

# **Chemistry A**

Advanced GCE A2 H434

Advanced Subsidiary GCE AS H034

## **Mark Schemes for the Units**

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**January 2010**

**H034/H434/MS/R/10J**

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**Advanced Subsidiary GCE Chemistry A (H034)**

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# F321 Atoms, Bonds and Groups

Question		Expected Answers	Marks	Additional Guidance
1	(a)	<p>Mass of the <b>isotope</b> compared to 1/12th  <b>OR</b>  mass of the <b>atom</b> compared to 1/12th ✓</p> <p>(the mass of a) carbon-12 <b>OR</b> <math>^{12}\text{C}</math> (atom) ✓</p>	2	<p><b>IGNORE</b> Reference to average <b>OR</b> weighted mean  (i.e. correct definition of relative atomic mass will score both marks)</p> <p><b>ALLOW</b> mass of a <b>mole</b> of the isotope/atom with 1/12th the mass of a <b>mole OR 12 g</b> of carbon-12 for two marks.</p> <p><b>ALLOW 2 marks for:</b>  ‘<b>Mass</b> of the isotope <b>OR mass</b> of the atom compared to <math>^{12}\text{C}</math> atom given a mass of 12.0’  i.e. ‘given a mass of 12’ <b>OR</b> C12 is 12 communicates the same idea as 1/12th.’</p> <p><b>ALLOW</b> 12C <b>OR</b> C12</p> <p><b>ALLOW 2 marks for:</b>  <math display="block">\frac{\text{mass of the isotope}}{\text{mass of 1/12th mass of carbon - 12}}</math> i.e. fraction is equivalent to ‘compared to’</p> <p><b>ALLOW 1 mark for</b> a mix of mass of atom and mass of mole of atoms, i.e. ‘mass of the isotope/mass of an atom compared with 1/12th the mass of a <b>mole OR 12 g</b> of carbon-12.’</p> <p><b>DO NOT ALLOW</b> mass of ‘ions’ <b>OR</b> mass of element</p>
	(b)	$\frac{(151 \times 47.77) + (153 \times 52.23)}{100}$ <p><b>OR</b>  72.1327 + 79.9119  <b>OR</b>  152.0446 (calculator value) ✓  <math>A_r = 152.04</math> ✓</p>	2	<p><b>ALLOW</b> Correct answer for two marks</p> <p><b>ALLOW</b> One mark for ECF from transcription error in first sum provided final answer is to 2 decimal points and is to between 151 and 153 and is a correct calculation of the transcription</p>

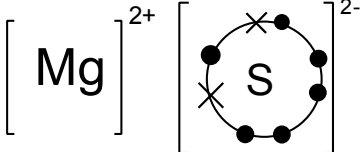
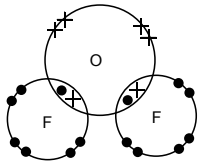
Question		Expected Answers	Marks	Additional Guidance
	(c) (i)	$^{153}\text{Eu}$ has (2) more neutrons <b>OR</b> $^{153}\text{Eu}$ has 90 neutrons <b>AND</b> $^{151}\text{Eu}$ has 88 neutrons ✓	1	<b>ALLOW</b> There are a different number of neutrons <b>IGNORE</b> Correct references to protons / electrons <b>DO NOT ALLOW</b> Incorrect references to protons / electrons
	(ii)	(It has the) same number of protons <b>AND</b> electrons <b>OR</b> Both have 63 protons and 63 electrons ✓	1	<b>ALLOW</b> Same number of protons <b>AND</b> same electron configuration <b>DO NOT ALLOW</b> 'Same number of protons' without reference to electrons (and vice versa)

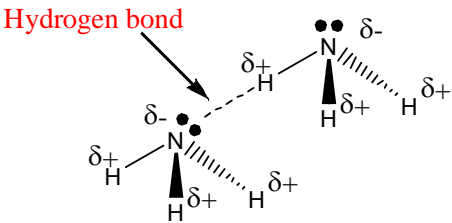
Question	Expected Answers	Marks	Additional Guidance
(d)	<p>Xe has a bigger atomic radius <b>OR</b> Xe has more shells ✓</p> <p>Xe has <b>more</b> shielding ✓</p> <p>The nuclear attraction decreases  <b>OR</b> Outermost electrons of Xe experience less attraction (to nucleus)  <b>OR</b> Increased shielding / distance outweighs the increased nuclear charge ✓  ORA throughout</p>	3	<p><b>ALLOW</b> Xe has more energy levels  <b>ALLOW</b> Xe has electrons in higher energy level  <b>ALLOW</b> Xe has electrons further from nucleus  <b>IGNORE</b> Xe has more orbitals <b>OR</b> more sub-shells  <b>DO NOT ALLOW</b> 'different shell' or 'new shell'</p> <p><b>ALLOW More</b> screening  There must be a clear comparison ie <b>more</b> shielding <b>OR</b> <b>increased</b> shielding.  i.e. <b>DO NOT ALLOW</b> Xe 'has shielding'  <b>ALLOW</b> Xe has <b>more</b> electron repulsion from inner shells</p> <p><b>ALLOW</b> Xe has less nuclear pull  <b>IGNORE</b> Xe has less effective nuclear charge  <b>DO NOT ALLOW</b> nuclear charge for nuclear attraction</p>
	<b>Total</b>	<b>9</b>	

Question			Expected Answers	Marks	Additional Guidance
2	(a)	(i)	The H <sup>+</sup> ion in an (nitric) acid has been replaced by a metal ion <b>OR</b> by a Ca <sup>2+</sup> ion ✓	1	<b>DO NOT ALLOW</b> it has been produced by the reaction of an acid and a base as this is stated in the question.  <b>IGNORE</b> references to replacement by NH <sub>4</sub> <sup>+</sup> ions or positive ions. <b>ALLOW</b> H <b>OR</b> Hydrogen for H <sup>+</sup> ; <b>DO NOT ALLOW</b> Hydrogen atoms <b>ALLOW</b> Ca <b>OR</b> Calcium for Ca <sup>2+</sup> . <b>DO NOT ALLOW</b> Calcium atoms <b>ALLOW</b> 'metal' for 'metal ion'
		(ii)	2HNO <sub>3</sub> (aq) + Ca(OH) <sub>2</sub> (aq) → Ca(NO <sub>3</sub> ) <sub>2</sub> (aq) + 2H <sub>2</sub> O(l) Formulae ✓ Balance <b>AND</b> states ✓	2	<b>ALLOW</b> multiples <b>ALLOW</b> (aq) <b>OR</b> (s) for Ca(OH) <sub>2</sub>
		(iii)	Accepts a <b>proton OR</b> accepts H <sup>+</sup> ✓	1	<b>ALLOW</b> H <sup>+</sup> + OH <sup>-</sup> → H <sub>2</sub> O <b>ALLOW</b> OH <sup>-</sup> reacts with H <sup>+</sup> <b>OR</b> OH <sup>-</sup> takes H <sup>+</sup> <b>ALLOW</b> OH <sup>-</sup> 'attracts' H <sup>+</sup> if 'to form water' is seen  <b>DO NOT ALLOW</b> OH <sup>-</sup> neutralises H <sup>+</sup> ('neutralises' is in the question)
	(b)	(i)	Calculates correctly $\frac{0.0880 \times 25.0}{1000} = 2.20 \times 10^{-3}$ mol <b>OR</b> 0.00220 mol ✓	1	<b>ALLOW</b> 0.0022 <b>OR</b> $2.2 \times 10^{-3}$ mol
		(ii)	Calculates correctly $\frac{0.00220}{2} = 1.10 \times 10^{-3}$ mol <b>OR</b> 0.00110 mol ✓	1	<b>ALLOW</b> 0.0011 <b>OR</b> $1.1 \times 10^{-3}$ mol  <b>ALLOW</b> ECF for answer (i)/2 as calculator value or correct rounding to 2 significant figures or more but ignore trailing zeroes
		(iii)	$\frac{0.00110 \times 1000}{17.60} = 0.0625$ mol dm <sup>-3</sup> <b>OR</b> $6.25 \times 10^{-2}$ mol dm <sup>-3</sup> ✓	1	<b>ALLOW</b> 0.063 <b>OR</b> $6.3 \times 10^{-2}$ mol dm <sup>-3</sup>  <b>ALLOW</b> ECF for answer (ii) × 1000/17.60 <b>OR</b> ECF from (i) for answer (i)/2 × 1000/17.60 as calculator value or correct rounding to 2 significant figures or more but ignore trailing zeroes

	(c)	(i)	(The number of) Water(s) of crystallisation ✓	1	<b>IGNORE</b> hydrated <b>OR</b> hydrous
		(ii)	142.1 ✓  $x = \frac{(322.1 - 142.1)}{18.0} = 10$ ✓	2	<b>ALLOW</b> 142 <b>ALLOW</b> $M_r$ expressed as a sum  <b>ALLOW</b> ECF from incorrect $M_r$ and $x$ is <b>calculated correctly</b>  <b>ALLOW</b> ECF values of $x$ from nearest whole number to calculator value  <b>ALLOW</b> 2 marks if final answer is 10 <b>without any working</b>
			<b>Total</b>	<b>10</b>	

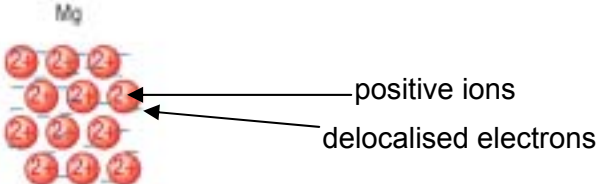


Question			Expected Answers	Marks	Additional Guidance
3	(a)	(i)	(Electrostatic) <b>attraction</b> between oppositely charged ions. ✓	1	<b>IGNORE</b> force <b>IGNORE</b> references to transfer of electrons <b>MUST</b> be ions, not particles
		(ii)	Mg shown with either 8 or 0 electrons <b>AND</b> S shown with 8 electrons <b>with</b> 2 crosses and 6 dots (or vice versa) ✓  Correct charges on both ions ✓  	2	Mark charges on ions and electrons independently <b>For first mark</b> , if 8 electrons are shown around the Mg then 'extra electrons' around S must match the symbol chosen for electrons around Mg  Shell circles not required  <b>IGNORE</b> inner shell electrons  Brackets are not required
	(b)	(i)	Electron pairs in covalent bonds shown correctly using dots and crosses in a molecule of the F <sub>2</sub> O ✓  Lone pairs correct on O and both F atoms ✓  	2	Must be 'dot-and-cross' circles for outer shells <b>NOT</b> needed <b>IGNORE</b> inner shells  Non-bonding electrons of O do not need to be shown as pairs  Non-bonding electrons of F do not need to be shown as pairs
		(ii)	Predicted bond angle 104–105°. ✓  There are 2 bonded pairs and 2 lone pairs ✓ Lone pairs repel more than bonded pairs ✓	3	<b>ALLOW</b> 103–105° (103° is the actual bond angle)  <b>ALLOW</b> responses equivalent to second marking point. e.g. There are 4 pairs of electrons and 2 of these are lone pairs <b>ALLOW</b> 'bonds' for 'bonded pairs' <b>DO NOT ALLOW</b> 'atoms repel' <b>DO NOT ALLOW</b> electrons repel <b>ALLOW</b> LP for 'lone pair' <b>ALLOW</b> BP for bonded pair <b>ALLOW</b> LP repel more if bonded pairs have already been mentioned

Question	Expected Answers	Marks	Additional Guidance
(c) (i)	<p>(At least) two <math>\text{NH}_3</math> molecules with correct dipole shown with at least one H with <math>\delta^+</math> and one N with <math>\delta^-</math> ✓</p> <p>(Only) one hydrogen bond from N atom on one molecule to a H atom on another molecule ✓</p> <p>Lone pair shown on the N atom and hydrogen bond must hit the lone pair ✓</p> 	3	<p><b>DO NOT ALLOW</b> first mark for ammonia molecules with incorrect lone pairs</p> <p><b>DO NOT ALLOW</b> first mark if <math>\text{H}_2\text{O}</math>, <math>\text{NH}_2</math> or <math>\text{NH}</math> is shown</p> <p><b>ALLOW</b> hydrogen bond need not be labelled as long as it clear the bond type is different from the covalent N–H bond</p> <p><b>ALLOW</b> a line (i.e. looks like a covalent bond) as long as it is labelled 'hydrogen bond'</p> <p><b>ALLOW</b> 2-D diagrams</p> <p><b>ALLOW</b> two marks if water molecules are used. One awarded for a correct hydrogen bond and one for the involvement of lone pair</p>
(ii)	<p>Liquid <math>\text{H}_2\text{O}</math> is denser than solid ✓</p> <p>In solid state <math>\text{H}_2\text{O}</math> molecules are held apart by hydrogen bonds <b>OR</b> ice has an open lattice ✓</p> <p><b>OR</b></p> <p><math>\text{H}_2\text{O}</math> has a relatively high boiling point <b>OR</b> melting point ✓</p> <p>(relatively strong) hydrogen bonds need to be broken <b>OR</b> a lot of energy is needed to overcome hydrogen bonds <b>OR</b> hydrogen bonds are strong ✓</p>	2	<p>ORA</p> <p><b>ALLOW</b> ice floats for first mark</p> <p><b>ALLOW</b> higher melting <b>OR</b> boiling point than expected</p> <p><b>DO NOT ALLOW</b> <math>\text{H}_2\text{O}</math> has a high melting / boiling point</p> <p><b>ALLOW</b> other properties caused by hydrogen bonding not mentioned within the specification</p> <p>E.g. high surface tension – strong hydrogen bonds on the surface</p>
	<b>Total</b>	<b>13</b>	

Question		Expected Answers	Marks	Additional Guidance
4	(a)	<p><i>Advantage</i> removes or kills bacteria <b>OR</b> kills germs <b>OR</b> kills micro-organisms <b>OR</b> make it safe to drink <b>OR</b> sterilises water <b>OR</b> disinfects water ✓</p> <p><i>Disadvantage</i> it is toxic <b>OR</b> poisonous <b>OR</b> could form chlorinated hydrocarbons ✓</p>	2	<p><b>ALLOW</b> to make water potable <b>IGNORE</b> virus <b>IGNORE</b> 'purifies water' <b>DO NOT ALLOW</b> 'antiseptic'</p> <p><b>ALLOW forms</b> carcinogens <b>OR</b> forms toxins <b>IGNORE</b> harmful <b>DO NOT ALLOW</b> 'it causes cancer' <b>DO NOT ALLOW</b> "It kills you"</p>
	(b)	$3d^{10} 4s^2 4p^5$ ✓	1	<p><b>ALLOW</b> <math>4s^2 3d^{10} 4p^5</math> <b>ALLOW</b> subscripts or <math>3D^{10}</math> <b>ALLOW</b> answers with <math>1s^2 2s^2 2p^6 3s^2 3p^6</math> appearing twice</p>
	(c) (i)	$Cl_2 + 2Br^- \rightarrow Br_2 + 2Cl^-$ ✓	1	<p><b>IGNORE</b> state symbols <b>ALLOW</b> any correct multiple including fractions</p>
	(ii)	Yellow / orange / red / brown ✓	1	<b>ALLOW</b> any combination of these, but no others
	(d) (i)	Disproportionation ✓	1	<p><b>ALLOW</b> versions which sound the same</p> <p><b>DO NOT ALLOW</b> disproportional <b>OR</b> disproportionate <b>OR</b> disproportion</p>
	(ii)	<p><math>Cl_2 + 2NaOH \rightarrow NaClO + NaCl + H_2O</math> ✓</p> <p><math>3Cl_2 + 6NaOH \rightarrow NaClO_3 + 5NaCl + 3H_2O</math></p> <p><math>Cl_2</math> and NaOH as reactants <b>AND</b> <math>NaClO_3</math> and NaCl as products ✓</p> <p>Rest of the equation ✓</p>	3	<p><b>ALLOW</b> multiples for either equation</p> <p><b>ALLOW</b> <math>3Cl_2 + 6NaOH \rightarrow 2NaClO_3 + 4NaCl + 3H_2</math></p>
	(iii)	$NaClO_4$ ✓	1	<b>ALLOW</b> $Na_3ClO_5$ etc
<b>Total</b>			<b>10</b>	

Question			Expected Answers	Marks	Additional Guidance
5	(a)	(i)	Potassium <b>AND</b> argon ✓	1	<b>ALLOW</b> K and Ar
		(ii)	They are arranged in increasing atomic number <b>OR</b> Neither would show properties <b>OR</b> trends of rest of group <b>OR</b> Neither would show properties <b>OR</b> trends of rest of period <b>OR</b> They are arranged by electron configuration ✓	1	<b>ALLOW</b> any correct property difference e.g. This would place a reactive metal in the same group as noble gases  <b>ALLOW</b> they do not fit in with the rest of the group
	(b)	(i)	$2\text{Mg} + \text{O}_2 \rightarrow 2\text{MgO}$ ✓	1	<b>ALLOW</b> multiples. Correct species must be seen <b>IGNORE</b> state symbols
		(ii)	Fizzes <b>OR</b> bubbles <b>OR</b> gas produced <b>OR</b> effervescing ✓  Mg dissolves <b>OR</b> Mg disappears <b>OR</b> a solution is formed ✓	2	<b>DO NOT ALLOW</b> 'carbon dioxide gas produced' <b>DO NOT ALLOW</b> 'hydrogen produced' without 'gas'  <b>ALLOW</b> 'it for Mg' <b>IGNORE</b> Mg reacts <b>IGNORE</b> temperature change <b>IGNORE</b> steam produced
		(iii)	Quicker <b>OR</b> more vigorous <b>OR</b> gets hotter	1	<b>MUST</b> be a comparison of a reaction observation, not just 'more reactive'  <b>ALLOW</b> any comparison of greater rate including more bubbles etc. <b>DO NOT ALLOW</b> more gas produced

Question	Expected Answers	Marks	Additional Guidance
(c)	<p>Mg has a <b>giant</b> structure ✓</p> <p>Mg has <b>metallic</b> bonding OR description of metallic bonding as positive ions and <b>delocalised</b> electrons ✓</p> <p>(There is electrostatic attraction between) positive ions and electrons ✓</p> <p>Cl has a simple molecular <b>OR</b> simple covalent (lattice) ✓</p> <p>Cl has van der Waals' forces (between molecules) <b>OR</b> Cl has instantaneous dipole–induced dipoles <b>OR</b> temporary dipole–temporary dipole ✓</p>	6	<p><b>Metallic OR delocalised</b> seen spelt correctly at least <b>ONCE</b></p> <p><b>DO NOT ALLOW</b> as label nuclei <b>OR</b> protons for positive ions</p> <p><b>ALLOW</b> labelled diagram of metallic bonding for second and third marks</p>  <p>Lattice must have at least two rows of positive ions. If a Mg ion is shown it must correct charge</p> <p><b>ALLOW</b> for labels: + ions, positive ions, cations</p> <p><b>DO NOT ALLOW</b> as label nuclei <b>OR</b> protons for positive ions</p> <p><b>ALLOW</b> e<sup>-</sup> or e as label for electron</p> <p><b>DO NOT ALLOW</b> '-' without label for electron</p> <p><b>Covalent OR molecule OR molecular</b> seen spelt correctly at least <b>ONCE</b></p> <p><b>ALLOW</b> Cl is a (covalent) <b>molecule</b></p> <p><b>IGNORE</b> Cl has intermolecular bonding</p>

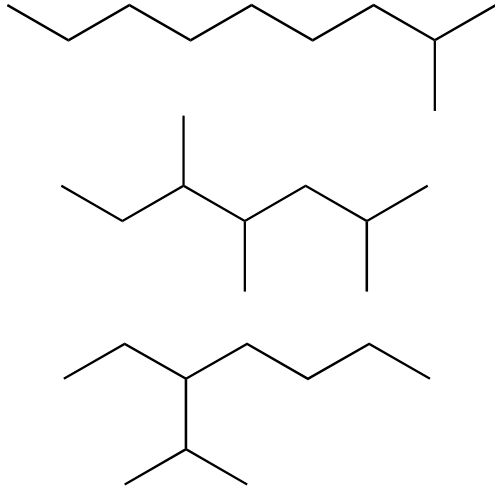
		<p>van der Waals' forces are weak <b>and</b> metallic bonds are strong  <b>OR</b>  van der Waals' forces are weaker than metallic bonds  <b>OR</b>  Less energy is needed to overcome van der Waals' than metallic bonds ✓</p>		<p><b>ALLOW</b> ECF from incorrect descriptions of giant structure with strong bonds; e.g. Mg has giant ionic structure  <b>ALLOW</b> ECF from any incorrect intermolecular forces e.g. permanent dipole –dipole from marking point 5    <b>ALLOW</b> vdW easier to break  ORA</p>
(d)	(i)	<p>O goes from –2 to 0 ✓    N goes from +5 to +4 ✓    N is reduced <b>AND</b> O is oxidised ✓</p>	3	<p>Oxidation numbers may be seen with equation    Third mark is dependent upon seeing a reduction in oxidation number of N and an increase in oxidation number of O    <b>ALLOW</b> ECF for third mark for N is oxidised <b>and</b> O is reduced if incorrect oxidation numbers support this    <b>IGNORE</b> references to strontium  <b>IGNORE</b> references to electron loss <b>OR</b> gain    <b>DO NOT ALLOW</b> 'One increases and one decreases'</p>

	<b>(d)</b>	<b>(ii)</b>	<p>Calculates correctly:  Mol of <math>\text{Sr}(\text{NO}_3)_2 = \frac{5.29}{211.6} = 0.0250 \checkmark</math></p> <p>Calculates correctly:  Mol of gas = <math>5/2 \times 0.0250 = 0.0625 \checkmark</math></p> <p>Calculates correctly:  Volume of gas = <math>24.0 \times 0.0625 = 1.50 \text{ dm}^3 \checkmark</math></p>	<b>3</b>	<p><b>ALLOW</b> 0.025</p> <p><b>ALLOW</b> ECF for first answer <math>\times 2.5</math> as calculator value or correct rounding to 2 significant figures or more but ignore trailing zeroes</p> <p><b>ALLOW</b> ECF for second answer <math>\times 24(.0)</math> as calculator value or correct rounding to 2 significant figures or more but ignore trailing zeroes</p> <p><b>DO NOT ALLOW</b> ECF of first answer <math>\times 24(.0)</math> (which gives <math>0.6(0) \text{ dm}^3</math>) as this has not measured the volume of any gas, simply <math>0.0250 \text{ mol}</math> of solid <math>\text{Sr}(\text{NO}_3)_2</math> converted into a gas  i.e. This answer would give <b>one</b> mark</p> <p><b>ALLOW</b> <math>1.5 \text{ dm}^3</math></p> <p><b>ALLOW</b> ECF producing correct volume of <math>\text{NO}_2</math> only  i.e. <math>1.2(0) \text{ dm}^3</math> would give <b>two</b> marks</p> <p><b>OR</b></p> <p><b>ALLOW</b> ECF producing correct volume of <math>\text{O}_2</math> only  i.e. <math>0.3(0) \text{ dm}^3</math> would give <b>two</b> marks</p>
<b>Total</b>			<b>18</b>		

# F322 Chains, Energy and Resources

Question		Expected Answers	Marks	Additional Guidance
1	(a)	Fractional distillation ✓  Because fractions have different boiling points ✓	2	<b>DO NOT ALLOW</b> just 'distillation'  For fractions, <b>ALLOW</b> components <b>OR</b> hydrocarbons <b>OR</b> compounds <b>ALLOW</b> condense at different temperatures <b>ALLOW</b> because van der Waals' forces differ between molecules <b>IGNORE</b> reference to melting points <b>IGNORE</b> 'crude oil' <b>OR</b> 'mixture' has different boiling points' ..... <b>but ALLOW</b> 'separates crude oil by boiling points
	(b) (i)	Decane ✓	1	<b>DO NOT ALLOW</b> deceane
	(ii)	Skeletal formula of branched C <sub>10</sub> H <sub>22</sub> ✓	1	Formula <b>must</b> be skeletal <b>AND</b> must not include any symbol, e.g. CH <sub>3</sub>  Any possible skeletal formulae e.g.

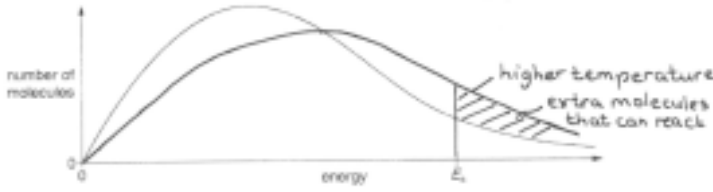


Question		Expected Answers	Marks	Additional Guidance
				
	(iii)	<p>Decane has more surface contact <b>OR</b> branched chains have less surface contact ✓</p> <p>Decane has more van der Waals' forces <b>OR</b> branched chains have fewer van der Waals' forces ✓</p>	2	<p><b>Both answers need to be comparisons</b> Assume 'it' refers to decane <b>IGNORE</b> surface area <b>ALLOW</b> straight chains can get closer together <b>OR</b> branched chains cannot get as close to one another <b>IGNORE</b> branched chain are more compact</p> <p><b>ALLOW</b> Decane has stronger van der Waals' forces <b>OR</b> branched chains have weaker van der Waals' forces</p> <p>More intermolecular forces is <b>not</b> sufficient</p>
	(iv)	<p>Branched chains have more efficient combustion <b>OR</b> decane has less efficient combustion ✓</p>	1	<p><b>ALLOW</b> branched chains are easier to burn <b>OR</b> easier to combust <b>OR</b> burn better <b>OR</b> more efficient fuel <b>OR</b> less likely to produce pre-ignition or knocking <b>OR</b> increases octane rating</p> <p><b>ALLOW</b> ORA for decane</p>

Question			Expected Answers	Marks	Additional Guidance
					Better fuel is <b>NOT</b> sufficient Burns more cleanly is <b>NOT</b> sufficient
	(c)	(i)	$\text{C}_{10}\text{H}_{22} + 15\frac{1}{2}\text{O}_2 \longrightarrow 10\text{CO}_2 + 11\text{H}_2\text{O}$ <p>All <b>four</b> species correct ✓</p> <p>balancing of four correct species ✓</p>	2	<b>ALLOW</b> any correct multiple <b>IGNORE</b> state symbols
		(ii)	$\text{N}_2 + \text{O}_2 \longrightarrow 2\text{NO} \quad \checkmark$	1	<b>ALLOW</b> any correct multiple including fractions <b>IGNORE</b> state symbols  The mark is for the equation <b>IGNORE</b> writing

Question		Expected Answers	Marks	Additional Guidance
	(d) (i)	Species with an unpaired electron ✓	1	<b>ALLOW</b> atom, molecule or particle with an unpaired electron <b>ALLOW</b> 'has an unpaired electron' <b>ALLOW</b> particle formed by homolytic fission  <b>DO NOT ALLOW</b> particle with a single electron <b>OR</b> particle with a free electron
	(ii)	catalyst ✓	1	
	(iii)	$O + O_2 \longrightarrow O_3$ <b>OR</b> O reacts with $O_2$ to make ozone <b>OR</b> the reaction is reversible ✓  Rate of formation of ozone is the same as rate of decomposition ✓	2	<b>ALLOW</b> $O_2 + O \rightleftharpoons O_3$ <b>OR</b> $O_3 \rightleftharpoons O_2 + O$ ✓✓  <b>ALLOW</b> is in equilibrium <b>OR</b> $\rightleftharpoons$ in <b>correct</b> equation <b>OR</b> has steady state condition ✓  <b>IGNORE</b> other equations involving ozone
	(iv)	absorbs (harmful) UV ✓	1	<b>ALLOW</b> 'keeps out UV' <b>OR</b> 'filters UV'  <b>ALLOW</b> increased UV could cause skin cancer <b>OR</b> increased UV could cause cataracts <b>OR</b> increased UV could cause mutation of crops ✓  <b>IGNORE</b> gamma
<b>Total</b>			<b>15</b>	

Question			Expected Answers	Marks	Additional Guidance
2	(a)	(i)	$2\text{H}_2\text{O}_2 \longrightarrow 2\text{H}_2\text{O} + \text{O}_2$ ✓	1	<b>ALLOW</b> any correct multiple including fractions <b>IGNORE</b> state symbols
		(ii)	More crowded particles <b>OR</b> more particles per (unit) volume ✓  more collisions per second <b>OR</b> more frequent collisions ✓	2	<b>ALLOW</b> particles are closer together <b>DO NOT ALLOW</b> 'area' instead of 'volume' <b>IGNORE</b> 'more concentrated particles'  <b>ALLOW</b> collisions more often <b>OR</b> increased rate of collision <b>OR</b> collisions are more likely <b>OR</b> there is a greater chance of collisions  'More collisions' is <b>not</b> sufficient
		(iii)	<b>Any two from the following:</b>  Reaction takes alternative route ✓  Activation energy is lowered ✓  More molecules have energy above activation energy <b>OR</b> more molecules have enough energy to react ✓	2	<b>ALLOW</b> catalyst changes reaction mechanism  <b>ALLOW</b> an alternative approach using adsorption particles <b>adsorbed</b> onto surface ✓  so bonds weakened as a result of the adsorption ✓

Question		Expected Answers	Marks	Additional Guidance
	(iv)	<p>Correct curve for higher temperature ✓</p> <p>Activation energy does not change  <b>OR</b> clearly labelled on diagram, e.g. <math>E_a</math> <b>OR</b> <math>E</math> ✓</p> <p>More molecules have energy above activation energy  <b>OR</b> more molecules have enough energy to react ✓</p>	3	<p>maximum of curve to right  <b>AND</b> lower than maximum of original curve  <b>AND</b> above dotted line at higher energy as shown in diagram below</p> <p><b>IGNORE</b> minor point of inflexion of curve</p>  <p>Note that the diagram above would score all 3 marks</p> <p>More successful collisions is <b>not</b> sufficient</p>
(b)	(i)	<p><math>\frac{34.0}{267.4} \times 100</math>  <b>267.4</b> ✓</p> <p>12.7% ✓</p>	2	<p>First mark for 267.4 <b>OR</b> (34.0 + 233.4) <b>OR</b> (169.3 + 98.1) at <b>bottom</b> of fraction with or without <math>\times 100</math></p> <p><b>ALLOW</b> from 2 sig figs up to calculator value  <b>ALLOW</b> full marks for 13 <b>OR</b> 12.7 <b>OR</b> 12.72 <b>OR</b> 12.715 up to calculator value with no working out  12.71 scores one mark only  <b>NO ECF</b> for this part from incorrect numbers in first expression</p>

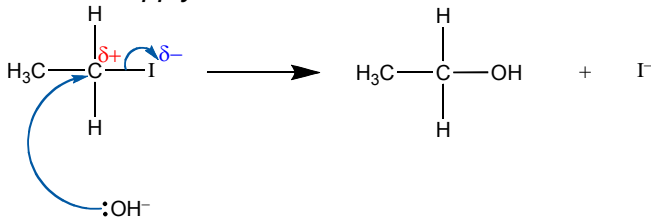
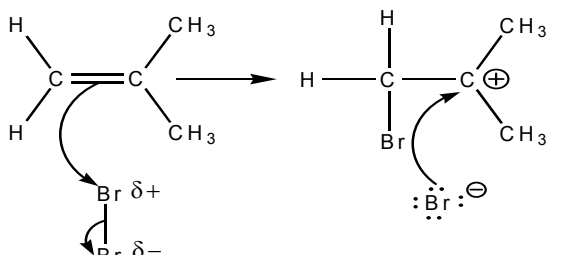
Question		Expected Answers	Marks	Additional Guidance
	(ii)	<p>Any three from the following:</p> <p>Oxygen comes from air ✓</p> <p>No poisonous materials formed  <b>OR</b> no poisonous materials involved ✓</p> <p>No waste products formed <b>OR</b> atom economy is 100% ✓</p> <p>Anthraquinone is regenerated <b>OR</b> recycled <b>OR</b> used again  <b>OR</b> Anthraquinone acts as a catalyst ✓</p>	3	<p><b>IGNORE</b> hydrogen comes from the air</p> <p><b>IGNORE</b> harmful</p> <p><b>ALLOW</b> higher atom economy</p>
	(c)	<p>Bond breaking absorbs energy  <b>AND</b> bond making releases energy ✓</p> <p>More energy released than absorbed ✓</p>	2	<p><b>ALLOW</b> bond breaking is endothermic  <b>AND</b> bond making is exothermic</p> <p><b>ALLOW</b> exothermic change transfers more energy than endothermic change  <b>OR</b> bond making transfers more energy than bond breaking  <b>OR</b> '(the sum of the) bond enthalpies in the products is greater than the (sum of the) bond enthalpies in the reactants'  <b>OR</b> '(the sum of the) bond enthalpies of the bonds made is greater than (the sum of) the bond enthalpies of the bonds broken'</p> <p><b>IGNORE</b> reference to strong and weak bonds</p> <p><b>IGNORE</b> enthalpy of products is less than enthalpy of reactants</p>
<b>Total</b>			<b>15</b>	

Question		Expected Answers	Marks	Additional Guidance
3	(a)	Respiration ✓	1	<b>IGNORE</b> anaerobic
	(b)	(i) $100 \times 4.18 \times 17.3$ ✓  7.23 (kJ) ✓	2	<b>ALLOW</b> 7231 J ✓  <b>ALLOW</b> 7.23 with no working out <b>ALLOW</b> from 7.2 up to calculator value of 7.2314  <b>ALLOW</b> from 0.060 up to calculator value for 1 mark (i.e. ECF from use of $m = 0.831$ in first stage)  <b>IGNORE</b> sign
		(ii) $M_r = 180$ ✓  amount = $4.62 \times 10^{-3}$ (mol) ✓	2	<b>ALLOW</b> $4.6 \times 10^{-3}$ <b>OR</b> $4.62 \times 10^{-3}$ <b>OR</b> $4.617 \times 10^{-3}$ up to calculator value <b>DO NOT ALLOW</b> 0.005 <b>ALLOW</b> ECF from wrong $M_r$
		(iii) $\Delta H_c = 1560$ (kJ) <b>OR</b> 1570 (kJ) but answer must be to 3 sig fig ✓  minus sign ✓	2	<b>ALLOW</b> ECF from 'answer to (i) ÷ answer to (ii)' but answer must be to 3 sig fig  minus mark is an independent mark

Question		Expected Answers	Marks	Additional Guidance
	(c)	+1250 ✓ +(-394 × 6) + (-286 × 6) <b>OR</b> -4080 ✓ -2830 ✓	3	<b>ALLOW</b> full marks for -2830 with no working out ✓✓✓  <b>ALLOW for 2 marks:</b> +2830 cycle wrong way around <b>OR</b> 1400 <b>OR</b> 860 one value not × 6 <b>OR</b> -5330 <b>OR</b> +5330 wrong sign for 1250 or 4080 <b>OR</b> +570 ✓✓ correct cycle but not × 6  <b>ALLOW for 1 mark:</b> -1400 <b>OR</b> -860 cycle wrong way around and one value not × 6 <b>OR</b> -570 cycle wrong way around and not × 6 <b>OR</b> -1930 <b>OR</b> +1930 ✓ wrong sign and not × 6  <b>Note:</b> There may be other possibilities.
	(d)	<b>Any two from the following:</b>  Heat released to the surroundings ✓  Incomplete combustion <b>OR</b> incomplete reaction <b>OR</b> not everything burns ✓  Non-standard conditions ✓	2	<b>ALLOW</b> heat loss  <b>IGNORE</b> reference to evaporation
		<b>Total</b>	<b>12</b>	

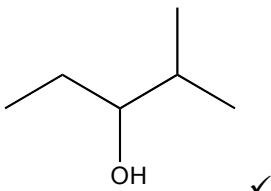
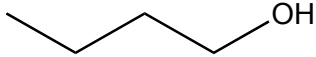
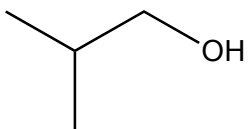
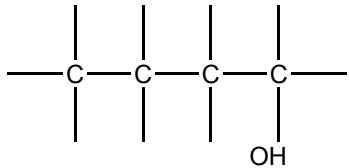
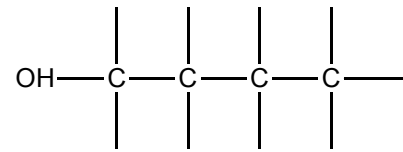


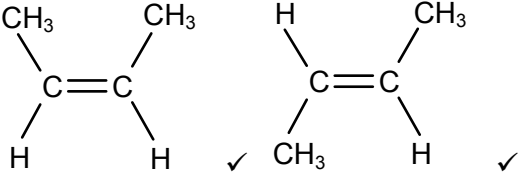
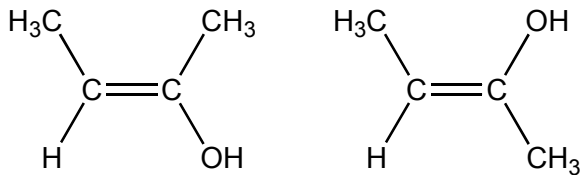
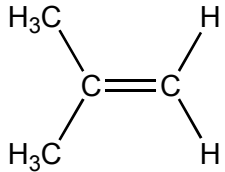
Question			Expected Answers	Marks	Additional Guidance
4	(a)	(i)	$\text{CH}_4 + \text{Br}_2 \longrightarrow \text{CH}_3\text{Br} + \text{HBr}$ ✓	1	<b>ALLOW</b> any correct multiple <b>IGNORE</b> state symbols
		(ii)	Dibromomethane <b>OR</b> tribromomethane <b>OR</b> tetrabromomethane ✓	1	<b>ALLOW</b> 1,1-dibromomethane <b>OR</b> 1,1,1-tribromomethane etc  <b>ALLOW</b> 1-dibromomethane  <b>DO NOT ALLOW</b> 2,2-dibromomethane etc  <b>ALLOW</b> correct formulae e.g. $\text{CH}_2\text{Br}_2$
		(iii)	$\text{Br}_2 \longrightarrow 2\text{Br}$ <b>OR</b> homolytic fission of bromine ✓  $\text{Br} + \text{CH}_4 \longrightarrow \text{HBr} + \text{CH}_3$ ✓ $\text{CH}_3 + \text{Br}_2 \longrightarrow \text{CH}_3\text{Br} + \text{Br}$ ✓  $\text{Br} + \text{CH}_3 \longrightarrow \text{CH}_3\text{Br}$ <b>OR</b> $\text{Br} + \text{Br} \longrightarrow \text{Br}_2$ ✓  Ethane made when two methyl radicals react <b>OR</b> $\text{CH}_3 + \text{CH}_3 \longrightarrow \text{C}_2\text{H}_6$ ✓  <b>Quality of Written Communication</b> – Consists of initiation step linked to correct equation propagation step linked to one equation in which there is a radical on the left and a radical on the right termination step linked to correct equation:  2 names of steps linked to correct equations ✓ <b>BUT</b> 3 names of steps linked to correct equations ✓✓	7	<b>All equations can be described in words</b>  Radicals do <b>NOT</b> need a single dot  <b>IGNORE</b> any state symbols  <b>ALLOW</b> any other suitable termination           If no equations are given to link the names of the step then award one mark for mention of all three steps

Question	Expected Answers	Marks	Additional Guidance
(b)	<p><b>EITHER</b>            Nucleophilic substitution ✓            Example of nucleophilic substitution ✓            Heterolytic fission ✓            C-I curly arrow ✓            Correct dipole on C—I bond ✓            OH<sup>-</sup> curly arrow from one lone pair on O of OH<sup>-</sup> ion  <b>OR</b> from minus sign on OH<sup>-</sup> ion ✓</p> <p><b>OR</b>            Electrophilic addition ✓            Example of electrophilic addition ✓            Heterolytic fission ✓            Curly arrow from C=C bond to Br—Br bond and            Dipole and curly arrow associated with Br<sub>2</sub> ✓            Correct carbocation ion ✓            Curly arrow from one lone pair on Br<sup>-</sup> ion  <b>OR</b> from minus sign on Br<sup>-</sup> ion ✓</p>	6	<p>The example mark can be awarded as an example of the name of the mechanism given or if the name is wrong can be given as an example of a reasonably correct drawn mechanism</p> <p>If <b>curly half arrows</b> drawn do not give a mark the first time used and then apply ECF</p>  <p><b>ALLOW</b> mechanisms for other halogenoalkanes</p>  <p><b>ALLOW</b> mechanisms for other halogens and hydrogen halides</p>
	<p><b>ALLOW</b>            Electrophilic substitution ✓            Example of electrophilic substitution ✓            Heterolytic fission ✓            Curly arrow from benzene ring to the electrophile (i.e. NO<sub>2</sub><sup>+</sup> OR Br<sup>+</sup>) ✓            Correct intermediate ✓            Curly arrow to show loss of hydrogen ion ✓</p>		<p><b>ALLOW</b>            Nucleophilic addition ✓            Example of nucleophilic addition ✓            Heterolytic fission ✓            Correct dipole on carbonyl group ✓            Curly arrow from lone pair on H<sup>-</sup> ion  <b>OR</b> from minus sign on H<sup>-</sup> to C=O carbon and breaking of C=O bond ✓            Curly arrow from carbonyl oxygen to either H<sup>+</sup> or H<sub>2</sub>O ✓</p>
<b>Total</b>	<b>15</b>		

Question		Expected Answers	Marks	Additional Guidance
5	(a)	Cracking ✓	1	<b>ALLOW</b> catalytic or thermal cracking ✓
	(b)	(i)	1	<b>ALLOW</b> correct formula if no name given: e.g. H <sub>3</sub> PO <sub>4</sub> <b>OR</b> H <sub>2</sub> SO <sub>4</sub> <b>OR</b> H <sup>+</sup> ✓  <b>ALLOW</b> correct name of acid even if an incorrect formula is used  <b>IGNORE</b> heterogeneous <b>OR</b> homogeneous
		(ii)	1	<b>DO NOT ALLOW</b> 'reaction shifts' The idea of a shift in equilibrium is essential
		(iii)	3	One mark for conditions. This mark is independent of the reasons for conditions  One mark for reason for the chosen temperature  One mark for reason for the chosen pressure <b>ALLOW</b> fewer moles of products
		(iv)	3	
	(c)	Propene ✓	1	<b>ALLOW</b> prop-1-ene ✓ <b>DO NOT ALLOW</b> prop-2-ene
	(d)	(i)	1	
		(ii)	1	<b>ALLOW</b> correct formula of or named carbonate <b>OR</b> alkali <b>OR</b> base Correct name and wrong formula does <b>not</b> score

Question		Expected Answers	Marks	Additional Guidance
	(e)	<p><b>Any two marks from the following:</b></p> <p>Develop photodegradable polymers ✓</p> <p>Develop biodegradable polymers <b>OR</b> develop compostable polymers ✓</p> <p>Develop techniques for cracking polymers <b>OR</b> develop use as a chemical feedstock ✓</p> <p>Develop ways of making polymers from plant-based substances <b>OR</b> reduce the need to use finite raw materials such as crude oil ✓</p> <p>Designing processes with high atom economy <b>OR</b> reduce waste products during manufacture ✓</p> <p>Develop ways of sorting <b>AND</b> recycling polymers ✓</p>	2	
		<b>Total</b>	<b>14</b>	

Question		Expected Answers	Marks	Additional Guidance
6	(a)	(i) 2-Methylpropan-2-ol ✓	1	<b>ALLOW</b> methylpropan-2-ol
	(b)	 ✓	1	Formula <b>must</b> be skeletal <b>AND</b> not include any symbol except for OH
	(c)	(i) Same <b>molecular</b> formula but different structural formulae ✓	1	<b>ALLOW</b> Same molecular formula but different arrangement of atoms <b>OR</b> Same molecular formula but different structures <b>OR</b> Same molecular formula but different displayed formulae  <b>DO NOT ALLOW</b> Same molecular formula but different spatial arrangement of atoms
		(ii) CH <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> CH <sub>2</sub> OH <b>OR</b> (CH <sub>3</sub> ) <sub>2</sub> CHCH <sub>2</sub> OH ✓  <b>ALLOW</b>  <b>OR</b> 	1	<b>ALLOW</b> displayed formula <b>ALLOW</b> sticks (i.e. no H shown bonded to C)  <b>ALLOW</b>  <i>sticks OK and -OH is OK</i> <b>DO NOT ALLOW</b> OH shown as below  <i>sticks OK but OH- is not OK</i>
				<b>ALLOW</b> correct ethers

Question		Expected Answers	Marks	Additional Guidance
	(d)	Has O–H (bonds) <b>OR</b> has hydroxyl (groups) <b>OR</b> has hydroxy (groups) ✓  Forms hydrogen bonds with water (molecules) ✓	2	<b>ALLOW</b> marks from a diagram of hydrogen bonding <b>IGNORE</b> reference to alcohol functional group  <b>DO NOT ALLOW</b> 'forms hydrogen bonds'
	(e)	CH <sub>3</sub> COOCH <sub>2</sub> CH <sub>2</sub> OOCCH <sub>3</sub>  1 mark for each ester end of molecule ✓✓	2	<b>ALLOW</b> displayed formula <b>OR</b> skeletal formula <b>ALLOW</b> sticks  CH <sub>3</sub> COOCH <sub>2</sub> CH <sub>2</sub> OH shows one of the two ester groups and scores one mark
(f)	(i)		2	<b>DO NOT ALLOW</b>   i.e. no ECF
	(ii)	<i>E/Z</i> ✓	1	<b>ALLOW</b> <i>cis-trans</i> <b>IGNORE</b> geometric
	(iii)	CH <sub>3</sub> CH <sub>2</sub> CH=CH <sub>2</sub> <b>OR</b> but-1-ene ✓	1	If but-1-ene given in part (i), <b>ALLOW</b> but-2-ene <b>OR</b> CH <sub>3</sub> CH=CHCH <sub>3</sub> i.e. ECF from (i)  <b>DO NOT ALLOW</b> methylpropene:  

Question	Expected Answers	Marks	Additional Guidance
From the evidence, candidates may have identified compound <b>F</b> as propanone, propanal or propanoic acid <ul style="list-style-type: none"> <li>The mark scheme for <b>F</b> = propanone and propanal is shown in the 'Expected Answers' column.</li> <li>The mark scheme for <b>F</b> = propanoic acid is shown in the 'Additional Guidance' column.</li> </ul> If <b>F</b> is propanone or propanoic acid, then maximum score = 7; <b>but</b> if <b>F</b> is propanal then maximum score = 6			
(g)	<b>Mark scheme for F = propanone and propanal</b>	7	<b>Mark scheme for F = propanoic acid</b>
	<b>mass spec of E– Remember to check the spectrum</b> <b>Quality of Written Communication</b> – mass spec gives M <sup>+</sup> or molecular ion of 60 <b>OR</b> mass spec gives parent ion of 60 <b>OR</b> highest <i>m/z</i> ( <b>ALLOW</b> <i>m/e</i> ) value is 60 ✓  <i>m/z</i> = 45 indicates loss of CH <sub>3</sub> <b>OR</b> <i>m/z</i> = 45 indicates presence of CH <sub>3</sub> CHOH <b>OR</b> CH <sub>2</sub> CH <sub>2</sub> OH <b>OR</b> C <sub>2</sub> H <sub>5</sub> O ✓		<b>mass spec of E– Remember to check the spectrum</b> <b>QWC</b> – mass spec gives M <sup>+</sup> or molecular ion of 60 <b>OR</b> mass spec gives parent ion of 60 <b>OR</b> highest <i>m/z</i> ( <b>OR</b> <i>m/e</i> ) value is 60 ✓  <i>m/z</i> = 45 indicates loss of CH <sub>3</sub> <b>OR</b> <i>m/z</i> = 45 indicates presence of CH <sub>3</sub> CHOH <b>OR</b> CH <sub>2</sub> CH <sub>2</sub> OH <b>OR</b> C <sub>2</sub> H <sub>5</sub> O ✓
	<b>IR of F – Remember to check the spectrum</b> IR shows no broad absorption between 2500 to 3300 cm <sup>-1</sup> so no O–H bond <b>OR</b> no broad absorption between 2500 to 3300 cm <sup>-1</sup> so not a carboxylic acid ✓  IR shows absorption at 1700 cm <sup>-1</sup> due to a C=O bond <b>OR</b> absorption at 1700 cm <sup>-1</sup> indicates a ketone <b>OR</b> aldehyde present ✓		<b>IR of F– Remember to check the spectrum</b> IR shows (broad) absorption somewhere between 3500 and 2500 cm <sup>-1</sup> suggests carboxylic acid <b>OR</b> O–H bond ✓  IR shows absorption at 1700 cm <sup>-1</sup> due to C=O <b>OR</b> absorption at 1700 cm <sup>-1</sup> indicates a carboxylic acid ✓
	<b>Identification and equation</b> <b>F</b> is CH <sub>3</sub> COCH <sub>3</sub> <b>OR</b> propanone ✓  <b>E</b> is CH <sub>3</sub> CHOHCH <sub>3</sub> <b>OR</b> propan-2-ol ✓  CH <sub>3</sub> CHOHCH <sub>3</sub> + [O] → CH <sub>3</sub> COCH <sub>3</sub> + H <sub>2</sub> O ✓  If <b>F</b> has been incorrectly identified as propanal, mark identification and equation as ECF, so max = 2 <b>ALLOW</b> <b>E</b> is CH <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> OH ✓  <b>ALLOW:</b> CH <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> OH + [O] → CH <sub>3</sub> CH <sub>2</sub> CHO + H <sub>2</sub> O ✓		<b>Identification and equation</b> <b>F</b> is CH <sub>3</sub> CH <sub>2</sub> COOH <b>OR</b> propanoic acid ✓  <b>E</b> is CH <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> OH <b>OR</b> propan-1-ol ✓  CH <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> OH + 2[O] → CH <sub>3</sub> CH <sub>2</sub> COOH + H <sub>2</sub> O ✓
<b>Total</b>		19	

**Extra guidance for marking of Q6(g)**

If **E** has **not** been identified **OR** if **F** has been identified as a **ketone or aldehyde**, use the **left-hand** mark scheme

If **F** has been identified as a **carboxylic acid**, use the **right-hand** mark scheme

**Mass spec**

These two marking points stand as **independent** marks whichever compounds have been identified.

The positive sign for fragment ions is not required. **IGNORE** negative charge.  
The mass spec may well be on the actual spectrum.

**IR mark**

These stand as **independent** marks whichever compounds have been identified.  
The IR analysis may well be on the actual spectrum.

**Identification marks**

If both structure and name are given they must **both** be correct  
but allow 'propanol' drawn with the correct structure because the position number of the –OH has been clearly identified

**ALLOW ECF** for identification of **F** e.g. if **E** is pentan-2-ol ✗ then an answer of pentan-2-one for **F** will be given a mark ✓ as ECF

**ALLOW** identification marks for **E** and **F** from equation

**Equation mark**

**ALLOW ECF** for any correct equation showing the oxidation of **any** alcohol to the appropriate product.

**ALLOW** molecular formulae in equations,

i.e.  $\text{C}_3\text{H}_7\text{OH} + [\text{O}] \rightarrow \text{C}_2\text{H}_5\text{CHO} + \text{H}_2\text{O} \checkmark$  ;  $\text{C}_3\text{H}_8\text{O} + [\text{O}] \rightarrow \text{C}_3\text{H}_6\text{O} + \text{H}_2\text{O} \checkmark$  ;  $\text{C}_3\text{H}_7\text{OH} + [\text{O}] \rightarrow \text{C}_2\text{H}_5\text{COH} + \text{H}_2\text{O} \checkmark$

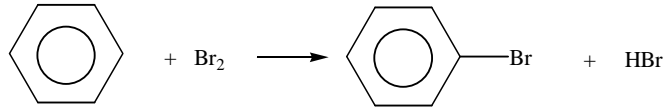
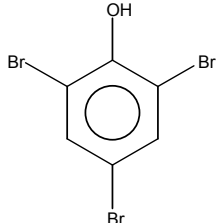


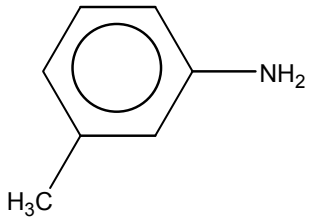
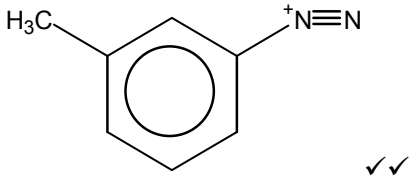
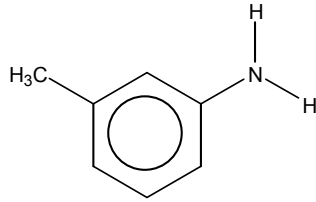
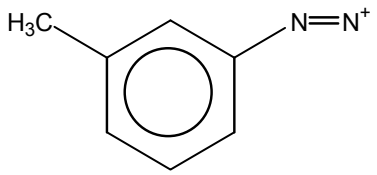
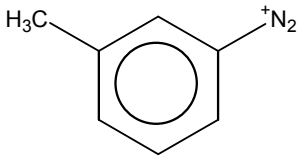
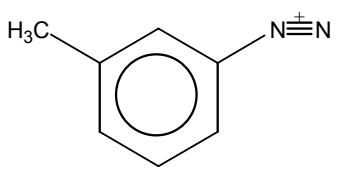
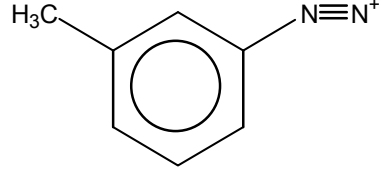
Question			Expected Answers	Marks	Additional Guidance
7	(a)	(i)	Infrared (radiation absorbed) ✓ by (C–H) bond vibration ✓	2	<b>ALLOW</b> bond stretching <b>OR</b> bond bending <b>DO NOT ALLOW</b> molecules vibrating
		(ii)	Greater concentration of carbon dioxide <b>OR</b> more carbon dioxide is being made ✓	1	<b>ALLOW</b> carbon dioxide is the main contributor to global warming <b>DO NOT ALLOW</b> any response that states that CO <sub>2</sub> causes ozone depletion <b>ALLOW</b> C=O bonds absorb IR more readily than C–H bonds <b>ALLOW</b> carbon dioxide has a greater greenhouse effect

Question		Expected Answers	Marks	Additional Guidance
7	(b)	<p><b>Any five from the following:</b></p> <p>Developing carbon capture <b>AND</b> storage ✓</p> <p>One example of CCS ✓</p> <p>Second example of CCS ✓</p> <p>Provide evidence to governments <b>OR</b> international conferences (e.g. Kyoto) <b>OR</b> reports to United Nations etc ✓</p> <p>Educating society <b>OR</b> writing in journals <b>OR</b> producing documentaries <b>OR</b> writing books <b>OR</b> making posters ✓</p> <p>Monitoring atmospheric changes ✓</p> <p>Develop alternative energy sources ✓ One example of an alternative energy source e.g. develop fuel cells <b>OR</b> developing solar power <b>OR</b> fuels that do not produce CO<sub>2</sub> ✓</p> <p>(Develop) more efficient engines for transport <b>OR</b> lean burn engines <b>OR</b> hybrid engines <b>OR</b> electric cars ✓</p> <p>Find uses for carbon dioxide <b>OR</b> named use: e.g. dry cleaning <b>OR</b> making decaffeinated coffee <b>OR</b> blowing agent <b>OR</b> fizzy drinks, etc ✓</p>	5	<p>carbon, capture <b>AND</b> storage required <b>ALLOW</b> CCS</p> <p><b>Examples of CCS</b></p> <p><b>deep</b> in the oceans <b>OR</b> on the <b>sea-bed</b> ✓ <b>DO NOT ALLOW</b> dissolve CO<sub>2</sub> in the sea <b>OR</b> stored in ocean</p> <p>storage in geological formations <b>OR</b> piped into disused or partially filled oil wells or porous rocks <b>OR</b> under the sea-bed ✓</p> <p>by reaction with metal oxides <b>OR</b> reaction to form (solid) carbonates <b>OR</b> stored as a carbonate <b>OR</b> equation to show formation of metal carbonate ✓ <b>IGNORE</b> mineral storage</p> <p><b>ALLOW</b> idea of biofuels only if linked to carbon-neutrality</p> <p><b>IGNORE</b> reforestation <b>IGNORE</b> reference to CFCs</p> <p><b>DO NOT ALLOW</b> use less carbon dioxide</p>

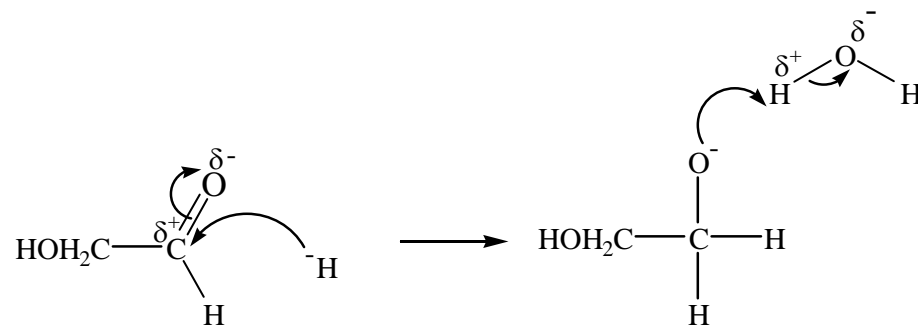
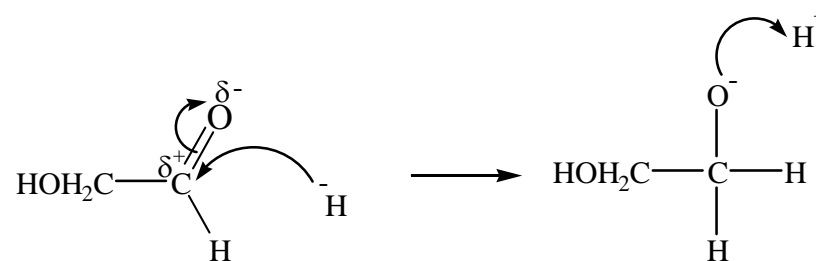
Question	Expected Answers	Marks	Additional Guidance
(c)	<p><b>Any two from the following:</b></p> <p>There are times when CO<sub>2</sub> has a <b>high</b> concentration and the temperature is also <b>high</b>  <b>OR</b>            There are times when CO<sub>2</sub> has a <b>low</b> concentration and the temperature is <b>low</b> ✓</p> <p>It is impossible to measure with certainty the average temperature years ago ✓</p> <p>There are other gases that may cause a greenhouse effect  <b>OR</b>            There are other factors that may cause a greenhouse effect ✓</p> <p>There are very few anomalous results ✓</p>	2	<p><b>ALLOW</b> a (positive) correlation between temperature and carbon dioxide concentration            but <b>DO NOT ALLOW</b> just 'a correlation'</p> <p><b>IGNORE</b> 'graphs are the same shape'  <b>IGNORE</b> 'graphs are similar'</p>
	<b>Total</b>	<b>10</b>	

# F324 Rings, Polymers and Analysis

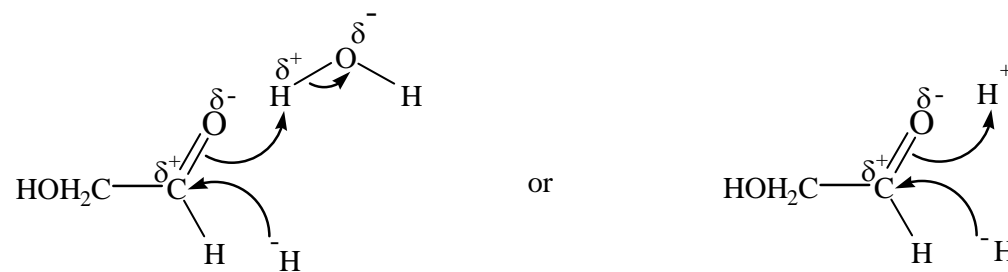
Question		Expected Answers	Marks	Additional Guidance
1	(a)		1	<p><b>ALLOW</b> <math>C_6H_6 + Br_2 \longrightarrow C_6H_5Br + HBr</math></p> <p><b>DO NOT ALLOW</b> multiple substitution <b>DO NOT ALLOW</b> <math>Br^+</math></p>
	(b) (i)	<p>White precipitate <b>OR</b> white solid <b>OR</b> white crystals ✓</p> 	2	<p><b>DO NOT ALLOW</b> colourless <b>DO NOT ALLOW</b> white ppt <u>and</u> bubbles</p> <p><b>DO NOT ALLOW</b> <math>Br_3C_6H_2OH</math> <b>OR</b> 2,4,6-tribromophenol <b>OR</b> tribromophenol</p>
	(ii)	1,2-Dibromocyclohexane ✓	1	<p><b>ALLOW</b> 1,2dibromocyclohexane <b>OR</b> 1-2dibromocyclohexane <b>OR</b> 1,2dibromocyclohexane <b>OR</b> cyclo-1,2-dibromohexane <b>DO NOT ALLOW</b> dibromocyclohexane <b>OR</b> <math>C_6H_{10}Br_2</math> <b>OR</b> structures</p>
	(iii)	<p><b>MUST</b> spell <u>delocalised/delocalized</u> or <u>localised/localized</u> correctly once in the answer to obtain all 5 marks</p> <p><b>benzene</b> <u>electrons</u> or <u><math>\pi</math>-bonds</u> are delocalised ✓</p> <p><b>phenol</b> a <u>lone</u> or <u>non-bonded</u> pair of electrons on the oxygen or the OH group is (partially) delocalised into the ring ✓</p> <p><b>cyclohexene</b> electrons are localised <b>OR</b> delocalised between two carbons ✓</p> <p>benzene has a lower <b>electron density</b> <b>OR</b> phenol has a higher electron density <b>OR</b> cyclohexene has a higher electron density ✓</p> <p>benzene cannot <b>polarise</b> or induce a dipole in <math>Br_2</math> <b>OR</b> phenol can polarise the <math>Br_2</math> <b>OR</b> cyclohexene can polarise <math>Br_2</math> or the Br-Br bond ✓</p>	5	<p><b>ALLOW</b> diagram to show overlap of all 6 p-orbitals for delocalisation <b>DO NOT ALLOW</b> benzene has delocalised structure or ring</p> <p><b>ALLOW</b> diagram to show movement of lone pair into ring for phenol</p> <p><b>ALLOW</b> diagram or description of overlap of 2 adjacent p-orbitals for bonding in cyclohexene <b>DO NOT ALLOW</b> cyclohexene has a C=C double bond <b>IGNORE</b> slip if cyclohexene is written as cyclohexane but <math>\pi</math>-bonding correctly described</p> <p><b>DO NOT ALLOW</b> charge density <b>OR</b> electronegativity instead of electron density <b>ALLOW</b> <math>Br^{\delta+}</math> <b>OR</b> electrophile <math>Br^+</math> as alternate to polarise</p>

(c)	 ✓  ✓✓ <div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 10px auto;"> <b>ALLOW ECF ✓✓ on incorrect amine</b> </div> <p>HNO<sub>2</sub> + HCl and temp &lt; 10 °C <b>OR</b> NaNO<sub>2</sub> + HCl and temp &lt; 10 °C ✓            alkaline <b>AND</b> phenol (if temperature stated must be below 10 °C) ✓</p>	<p><b>5</b></p>	<p><b>ALLOW</b></p>  <p><b>IGNORE</b> Cl<sup>-</sup> ion  <b>DO NOT ALLOW</b> if ring is connected to the N triple bond in the diazonium or if diazonium has a negative charge  <b>ALLOW</b> one mark for correct displayed diazonium if alkyl group is not shown</p> <p><b>ALLOW</b></p>  for both marks  for one mark <p><b>ALLOW</b></p>  for one mark  for one mark <p><b>ALLOW</b> NaOH <b>OR</b> KOH &amp; C<sub>6</sub>H<sub>5</sub>OH <b>OR</b> phenoxide ion <b>OR</b> C<sub>6</sub>H<sub>5</sub>O<sup>-</sup>  <b>ALLOW</b> reagents and conditions from the equations</p>
	<b>Total</b>	<b>14</b>	

Question		Expected Answers	Marks	Additional Guidance
2	(a) (i)	silver mirror ✓	1	<b>ALLOW</b> Ag(s) <b>OR</b> Ag mirror <b>OR</b> precipitate <b>OR</b> ppt <b>OR</b> solid <b>ALLOW</b> brown <b>OR</b> black <b>OR</b> grey
	(ii)	HOCH <sub>2</sub> COOH ✓	1	<b>ALLOW</b> CH <sub>2</sub> OHCOOH <b>OR</b> CH <sub>2</sub> OHCO <sub>2</sub> H <b>OR</b> HOCH <sub>2</sub> CO <sub>2</sub> H <b>OR</b> displayed <b>OR</b> skeletal formula <b>OR</b> HOCH <sub>2</sub> COO <sup>-</sup> <b>DO NOT ALLOW</b> C <sub>2</sub> H <sub>4</sub> O <b>OR</b> 2-hydroxyethanoic acid
	(b)	$\text{HOCH}_2\text{CHO} + 3[\text{O}] \rightarrow \text{HOCCOOH} + \text{H}_2\text{O}$ reagents ✓                      both products ✓	2	<b>ALLOW</b> displayed/skeletal formula/COOHCOOH ✓✓ if molecular formula used C <sub>2</sub> H <sub>4</sub> O <sub>2</sub> + 3[O] → C <sub>2</sub> H <sub>2</sub> O <sub>4</sub> + H <sub>2</sub> O max = 1 ✓  <b>Any correctly balanced equation for partial oxidation</b> can score 1 mark ✓ HOCH <sub>2</sub> CHO + [O] → HOCH <sub>2</sub> COOH <b>OR</b> HOCH <sub>2</sub> CHO + 2[O] → OHCCOOH + H <sub>2</sub> O <b>OR</b> HOCH <sub>2</sub> CHO + [O] → OHCCHO + H <sub>2</sub> O <b>OR</b> HOCH <sub>2</sub> CHO + 2[O] → HOCCCHO + H <sub>2</sub> O
	(c) (i)	HOCH <sub>2</sub> CH <sub>2</sub> OH ✓	1	<b>ALLOW</b> HO(CH <sub>2</sub> ) <sub>2</sub> OH <b>OR</b> (CH <sub>2</sub> OH) <sub>2</sub> <b>OR</b> skeletal formula <b>OR</b> displayed formula <b>DO NOT ALLOW</b> molecular formula (C <sub>2</sub> H <sub>6</sub> O <sub>2</sub> )
	(ii)	curly arrow from H <sup>-</sup> to C <sup>δ+</sup> ✓ dipoles <u>and</u> curly arrow from C=O bond to O ✓ intermediate ✓ curly arrow from intermediate to H <sup>δ+</sup> in H <sub>2</sub> O/ H <sup>+</sup> and if H <sub>2</sub> O is used it must show the curly arrow from the O–H bond to the O ✓  <i>lone pairs are not essential</i>	4	<b>ALLOW</b> curly arrow to C even if dipole missing or incorrect  <b>ALLOW</b> maximum of 3 marks if incorrect starting material is used  See page 36 for detailed mechanisms – <b>Alternative 3</b> scores all 4 marks even though the intermediate is not shown

**Alternative 1****Alternative 2**

products  
are not  
required

**Alternative 3****Total****9**

Question		Expected Answers	Marks	Additional Guidance
3	(a) (i)	adsorption ✓	1	<b>ALLOW</b> partition <b>OR</b> adsorbtion <b>IGNORE</b> solubility <b>OR</b> desorption <b>DO NOT ALLOW</b> absorption
	(ii)	measure how far each spot travels relative to the solvent front or calculate the $R_f$ value ✓  compare $R_f$ values to those for known amino acids ✓	2	<b>ALLOW</b> compare $R_f$ values to database <b>ALLOW</b> compare to known amino acids <b>DO NOT ALLOW</b> retention times for first mark, but the 2nd mark would be available as ✓ ECF <b>ALLOW</b> alternative approach: on the same plate compare position of spots ✓ with known amino acids ✓
	(iii)	(amino acids won't separate because) similar compounds have similar $R_f$ (values) ✓	1	<b>ALLOW</b> spots often overlap <b>OR</b> don't (fully) separate <b>ALLOW</b> they have similar $R_f$ (values) or similar adsorptions or similar retention times ECF to <b>a(ii)</b>
(b)	(i)	$\begin{array}{c} \text{H} \\   \\ \text{H}_2\text{N}-\text{C}-\text{COOH} \\   \\ \text{R} \end{array}$ ✓	1	<b>ALLOW</b> $\text{RCH}(\text{NH}_2)\text{COOH}$ any order for R, $\text{NH}_2$ and $\text{COOH}$ but C must be next to H ' <u>CH</u> ' must be shown <b>ALLOW</b> $\text{CO}_2\text{H}$ brackets around $\text{NH}_2$ are <b>not</b> essential <b>ALLOW</b> structure
	(ii)	must attempt 3D use <b>RE</b> symbol in the "tools" to denote whether or not each chiral C is a reflection of the one given in the question	3	each chiral C must have 2 — bonds, 1 wedge bond ( <b>IGNORE</b> shading) & 1 dash bond ( <b>IGNORE</b> wedge) check the clockwise orientation of each C. For each C start with the H and if on the: <ul style="list-style-type: none"> <li>• top C the H is followed by <math>\text{COOH}</math> it is not a mirror image. If it is a mirror image annotate using RE.</li> <li>• bottom C the H is followed by <math>\text{CH}_3</math> it is not a mirror image. If it is a mirror image annotate using RE.</li> </ul> the four groups can be attached in any order. If the molecule is drawn upside down – clockwise becomes anti-clockwise.  <b>MUST</b> check that the drawn structure is non-superimposable irrespective of the orientation or the way it has been drawn.  <b>IGNORE</b> bond linkage for all groups



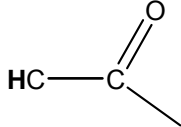
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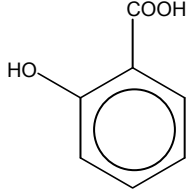

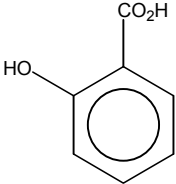
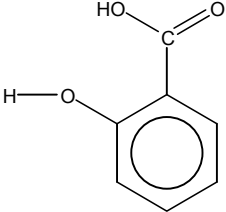
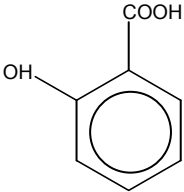
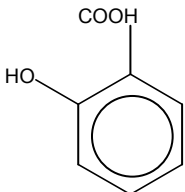
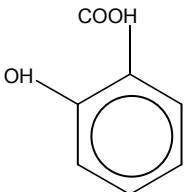

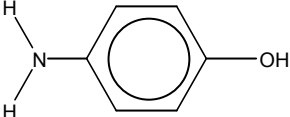
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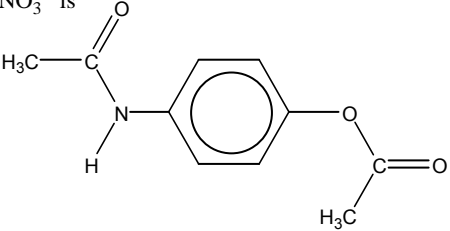
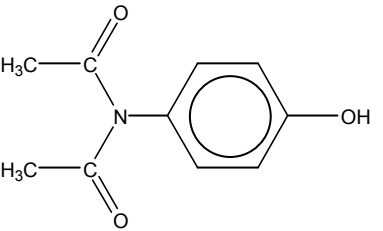
January 2010

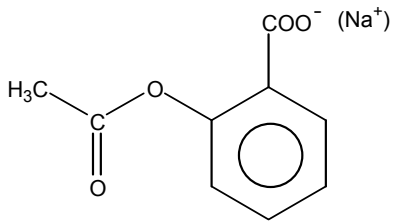
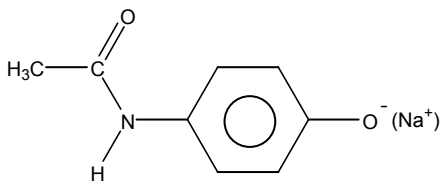
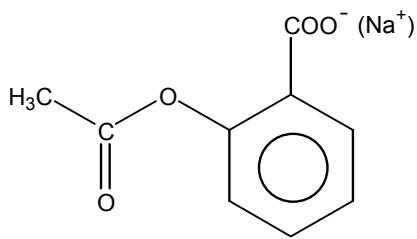
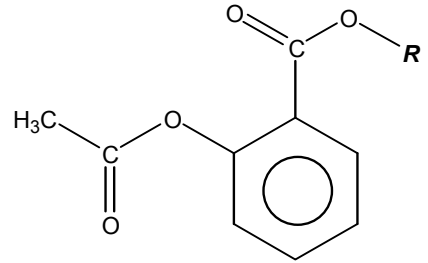
	(c)	<div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;"> <math display="block">\begin{array}{c} \text{H} \\   \\ \text{H}_3\text{N}^+ - \text{C} - \text{COO}^- \\   \\ \text{CH}_3 \end{array}</math> <p>alanine at pH = 6.0 ✓</p> </div> <div style="text-align: center;"> <math display="block">\begin{array}{c} \text{H} \\   \\ \text{H}_2\text{N} - \text{C} - \text{COO}^- \\   \\ (\text{CH}_2)_2 \\   \\ \text{COO}^- \end{array}</math> <p>glutamic acid at pH = 10 ✓</p> </div> <div style="text-align: center;"> <math display="block">\begin{array}{c} \text{H} \\   \\ \text{H}_3\text{N}^+ - \text{C} - \text{COOH} \\   \\ (\text{CH}_2)_4 \\   \\ \text{}^+\text{NH}_3 \end{array}</math> <p>lysine at pH = 2.0 ✓</p> </div> </div>		<p><b>ALLOW</b> <math>\text{CO}_2^-</math></p> <p><b>ALLOW</b> <math>\text{NH}_3^+</math></p> <p>If <math>\text{NH}_3</math> fully displayed <b>ALLOW</b> + charge on N or H</p> <p>If <math>\text{COO}</math> fully displayed <b>ALLOW</b> <math>-</math> charge on O only</p>
	(d)	valine–glycine–leucine ✓	1	<p><b>ALLOW</b> val–gly–leu</p> <p><b>DO NOT ALLOW</b> structures</p>
	(e)	$\text{H}_2\text{N}(\text{CH}_2)_6\text{NH}_2$ ✓  $\text{HOOC}(\text{CH}_2)_8\text{COOH}$ ✓	2	<p><b>ALLOW</b> <math>\text{H}_2\text{NCH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_2</math></p> <p><b>ALLOW</b> <math>\text{HOOCCH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{COOH}</math></p> <p><b>ALLOW</b> <math>\text{CO}_2\text{H}</math> for <math>\text{COOH}</math></p> <p><b>ALLOW</b> acid chloride, <math>\text{ClOC}(\text{CH}_2)_8\text{COCl}</math></p> <p><b>ALLOW</b> displayed formulae or skeletal formulae</p>
<b>Total</b>			<b>14</b>	

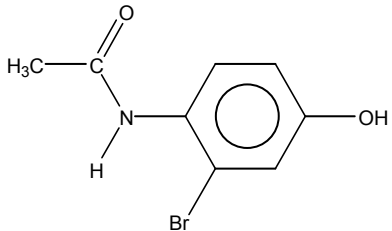
Question	Expected Answers	Marks	Additional Guidance
4 (a)	<p><b>infrared – 1 mark only</b> shows (very broad) peak between 2500–3300 (cm<sup>-1</sup>) (due to O–H bond) ✓</p> <p><b><sup>13</sup>C NMR – 2 marks</b> (CH<sub>3</sub>)<sub>2</sub>CHCH<sub>2</sub>COOH has 4 peaks (due to 4 different C environments) ✓ (CH<sub>3</sub>)<sub>3</sub>CCOOH has 3 peaks (due to 3 different C environments) ✓</p>	3	<p><b>ALLOW</b> (very broad) peak around 3000 (cm<sup>-1</sup>) <b>OR</b> any stated value between 2500 and 3300 (cm<sup>-1</sup>) for O–H <b>DO NOT ALLOW</b> peak in range 3200–3550 (cm<sup>-1</sup>)</p> <p><b>IGNORE</b> any reference to C=O or C–O as both are also present in an ester <b>OR</b> to fingerprint region</p> <p><b>ALLOW</b> '<sup>13</sup>C NMR detects the number of/different C environments' for 1 ✓, suitable example for the 2nd mark</p>
(b)	<p><b>splitting pattern</b> explains any two in terms of 'n + 1 rule' for two marks ✓✓ Explains any one peak for 1 mark ✓</p> <ul style="list-style-type: none"> <li>• <i>singlet</i> therefore adjacent C (if any) has no Hs</li> <li>• <i>multiplet</i> <b>OR</b> split into 7 therefore adjacent Cs have lots of/6 Hs</li> <li>• <i>doublet</i> therefore adjacent C is bonded to 1H</li> </ul> <p><i>must spell one of multiplet / heptet, singlet, doublet correctly</i></p> <p style="text-align: right;"><b>max = 2 marks</b></p> <p><b>chemical shifts</b></p>	6	<p><b>1 mark</b> for correct ester</p> <p>if two splitting patterns are correctly analysed <b>ignore</b> the third</p> <p><b>ALLOW</b> singlet because next or bonded to an O</p> <p><b>ALLOW</b> multiplet/heptet because next to 2 CH<sub>3</sub>s</p> <p><b>ALLOW</b> doublet because next to a CH</p> <p><b>ALLOW</b> tolerance on δ values; 3.6–3.8, 2.6–2.8 and 1.1–1.3</p>

	<p>two marks if any two absorptions are identified correctly ✓✓  one mark if any one absorption is identified correctly ✓</p> <ul style="list-style-type: none"> <li>• peak ~3.7 (ppm) – bonded to an O</li> <li>• peak ~2.7 (ppm) – indicates it is next to a C=O</li> <li>• peak ~1.2 (ppm) – bonded to other Cs <b>OR</b> part of a chain</li> </ul> <p style="text-align: right;"><b>max = 2 marks</b></p> <p>compound identified as <math>(\text{CH}_3)_2\text{CHCOOCH}_3</math> ✓✓  <b>2 marks</b></p> <p>compound identified as <math>\text{CH}_3\text{COOCH}(\text{CH}_3)_2</math> ✓  <b>1 mark</b></p>		<p>(ppm)</p> <p><b>ALLOW</b> any two gets 2 marks, any one scores 1 mark</p> <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;"> <math>\text{HC}-\text{O}</math>  3.7 (ppm) </div> <div style="text-align: center;">   2.7 (ppm) </div> <div style="text-align: center;"> <math>\text{R}-\text{CH}</math>  1.2 (ppm) </div> </div> <p><b>ALLOW</b> peaks labelled on the spectrum  <b>ALLOW</b> singlet must be bonded to O, multiplet to C=O and doublet to CH or R for both chemical shift marks</p> <p>if two chemical shifts are correctly identified <b>IGNORE</b> the third</p>
	<b>Total</b>	<b>9</b>	

Question	Expected Answers	Marks	Additional Guidance
5 (a)	 	1	<p><b>ALLOW</b></p>  or  <p><b>DO NOT ALLOW</b> incorrect bond linkage</p>  or  or 
(b) (i)	<p>equation</p> $(\text{CH}_3\text{CO})_2\text{O} + \text{H}_2\text{N}-\text{C}_6\text{H}_4-\text{OH}$ <p>reactants ✓</p>  $\text{H}_3\text{C}-\text{C}(=\text{O})-\text{N}(\text{H})-\text{C}_6\text{H}_4-\text{OH} + \text{CH}_3\text{COOH}$ <p>products ✓</p>	2	<p><b>ALLOW</b></p> $(\text{CH}_3\text{CO})_2\text{O} + \text{H}_2\text{NC}_6\text{H}_4\text{OH} \rightarrow \text{CH}_3\text{CONHC}_6\text{H}_4\text{OH} + \text{CH}_3\text{COOH}$ <p><b>ALLOW</b></p>  <p><b>DO NOT ALLOW</b> molecular formulae</p>

	(ii)	<p><math>C_{10}H_{11}NO_3</math> is</p>  <p>or</p>  <p style="text-align: right;">✓</p>	1	<p><b>ALLOW</b> amide shown as either <math>CH_3CONH-</math> <b>OR</b> <math>H_3CCONH-</math> <b>OR</b> <math>CH_3COHN-</math> <b>OR</b> <math>H_3CCOHN-</math></p> <p><b>ALLOW</b> ester shown as either <math>-OCOCH_3</math> <b>OR</b> <math>-OOCCH_3</math></p>
	(iii)	to ensure that there are no (harmful) side effects ✓	1	<p><b>ALLOW</b> impurities reduce effectiveness (of drug) <b>OR</b> might be toxic <b>OR</b> avoids litigation <b>OR</b> harmful <b>OR</b> hazardous</p> <p><b>ALLOW</b> to ensure that the drug/active component is safe</p> <p><b>IGNORE</b> dangerous <b>OR</b> nasty <b>OR</b> can kill <b>OR</b> increased dosage</p>
(c)		<p>(aspirin contains) ester <b>AND</b> carboxylic acid ✓</p> <p>(paracetamol contains) amide <b>AND</b> phenol ✓</p>	2	<p><b>IGNORE</b> arene or benzene or aromatic or phenyl or methyl but any other group loses the mark</p> <p><b>ALLOW</b> carboxyl group</p> <p><b>DO NOT ALLOW</b> acid</p> <p><b>IGNORE</b> arene or benzene or aromatic or phenyl or methyl but any other group loses the mark</p> <p><b>ALLOW</b> peptide</p> <p><b>ALLOW</b> hydroxy(l)</p> <p><b>DO NOT ALLOW</b> hydroxide or alcohol</p> <p><b>DO NOT ALLOW</b> amine</p>
(d)	(i)	<b>Both</b>	3	<b>ALLOW</b> hydrolysis by $H^+(aq)$ or $H^+$ or $HCl(aq)$ or $HCl$ or $H_2SO_4(aq)$

	<p>Na <b>OR</b> NaOH ✓</p>  <p>from aspirin</p>  <p>from paracetamol</p>	<p>✓</p> <p>✓</p>	<p>or H<sub>2</sub>SO<sub>4</sub> to give hydroxybenzoic acid + ethanoic acid with aspirin ✓ and ammonium salt of 4-aminophenol + ethanoic acid with paracetamol ✓</p> <p><b>ALLOW</b> hydrolysis by OH<sup>-</sup>(aq) or NaOH(aq) and other alkali leading to hydrolysis to give carboxylate salt and phenoxide salt on the ring + ethanoate with aspirin ✓ and 4-aminophenoxide ion + ethanoate ion with paracetamol ✓</p> <p><b>ALLOW</b> HNO<sub>3</sub> (and H<sub>2</sub>SO<sub>4</sub>) to give NO<sub>2</sub> in one or more positions on the ring in both aspirin and paracetamol ✓✓</p> <p><b>DO NOT ALLOW</b> NH<sub>3</sub> but correct ammonium salts can be awarded 2 marks ECF</p> <p><b>DO NOT ALLOW</b> H<sub>2</sub>O but correct products can be awarded 2 marks ECF</p> <p>if no reagent there cannot be any marks for the products If reagent selected is incorrect but would react with <b>either</b> aspirin or paracetamol <b>ALLOW</b> ✓ ECF for the correct organic product</p>
(ii)	<p><b>aspirin only</b> NaHCO<sub>3</sub> <b>OR</b> Na<sub>2</sub>CO<sub>3</sub> <b>OR</b> metal oxide ✓</p> 	<p>✓</p>	<p><b>ALLOW</b> Mg, carbonates, NH<sub>3</sub> <b>ALLOW</b> alcohols (<b>ROH</b>) to give ester if no reagent there cannot be any marks for the products</p> <p>2</p>  <p>If reagent selected is incorrect but would react with <b>BOTH</b> aspirin and paracetamol <b>ALLOW</b> ✓ ECF for the correct organic product</p>
(iii)	<p><b>paracetamol only</b></p>		<p><b>ALLOW</b> Br<sub>2</sub> water</p>

			<p>Br<sub>2</sub> ✓</p>  <p style="text-align: right;">✓</p>	<p><b>2</b></p> <p><b>ALLOW</b> one or more Br at <b>any</b> position on the ring  <b>DO NOT ALLOW</b> Br substitution of OH  <b>ALLOW</b> acyl chloride or acid anhydride and corresponding ester  <b>ALLOW</b> FeCl<sub>3</sub> to form a purple <u>complex ion</u> (structure not required)  <b>ALLOW</b> diazonium and structure showing azo group substituting one of the Hs in the ring  if no reagent there cannot be any marks for the products</p> <p>If reagent selected is incorrect but would react with <b>BOTH</b> aspirin and paracetamol <b>ALLOW</b> ✓ ECF for the correct organic product</p>
			<b>Total</b>	<b>14</b>

# Grade Thresholds

Advanced GCE Chemistry A (H034/H434)  
January 2010 Examination Series

## Unit Threshold Marks

Unit		Maximum Mark	a	b	c	d	e	u
F321	Raw	60	46	40	35	30	25	0
	UMS	90	72	63	54	45	36	0
F322	Raw	100	77	68	59	51	43	0
	UMS	150	120	105	90	75	60	0
F324	Raw	60	43	38	33	29	25	0
	UMS	90	72	63	54	45	36	0

## Specification Aggregation Results

Overall threshold marks in UMS (i.e. after conversion of raw marks to uniform marks)

	Maximum Mark	A	B	C	D	E	U
H034	300	240	210	180	150	120	0

The cumulative percentage of candidates awarded each grade was as follows:

	A	B	C	D	E	U	Total Number of Candidates
H034	12.9	37.5	62.7	83.1	96.2	100	1415

**1415 candidates aggregated this series.**

For a description of how UMS marks are calculated see:  
<http://www.ocr.org.uk/learners/ums/index.html>

Statistics are correct at the time of publication.



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