 1.498470948 correctly rounded ALLOW theoretical mass of H ₂ SO ₄ = 157 (tonnes) up to the calculator value of 157.0822430 correctly rounded for two marks ALLOW ECF for a percentage yield from wrong moles above but answer must have two significant figures	
	(c)	(i)	Position of equilibrium – unchanged ✓ Rate of backward reaction – decreases ✓	2	

Question			Answer	Marks	Guidance
5	(c)	(ii)	<p>(equilibrium position shifts) to the left because (forward) reaction is exothermic OR (equilibrium position shifts) to the left because reverse reaction is endothermic ✓</p>	1	<p>Both position of equilibrium AND explanation needed for one mark</p> <p>Note: ALLOW suitable alternatives for 'to left', e.g. towards SO₂ or O₂ / towards reactants OR in backward direction OR in reverse direction OR decreases yield of SO₃/products ALLOW 'favours the left', as alternative for 'shifts equilibrium to left' ALLOW reaction gives out heat for exothermic ALLOW reaction takes in heat for endothermic ALLOW moves to the left in the endothermic direction</p> <p>ALLOW ORA if specified IGNORE responses in terms of rate</p>
		(iii)	<p>(equilibrium position shifts) to the left because there are more moles (of gas) on the reactant side OR (equilibrium position shifts) to the left because there are fewer moles (of gas) on product side ✓</p>	1	<p>Both position of equilibrium AND explanation needed for one mark</p> <p>Note: ALLOW suitable alternatives for 'to left', e.g.: towards SO₂ or O₂ / towards reactants OR in backward direction OR in reverse direction OR decreases yield of SO₃/products ALLOW 'favours the left', as alternative for 'shifts equilibrium to left' ALLOW correct reference to volume of gases e.g. shifts to the left because there is a smaller volume of gas on the product side ALLOW ORA if specified IGNORE responses in terms of rate</p>

Question			Answer	Marks	Guidance
5	(d)	(i)	Correct structure ✓ $ \begin{array}{cccc} \text{H} & \text{H} & \text{CH}_3 & \text{H} \\ & & & \\ \text{H}-\text{C} & -\text{C} & -\text{C} & -\text{C}-\text{OH} \\ & & & \\ \text{H} & \text{H} & \text{H} & \text{H} \end{array} $ OR $ \begin{array}{cccc} \text{H} & \text{CH}_3 & \text{H} & \text{H} \\ & & & \\ \text{H}-\text{C} & -\text{C} & -\text{C} & -\text{C}-\text{OH} \\ & & & \\ \text{H} & \text{H} & \text{H} & \text{H} \end{array} $ OR $ \begin{array}{ccc} \text{H} & \text{CH}_3 & \text{H} \\ & & \\ \text{H}-\text{C} & -\text{C} & -\text{C}-\text{OH} \\ & & \\ \text{H} & \text{CH}_3 & \text{H} \end{array} $	1	ALLOW correct structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous) ALLOW bonds going to any part of the CH ₃ , CH ₂ and CH bonds ALLOW vertical 'bond' to any part of the OH group DO NOT ALLOW horizontal –HO in the formula ALLOW as a slip one stick with no H on in a displayed formula IGNORE name

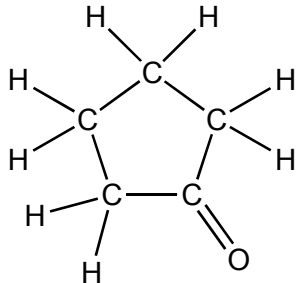
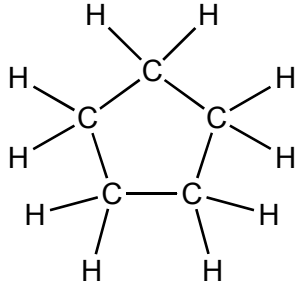
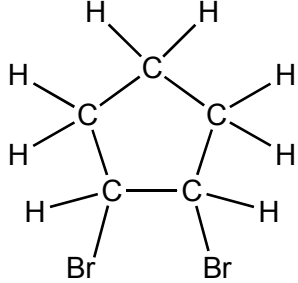
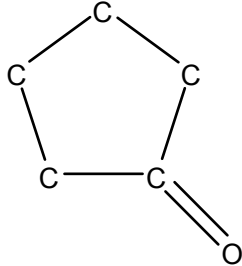
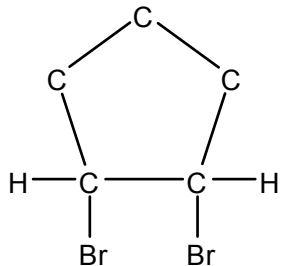
Question			Answer	Marks	Guidance
5	(d)	(ii)	<p>Correct structure for L ✓</p>  <p>Correct structure for M ✓</p>  <p>Correct structure for N ✓</p> 	3	<p>ALLOW correct structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous) for L, M and N</p> <p>e.g.</p>  <p>L or M L or M</p> <p>N – CH₂CHCH₂CH₂CH₃</p> <p>Answers to L and M are interchangeable</p> <p>IGNORE <i>cis/trans</i> OR <i>E/Z</i> labels</p> <p>ALLOW as a slip one stick with no H on in a displayed formula</p> <p>ALLOW 2 marks if three correct structures are drawn but some are in the wrong boxes</p> <p>ALLOW 1 mark if two correct structures are drawn but in the wrong boxes</p>

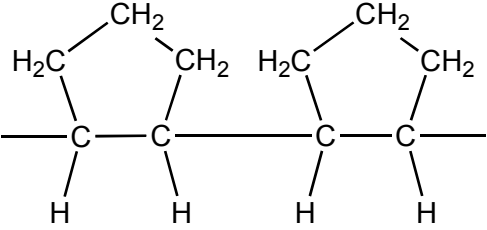
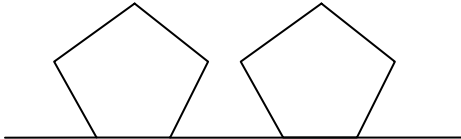
Question			Answer	Marks	Guidance
5	(d)	(iii)	$ \begin{array}{ccccccc} & \text{H} & & \text{CH}_3 & & \text{H} & & \text{H} \\ & & & & & & & \\ \text{H} & - \text{C} & - & \text{C} & - & \text{C} & - & \text{C} & - \text{H} \\ & & & & & & & \\ & \text{H} & & \text{OH} & & \text{H} & & \text{H} \end{array} $ <p style="text-align: right;">✓</p>	1	<p>ALLOW correct structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous)</p> <p>ALLOW vertical 'bond' to any part of the OH group DO NOT ALLOW horizontal -HO in the formula</p> <p>ALLOW as a slip one stick with no H on in a displayed formula</p>
Total				13	

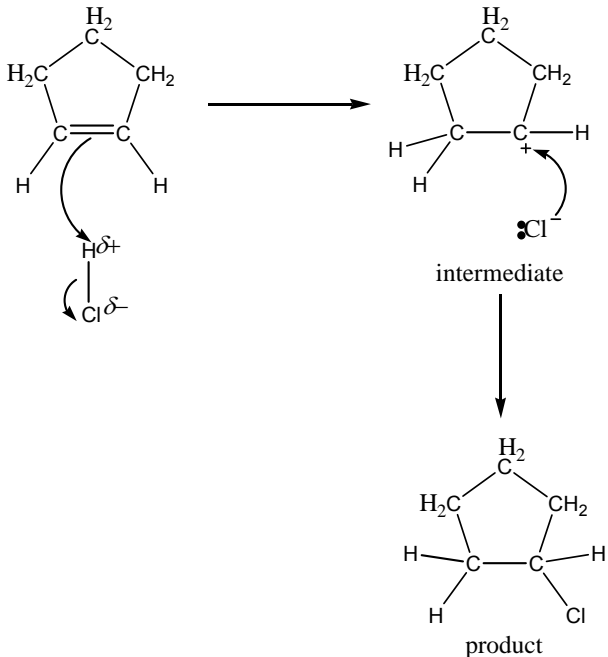
Question			Answer	Marks	Guidance
6	(a)	(i)	$(m/z =) 46 \checkmark$	1	
		(ii)	$\text{CH}_3\text{O}^+ \text{ OR } \text{CH}_2\text{OH}^+ \checkmark$	1	MUST show '+'
		(iii)	$\text{C}_2\text{H}_6\text{O} \checkmark$	1	ALLOW H_2CO_2
	(b)		$\frac{63 \times 72.2 + 65 \times 27.8}{100} \text{ OR } 63.556 \text{ OR } 63.56 \checkmark$ $A_r = 63.6 \checkmark$ Copper / Cu \checkmark	3	ALLOW two marks for 63.6 with no working out
			Total	6	

Question		Answer	Marks	Guidance
7	(a)	Shape – tetrahedral ✓ Bond angle 109.5° ✓	2	ALLOW 109–110°
	(b)	(i) Volatile OR non-toxic OR non-flammable OR easily vaporised ✓	1	ALLOW not carcinogenic / not an irritant / not harmful / not hazardous IGNORE cheap / not dangerous / gas / low boiling point DO NOT ALLOW inflammable
		(ii) (C–F or C–Cl) bonds need a large amount of energy to break ✓	1	ALLOW (the C–F or C–Cl) bonds are strong / bonds have a large bond enthalpy ALLOW the molecule is not polar enough / non-polar molecule is not sufficient ALLOW the activation energy is too high DO NOT ALLOW dissolves IGNORE references to hydrogen bonding
	(c)	$\text{CF}_2\text{Cl}_2 \rightarrow \text{CF}_2\text{Cl} + \text{Cl} \checkmark$ AND ANY TWO FROM Cl catalyses the decomposition of ozone ✓ $\text{Cl} + \text{O}_3 \rightarrow \text{ClO} + \text{O}_2 \checkmark$ $\text{ClO} + \text{O} \rightarrow \text{Cl} + \text{O}_2 \checkmark$	3	ALLOW CF_2Cl_2 (breaks down to) produces chlorine atoms/radicals ALLOW equation with any CFC ALLOW $\text{ClO} + \text{O}_3 \rightarrow \text{Cl} + 2\text{O}_2$ ALLOW $\text{O}_3 + \text{O} \rightarrow 2\text{O}_2$ OR $3\text{O}_2 \rightarrow 2\text{O}_3$ for one mark if the two equations for the steps have not been given IGNORE other propagation equations

Question		Answer	Marks	Guidance
7	(d)	Because (more) <u>UV</u> will reach the Earth's surface and risk of (skin) cancer increased/risk of cataracts/crop mutation increased ✓	1	DO NOT ALLOW global warming ALLOW protects from <u>UV</u> which causes skin cancer etc
	(e)	<i>Ideas related to uses</i> CFCs are still entering the atmosphere (from disused items) OR CFCs are still used (for some purposes and by some countries) ✓ <i>Ideas relating to lifetime within the atmosphere</i> CFCs have a long lifetime in the atmosphere OR it takes a long time for CFCs to reach upper atmosphere OR CFCs are inert ✓	2	ALLOW 'stratosphere' for 'upper atmosphere' ALLOW CFCs are still entering the ozone layer
Total			10	

Question	Answer	Marks	Guidance
8 (a)	 <p>compound P ✓</p>  <p>compound Q ✓</p>  <p>compound R ✓</p>	3	<p>ALLOW structures with missing hydrogen atoms on the carbon atoms that do not take part in the reaction. i.e. all hydrogen atoms must be shown in Q but not in P and R</p> <p>For example for the structures of P and R</p>  

Question	Answer	Marks	Guidance
8 (b)	Orange OR brown to colourless ✓	1	<p>ALLOW shades of orange OR yellow OR brown DO NOT ALLOW red alone DO NOT ALLOW any response that includes precipitate OR solid, irrespective of colour</p>
(c)	<p>Two or more repeat units ✓</p> 	1	<p>ALLOW correct structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous)</p> <p>Must have at least two repeat units and the free bonds at the end ALLOW free bonds with dotted lines All carbon-carbon bonds in the polymer chain must be shown IGNORE any brackets drawn IGNORE any missing hydrogen atoms on the CH₂ groups</p> <p>ALLOW skeletal formula</p> 

Question	Answer	Marks	Guidance
8 (d)	<p>Curly arrow from double bond to attack hydrogen of H-Cl and breaking of H-Cl bond ✓</p> <p>Correct dipole shown on H-Cl ✓</p> <p>Correct carbonium ion drawn ✓</p> <p>Curly arrow from Cl⁻ to the carbonium ion ✓</p>  <p>Correct product ✓</p>	5	<p>ANNOTATE ANSWER WITH TICKS AND CROSSES ETC</p> <p>Curly arrow must start from the double bond and not a carbon atom; other curly arrow must start from H-Cl bond</p> <p>DO NOT ALLOW dipoles on double bond</p> <p>Dipole must be partial charge and not full charge</p> <p>Carbocation needs a full charge and not a partial charge (charges do not need to be in a circle)</p> <p>Cl⁻ curly arrow must come from one lone pair on Cl⁻ ion OR from minus sign on Cl⁻ ion</p> <p>Lone pair does not need to be shown on Cl⁻ ion</p> <p>ALLOW structures with missing hydrogen atoms on the CH₂ groups</p>

Question	Answer	Marks	Guidance
8 (e)	<p>Nucleophilic substitution ✓</p> <p>Heterolytic (fission) spelt correctly ✓</p> <p>dipole shown on C—Cl bond, C^{δ+} and Cl^{δ-} ✓</p> <p>curly arrow from HO⁻ to carbon atom of C—Cl bond ✓</p> <p>curly arrow from C—Cl bond to the chlorine atom and formation of Cl ✓</p>	5	<p>ANNOTATE ANSWER WITH TICKS AND CROSSES ETC</p> <p>Dipole must be partial charge and not full charge</p> <p>HO⁻ curly arrow must come from one lone pair on O of HO⁻ ion OR from minus sign on HO⁻ ion</p> <p>curly arrow must start from C—Cl bond and not from C atom</p> <p>ALLOW structures with missing hydrogen atoms on the CH₂ groups</p> <p>ALLOW S_N1 mechanism dipole shown on C—Cl bond, C^{δ+} and Cl^{δ-} ✓ curly arrow from C—Cl bond to the Cl atom and Cl shown ✓ curly arrow from HO⁻ to correct carbonium ion ✓</p>
	Total	15	

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