OCR
RECOGNISING ACHIEVEMENT

GCE

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.

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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
__	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

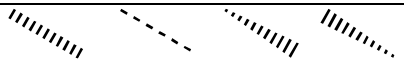
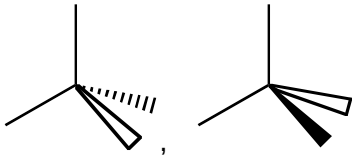
For an OH group shown within a structure,

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

For a CHO group shown within a structure,

- **DO NOT ALLOW** COH

For a 3D structure,

• For bond in the plane of paper, a solid line is expected:	
• For bond out of plane of paper, a solid wedge is expected:	
• For bond into plane of paper, **ALLOW**:	
• **ALLOW** a hollow wedge for 'in bond' OR an 'out bond', provided it is different from the other in or out wedge e.g.:	

NAMES

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

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

Names with multiple numbers and hyphens:
Use of 'e'
- **ALLOW** superfluous 'e' , e.g. propane-1-ol ('e' is kept if followed by consonant)
- **ALLOW** absence of 'e', e.g. propan-1,2-diol ('e' is omitted if followed by vowel)

Hyphens separate name from numbers:
- **ALLOW** absence of hyphens, e.g. propane 1,2 diol

Multiple locant numbers must be clearly separated:
- **ALLOW** full stops: e.g. 1.2 OR spaces: 1 2
- **DO NOT ALLOW e.g.** 12

Locant numbers in formula must be correct
- **DO NOT ALLOW** propan-3-ol

Order of substituents should be alphabetical:
- **ALLOW** any order (as long as unambiguous), e.g. 2-chloro-3-bromobutane

ABBREVIATIONS
van der Waal's forces
ALLOW vdw forces **OR** VDW forces (and any combination of upper and lower cases)

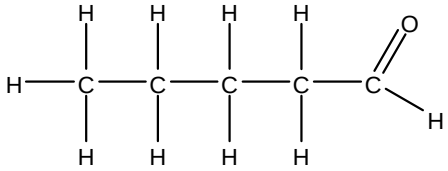
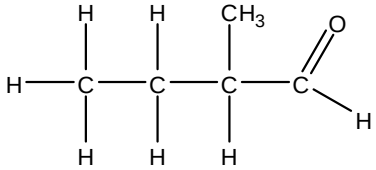
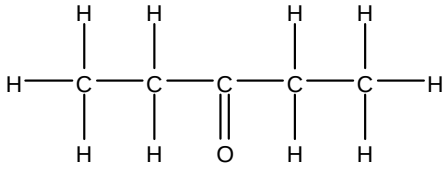
Question			Answer	Marks	Guidance
1	(a)		(a compound) with no double bond (or triple bond) ✓ containing hydrogen and carbon **only** ✓	2	**ALLOW** contains single bonds only **ALLOW** it contains just carbon and hydrogen **DO NOT ALLOW** a mixture of carbon and hydrogen **OR** only carbon and hydrogen molecules
	(b)		CH_2 ✓	1	**ALLOW** H_2C
	(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

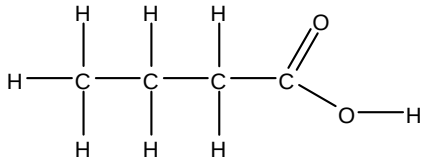
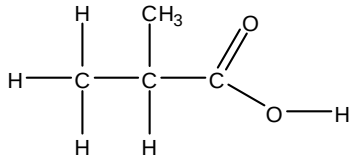
Question			Answer	Marks	Guidance
1	(d)	(ii)	$C_7H_{16} \rightarrow C_7H_{14} + H_2$ ✓	1	**ALLOW** molecular formulae **OR** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above (as long as unambiguous) **DO NOT ALLOW** cycloheptane structure in equation
	(e)		**D** 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)	Group of atoms (in a molecule or compound) that is responsible for the reactions ✓	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)	8 ✓	1	
		(iii)	has an unpaired electron ✓	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)		***Any three from:***	3	Assume it refers to **Process 1**
			Process 1 has a high atom economy **OR** has 100% atom economy **OR** a greater atom economy **OR** makes only the desired product ✓		**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
			Process 1 has a very efficient conversion of reactants to products **OR** not much waste of **starting material** ✓		**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**
			Process 1 uses a low**er** pressure ✓		**ALLOW** ORA if process **2** is specified
			Process 1 uses up **toxic** carbon monoxide ✓		
			Process 1 uses methanol which can be produced from biomass ✓		**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 **IGNORE** reference to catalyst and rate of reaction

Question			Answer	Marks	Guidance
2	(b)	(i)		5	**ANNOTATE ANSWER WITH TICKS AND CROSSES ETC**
			Contains C=O bond because of absorption between 1700 and 1740 cm^{-1} (from the spectrum) ✓		**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} ✓ Mention of only an aldehyde or a ketone is not sufficient it needs reference to the wavenumber **LOOK FOR THIS MARK ON THE SPECTRUM**
			does not contain an O–H bond ✓		**ALLOW** not a carboxylic acid ✓ **ALLOW** does not have any other characteristic absorbance due to other functional groups
			(So was a) ketone **OR** aldehyde ✓		**ALLOW (**so was a) carbonyl compound **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
			M_r = 86 ✓		
			Correct structure ✓		**ALLOW** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above (as long as unambiguous) 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 **IGNORE** incorrect name **DO NOT ALLOW** COH for an aldehyde

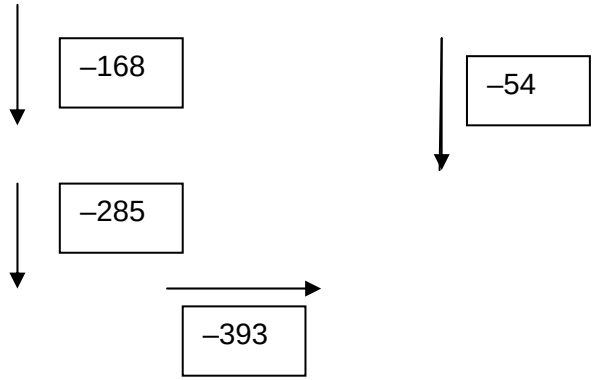
Question	Answer	Marks	Guidance
	 pentanal **OR**  2-methylbutanal **OR**  pentan-3-one		**ALLOW** as a slip one stick with no H on in a displayed formula

Question			Answer	Marks	Guidance
2	(b)	(ii)	Correct structure ✓	2	**ALLOW** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above (as long as unambiguous) All bonds and all hydrogen atoms must be shown in a displayed formula within this question
			Name of the structure drawn ✓		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
			 butanoic acid		**ALLOW** $CH_3CH_2CH_2COOH$
			OR		
			 2-methylpropanoic acid		**ALLOW** $(CH_3)_2CHCOOH$ **ALLOW** methylpropanoic acid

Question			Answer	Marks	Guidance
2	(c)		Use of propan-1-ol ✓ $CH_3COOH + C_3H_7OH \rightarrow CH_3COOCH_2CH_2CH_3 + H_2O$ Correct formulae for the ester ✓ Correctly balanced equation ✓ Add H_2SO_4 **OR** acid catalyst **OR** H^+ ✓	4	**ALLOW** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above (as long as unambiguous) **ALLOW** from the equation propanol **OR** C_3H_7OH is **not** sufficient **ALLOW** molecular formula **OR** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above **ALLOW** propan-2-ol in the equation **ALLOW** conditions mark over the arrow in the equation
			Total	**14**	

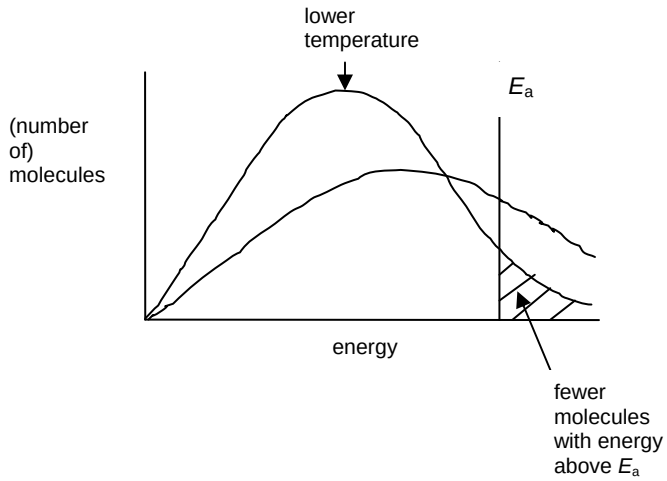
Question			Answer	Marks	Guidance
3	(a)	(i)	**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF answer = 2.68 (kJ) award 2 marks** $q = mc\Delta T$ **OR** = 50.0 × 4.18 × 12.8 ✓ = 2.68 (kJ) ✓	2	**IF** there is an alternative answer, check to see if there is any **ECF** credit possible using working below IF ECF, **ANNOTATE WITH TICKS AND CROSSES, etc** **ALLOW** ecf only from using mass of 50.486 **ALLOW** 2675.2 J **IGNORE** sign If mass used is 50.486 answer is 2701.202944 **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 **ALLOW** one mark for using 4.2 and correctly calculating q in kJ to at least 2 sig figs
		(ii)	amount = 0.02(00) (mol) ✓	1	**ALLOW** $1/50$ **IGNORE** trailing zeroes

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

Question			Answer	Marks	Guidance
3	(b)	(ii)	Correct labelling of enthalpy cycle  Two or three boxes correct ✓ **BUT** all four boxes correct ✓✓ ΔH_f –792 (kJ mol^{-1}) ✓	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** **ALLOW** ECF from wrong enthalpy changes in the boxes
			Total	**12**	

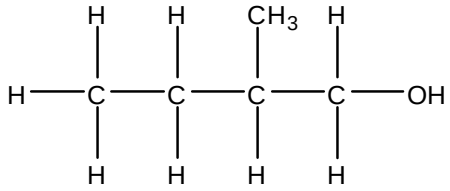
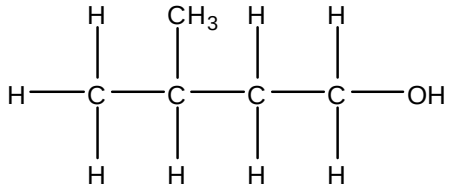
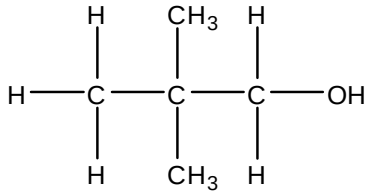
Question			Answer	Marks	Guidance
4	(a)		**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF answer = 431.5 (kJ mol^{-1}) award 2 marks** Energy required to break bonds = (+)679 kJ ✓ so bond enthalpy = (+)431.5 ✓	2	**IF** there is an alternative answer, check to see if there is any **ECF** credit possible using working below IF ECF, **ANNOTATE WITH TICKS AND CROSSES, etc** **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)
	(b)		more concentrated (particles) **OR** more particles per (unit) volume ✓ more collisions per second **OR** more frequent collisions ✓	2	**Must state somewhere in the answer that the rate is faster for full marks** **ALLOW ORA** if lower pressure is specified **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' **ALLOW** collisions more often **OR** increased rate of collision **OR** collisions are more likely **OR** there is a greater chance of collisions 'More collisions' is **not** sufficient **IGNORE** successful

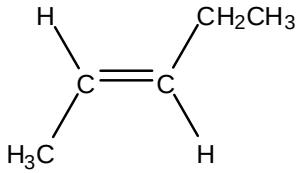
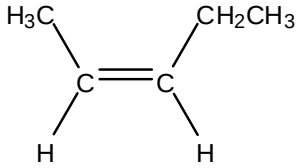
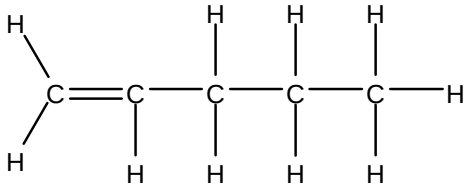
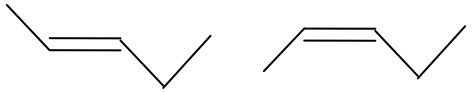
Question			Answer	Marks	Guidance
4	(c)			5	**ANNOTATE ANSWER WITH TICKS AND CROSSES ETC** Assume answers refer to lower temperature and rate decreases unless specified otherwise **ALLOW** ORA i.e. correct explanation for why higher temperatures increase rate if clearly specified **ALLOW** particles instead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

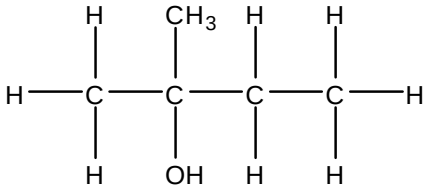
Question			Answer	Marks	Guidance
					
	(d)	(i)	$Cl_2 \rightarrow 2Cl$ ✓	1	No need to show radicals with a 'dot'
		(ii)	HCl + H ✓ HCl + Cl ✓	2	No need to show radicals with a 'dot'
		(iii)	***Any two from:*** H + H → H_2 ✓ Cl + Cl → Cl_2 ✓ H + Cl → HCl ✓	2	No need to show radicals with a 'dot'
			Total	**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_2SO_4 = 1.60×10^6 ✓ Actual moles of H_2SO_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_2SO_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)	(equilibrium position shifts) to the left **because** (forward) reaction is exothermic **OR** equilibrium position shifts) to the left **because reverse** reaction is endothermic ✓	1	Both position of equilibrium **AND** explanation needed for one mark **Note: ALLOW** suitable alternatives for 'to left', e.g. towards SO_2 or O_2 / towards reactants **OR** in backward direction **OR** in reverse direction **OR** decreases yield of SO_3/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 **ALLOW ORA** if specified **IGNORE** responses in terms of rate
		(iii)	(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 ✓	1	Both position of equilibrium **AND** explanation needed for one mark **Note: ALLOW** suitable alternatives for 'to left', e.g.: towards SO_2 or O_2 / towards reactants **OR** in backward direction **OR** in reverse direction **OR** decreases yield of SO_3/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

Question			Answer	Marks	Guidance
5	(d)	(i)	Correct structure ✓  **OR**  **OR** 	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

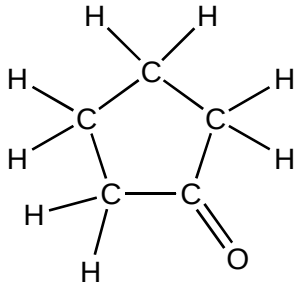
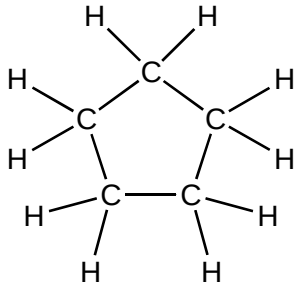
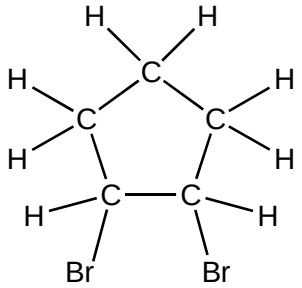
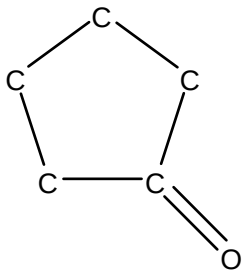
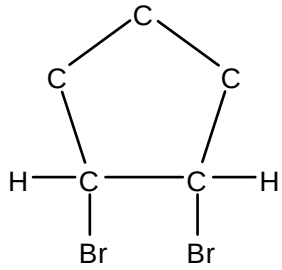
Question			Answer	Marks	Guidance
5	(d)	(ii)	Correct structure for **L** ✓  Correct structure for **M** ✓  Correct structure for **N** ✓  	3	**ALLOW** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above (as long as unambiguous) for **L**, **M** and **N** **e.g.**  **L or M** ***L or M*** **N –** $CH_2CHCH_2CH_2CH_3$ Answers to **L** and M are interchangeable **IGNORE** *cis*/*trans* **OR** *E*/*Z* labels **ALLOW** as a slip one stick with no H on in a displayed formula **ALLOW** 2 marks if three correct structures are drawn but some are in the wrong boxes **ALLOW** 1 mark if two correct structures are drawn but in the wrong boxes

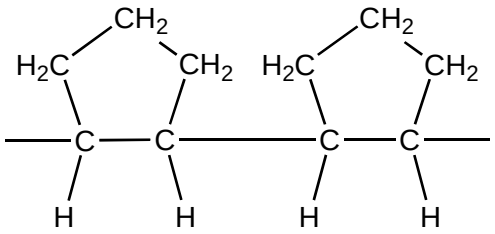
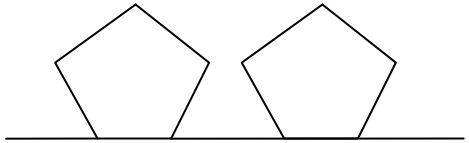
Question			Answer	Marks	Guidance
5	(d)	(iii)	 ✓	1	**ALLOW** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above (as long as unambiguous) **ALLOW** vertical 'bond' to any part of the OH group **DO NOT ALLOW** horizontal –HO in the formula **ALLOW** as a slip one stick with no H on in a displayed formula
			Total	**13**	

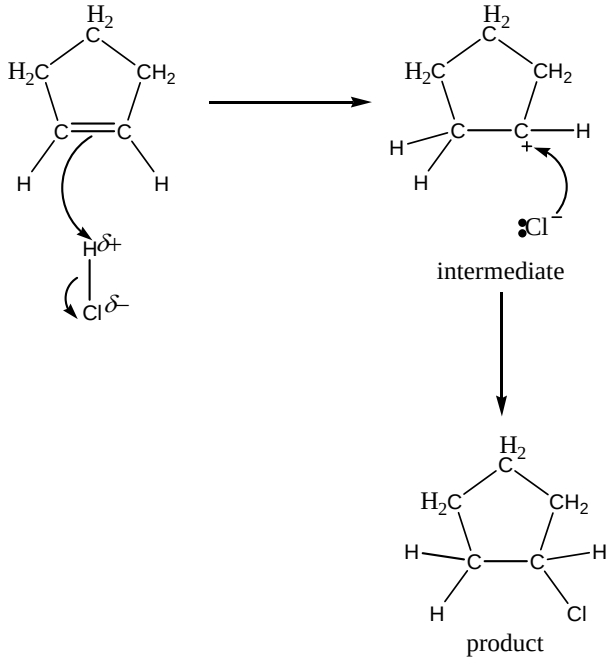
Question			Answer	Marks	Guidance
6	(a)	(i)	(*m*/*z* =) 46 ✓	1	
		(ii)	CH_3O^+ **OR** CH_2OH^+ ✓	1	**MUST** show '+'
		(iii)	C_2H_6O ✓	1	**ALLOW** H_2CO_2
	(b)		$\frac{63 \times 72.2 + 65 \times 27.8}{100}$ **OR** 63.556 **OR** 63.56✓ A_r = 63.6 ✓ Copper / Cu ✓	3	**ALLOW** two marks for 63.6 with no working out
			Total	**6**	

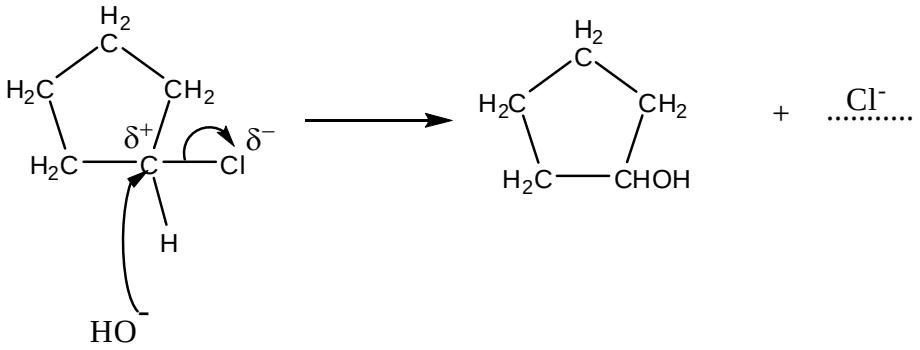
Question			Answer	Marks	Guidance
7	(a)		Shape – tetrahedral ✓ Bond angle 109.5^{o} ✓	2	 **ALLOW** 109–110^{o}
	(b)	(i)	Volatile **OR** non-toxic **OR** non-flammable **OR** easily vaporised ✓	1	**ALLOW** not carcinogenic / not an irritant / not harmful / not hazardous **IGNORE** cheap / not dangerous / gas / low boiling point **DO NOT ALLOW** inflammable
		(ii)	(C–F or C–C*l*) bonds need a large amount of energy to break ✓	1	**ALLOW (**the C–F or C–C*l*) 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)		$CF_2Cl_2 \rightarrow CF_2Cl + Cl$ ✓ **AND ANY TWO FROM** C*l* catalyses the decomposition of ozone ✓ $Cl + O_3 \rightarrow ClO + O_2$ ✓ $ClO + O \rightarrow Cl + O_2$ ✓	3	**ALLOW** CF_2Cl_2 (breaks down to) produces **chlorine** atoms/radicals **ALLOW** equation with any CFC **ALLOW** $ClO + O_3 \rightarrow Cl + 2O_2$ **ALLOW** $O_3 + O \rightarrow 2O_2$ **OR** $3O_2 \rightarrow 2O_3$ 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) UV 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 UV which causes skin cancer etc
	(e)		***Ideas related to uses*** CFCs are still entering the atmosphere (from disused items) **OR** CFCs are still used (for some purposes and by some countries) ✓ ***Ideas relating to lifetime within the atmosphere*** 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**	

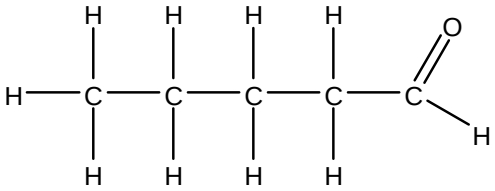
Question			Answer	Marks	Guidance
8	(a)		 **compound P ✓**  **compound Q ✓**  **compound R ✓**	3	**ALLOW** structures with missing hydrogen atoms on the carbon atoms that do not take part in the reaction. i.e. all hydrogen atoms must be shown in **Q** but not in **P** and **R** For example for the structures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

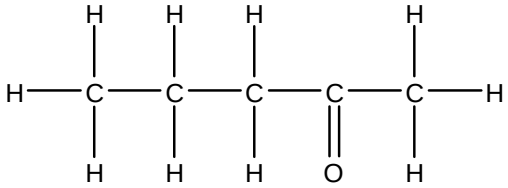
Question			Answer	Marks	Guidance
8	(b)		Orange **OR** brown to colourless ✓	1	**ALLOW** shades of orange **OR** yellow **OR** brown **DO NOT ALLOW** red alone **DO NOT ALLOW** any response that includes precipitate **OR** solid, irrespective of colour
	(c)		Two or more repeat units ✓  	1	**ALLOW** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above (as long as unambiguous) 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 CH_2 groups **ALLOW** skeletal formula 

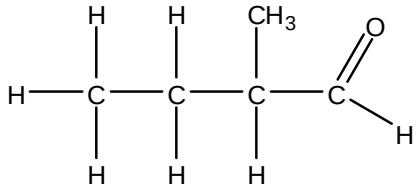
Question			Answer	Marks	Guidance
8	(d)		Curly arrow from double bond to attack hydrogen of H–C*l* and breaking of H–C*l* bond ✓ Correct dipole shown on H–Cl ✓ Correct carbonium ion drawn ✓ Curly arrow from Cl^- to the carbonium ion ✓  intermediate product Correct product ✓	5	**ANNOTATE ANSWER WITH TICKS AND CROSSES ETC** Curly arrow must start from the double bond and not a carbon atom; other curly arrow must start from H–C*l* bond **DO NOT ALLOW** dipoles on double bond Dipole must be partial charge and not full charge Carbocation needs a full charge and not a partial charge (charges do not need to be in a circle) C*l*$^-$ curly arrow must come from one lone pair on C*l*$^-$ ion **OR** from minus sign on C*l*$^-$ ion Lone pair does not need to be shown on C*l*$^-$ ion **ALLOW** structures with missing hydrogen atoms on the CH_2 groups

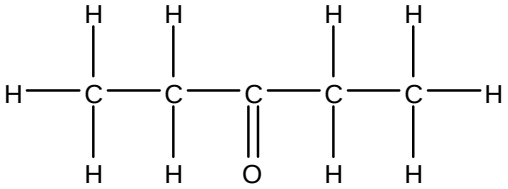
Question			Answer	Marks	Guidance
8	(e)			5	**ANNOTATE ANSWER WITH TICKS AND CROSSES ETC**
			Nucleophilic substitution ✓		
			Heterolytic (fission) spelt correctly ✓		
			dipole shown on C—C*l* bond, $C^{\delta+}$ and $Cl^{\delta-}$✓		Dipole must be partial charge and not full charge
			curly arrow from HO^- to carbon atom of C—C*l* bond ✓		HO^- curly arrow must come from one lone pair on O of HO^- ion **OR** from minus sign on HO^- ion
			curly arrow from C—C*l* bond to the chlorine atom **and** formation of Cl^- ✓		curly arrow must start from C–C*l* bond and not from C atom
					**ALLOW** structures with missing hydrogen atoms on the CH_2 groups
					ALLOW S_N1 mechanism dipole shown on C—C*l* bond, $C^{\delta+}$ and $Cl^{\delta-}$ ✓ curly arrow from C—C*l* bond to the Cl atom and Cl^- shown✓ curly arrow from HO^- to correct carbonium ion ✓
			Total	**15**	

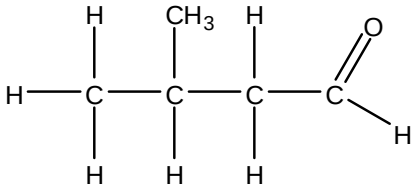
APPENDIX 1

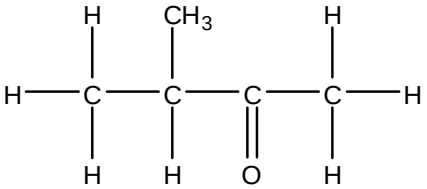


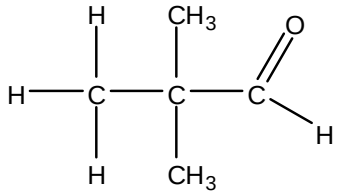


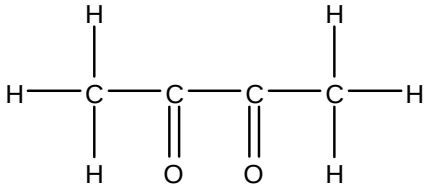


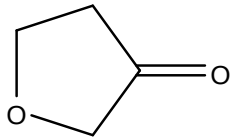


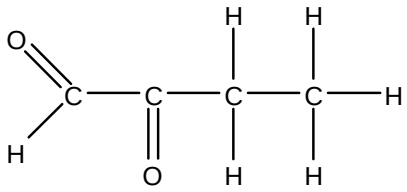


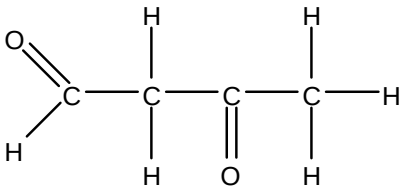


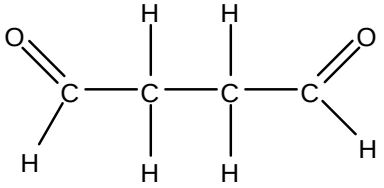












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