



GCE

Chemistry A

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

Advanced Subsidiary GCE

Mark Scheme for June 2015

OCR (Oxford Cambridge and RSA) is a leading UK awarding body, providing a wide range of qualifications to meet the needs of candidates of all ages and abilities. OCR qualifications include AS/A Levels, Diplomas, GCSEs, Cambridge Nationals, Cambridge Technicals, Functional Skills, Key Skills, Entry Level qualifications, NVQs and vocational qualifications in areas such as IT, business, languages, teaching/training, administration and secretarial skills.

It is also responsible for developing new specifications to meet national requirements and the needs of students and teachers. OCR is a not-for-profit organisation; any surplus made is invested back into the establishment to help towards the development of qualifications and support, which keep pace with the changing needs of today's society.

This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

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

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

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













© OCR 2015

F322

Mark Scheme

June 2015

1. 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

12 Subject-specific Marking Instructions

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

3(c)(i), 3(d), 4(c)(ii) 5(d)(i), 5(e)(i), 5(f)(ii), 6(a)(i), 6(b)(ii), 6(c) and 7(b)

All questions where an ECF has been applied.

Checking additional pages

All the Additional Pages in the examination script must be checked to see if any candidates include any answers.

- When you open question **1(a)** you will see a view of page 22 one of the Additional Pages.
- If the page is blank then, using the marking mode, annotate the page with an omission mark, ^, or the BP annotation
- Scroll down to page 24 and annotate with a ^ if the page is blank.
- If pages 22, 23 or 24 are not blank then use the paper clip icon to link the pages to the correct questions.
- You may need to contact your Team Leader if you do not know how to do this.

Generic comments

ORGANIC STRUCTURES

For a 'structure' or 'structural formula',

- **ALLOW** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above (as long as unambiguous)

For an alkyl group shown within a structure,

- **ALLOW** bond drawn to C or H,
e.g. **ALLOW** 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** 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,

<ul style="list-style-type: none"> • For bond in the plane of paper, a solid line is expected: 	
<ul style="list-style-type: none"> • For bond out of plane of paper, a solid wedge is expected: 	
<ul style="list-style-type: none"> • For bond into plane of paper, ALLOW: 	
<ul style="list-style-type: none"> • 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

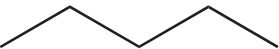
van der Waal's forces

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

F322

Mark Scheme

June 2015

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

F322

Mark Scheme

June 2015

Question	Answer	Mark	Guidance
(ii)	$(n(\text{C}_8\text{H}_{18}) \text{ burned}) = 0.32 \text{ (mol)} \checkmark$ $(n(\text{CO}_2) \text{ from complete combustion}) = 2.56 \text{ or } 2.6 \text{ mol}$ OR $(\text{ratio } n\text{CO}_2/n\text{C}_8\text{H}_{18}) = 7.8(125)$ OR $(n \text{ C}_8\text{H}_{18} \text{ produce } 2.5 \text{ mol CO}_2) = 0.31(25) \checkmark$	2	<p>DO NOT ALLOW ECF from an incorrect moles of octane</p> <p>DO NOT ALLOW ECF from incorrect ratio from equation in (i)</p> <p>ALLOW the following alternate methods</p> <p>-----</p> <p>Method 1</p> <p>$(\text{mass CO}_2 \text{ produced}) = 110 \text{ g} \checkmark$</p> <p>$(\text{mass CO}_2 \text{ from complete combustion})$ $= 8 \times 0.32 \times 44 = 112.64 \text{ or } 112.6 \text{ or } 113 \text{ g} \checkmark$</p> <p>-----</p> <p>Method 2</p> <p>$(n \text{ C}_8\text{H}_{18} \text{ to produce } 2.5 \text{ mol CO}_2) = 0.31(25) \checkmark$</p> <p>$(\text{mass of octane required to produce } 2.50 \text{ mol CO}_2)$ $= 35.6 \text{ OR } 35.63 \text{ OR } 35.625 \text{ g} \checkmark$</p>

F322

Mark Scheme

June 2015

Question		Answer	Mark	Guidance	
	(e)	(i)	Fractional distillation AND cracking ✓	1	ALLOW either order
		(ii)	Correct equation showing cracking of an alkane to form ethene ✓	1	<p>ALLOW any correct equation with correct formulae to show cracking forming C₂H₄ of the type: alkane → shorter alkane(s) + alkene, e.g. C₁₀H₂₂ → C₈H₁₈ + C₂H₄ C₁₀H₂₂ → C₆H₁₄ + 2C₂H₄</p> <p>^C ALLOW C₂H₆ → C₂H₄ + H₂</p> <p>ALLOW correct molecular formulae OR structural OR displayed OR skeletal OR mixture of the above.</p> <p>IGNORE state symbols</p>
			Total	9	

F322

Mark Scheme

June 2015

Question		Answer	Mark	Guidance
2	(a)	<p>Method 1: 100% OR (only) one product OR no waste product OR addition (reaction) ✓</p> <p>Method 2: < 100% AND two products OR (also) produces NaBr OR (There is a) waste product OR substitution (reaction) ✓</p>	2	<p>ALLOW co-product or by-product for waste product</p> <p>For '< 100%' ALLOW not 100% OR method 2 has a low(er) atom economy (compared to method 1)</p> <p>IGNORE produces Br⁻/ Na⁺ DO NOT ALLOW incorrect waste products e.g. Br₂, HBr, Br, Na</p> <p>ALLOW correctly calculated value of 42 or 41.8 up to calculator value of 41.83154324 correctly rounded for second mark</p> <p>DO NOT ALLOW incorrect values for the atom economy of method 2.</p> <p>ALLOW ONLY 1 mark for a statement that both methods have 100% atom economy.</p>
	(b)	Acid ✓	1	<p>ALLOW H⁺ / named mineral acid / H₂SO₄ / H₃PO₄</p> <p>DO NOT ALLOW 'weak acid' e.g. ethanoic acid</p> <p>IGNORE pressure IGNORE temperature</p>

F322

Mark Scheme

June 2015

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

F322

Mark Scheme

June 2015

Question	Answer	Mark	Guidance
(d)	<p>FIRST, CHECK THE ANSWER ON ANSWER LINE IF mass = 8.21 (g) award 3 marks</p> <p>Actual</p> $n(\text{C}_4\text{H}_9\text{OH}) \text{ produced} = \frac{3.552}{74} = 0.048 \text{ (mol)} \checkmark$ <p>theoretical</p> $n(\text{C}_4\text{H}_9\text{OH}) = n(\text{C}_4\text{H}_9\text{Br}) = 0.048 \times \frac{100}{80} = 0.06 \text{ (mol)} \checkmark$ <p>Mass of $\text{C}_4\text{H}_9\text{Br} = 0.06 \times 136.9 = 8.21 \text{ (g)} \checkmark$ 3 SF required</p>	3	<p>ALLOW ECF at each stage</p> <p>ALLOW expected mass $\text{C}_4\text{H}_9\text{OH} = 3.552 \times \frac{100}{80} = 4.44 \text{ (g)}$</p> <p>ALLOW Mass $\text{C}_4\text{H}_9\text{Br}$ reacted = $0.048 \times 136.9 = 6.5712 \text{ (g)}$</p> <p>ALLOW Mass of $\text{C}_4\text{H}_9\text{Br}$ used = $6.5712 \times \frac{100}{80} = 8.21 \text{ (g)}$</p> <p>DO NOT ALLOW 8.22 (<i>from use of 137 as M_r of $\text{C}_4\text{H}_9\text{Br}$</i>)</p>
	Total	11	

F322

Mark Scheme

June 2015

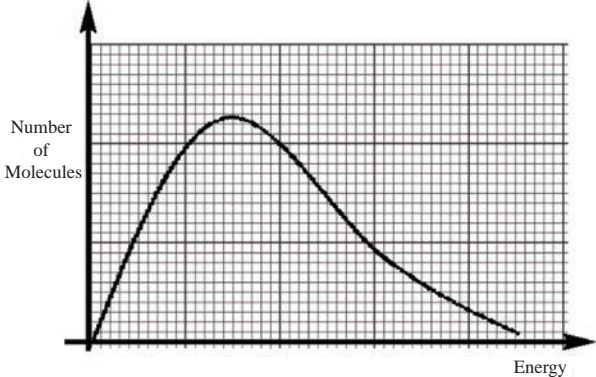
Question		Answer	Mark	Guidance
3	(a)	<p>Increased rate AND greater concentration of molecules / more molecules per (unit) volume ✓</p> <p>More collisions per second / more frequent collisions ✓</p>	2	<p>ALLOW particles for molecules IGNORE atoms</p> <p>Response must imply a volume and not area ALLOW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

F322

Mark Scheme

June 2015

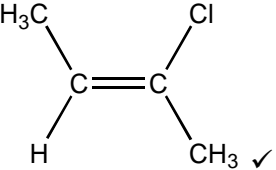
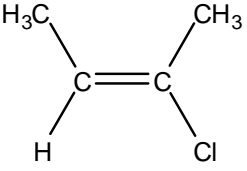
Question		Answer	Mark	Guidance
(c)	(i)	<p>Pressure: Right-hand side has fewer (gaseous) moles/molecules OR left-hand side has more (gaseous) moles/molecules ✓</p> <p>Temperature: Statement that: (Forward) reaction is exothermic OR (forward) reaction gives out heat OR reverse reaction is endothermic OR reverse reaction takes in heat ✓</p> <p>Equilibrium Lower temperature/cooling AND increasing pressure shifts (equilibrium position) to the right ✓</p>	3	<p>ANNOTATE ANSWER WITH TICKS AND CROSSES ETC</p> <p>DO NOT ALLOW fewer atoms on right-hand side OR more atoms on left-hand side.</p> <p>IGNORE comments about the 'exothermic side' or 'endothermic side'</p> <p>Equilibrium mark is for stating that BOTH low temperature and high pressure shift equilibrium to the right (Could be separate statements)</p> <p>Note: ALLOW suitable alternatives for 'to right', e.g.: towards products OR towards CH₃OH / H₂O OR in forward direction OR favours the right</p> <p>IGNORE Increases yield of CH₃OH/products (<i>in question</i>)</p> <p>IGNORE responses in terms of rate</p>
	(ii)	<p>Low temperature gives a slow rate OR high temperatures needed to increase rate ✓</p> <p>High pressure is expensive (to generate) OR high pressure provides a safety risk ✓</p>	2	<p>ALLOW high pressure is dangerous IGNORE high pressure is explosive</p>

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

F322

Mark Scheme

June 2015

Question		Answer	Mark	Guidance
4	(a)	B ✓	1	ALLOW CF ₂ CF ₂ OR C ₂ F ₄ OR tetrafluoroethene
	(b) (i)		1	ALLOW correct structural OR displayed OR skeletal OR mixture of the above ALLOW <i>E</i> isomer 
	(b) (ii)	HCl ✓	1	DO NOT ALLOW Cl ₂ IGNORE names IGNORE nitrogen oxides / NO _x
	(c) (i)	ANY TWO FROM THE FOLLOWING ✓ Low reactivity OR will not burn/non-flammable Volatile OR low boiling point non-poisonous OR non-toxic	1	ALLOW inert OR stable DO NOT ALLOW inflammable ALLOW it is a gas IGNORE easily compressed IGNORE not harmful IGNORE references to solubility

F322

Mark Scheme

June 2015

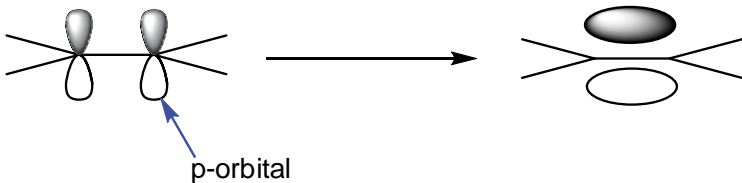
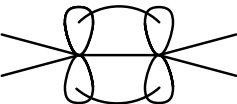
Question	Answer	Mark	Guidance
(ii)	<p><i>Benefit of ozone layer to life (1 mark)</i></p> <p>Ozone absorbs UV (radiation)</p> <p>UV at Earth's surface is reduced ✓</p> <p>OR-----</p> <p><i>Maintenance of O₃ concentration (1 mark)</i></p> $O_3 \rightleftharpoons O_2 + O \checkmark$ <p>O</p> <p>-----</p> <p><i>Production of radicals from G (1 mark)</i></p> $2C_2Cl_2 \longrightarrow C_2Cl + CF_2Cl \checkmark$ <p>-----</p> <p>CF</p> <p><i>Breakdown of O₃ (2 marks)</i></p> $Cl + O_3 \longrightarrow ClO + O_2 \checkmark$ $ClO + O \longrightarrow Cl + O_2$ <p>OR</p> $ClO + O_3 \longrightarrow Cl + 2O_2 \checkmark$ <p>C</p>	5	<p>ANNOTATE ANSWER WITH TICKS AND CROSSES ETC</p> <p>For all equations, IGNORE dots on radicals</p> <p>-----</p> <p>Essential idea for first mark is that UV is removed in some way.</p> <p>ALLOW Prevents UV damaging life or stated type of damage, e.g. cataracts, skin cancer, mutation, crop damage</p> <p>DO NOT ALLOW ozone absorbs IR</p> <p>-----</p> <p>ALLOW</p> $O_3 \longrightarrow O_2 + O$ $O_2 + O \longrightarrow O_3$ <p>DO NOT ALLOW $2O_3 \rightleftharpoons 3O_2$</p> <p>OR $O_3 + O \longrightarrow 2O_2$ for this mark</p> <p>-----</p> <p>DO NOT ALLOW equations with other CFCs</p> <p>DO NOT ALLOW $CF_2Cl_2 \longrightarrow 2C_2Cl + CF_2$</p> <p>-----</p> <p>These are the only acceptable equations</p> <p>IGNORE overall equation (<i>does not show role of catalyst</i>) e.g. $O_3 + O \longrightarrow 2O_2$</p>

F322

Mark Scheme

June 2015

Question		Answer	Mark	Guidance
	(iii)	D ✓	1	ALLOW CHF ₂ Cl ALLOW B OR C ₂ F ₄ OR CF ₂ CF ₂
(d)	(i)	bond vibrates (more) OR bond bends (more) OR bond stretches (more) ✓	1	BOND essential IGNORE molecule vibrates/rotates Assume "It" refers to the molecule and is insufficient DO NOT ALLOW any reference to bond breaking DO NOT ALLOW a stated bond if not present in C and F e.g. C–O, C–H not present
	(ii)	Cl ₃ C ⁺ ✓ CF ₂ Cl ⁺ ✓	2	ALLOW 1 mark for Cl ₃ C AND CF ₂ Cl <i>i.e. no + charge used</i> ALLOW 1 mark for Cl ₃ C ⁻ AND CF ₂ Cl ⁻ <i>i.e. – charge used on both</i>
Total			13	

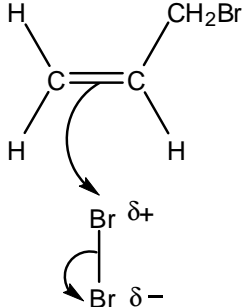
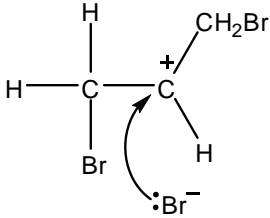
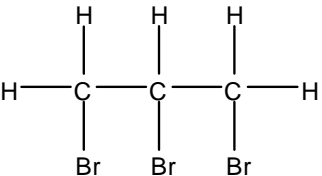
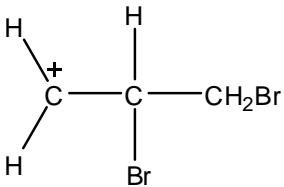
		Answer	Mark	Guidance	
5	(a)	 <p>First mark diagram on left with p-orbitals labelled OR unlabelled diagram AND the statement: (sideways) overlap of p orbitals ✓</p> <p>Second mark (labelled) diagram on right showing π-bond ✓</p>	2	<p>Note: A diagram is required for each mark</p> <p>DO NOT ALLOW C=C in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

F322

Mark Scheme

June 2015

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

	Answer	Mark	Guidance
(e)	<p>(i)</p> <p>Curly arrow from double bond to Br of Br–Br ✓</p> <p>Correct dipole shown on Br–Br AND curly arrow showing breaking of Br–Br bond ✓</p>  <p>-----</p> <p>Correct carbocation with + charge on C with 3 bonds AND curly arrow from Br⁻ to C⁺ of carbocation ✓</p>  <p>-----</p> <p>Correct product: ✓</p> 	4	<p>ANNOTATE ANSWER WITH TICKS AND CROSSES ETC</p> <p>Curly arrow must start from bond and go to correct atom</p> <p>DO NOT ALLOW any other partial charges e.g. shown on double bond</p> <p>ALLOW carbocation on terminal CH₂</p>  <p>DO NOT ALLOW δ+ on C of carbocation.</p> <p>Curly arrow must come from a lone pair on Br⁻ OR from the negative sign of Br⁻ ion (then lone pair on Br⁻ ion does not need to be shown)</p>
	(ii) Electrophilic addition ✓	1	

F322

Mark Scheme

June 2015

		Answer	Mark	Guidance
	(f)	(i) H ₂ AND Ni (catalyst) ✓	1	ALLOW name or formula for each IGNORE any stated temperature and pressure
		(ii) (Initiation) Cl ₂ → 2Cl ✓ AND UV ✓ (Propagation) C ₃ H ₇ Br + Cl → C ₃ H ₆ Br + HCl ✓ C ₃ H ₆ Br + Cl ₂ → C ₃ H ₆ BrCl + Cl ✓ (Termination) Two from the three termination equations below ✓ 2Cl → Cl ₂ C ₃ H ₆ Br + Cl → C ₃ H ₆ BrCl 2C ₃ H ₆ Br → C ₆ H ₁₂ Br ₂ names of steps initiation, propagation and termination linked to one correct equation for each step in this mechanism ✓	5	ANNOTATE ANSWER WITH TICKS AND CROSSES ETC DO NOT ALLOW any ECF in this question IGNORE references to temperature THROUGHOUT, ALLOW correct molecular formulae OR structural OR displayed OR skeletal OR mixture of the above IGNORE dots IGNORE state symbols IGNORE one incorrect termination equation
		(iii) further substitution OR produces different termination products OR More than one termination step ✓ substitution at different positions along chain ✓	2	IGNORE mixture of organic products (<i>in question</i>) ALLOW dichloro/multichloro/dibromo/multibromo compounds formed OR an example of a further substitution product OR an example of a different termination product ALLOW more than one hydrogen (atom) can be replaced ALLOW radicals react with each other to form other products ALLOW forms different structural isomers ALLOW a hydrogen (atom) on a different carbon (atom) can be replaced
Total			25	

Question		Answer	Mark	Guidance
6	(a) (i)	<p>FIRST, CHECK THE ANSWER ON ANSWER LINE IF $\Delta H_c = -2260$ (kJ mol⁻¹) award 4 marks IF $\Delta H_c = (+)2260$ (kJ mol⁻¹) award 3 marks (incorrect sign) IF $\Delta H_c = (\pm)2257(.2)$ (kJ mol⁻¹) award 3 marks (not 3 sf)</p> <p>Moles Amount, n, C₅H₁₂O calculated correctly = 0.0175 (mol) ✓</p> <p>Energy q calculated correctly = 39501 (J) OR 39.5(01) (kJ) ✓</p> <p>Calculating ΔH correctly calculates ΔH in kJ mol⁻¹ to 3 or more sig figs ✓</p> <p>Rounding and Sign calculated value of ΔH rounded to 3 sig. fig. with minus sign ✓</p>	4	<p>ANNOTATE ANSWER WITH TICKS AND CROSSES ETC</p> <p>Note: $q = 180 \times 4.18 \times 52.5$ ALLOW 39501 OR correctly rounded to 3 sig. fig. (J) IGNORE sign IGNORE working</p> <p>Note: from 39501 J and 0.0175 mol $\Delta H = (-)2257.2$ kJ mol⁻¹</p> <p>IGNORE sign at this intermediate stage ALLOW ECF from incorrect q and/or incorrect n</p> <p>Final answer must have correct sign and three sig figs</p>
	(ii)	<p>ANY TWO FROM THE FOLLOWING ✓✓</p> <p>incomplete combustion</p> <p>non-standard conditions</p> <p>evaporation of alcohol/water</p> <p>specific heat capacity of beaker/apparatus</p>	2	<p>IGNORE heat loss (<i>in question</i>)</p> <p>ALLOW burns incompletely IGNORE incomplete reaction</p>

F322

Mark Scheme

June 2015

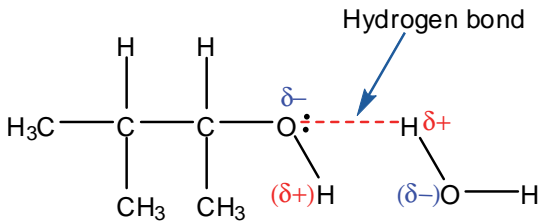
Question	Answer	Mark	Guidance
(b) (i)	$5\text{C}(\text{s}) + 6\text{H}_2(\text{g}) + \frac{1}{2}\text{O}_2(\text{g}) \longrightarrow \text{C}_5\text{H}_{12}\text{O}(\text{l}) \checkmark$	1	Balancing numbers AND species AND states all required DO NOT ALLOW multiples of this equation
	<p>(ii) FIRST, CHECK THE ANSWER ON ANSWER LINE IF enthalpy change = $-3320 \text{ (kJ mol}^{-1}\text{)}$ award 3 marks IF enthalpy change = $(+3320 \text{ (kJ mol}^{-1}\text{)})$ award 2 marks ----- Working for CO_2 AND H_2O seen anywhere</p> <p>$5 \times (-)394$ AND $6 \times (-)286$ OR $(-)1970$ AND OR $(-)3686 \checkmark$ $(-)1716$</p> <p>Calculates ΔH_c</p> <p>A further 2 marks for correct answer AND correct sign $= 5 \times -394 + 6 \times -286 - -366$ $= -3320 \text{ (kJ mol}^{-1}\text{)} \checkmark\checkmark$</p> <p>A further 1 mark for correct answer AND incorrect or no sign $= (+)3320 \text{ (kJ mol}^{-1}\text{)} \checkmark$ <i>Cycle wrong way around:</i> $-366 - (5 \times -394 + 6 \times -286)$</p>	3	<p>ANNOTATE ANSWER WITH TICKS AND CROSSES ETC</p> <p>IF there is an alternative answer, check to see if there is any ECF credit possible</p> <p>Common incorrect answers are shown below Award 2 marks for -1744 OR -1890 OR -314 OR -4052 Award 1 mark for 1744 OR 1890 OR 314 OR 4052</p>

Question	Answer	Mark	Guidance
(c)	<p>QWC: Evidence of the IR absorption at 1720 (cm^{-1}) for presence of C=O/carbonyl group ✓</p> <p>QWC: No carboxylic acid OH absorption in IR OR no peak between 2500–3300 cm^{-1} AND so J is a secondary alcohol OR so K is a ketone ✓</p> <p>Alcohol J</p> $\begin{array}{c} \text{OH} \quad \text{H} \\ \quad \\ \text{H}_3\text{C}-\text{C}-\text{C}-\text{CH}_3 \\ \quad \\ \text{H} \quad \text{CH}_3 \end{array}$ <p style="text-align: right;">✓✓</p> <p>Compound K Structure of a carbonyl compound that could be obtained from alcohol J ✓</p> <p>Equation Balanced equation for conversion of J to K ✓ e.g. $\text{CH}_3\text{CHOHCH}(\text{CH}_3)_2 + [\text{O}] \longrightarrow \text{CH}_3\text{COCH}(\text{CH}_3)_2 + \text{H}_2\text{O}$</p>	6	<p>ANNOTATE ANSWER WITH TICKS AND CROSSES ETC</p> <p>LOOK ON THE SPECTRUM for labelled peaks which can be given credit BOTH IR at ~ 1720 (cm^{-1}) AND C=O required ALLOW ranges from <i>Data Sheet</i>, i.e. C=O within range 1640–1750 cm^{-1};</p> <p>IGNORE any reference to C-O absorption For structures of J and K, ALLOW correct structural OR displayed OR skeletal formula OR mixture of the above IGNORE any names given for J and K</p> <p>ALLOW 1 mark for the structure of an alcohol with the molecular formula $\text{C}_5\text{H}_{12}\text{O}$ DO NOT ALLOW pentan-1-ol (<i>primary and unbranched</i>) or 2-methylbutan-2-ol (<i>branched but tertiary</i>)</p> <p>DO NOT ALLOW any marks for J and K if more than one structure is given for J</p> <p>Note: 'sticks' in either J and/or K will lose only 1 mark</p> <p>ALLOW 1 mark for:</p> $\begin{array}{c} \text{O} \quad \text{H} \\ \quad \\ \text{H}_3\text{C}-\text{C}-\text{C}-\text{CH}_3 \\ \\ \text{CH}_3 \end{array}$ <p style="text-align: right;">IF a structure is not given for J</p> <p>NOTE: structures for J and K could be awarded from the equation, even if not labelled.</p> <p>ALLOW molecular formulae in equation i.e. $\text{C}_5\text{H}_{12}\text{O} + [\text{O}] \longrightarrow \text{C}_5\text{H}_{10}\text{O} + \text{H}_2\text{O}$ DO NOT ALLOW equations that form a carboxylic acid</p>

F322

Mark Scheme

June 2015

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

F322

Mark Scheme

June 2015

Question		Answer	Mark	Guidance
7	(a)	Mole ratio C : H : O is 3.33 : 6.67 : 3.33 ✓ Empirical formula is CH ₂ O ✓ Molecular formula is C ₃ H ₆ O ₃ AND use of 90 OR 3 × 30 ✓	3	ALLOW $\frac{40.00}{12.0} : \frac{6.67}{1.0} : \frac{53.33}{16.0}$ ALLOW mass of C = 0.400 x 90 or 36 AND mass of H = 0.06677 x 90 or 6 AND mass of O = 0.5333 x 90 or 48

F322

Mark Scheme

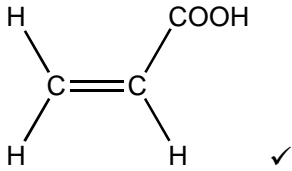
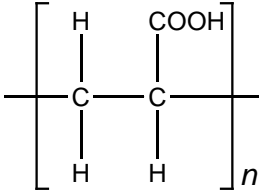
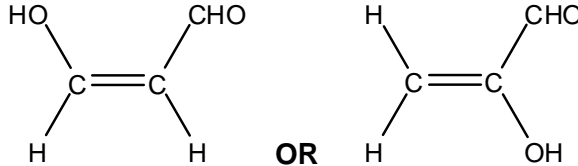
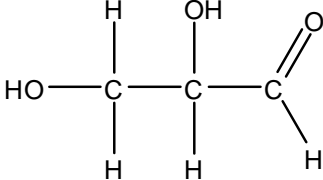
June 2015

Question	Answer	Mark	Guidance
(b)	<p>Evidence of carboxylic acid (1 mark) IR: 1550–1800 cm⁻¹ AND C=O/carbonyl AND 2300–3700 cm⁻¹ AND O–H in carboxylic acid ✓</p> <p>Evidence of alcohol (1 mark)</p> <p>(broad) 3200–3700 cm⁻¹ linked to O–H in alcohol OR (is a primary) alcohol as oxidised (to a COOH) OR is an alcohol as it forms a carboxylic acid OR is an alcohol as water is eliminated. ✓</p> <p>Identifications (2 marks)</p> <p>L:</p> $\begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{HO}-\text{C}-\text{C}-\text{COOH} \\ \quad \\ \text{H} \quad \text{H} \end{array} \quad \checkmark$ <p>M:</p> $\begin{array}{c} \text{H} \\ \\ \text{HOOC}-\text{C}-\text{COOH} \\ \\ \text{H} \end{array} \quad \checkmark$ <p>Equation (1 mark)</p> $\text{C}_3\text{H}_6\text{O}_3 + 2[\text{O}] \longrightarrow \text{C}_3\text{H}_4\text{O}_4 + \text{H}_2\text{O} \quad \checkmark$	5	<p>ANNOTATE ANSWER WITH TICKS AND CROSSES ETC</p> <p>LOOK ON THE SPECTRUM for labelled peaks which can be given credit</p> <p>ALLOW ranges from <i>Data Sheet</i>: C=O within range 1640–1750 cm⁻¹; (broad) O–H within range 2500–3300 cm⁻¹ (broad) O–H within range 3200–3550 cm⁻¹</p> <p>For ALL structures: ALLOW correct structural OR skeletal OR displayed formula OR mixture of the above</p> <p>IGNORE names</p> <hr/> <p>FOR M: ALLOW 1 mark for $\text{HOOC}-\overset{\text{O}}{\parallel}{\text{C}}-\text{COOH} \quad \checkmark$</p> <p>AS ECF from L as either</p> $\begin{array}{c} \text{H} \quad \text{O} \quad \text{H} \\ \quad \quad \\ \text{HO}-\text{C}-\text{C}-\text{C}-\text{OH} \\ \quad \\ \text{H} \quad \text{H} \end{array} \quad \text{OR} \quad \begin{array}{c} \text{H} \quad \text{OH} \\ \quad \\ \text{HO}-\text{C}-\text{C}-\overset{\text{O}}{\parallel}{\text{C}}-\text{H} \\ \quad \\ \text{H} \quad \text{H} \end{array}$ <p>Equation: $\text{C}_3\text{H}_6\text{O}_3 + 4[\text{O}] \longrightarrow \text{C}_3\text{H}_2\text{O}_5 + 2\text{H}_2\text{O} \quad \checkmark$</p> <hr/> <p>ALLOW correct structural OR displayed OR skeletal formula OR mixture of the above in equation</p>

F322

Mark Scheme

June 2015

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

F322

Mark Scheme

June 2015

Question	Answer	Mark	Guidance
	<p>Repeat units (1 mark)</p> <p>$n = 10000/72 = 139 \checkmark$</p> <p>Equation (1 mark)</p> <p>Balanced equation for formation of P from N ✓ e.g.</p> $n \begin{array}{c} \text{H} & & \text{COOH} \\ & \diagdown & / \\ & \text{C} = \text{C} \\ & / & \diagdown \\ \text{H} & & \text{H} \end{array} \longrightarrow \left[\begin{array}{cc} \text{H} & \text{COOH} \\ & \\ -\text{C} & - & \text{C}- \\ & \\ \text{H} & \text{H} \end{array} \right]_n$		<p>MUST be a whole number. ALLOW 138 OR 140</p> <hr/> <p>For equation, ALLOW molecular OR structural OR skeletal OR displayed formulae OR mixture of the above e.g. ALLOW $n\text{C}_3\text{H}_4\text{O}_2 \longrightarrow (\text{C}_3\text{H}_4\text{O}_2)_n$</p> <p>$n$ on LHS can be at any height to the left of formula AND n on the RHS must be a subscript (essentially below the side link if displayed/skeletal formula is used)</p> <p>ALLOW use of calculated value for n in equation e.g. $139\text{C}_3\text{H}_4\text{O}_2 \longrightarrow (\text{C}_3\text{H}_4\text{O}_2)_{139}$</p>
	Total	12	

OCR (Oxford Cambridge and RSA Examinations)
1 Hills Road
Cambridge
CB1 2EU

OCR Customer Contact Centre

Education and Learning

Telephone: 01223 553998

Facsimile: 01223 552627

Email: general.qualifications@ocr.org.uk

www.ocr.org.uk

For staff training purposes and as part of our quality assurance programme your call may be recorded or monitored

Oxford Cambridge and RSA Examinations
is a Company Limited by Guarantee
Registered in England
Registered Office; 1 Hills Road, Cambridge, CB1 2EU
Registered Company Number: 3484466
OCR is an exempt Charity

OCR (Oxford Cambridge and RSA Examinations)
Head office
Telephone: 01223 552552
Facsimile: 01223 552553

© OCR 2015

