OCR
RECOGNISING ACHIEVEMENT

GCE

Chemistry

Advanced GCE **A2 7882**

Advanced Subsidiary GCE **AS 3882**

Mark Schemes for the Units

June 2008

3882/7882/MS/R/08

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

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MARK SCHEME FOR THE UNITS

2811 Foundation Chemistry

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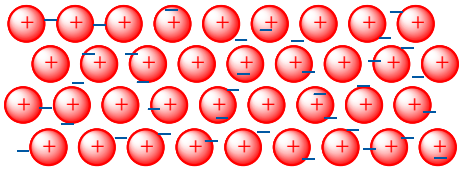
<tr><td>1</td><td>a</td><td></td><td>
<table>
<tr><th></th><th>protons</th><th>neutrons</th><th>electrons</th></tr>
<tr><td>^{113}In</td><td>49</td><td>64</td><td>49</td></tr>
<tr><td>^{115}In</td><td>49</td><td>66</td><td>49</td></tr>
</table>
^{113}In line correct ✓
^{115}In line correct ✓</td><td>2</td><td>mark by row</td></tr>
<tr><td></td><td>b</td><td></td><td>A_r = 113 x 4.23/100 + 115 x 95.77/100 /
114.9154 ✓ (calculator value)
= 114.9 ✓ to 1 decimal place</td><td>2</td><td>Allow one mark for A_r = 114.9154 with no working out
Allow two marks for A_r = 114.9 with no working out

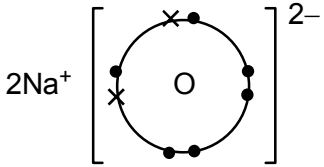
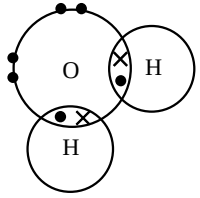
If a candidate uses incorrect values in 1st line, then the 2nd mark can still be awarded if the calculated value is from 113.1 to 114.9 expressed to one decimal place. ie if %s are the wrong way round in 1st line, then an answer of 113.1 gets the 2nd mark.</td></tr>
<tr><td></td><td>c</td><td></td><td>  with labels:
scattering of labelled electrons between other species ✓

regular 2-D arrangement of labelled + ions with some attempt to show electrons ✓</td><td>2</td><td>1st mark is for any symbol that is labelled an electron that is between something else:
ie: between + ions, atoms, protons, nuclei, +, p, circles, etc.

Allow: e or e$^-$ with no label
Do not allow '–' with no label

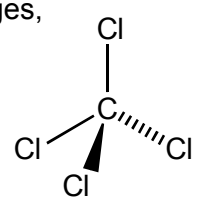
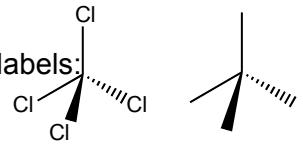
2nd mark for labelled + ions, positive ions, cations that can be touching and must be 2-D
(ie not just a row).
Allow In$^+$ or In+ with charge from 1+ to 7+
NOT protons (commonest mistake)</td></tr>
</table>

Question			Expected Answers	Marks	Additional Guidance
	d	i	M_r = weighted mean/average mass of a **molecule** ✓ compared with carbon-12 ✓ 1/12th (of mass) of carbon-12/ on a scale where carbon-12 is 12 ✓ *(but not 12 g)*	3	**1st mark**: reference to **molecule** is essential **Allow** just 'average mass of molecule' or 'mean mass of molecule' *alternative **allowable** definitions:* mass of one mole of molecules ✓ compared to $1/12^{th}$ ✓ (the mass of) one mole/12 g of carbon-12 ✓ mass of one mole of molecules ✓ . $1/12^{th}$ ✓ the mass of one mole/12 g of carbon-12 ✓
		ii	ratio: In : I = 23.19/115 : 76.81/127 Empirical formula: InI_3 ✓ Molecular formula = In_2I_6 ✓ *OR* mass In = 23.19 x 992/100 *OR* 230 (g) *AND* mass I = 76.81 x 992/100 *OR* 762 (g) ✓ moles In = 230/115 *OR* 2 *AND* moles I = 762/127 *OR* 6 ✓ Molecular formula = In_2I_6 ✓	3	**Allow** use of 114.9 for In (ie from answer to 1(b)) If a candidate uses atomic numbers, the ratio is still 1:3. The 2nd and 3rd marks can still be awarded by error carried forwards. Although unlikely, an correct answer of In_2I_6 with no working should be awarded **all** three marks. If candidate shows inverse for ratios: ie In : I = 115/23.19 : 127/76.81 ……then the candidate can be awarded the 2nd mark **only** for In_3I by error carried forwards.
			Total	**12**	

Question			Expected Answers	Marks	Additional Guidance
2	a	i	Ca ✓	1	***Allow*** *names throughout (i)–(vi)*
		ii	N✓	1	
		iii	Cl✓	1	
		iv	B✓	1	**Allow** Al
		v	K✓	1	
		vi	C/Si/B✓	1	
	b	i	cation shown with either 8 or 0 electrons ***AND*** anion shown with 8 electrons ***AND*** correct number of crosses and dots for example chosen ✓ Correct charges on both ions ✓ e.g.  	2	***An ionic compound must be chosen and it must have correct formula to score at all*** **For 1st mark,** if 8 electrons shown around cation then 'extra' electron(s) around anion must match symbol chosen for electrons in cation. *Circles not required* **Ignore** inner shell electrons **Allow:** $2[Na^+]$ $2[Na]^+$ $[Na^+]_2$ (brackets not required) Do **not** allow: for Na_2O, $[Na_2]^{2+}$ $[Na_2]^+$ $[2Na]^{2+}$ $[Na]$
		ii	electron pair(s) in covalent bond shown correctly using dots and crosses in a molecule of a compound ✓ correct number of outer shell electrons in example chosen ✓ e.g.  2 'x o' between O and H for 1st mark correct outer shell electrons for O and H for 2nd mark	2	***A covalent compound must be chosen and it must have correct formula to score at all*** For '*dot-and-cross*' diagram, accept different symbols for electrons from each atom. ie X and / If example chosen is molecule of an element, then 2nd mark can be awarded if candidate has used dots and crosses for **all** outer shell electrons around each atom. *Circles not required*

Question			Expected Answers	Marks	Additional Guidance
	c			4	***USE annotations with ticks, crosses, con, ecf, etc for this part.***
			(across a period)		Ignore 'down a period', 'across a group'
			atomic radius decreases/ outer electrons closer to nucleus ✓ electrons are (pulled in) closer		If candidate responds with 'electrons are same distance from the nucleus' anywhere is a CON. …… but ignore '**about** the same distance'
			nuclear charge increases/ protons increase ✓		Ignore 'atomic number increases' Ignore 'nucleus gets bigger' 'charge increases' is not sufficient **Allow** 'effective nuclear charge increases' *OR* 'shielded nuclear charge increases'
			greater attraction/ greater pull ✓		A comparison must be included: ie 'greater pull', 'more pull', 'held more tightly'; so …… 'pulled in closer' would score the 1st marking point but not the 3rd marking point here
			electrons added to the same shell *OR* screening / shielding remains the same or similar ✓		**Allow** 'very small increase' for 'similar'
			Total	**14**	

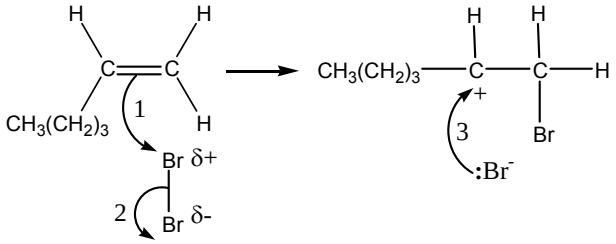
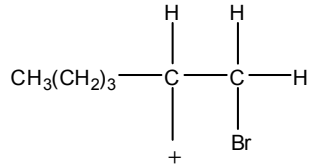
Question			Expected Answers	Marks	Additional Guidance
3	a	i	moles = 55/24,000 = 2.3 x 10^{-3} / 0.0023 (mol) ✓	1	**Allow** calc 2.291666667 x 10^{-3} and correct rounding to a minimum of 2 sig fig, ie 0.0023 (ie rounding is being assessed here)
		ii	[bleach] = 1000 x 2.3 x 10^{-3} / 3 = 0.77 (mol dm^{-3}) ✓	1	From (a)(i), allow use of calc value = 0.763888888 For any rounded value of 2.291666667 x 10^{-3} down to a minimum of 2 sig fig, ie 0.0023, **allow** any value in range **0.76** to **0.77** mol dm^{-3} (ie rounding has been assessed above) For **ECF**, = 1000 x ans to (i) / 3
		i ii iii	moles HCl at start = 1.0 x 6.0/1000 = 6 x 10^{-3} ✓ moles HCl that reacted = 2 x 2.3 x 10^{-3} = 4.6 x 10^{-3} / 0.0046 mol ✓ excess HCl = 6 x 10^{-3} – 4.6 x 10^{-3} = 1.4 x 10^{-3} mol / 0.0014 mol ✓ (mark is for answer)	3	Marking screen shows parts (i) and (iii) **ECF** = ans to (i) x 2 **ECF**: moles HCl at start – moles HCl that reacted Common mistake: If a candidate does not multiply ans to (i) by 2, then ECF answer will be 0.00371 (from 0.00229) or 0.0037 (from 0.0023) Both answers would gain 2 marks for this part.
	b	i	iodine / I_2 produced ✓ correct balanced equation: $Cl_2 + 2I^- \longrightarrow I_2 + 2Cl^-$ / $Cl_2 + 2NaI \longrightarrow I_2 + 2NaCl$ ✓	2	I_2 as a product in an attempted equation would score 1st mark
		i ii	chlorine reacts with water forming Cl^- *OR* chloride / $Cl_2 + H_2O \longrightarrow ClO^- + 2H^+ + Cl^-$ ✓ AgCl(s) / precipitate is silver chloride *OR* AgCl(s) ✓ chloride *OR* Cl^- reacts with silver nitrate *OR* Ag^+ ✓ $Ag^+ + Cl^- \longrightarrow AgCl$ / $AgNO_3 + HCl \longrightarrow AgCl + HNO_3$ ✓	4	**Allow**: $Cl_2 + H_2O \longrightarrow HClO + HCl$ can be credited for this marking point in equation as AgCl(s) can be credited for this marking point in equation as Cl^- State symbols **not** required $Ag^+ + Cl^- \longrightarrow$ AgCl(s) would get last three marks!

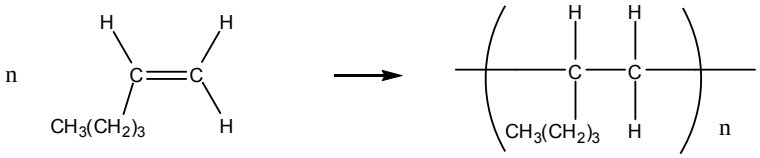
Question			Expected Answers	Marks	Additional Guidance
	c	i	attraction of an atom/nucleus for electrons ✓ attraction for electrons in a (covalent) bond ✓	2	For **1st mark**, atom/nucleus is essential Commonest correct answer: 'Attraction of an atom for the electrons in a covalent bond'
		ii	four bonds shown with at least 2 wedges, one in; one out ✓  bond angle = 109.5° ✓	2	For bond into paper, accept:  **Allow** correct shape with no atom labels:  Bond angle can just be stated as this is the only one bond angle that applies, so no labelling required. **Allow** 109° – 110°
		iii	Cl is more electronegative (than H or C) ✓ CCl_4 is symmetrical ✓ In CCl_4 dipoles cancel ✓	3	***USE annotations with ticks, crosses, con, ecf, etc for this part.*** **Allow**: Cl is δ– /slightly negative *OR* shown as dipole: $H^{\delta+}$–$Cl^{\delta-}$ *OR* $C^{\delta+}$–$Cl^{\delta-}$ Do **not** allow 'negative' OR Cl^- *OR* chloride ion *OR* chlorine ion **Allow** CCl_4 is tetrahedral
			Total	**18**	

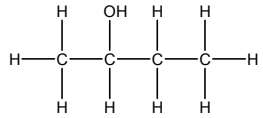
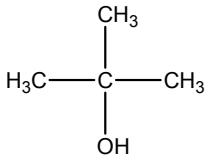
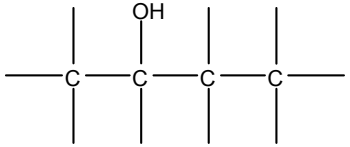
Question			Expected Answers	Marks	Additional Guidance
4	a		**A**: CaO ✓ **B**: CO_2 ✓ **C**: $Ca(OH)_2$ ✓ **D**: $CaCl_2$ ✓ **E**: H_2O ✓ **F**: $Ca(HCO_3)_2$ / $CaH_2C_2O_6$ ✓	6	**Brackets essential** **Allow** any order of atoms in a correct formula
	b		$2Ca(s) + O_2(g) \longrightarrow 2CaO(s)$ / $Ca(s) + ½ O_2(g) \longrightarrow CaO(s)$ state symbols for Ca, O_2 and CaO ✓ correct balanced equation ✓ Oxidation is loss of electrons AND reduction is gain of electrons ✓ Ca loses 2 electrons AND O gains 2 electrons OR Ca loses 2 electrons AND O_2 gains 4 electrons ✓	4	***USE annotations with ticks, crosses, con, ecf, etc for this part.*** **Allow** 'multiples', ie $4Ca(s) + 2O_2(g) \longrightarrow 4CaO(s)$ **Allow** balanced equation with a species on both sides, ie $Ca(s) + O_2(g) \longrightarrow CaO(s) + ½ O_2(g)$ Must be in terms of electrons Ignore any reference to oxidation number **Allow** equations (**accept** 'e' without '–' sign): $Ca \longrightarrow Ca^{2+} + 2e^- / Ca - 2e^- \longrightarrow Ca^{2+}$ $O_2 + 4e^- \longrightarrow 2O^{2-} / O + 2e^- \longrightarrow O^{2-}$
			reactivity increases (down the group) ✓ atomic radii increases/ there are more shells ✓ there is more shielding/ more screening ✓ Increased shielding and distance outweigh the increased nuclear charge / the nuclear attraction decreases ✓ easier to remove outer electrons/ ionisation energy decreases/ ✓	5	***USE annotations with ticks, crosses, con, ecf, etc for this part.*** 'down the group' not required '**more'** *is essential* allow 'more electron repulsion from inner shells' **Allow** 'nuclear pull' ignore any reference to 'effective nuclear charge'
			QWC – At least two sentences that show legible text with accurate spelling, punctuation and grammar so that the meaning is clear. ✓	1	QWC mark **must** be indicated with a tick or cross through the Quality of Written Communication prompt at the bottom of page 9. **Then scroll up to start of (b), counting ticks.**
			Total	**16**	

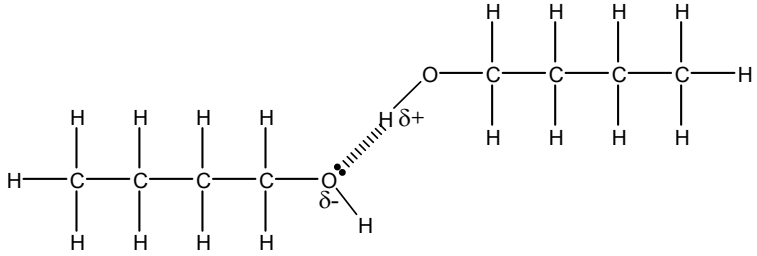
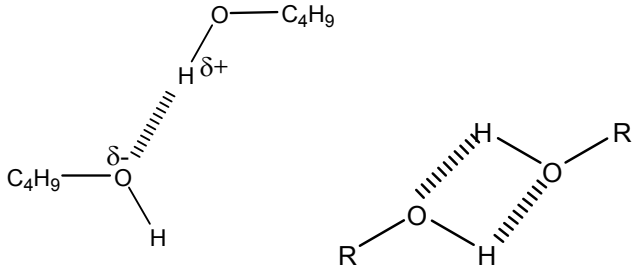
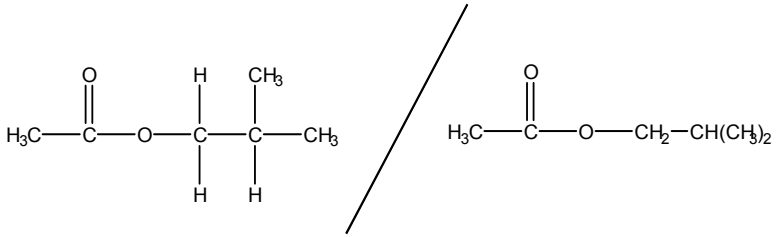
2812 Chains and Rings

Question	Expected Answers	Marks	Additional Guidance
1 a i	C_6H_{14} ✓	1	there is no other acceptable response
ii	C_3H_6Br ✓	1	there is no other acceptable response
iii	hexan-2-ol ✓	1	Allow hexanol-2 do **not allow** e.g. 2-hexanol, hex-2-ol, hexa-2-ol
iv	HBr ✓	1	Allow NaBr + H_2SO_4/ HBr + H_2SO_4 Do **not allow** dil. H_2SO_4/ H_2SO_4(aq)

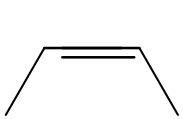
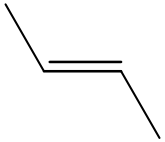
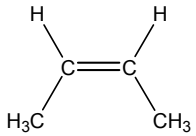
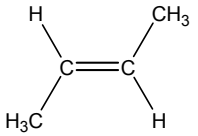
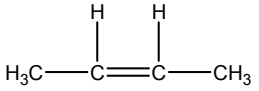
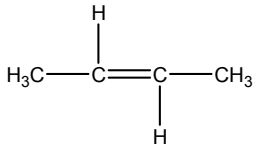
b i	 1. curly arrow from π- bond to $Br^{(\delta+)}$✓ 2. correct dipoles **&** curly arrow from bond to $Br^{\delta-}$✓ 3. intermediate (either primary/secondary carbonium/bromonium ion) ✓ 4. Br must have charge **and** lone pair. Curly arrow from anywhere on Br to C+✓	**4**	curly arrow must have full arrow head if half-arrow heads used, penalize once **only**. **ignore** δ– on C=C double bond **ignore** ·· on Br—Br bond curly arrows must be precise – curly arrow **1** must start at the C=C double bond (not the C) and must go to the $Br^{\delta+}$ or just above the $Br^{\delta+}$ curly arrow **2** must start from the Br–Br bond and go to the $Br^{\delta-}$ or just past the $Br^{\delta-}$ curly arrow **3** must go from Br^- to the C+ **allow** primary carbonium ion or bromonium ion as an alternative to the carbonium ion If HBr is used instead of Br_2 candidate loses marking point 1. If ethene (or other alkene) appears as the intermediate, candidate loses marking point 3. If intermediate has $C^{\delta+}$, candidate loses marking point 3. If intermediate drawn as  candidate loses marking point 3.

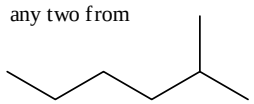
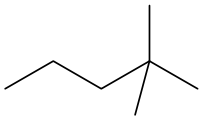
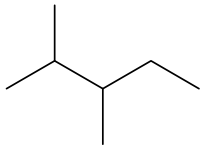
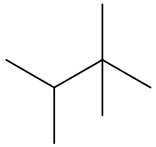
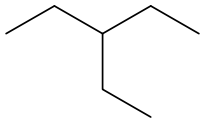
Question	Expected Answers	Marks	Additional Guidance
ii	(electrophilic) addition ✓	1	nucleophilic addition loses the mark **ignore** bromination.
iii	decolourises/(red/orange/brown/yellow) to colourless ✓	1	**not** goes clear **not** discolours
c i	 1. 1 mark if monomer and repeat unit are correct ✓ 2. 1 mark if the n_s are shown in correct position and bracket around repeat unit✓	2	**Ignore** bond linkage to $(CH_2)_3CH_3$ **unless** the bond clearly goes to the CH_3. *n* $C_6H_{12} \longrightarrow (C_6H_{12})_n$ also gets both marks **Allow** if end bonds are within brackets. If end bonds are not shown, candidate loses marking point 1. If equation is not balanced, candidate loses marking point 2. If they draw 2(monomers) $\longrightarrow$ 2 repeat units candidate loses marking point 2.
ii	poly(hex-1-ene)/polyhex-1-ene ✓	1	**Allow** poly(hexene-1) / polyhexene-1
	Total	13	

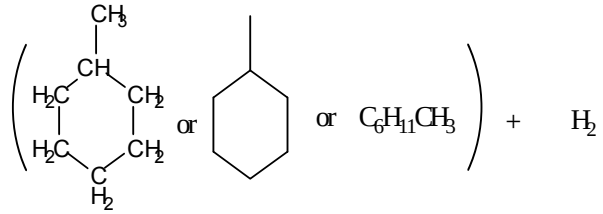
Question No.	Expected Answers			Marks	Additional Guidance
2a	same molecular formula, different structure/arrangement of atoms ✓			**1**	**not** same formula **Allow** different displayed/skeletal formulae
b	 ✓		secondary ✓	**6**	**Penalise** bond linkage to OH **once** in this question. Do **not** penalise bond linkage to CH_3. If names written as methylprop-1-ol and methylprop-2-ol, penalise once in this question. **allow** $CH_3CH(OH)CH_2CH_3$ / $CH_3CH(OH)C_2H_5$
		methylpropan-1-ol ✓	primary ✓		**allow** 2-methylpropan-1-ol
	✓ 	methylpropan-2-ol ✓			**allow** 2-methylpropan-2-ol **allow** $(CH_3)_3COH$ **penalise** "sticks" once **only** in this question. e.g  **DO NOT** penalise "sticks" elsewhere on the paper.

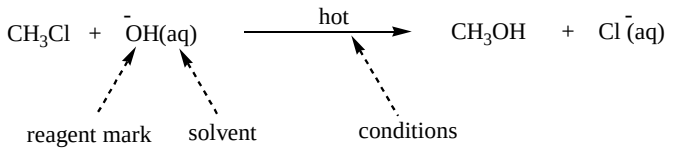
c	 1. H-bond shown in correct position ✓ 2. dipoles shown as $O^{\delta-}$ and as $-O—H^{\delta+}$ ✓ 3. lone pair shown on O as part of a dotted …. hydrogen bond ✓	**3**	**allow**  if two H-bonds are shown between the two O–H, candidate loses marking point 1. If hydrogen bond drawn between butan-1-ol and water candidate loses marking point 1.
d		**1**	ester group **must** be displayed **Allow** C_4H_9 etc.
e i	1. butanoic acid ✓ 2. ir spectrum shows OH at about 3000 cm^{-1} ✓ 3. C=O at about 1700 cm^{-1} ✓ OR 1. butanoic acid ✓ 2. ir spectrum shows peaks at about 1700 cm^{-1} and 3000 cm^{-1} ✓ 3. peaks correctly identified as C=O and O–H respectively. ✓	**3**	**Check spectrum for labels.** **Allow** correctly labelled peaks on spectrum. **allow** ranges in data book: 2500 – 3300 cm^{-1} for O–H 1680 – 1750 cm^{-1} for C=O **not** 3230 – 3550 cm^{-1} for O–H

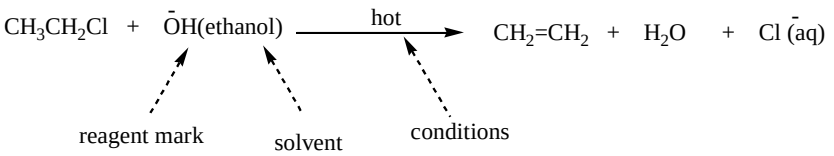
ii	$C_4H_9OH + 2[O] \longrightarrow C_3H_7COOH + H_2O$ ✓✓ Allow ecf to e(i) as aldehyde/butanal. $C_4H_9OH + [O] \rightarrow CH_3\,CH_2CH_2CHO + H_2O$ ✓✓	**2**	If candidate identifies e(i) as carboxylic acid but writes equation for aldehyde. No marks. **allow** $C_4H_{10}O + 2[O] \longrightarrow C_4H_8O_2 + H_2O$ ✓✓ correct product C_3H_7COOH / $C_3H_7CO_2H$ scores 1 ✓ **Allow** as ecf $C_4H_{10}O + [O] \rightarrow C_4H_8O + H_2O$ ✓✓ but as ecf $C_4H_{10}O + [O] \rightarrow CH_3\,CH_2CH_2COH + H_2O$ / scores 1 mark. If the equation is not balanced, 1 mark available for unambiguous formula of the correct / ecf organic product. e.g $C_4H_8O_2$ or C_4H_8O would **not** score the mark
	Total	**16**	

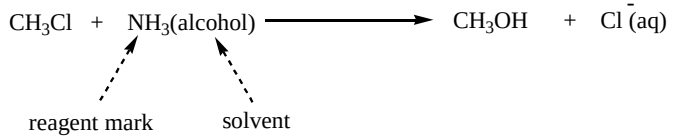
Question No.	Expected Answers	Marks	Additional Guidance
3a i	working to show C : H ratio 1 : 2 ✓ CH_2 ✓	**2**	**must** see working as C_4H_8 is given as the molecular formula in part (ii) If calculation of C : H ratio is incorrect allow ecf for empirical formula.
ii	working (56/14 = 4) to show molecular formula is C_4H_8 / 4 x 12 + 8 =56 ✓	**1**	**Allow** 85.7% of 56 = 48 therefore 4 C
b	 cis  trans 1. skeletal formulae ✓ 2. correct structure in correct box✓	**2**	**allow** 1 mark if *cis-trans* correctly drawn as structural/displayed formulae and correctly labeled.  cis  trans or  cis  trans scores 1 mark if both skeletal formulae drawn correctly but in the wrong boxes – 1 mark can be awarded
	Total	**5**	

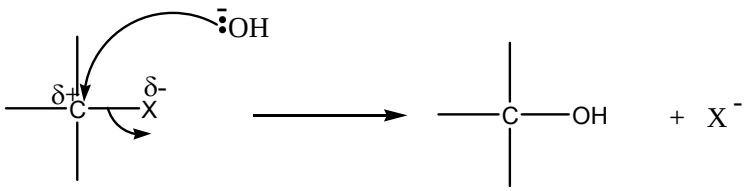
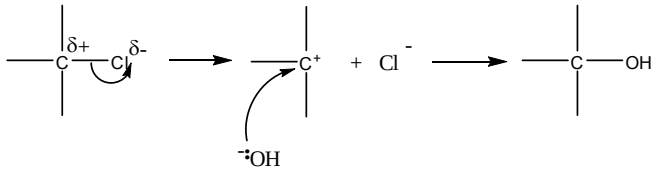
Question	Expected Answers	Marks	Additional Guidance
4a i	any two from  2-methylhexane  2,2-dimethylpentane  2,3-dimethylpentane  2,2,3-trimethylbutane  3-ethylpentane ✓✓	2	**allow** 1 mark if **two** correct isomers are drawn using either displayed or structural formula e.g. any two from: $(CH_3)_2CH(CH_2)_3CH_3$, $(CH_3)_3C\ (CH_2)_2CH_3$, $(CH_3)_2CHCH(CH_3)CH_2CH_3$, $(CH_3)_2CHC(CH_3)_3$, $(C_2H_5)_3CH$ award 1 mark for correct isomers but deduct one mark for not drawing skeletal formulae.
ii	3,3-dimethylpentane ✓	1	**Ignore** comma and hyphen Not bimethyl/bismethyl
iii	F ✓	1	**Allow** 3-methylhexane.

b		heptane correct formula or structure →  + H_2 1. Unambiguous organic product ✓ 2. Balanced equation ✓	**2**	heptane correct formula or structure → C_7H_{14} + H_2 scores only 1 ✓ Do not allow 2H / 2[H].
c	**i**	M_r = 88 ✓ % O = $^{16}/_{88}$ * 100 = 18.2 (%) ✓	**2**	18.2(%) with no working scores 2 marks 18.18 (%) with no working scores 1 mark **Allow** ecf on incorrect M_r
	ii	$C_5H_{12}O$ + 7½ O_2 ⟶ 5 CO_2 + 6 H_2O ✓✓	**2**	correct formula for MTBE – **allow** $C_5H_{12}O$/ $C_4H_9OCH_3$/ displayed formula as shown in question **allow** 1 mark if formula for MTBE and mole ratio are correct such that **1**MTBE :**5**CO_2 + **6**H_2O gets 1 mark✓ If formula of MTBE is incorrect **allow** ecf for balanced equation. Max 1 mark.
d	**i**	low boiling point/easily vapourised/evaporates quickly/turns to a gas easily ✓	**1**	**Ignore** reference to flammability.
	ii	loss of petrol by evaporation/fuel-air mixture might be incorrect/not enough liquid petrol getting to the engine/carburettor/causes knocking/ causes pre-ignition/ causes auto-ignition/more difficult to store or transport/more difficult to fill-up ✓	**1**	**Ignore** vague answers such as more chance of catching fire/explosion/dangerous

Question	Expected Answers	Marks	Additional Guidance
	Ticks ✓must be used for this question. Use ✓or ✖ for QWC		
5a	1. reagent – OH^-/NaOH/KOH 2. solvent – water/aqueous (ignore reference to ethanol) 3. conditions- hot/warm/reflux/heat ✓✓ $RX + OH^-/H_2O \longrightarrow ROH + X^-/HX$ ✓	3	**need** all three for 2 marks, any 2 scores 1 mark **allow** general equation using **R** or any correct equation **allow** reagent, conditions & solvent mark from the equation such that  scores all 3 marks if acid catalyst used ….it **cancels** the OH^- reagent

	1. reagent – OH^-/NaOH/KOH 2. solvent – ethanol/alcohol/ethanolic 3. conditions- hot/warm/reflux/heat ✓✓ e.g. $C_2H_5X + OH^- \longrightarrow C_2H_4 + X^- + H_2O$ ✓	3	**need** all three for 2 marks, any 2 scores 1 mark if acid catalyst used ….it **cancels** the OH^- reagent **any** mention of water/(aq) candidate loses marking point 2. **allow** any correct equation If HBr is a product, candidate loses equation mark. **allow** reagent, conditions & solvent mark from the equation such that  scores all 3 marks If ethanoic is used instead of ethanolic penalise only once.

	reagent – NH_3 ✓ solvent – ethanol/alcohol/ethanolic ✓ $RX + 2NH_3 \longrightarrow RNH_2 + NH_4X$/ $RX + NH_3 \longrightarrow RNH_2 + HX$ ✓ using an acid (catalyst) loses the NH_3 mark.	3	**ignore** any reference to temperature and pressure **ignore** any reference to heating in a sealed tube **any** mention of water/(aq) candidate loses marking point 2. **allow** general equation using **R** or any correct equation **allow** reagent, conditions & solvent mark from the equation such that  scores all 3 marks If ethanoic is used instead of ethanolic penalise only once.
QWC	correct use of at least **two** specific terms such as solvent, reflux, mechanism, hydrolysis, elimination, nucleophilic, substitution, nucleophile, dipole, base, aqueous, (aq), ethanol, ethanolic, alcohol, alcoholic, (alc),	1	**Put tick or cross** through "quality of written communication" at bottom of page 10.

b	 1. correct dipole ✓ 2. The OH must have lone pair on O **and** charge e.g. :OH^-. Curly arrow from anywhere on the OH^- to $C^{\delta+}$ ✓ 3. curly arrow from C—X bond to $X^{\delta-}$ ✓ 4. states that the mechanism is nucleophilic substitution/draws correct products ✓	4	"nucleophilic substitution" **cannot** be credited from part a. **Penalise** bond linkage to OH **once** in this question. **credit** S_N1 mechanism: can score all 4 marks. 
	Total	**14**	

2813/01 How Far? How Fast?/Experimental Skills 1 Written Paper

Question			Expected Answers	Marks	Additional Guidance
1	(a)	i	enthalpy/energy change to break 1 mole of a (covalent) bond ✓ in the gaseous state ✓	2	do **not** allow first mark: • if **energy released** • if **break and make** • if **ionic** • if **heat** 2nd mark stand alone ignore 'under standard conditions'
		ii	bonds broken = 1 (C–C) + 5(C–H) + 1(C–O) + 1(O–H) + 3 (O=O) = 4728 (kJ) ✓ bonds formed = 4(C=O) + 6(O–H) = 6004 (kJ) ✓ ΔH_c = 1276 (kJmol^{-1}) ✓ **Alternative** if 1(O–H) cancelled on both sides the values are bonds broken = 4264 (kJ) ✓ bonds formed = 5540 (kJ) ✓ ΔH_c = –1276 (kJmol^{-1}) ✓	3	no working necessary -**allow one mark** for each value **allow ecf** on values for final answer but sign must be consistent with their values no working necessary -**allow one mark** for each value **allow ecf** on values for final answer but sign must be consistent with their values
	(b)	i	cycle/ $\Delta H_r = \Sigma\Delta H$ (products) – $\Sigma\Delta H$(reactants) ✓ 1273 + ΔH_c = 6394) + 6(286) ✓ ΔH_c = 2807 (kJ mol^{-1}) ✓	3	cycle need not be drawn correctly/drawn at all 2807 **scores 3** common errors and their effect –5353, –1377, –837, 181, 625, 1921, 2807 **score 2** –3923, –3637, –3383, –2989, –1921, –625, –181, 593, 837 **score 1**

					–1953, –593 **score 0** if these answers are seen, score appropriately any other answers **must be checked** one error **scores 2**, two errors **scores 1**
		ii	respiration	1	no other answer is acceptable **ignore** qualification eg exothermic, aerobic, anaerobic
			Total	**9**	

Question			Expected Answers	Marks	Additional Guidance
2	(a)	i	(becomes paler because equilibrium) moves to RHS /towards products /towards HI ✓ (because) the (forward) reaction is endothermic/ reverse reaction is exothermic ✓	2	becomes paler is in the question, **first mark** is for direction of equilibrium movement **Ignore** any discussion on number of moles/rates both marks stand alone
		ii	(becomes darker because) the molecules are pushed closer together/ space between particles decreases/ their concentration increases/ density increases/ ✓ equilibrium position does not alter ✓ because there are the same number of moles (of gas) on each side ✓	3	becomes darker is in the question, **first mark** is for comment on effect on particles all three marks are stand alone
	(b)	i	because there are <u>more</u> collisions ✓ and more of the collisions have <u>E_a</u>/ exceed <u>E_a</u> /have the required energy to react ✓	2	activation energy/ E_a / required energy to react must be mentioned for the 2nd mark
		ii	because the particles collide more (frequently) ✓	1	any mention of energy or E_a negates the mark any idea of **more particles are added** negates the mark
	(c)	i	hydrogen was added/used✓	1	**not** 'concentration of hydrogen increases'
		ii	amount of HI/products goes up/ amount of I_2 /H_2/reactants goes down/ as equilibrium moves to RHS ✓ (new) equilibrium established/reaches equilibrium again/ concentrations become constant / rate forward = rate back ✓	2	do not allow 2nd mark if restore to **original** equilibrium or if the reason given is **invalid** eg increase in temperature
			Total	**11**	

Question			Expected Answers	Marks	Additional Guidance
3	(a)	i	*x* axis energy ✓ *y* axis number/fraction of particles/molecules/atoms ✓	2	**not** activation energy/E_a **allow** kinetic energy/KE/speed/velocity/enthalpy **allow** 1 mark if labels both correct but on reversed axes
		ii	on diagram labelled E_a lines with and without catalyst ✓ explanation – more particles/collisions have energy greater or equal to $\underline{E}_a$ / required energy to react, with catalyst ✓	2	E_a must be labelled on one line (lines must be drawn **and** meet the curve) lines must be to RHS of hump if two graphs are drawn, first mark not awarded activation energy/ E_a /required energy to react must be mentioned for the 2nd mark
	(b)	i	gas/ hydrogen is given off/produced/formed/released ✓	1	
		ii	sketch to show line falling more steeply ✓ finishing at same horizontal level ✓	2	graph must start at the same point as the original the line need not continue very far as long as it is clearly at the same horizontal
	(c)	i	diagram to show products below reactants ✓ energy 'hump' between reactants and products ✓	2	products **must be** labelled hump can be rectangular or curved AW
		ii	ΔH labelled/ (–)120 ✓ E_a labelled/250 ✓	2	accept double headed arrows or lines single headed arrows must have arrow in correct direction
		iii	E_a = 370 (kJ mol^{-1}) ✓	1	If answer = 130, refer back to Q3(c)i **ecf** if endothermic drawn
			Total	**12**	

Question			Expected Answers	Marks	Additional Guidance
4	(a)	i	use ticks from annotation box– place as close to marking point as possible **high pressure** 1. would give good <u>rate</u> ✓ 2. and move equilibrium to RHS or towards products/ give good yield of ammonia ✓ 3. too high is expensive/ safety considerations ✓ **high temperature** 4. would give good <u>rate</u> ✓ 5. but moves equilibrium to LHS or towards reactants/ gives poor yield of ammonia ✓ 6. temperature is a compromise ✓ **catalyst** 7. iron used ✓	7	**no credit for specified conditions of temperature and pressure** **low temperature** would give a slow <u>rate</u> ✓ but moves equilibrium to RHS or towards products/ gives good yield of ammonia ✓ temperature is a compromise ✓ 'compromise' is a stand alone mark
		ii	cooling to/below –33^{o}C ✓ to liquefy/condense ammonia ✓	2	actual temperature need to be quoted (–196 to –33 ^{o}C) **or** cool to below boiling point of ammonia any mention of (fractional) distillation/evaporation/heating negates 2nd mark
		iii	(unreacted) nitrogen and hydrogen are recycled ✓	1	must be nitrogen and hydrogen **or** reactants

	(b)	**i**	$NH_3 + H^+ \rightarrow NH_4^+$ ✓	1	$NH_3 + H_3O^+ \rightarrow NH_4^+ + H_2O$ ✓ multiples allowed accept any acid **NOT** water eg $NH_3 + H_3PO_4 \rightarrow NH_4^+ + H_2PO_4^-$ ✓ $NH_3 + H_2SO_4 \rightarrow NH_4^+ + HSO_4^-$ ✓ $2NH_3 + H_2SO_4 \rightarrow 2NH_4^+ + SO_4^{2-}$ ✓ $NH_3 + HCl \rightarrow NH_4^+ + Cl^-$ ✓
		ii	$3NH_3 + H_3PO_4 \rightarrow (NH_4)_3PO_4$ formula of ammonium phosphate ✓ balancing ✓	2	 balancing only for correct species
			Total	**13**	

2813/03 How Far? How Fast?/Experimental Skills 1 Practical Examination

AS Practical Test 2813/03: May 2008
Mark Scheme

PLAN (Skill P) **[16 marks** (out of 19 available)**]**

T Titration procedure – 7 marks

T1 Accurate dilution of the sulphuric acid provided:
Acid measured with a pipette, use of distilled water ***and*** a volumetric flask [1]
Dilution factor does not need to be justified, but should be between 5 and 25

T2 Correct equation for suitably selected neutralisation reaction *(not ionic)* [1]
The alkaline reagent chosen must be water-soluble
*No T2 for incorrect sub-scripts **or** letter cases (eg H^2So4)*

T3 Uses equation to justify concentration ***or*** mass of alkali used in titration [1]
T3 can only be awarded if acid was diluted and this is allowed for in calculation.

T4 Outline description of use of burette and pipette in procedure [1]

T5 At least two consistent titres (***or*** within 0.1 cm^3 – *unit needed*) obtained [1]

T6 Suitable indicator chosen ***and*** correct end-point/final colour stated [1]
eg Phenolphthalein goes colourless – not 'clear' (acid in burette)
or pink (alkali in burette)

T7 Gives clear specimen calculation ***or*** explains showing how the titre gives evidence for the dibasic nature of the acid, related to a chemical equation. [1]
An explained comparison with results for equimolar HCl can score the mark

G Gas collection procedure - 8 marks

Use of a suitable metal (Mg or Zn) or any metal carbonate is acceptable.
Use of Na, Ca, Al, Fe (or other less reactive metal) can score G2, G3, G4, G5 and G6 only

G1 Equation for a suitable reaction (for which the produced gas can be measured) [1]

G2 Diagram showing gas collection in a syringe ***or*** inverted burette ***or*** measuring cylinder [1]
Do not penalise minor inaccuracies in diagram – but will it work as drawn?

G3 Ignition tube inside flask ***or*** inner container ***or*** divided flask used
and this keeps reagents apart/stops them reacting while apparatus is assembled
or this prevents gas being lost before bung is inserted
or [when apparatus assembled] tilt the ignition tube [to mix reagents/ start the reaction][1]
*Two points required for G3 – the precaution **and** a reason/description*

G4 Measure volume of gas when fizzing stops ***or*** syringe stops moving [1]
There must be some visual indication of completed reaction before reading is taken.

G5 Calculates the [maximum] volume of acid so that all the gas fits into the collector. [1]
Calculation must be explicitly based on the volume of the syringe/collecting vessel

G6 Excess metal/metal carbonate is used to ensure that all of the sulphuric acid reacts [1]

G7 Calculates [minimum] mass of metal ***or*** metal carbonate [so that it is in excess] [1]

G8 One accuracy precaution [1]
Either repeat whole experiment
and take mean of readings ***or*** until volume of gas is consistent
Or use of gas syringe reduces loss of carbon dioxide caused by its solubility in water

S Safety, Sources and QWC – 4 marks

S1 Sulphuric acid (1M) is irritant/corrosive ***and*** one of the following precautions
- if spilt rinse spill with plenty of water
- dilute before use [in titration] to reduce hazard level
- wear gloves [1]

*No S1 if the hazard is over stated – eg "sulphuric acid is **very** corrosive"*

S2 References to **two** secondary sources quoted as footnotes ***or*** at end of Plan. [1]
- *Book references must have page numbers*
- *Internet references must go beyond the first slash of web address*
- *Accept one specific reference to "Hazcards" (number **or** title required)*

S3 **QWC**: text is legible and spelling, punctuation and grammar are accurate [1]
*Allow not more than **five** different errors in legibility, spelling, punctuation or grammar.*

S4 **QWC**: information is organised clearly and accurately [1]
Is the answer "yes" to all three of the following questions?
- *Is a word count given and within the limits 450 – 1050 words?*
- *Is scientific language used correctly? (Allow **one** error without penalty.)*
- *Are the descriptions logical and without lots of irrelevant or repeated material?*

Practical Test (B)

Page 3 Part 1 (Skill I) 16 marks]

Mass readings [2]

Check the following five points.
- Both mass readings must be listed
- Labelling of masses must have minimum of the words "bottle"/"container" (*aw*)
- Unit (g) must be shown with one (or both) of the weighings
- **All** three masses should be recorded to two (or, consistently, to three) decimal places.
- Subtraction to give mass of **Z** must be correct

Five bullets correct = 2 marks: Four bullets correct = 1 mark
*If only the mass of **Z** is shown award 0.*

Presentation of titration data **[2]**

Check the following six points.

- Table grid drawn (at least three lines) ***and*** all burette data is shown in the table, including first/trial.
- Correctly labelled table (initial, final and difference - *aw*) for burette data
- Three (or more) titres are shown
- All "accurate" burette data are quoted to **two** decimal places, ending in .00 or .05
- No readings recorded above 50 cm^3
- All subtractions are correct

Six bullets correct = 2 marks: Five bullets correct = 1 mark

*A table giving **only** the titre differences scores 0 in this sub-section.*

Self-consistency of titres **2]**

Check the following four points

- The titres for two accurate experiments are within 0.20 cm^3.
- The ticked titres (*or* the titres used to calculate the mean) are within 0.10 cm^3
- Two titres are ticked
- Units, cm^3 or ml, must be given somewhere *(**once** in or alongside the table is sufficient).*

Four bullets correct = 2 marks: Three bullets correct = 1 mark

Mean titre correctly calculated 1]

- *The mean should normally be calculated using the **closest** two accurate titres. However, a candidate may use the trial/first reading if appropriate, without penalty.*

Accuracy – 7 marks

- *If a Centre worked in two or more different sessions using different solutions, each candidate must be matched to the appropriate set of supervisor's data.*

Write down the supervisor's mass and mean titre, rounded to nearest 0.05 cm^3, in a ring next to the candidate's table.

Calculate what the adjusted candidate's titre (T) would have been if the candidate had used the same mass of Z as the supervisor.

***Adjusted titre, T* = candidate's mean titre x $^{\text{supervisor's mass}}/_{\text{candidate's mass}}$**

Use the conversion chart below to award the mark out of 7 for accuracy.

T is within **0.25** cm^3 of mean supervisor's value	[7 marks]
T is within **0.40** cm^3 of mean supervisor's value	[6]
T is within **0.60** cm^3 of mean supervisor's value	[5]
T is within **0.80** cm^3 of mean supervisor's value	[4]
T is within **1.00** cm^3 of mean supervisor's value	[3]
T is within **1.20** cm^3 of mean supervisor's value	[2]
T is within **1.50** cm^3 of mean supervisor's value	[1 mark]

Spread penalty

("Spread" is* defined *by the titres* actually *used by the candidate to calculate the mean)

If the titres used have a spread > 0.40 cm^3, deduct 1 mark from accuracy.
Increase the deduction by 1 mark for every 0.20 cm^3 of spread

Safety – 2 marks

Diluting the alkali/ making a solution/ adding water….. [1]

…..reduces the [level of] hazard /makes it less corrosive [1]
*A **comparison** is required for this mark*

Pages 4 – 6: Part 2 (Skill A) **[14 marks]**

Answers should be quoted to 3 significant figures.
*Use of wrong sig. fig. in an otherwise correct answer loses one mark on the **first** occasion only.*
Allow "error carried forward" between sections of this Part

(a) 1 mark

Mass of pure KOH = 5.50 x 0.86 = 4.73 g [1]

(b) 2 marks

M_r of KOH = 56.1
[1]

Concentration = $^{4.73}/_{56.1}$ = 0.0843 mol dm^{-3} [1]
Correct answer only = 1 mark

(c) 2 marks

n(KOH) = answer **(*b*)** x $^{\text{mean titre}}/_{1000}$ [1]
This is a method mark

Correct answer obtained from candidate's own data (approximately 0.00230 mol) [1]

(d) 2 marks

M_r of sulphamic acid = 97.1 [1]

n (sulphamic acid) = $^{\text{mass used}}/_{97.1}$ (see table below) [1]

(e) 1 mark

Candidate multiplies answer (***d***) by $^{25}/_{250}$ (or divides by 10) [1]

(f) 2 marks

Ratio = $^{(c)}/_{(e)}$ = $^{\text{mol KOH}}/_{\text{mol acid}}$ [1]
Correct working is essential for this mark.

Answer = 1 [1]

(g) 3 marks

(i) $2H_2O$, $3H_2O$ [1]

(ii) First of three equations ticked [1]

The equation shows I mole KOH reacting with 1 mole sulphamic acid [1]
The justification must include the word "mole" (or molar).

(h) 1 mark

1 mole of H^+ [1]

Pages 7 – 9: Part 3 (Skill E) (14 marks max *but 18 available*)

(a) 4 marks available (*but 3 on question paper*)

*Only **two** marks can be awarded if the **second** equation (1:1 mole ratio) is used.*

Valid explanation of choice of the balanced equation, first or third, chosen [1]

$n(H_3NSO_3) = 0.010$ (0.00999) [1]

$n(H_2) = 0.0050$ [or 0.010] or 0.015 (depending on the equation/mole ratio selected) [1]

Volume (H_2) = 120 cm^3 or 240cm^3 or 360 cm^3, which is too much for the syringe [1]

(b) 1 mark

[Mg is in excess] to ensure that all sulphamic acid, Z, reacts [1]

(c) 9 marks available *(but 6 on question paper)*

The candidate's best three strands are counted

C1 Some gas escapes while bung is being inserted
or reaction begins before stopper is put in [1]

C2 Use an inner ignition tube to hold a reagent ***or*** divided flask to hold one of the reagents [1]

C3 Keep reagents apart before inserting the stopper
or prevent collisions between reagents while apparatus is being assembled [1]

D1 Error in measuring the mass of [sulphamic] acid ***or*** mass of acid used is very small [1]

D2 Calculates correctly the % error in measurement of mass [1]
*Allow $^{0.01}/_{0.97}$ x 100 = 1.03% **or** $^{0.02}/_{0.97}$ x 100 = 2.06%*

D3 Use balance reading to 3 (or more) decimal places [1]

E1 Syringe only is less accurately calibrated/ reads to nearest cm^3 [1]

E2 Use an **inverted** burette instead of a syringe [1]

F1 Friction/ stiffness in gas syringe [1]

F2 Rotate the syringe gently while gas is being collected ***or*** lubricate the syringe [1]

G1 Reaction is exothermic, so volume of gas expands ***or*** gas is not collected at RTP [1]

G2 Wait until gas cools to room temperature before measuring the volume
or carry out reaction in water bath [1]

H1 Corrosion/ oxide layer on the surface of magnesium [1]

H2 MgO/ oxide layer reacts with acid without producing any gas/hydrogen [1]

H3 Clean surface of Mg by a specified method (eg rub with sand paper) [1]

J1 A small volume of air is displaced when the bung is inserted [1]

J2 Record initial volume from syringe after this displacement has occurred [1]

K1 Magnesium will react slowly with water [1]
Award one mark only for this strand, since this effect is insignificant

(d) 4 marks

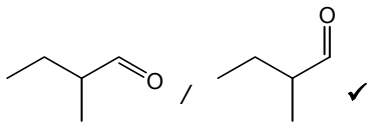
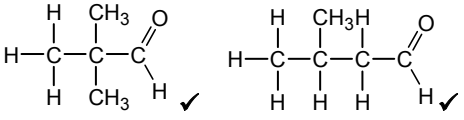
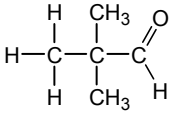
(i) Logical attempt to use the ratios ($^{80}/_{0.64}$ and $^{50}/_{0.45}$) ***or*** inverted
or attempts to calculate mole ratios of gas:acid for both experiments [1]

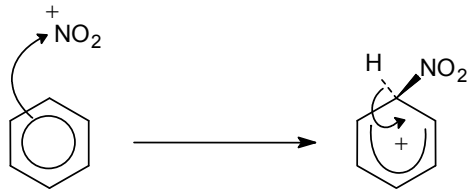
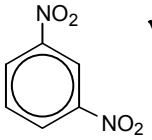
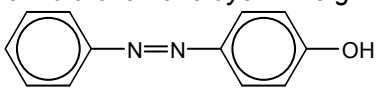
Use calculated ratios to show clearly that readings aren't consistent, so repeat needed [1]

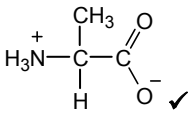
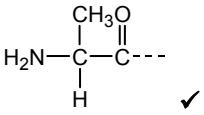
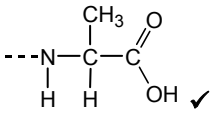
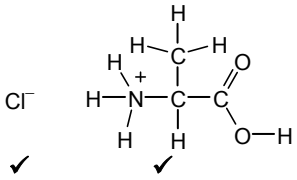
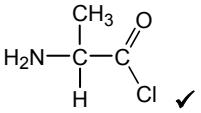
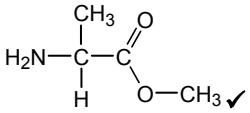
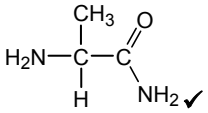
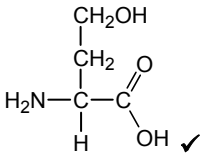
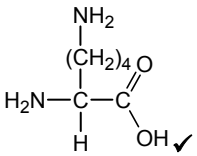
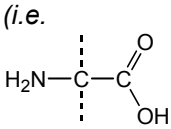
(ii) Titres obtained in titration agreed within 0.1 cm^3 ***or*** were consistent [1]

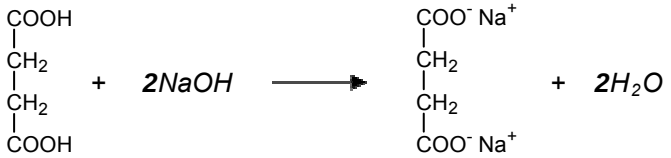
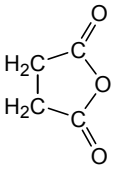
Student's readings are not consistent ***and*** these results are not reliable [1]

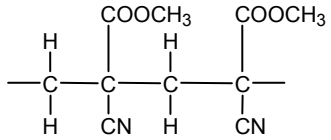
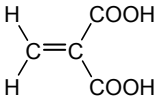
2814 Chains, Rings and Spectroscopy

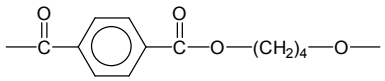
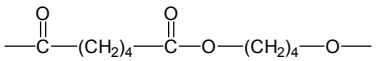
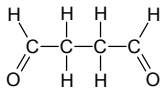
Question	Expected Answers	Marks
1 (a) (i)	*silver mirror* ✓ *(warm) with Tollens' Reagent / ammoniacal silver nitrate* ✓	[2]
(ii)	*carboxylic acid / COOH / COO^- etc* ✓	[1]
(b)	*yellow/red/orange solid* ✓ *with 2,4-dintitrophenylhydrazine / 2,4-DNPH / Brady's Reagent* ✓ *compare m.p. (of the product /solid / ppt) with known values* ✓	[3]
(c)	*86* ✓	[1]
(d) (i)	 ✓	[1]
(ii)	 ✓ *(displayed formulae not essential)*	[2]
(e)	*indentity* ✓ *– e.g.*  *reasoning* ✓ ***either*** *two types of proton / two peaks /* *all CH_3 protons are the same type* ***AW*** ***or*** *no splitting / no protons on the neighbouring C* ***AW*** ✓ *(allow any unambiguous way to identify the correct isomer)*	[2]
		[Total: 12]

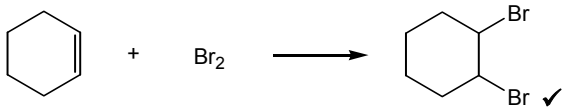
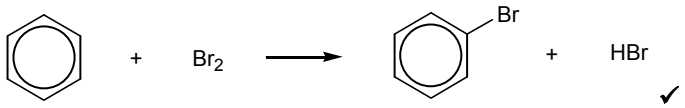
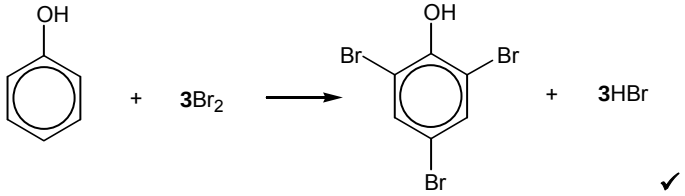
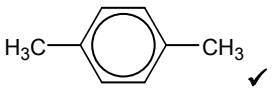
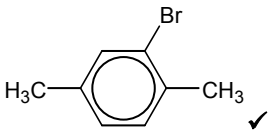
Question	Expected Answers	Marks
2 (a) (i)	$C_6H_6 + HNO_3 \longrightarrow C_6H_5NO_2 + H_2O$ ✓	[1]
(ii)	***conc*** H_2SO_4 ✓	[1]
(b)	***mechanism***	
	NO_2^+ ✓ *curly arrow from □ bond to electrophile* ✓	
	 *intermediate* ✓ *curly arrow from C–H bond to □ bond* ✓ *(the 'smile' must end at C2 and C5 and the + charge must not be at the tetrahedral carbon)*	
	involvement of catalyst	
	equation to show formation of $NO_2^+ / H_2NO_3^+$ ✓ *e.g.* $HNO_3 + H_2SO_4 \longrightarrow NO_2^+ + H_2O + HSO_4^-$	
	regeneration of H_2SO_4 ✓ *e.g.* HSO_4^- *shown accepting* H^+ *or equation:* $HSO_4^- + H^+ \longrightarrow H_2SO_4$	[6]
(c)	*accept any dinitrobenzene isomer - eg*  ✓	[1]
(d)	*Sn* ***and*** *(conc) HCl* ✓ *to give* $C_6H_5NH_2$ */ phenylamine* ✓ *(allow any other suitable reducing agents)* *equation* ✓ $C_6H_5NO_2 + \mathbf{6}[H] \longrightarrow C_6H_5NH_2 + \mathbf{2}H_2O$ $NaNO_2 / HNO_2$ ***and*** *HCl* ***and*** *<10°C* ✓ *to give* $C_6H_5N_2^+$ */ diazonium* ✓ *equation* ✓ *e.g.* $C_6H_5NH_2 + H^+ + HNO_2 \longrightarrow C_6H_5N_2^+ + \mathbf{2}H_2O$ *phenol* ***and*** *alkali* ✓ *formula of an azo dye* ✓ *e.g. -* 	[8]
		[Total: 17]

Question	Expected Answers		Marks
3 (a)	 ✓	*(allow any unambiguous structures)*	**[1]**
(b)	*peptide bond correct on at least one structure* ✓ *alanine as N–terminal…* *and C–terminal*  ✓  ✓	*(ignore the attempted structure of valine as the formula given is not easy to interpret)*	**[3]**
(c)	*correct ionisation of –NH_2 and –COO^- /–COONa groups* ✓	*(do not allow a covalent O–Na bond)*	**[1]**
(d)	 ✓ ✓		**[2]**
(e)	 ✓  ✓  ✓		**[3]**
(f)	*any valid isomers which are 2-amino carboxylic acids – e.g.* ***C*** ***D***  ✓  ✓	*(i.e.*  *plus any isomers of C_2H_6O and $C_4H_{11}N$)*	**[2]**
			[Total: 12]

Question	Expected Answers	Marks
4 (a)	*fumaric acid **and** malic acid identified* ✓	
	***one** correct explanation* ✓ *- e.g.*	
	*the C=C bond does not rotate /has restricted rotation / has different groups on both C=C carbons **AW*** ✓	
	has a chiral centre / four different groups around a C ✓	**[2]**
(b)	*use of NaOH / Na / Na_2CO_3 $NaHCO_3$* ✓ *rest of the equation and balancing* ✓ *- e.g.* 	**[2]**
(c)	 ✓	**[1]**
(d) (i)	***in presence of D_2O*** *two peaks* ✓ *relative peak areas 2:1* ✓ *(splitting of peak with area 2) is a doublet /1:1* ✓ *(splitting of peak with area 1) is a triplet/1:2:1* ✓ ***without D_2O*** *five / three more peaks* ✓ *due to the OH protons (not shown in D_2O)* ✓ ***AW***	**[6]**
QWC	*mark for good communication of how the adjacent /neighbouring hydrogens affect the splitting (e.g. use of the n + 1 rule)*	**[1]**
(ii)	***shifts*** *peak at δ = 11.0–11.7 ppm **and** peak at δ = 2.0 – 2.9 ppm* ✓ ***explanation: either …*** *(only) two environments / molecule is symmetrical **AW*** ✓ ***or*** *(peak at δ = 11.0–11.7 ppm is due to) COOH **and*** *(peak at δ = 2.0–2.9 ppm is due to) CH_2* ✓	**[2]**
		[Total: 14]

Question	Expected Answers		Marks
5 (a)	*section of the polymer ✓– eg* 	*(structure must show end bonds)* *(do **not** allow connection errors or 'sticks' here)*	**[1]**
(b)	 *one COOH group ✓* *other COOH group and the rest of the structure ✓*	*(allow $CONH_2$ from the partial hydrolysis of the CN group)*	**[2]**
(c) (i)	*CH_3OH ✓* *(heat) with **conc** H_2SO_4 ✓*		**[2]**
(ii)	*HCN / KCN ✓*	*(allow any mixtures that would create HCN in situ)*	**[1]**
(iii)	*nucleophilic addition ✓*		**[1]**
(iv)	*H_2O ✓*		**[1]**
(d)	*M_r $CH_3COCOOH$ = 88* **and** *M_r $CH_2C(CN)COOCH_3$ = 111 ✓* *theoretical yield = 12.6 (kg) / 113.6 (moles) ✓* *@30% = **3.78** kg ✓* *answer rounded to 2 sig figs ✓*	*(allow ecf throughout)*	**[4]**
			[Total: 12]

Question	Expected Answers	Marks
6 (a)	*ester bond* ✓ *a correct repeat unit* ✓ ***either***:  ***or***:  *(allow ecf for a correct repeat of an anhydride for the 2nd mark)*	**[2]**
(b)	*condensation* ✓	**[1]**
(c)	*any sequence with H every second position and at least one F and one G – eg* *–F–H–F–H–G–H–F–H–G–H–* ✓	**[1]**
(d) (i)	$NaBH_4$ / $LiAlH_4$ ✓	**[1]**
(ii)	*any unambiguous name or structure – eg*  ✓ *(do not allow –COH for the aldehyde group)*	**[1]**
(iii)	$OHC(CH_2)_2CHO + 4[H] \longrightarrow HO(CH_2)_4OH$ ✓	**[1]**
(iv)	*peak at 1680–1750 (cm^{-1}) for **J*** ✓ *peak at 3230–3550 (cm^{-1}) for **H*** ✓ *(allow any named value in between the ranges)* *(ignore reference to the C–O peak)*	**[2]**
		[Total: 9]

Question	Expected Answers	Marks
7 (a)	***reaction with cyclohexene*** *addition* ✓  *(□-)electrons are localised / not delocalised* ✓ ***reaction with benzene*** *substitution* ✓  *(□-)electrons are delocalised* ✓ ***reaction with phenol*** *substitution* ✓  *lone pair of electrons from O are delocalised around the ring* ✓ ***explaining reactivity in the context of any compound*** *valid discussion of relative electron density (around the ring)* ✓ *valid discussion of relative polarisation of the bromine* ***or*** *the (electrostatic) attraction of electrophiles to the ring* ✓ *correct use of the term electrophilic / electrophile* ✓ ***any 11 out of 12 marks***	**[11]**
QWC	*mark for at least two sentences or bullet points in context with correct spelling, punctuation and grammar* ✓	**[1]**
(b)	***K***  *allow any dimethyl benzene or ethylbenzene* ***L*** 	**[2]**
		[Total: 14]

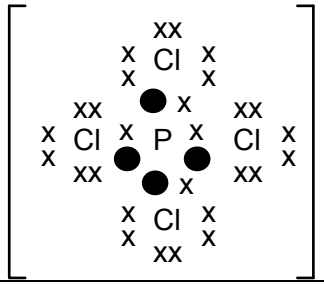
2815/01 Trends and Patterns

Mark Scheme Page 1 of 5	Unit Code	Session	Year	Version
	2815/01	June	2008	Final Mark Scheme

Question	Expected Answers	Marks	Additional Guidance
1 (a)	**Any three from** Strontium ion smaller than barium ion / strontium ion has a higher charge density / ora (1); Strontium ion is more polarising / ora (1); Strontium ion distorts the carbonate ion more than barium ion / ora (1); So carbon–oxygen or covalent bond (in carbonate) is weaker (1)	3	**No** mark for just writing decomposition temp is higher for $BaCO_3$ If $SrCO_3$ with higher temp award 0 marks **Must** use correct particle but only penalise once in part (a) **Allow** Sr^{2+} is more polarising and distorts the carbonate ion (2) / Sr^{2+} polarises the carbonate ion causing more distortion (2) **Allow** marks from a labeled diagram
(b) (i)	$2Mg(NO_3)_2 \rightarrow 2MgO + 4NO_2 + O_2$ (1)	1	**Allow** any correct multiple **Ignore** state symbols
(ii)	Oxide (ion) smaller than nitrate (ion) / oxide (ion) has a higher charge density than nitrate (ion) / oxide (ion) has a higher charge than nitrate (ion) (1); So oxide (ion) has a stronger attraction to magnesium ion / nitrate (ion) has a weaker attraction to positive ion / MgO has stronger ionic bond / MgO has stronger attraction between ions (1)	2	**Allow** ora **Must** use correct particle but only penalise once 'It' refers to oxide (ion) or MgO **Allow** MgO has stronger bond between charged particles

Mark Scheme Page 2 of 5	Unit Code	Session	Year	Version	
	2815/01	June	2008	Final Mark Scheme	
Question	**Expected Answers**			**Marks**	**Additional Guidance**
1 (c) (i)	Fe goes from +2 to +3 which is oxidation (1); S goes from +6 to +4 which is reduction (1)			2	If no other marks awarded **allow** one mark for correct identification of all oxidation numbers or ecf from wrong oxidation numbers if both oxidation and reduction identified
(c) (ii)	Idea of use of (2 ×) +929 –826 – 297 – 396 / correct use of molar ratios (1); = (+)339 (1)			2	**Allow** full marks for correct answer with no working out **Allow** one mark for –590 / –339 / 3377 / –3377 Unit **not** needed
(iii)	(Moles of SO_2 = 0.00385 so) moles of $FeSO_4.7H_2O$ = 0.00771 (1); M_r of $FeSO_4.7H_2O$ = 277.9 (1); (So mass = 2.14) and % = 76.9 / 77.0 (1) Or M_r of $FeSO_4.7H_2O$ = 277.9 (1); (Moles of $FeSO_4.7H_2O$ = 0.01 so) moles of SO_2 = 0.005 (1); (So volume = 120) and % = 76.9 / 77.0 (1)			3	**Allow** (Moles of SO_2 = 0.004 so) moles of $FeSO_4.7H_2O$ = 0.008 (1) **Allow** ecf from wrong moles and/or M_r of $FeSO_4.7H_2O$ **Allow** ecf from wrong M_r **Allow** ecf from wrong moles of SO_2 **Percentage** must be quoted to 3 sig figs
				Total = 13	

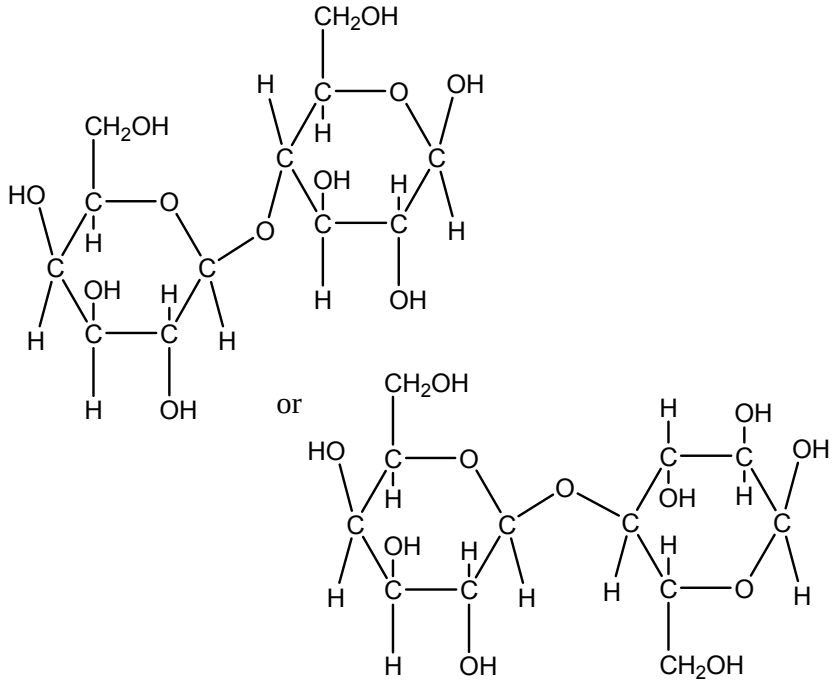
Mark Scheme Page 3 of 5	Unit Code 2815/01	Session June	Year 2008	Version Final Mark Scheme	
Question	**Expected Answers**			**Marks**	**Additional Guidance**
2 (a)	$MoO_3 + 2Al \rightarrow Al_2O_3 + Mo$ (1)			1	**Ignore** state symbols **Allow** correct multiples
(b)	[Kr] $4d^3$ **and** (Mo^{3+}) has an incomplete filled d-subshell (1)			1	**Allow** has incomplete 4d sub-shell / incomplete d orbital **Ignore** errors in [Kr]
(c)	Correct molar ratio of Mo and Cr species $3MoO_2 + Cr_2O_7^{2-} \rightarrow 2Cr^{3+} + 3MoO_4^{2-}$ (1); **But** $3MoO_2 + Cr_2O_7^{2-} + 2H^+ \rightarrow 2Cr^{3+} + H_2O + 3MoO_4^{2-}$ (2)			2	Ignore H^+, H_2O and e^- in equation For the second mark the H^+ and H_2O must be cancelled down to 2 and 1
(d) (i)	K_2FeO_4 (1)			1	
(ii)	Moles of Fe_2O_3 = 0.00627 (1); Moles of OH^- = 0.0400 (1); Fe_2O_3 in excess since there needs to be 0.0627 moles of OH^- / evidence of working out the reagent in excess (1)			3	**Allow** reverse argument e.g. 0.0400 moles of OH^- can only react with 0.004 moles of Fe_2O_3 **Allow** ecf from wrong moles
				Total = 8	

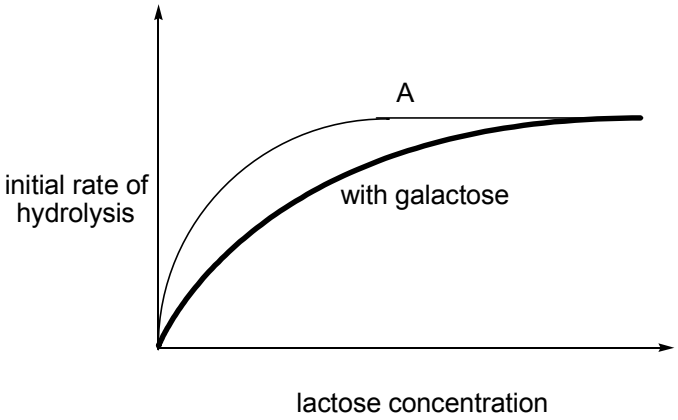
Mark Scheme Page 4 of 5	Unit Code 2815/01	Session June	Year 2008	Version Final Mark Scheme	
Question	**Expected Answers**			**Marks**	**Additional Guidance**
3 (a)	$Ca^{+}(g) \rightarrow Ca^{2+}(g) + e^{-}$ (1); atomisation (of oxygen) / ΔH_{at} (1); Second electron affinity (of oxygen) / ΔH_{ea2} (1); $Ca(s) \rightarrow Ca(g)$ (1)			4	State symbols needed
(b)	Al_2O_3 – intermediate bonding / electrostatic attraction between ions (1); $AlCl_3/Al_2Cl_6$ – van der Waals / temporary dipole – temporary dipole / induced dipole – induced dipole interactions / intermolecular forces (1); Correct comparison of strength of forces e.g. intermediate bonds stronger than van der Waals (1)			3	**Allow** giant ionic / giant intermediate **Allow** simple molecular Comparison of forces **dependent** on forces being correct
(c)	Al_2O_3 does not dissolve / does not react (1); $AlCl_3$ reacts / $AlCl_3$ is hydrolysed / polarisation of water molecules by aluminium ion (1) $AlCl_3$ – gives a colourless solution / misty fumes / steamy fumes / pH 1 to 6 (1)			3	**Allow** mark from an appropriate equation **Allow** acidic solution / gets hot / exothermic
(d) (i)	Correct dot and cross diagram (1)  			1	**Ignore** lack of charge **Ignore** inner shells
(ii)	Tetrahedral / correct drawing of tetrahedral (1); Has four bond pairs / repulsion between four bond pairs / four bonds repelling (1)			2	**Allow** ecf from wrong dot and cross diagram for a PCl_4^+ species
				Total 13	

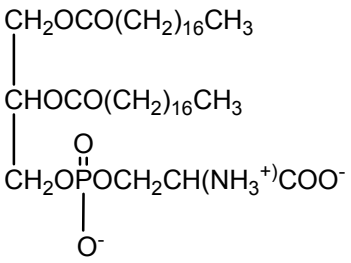
Mark Scheme Page 5 of 5	Unit Code 2815/01	Session June	Year 2008	Version Final Mark Scheme	
Question	**Expected Answers**			**Marks**	**Additional Guidance**
4	Bonding in complex ion Ligand donates an electron pair / copper accepts electron pair (1); Dative (covalent) / coordinate (1)			2	**Allow** even if not a copper complex **Allow** marks from a diagram
	Shape of complex ion Correct name or formula of copper complex ion (1); Correct shape of a copper complex either by name or clear drawing with indication of three dimensions (1); Correct bond angle (1) • *e.g.* $[Cu(H_2O)_6]^{2+}$ is octahedral and 90^o • *e.g.* $[CuCl_4]^{2-}$ is (flattened) tetrahedral and bond angle between 90^o and 110^o			3	**Allow** last two marking points if not a copper complex
	Ligand substitution Correct example of ligand substitution reaction involving a copper complex (1); Correct equation (1); Idea of one ligand being swapped with another one (1)			3	**Allow** all marks from an equation **Allow** last two marking points if not a copper complex
	Colour Correct colour of two copper complex ions one mark for each correct colour			2	If one colour given is wrong max 1 If two colours wrong score 0
	Quality of Written Communication. Answer must address the question set and include at least three of the following terms in the correct context • Electron / lone pair • Covalent • Dative • Coordinate • Octahedral • Tetrahedral • Square planar • Molecule			1	
				Total = 11	

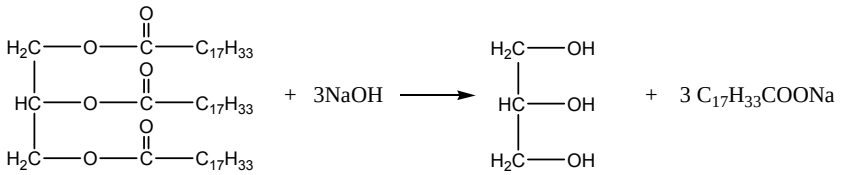
2815/02 Biochemistry

Question	Expected Answers	Marks
1 (a)(i)	(α)–Helix in the spiral region✓ (β)–Sheets where there are parallel strands of amino acids✓ Hydrogen bonds ✓	[2]
(ii)	Diagram using NH and CO of amide/peptide groups : CO ----HN✓. The link must be dotted or dashed.	[2]
(b)	Two of: • Ionic/electrostatic attraction using the N+/ positive charge ✓. • Van der Waals (Instantaneous dipole/induced dipole) using the (flat/ aryl/ imidazole) ring or CH_2 or C=C✓. • Hydrogen bonding using either NH ✓.	[2]
(c)(i)	Heat energy causes weak/ R–group/sidechain interactions to break✓. Accept a specific example eg hydrogen bonding.	[2]
(ii)	Heavy metal ions react with SH groups/ interfere with disulphide bridges/disrupt van der Waals (Instantaneous dipole/induced dipole) forces/ react with COO^- groups ✓	
2 (a)	OHCCHOHCHOHCHOHCHOHCH$_2$OH ✓ for the aldehyde/CHO ✓ for the rest. Allow the rest mark if –COOH or a midchain ketone are used instead of aldehyde. Do not allow missing H atoms. Vertical versions acceptable, as are displayed structures. Do not expect stereochemistry.	[2]

(b)	 or ✓ for correct –CH–O–CH– link, ignoring stereochem of CH s. ✓ for the rest including all stereochemistry. The orientation of the OH on the free C1 can be either α or β. They may have either glucose or galactose on the left, and flipped versions, such as the lower one above , are correct. Allow up to two missing H atoms attached to C (slips).	**[2]**
(c)(i)	Filtration/centrifugation/decant …. ✓. Not simply tapped off or removed.	**[1]**
(ii)	Any two points from: • stability (to heat) increased • optimum temperature of enzyme may be increased • end product inhibition can be avoided • continuous process • can be reused • purification of product easier <u>because</u> enzyme will not be present	**[2]**

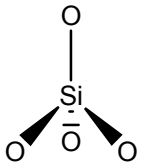
(d)(i)	*Increasing concentration gives more chance of/frequent collisions(accept 'more collisions')* */First order kinetics operating✓* *Plenty of vacant <u>active/binding sites</u> available.✓AW*	**[2]**
(ii)	*Inhibitor competes (with substrate) for the <u>active/binding site.</u>* *Or: The inhibitor binds to the <u>active site</u> reversibly/ because it has a similar shape to substrate/blocking or preventing substrate from binding. AW ✓*	**[1]**
(iii)	*Initial inhibition (increase in initial rate is at a shallower angle) <u>and</u> returning to uninhibited V_{max} at high lactose concentrations.✓*  	**[1]**

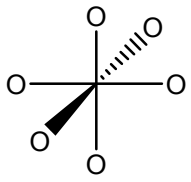
3	*Find six of the following points:* *Structure(max 4)✓✓✓✓* • *①Cellulose molecules have 1β-4 glycosidic link, amylose 1α-4.(Ignore any reference to 1–6.)* • *②Both are polymers of glucose* • *③Cellulose molecules are linear/have straight chains.* • *④Amylose has a helical structure.(Branched woukd be CON)* • *⑤Intermolecular hydrogen bonding holds cellulose together/ hydrogen bonding holds cellulose molecules close together. A diagram can help.* • *⑥Hydrogen bonding holds amylase helix together A diagram can help.* *Function(max 2)✓✓* • *⑦For amylose accept one of the following:* *Easily hydrolysed to glucose when needed for energy* *Compact- does not take up much space (in cell)* *Insoluble- cannot leave cell* *Stores much glucose with minimum osmotic effect* *Not involved in immediate cell metabolism* • *⑧ Cellulose molecules form strong fibres* *The QWC mark should be awarded to a well organised answer which shows understanding of three of the following : hydrogen bonding, helix, linear, glycosidic link , α β, link between structure and function.* *The answer may be presented as a table.*	**[7]**
4 (a)	 A link between stearic acid and glycerol✓ Link between phosphate and glycerol ✓ Link between serine and phosphate.✓ *Accept OOC.* *Allow up to two missing H atoms attached to C on glycerol but not extra OH groups.*	**[3]**
(b)	*van der Waals /instantaneous dipole-induced dipole forces* *Do not accept' hydrophobic'.*	**[1]**

	(c)(i)	 *one mark for correct sodium oleate✓.* *Balance✓. Allow partial hydrolysis or hydrolysis using water giving oleic acid for the balancing mark..*	**[2]**
	(ii)	*Making soap/saponification.✓*	**[1]**
	(d)	• *Triglycerides contain a higher proportion of carbon and hydrogen than carbohydrates/ carbohydrates are already partally oxidised/ more C to O or O to H bonds present in carbohydrates ✓.* • *Energy comes from formation of CO_2 and H_2O/ CO and HO bonds✓.(accept oxidation of C and H releases energy)*	**[2]**
5	**(a)** **(i)** **(ii)**	They should identify: *Phosphate attached to C3 <u>and</u> C5 ✓* *Base attached to C1✓*	**[2]**
	(b)(i)	*Chain of nucleotides/chain of sugar- phosphate units ✓* *Formed by elimination of water between nucleotide units/sugar–phosphate units/molecules/monomers.✓*	**[2]**
	(ii)	*Hydrogen bonding✓ between bases AT <u>and</u> CG✓.This may be given as a diagram.* *or for second mark NH…N or NH… O* *Alternatively accept: van der Waals' forces✓ between the (non-polar aromatic) rings on the bases✓*	**[2]**

(c)	*Four marks from*: Four points from the following.✓✓✓✓.AW. • ①Double helix unwinds with breaking of hydrogen bonds/ van der Waals/mention of enzyme helicase. • ②The <u>complementary</u> base pairs are CG and AT. • ③Exposed bases become hydrogen bonded to bases on free nucleotides/ mention of nucleotide triphosphates/ both strands act as templates for replication • ④Incoming nucleotides attached to growing chain by a (phosphate) ester link / the joining of each nucleotide is catalysed by DNA polymerase • ⑤Semi-conservative replication/ each of the two resulting double helices contains one original strand and one newly synthesised strand No credit for pyrophosphate formation and hydrolysis. If candidates include RNA in their answer, award a maximum of 3 marks. *Allow the marks for diagrams as long as the meaning is clear.*	**[4]**

2815/03 Environmental Chemistry

Question		Expected Answers	Marks
1	(a)(i)	*Methane/CH_4.✓*	[1]
	(ii)	*Anaerobic/without oxygen✓*	[1]
	(b)(i)	*Any two of the following @ ✓✓each.:* *Plastics: PVC/polythene/polypropylene/ etc* *Textiles: nylon/terylene/etc.Or cellulose in cotton/protein in wool/* *Paper/cardboard: cellulose* *Plant material: cellulose/starch/etc* *AW throughout. Allow sensible alternatives*	[4]
	(ii)	*Reduces bulk of waste/need for landfill sites✓*	[1]
	(iii)	*To minimise formation of dioxins, or of HCl from PVC.✓*	[1]
	(c)	*Batteries. Other sensible alternatives. Not pencils.✓*	[1]
2	(a)(i)	 *SiO_4✓Their diagram should show four oxygens attached to the central Si.* *The correct shape of the unit is tetrahedral✓* *Units share✓three of their four oxygen atoms ✓* *(with neighbouring units on the sheet.)*	[4]

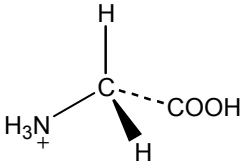
(ii)	 *AlO_6* ✓ *Allow two of the O atoms to have H attached.* *The correct shape of the unit is octahedral* ✓ *Their diagram should show six oxygens attached to the central Al with 90^o angles*	**[2]**
(iii)	*Links between sheets within the layer are due to the sharing of the free O atoms* ✓ */ Si–O–Al / comment on covalent bonds* ✓.	**[2]**
(b)(i)	*Any one e.g. K^+* ✓ *Must show the correct charge.* *Accept NH_4^+, Mg^{2+}*	**[1]**

	(ii)	*They have a larger available (internal) surface area✓.*	[1]
3	(a)	*Five marks from:✓✓✓✓✓* • ①*Dissolved CO_2 produces carbonic acid* • ②*Equation $H_2O + CO_2 = H_2CO_3$* • ③*Sulphur dioxide reacts with water and oxygen✓* • ④ *to make sulphuric acid .(Allow 1 mark only here for making sulphurous acid instead.)* • ⑤*Equation $SO_2 + H_2O + 0.5O_2 = H_2SO_4$ (Allow H_2SO_3 one.)* • ⑥*Equation for dissociation, partial or complete of carbonic, sulphuric or sulphurous acids* • ⑦*Carbonic acid weak, sulphuric/ous acid stronger*	[5]
	(b)(i)	*QWC Well organised response which includes at least one balanced equation and correct use of two of the following terms: dissolved/solution, oxidation/oxidised, weak acid.*	[1]
	(ii)	*Boiling temporary hard water precipitates/ makes insoluble✓ $CaCO_3$ ✓. Symbol equation✓.(Equation + state symbols✓✓✓)* *$Ca(HCO_3)_2$ = $CaCO_3$ + H_2O + CO_2* *Ion exchange✓. Calcium ions exchanged for sodium/hydrogen ions.✓ or equation, eg $Ca^{2+}(aq) + Na_2R(s) = CaR(s) + 2Na^+(aq)$* *Accept use of sodium carbonate✓ with equation✓.* Na_2CO_3 + $CaSO_4$ = $CaCO_3$ (s) + Na_2SO_4 *Or ionic* $Ca^{2+}(aq)$ + CO_3^{2-} (aq) = $CaCO_3$ (s)	[3] [2]
	(c)	*It forms HOCl /chlorate(I)ion/equation✓* Cl_2 + H_2O = HCl + HOCl *This is an oxidising agent ✓which kills bacteria* 'Kills bacteria' with an attempt at a chemical explanation ✓ 'Kills bacteria' without such an attempt earns no marks).	[2]
4	(a)	Accept any three of ✓✓✓ • *Increased by respiration* • *Decreased by photosynthesis* • *Varied by equilibrium(dissolving/evaporation) at water surface* • *Combustion (of fossil fuels/forests/wood/coal etc).* • *Emission from volcanoes*	[3]

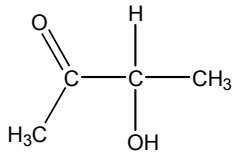
(b)(i)	*They absorb infrared radiation ✓ which causes the bonds in the molecule to vibrate (more)✓. IR then radiated back to Earth✓.*	**[3]**
(ii)	Any two of: • *Concentration ✓* • *Residence time✓* • *Ability to absorb IR (in the water window)✓.*	**[2]**
(c)	*Any five marks from:✓✓✓✓✓* • *UV radiation* • *Causes $CFCl_3$ to break down producing Cl radical $CFCl_3 = CFCl_2 + Cl$* • *Cl radical reacts with ozone $Cl + O_3 = ClO + O_2$* • *ClO reacts with O atom $ClO + O = Cl + O_2$* • *Mention of chain reaction or regeneration of Cl* • *O produced by photolysis/decomposition of O_3/ NO_2/O_2* *Accept a description in words instead of one only of the above equations.* *Termination reactions are not required.*	**[5]**

2815/04 Methods of Analysis and Detection

Question		Expected Answers	Marks
1a	i	$C_3H_7{}^{35}Cl^+$ ✓ $C_3H_7{}^{37}Cl^+$✓ (penalise lack of + charge only once on the paper)	2
	ii	3 : 1 ✓	1
b		$CH_3CH_2{}^+$/ $CH_3CH_2CH_2{}^+$ /CH_2Cl^+ / $C_2H_5{}^+$ / $C_2H_4Cl^+$ ✓ Do not allow $C_3H_7{}^+$	1
c	i	CO_2 –calculation ✓ C_3H_8 –calculation✓	2
	ii	Exactly the same M_r / the same number of atoms of each element	1
			7

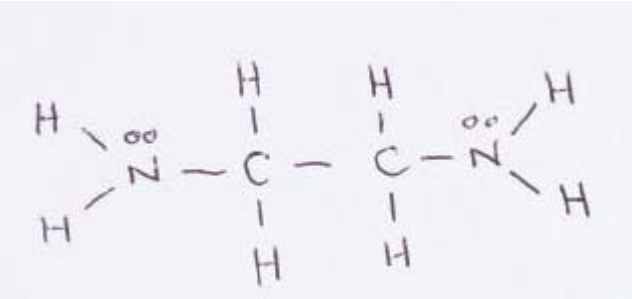
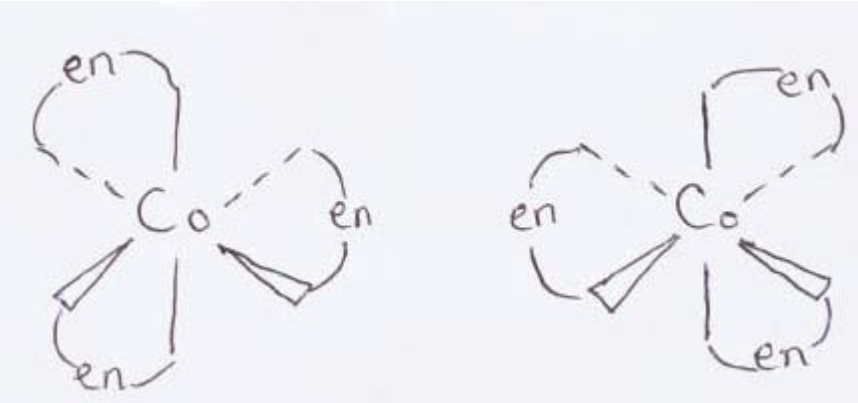
Question	Expected Answers	Marks
2a i	mobile phase = solvent/water ✓ stationary phase = solid/SiO_2/Al_2O_3 ✓	**2**
ii	mark consequentially to (a) (i) If stationary phase = SiO_2/Al_2O_3 - a**d**sorption in stationary phase ✓ separation depends on attraction of solutes for the stationary phase. / relative solubility in solvent ✓ or If stationary phase = solvent trapped in cellulose – partition ✓ separation depends on relative solubility between the mobile and the stationary phases. ✓	**2**
iii	Ninhydrin / iodine ✓ allow appropriate locating agent e.g. uv	**1**
b	run in one solvent ✓ rotate through 90° and run in a different solvent✓ More effective as it is highly unlikely that any two solutes will have the same R_f values in two different solvents✓	**3**
c i	3 ✓	**1**
ii	(1.1/3.9 = 0.28) range of 0.23 – 0.33 ✓	**1**
d	pH = 2  ✓	**1**
e	order from left to right is **C** – **D** – **B** – **E** correct order scores all 3 **B** remains at starting point scores 1 **E** moves towards negative scores 1 **C** & **D** correct scores 1	**3**
		14

Question		Expected Answers	Marks
3a		electron falls from high level to a lower levels & emits (electromagnetic) radiation ✓	**1**
b	**i**	electrons fall from higher levels back to **same** lower level✓	**1**
	ii	electrons fall back to different lower levels✓	**1**
c	**i**	5.08×10^{14} ✓ s^{-1}/Hz✓	**2**
	ii	ecf on (i) E = hfL ✓ E = 203000/ 2.03×10^{5} J mol^{-1} ✓ 3 Significant figures ✓	**3**
d		uses graph to obtain Na^{+} content = 550 μg ✓ x 100 = 55000 μg ✓ ecf 5.5% ✓ ecf	**3**
			11

Question	Expected Answers	Marks
4a	Calculates empirical to be C_2H_4O – **must** see working (%/Ar) ✓ empirical mass = 44 ✓ M_r = 88 hence molecular formula is $C_4H_8O_2$ ✓	**3**
b	**infra-red:** identifies C=O at about 1700 cm^{-1} /1680–1750 ✓ identifies C–O at about 1100 cm^{-1} /1000–1300 ✓ identifies O–H at about 3500 cm^{-1} /3230–3550 ✓ **nmr:** Four different H environments✓ δ = 1.4 CH_3 split into a doublet showing it to be next to a CH✓ δ = 2.2 CH_3 next to a C=O singlet – no Hs on the adjacent C✓ δ = 3.7 due to OH✓ δ = 4.2 due to H next to CH_3 because it is split into a quartet✓ identifies compound **F** as 3-hydroxybutanone/ ✓ 	**9**
QWC	Uses three correct scientific terms such as: fingerprint region, wavenumber, abundance, chemical shift, splitting patterns, environment, doublet, singlet, quartet, , absorptions, peak or correct units such as cm^{-1}, δ, ppm,	**1**
		13

2815/06 Transition Elements

Mark Scheme Page 1 of	Unit Code	Session	Year	Version
Abbreviations, annotations and conventions used in the Mark Scheme	/ = alternative and acceptable answers for the same marking point ; = separates marking points NOT = answers which are not worthy of credit ( ) = words which are not essential to gain credit ____ = (underlining) key words which **must** be used to gain credit ecf = error carried forward AW = alternative wording ora = or reverse argument			

Question	Expected Answers	Marks
1 (a) (i)	Pink to blue	1
(ii)	Tetrahedral	1
(iii)	Ligand substitution Accept ligand exchange	1
(b)	 Lone pairs shown on both nitrogens Accept H_2N – with lone pair shown on nitrogen atom Accept a complex if ligand is shown as a displayed formula	1
(c) (i)	Optical	1
(ii)	 Accept three loops Accept other correct ways of showing 3-d structure Ignore charges or lack of charge	2 Total: 7

Mark Scheme Page 2 of	Unit Code	Session	Year	Version
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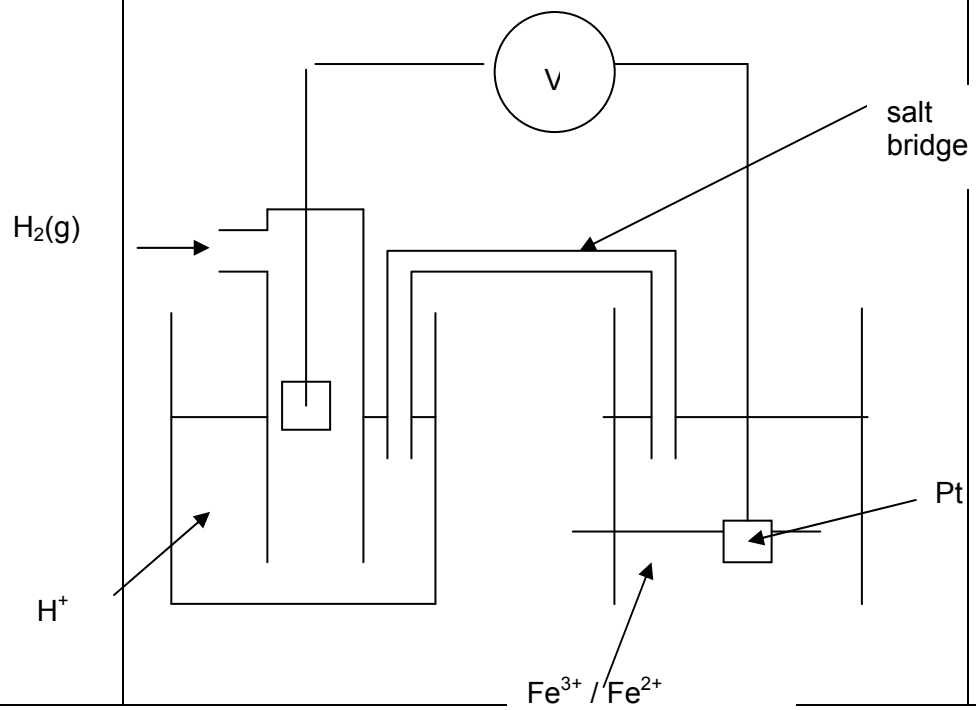
Question	Expected Answers	Marks
2 (a)	The emf / voltage / potential difference of a cell made from a Fe^{3+} / Fe^{2+} half cell	1
	Combined with a (standard) hydrogen half cell	1
	Solutions all 1 mol dm^{-3} (accept equimolar solutions)	
	and	
	Temp 298 K / 25 ^{0}C	
	and	
	Pressure of gas 1 atm / 100 / 101 kPa	1
	(all three needed)	
(b)	Complete circuit including voltmeter and salt bridge	1
	Platinum electrode for Fe^{3+} / Fe^{2+} half cell labelled	1
	Fe^{3+} / Fe^{2+}	1



(c) (i)	Emf = (+) 0.23 V	1
(ii)	$2Fe^{3+} + 2I^- \rightarrow 2Fe^{2+} + I_2$ Electrons must be cancelled Accept multiples	1 Total: 8

Mark Scheme Page 3 of	Unit Code	Session	Year	Version
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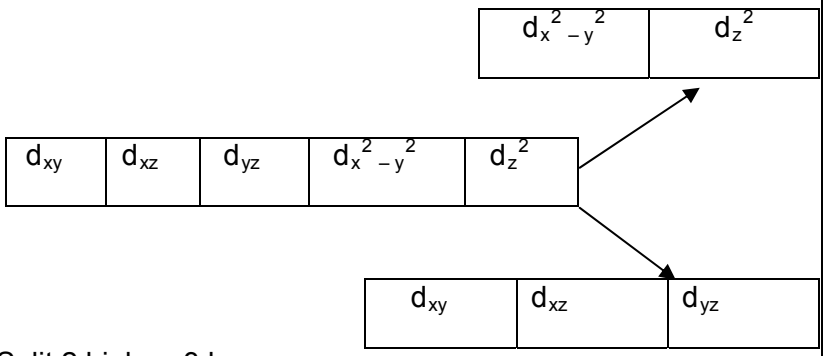
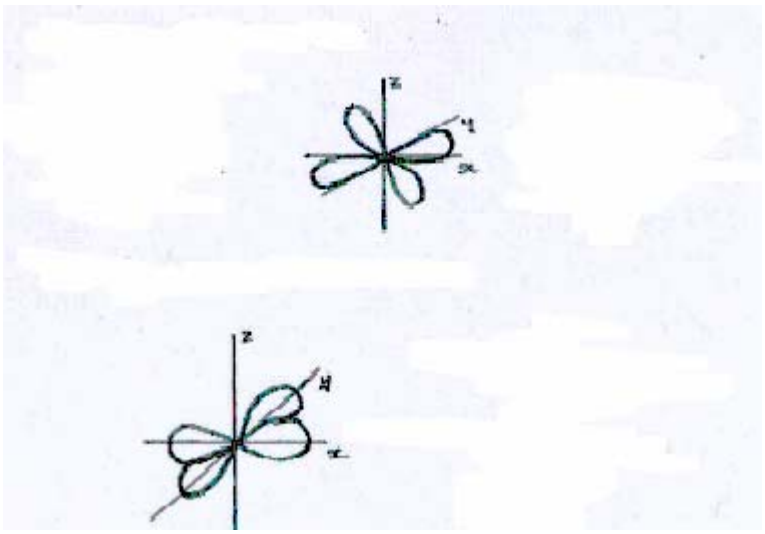
Question	Expected Answers	Marks
3 (a)	 Split 2 higher, 3 lower Correct labels If reversed award 1 mark	1 1
(b)	Correct d_{xy} with labels. Correct $d_{x^2-y^2}$ with labels. 	1 1

(c)	In octahedral complexes d-electrons are repelled/made less stable by ligand lone pairs or, ligands approach along *x*, *y* and *z* axes AW Repulsion/interaction between ligand 'lone pair' and axial orbitals is greater than for inter-axial orbitals	 1 1
(d)	Idea of different energy gaps Idea of different frequency / wavelength / colour of visible light <u>absorbed or transmitted</u>	1 1
(e)	Complex **A** is red-blue / violet-red / purple / magenta Complex **B** is violet / violet-blue / mauve / blue	1 1 Total: 10

Mark Scheme Page 4 of	Unit Code	Session	Year	Version
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Question	Expected Answers	Marks
4 (a)	Standard cell potential is + 0.37 V Standard cell potential is positive therefore the reaction is feasible Alternative: Second equilibrium is less positive and will move from right to left supplying electrons First equilibrium will accept electrons and move from left to right so that equation as written is likely to occur.	1 1
(b)	Oxidation ***and*** reduction Of the same species / Cu^+	1 1
(c)	As solid / in non aqueous solvents / when ***not*** in aqueous solution	1 Total: 5

Mark Scheme Page 5 of	Unit Code	Session	Year	Version
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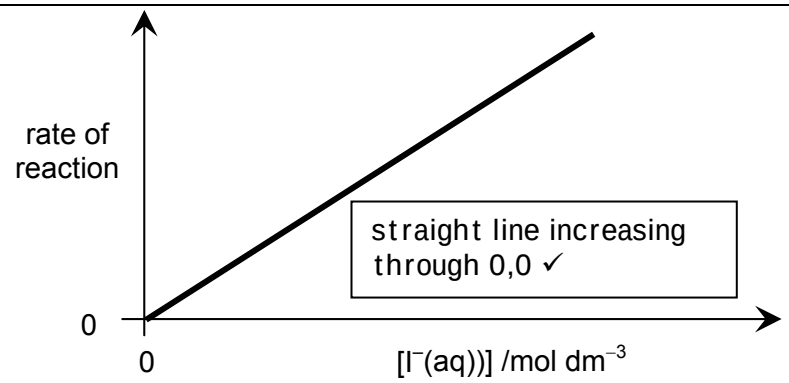
Question	Expected Answers	Marks
5 (a)	Zinc (Accept Zn)	1
(b)	On titration, solution changes from (dark) brown	1
	to straw coloured /becomes lighter / straw coloured / accept colour starts to disappear	1
	Starch indicator added close to end point / when straw coloured	1
	End point is when blue/black colour disappears to leave 'off white' precipitate / solid	1
	$2Cu^{2+} + 4I^- \rightarrow 2CuI + I_2$ (1 mark for correct species 1 mark for balanced)	2
	$I_2 + 2S_2O_3^{2-} \rightarrow 2I^- + S_4O_6^{2-}$ (1 mark for correct species 1 mark for balanced)	2
	Quality of Written Communication: One mark awarded for correct spelling, punctuation and grammar in at least two complete and relevant sentences	1

(c)	Moles $S_2O_3^{2-}$ used = 0.00378 moles	1
	25 cm^3 Cu^{2+} = 0.00378 moles	1
	500 cm^3 Cu^{2+} = 0 0756 moles Cu^{2+}	1
	Mass of Cu = 0.0756 x 63.5 = 4.80 g	1
	% Cu = (4.80/6.00) x 100 = 80.0%	1
	Allow ecf on the calculation.	
		Total: 15

2816/01 Unifying Concepts in Chemistry/ Experimental Skills 2 Written Paper

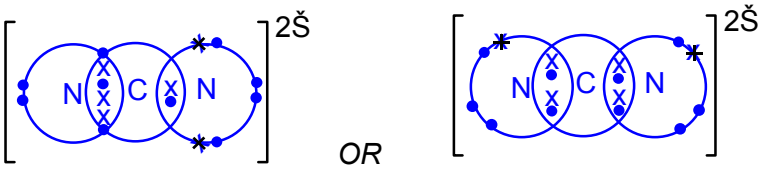
Question	Expected Answers	Marks
1 (a)	$K_c = \frac{[CH_3COOH]\,[C_2H_5OH]}{[CH_3COOC_2H_5]\,[H_2O]}$ ✓ Square brackets required. Do **not** award if *p* used anywhere	[1]
(b)(i)	component $CH_3COOC_2H_5$ H_2O CH_3COOH C_2H_5OH initial amount /mol 8.0 5.0 0.0 0.0 ⇌ amount /mol *6.0* *3.0* 2.0 *2.0* ✓ ✓	[2]
(ii)	Allow 6, 3, 2 and 2 (ie without '.0') $\frac{\text{moles of component}}{\text{total number of moles}}$ ✓ For 'component', **allow** a specific example or 'substance' moles of a component relative to *OR* compared with total number of moles **credit** 'amount' in place of 'moles' 2/total moles in (i) = 2/13 *OR* 0.15(4) ✓ ie answer depends on total moles in (i) allow 0.153846153 and any correct rounding back to 2 sig figs If 2/13 is shown, then ignore anything that follows.	[2]
	$K_c = \frac{2.0 \times 2.0}{6.0 \times 3.0}$ = 4.0/18.0 = 0.22222…. ✓ = 0.22 (ie to 2 sig figs) ✓ no units *OR* '–' *OR* 'none' ✓ **Credit** units if shown cancelled in working For ECF, the values used should be the candidate values from (b)(i). If K_c expression is incorrect, then the **only** acceptable *ECF* response is from an 'upside-down' expression.	[3]
(c)	**equilibrium/reaction** has **shifted** to the right/in favour of products ✓ forward reaction is endothermic ✓ **allow** 'it is endothermic' *OR* 'the reaction is endothermic' K_c has increased ✓	[3]
		11

2	**(a)(i)**	Expt 2: initial rate = 4.6×10^{-6} mol dm^{-3} s^{-1} ✓ Expt 3: initial rate = 2.3×10^{-6} mol dm^{-3} s^{-1} ✓ Expt 4: initial rate = 5.75×10^{-6} mol dm^{-3} s^{-1} ✓ If powers of ten are not shown, then do **not** credit on the first occasion. Then treat as *ECF*.	**[3]**
	(ii)	$k = \frac{\text{rate}}{[H_2O_2]\,[I^-]}$ *OR* $\frac{2.30 \times 10^{-6}}{0.020 \times 0.010}$ ✓ $= 1.15 \times 10^{-2}$ / 0.0115 / 0.012 ✓ units: $dm^3\ mol^{-1}\ s^{-1}$ ✓ **allow**: $mol^{-1}\ dm^3\ s^{-1}$ Correct numerical value automatically gets the 1st mark also, even if values from a **different** experiment have been used. If an incorrect rate value is used from (a)(i), then mark 2nd mark and units mark are available (ie *ECF*)	**[3]**
	(iii)	Overall reaction: 1 mol H_2O_2 reacts with 2 mol I^- and 2 mol H^+ / shows stoichiometry/shows mole ratio ✓ 2nd order (overall) OR 1st order wrt H_2O_2 *and* 1st order wrt I^- / rate determining step involves H_2O_2 and I^- ✓ rate is not affected by H^+ / the reaction is zero order wrt H^+ / the rate determining step does not involve H^+ ✓ Note that '$[H^+]$ is a catalyst' will *CON* this marking point. reaction must proceed via more than one step ✓	**4 marking points giving 3 max**
	(b)	 Allow 2 mm tolerance on 0,0	**[1]**

(c)	H : O : N : C = 6.38/1 : 51.06/16 : 29.79/14 : 12.77/12 *OR* = 6.38 : 3.19 : 2.13 : 1.06 ✓ empirical/molecular formula = $H_6O_3N_2C$✓ Correct empirical formula automatically gets 1st mark M_r = 6 + 48 + 28 + 12 = 94 ✓ 150 cm^3 of solution needs 2.30 x 150/1000 = 0.345 mol ✓ mass required = 94 x 0.345 = 32.43 g ✓ --- Upside down expression can gain final 4 marks ECF from 1st marking point gives $C_6N_3O_2H$ ✓ M_r = 147 ✓ 150 cm^3 of solution needs 2.30 x 150/1000 = 0.345 mol ✓ mass required = 147 x 0.345 = 50.715 g ✓ (or *ECF* from 2 steps above) --- Use of atomic numbers can gain final 4 marks ECF from 1st marking point gives $H_3O_3N_2C$ ✓ M_r = 91 ✓ 150 cm^3 of solution needs 2.30 x 150/1000 = 0.345 mol ✓ mass required = 91 x 0.345 = 31.395 g ✓ (or *ECF* from 2 steps above) --- **For all possible routes, allow rounding back to 2 sig figs in final answer**	**[5]**
		15

3	**(a)**	partly dissociates/ionises ✓ proton/H^+ donor ✓	**[2]**
	(b)	(K_w =) $[H^+(aq)]$ $[OH^-(aq)]$ ✓ *state symbols not needed* $[H^+(aq)] = 10^{-pH} = 10^{-12.72} = 1.91/1.9 \times 10^{-13}$ mol dm^{-3} ✓ $[KOH] / [OH^-(aq)] = \frac{K_w}{[H^+(aq)]} = \frac{1.0 \times 10^{-14}}{1.91 \times 10^{-13}}$ = 0.0524 mol dm^{-3} ✓ (calculator: 0.052480746) Accept any value between 0.052 and 0.053 (answer depends on degree of rounding for H^+ but 2 sig fig minimum.) Alternatively via pOH pOH = 14 – 12.72 = 1.28 ✓ $[KOH] / [OH^-(aq)] = 10^{-pOH}$ = 0.0524 mol dm^{-3} ✓ (calculator: 0.052480746)	**[1]** **[2]**
	(c)	n(vitamin C) = 0.500/176 = 2.84×10^{-3} ✓ [vitamin C] = 1000/125 x 2.84×10^{-3} = 0.0227(2) mol dm^{-3} ✓ $K_a = \frac{[H^+]\,[C_6H_7O_6^-]}{[C_6H_8O_6]}$ ✓ $= \frac{[H^+]^2}{[C_6H_8O_6]}$ $[H^+] = \sqrt{(K_a \times [C_6H_8O_6])}$ *OR* $\sqrt{(6.76 \times 10^{-5} \times 0.0227)}$ ✓ = 1.24×10^{-3} mol dm^{-3} ✓ (must involve a square root of two numbers multiplied together) pH = $-\log(1.24 \times 10^{-3})$ = 2.91 ✓ Accept a calculated value between 2.90 to 2.91 Common incorrect responses: 4.41 would score 5 marks (uses cm^3 instead of dm^3) 5.91 would score 5 marks (conversion multiplies by 1000 instead of dividing by 1000) 5.81 would score 5 marks (no square root) 2.1 would score 1 mark in isolation ($[H^+] = \sqrt{K_a}$)	**[6]**
			13

4	**Buffer** A buffer solution minimises/resists/opposes pH changes ✓ Do not **allow** 'keeps pH constant'. **How a buffer works** *Mark this part for any of the possible buffer systems above.* equilibrium: HA □ $H^+ + A^-$ ✓ HA reacts with added alkali / $HA + OH^- \rightarrow$ / added alkali reacts with H^+ / $H^+ + OH^- \rightarrow$ ✓ $\rightarrow A^-$ / Equil $\rightarrow$ right ✓ A^- reacts with added acid / $[H^+]$ increases ✓ $\rightarrow$ HA / Equil $\rightarrow$ left ✓ **Components** methanoic acid / HCOOH ✓ sodium methanoate / HCOONa ✓ *ECF*: salt of weak acid chosen above. Do **not** allow a carboxylate ion **Quality of Written Communication** A correct equation and a correct chemistry sentence related to buffers ✓ *Write Q by equation and tick through QWC prompt*	**[1]** **[5]** **[2]** **[1]**
		9

5	**(a)**	stage 1 $CaCO_3 \longrightarrow CaO + CO_2$ ✓ stage 2 $2CaO + 5C \longrightarrow 2CaC_2 + CO_2$ / $CaO + 3C \longrightarrow CaC_2 + CO$ ✓ stage 3 $CaC_2 + N_2 \longrightarrow CaCN_2 + C$ ✓ ignore state symbols. These are the **only** acceptable equations. For stage 2, O_2 is **not** an acceptable product.	**[3]**
	(b)	 *OR* *'dot-and-cross'* correct except for extra two electrons ✓ two extra electrons shown as dots, crosses or as other symbols so that there are 8 electrons around each atom with a 2– charge shown ✓	**[2]**
	(c)	$CaCN_2 + 3H_2O \longrightarrow CaCO_3 + 2NH_3$ / $CaCN_2 + 3H_2O \longrightarrow CaO + CO_2 + 2NH_3$ / $CaCN_2 + 4H_2O \longrightarrow Ca(OH)_2 + CO_2 + 2NH_3$ / $CaCN_2 + 2H_2O \longrightarrow CaO + CO(NH_2)_2$ / $CaCN_2 + 3H_2O \longrightarrow Ca(OH)_2 + CO(NH_2)_2$ / $CaCN_2 + 4H_2O \longrightarrow CaO + (NH_4)_2CO_3$ / $CaCN_2 + 5H_2O \longrightarrow Ca(OH)_2 + (NH_4)_2CO_3$ or other correct alternative. Products **must** be compounds, **not** elements such as N_2 and H_2, O_2, Ca and C. Equation that forms a sensible calcium compound, eg $CaCO_3$, CaO, $Ca(OH)_2$, $Ca(HCO_3)_2$, $Ca(NO_3)_2$ ✓ complete balanced equation (see above for examples) ✓ $CaCO_3$/CaO/$Ca(OH)_2$/$Ca(HCO_3)_2$/NH_3 react with acid soils ✓ NH_3 / $(NH_4)_2CO_3$ / $CO(NH_2)_2$ acts as fertiliser ✓	**[4]**
	(d)	$CaC_2 + 2H_2O \longrightarrow C_2H_2 + Ca(OH)_2$ / $CaC_2 + H_2O \longrightarrow C_2H_2 + CaO$: ✓ $M(CaCO_3)$ = 100.1 (g mol^{-1}) ✓ **Not** 100 $n(CaCO_3)$ = 20 x 10^3 /100.1 = 199.8 mol ✓ allow 200 mol Same number of moles C_2H_2 formed, volume C_2H_2 = 199.8 x 24 = 4795.2 dm^3 ✓ allow 4800 dm^3 Calc value = 4795.204795 dm^3 $2C_2H_2 + 5O_2 \longrightarrow 4CO_2 + 2H_2O$ / $C_2H_2 + 2½O_2 \longrightarrow 2CO_2 + H_2O$ / $2C_2H_2 + 3O_2 \longrightarrow 4CO + 2H_2O$ / $C_2H_2 + 1½O_2 \longrightarrow 2CO + H_2O$ ✓	**[5]**
			14

2816/03 Unifying Concepts in Chemistry/ Experimental Skills 2 Practical Examination

Skill P 16 marks maximum (out of 19 available)

A titration (T) must be used as one method.
For the second method, several alternatives are available, including:

- *P (Precipitation)*
- *G (Gas Measurement*
- *N (Enthalpy of neutralisation)*

A number of other methods, such as a "thermometric titration" and neutralisation followed by evaporation, were also credited

Titration method (T) – 7 marks

T1 Controlled dilution of concentrated NaOH provided [1]
Use of pipette, distilled water and [any] volumetric flask are required for this.

T2 Uses dilution volumes that produce [NaOH] between 0.020 and 0.20 mol dm^{-3}
and states correct concentration when diluted
and simple justification (eg by ratio of volumes) ***or*** related safety comment [1]
Do not allow a volume less than 5.0 cm^3 (or "awkward to measure" volumes)

T3 Titrate with specified acid of suitable stated concentration
and the chemical equation for the reaction selected [1]

T4 Statement of use of pipette ***and*** burette in titration procedure [1]
Acid and alkali may be used either way round in the apparatus

T5 Obtain two consistent/ concordant titres (***or*** within 0.1 cm^3) [1]

T6 Named indicator ***and*** correct **final** colour [1]
Phenolphthalein is colourless (if acid in burette) or pink (not purple) (alkali in burette)
Many other indicators are acceptable if a strong acid is used.

T7 Sketched pH curve to justify choice of indicator.
Sketch must show indicator "change range" within sudden pH change.

Precipitation method (P) – 8 marks

P1 Pipette a known/specified volume of the NaOH provided [1]

P2 Add excess of a **solution** of a suitable reagent for the precipitation reaction
and this ensures that **all** of NaOH reacts [1]
Any soluble salt of Mg, Cu, Ni or Fe (etc) is suitable.

P3 Equation/ionic equation for reaction, **with** state symbols [1]
eg $CuSO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + Cu(OH)_2(s)$

P4 Calculate [minimum] mass of salt to be added to NaOH [1]
*Calculation does **not** need to allow for mass of water of crystallisation*

P5 Filter mixture using <u>pre-weighed</u> filter paper [1]

P6 **Two** accuracy precautions *(from the six below)*
- stir ***or*** swirl mixture of solutions [to ensure complete reaction]
- use distilled water to transfer all traces of precipitate [from beaker] into filter paper
- use of reduced pressure/Buchner filtration
- use fine/ high grade filter paper (***or*** multiple thickness)
- wash residue [while on filter paper] with distilled water
- repeat **whole** experiment to obtain consistent results [1]

P7 Dry residue in an oven/ hot cupboard/ desiccator ***and*** re-weigh to constant mass [1]

P8 Specimen calculation of [NaOH] from mass of precipitate/residue obtained [1]
*Calculation **must** include correct M_r value*
eg $Cu(OH)_2$ = 97.5

Gas collection method (G) – 8 marks

G1 Use <u>powdered</u> zinc/aluminium with <u>undiluted/2M</u> NaOH [1]

G2 Valid equation for the reaction chosen [1]
$2Al + 2NaOH + 6H_2O \rightarrow 2NaAl(OH)_4 + 3H_2$ ***or*** $Zn + 2NaOH + 2H_2O \rightarrow Na_2Zn(OH)_4 + H_2$
or $2Al + 2NaOH + 2H_2O \rightarrow 2NaAlO_2 + 3H_2$
or $Zn + 2NaOH + 2H_2O \rightarrow Na_2ZnO_2 + H_2$
or $2Al + 6NaOH \rightarrow 2Na_3AlO_3 + 3H_2$
or $2Al + 6NaOH + 3H_2O \rightarrow 2Na_3Al(OH)_6 + 3H_2$

G3 Justify volume of NaOH by calculation, so that collecting vessel is not over-filled [1]

G4 Calculate mass of Al or Zn needed ***and*** states that it is used in excess. [1]

G5 **Diagram** showing apparatus used:
flask with gas collection in a gas syringe/measuring cylinder/inverted burette [1]

G6 Description includes the three required **measurements**:
- the volume of NaOH using a pipette/ burette
- the mass of Al or Zn
- the volume of gas collected when fizzing ceases/syringe stops moving [1]

G7 An "inner tube" (***or*** equivalent precaution) containing one reagent is needed to keep reagents apart ***or*** prevent premature reaction/gas loss.

G8 Calculation of [NaOH] from volume of gas collected [1]

Enthalpy of neutralisation method (N) – 8 marks

N1 Measure 2M NaOH solution with a pipette/burette [1]

N2 Add measured <u>excess</u> (+ reason) of specified acid from burette/ pipette [1]
Reason: to ensure that all NaOH reacts/ is neutralised

N3 Calculation to justify [minimum] volume (or concentration) of acid selected [1]

N4 Measure initial temperatures of **both** solutions

and measure maximum temperature reached when mixed/ after reaction [1]

N5 Precautions: stir mixture ***and*** use a plastic cup, calorimeter ***or*** a vacuum flask [1]

N6 Repeat whole experiment
and take mean of temperature rise ***or*** until consistent temperature rise obtained [1]

N7 Calculation of the heat change (with unit) [1]
The sum of the volumes of the two solutions must be used in $m \times s \times \delta T$

N8 Comparison with enthalpy change of neutralisation for 1 mole (ΔH_{neut})
and calculation of the concentration of NaOH [1]
Candidate must refer to use of data source for value of ΔH_{neut} = -57kJ mol^{-1}

Safety, sources and qwc (S) – 4 marks

S1 **Risk assessment** for sodium hydroxide in the procedure chosen [1]
NaOH is corrosive: wear gloves ***or*** face shield when handling/pouring.
or NaOH is corrosive: wash spillages with **plenty** of water

S2 **Two sources** quoted in the text ***or*** at end of Plan. [1]
- *Book references **must** have chapter or page numbers*
- *Internet reference must go beyond the first slash of web address*
- *Accept one reference to a specific "Hazcard"*

S3 **QWC**: text is legible and spelling, punctuation and grammar are accurate [1]
Candidate makes no more than 5 different types of error in legibility, spelling, punctuation or grammar.

S4 **QWC**: information is organised clearly and coherently [1]
- *Is a word count given and within the limits 450 – 1050 words?*
- *Is scientific language, including units, used correctly?*
- *Are the descriptions logical and without lots of irrelevant or repeated material?*

Practical Test (B)

Part 1 (page 3) – 5 marks

Four mass readings, listed and clearly labelled [1]

All readings quoted to 2 dp (***or*** 3 dp consistently) ***and*** unit (g) given for each [1]

Two accuracy marks for mass loss are awarded relative to Supervisor's results.
Mass loss (CO_2) = readings (**1 + 2 – 3 – 4**)
Candidate's mass loss is within **0.10 g** (incl) of supervisor……. **award 2 marks**
Candidate's mass loss is within **0.25 g** (incl) of supervisor……..**award 1 mark**

Acid spray is harmful to eyes ***or*** acid spray is irritant [1]

Part 2 (page 4) – 7 marks

13 readings of maximum temperature shown in table [1]
__All__ readings must be recorded to nearest 0.0 or 0.5oC, as instructed on paper.

Initial reading shown (V = 0) at a "sensible" room temperature (within 2.0oC of supervisor) **and** readings show a continuous increase to a max temperature then a continuous fall [1]

There are** 5 accuracy marks **awarded from the** results table **(not from the graph)..

Volume of acid added for highest temp recorded is **same** as supervisor → **2 marks** **[2]**
Award **1 mark** if volume of acid added for maximum is within 2.0 cm3 of supervisor
Maximum temperature **rise** recorded is within 0.5oC of supervisor's → **3 marks** **[3]**
Maximum temperature **rise** is within 1.0oC of supervisor's → **2 marks**
Maximum temperature **rise** is within 2.0oC of supervisor's → **1 mark**

Part 3 – 10 marks

[Page 5 - 5 marks]

(a) Graph axes labelled with names/symbols and units ***and*** temp as y-axis [1]

Sensible uniform scales for both axes
***Plotted** points must use at least **half** of the large squares (7 x 5)* [1]

Points plotted correctly (within half of a small square) [1]
Two best fit lines/curves plotted [1]
*The LHS will be a **curve** – allow curve or line for RHS, if it is the best fit.*

Two lines/curves show a **distinct** intersection (**not** rounded at maximum) [1]

[Page 6 – 5 marks]

(b) Maximum temperature reached, read **from graph** to 1 d.p. [1]
Answer must be given to 3 sig fig and be correct to nearest 0.5oC (or closer)

(c) Suitable volume of sulphuric acid, **G**, for neutralisation volume chosen [1]
*For a plateau graph, the **middle** of the plateau must be selected*

(d) LHS: as **more** acid is added and more reacts, **more** heat is produced [1]

MAX: all alkali neutralised/reacted [so maximum amount of heat produced] [1]

RHS: cold acid added cools the solution down [1]

Part 4 – 8 marks

[Page 7 – 5 marks]

All answers are required to 3 significant figures.

(a) Mass loss correctly calculated *(readings 1 + 2 – 3 – 4)* [1]

(b) Number of moles calculated correctly from data = mass loss/$_{44}$ [1]

(c) **2**$NaHCO_3$ + H_2SO_4 → Na_2SO_4 + **$2CO_2$ + $2H_2O$** [1]

(d) n(sulphuric acid) used = 0.5 x (b) [= 0.030 mol approx] [1]
*This is a **method** mark for correct use of the 2:1 mole ratio*

Answer: concentration of acid correctly calculated = ["b" x 0.5 x $1000/_{25}$] [1]

[Page 8 – 3 marks]

(e)(i) $2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$ [1]

(ii) No of moles of sulphuric acid used = $1/_{1000}$ *x* "4d" *x* "3c" (= volume at max) [1]

Concentration of NaOH correctly calculated from candidate's answer to 4(d) [1]
*Concentration of NaOH = [2 x $1000/_{25}$ x moles of acid **G**] = 0.080 x "4d" x "3c"*

Part 5 – 14 marks maximum (but 15 marks possible)

[Page 9 – 5 marks available]

(a) **2 marks**

n($NaHCO_3$) = 1.25 x 0.025 x 2 [= 0.0625 mol] [1]

mass of $NaHCO_3$ = 2 x 0.03125 x 84 = 5.25 g … so 6g is excess [1]
Answer allowed to 2, 3 or 4 sig fig

(b) ***3 marks available*** *(but only 2 on the question paper)*

Gives time for the reaction to finish *[1]*

*Gives time for CO_2 (*not "gas"*) to escape from/ diffuse out **of flask*** *[1]*

Carbon dioxide is denser than air **so** *it diffuses slowly*
or *CO_2 is denser than air,* **so** *mass of flask and contents would be too high* *[1]*

(c) ***Page 10 - 8 marks maximum*** (but 11 marking points)

C1 *Heat is lost/transferred.....* *[1]*

C2 *.....by convection* **or** *escape of heat through top* **or** *by loss of acid spray*
or *by conduction* **or** *escape through sides/bottom* *[1]*

C3 *Use a lid on cup* **or** *use thicker plastic/ dewar flask/ lagging with insulation* *[1]*

C4 ***If*** *<u>both</u> conduction* **and** *convection are <u>specifically</u> named, this mark can be awarded for the second corresponding accuracy precaution stated.* *[1]*

D1 *Temperature difference between successive [maximum] readings is small*
or *thermometer only reads to 0.5/1.0°C* *[1]*
No mark for human errors in reading – parallax etc.

D2 *Use a thermometer reading to 0.1/0.2°C* **or** *to more decimal places*
or *use a more accurately calibrated instrument*
Do not allow "digital thermometer" or similar without reference to calibration

D3 ***Calculation*** *of the percentage error for* **any** *reading or rise in temperature* *[1]*
eg % error in temp = $^{0.5}/_{25}$ x 100 = 2.0%. (Allow answer = 4%)

D4 *An extra mark for correctly* ***calculating*** *% error for a* **rise** *in temperature* *[1]*

E1 *Volumes of acid added are too small to be accurate*
or *large percentage error in reading burette volumes* *[1]*

E2 ***Calculated*** *% error for 2 cm³ addition =* $^{0.05}/_{2.0}$ *x 100 = 2.5%.* (Allow = 5%) *[1]*

E3 *Use larger additions of acid from burette* **and** *a larger volume of alkali*
or *Use a burette with a narrower bore* **or** *use a more accurately calibrated burette* *[1]*
or *Carry out a series of separate experiments with different volumes of acid*

Note - The following alternative answers in the "burette strand" **E** are also valid (2 marks).

E4 *Volumes of acid added near maximum/end point are too large* *[1]*

E5 *Add smaller volumes so that end point may be determined with more precision* *[1]*

(d) ***Page 11 – 2 marks***

Student should ***repeat*** *each reading to get* ***consistent*** *results*
or *procedure is* ***unreliable*** *since only* ***one set*** *of readings was taken* *[1]*

All points on graph are close to the best fit curve/lines, so they are reliable (ora) *[1]*
Explicit link between correlation and reliability is needed for this mark

Grade Thresholds

Advanced GCE Chemistry (3882/7882)
June 2008 Examination Series

Unit Threshold Marks

Unit		Maximum Mark	a	b	c	d	e	u
2811	Raw	60	48	42	36	31	26	0
	UMS	90	72	63	54	45	36	0
2812	Raw	60	47	40	33	26	19	0
	UMS	90	72	63	54	45	36	0
2813A	Raw	120	93	84	75	66	57	0
	UMS	120	96	84	72	60	48	0
2813B	Raw	120	93	84	75	66	57	0
	UMS	120	96	84	72	60	48	0
2813C	Raw	120	87	76	65	55	45	0
	UMS	120	96	84	72	60	48	0
2814	Raw	90	66	58	50	42	34	0
	UMS	90	72	63	54	45	36	0
2815A	Raw	90	74	65	57	49	41	0
	UMS	90	72	63	54	45	36	0
2815B	Raw	90	73	65	58	51	44	0
	UMS	90	72	63	54	45	36	0
2815C	Raw	90	74	67	60	53	46	0
	UMS	90	72	63	54	45	36	0
2815E	Raw	90	72	64	56	49	42	0
	UMS	90	72	63	54	45	36	0
2816A	Raw	120	99	89	80	71	62	0
	UMS	120	96	84	72	60	48	0
2816B	Raw	120	99	89	80	71	62	0
	UMS	120	96	84	72	60	48	0
2816C	Raw	120	92	82	73	64	55	0
	UMS	120	96	84	72	60	48	0

Specification Aggregation Results

Overall threshold marks in UMS (ie after conversion of raw marks to uniform marks)

	Maximum Mark	A	B	C	D	E	U
3882	300	240	210	180	150	120	0
7882	600	480	420	360	300	240	0

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

	A	B	C	D	E	U	Total Number of Candidates
3882	20.0	38.9	57.1	73.2	86.5	100	15165
7882	30.9	56.9	75.8	88.5	96.4	100	11473

26638 candidates aggregated this series

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

Statistics are correct at the time of publication.

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