OCR
RECOGNISING ACHIEVEMENT

GCE

Chemistry A

Advanced GCE **A2 H434**

Advanced Subsidiary GCE **AS H034**

Mark Schemes for the Units

January 2010

H034/H434/MS/R/10J

Oxford Cambridge and RSA Examinations

OCR (Oxford Cambridge and RSA) is a leading UK awarding body, providing a wide range of qualifications to meet the needs of pupils of all ages and abilities. OCR qualifications include AS/A Levels, Diplomas, GCSEs, OCR Nationals, 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.

Any enquiries about publications should be addressed to:

OCR Publications
PO Box 5050
Annesley
NOTTINGHAM
NG15 0DL

Telephone: 0870 770 6622
Facsimile: 01223 552610
E-mail: publications@ocr.org.uk

CONTENTS

Advanced GCE Chemistry A (H434)

Advanced Subsidiary GCE Chemistry A (H034)

MARK SCHEME FOR THE UNITS

F321 Atoms, Bonds and Groups

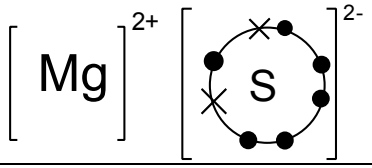
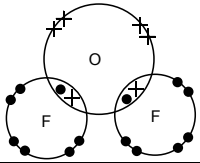
Question			Expected Answers	Marks	Additional Guidance
1	(a)		**Mass** of the **isotope** compared to 1/12th **OR** **mass** of the **atom** compared to 1/12th ✓ (the mass of a) carbon-12 **OR** ^{12}C (atom) ✓	2	**IGNORE** Reference to average **OR** weighted mean (i.e. correct definition of relative atomic mass will score both marks) **ALLOW** mass of a **mole** of the isotope/atom with 1/12th the mass of a **mole OR** 12 **g** of carbon-12 for two marks. **ALLOW 2 marks for:** '**Mass** of the isotope **OR mass** of the atom compared to ^{12}C atom given a mass of 12.0' i.e. 'given a mass of 12' **OR** C12 is 12 communicates the same idea as 1/12th.' **ALLOW** 12C **OR** C12 **ALLOW 2 marks for:** $\frac{\text{mass of the isotope}}{\text{mass of 1/12th mass of carbon-12}}$ i.e. fraction is equivalent to 'compared to' **ALLOW 1 mark for** 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 **mole OR** 12 g of carbon-12.' **DO NOT ALLOW** mass of 'ions' OR mass of element
	(b)		$\frac{(151 \times 47.77) + (153 \times 52.23)}{100}$ **OR** 72.1327 + 79.9119 **OR** 152.0446 (calculator value) ✓ A_r = 152.04 ✓	2	**ALLOW** Correct answer for two marks **ALLOW** 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

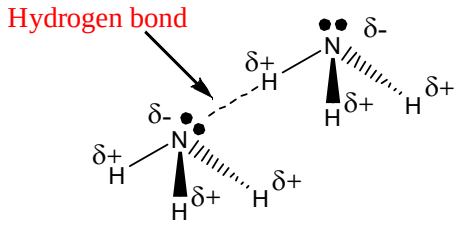
Question			Expected Answers	Marks	Additional Guidance
	(c)	(i)	^{153}Eu has (2) more neutrons **OR** ^{153}Eu has 90 neutrons **AND** ^{151}Eu has 88 neutrons ✓	1	**ALLOW** There are a different number of neutrons **IGNORE** Correct references to protons / electrons **DO NOT ALLOW** Incorrect references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

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

Question			Expected Answers	Marks	Additional Guidance
2	(a)	(i)	The H^+ ion in an (nitric) acid has been replaced by a metal ion **OR** by a Ca^{2+} ion ✓	1	**DO NOT ALLOW** it has been produced by the reaction of an acid and a base as this is stated in the question. **IGNORE** references to replacement by NH_4^+ ions or positive ions. **ALLOW** H **OR** Hydrogen for H^+; **DO NOT ALLOW** Hydrogen atoms **ALLOW** Ca **OR** Calcium for Ca^{2+}. **DO NOT ALLOW** Calcium atoms **ALLOW** 'metal' for 'metal ion
		(ii)	$2HNO_3(aq) + Ca(OH)_2(aq) \rightarrow Ca(NO_3)_2(aq) + 2H_2O(l)$ Formulae ✓ Balance **AND** states ✓	2	**ALLOW** multiples **ALLOW** (aq) **OR** (s) for $Ca(OH)_2$
		(iii)	Accepts a **proton OR** accepts $\mathbf{H^+}$ ✓	1	**ALLOW** $\mathbf{H^+} + OH^- \rightarrow H_2O$ **ALLOW** OH^- reacts with $\mathbf{H^+}$ **OR** OH^- takes $\mathbf{H^+}$ **ALLOW** OH^- 'attracts' $\mathbf{H^+}$ if 'to form water' is seen **DO NOT ALLOW** OH^- neutralises H^+ ('neutralises' is in the question)
	(b)	(i)	Calculates correctly $\frac{0.0880 \times 25.0}{1000} = 2.20 \times 10^{-3}$ mol **OR** 0.00220 mol ✓	1	**ALLOW** 0.0022 **OR** 2.2×10^{-3} mol
		(ii)	Calculates correctly $\frac{0.00220}{2} = 1.10 \times 10^{-3}$ mol **OR** 0.00110 mol ✓	1	**ALLOW** 0.0011 **OR** 1.1×10^{-3} mol **ALLOW** 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^{-3} **OR** 6.25×10^{-2} mol dm^{-3} ✓	1	**ALLOW** 0.063 **OR** 6.3×10^{-2} mol dm^{-3} **ALLOW** ECF for answer **(ii)** × 1000/17.60 **OR** 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

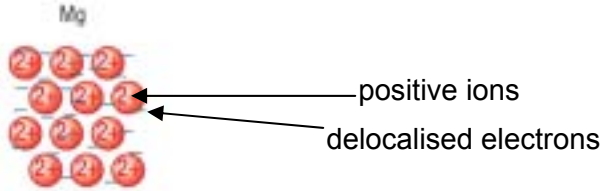
	(c)	**(i)**	(The number of) Water(s) of crystallisation ✓	**1**	**IGNORE** hydrated **OR** hydrous
		(ii)	142.1 ✓ $x = \frac{322.1 - 142.1}{18.0} = 10$ ✓	**2**	**ALLOW** 142 **ALLOW** M_r expressed as a sum **ALLOW** ECF from incorrect M_r and x is **calculated correctly** **ALLOW** ECF values of x from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

Question			Expected Answers	Marks	Additional Guidance
3	(a)	(i)	(Electrostatic) **attraction** between oppositely charged **ions**. ✓	1	**IGNORE** force **IGNORE** references to transfer of electrons **MUST** be ions, not particles
		(ii)	Mg shown with either 8 of 0 electrons **AND** S shown with 8 electrons **with** 2 crosses and 6 dots (or vice versa) ✓ Correct charges on both ions ✓ 	2	Mark charges on ions and electrons independently **For first mark**, 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 **IGNORE** 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_2O ✓ Lone pairs correct on O and both F atoms ✓ 	2	Must be '*dot-and-cross*' circles for outer shells **NOT** needed **IGNORE** 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^{O}. ✓ There are 2 bonded pairs and 2 lone pairs ✓ Lone pairs repel more than bonded pairs ✓	3	**ALLOW** 103–105^{O} (103^{O} is the actual bond angle) **ALLOW** responses equivalent to second marking point. e.g. There are 4 pairs of electrons and 2 of these are lone pairs **ALLOW** 'bonds' for 'bonded pairs' **DO NOT ALLOW** 'atoms repel' **DO NOT ALLOW** electrons repel **ALLOW** LP for 'lone pair' **ALLOW** BP for bonded pair **ALLOW** LP repel more if bonded pairs have already been mentioned

Question			Expected Answers	Marks	Additional Guidance
	(c)	(i)	(At least) two **NH_3** molecules with correct dipole shown with at least one H with δ^+ and one N with δ^- ✓	3	**DO NOT ALLOW** first mark for ammonia molecules with incorrect lone pairs **DO NOT ALLOW** first mark if H_2O, NH_2 or NH is shown
			(Only) one hydrogen bond from N atom on one molecule to a H atom on another molecule ✓		**ALLOW** hydrogen bond need not be labelled as long as it clear the bond type is different from the covalent N–H bond **ALLOW** a line (i.e. looks like a covalent bond) as long as it is labelled 'hydrogen bond)
			Lone pair shown on the N atom and hydrogen bond must hit the lone pair ✓  		**ALLOW** 2-D diagrams **ALLOW** two marks if water molecules are used. One awarded for a correct hydrogen bond and one for the involvement of lone pair
		(ii)	Liquid H_2O is denser than solid ✓ In solid state H_2O molecules are held apart by hydrogen bonds **OR** ice has an open lattice ✓ **OR** H_2O has a relatively high boiling point **OR** melting point ✓ (relatively strong) hydrogen bonds need to be broken **OR** a lot of energy is needed to overcome hydrogen bonds **OR** hydrogen bonds are strong ✓	2	ORA **ALLOW** ice floats for first mark **ALLOW** higher melting **OR** boiling point than expected **DO NOT ALLOW** H_2O has a high melting / boiling point **ALLOW** other properties caused by hydrogen bonding not mentioned within the specification E.g. high surface tension – strong hydrogen bonds on the surface
			Total	**13**	

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

Question			Expected Answers	Marks	Additional Guidance
5	(a)	(i)	Potassium **AND** argon ✓	1	**ALLOW** K and Ar
		(ii)	They are arranged in increasing atomic number **OR** Neither would show properties **OR** trends of rest of group **OR** Neither would show properties **OR** trends of rest of period **OR** They are arranged by electron configuration ✓	1	**ALLOW** any correct property difference e.g. This would place a reactive metal in the same group as noble gases **ALLOW** they do not fit in with the rest of the group
	(b)	(i)	$2Mg + O_2 \rightarrow 2MgO$ ✓	1	**ALLOW** multiples. Correct species must be seen **IGNORE** state symbols
		(ii)	Fizzes **OR** bubbles **OR** gas produced **OR** effervescing ✓ Mg dissolves **OR** Mg disappears **OR** a solution is formed ✓	2	**DO NOT ALLOW** 'carbon dioxide gas produced' **DO NOT ALLOW** 'hydrogen produced' without 'gas' **ALLOW** 'it for Mg' **IGNORE** Mg reacts **IGNORE** temperature change **IGNORE** steam produced
		(iii)	Quicker **OR** more vigorous **OR** gets hotter	1	**MUST** be a comparison of a reaction observation, not just 'more reactive' **ALLOW** any comparison of greater rate including more bubbles etc. **DO NOT ALLOW** more gas produced

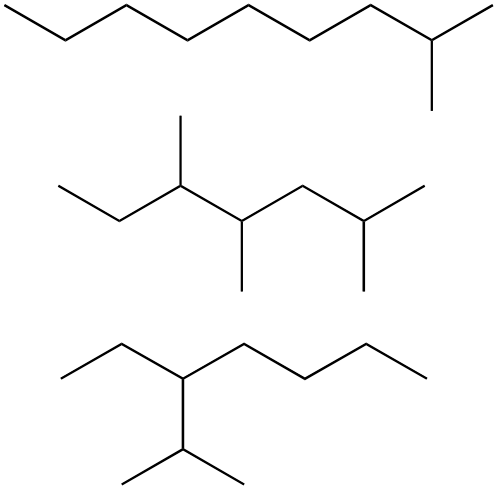
Question	Expected Answers	Marks	Additional Guidance
(c)	Mg has a **giant** structure ✓	6	
	Mg has **metallic** bonding OR description of metallic bonding as positive ions and **delocalised** electrons ✓		**Metallic OR delocalised** seen spelt correctly at least **ONCE**
	(There is electrostatic attraction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

			van der Waals' forces are weak **and** metallic bonds are strong **OR** van der Waals' forces are weak**er** than metallic bonds **OR** Less energy is needed to overcome van der Waals' than metallic bonds ✓		**ALLOW** ECF from incorrect descriptions of giant structure with strong bonds; e.g. Mg has giant ionic structure **ALLOW** ECF from any incorrect intermolecular forces e.g. permanent dipole –dipole from marking point 5 **ALLOW** vdW easi**er** to break ORA
	(d)	**(i)**	O goes from –2 to 0 ✓ N goes from +5 to +4 ✓ N is reduced **AND** O is oxidised ✓	**3**	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 **ALLOW** ECF for third mark for N is oxidised **and** O is reduced if incorrect oxidation numbers support this **IGNORE** references to strontium **IGNORE** references to electron loss **OR** gain **DO NOT ALLOW** 'One increases and one decreases'

	(d)	**(ii)**	Calculates correctly: Mol of $Sr(NO_3)_2$ = $\frac{5.29}{211.6}$ = 0.0250 ✓ Calculates correctly: Mol of gas = 5/2 × 0.0250 = 0.0625 ✓ Calculates correctly: Volume of gas = 24.0 × 0.0625 = 1.50 dm^3 ✓	**3**	**ALLOW** 0.025 **ALLOW** ECF for first answer × 2.5 as calculator value or correct rounding to 2 significant figures or more but ignore trailing zeroes **ALLOW** ECF for second answer × 24(.0) as calculator value or correct rounding to 2 significant figures or more but ignore trailing zeroes **DO NOT ALLOW** ECF of first answer × 24(.0) (which gives 0.6(0) dm^3) as this has not measured the volume of any gas, simply 0.0250 mol of solid $Sr(NO_3)_2$ converted into a gas i.e. This answer would give **one** mark **ALLOW** 1.5 dm^3 **ALLOW** ECF producing correct volume of NO_2 only i.e. 1.2(0) dm^3 would give **two** marks **OR** **ALLOW** ECF producing correct volume of O_2 only i.e. 0.3(0) dm^3 would give **two** marks
			Total	**18**	

F322 Chains, Energy and Resources

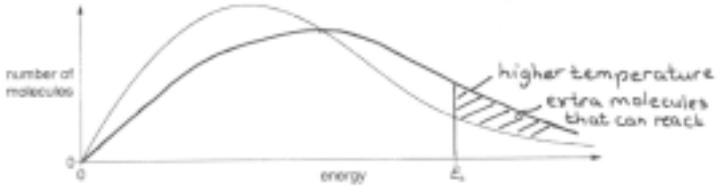
Question			Expected Answers	Marks	Additional Guidance
1	(a)		Fractional distillation ✓ Because fractions have different boiling points ✓	2	**DO NOT ALLOW** just 'distillation' For fractions, **ALLOW** components **OR** hydrocarbons **OR** compounds **ALLOW** condense at different temperatures **ALLOW** because van der Waals' forces differ between molecules **IGNORE** reference to melting points **IGNORE '**crude oil' **OR** 'mixture' has different boiling points' …… **but ALLOW** 'separates crude oil by boiling points
	(b)	(i)	Decane ✓	1	**DO NOT ALLOW** deceane
		(ii)	Skeletal formula of branched $C_{10}H_{22}$ ✓	1	Formula **must** be skeletal **AND** must not include any symbol, e.g. CH_3 Any possible skeletal formulae e.g.

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

Question			Expected Answers	Marks	Additional Guidance
					Better fuel is **NOT** sufficient Burns more cleanly is **NOT** sufficient
	(c)	**(i)**	$C_{10}H_{22} + 15½O_2 \longrightarrow 10CO_2 + 11H_2O$ All **four** species correct ✓ balancing of four correct species ✓	**2**	**ALLOW** any correct multiple **IGNORE** state symbols
		(ii)	$N_2 + O_2 \longrightarrow 2NO$ ✓	**1**	**ALLOW** any correct multiple including fractions **IGNORE** state symbols The mark is for the equation **IGNORE** writing

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

Question			Expected Answers	Marks	Additional Guidance
2	(a)	(i)	$2H_2O_2 \longrightarrow 2H_2O + O_2$ ✓	1	**ALLOW** any correct multiple including fractions **IGNORE** state symbols
		(ii)	More crowded particles **OR** more particles per (unit) volume ✓ more collisions per second **OR** more frequent collisions ✓	2	**ALLOW** particles are closer together **DO NOT ALLOW** 'area' instead of 'volume' **IGNORE** 'more concentrated particles' **ALLOW** collisions more often **OR** increased rate of collision **OR** collisions are more likely **OR** there is a greater chance of collisions 'More collisions' is **not** sufficient
		(iii)	**Any two from the following:** Reaction takes alternative route ✓ Activation energy is lowered ✓ More molecules have energy above activation energy **OR** more molecules have enough energy to react ✓	2	 **ALLOW** catalyst changes reaction mechanism **ALLOW** an alternative approach using adsorption particles **adsorbed** onto surface ✓ so bonds weakened as a result of the adsorption ✓

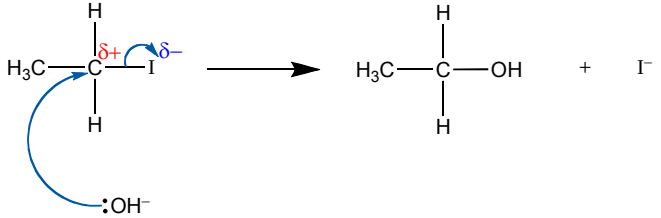
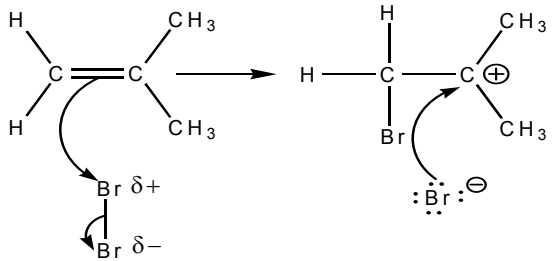
Question			Expected Answers	Marks	Additional Guidance
		(iv)	Correct curve for higher temperature ✓	3	maximum of curve to right **AND** lower than maximum of original curve **AND** above dotted line at higher energy as shown in diagram below **IGNORE** minor point of inflexion of curve
			Activation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

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

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

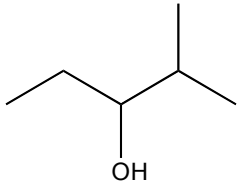
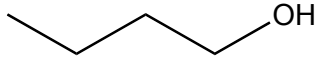
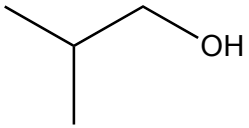
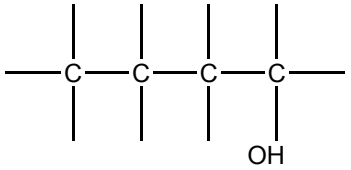
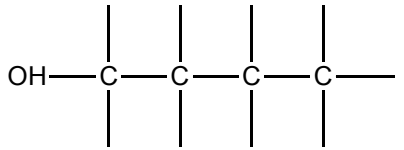
Question	Expected Answers	Marks	Additional Guidance
(c)	+1250 ✓ +(−394 × 6) + (−286 × 6) **OR** –4080 ✓ −2830 ✓	3	**ALLOW** full marks for −2830 with no working out ✓✓✓ **ALLOW for 2 marks:** +2830 cycle wrong way around **OR** 1400 **OR** 860 one value not × 6 **OR** –5330 **OR** +5330 wrong sign for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

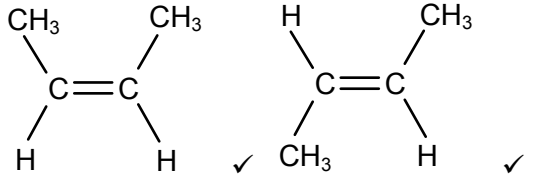
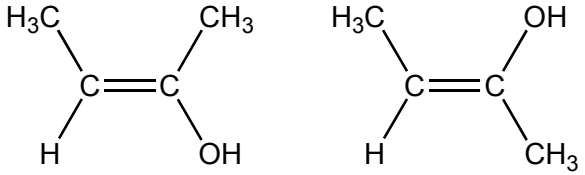
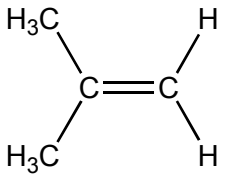
Question			Expected Answers	Marks	Additional Guidance
4	(a)	(i)	$CH_4 + Br_2 \longrightarrow CH_3Br + HBr$ ✓	1	**ALLOW** any correct multiple **IGNORE** state symbols
		(ii)	Dibromomethane **OR** tribromomethane **OR** tetrabromomethane ✓	1	**ALLOW** 1,1-dibromomethane **OR** 1,1,1-tribromomethane etc **ALLOW** 1-dibromomethane **DO NOT ALLOW** 2,2-dibromomethane etc **ALLOW** correct formulae e.g. CH_2Br_2
		(iii)	$Br_2 \longrightarrow 2Br$ **OR** homolytic fission of bromine ✓ $Br + CH_4 \longrightarrow HBr + CH_3$ ✓ $CH_3 + Br_2 \longrightarrow CH_3Br + Br$ ✓ $Br + CH_3 \longrightarrow CH_3Br$ **OR** $Br + Br \longrightarrow Br_2$ ✓ Ethane made when two methyl radicals react **OR** $CH_3 + CH_3 \longrightarrow C_2H_6$ ✓ **Quality of Written Communication** – 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 ✓ **BUT** 3 names of steps linked to correct equations ✓✓	7	**All equations can be described in words** Radicals do **NOT** need a single dot **IGNORE** any state symbols **ALLOW** 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)	**EITHER** Nucleophilic substitution ✓ Example of nucleophilic substitution ✓ Heterolytic fission ✓ C–I curly arrow ✓ Correct dipole on C— I bond ✓ OH^- curly arrow from one lone pair on O of OH^- ion **OR** from minus sign on OH^- ion ✓ **OR** 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_2 ✓ Correct carbocation ion ✓ Curly arrow from one lone pair on Br^- ion **OR** from minus sign on Br^- ion ✓	6	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 *If **curly half arrows** drawn do not give a mark the first time used and then apply ECF*  **ALLOW** mechanisms for other halogenoalkaes  **ALLOW** mechanisms for other halogens and hydrogen halides
	ALLOW Electrophilic substitution ✓ Example of electrophilic substitution ✓ Heterolytic fission ✓ Curly arrow from benzene ring to the electrophile (i.e. NO_2^+ OR Br^+) ✓ Correct intermediate ✓ Curly arrow to show loss of hydrogen ion ✓		**ALLOW** Nucleophilic addition ✓ Example of nucleophilic addition ✓ Heterolytic fission ✓ Correct dipole on carbonyl group ✓ Curly arrow from lone pair on H^- ion **OR** from minus sign on H^- to C=O carbon and breaking of C=O bond ✓ Curly arrow from carbonyl oxygen to either H^+ or H_2O ✓
	Total	**15**	

Question			Expected Answers	Marks	Additional Guidance
5	(a)		Cracking ✓	1	**ALLOW** catalytic or thermal cracking ✓
	(b)	(i)	Acid ✓	1	**ALLOW** correct formula if no name given: e.g. H_3PO_4 **OR** H_2SO_4 **OR** H^+ ✓ **ALLOW** correct name of acid even if an incorrect formula is used **IGNORE** heterogeneous **OR** homogeneous
		(ii)	The position of equilibrium will shift so as to minimise the effect of any change in conditions ✓	1	**DO NOT ALLOW** 'reaction shifts' The idea of a shift in equilibrium is essential
		(iii)	Low temperature **AND** high pressure ✓ Low temperature because the (forward) reaction is exothermic ✓ High pressure because there are fewer moles (of gas) on the right hand side ✓	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 **ALLOW** fewer moles of products
		(iv)	(60 atmosphere pressure is a) high pressure may be too expensive **OR** may cause safety problems ✓ (300 ºC is sufficiently high) to give a fast rate of reaction ✓ without shifting equilibrium to the left **OR** compromising equilibrium yield ✓	3	
	(c)		Propene ✓	1	**ALLOW** prop-1-ene ✓ **DO NOT ALLOW** prop-2-ene
	(d)	(i)	—CH_2CHCl— + $2\frac{1}{2}O_2 \longrightarrow 2CO_2 + H_2O + HCl$ ✓	1	
		(ii)	Alkali **OR** base **OR** carbonate ✓	1	**ALLOW** correct formula of or named carbonate **OR** alkali **OR** base Correct name and wrong formula does **not** score

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

Question			Expected Answers	Marks	Additional Guidance
6	(a)	(i)	2-Methylpropan-2-ol ✓	1	**ALLOW** methylpropan-2-ol
	(b)		 ✓	1	Formula **must** be skeletal **AND** not include any symbol except for OH
	(c)	(i)	Same **molecular** formula but different structural formulae ✓	1	**ALLOW** Same molecular formula but different arrangement of atoms **OR** Same molecular formula but different structures **OR** Same molecular formula but different displayed formulae **DO NOT ALLOW** Same molecular formula but different spatial arrangement of atoms
		(ii)	$CH_3CH_2CH_2CH_2OH$ **OR** $(CH_3)_2CHCH_2OH$ ✓ **ALLOW**  **OR** 	1	**ALLOW** displayed formula **ALLOW** sticks (i.e. no H shown bonded to C) **ALLOW**  *sticks OK and –OH is OK* **DO NOT ALLOW** OH shown as below  *sticks OK but OH– is not OK* **ALLOW** correct ethers

Question	Expected Answers	Marks	Additional Guidance
(d)	Has O–H (bonds) **OR** has hydroxyl (groups) **OR** has hydroxy (groups) ✓ Forms hydrogen bonds with water (molecules) ✓	**2**	**ALLOW** marks from a diagram of hydrogen bonding **IGNORE** reference to alcohol functional group **DO NOT ALLOW** 'forms hydrogen bonds'
(e)	$CH_3COOCH_2CH_2OOCCH_3$ 1 mark for each ester end of molecule ✓✓	**2**	**ALLOW** displayed formula **OR** skeletal formula **ALLOW** sticks $CH_3COOCH_2CH_2OH$ shows one of the two ester groups and scores one mark
(f) (i)	 ✓ ✓	**2**	**DO NOT ALLOW**  i.e. no ECF
(ii)	*E/Z* ✓	**1**	**ALLOW** *cis-trans* **IGNORE** geometric
(iii)	$CH_3CH_2CH=CH_2$ **OR** but-1-ene ✓	**1**	If but-1-ene given in part **(i)**, **ALLOW** but-2-ene **OR** $CH_3CH=CHCH_3$ i.e. ECF from **f(i)** **DO NOT ALLOW** methylpropene: 

Question	Expected Answers	Marks	Additional Guidance
From the evidence, candidates may have identified compound **F** as propanone, propanal or propanoic acid • The mark scheme for **F** = propanone and propanal is shown in the 'Expected Answers' column. • The mark scheme for **F** = propanoic acid is shown in the 'Additional Guidance' column. If **F** is propanone or propanoic acid, then maximum score = 7; **but** if **F** is propanal then maximum score = 6			
(g)	**Mark scheme for F = propanone and propanal**	**7**	**Mark scheme for F = propanoic acid**
	mass spec of E– Remember to check the spectrum **Quality of Written Communication –** mass spec gives M^+ or molecular ion of 60 **OR** mass spec gives parent ion of 60 **OR** highest *m*/*z* (**ALLOW** *m*/*e*) value is 60 ✓ *m*/*z* = 45 indicates loss of CH_3 **OR** *m*/*z* = 45 indicates presence of CH_3CHOH **OR** CH_2CH_2OH **OR** C_2H_5O ✓		**mass spec of E– Remember to check the spectrum** **QWC –** mass spec gives M^+ or molecular ion of 60 **OR** mass spec gives parent ion of 60 **OR** highest *m*/*z* (**OR** *m*/*e*) value is 60 ✓ *m*/*z* = 45 indicates loss of CH_3 **OR** *m*/*z* = 45 indicates presence of CH_3CHOH **OR** CH_2CH_2OH **OR** C_2H_5O ✓
	IR of F – Remember to check the spectrum IR shows no broad absorption between 2500 to 3300 cm^{-1} so no O—H bond **OR** no broad absorption between 2500 to 3300 cm^{-1} so not a carboxylic acid ✓ IR shows absorption at 1700 cm^{-1} due to a C=O bond **OR** absorption at 1700 cm^{-1} indicates a ketone **OR** aldehyde present ✓		**IR of F– Remember to check the spectrum** IR shows (broad) absorption somewhere between 3500 and 2500 cm^{-1} suggests carboxylic acid **OR** O–H bond ✓ IR shows absorption at 1700 cm^{-1} due to C=O **OR** absorption at 1700 cm^{-1} indicates a carboxylic acid ✓
	Identification and equation **F** is CH_3COCH_3 **OR** propanone ✓ **E** is $CH_3CHOHCH_3$ **OR** propan-2-ol ✓ $CH_3CHOHCH_3 + [O] \longrightarrow CH_3COCH_3 + H_2O$ ✓		**Identification and equation** **F** is CH_3CH_2COOH **OR** propanoic acid ✓ **E** is $CH_3CH_2CH_2OH$ **OR** propan-1-ol ✓ $CH_3CH_2CH_2OH + 2[O] \longrightarrow CH_3CH_2COOH + H_2O$ ✓
	If **F** has been incorrectly identified as propanal, mark identification and equation as ECF, so max = 2 **ALLOW E** is $CH_3CH_2CH_2OH$ ✓ **ALLOW**: $CH_3CH_2CH_2OH + [O] \rightarrow CH_3CH_2CHO + H_2O$ ✓		
	Total	**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

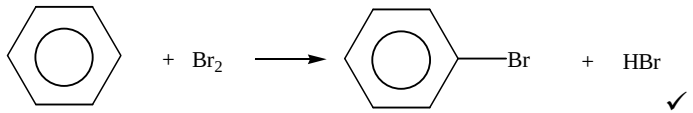
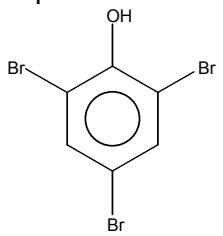
ALLOW ECF for any correct equation showing the oxidation of **any** alcohol to the appropriate product.
ALLOW molecular formulae in equations,
i.e. $C_3H_7OH + [O] \rightarrow C_2H_5CHO + H_2O$ ✓ ; $C_3H_8O + [O] \rightarrow C_3H_6O + H_2O$ ✓ ; $C_3H_7OH + [O] \rightarrow C_2H_5COH + H_2O$ ✓

Question			Expected Answers	Marks	Additional Guidance
7	(a)	(i)	Infrared (radiation absorbed) ✓ by (C–H) bond vibration ✓	2	**ALLOW** bond stretching **OR** bond bending **DO NOT ALLOW** molecules vibrating
		(ii)	Greater concentration of carbon dioxide **OR** more carbon dioxide is being made ✓	1	**ALLOW** carbon dioxide is the main contributor to global warming **DO NOT ALLOW** any response that states that CO_2 causes ozone depletion **ALLOW** C=O bonds absorb IR more readily than C–H bonds **ALLOW** carbon dioxide has a greater greenhouse effect

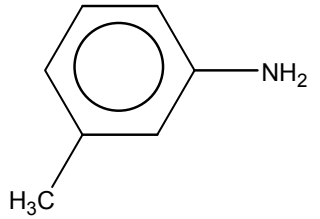
Question			Expected Answers	Marks	Additional Guidance
7	(b)		**Any five from the following:** Developing carbon capture **AND** storage ✓ One example of CCS ✓ Second example of CCS ✓ Provide evidence to governments **OR** international conferences (e.g. Kyoto) **OR** reports to United Nations etc ✓ Educating society **OR** writing in journals **OR** producing documentaries **OR** writing books **OR** making posters ✓ Monitoring atmospheric changes ✓ Develop alternative energy sources ✓ One example of an alternative energy source e.g. develop fuel cells **OR** developing solar power **OR** fuels that do not produce CO_2 ✓ (Develop) more efficient engines for transport **OR** lean burn engines **OR** hybrid engines **OR** electric cars ✓ Find uses for carbon dioxide **OR** named use: e.g. dry cleaning **OR** making decaffeinated coffee **OR** blowing agent **OR** fizzy drinks, etc ✓	**5**	carbon, capture **AND** storage required **ALLOW** CCS **Examples of CCS** **deep** in the oceans **OR** on the **sea-bed** ✓ **DO NOT ALLOW** dissolve CO_2 in the sea **OR** stored in ocean storage in geological formations **OR** piped into disused or partially filled oil wells or porous rocks **OR** under the sea-bed ✓ by reaction with metal oxides **OR** reaction to form (solid) carbonates **OR** stored as a carbonate **OR** equation to show formation of metal carbonate ✓ **IGNORE** mineral storage **ALLOW** idea of biofuels only if linked to carbon-neutrality **IGNORE** reforestation **IGNORE** reference to CFCs **DO NOT ALLOW** use less carbon dioxide

Question			Expected Answers	Marks	Additional Guidance
	(c)		**Any two from the following:** There are times when CO_2 has a **high** concentration and the temperature is also **high** **OR** There are times when CO_2 has a **low** concentration and the temperature is **low** ✓ It is impossible to measure with certainty the average temperature years ago ✓ There are other gases that may cause a greenhouse effect **OR** There are other factors that may cause a greenhouse effect ✓ There are very few anomalous results ✓	**2**	**ALLOW** a (positive) correlation between temperature and carbon dioxide concentration but **DO NOT ALLOW** just 'a correlation' **IGNORE** 'graphs are the same shape' **IGNORE** 'graphs are similar'
			Total	**10**	

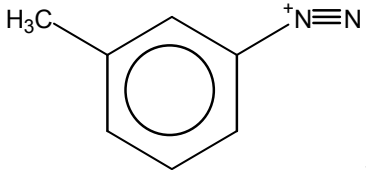
F324 Rings, Polymers and Analysis

Question			Expected Answers	Marks	Additional Guidance
1	(a)		 ✓	1	**ALLOW** $C_6H_6 + Br_2 \longrightarrow C_6H_5Br + HBr$ **DO NOT ALLOW** multiple substitution **DO NOT ALLOW** Br^+
	(b)	(i)	White precipitate **OR** white solid **OR** white crystals ✓  ✓	2	**DO NOT ALLOW** colourless **DO NOT ALLOW** white ppt and bubbles **DO NOT ALLOW** $Br_3C_6H_2OH$ **OR** 2,4,6-tribromophenol **OR** tribromophenol
		(ii)	1,2-Dibromocyclohexane ✓	1	**ALLOW** 1,2dibromocyclohexane **OR** 1-2dibromocyclohexane **OR** 12dibromocyclohexane **OR** cyclo-1,2-dibromohexane **DO NOT ALLOW** dibromocyclohexane **OR** $C_6H_{10}Br_2$ **OR** structures
		(iii)	**MUST** spell delocalised/delocalized or localised/localized correctly once in the answer to obtain all 5 marks **benzene** electrons or π-bonds are delocalised ✓ **phenol** a lone or non-bonded pair of electrons on the oxygen or the OH group is (partially) delocalised into the ring ✓ **cyclohexene** electrons are localised **OR** delocalised between two carbons ✓ benzene has a lower **electron density OR** phenol has a higher electron density **OR** cyclohexene has a higher electron density ✓ benzene cannot **polarise** or induce a dipole in Br_2 **OR** phenol can polarise the Br_2 **OR** cyclohexene can polarise Br_2 or the Br–Br bond ✓	5	**ALLOW** diagram to show overlap of all 6 p-orbitals for delocalisation **DO NOT ALLOW** benzene has delocalised structure or ring **ALLOW** diagram to show movement of lone pair into ring for phenol **ALLOW** diagram or description of overlap of 2 adjacent p-orbitals for bonding in cyclohexene **DO NOT ALLOW** cyclohexene has a C=C double bond **IGNORE** slip if cyclohexene is written as cyclohexane but π - bonding correctly described **DO NOT ALLOW** charge density **OR** electronegativity instead of electron density **ALLOW** $Br^{\delta+}$ **OR** electrophile Br^+ as alternate to polarise

(c)



✓



✓✓

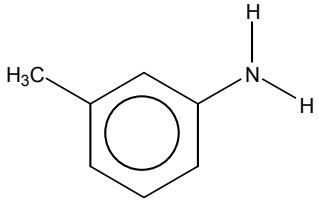
ALLOW ECF ✓✓ on incorrect amine

HNO_2 + HCl and temp < 10 °C **OR** $NaNO_2$ + HCl and temp < 10 °C ✓

alkaline **AND** phenol (if temperature stated must be below 10 °C) ✓

5

ALLOW

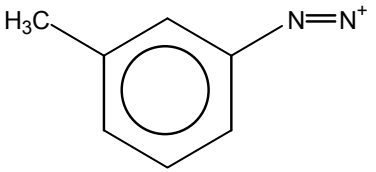


IGNORE Cl^- ion

DO NOT ALLOW if ring is connected to the N triple bond in the diazonium or if diazonium has a negative charge

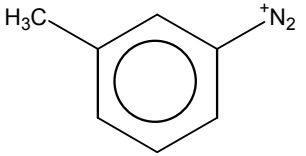
ALLOW one mark for correct displayed diazonium if alkyl group is not shown

ALLOW



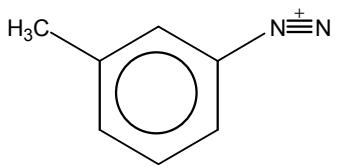
for both marks

ALLOW



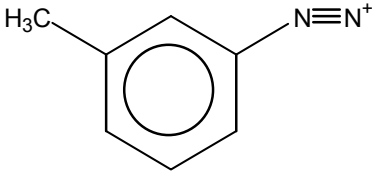
for one mark

ALLOW



for one mark

ALLOW



for one mark

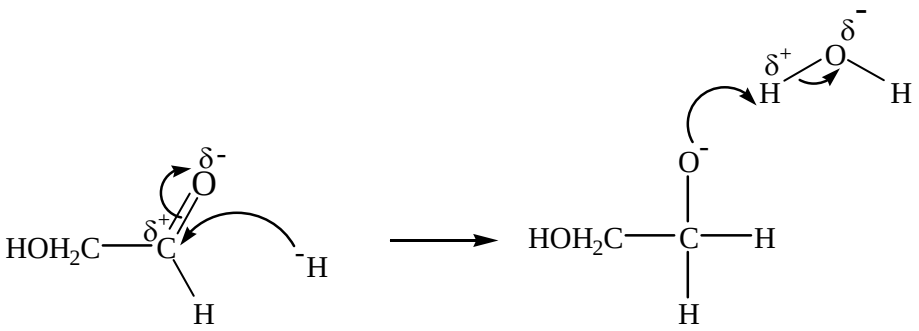
ALLOW NaOH **OR** KOH & C_6H_5OH **OR** phenoxide ion **OR** $C_6H_5O^-$

ALLOW reagents and conditions from the equations

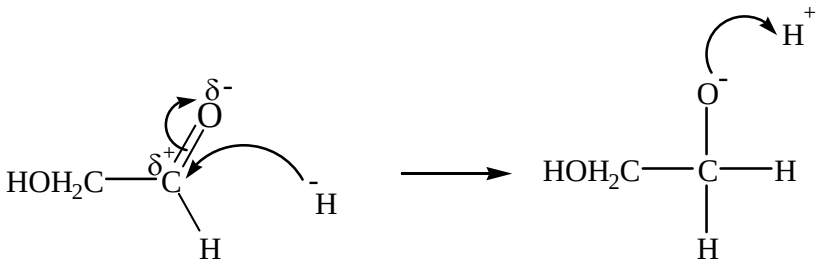
			Total	**14**	

Question			Expected Answers	Marks	Additional Guidance
2	(a)	(i)	silver mirror ✓	1	**ALLOW** Ag(s) **OR** Ag mirror **OR** precipitate **OR** ppt **OR** solid **ALLOW** brown **OR** black **OR** grey
		(ii)	$HOCH_2COOH$ ✓	1	**ALLOW** $CH_2OHCOOH$ **OR** CH_2OHCO_2H **OR** $HOCH_2CO_2H$ **OR** displayed **OR** skeletal formula **OR** $HOCH_2COO^-$ **DO NOT ALLOW** C_2H_4O **OR** 2-hydroxyethanoic acid
	(b)		$HOCH_2CHO + 3[O] \rightarrow HOOCCOOH + H_2O$ reagents ✓ both products ✓	2	**ALLOW** displayed/skeletal formula/COOHCOOH ✓✓ if molecular formula used $C_2H_4O_2 + 3[O] \rightarrow C_2H_2O_4 + H_2O$ max = 1 ✓ **Any correctly balanced equation for partial oxidation** can score 1 mark ✓ $HOCH_2CHO + [O] \rightarrow HOCH_2COOH$ **OR** $HOCH_2CHO + 2[O] \rightarrow OHCCOOH + H_2O$ **OR** $HOCH_2CHO + [O] \rightarrow OHCCHO + H_2O$ **OR** $HOCH_2CHO + 2[O] \rightarrow HOOCCHO + H_2O$
	(c)	(i)	$HOCH_2CH_2OH$ ✓	1	**ALLOW** $HO(CH_2)_2OH$ **OR** $(CH_2OH)_2$ **OR** skeletal formula **OR** displayed formula **DO NOT ALLOW** molecular formula ($C_2H_6O_2$)
		(ii)	curly arrow from H^- to $C^{\delta+}$ ✓ dipoles and curly arrow from C=O bond to O ✓ intermediate ✓ curly arrow from intermediate to $H^{\delta+}$ in H_2O/ H^+ and if H_2O is used it must show the curly arrow from the O–H bond to the O ✓ *lone pairs are not essential*	4	**ALLOW** curly arrow to C even if dipole missing or incorrect **ALLOW** maximum of 3 marks if incorrect starting material is used See page 36 for detailed mechanisms – ***Alternative 3*** scores all 4 marks even though the intermediate is not shown

Alternative 1

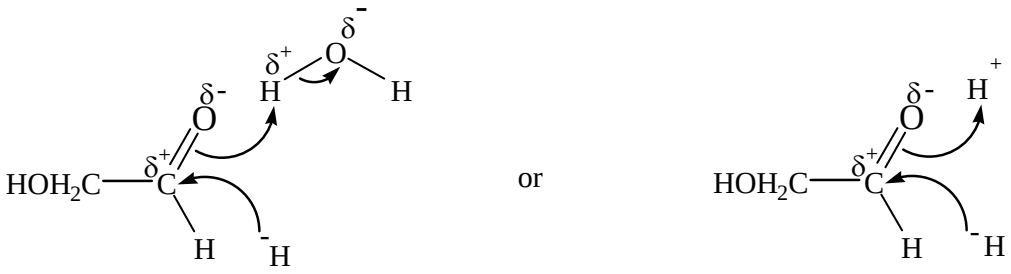


Alternative 2

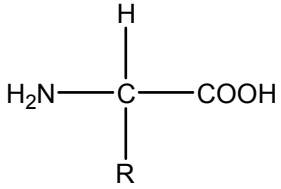
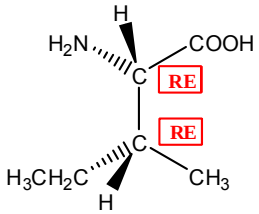
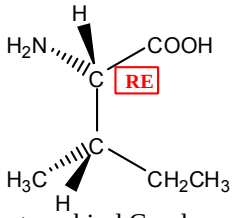
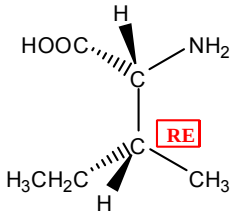


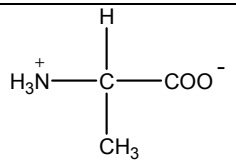
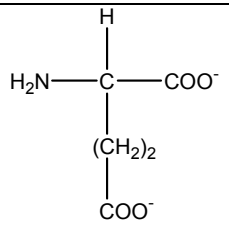
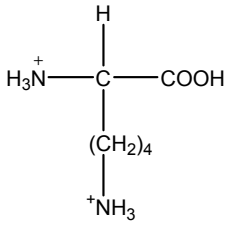
products are not required

Alternative 3



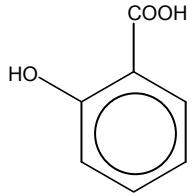
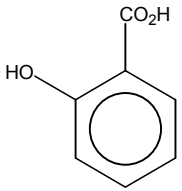
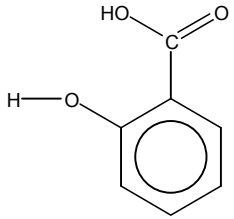
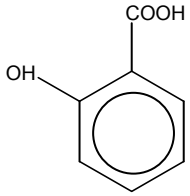
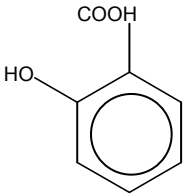
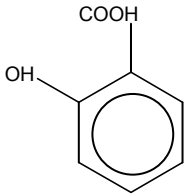
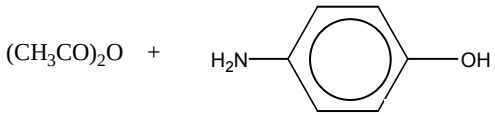
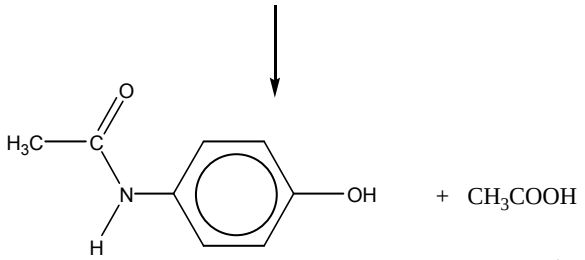
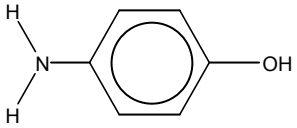
			Total	**9**	

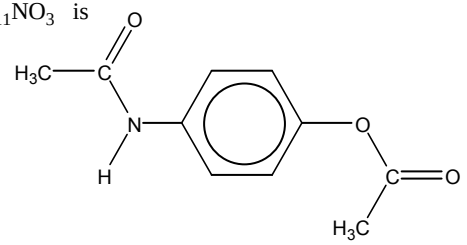
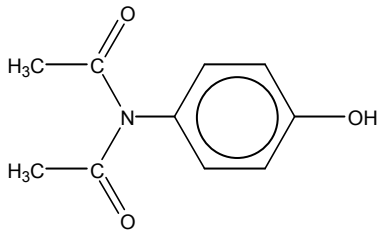
Question			Expected Answers	Marks	Additional Guidance
3	(a)	(i)	adsorption ✓	1	**ALLOW** partition **OR** adsorbtion **IGNORE** solubility **OR** desorption **DO NOT ALLOW** absorption
		(ii)	measure how far each spot travels relative to the solvent front or calculate the R_f value ✓ compare R_f values to those for known amino acids ✓	2	**ALLOW** compare R_f values to database **ALLOW** compare to known amino acids **DO NOT ALLOW** retention times for first mark, but the 2nd mark would be available as ✓ ECF **ALLOW** 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	**ALLOW** spots often overlap **OR** don't (fully) separate **ALLOW** they have similar R_f (values) or similar adsoptions or similar retention times ECF to **a(ii)**
	(b)	(i)	 ✓	1	**ALLOW** $RCH(NH_2)COOH$ any order for R, NH_2 and COOH but C must be next to H 'CH' must be shown **ALLOW** CO_2H brackets around NH_2 are **not** essential **ALLOW** structure
		(ii)	must attempt 3D use **RE** symbol in the "tools" to denote whether or not each chiral C is a reflection of the one given in the question  both chiral Cs are mirror images  top chiral C only is a mirror image  bottom chiral C only is a mirror image	3	each chiral C must have 2 — bonds, 1 wedge bond (**IGNORE** shading) & 1 dash bond (**IGNORE** wedge) check the clockwise orientation of each C. For each C start with the H and if on the: • top C the H is followed by COOH it is not a mirror image. If it is a mirror image annotate using RE. • bottom C the H is followed by CH_3 it is not a mirror image. If it is a mirror image annotate using RE. the four groups can be attached in any order. If the molecule is drawn upside down – clockwise becomes anti-clockwise. **MUST** check that the drawn structure is non-superimposable irrespective of the orientation or the way it has been drawn. **IGNORE** bond linkage for all groups

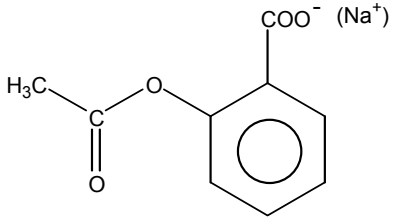
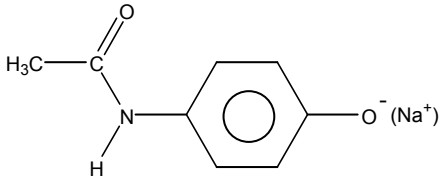
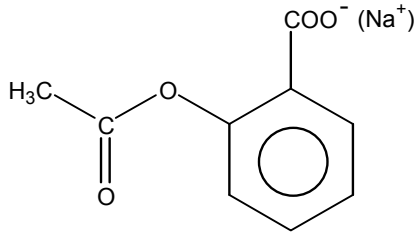
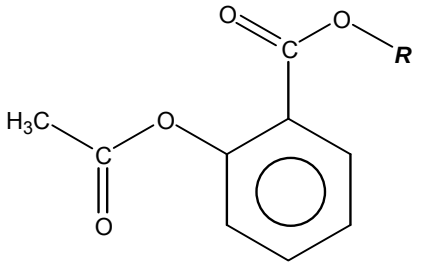
	(c)		 alanine at pH = 6.0 ✓  glutamic acid at pH =10 ✓  lysine at pH = 2.0 ✓		**ALLOW** CO_2^- **ALLOW** NH_3^+ If NH_3 fully displayed **ALLOW** + charge on N or H If COO fully displayed **ALLOW** $^-$ charge on O only
	(d)		valine–glycine–leucine ✓	**1**	**ALLOW** val–gly–leu **DO NOT ALLOW** structures
	(e)		$H_2N(CH_2)_6NH_2$ ✓ $HOOC(CH_2)_8COOH$ ✓	**2**	**ALLOW** $H_2NCH_2CH_2CH_2CH_2CH_2CH_2NH_2$ **ALLOW** $HOOCCH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2COOH$ **ALLOW** CO_2H for COOH **ALLOW** acid chloride, $ClOC(CH_2)_8COCl$ **ALLOW** displayed formulae or skeletal formulae
			Total	**14**	

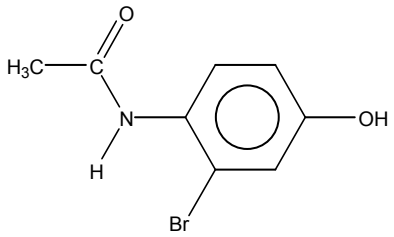
Question			Expected Answers	Marks	Additional Guidance
4	(a)		**infrared – 1 mark only** shows (very broad) peak between 2500–3300 (cm^{-1}) (due to O–H bond) ✓	3	**ALLOW** (very broad) peak around 3000 (cm^{-1}) **OR** any stated value between 2500 and 3300 (cm^{-1}) for O–H **DO NOT ALLOW** peak in range 3200–3550 (cm^{-1}) **IGNORE** any reference to C=O or C–O as both are also present in an ester **OR** to fingerprint region
			^{13}C NMR – 2 marks $(CH_3)_2CHCH_2COOH$ has 4 peaks (due to 4 different C environments) ✓ $(CH_3)_3CCOOH$ has 3 peaks (due to 3 different C environments) ✓		**ALLOW** '*^{13}C NMR detects the number of/different C environments*' for 1 ✓, suitable example for the 2nd mark
	(b)		**splitting pattern** explains any two in terms of '*n* + 1 rule' for two marks ✓✓ Explains any one peak for 1 mark ✓ • *singlet* therefore adjacent C (if any) has no Hs • *multiplet* **OR** split into 7 therefore adjacent Cs have lots of/6 Hs • *doublet* therefore adjacent C is bonded to 1H *must spell **one** of multiplet / heptet, singlet, doublet correctly* **max = 2 marks**	6	**1 mark** for correct ester if two splitting patterns are correctly analysed **ignore** the third **ALLOW** singlet because next or bonded to an O **ALLOW** multiplet/heptet because next to 2 CH_3s **ALLOW** doublet because next to a CH
			chemical shifts		**ALLOW** tolerance on δ values; 3.6–3.8, 2.6–2.8 and 1.1–1.3

			two marks if any two absorptions are identified correctly ✓✓ one mark if any one absorption is identified correctly ✓ • peak ~3.7 (ppm) – bonded to an O • peak ~2.7 (ppm) – indicates it is next to a C=O • peak ~1.2 (ppm) – bonded to other Cs **OR** part of a chain **max = 2 marks** compound identified as $(CH_3)_2CHCOOCH_3$ ✓✓ **2 marks** compound identified as $CH_3COOCH(CH_3)_2$ ✓ **1 mark**		(ppm) **ALLOW** any two gets 2 marks, any one scores 1 mark  3.7 (ppm) 2.7 (ppm) 1.2 (ppm) **ALLOW** peaks labelled on the spectrum **ALLOW** singlet must be bonded to O, multiplet to C=O and doublet to CH or R for both chemical shift marks if two chemical shifts are correctly identified **IGNORE** the third
			Total	**9**	

Question			Expected Answers	Marks	Additional Guidance
5	(a)		 ✓	1	**ALLOW**  or  **DO NOT ALLOW** incorrect bond linkage  or  or 
	(b)	(i)	equation  reactants ✓  products✓	2	**ALLOW** $(CH_3CO)_2O + H_2NC_6H_4OH \rightarrow CH_3CONHC_6H_4OH + CH_3COOH$ **ALLOW**  **DO NOT ALLOW** molecular formulae

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

			Na **OR** NaOH ✓  from aspirin ✓  from paracetamol ✓		or H_2SO_4 to give hydroxybenzoic acid + ethanoic acid with aspirin ✓ and ammonium salt of 4-aminophenol + ethanoic acid with paracetamol ✓ **ALLOW** hydrolysis by $OH^-(aq)$ 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 ✓ **ALLOW** HNO_3 (and H_2SO_4) to give NO_2 in one or more positions on the ring in both aspirin and paracetamol ✓✓ **DO NOT ALLOW** NH_3 but correct ammonium salts can be awarded 2 marks ECF **DO NOT ALLOW** H_2O but correct products can be awarded 2 marks ECF if no reagent there cannot be any marks for the products If reagent selected is incorrect but would react with **either** aspirin or paracetamol **ALLOW** ✓ ECF for the correct organic product
		(ii)	**aspirin only** $NaHCO_3$ **OR** Na_2CO_3 **OR** metal oxide ✓  ✓	**2**	**ALLOW** Mg, carbonates, NH_3 **ALLOW** alcohols (***R***OH) to give ester if no reagent there cannot be any marks for the products  If reagent selected is incorrect but would react with **BOTH** aspirin and paracetamol **ALLOW** ✓ ECF for the correct organic product
		(iii)	**paracetamol only**		**ALLOW** Br_2 water

			Br_2 ✓  ✓	**2**	**ALLOW** one or more Br at **any** position on the ring **DO NOT ALLOW** Br substitution of OH **ALLOW** acyl chloride or acid anhydride and corresponding ester **ALLOW** $FeCl_3$ to form a purple <u>complex ion</u> (structure not required) **ALLOW** 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 If reagent selected is incorrect but would react with **BOTH** aspirin and paracetamol **ALLOW** ✓ ECF for the correct organic product
			Total	**14**	

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.

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

OCR Customer Contact Centre

14 – 19 Qualifications (General)
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