OCR
RECOGNISING ACHIEVEMENT

GCE

Chemistry

Advanced GCE **A2 7882**

Advanced Subsidiary GCE **AS 3882**

Mark Schemes for the Units

January 2009

3882/7882/MS/R/09J

Oxford Cambridge and RSA Examinations

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Mark schemes should be read in conjunction with the published question papers and the Report on the Examination.

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Advanced GCE Chemistry (7882)

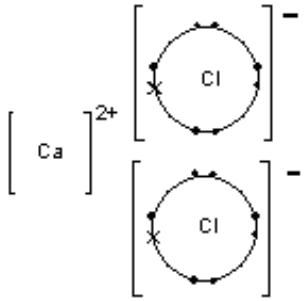
Advanced Subsidiary GCE Chemistry (3882)

MARK SCHEME FOR THE UNITS

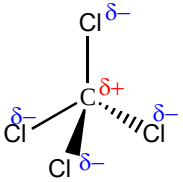
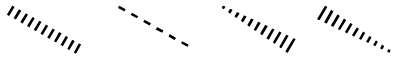
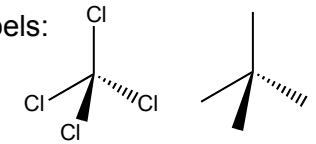
2811 Foundation Chemistry

Question			Expected Answers	Marks	Additional Guidance
1	(a)	i	20✓	1	
		ii	2✓	1	
		iii	5 ✓	1	
	(b)	i	69.8 ✓	1	
		ii	96.0 ✓	1	**Allow** 96
		iii	moles of $NaNO_3$ = 0.05 ✓ mass = 0.05 x 85 = 4.25 (g) ✓	2	4.8 g worth 1 (wrong M_r) Accept 4.3 but not 4.2 (ecf for calculated moles x 85)
		iv	2.51 x 10^{21}✓	1	**Allow** 2.5 x 10^{21} Calc: 2.508333333 x 10^{21} **Allow** calc value and any degree of correct rounding down to 2.5 x 10^{21}
	(c)		(+)7 ✓	1	Sign not required but do not credit '–7' Accept VII
			Total	**9**	

Question			Expected Answers	Marks	Additional Guidance
2	(a)		Energy change when **each atom in 1 mole** ✓ of **gaseous** atoms ✓ **loses an electron** ✓ (to form 1 mole of gaseous 1+ ions)	3	Not 'element' alone Compensate missed marks from correct equation
	(b)		Si ✓ Sharp rise in successive ionisation energy between 4th and 5th IE ✓ marking a change to a new shell / there are 4 electrons in the outer shell✓	3	Not consequential Not sub-shell
	(c)		 atomic radii increases/ there are more shells/atoms get bigger ✓ there is more shielding/ more screening ✓ ionisation energy decreases because the Increased shielding and distance outweigh the increased nuclear charge / the nuclear attraction decreases ✓	3	***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'
			Total	**9**	

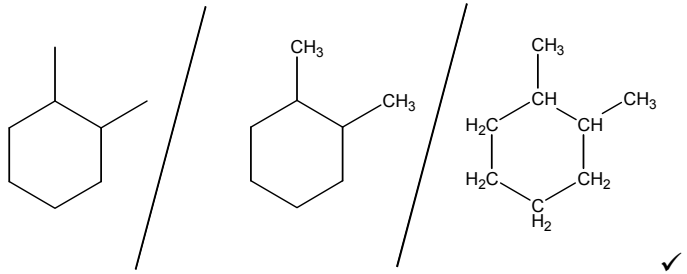
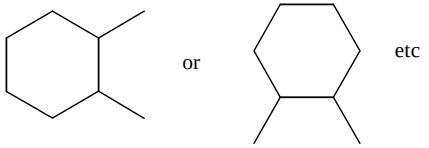
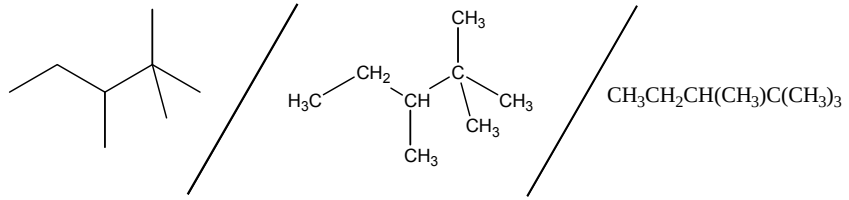
Question			Expected Answers	Marks	Additional guidance
3	(a)		Ca^{2+}: 20 protons; 18 electrons ✓ Cl^-: 17 protons; 18 electrons ✓	2	
	(b)		cation shown with either 8 or 0 electrons ***AND*** anion shown with 8 electrons ***AND*** correct number of crosses and dots ✓ Correct charges on both ions ✓  	2	**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 For charges, **Allow:** $2[Cl^-]$ $2[Cl]^-$ $[Cl^-]_2$ (brackets not required except for last one) Do **not** allow: for $CaCl_2$, $[Cl_2]^{2-}$ $[Cl_2]^-$ $[2Cl]^{2-}$ $[Cl]$ Max 1 if only one Cl^-
	(c)		solid: ions are fixed (AW) ✓ aqueous: ions are free (to move) (AW) ✓	2	If charge carriers are wrong but comparison is given, then award one mark, *e.g.* solid: *electrons* are fixed in lattice *AND* aqueous: *electrons* are free to move ✓ (1 mark
	(d)	i	molar mass $CaCO_3$: 100.1 (g mol^{-1}) ✓ 4.85/100.1 = 0.0485 mol ✓	2	Not 100 for molar mass calc. 0.048451548 **Allow** rounding of calculator value back to 2 sig figs allow 0.048-0.049 **ECF** If working shown for an incorrect molar mass, then the 2nd mark can be awarded as 4.85/calculated molar mass
		ii	5.38 or 5.39 g or 5.4 g ✓	1	For information: 0.0485 x 111.1 = 5.39 0.048451548 x 111.1 = 5.38

Question			Expected Answers	Marks	Additional guidance
					ECF: moles from (i) x 111.1 or 111
		iii	0.0970 or 0.097 or 0.0969 ✓ volume = 64.7 or 64.6 cm^3 or 65 ✓	2	For information: 2 x 0.0485 = 0.0970 mol 2 x 0.048451548 = 0.0969 **ECF** moles from (i) x 2 For information (0.0970/1.50) x 1000 = 64.7 cm^3 (0.0969/1.50) x 1000 = 64.6 cm^3 **ECF** (moles above/1.50) x 1000
	(e)		$Ca/CaO/Ca(OH)_2$ ✓ $Ca + 2HCl \longrightarrow CaCl_2 + H_2$ / $CaO + 2HCl \longrightarrow CaCl_2 + H_2O$ / $Ca(OH)_2 + 2HCl \longrightarrow CaCl_2 + 2H_2O$ ✓	2	Ignore state symbols **Allow** any other suitable alternatives
	(f)	**i**	Ca : H : S : O = 19.82/40.1 : 0.99/1 : 31.74/32.1 : 47.45/16 or 1 : 2 : 2 : 6 ✓ empirical formula = $CaH_2S_2O_6$ ✓	2	Using atomic numbers gives $CaHS_2O_6$ worth 1 **Allow** $Ca(HSO_3)_2$!
		ii	$Ca(OH)_2 + 2SO_2 \longrightarrow CaH_2S_2O_6$ ✓	1	If you see it, **allow** $Ca(HSO_3)_2$!
			Total	**16**	

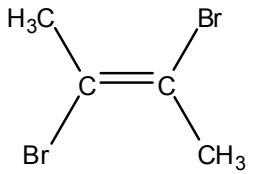
Question			Expected Answers	Marks	Additional Guidance
4	(a)		down group/from Cl to I/, number of electrons/shells increases ✓ more/ stronger/ van der Waals'/ intermolecular forces/ induced dipoles/ instantaneous dipoles ✓ greater forces to break/more energy has to be put in to break forces ✓	3	Answers involving ionisation energies score 0
	(b)		$I_2 \rightarrow IO^-$, 0 to +1 ✓: oxidised $I_2 \rightarrow I^-$, 0 to –1 ✓: reduced **correct** 'oxidised' **and** 'reduced' above/I is both oxidised and reduced / disproportionation ✓	3	Sign not required but do not credit '–1' '–' Sign required here
	(c)	i	goes orange/red/yellow ✓ $Cl_2 + 2Br^- \longrightarrow Br_2 + 2Cl^-$ ✓	2	Ignore brown Ignore spectator ions
		ii	$Ag^+(aq) + Cl^-(aq) \longrightarrow AgCl(s)$ correct equation ✓ correct state symbols ✓	2	Allow state symbols for (slightly) incorrect equations
	(d)	i	attraction of an atom for electrons ✓ in a (covalent) bond/ bonding pair ✓	2	
		ii	correct 3-D tetrahedral shape shown showing one outward wedge and 1 inward wedge; 3 bonds below horizontal ✓ correct dipoles: δ+ on C and δ– on each Cl ✓  	2	For bond into paper, accept:  **Allow** correct shape with no atom labels:  Only need to show one dipole
		iii	the polarities/ dipoles cancel out / the molecule is symmetrical	1	
			Total	**15**	

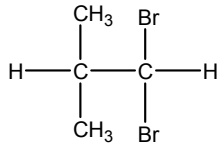
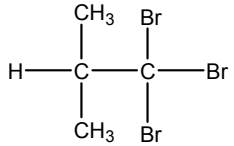
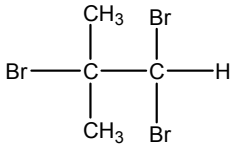
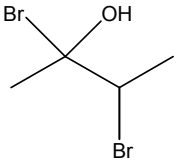
Question			Expected Answers	Marks	Additional Guidance
5			Magnesium structure/bonding: giant ✓ metallic ✓ conducts by delocalised/free/mobile electrons ✓ melting point high because of the electrostatic attraction / attraction between (positive) ions and electrons ✓ Diamond does not conduct/poor conductor: no mobile charge carriers/electrons/ions ✓ structure/bonding: giant (✓) covalent ✓ melting point: high because strong/ lots of (covalent) bonds are broken ✓ Ice does not conduct: no mobile charge carriers/electrons/ions ✓ structure/bonding: H-bonds/intermolecular forces/ simple molecular ✓ melting point: Low because H bonds/intermolecular/ weak forces between molecules (are broken)/ higher than expected because H-bonds broken/ H-bonds stronger than other (named) intermolecular forces ✓	10	***USE annotations with ticks, crosses, con, ecf, etc for this part.*** ***Credit information if given in annotated diagrams*** ***Watch out for contradictions, especially of bonding type*** **Allow**: positive ions with a sea of electrons for both structure and bonding marks if labelled, one if not. Giant only awarded if not given above must refer to bonds being broken once
			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	**11**	

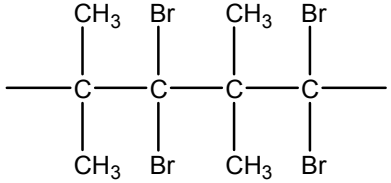
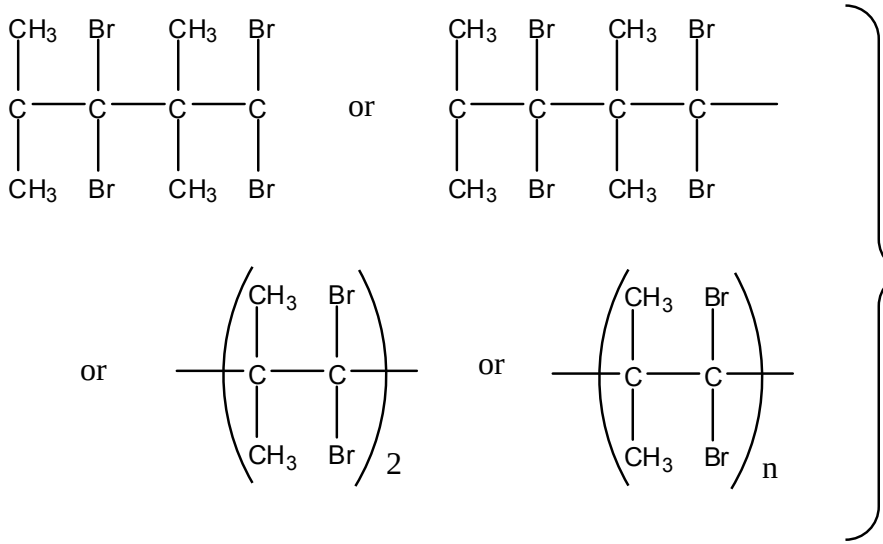
2812 Chains and Rings

Question			Expected Answers	Marks	Additional Guidance
1	(a)		compound/molecule that contains carbon & hydrogen **only** ✓	1	**allow** hydrocarbons contain carbon & hydrogen **only** **allow** molecules that contain carbon & hydrogen **only**
	(b)		$C_{14}H_{30} \longrightarrow C_8H_{18} + C_6H_{12}$ ✓	1	**allow** $CH_3(CH_2)_{12}CH_3 \longrightarrow CH_3(CH_2)_6CH_3 + C_6H_{12}$ **allow** any isomer of C_6H_{12} or any combination of alkenes that add up to C_6H_{12}.
	(c)	(i)	 ✓	1	**allow** different orientations as long as the two methyl groups are on adjacent Cs 
		(ii)	hydrogen/H_2✓	1	no other correct response
	(d)	(i)	 ✓	1	**allow** any unambiguous form of 2,2,3-trimethylpentane

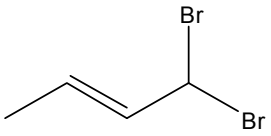
Question			Expected Answers	Marks	Additional Guidance
		(ii)	C_8H_{18} + $12½O_2$ ⟶ $8CO_2$ + $9H_2O$ ✓✓ 1 mark if all formulae are correct both marks if correctly balanced	2	**allow** $2C_8H_{18}$ + $25O_2$ ⟶ $16CO_2$ + $18H_2O$ **allow** structural, displayed or skeletal formula of C_8H_{18}.
	(e)	**(i)**	(feedstock is obtained) from plants ✓ which can be re-grown ✓	2	**allow** made from sugar cane/beet/biomass *for 1 mark* **not allow** just sugar **allow** made from sugar because it can be re-grown *for 2 marks* **not allow** just fermentation **allow** fermentation from/of plants *for first marking point*
		(ii)	CO_2 used in photosynthesis is balanced by CO_2 released in combustion/ it is carbon neutral ✓	1	**not allow** does not produce greenhouse gases **allow** doesn't emit any oxides of nitrogen/sulphur **not allow** doesn't produce toxic gases/acid rain If two statements are made and one is incorrect the mark is lost e.g. is carbon neutral and does not produce greenhouse gases *this gets ✗ con*
			Total	**10**	

Question			Expected Answers	Marks	Additional Guidance
2	(a)	i	1,1-dibromomethylpropene✓	1	**allow** 1,1-dibromo-2-methylpropene **allow** 2-methyl-1,1-dibromopropene **allow** methyl-1,1-dibromopropene **also allow** any of the above with prop-1-ene
		ii	M_r = 213.8 ✓ % = (159.8/213.8) x 100 = 74.7 ✓	2	**not allow** M_r = 214 for first mark **allow** any of: % = 75/74.74 or any correct rounding up to and including the calculator value of 74.74275023 **allow** **ecf** for correct rounding of 74.76635514 if used M_r 214 **ecf** for correctly calculating percentage from incorrect M_r 37.4% scores 1 mark
		(iii)	any dibromobut-1-ene any dibromobut-2-ene (except 2,3-dibromobut-2-ene) any dibromomethylpropene (except 1,1-dibromomethylpropene) any dibromocyclobutane any dibromomethylcyclopropane ✓	1	see page 10 at end of question for skeletal formulae of acceptable isomers Most common **incorrect** response is *trans*-2,3-dibromobut-2-ene 
	(b)	i	decolourised ✓	1	**not allow** goes clear / discoloured **allow** turns colourless/orange colour disappears **ignore** "clear" if "decolourises and goes clear" i.e. not 'CON'
		ii	electrophilic addition ✓	1	
		iii	molecular formula = $C_4H_6Br_4$ ✓ empirical formula = $C_2H_3Br_2$ ✓	2	 **allow** ecf from molecular formula $C_xH_yBr_z$

Question			Expected Answers	Marks	Additional Guidance
	(c)		 ✓ Ni/Pt ✓	2	Ignore bond linkage
	(d)	i	**B** is symmetrical ✓	1	**allow** **A** isn't symmetrical **ignore** A is asymmetric
		ii	 ✓  ✓	2	Ignore bond linkage
	e)	i	 ✓	1	**Do not allow** bond linkage to H in the OH, bond must **clearly** go to the O
		ii	reagent: steam/$H_2O_{(g)}$ ✓ conditions: phosphoric acid ✓	2	**allow** H_2O but only if temp is quoted above 100^oC **allow** sulphuric acid **not allow** acid catalyst **allow** reagent: phosphoric acid ✓ **allow** conditions: steam ✓ mention of alkali ✗ *con* acid mark

Question	Expected Answers	Marks	Additional Guidance
(f)	 backbone of 4 carbon atoms with "two end bonds" ✓ 4 CH_3s and 4 Brs attached ✓	2	 score 1 mark **allow** more than two repeat units **ignore** CH_3 bond linkage
	Total	**18**	

dibromobut-2-ene



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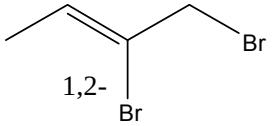

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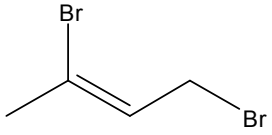

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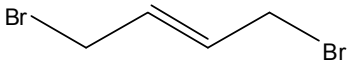
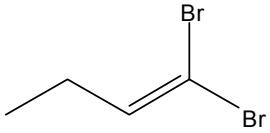


1,4-

dibromobut-1-ene



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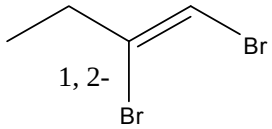

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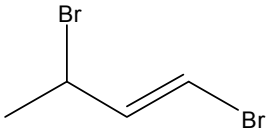

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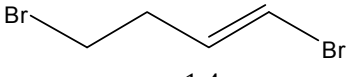

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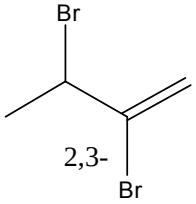

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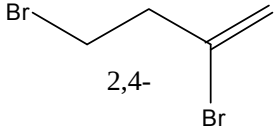

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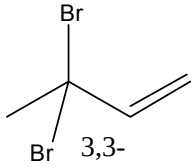

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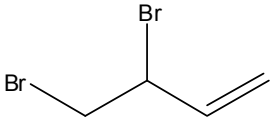
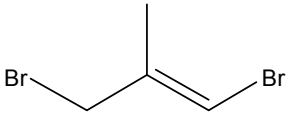


3,4-

dibromomethylpropene



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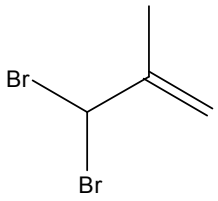

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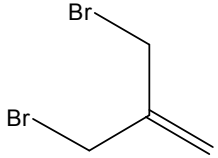
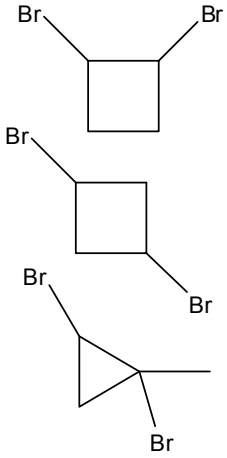
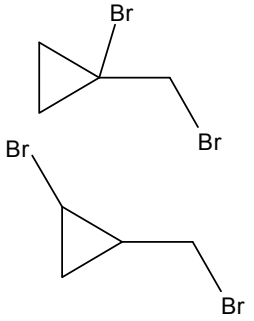
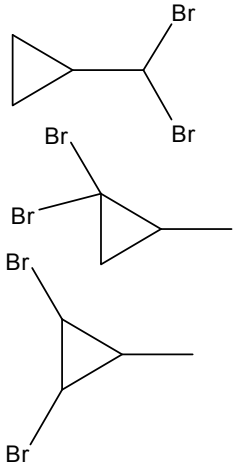


dibromocycloalkanes

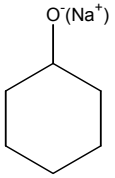
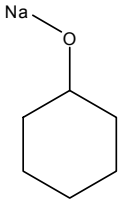
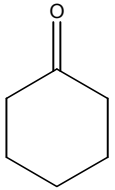
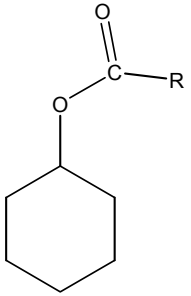
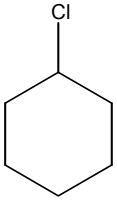
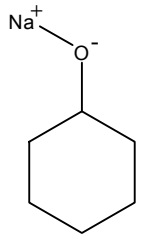


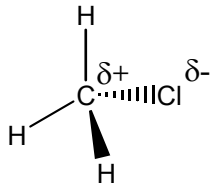
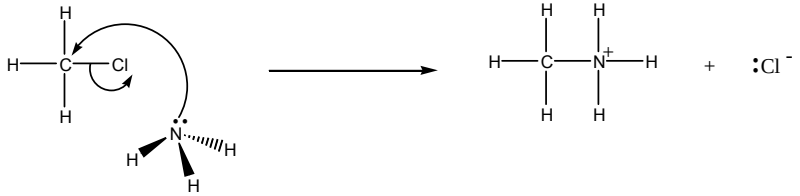




Q3a should be marked as a complete question NOT by item response

Question			Expected Answers	Marks	Additional Guidance
3	**(a)**	**i**	100 ✓	1	If incorrect ecf can be awarded for 3a(ii)
		ii	0.05 ✓	1	Check for ecf from 3a(i) if incorrect check response to part (iii) which can score all 3 marks as **ecf** to incorrect answer in (ii)
		iii	moles of cyclohexene = 1.8/82 / 0.02195 / 0.022 ✓ % yield = (0.022/0.05) x 100 = 43.9% ✓ % yield to 2 sig figs = 44% ✓	3	44% scores all 3 marks **allow** alternative method theoretical mass of cyclohexene = 0.05 x 82 = 4.1(g)✓ % yield = (1.8/4.1) x 100 = 43.9%✓ % yield to 2 sig figs = 44% ✓ **ecf** if M_r of cyclohexene is incorrect, the remaining two marks can be awarded e.c.f **ecf** % yield = (0.022/incorrect answer to (a)(ii)) x 100 for *max 3 marks* **do not allow** moles of cyclohexene rounded to 0.02 which will then lead to 40% yield. **allow** 40% will score 2 out of the 3 available marks **allow** 36% for *max 1 mark*

Question			Expected Answers				Marks	Additional Guidance
	(b)	i	(peak between) 3230–3550 (cm^{-1}) ✓ which shows presence of OH ✓				2	**do not allow** 2500–3500 (cm^{-1}) For OH **allow** peak within stated range Ignore any reference to C–O peak
		ii	Na	H^+ and $Cr_2O_7^{2-}$	RCOOH and conc H_2SO_4	PCl_5/ $SOCl_2$	1	**allow** RCOCl with observation of white fumes and product same as carboxylic acid
			bubbles/fizzes/effervesces **not allow** hydrogen gas/ gas evolved	orange to green	if RCOOH observation mark is not available	white fumes	1	If manganate(VII) used as oxidising agent then allow marks for observation (purple to colourless/green/brown) and product of cyclohexanone only
		iii	 charges not essential but **do not allow** 				1	**not allow** $C_6H_{11}ONa$ / $C_6H_{11}OOCR$/ $C_6H_{11}Cl$ product mark must be related to correct reagent. If no reagent then no product mark is possible **allow** one mark for bromocyclohexane as product if HBr used as reagent but no marks for reagent or observations **not allow** 
						Total	**10**	

Question			Expected Answers	Marks	Additional Guidance
4	(a)		 ✓ bond angle 109° 28' ✓	2	**allow** 109·5/ 109–110
	(b)	i	electron pair donor ✓	1	**allow** lone pair (of electrons) donor
		ii	 Step 1 curly arrow from lone pair on N to C ✓ curly arrow from C—Cl bond to Cl ✓	2	**not allow** any incorrect charges on reagents ✗*con 1 mark*
		iii	$CH_3Cl + 2NH_3 \longrightarrow CH_3NH_2 + NH_4Cl$ ✓	1	**allow** $CH_3Cl + 2NH_3 \longrightarrow CH_3NH_2 + NH_4^+ + Cl^-$ **not allow** $CH_3Cl + NH_3 \longrightarrow CH_3NH_2 + HCl$ **not allow** $CH_3Cl + 2NH_3 \longrightarrow CH_3NH_2 + HCl + NH_3$
		iv	methylamine/aminomethane ✓	1	**allow** even if equation in (b)(iii) is incorrect.

Question			Expected Answers	Marks	Additional Guidance
	(c)		reaction would be faster ✓ C—I bond is weaker/has lower bond enthalpy (than C—Cl bond) ✓	2	second mark is dependent on first mark *e.g. reaction is slower because C—I bond is weaker* scores no marks. **not allow** iodomethane / CH_3I has lower/weaker bond energy/enthalpy **not allow** C—I bond is longer **allow** C—I bond is longer, therefore weaker **not allow** iodine bond is weaker
			Total	**9**	

Question			Expected Answers	Marks	Additional Guidance
5	(a)		alkanes are non-polar ✓ nucleophiles/electrophiles are **attracted** to polar substances ✓ C–H bonds are strong ✓ allow max of 2 from 3	2	**allow** C–H bonds have little/no polarity/no dipoles **allow** no regions of high or low electron density **allow** nucleophiles/electrophiles/reagents are **not** attracted to non-polar substances **not allow** attacks/reacts as an alternative to attracts **allow** bonds in alkanes are strong
	(b)		Free radical substitution ✓ balanced equation $C_5H_{12} + Br_2 \rightarrow C_5H_{11}Br + HBr$ ✓ mechanism $Br_2 \longrightarrow 2Br\bullet$ ✓ $Br\bullet + C_5H_{12} \longrightarrow HBr + \bullet C_5H_{11}$ ✓ $\bullet C_5H_{11} + Br_2 \longrightarrow C_5H_{11}Br + Br\bullet$ ✓ any two free radicals to show termination step ✓ conditions: uv ✓ bond fission: homolytic fission ✓ mixed products due to: • multiple substitution of H (in C_5H_{12}) • several isomers of $C_5H_{11}Br$ • different products could be formed in termination step***** any two from three ✓✓	10	if a different alkane is used **do not allow** mark for either propagation step but the rest can be marked ecf If error in first propagation step ecf can be awarded for second propagation step **allow** any one of: $2Br\bullet \longrightarrow Br_2$ $Br\bullet + \bullet C_5H_{11} \longrightarrow C_5H_{11}Br$ $\bullet C_5H_{11} + \bullet C_5H_{11} \longrightarrow C_{10}H_{22}$ If H• formed in propagation allow ecf for a termination equation using the H• **allow** sunlight/high temperature **allow** homolysis/homolytic cleavage **do not allow** free radicals are very reactive/difficult to control ***** must be stated not just assumed if they write more than one termination step.

Question	Expected Answers	Marks	Additional Guidance
QWC	Well structured answer and uses all three of initiation, propagation and termination correctly✓	1	
	Total	**13**	

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

Question			Expected Answers	Marks	Additional Guidance
1	(a)	i	reaction slows ✓	1	Not becomes constant
		ii	because there are less particles per unit volume (as the reaction proceeds)/particles further apart/ the concentration decreases ✓ (rate) of collision decreases ✓	2	marks are stand alone allow successful collisions
	(b)		sketch to show graph starting more steeply ✓ finishing at same level ✓	2	
			Total	**5**	

Question			Expected Answers	Marks	Additional Guidance
2	(a)	i	energy/enthalpy 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 is stand alone ignore 'under standard conditions'
		ii	energy is put in to break the bond/ energy is needed to overcome the attraction (between electrons and nuclei) in the bond ✓	1	**not** attraction between oppositely charged ions endothermic alone does not score.
	(b)		bonds broken = 1(H–H) + 1(F–F) = 436 + (F–F) **and** bonds made = 2(H–F) = 1136 ✓ 436 + (F–F) – 1136 = –542 ✓ bond enthalpy = 158 (kJ mol^{-1}) ✓	3	ecf possible
	(c)		enthalpy change is ΔH for ½ H_2 + ½ Cl_2 → HCl ✓ bonds broken = 218 + 121 = 339 and bonds made = –432 ΔH = –93 (kJ mol^{-1}) ✓	2	
	(d)	i	a weak acid is partially dissociated ✓ to form H^+ ions/ protons ✓	2	allow partially ionised can be shown in an equation
		ii	the H–F bond is stronger ora ✓	1	accept harder to break the bond.
		iii	Na_2CO_3 + 2HF → 2NaF + CO_2 + H_2O ✓	1	ignore state symbols; allow H_2CO_3
		iv	CO_3^{2-} + $2H^+$ →. CO_2 + H_2O/ Na_2CO_3 + $2H^+$ → $2Na^+$ + CO_2 + H_2O ✓	1	ignore state symbols do not allow the inclusion of spectator ions
		v	hydrochloric acid bubbles faster / solid disappears faster ✓ concentrations (of acids) must be the same ✓	2	 allow conditions must be the same
			Total	**15**	

Question			Expected Answers	Marks	Additional guidance
3	(a)		high temperature needed (to send equilibrium to RHS) ✓ since (forward) reaction is endothermic ✓ low pressure needed (to send equilibrium to RHS) ✓ since fewer moles of gas on LHS ✓	4	all stand alone marks
	(b)		high temperature (gives a fast rate of reaction) ✓ because a higher proportion of collisions exceed *E*a ✓ high pressure (gives a fast rate of reaction) ✓ because molecules are closer together **and** collide at a faster rate/ because particles are more concentrated **and** collide at a faster rate ✓	4	all stand alone marks accept because a 'higher proportion of collisions have enough energy to cause a reaction' do not accept 'more collisions' or 'more energetic collisions' not answer based on E_a
	(c)		would use high temperature – for rate **and** yield ✓ but compromise on pressure ✓ because high pressure gives a fast rate but poor yield ✓	3	compromise must be on pressure not temperature both rate and yield needed
	(d)	i	the (total) enthalpy change for a reaction is the same whichever route is taken ✓ owtte	1	
		ii	cycle/ $\Sigma\Delta H$ (products) - $\Sigma\Delta H$ (reactants) ✓ $-75 - 242 + 210 = \Delta H_f$ ✓ ΔH_f = - 107 ($kJmol^{-1}$) ✓	3	cycle need not be drawn correctly/ drawn at all –107 scores 3
			Total	**15**	

Question			Expected Answers	Marks	Additional Guidance
4	(a)		**enthalpy profile diagram** *y* axis labelled energy/enthalpy and one curve drawn to include either horizontal lines or reactants and products labelled✓ second curve included to start and finish at same energy level and one curve labelled (catalysed or uncatalysed) ✓ **Boltzmann distribution** axes labelled *x* as energy **and** *y* as number/ fraction or % of particles/ molecules/atoms ✓ shape of curve ✓ catalysed and uncatalysed E_a shown as vertical lines touching or crossing the curve and labelled ✓ **explanation** to increase the rate of reaction more collisions/particles/molecules have to exceed E_a/have enough energy to react ✓ a catalyst acts by lowering E_a ✓ by allowing the reaction to proceed via a different route ✓	8	1 max for enthalpy profile diagram if diagrams are reversed for x axis allow kinetic energy/ KE/ velocity/ enthalpy do not allow activation energy/ E_a must start at 0,0 and at higher energies must not touch or cross the x axis if 2 graphs are drawn , this mark does not score if candidate says catalyst gives molecule more energy, this mark does not score
	(b)		equilibrium position unchanged ✓ <u>rate</u> of forward and reverse reaction increased <u>by same amount</u> ✓	2	
			Total	**10**	

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

Skill P: 16 marks (out of 19 available)

A Analysis of the acids – 8 marks

***Four different chemical tests must be described**, one for each acid.*
- *If the same reagent is used twice, **award zero** on the second occasion.*
- *If the test described is ambiguous, the first two correct bullets are not credited.*
- *For each test, two or three bullets correct = 1 mark: four bullets correct = 2 marks*

1. Test for sulphuric acid (marks A1, A2) [2]

Use of CuO (giving blue solution) scores 1 mark (max) as test for sulphuric acid

- Add aqueous barium nitrate/chloride
  Aq or solution is needed, but do not penalise twice in the Plan
- White precipitate indicates that the solution tested is sulphuric acid
- The precipitate is barium sulphate *(can be credited from 's' state symbol in the equation)*
- Equation ***or*** ionic equation for reaction – $Ba(NO_3)_2 + H_2SO_4 \rightarrow BaSO_4 + 2HNO_3$

2. Use of $AgNO_3$ (marks A3, A4) [2]

- Add aqueous silver nitrate
- Cream/off-white precipitate obtained indicates HBr
  or white/milky precipitate indicates HCl
- Precipitate is silver chloride/bromide *(can be scored from 's' state symbol in an equation)*
- Equation or ionic equation for reaction (ignore state symbols)

3. Test for the other hydrohalic acid (marks A5, A6) [2]

Option (a) For HBr

- Add chlorine ***or*** concentrated sulphuric acid
- Goes orange (or appropriate observation)
  *Do **not** allow brown as the colour of aq bromine*
  *Accept **any** reasonable colour if an organic solvent is used to show Br_2 colour*
- Chlorine is more reactive than bromine ***or*** chlorine displaces bromine (*owtte*)
- Equation ***or*** ionic equation for reaction

Option (b) For either HCl or HBr

- [Add silver nitrate] – then add ammonia to the precipitate formed
- Use excess aqueous ammonia and shake the tube
  All three points required (excess, aqueous/solution, invert/shake/stir)
- For HCl, the precipitate dissolves/ goes clear
- For HBr, the precipitate is insoluble/ partially soluble/ does not dissolve
  or precipitate is soluble in concentrated ammonia

4. Test for ethanoic acid (marks A7, A8) **[2]**

Option (a)

- Add magnesium, a named metal carbonate ***or*** $NaHCO_3$
- Fizzing, bubbling ***or*** effervescence observed
- Test for gas outlined ***or*** reference to the slow reaction [compared to the other acids]
- Equation ***or*** ionic equation for reaction

Option (b)

- Add any named alcohol
- Heat with concentrated sulphuric acid
- [Sweet/fruity] smell of ester obtained
- Equation for chosen reaction
  Accept molecular formulae, but the -COO- ester linkage must be shown

Option (c) – ***1 mark*** *available, only, for these tests*

- Add a named indicator ***or*** add PCl_5 (or similar reagent) ***or*** aq $FeCl_3$
- Correct final colour of indicator ***or*** steamy/ acidic fumes produced ***or*** red colour

T Titration procedure – 7 marks

T1 Makes up accurately a **known solution** of KOH **[1]**
Detail needed: weighed mass of KOH + distilled water + volumetric flask

T2 Quantitative **dilution** of acid chosen using suitable pipette and volumetric flask **[1]**
The dilution must make the concentration of acid to 0.04 - 0.2 mol dm^{-3}

T3 Correct **equation** for neutralisation reaction used **[1]**

T4 Uses equation to **justify mass of alkali** to make up the solution **[1]**
T4 cannot be awarded if the acid used was 1.0 mol dm^{-3}

T5 Outline description of use of burette ***and*** pipette in **titration procedure** **[1]**

T6 At least two **consistent titres** (or within 0.1 cm^3) obtained
and suitable **indicator** chosen ***and*** correct end-point/final colour stated **[1]**

T7 **Specimen calculation** to determine % purity of KOH from the mean titre. **[1]**
56 (or 56.1) for the M_r of KOH must be shown in figures somewhere.

S **Safety, Sources and QWC - 4 marks**

S1 **Safety**:
Solid/pure potassium hydroxide is corrosive/ burns the skin:
wear gloves ***or*** face mask ***or*** if spilt on skin wash with plenty of water **[1]**
Hazard and precaution are both required
No credit for references to hazard of the acids

S2 **Two sources** quoted in the text ***or*** at end of Plan. **[1]**

S3 **QWC**: text is legible and spelling, punctuation and grammar are accurate **[1]**
Accept no more than five different errors 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 used correctly and are chemical formulae correct?*
- *Are the four tests described in a logical sequence without excessive repetition?*

Practical Test (B)

Part 1 **[14 marks]**

Presentation of titration data **[2]**

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

- 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 and subtractions are quoted to **two** decimal places, ending in .00 or .05
- No readings recorded above 50 cm^3
- All subtractions are correct *(these must be checked and indicated by a dot)*
  Two subtraction errors count as two bullet errors, ie scores 0 for presentation

Self-consistency of titres **[2]**

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

- The titres for any two accurate experiments are within 0.20 cm^3.
  For this bullet, assume that the first reading is a trial, whether labelled as such or not.
- The ticked titres (***or*** the titres used to calculate the mean) are all within 0.10 cm^3
  *If three titres are ticked, award the self-consistency on the spread of **all** three.*
- Two ***or*** three titres are ticked
- **Units**, cm^3 or ml, must be given somewhere *(**once** in the table is sufficient).*

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.
- *The mean must be quoted to 1 or 2 d.p (but **not** to 3 d.p. except for 0.025 and 0.075).*
  "Rounding up" must be done correctly if it is needed.

Accuracy **[7]**

The supervisor's mean titre is rounded to nearest 0.05 cm^3
Compare the mean supervisor's titre with the candidate's mean titre (T).
Put "δ = __" on the script to show the difference between these two titres.

Use the 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 used by the candidate to calculate his/her mean)*
If these titres have a spread = 0.40 cm^3 or more, deduct 1 accuracy mark.
If these titres have a spread = 0.60 cm^3 or more, deduct 2 marks.
If these titres have a spread = 1.00 cm^3 or more, deduct 3 marks (max spread penalty)

Safety

Diluted **W** will have no hazard symbol **[1]**

Diluting the acid/ adding water reduces the [level of] hazard
or adding water makes the acid safer (*owtte*) **[1]**
The second mark is independent of the first

Part 2 **[10 marks]**

*Mark **ecf** from one part of the question to the next, but **not** within a part.*
When a mark is awarded for the answer, it must be quoted to 3 significant figures

(a) Dilution factor was $^{250}/_{10}$ = 25, so concentration = $^{1.00}/_{25}$ = 0.0400 **[1]**
Minimum "proof" needed is figures 1.0, 10 and 250 suitably used.

(b) Answer **(a)** is multiplied by $^{\text{mean titre}}/_{1000}$ **[1]**
This is a method mark; check that the candidate's mean titre was actually used

Correct answer was obtained from candidate's own mean titre **[1]**

(c) $Ca(OH)_2(aq) + \mathbf{2}HX(aq) \rightarrow CaX_2(aq) + \mathbf{2H_2O}(l)$ **[1]**

State symbols are correct (*mark is conditional on H_2O shown as by-product*) **[1]**

(d) Answer **(b)** is multiplied by 0.5 **[1]**

(e) Answer **(d)** is multiplied by 40 (***or*** $^{1000}/_{25}$) **[1]**

$[Ca(OH)_2]$ correctly calculated **[1]**
*Candidate's answer should be 20 x **(b)** unless ecf has been applied*

(f) **2 marks**
M_r of calcium hydroxide = 74.1 **[1]**

Mass = answer **(e)** x 74.1 **[1]**
Use of 74 as the M_r can score 1 mark out of 2 in (f)

Part 3 **[6 marks]**

(a) White/milky precipitate/solid formed **[1]**

(b) Precipitate disappears ***or*** solid dissolves
or colourless solution formed ***or*** [mixture] goes clear **[1]**

(c) **Identity**: **HX** is HCl ***or*** hydrochloric acid **[1]**

Reason: Chlorides give a white precipitate with $AgNO_3/Ag^+$, soluble in ammonia **[1]**
*Reference to correct evidence from **both** tests is required for this mark*

(d) $AgNO_3(aq) + HX$ (*or* HCl)$(aq) \rightarrow AgX$ (*or* AgCl)$(s) + HNO_3(aq)$
or $Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$
For getting all formulae correct **[1]**
Mark ecf if HX was identified as HBr or HI

For absence of any balancing figures ***and*** all state symbols correct **[1]**

Part 4: (Skill E) **[14 marks]**

(a)(i) To ensure that <u>all</u> **HX** reacts **[1]**

(a)(ii) Number of moles of HX used = 0.01(0) mol **[1]**

Number of moles of Mg used = $^{0.15}/_{24.3}$ = 0.0062 mol **[1]**

Use of 2:1 mole reacting ratio to show clearly that Mg is in excess **[1]**
There are alternative methods of doing this calculation.

(a)(iii) There would be solid/magnesium left in the tube at the end of the experiment. **[1]**

(b) No of moles of HX used = 0.01 **[1]**

Volume of gas produced = 0.005 x 24000 = 120 cm^3 **[1]**

This volume exceeds the capacity of the cylinder, so too much acid was used **[1]**
Maximum 1 mark awarded for the calculation if 1:1 mole ratio is used
There are alternative methods of doing this calculation.

(c)(i) 4 marks *(Mark the best **two** strands given by the candidate)*

C1 Gas would escape before the bung could be fitted **[1]**

C2 Put one reagent into an ignition tube inside the flask (***or*** similar precaution) **[1]**

D1 Reaction might still be taking place [after one minute] **[1]**

D2 Take final reading when fizzing/bubbling stops
or wait until the volume of gas [in cylinder] stops increasing **[1]**

E1 Use a burette instead of a measuring cylinder for gas collection **[1]**
Allow use of a gas syringe for E1, but this improvement cannot score E2

E2 Burette is more accurately calibrated/manufactured ***or*** has narrower stem
or burette can be read to 0.05/0.1 cm^3 [whereas measuring cylinder to 1 cm^3] **[1]**

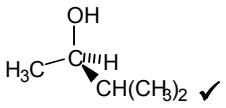
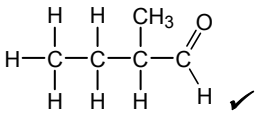
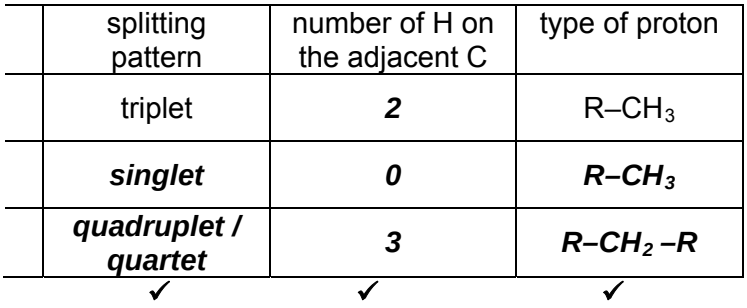
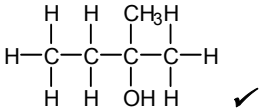
F1 Remove oxide layer on Mg before use by scraping/ sandpapering **[1]**

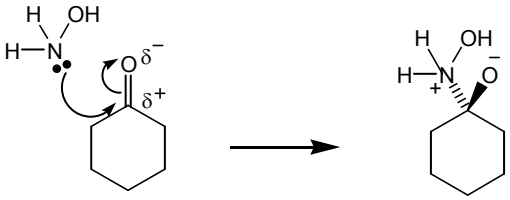
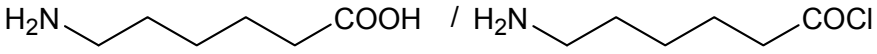
F2 The MgO would react with the acid without producing any gas **[1]**

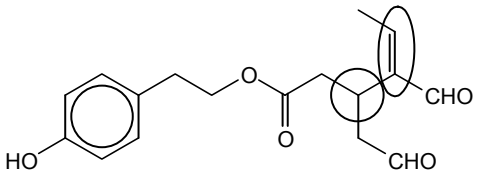
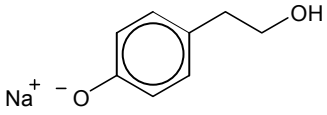
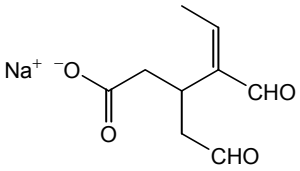
(c)(ii) Gas collection experiment was carried out only once / was not repeated **[1]**

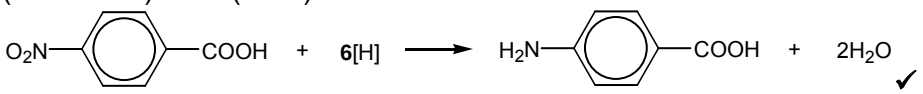
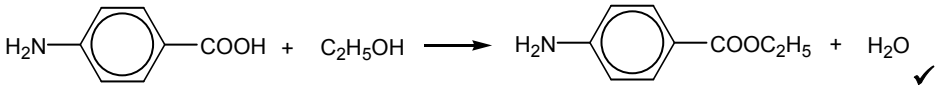
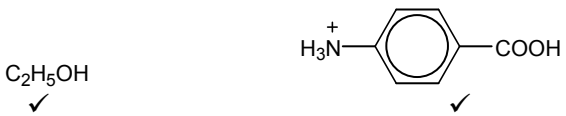
Titration was repeated to obtain consistent results/titres so it is [more] reliable **[1]**
The reliability must be clearly linked to the consistency (not to accuracy)

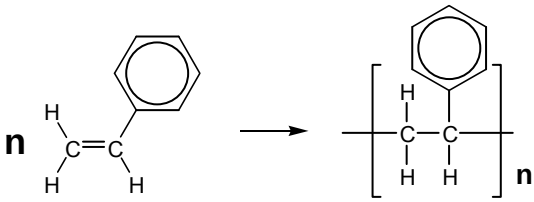
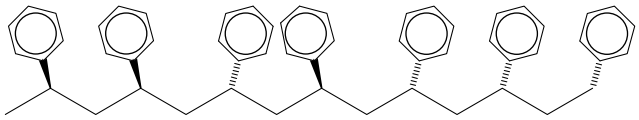
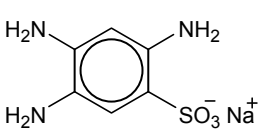
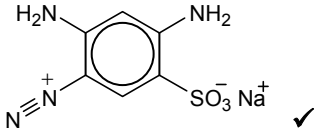
2814 Chains, Rings and Spectroscopy

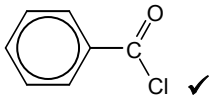
Question	Expected Answers		Marks
1(a)(i)	pentan-2-ol ✔ 2-methylbutan-1-ol ✔		2
(ii)	any arrangement of the four groups - e.g.  ✔	do not allow ~~HO connection error allow ~~C_3H_7	1
(b)	first mark for any aldehyde attempted ✔ second mark for correct structure or name of 2-methylbutanal – e.g.  ✔		2
(c)(i)	 splitting pattern / number of H on the adjacent C / type of proton triplet / ***2*** / $R–CH_3$ ***singlet*** / ***0*** / ***$R–CH_3$*** ***quadruplet / quartet*** / ***3*** / ***$R–CH_2–R$*** ✔ ✔ ✔ one mark for each column		3
(ii)	 ✔	allow the correct name 2-methybutan-2-ol	1
(iii)	(extra) peak (due to OH) ✔ range 3.5–5.5 ppm ✔		2
			Total: 11

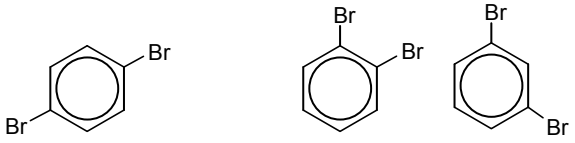
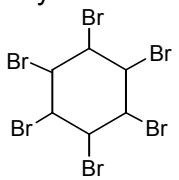
Question	Expected Answers	Marks
2(a)(i)	orange solid / ppt (when added to) 2,4-DNPH / Brady's Reagent ✓	
(ii)	(when warmed) with ammoniacal silver nitrate (solution) / Tollens' Reagent ✓ **no** silver (mirror) / reaction ✓ or no green colour with acidified dichromate allow 'no reaction' only if a suitable reagent used	1 2
(iii)	 dipole on C=O ✓ curly arrow breaking □ bond ✓ curly arrow from lone pair on N in the direction of the carbonyl C ✓	3
(iv)	M_r caprolactam = 113 ✓ mass of cyclohexanone needed = 98 / M_r = 0.867 tonnes or ecf ✓ scale for 99% yield = mass * 100/99 = **0.88** tonnes or ecf ✓ (or any number rounding to 0.876 tonnes)	3
(b)	a single molecule with six carbon atoms in a straight chain ✓ correct end groups on a straight chain ✓- e.g. 	2
		Total: 11

Question	Expected Answers		Marks
3(a)(i)	same structure / displayed formula / order of bonds different 3-D / spatial arrangement ✔		1
(ii)	 chiral centre circled ✔ C=C double bond circled ✔		2
(b)(i)	substitution: phenol / benzene / arene ✔ addition: alkene ✔	(allow C=C, but not just 'double bond')	2
(ii)	$C_{17}H_{20}O_5$ + **4**[H] ⟶ $C_{17}H_{24}O_5$ ✔ (or correct structure)		1
(iii)	correct products of hydrolysis (in acid or alkali conditions) ✔✔   ionisation of phenolic group **and** carboxylate group for alkali conditions ✔	Na^+ is not essential, but do not allow covalent Na-O	3
(c)(i)	304 ✔		1
(ii)	1000–1300 (cm^{-1}) due to C–O ✔ 1680–1750 (cm^{-1}) due to C=O ✔ 3230–3550 (cm^{-1}) due to O-H ✔		3
(d)	only one (stereo)isomer is active / effective / needed **AW** ✔ natural oil contains one optical/stereoisomer isomer **and** lab synthesis contains a mixture ✔ **AW**		2
			[Total: 15]

Question	Expected Answers	Marks
4(a)(i)	$LiAlH_4$ (in ether) / Na in ethanol ✓	1
(ii)	reduction/hydrogenation /redox ✓ allow addition	1
(b)(i)	$C_2H_5NH_3^+ Cl^-$ ✓ + and - not essential, but both or neither must be present	1
(ii)	$C_2H_5NH_3^+ CH_3COO^-$ ✓	1
(c)	ethylamine is a stronger base / accepts a proton more readily than phenylamine ✓ (can be implied) **phenylamine** lone pair on N is (partially) delocalised / incorporated into the benzene ring / p-orbital overlap described **AW** ✓ **ethylamine** C_2H_5 has a positive inductive effect / electrons move towards the N **AW** ✓ **comparison to explain relative basicity** discussion of negative charge / electron density on the nitrogen ✓ discussion of the ease of donation/availability of the lone pair of electrons on the N ✓ (ignore any reference to the inductive effect for phenylamine) **any 4 out of 5 marks**	4
QWC	mark for well organised response with correct use of **one** of the terms: **inductive effect**, **delocalised, mesomeric**	1
(d)	correct formula of 4-nitrobenzoic acid as starting material ✓ correct formula of 4-aminobenzoic acid or ethyl-4-nitrobenzoate ✓ **reduction of nitro group** (reflux with) Sn + (conc) HCl ✓  ✓ **esterification** (reflux / distil / heat with) ethanol + (conc.) H_2SO_4 ✓  ✓ (steps can be in either order)	6
(e)	 ✓ ✓	2
	Total: 17	

Question	Expected Answers	Marks
5(a)(i)	addition ✓	1
(ii)	 monomer ✓ repeat unit with 'side bonds' ✓ allow one or more repeats	2
(iii)	 benzene rings on every second carbon in random directions ✓ diagram also shows correct use of 3-D bonds ✓ allow ecf from (ii)	2
(iv)	isotactic has side chains on the same side **AW** ✓	1
(b)	 ✓  ✓ add the amine to HCl + $NaNO_2$ /HNO_2 ✓ temp < 10 °C ✓ add to alkaline phenol ✓	5
		Total: 11

Question	Expected Answers	Marks
6(a)(i)	 ✓	1
(ii)	$C_6H_5COOH + PCl_5 \longrightarrow C_6H_5COCl + HCl + POCl_3$ $+ SOCl_2 \qquad\qquad + SO_2$ reagent ✓ balanced equation ✓	2
(b)	**ester** eg $C_6H_5COCl + C_2H_5OH \longrightarrow C_6H_5COOC_2H_5 + HCl$ alcohol / correct name/formula of a suitable example ✓ equation ✓ **amide** eg $C_6H_5COCl + C_2H_5NH_2 \longrightarrow C_6H_5CONHC_2H_5 + HCl$ $C_6H_5COCl + 2NH_3 \longrightarrow C_6H_5CONH_2 + NH_4Cl$ amine / ammonia / correct name/formula of a suitable example ✓ equation ✓	4
(c) (i)	$FeCl_3$ / $AlCl_3$	1
(ii)	electrophilic substitution	1
		Total: 9

Question	Expected Answers	Marks
7(a)	**cyclohexene** (electrophilic) addition ✓ C_6H_{10} + Br_2 ⟶ $C_6H_{10}Br_2$ ✓ **benzene** (electrophilic) substitution ✓ C_6H_6 + Br_2 ⟶ C_6H_5Br + HBr ✓ needs a / halogen carrier / catalyst/ Fe / $FeBr_3$ / $AlBr_3$ etc ✓ **relative reactivites** benzene is: (more) stable / less reactive / less susceptible to electrophiles ✓ **AW ora** (□)-electron electron density in benzene is low **ora** ✓ comparison of the relative ability to attract /polarise the electrophile or relative ability to donate an electron pair ✓ **QWC** mark for at least two sentences/bullet points in context with correct spelling, punctuation and grammar	8 1
(b)(i)	$^{30.5}/_{12.0}$ = $^{1.7}/_{1.0}$ = $^{67.8}/_{79.9}$ = *2.54* *1.7* *0.85* ✓ *3* : *2* : *1* empirical formula = C_3H_2Br ✓	2
(ii)	(M_r of C_3H_2Br = 117.9 = $^{235.8}/_{2,}$ so) molecular formula = $C_6H_4Br_2$ ✓  one correct structure ✓ all three correct ✓	3
(c)	any valid structure for 1,2,3,4,5,6-hexabromocyclohexane – e.g.  ✓ C_6H_6 + **3**Br_2 ⟶ $C_6H_6Br_6$ ✓	2
		Total: 16

2815/01 Trends and Patterns

Question	Expected Answers	Marks	Additional Guidance
1 (a)	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^9$ (1)	1	
(b) (i)	Correct formula of a copper(II) complex ion e.g. $CuCl_4^{2-}$ / $[Cu(NH_3)_4(H_2O)_2]^{2+}$ / $[Cu(H_2O)_6]^{2+}$ (1)	1	
(ii)	Correct colour (1) e.g. $CuCl_4^{2-}$ green/yellow, $[Cu(NH_3)_4(H_2O)_2]^{2+}$ dark blue and $[Cu(H_2O)_6]^{2+}$ blue	1	**Allow** ecf from a known copper compound
(iii)	Coordinate bond / dative bond (1) Lone pair donated by ligand / lone pair accepted by copper (1)	2	
(c) (i)	Blue precipitate / blue solid	1	Can get credit for ppt from state symbol of correct product in part (ii)
(ii)	$Cu^{2+} + 2OH^- \rightarrow Cu(OH)_2$ / $[Cu(H_2O)_6]^{2+} + 2OH^- \rightarrow Cu(OH)_2 + 6H_2O$ / $[Cu(H_2O)_6]^{2+} + 2OH^- \rightarrow Cu(H_2O)_4(OH)_2 + 2H_2O$ (1)	1	**Allow** correct multiples **Ignore** state symbol
(d) (i)	Mole ratio C:Cu:K:N = 0.0320:0.00800:0.0240:0.0320 (1) $K_3CuC_4N_4$ (1)	2	**Allow** the four masses ÷ appropriate A_r if mole ratio not calculated **Allow** any order of atoms Can award formula mark if given in part (ii) **Allow** ecf from wrong mole ratio
(ii)	$[Cu(CN)_4]^{3-}$ / $CuC_4N_4^{3-}$ (1)	1	**Allow** any order of atoms with or without brackets **Allow** ecf from wrong formula
	Total	**10**	

Question	Expected Answers	Marks	Additional Guidance
2 (a) (i)	Magnesium 2.8 or diagram with 8 or 0 electrons in outer shell and two chloride ions of 2.8.8 or diagram with 8 electrons in outer shell (1) Correct charge Mg^{2+} and Cl^- (1) Mark independently from dot and cross	2	**Allow** one mark for a correct magnesium ion with charge / two correct chloride ions with charge **Not** $[Cl_2]^{2-}$
(ii)	Giant structure (1) Strong attraction between ions / lots of energy needed to overcome attraction between ions / lots of energy needed to break ionic bonds (1)	2	**Allow** strong ionic bonds
(b)	$Si + 2Cl_2 \rightarrow SiCl_4$ (1)	1	**Allow** any correct multiples **Ignore** state symbols
(c)	Correct outer shell of phosphorus (five bond pairs) (1) Rest of structure correct (1) **independent** of outer shell of phosphorus mark so that PCl_4, PCl_3 or PCl_6 could get this mark if all chlorine atoms are correct	2	Rest of structure of mark
(d) (i)	$PCl_5 + 4H_2O \rightarrow H_3PO_4 + 5HCl$ / $PCl_5 + H_2O \rightarrow POCl_3 + 2HCl$ (1)	1	**Allow** any correct multiples **Allow** H^+ and Cl^- instead of HCl **Ignore** state symbols
(ii)	Hydrolysis (1)	1	
(e)	Covalent (1)	1	**Allow** simple molecule / dative bond / has considerable covalent character
(f) (i)	(orange, brown, rusty or yellow) to (blood) red (1)	1	**Allow** (deep) red **Not** green / blue to red **Not** precipitate
(ii)	Ligand substitution / ligand exchange (1)	1	**Allow** ligand displacement / ligand replacement
	Total	**12**	

Question	Expected Answers	Marks	Additional Guidance
3 (a)	$2Cr^{3+} + 3H_2O_2 + 10OH^- \rightarrow 2CrO_4^{2-} + 8H_2O$ Correct reactants and products (allow e^- and OH^- on **both** left and right) and correct molar ratio of Cr^{3+} and H_2O_2 (1); Balanced (1)	2	For the second mark the OH^- and e^- must be cancelled down
(b)	Moles MnO_4^- = 0.000463 (1) Moles Fe^{2+} = 5 × moles MnO_4^- / 0.002315 (1) M_r = 392 / 391.8 (1) x = 6 (1) **dependent** on M_r given	4	**Allow** ecf within the question ecf is 0.907 ÷ moles of Fe^{2+} **Allow** three marks for 392 / 391.8 with no working ecf is (M_r – 283.8) ÷ 18 **Allow** one mark for 6 with no working
	Total	**6**	

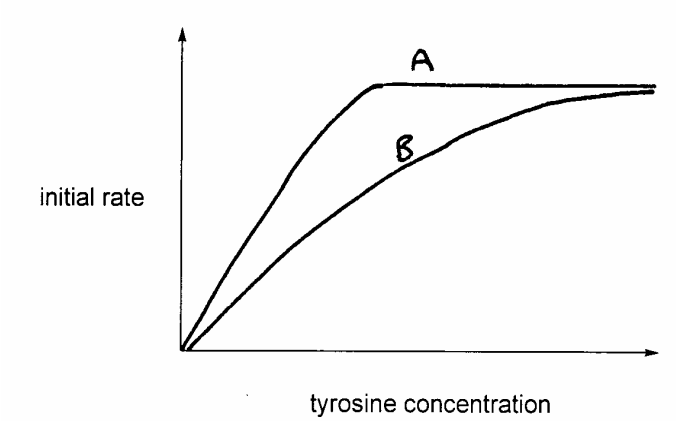
Question	Expected Answers	Marks	Additional Guidance
4 (a) (i)	**Any three from** Magnesium ion smaller than barium ion / magnesium ion has a higher charge density / ora (1); Magnesium ion is more polarising / ora (1): Magnesium ion distorts the carbonate ion more than barium ion / ora (1); So carbon–oxygen bond (in carbonate) is weaker / so covalent bond in carbonate is weaker (1)	3	**Must** use correct particle but only penalise once **Assume** carbonate refers to an ion **Allow** CO_3^- Only need one comparative statement in the last three marking points
(ii)	Contains Na^+ which has a low charge density / contains Na^+ which is not very polarising (1)	1	**Ignore** Na^+ is a large ion **Allow** Na^+ is a larger ion than Mg^{2+} **Allow** Na^+ has a smaller charge than Mg^{2+}

Question	Expected Answers	Marks	Additional Guidance
4 (b)	Definitions $2Na^+ + O^{2-} \rightarrow Na_2O$ (1) $2Na + ½O_2 \rightarrow Na_2O$ (1) Lattice enthalpy is the enthalpy change when one mole (of ionic solid) is made from its constituent gaseous ions but formation from its constituent elements (1)	3	If given state symbols must be **correct** **Allow** energy released **Not** energy absorbed **Allow** states from equations
	Born-Haber cycle Correct state symbols for the formulae given (1); Correct formula (1); Labelling of enthalpy changes Three correct labels (1) but five correct labels (2) but all labels correct (3) Expression or statement in words or symbols to show how lattice enthalpy is calculated (1)	6	Formula must have correct state symbol at least once in the cycle Formulae given must be correct but there can be a formula missing **Allow** ecf from the cycle drawn **Allow** conventional symbols e.g. ΔH_f **Allow** ecf from cycle drawn

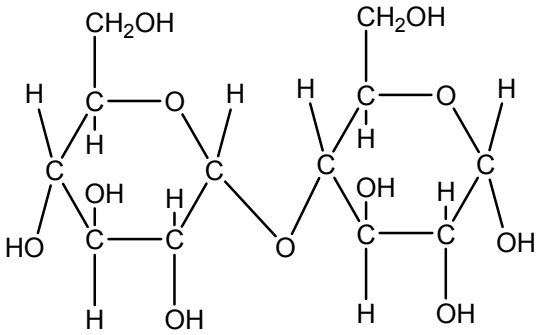
Question	Expected Answers	Marks	Additional Guidance
4	**Lattice enthalpy** magnesium oxide, sodium chloride and potassium bromide (1) **Any two from** Comparison of charge density or ionic radius of cation (1) e.g. ionic radius decreases from K^+, Na^+ to Mg^{2+} / charge density increases from K^+, Na^+ to Mg^{2+} (1) Comparison of charge density or ionic radius of anion (1) e.g. e.g. ionic radius decreases from Br^-, Cl^- to O^{2-} / charge density increases from Br^-, Cl^- to O^{2-} (1) Comparison of charge on ions (1) Na^+ but Mg^{2+} / O^{2-} but Cl^-	3	**Allow** Mg^{2+} but Na^+ (1) and Na^+ is smaller than K^+ (1) **Allow** O^{2-} but Cl^- (1) and Cl^- is smaller than Br^- (1)
	Quality of Written Communication (1) At least two complete sentences with correct spelling, punctuation and grammar that address the question set	1	
	Total	**17**	

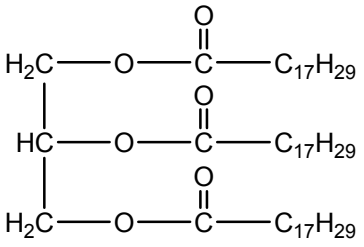
2815/02 Biochemistry

Question		Expected Answers	Mark
1	(a)(i)	Diagram must include –CO–NH- (or displayed version)✓ Amide/peptide link ✓ Phenylalanine and alanine.✓	2
	(ii)	Any logical reasoning eg a dipeptide has general formula $H_2NCHRCONHCHRCOOH$ which leaves C_7H_8 – can only be those two.✓	2
	(b)	Any three examples from the following four using the amino acids provided in each case @ 2 marks each. • Ionic(accept electrostatic)✓ between COO^- and NH_3^+✓ • van der Waals/Instantaneous dipole–induced dipole✓ between any two sidechains from alanine and phenylalanine✓ Not 'hydrophobic bonding'**.** • Covalent or disulphide or C–S–S–C ✓ between two cysteines.✓ • Accept hydrogen bonding ✓ between two suitable groups such as COOH and NH_2 ✓ as long as these groups are not ionised. Where candidate uses both ionised, for ionic, and non-ionised, for hydrogen bonding allow both bonding type marks but only one example mark – max 3 marks from 4. Diagrams, if given, must be correct. QWC. Award the mark for correct reference to three types of interaction, and one appropriate amino acids (by name or diagram)	6 1

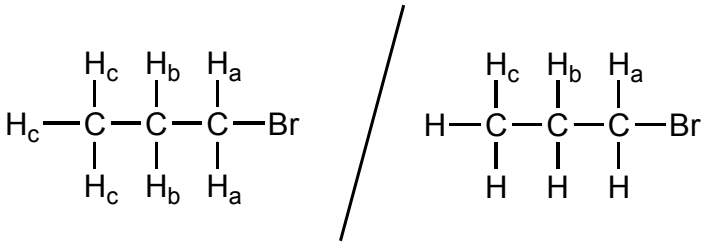
Question	Expected Answers	Mark
2 (a)(i)	Only one optical isomer of tyrosine is the right shape to fit in the <u>active site</u> AW.✓	1
(ii)	COOH becomes COO^- and NH_2 becomes NH_3^+ and no change to phenol✓	1
(iii)	<u>NH_3^+ group becomes uncharged (NH_2)</u>, losing <u>ionic</u> attraction.✓ No mark for protonating COO-	1
(b)(i)	Binds/**fits** to active site **reversibly/**instead of tyrosine✓ AW	1
(ii)	 One mark for each curve.✓✓ Labels wrong way round on correct graphs, max 1mark.	2

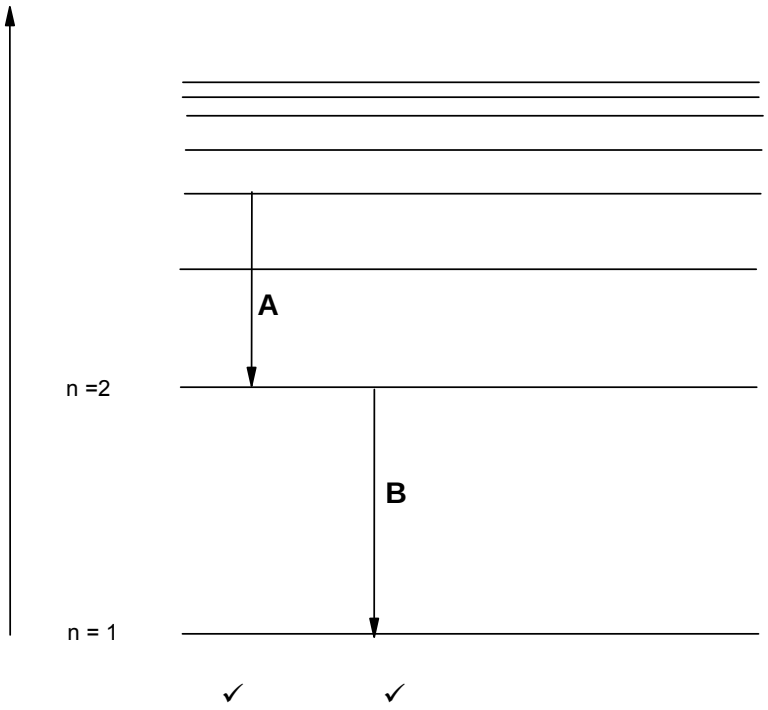
Question		Expected Answers	Mark
3	(a)	CTATGC ✓	1
	(b)	Three each ✓ of AT and CG links. (3 x 2) + (3 x 3) = 15 ✓ Correct answer(15) earns both marks	2
	(c)	CUAUGC ✓	1
	(d)	Six points from: • Base triplet on m-RNA attract t-RNA molecule with the complementary triplet✓ **(**Not codon etc without reference somewhere to base triplets) • Hydrogen bond forms between t-RNA and m-RNA ✓ • Each t-RNA carries its appropriate amino acid AW✓ • Two t-RNA molecules are attached to m-RNA at a time✓ • Bond between t-RNA and its amino acid breaks✓ • The amino acid is then joined, to the growing peptide/polypeptide chain by a peptide/amide/C–N link✓ • by a condensation reaction ***/*** mention of peptidyl transferase • Hydrogen bonds between the t-RNA and m-RNA break.✓ • The pair UA has two hydrogen bonds and CG three✓ • Start codon is AUG/ for methionine✓ Marks may be found on a suitable diagram.	6

Question	Expected Answers	Mark
4 (a)(i)	(α) means that the O on the right hand carbon (C1) points down/is below plane of ring✓. (pyranose) means a ring of five carbon atoms and one oxygen.✓AW	1 1
(ii)	$HOCH_2CHOHCHOHCHOHCHOHCHO$ or fully displayed. Ignore stereochemistry.✓	1
(b) (i)	 ✓ for glycosidic link C-O-C (which may be skeletal) ✓ for the rest including stereochemistry	2
(ii)	maltose✓	1
(c)(i)	Because the necessary OH groups are not available o hydrogen bond to water✓ being • used in glycosidic links✓ • used in hydrogen bonding between chains.✓ Any two points	2
(ii)	Any three points from: • A linear polymer (not helical)✓ • The polymer molecules lie alongside each other and hydrogen bond across✓ • Diagram or explanation of the hydrogen bonds involved O–H···O ✓ • The molecules/ fibrils form bundles of fibres which have tensile strength ✓	3

Question		Expected Answers	Mark
5	(a)	Three ✓	1
	(b)(i)	 ✓ for ester group ✓ for rest	2
	(ii)	alkene/C=C ✓ and ester✓ (not ecf from (i))	2
	(c)	Hydrocarbon chains in triglyceride molecules ✓ Can form van der Waals ✓ forces with non polar solvents. Allow the marks for arguments based on the van der Waals forces being similar in separate triglyceride and solvent, and in a mixture of the two. This presents no energy barrier to mixing.	2

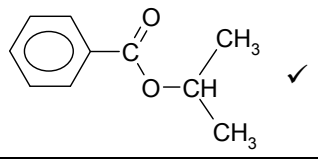
2815/04 Methods of Analysis and Detection

Question		Expected Answers	Marks
1(a)	(i)	$C_3H_7{}^{79}Br^+$ /$CH_3CH^{79}BrCH_3$ ✓ $C_3H_7{}^{81}Br^+$ /$CH_3CH^{81}BrCH_3$ ✓	2
	(ii)	1 : 1 ✓	1
(b)		29 /43/ 93 / 95 ✓	1
(c)	(i)	 all 3 correctly labelled scores two marks, 1 correctly labelled gets 1 mark ✓ ✓	2
	(ii)	Adjacent C has 2 Hs/protons/next to a CH_2 ✓	1
	(iii)	number of peaks = 2 ✓ relative peak areas = 6 : 1 ✓	2
		Total	**9**

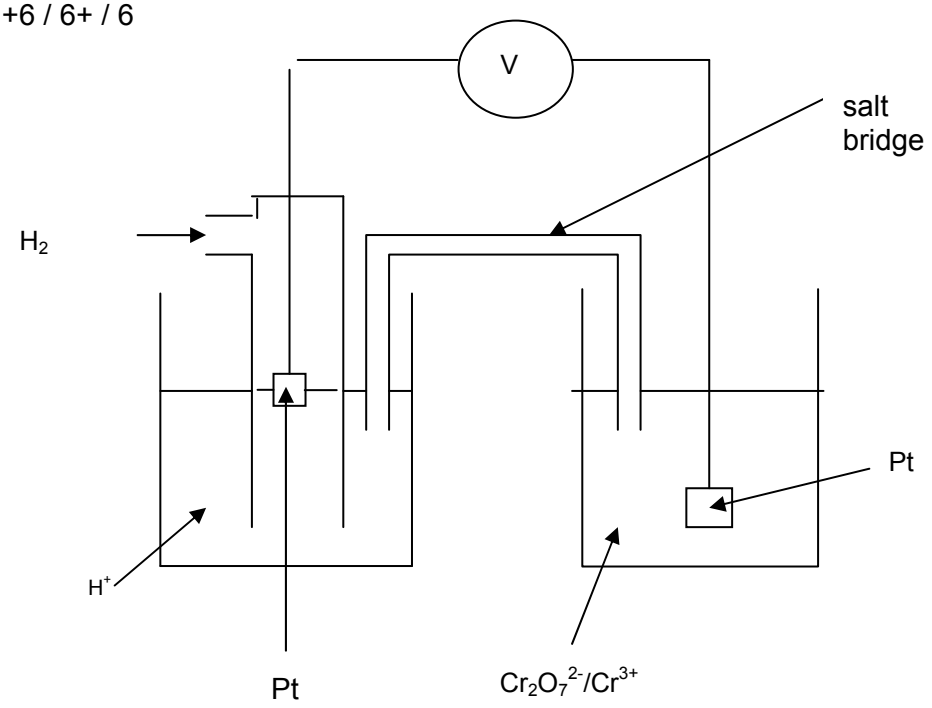
Question	Expected Answers	Marks
2 (a)	(electrons excited to higher energy levels) and fall back to lower levels ✓ & emit energy/light ✓	2
(b)	excited electrons fall back to different energy levels / in a series, each electron falls back to the same energy level ✓	1
(c)	 ✓ ✓ 1 mark for each transition. If arrows point upwards, credit one mark only	2
(d)	uses correct formulae $f = c/\lambda$ and $E = hf$ or $E = hc/\lambda$ ✓ $f = 3.29 \times 10^{15}$ (calculator value $3.289473684 \times 10^{15}$) ✓ $E = h \times f = 2.18 \times 10^{-18}$ J / 2.18×10^{-21} kJ (calculator value $2.180921053 \times 10^{-18}$) ✓ 1313 / 1310 / 1312.9 ✓ (allow ecf throughout the calculation)	4
	Total	**9**

Question	Expected Answers	Marks
3(a) (i)	R_f = distance moved by solute/spot ✓ distance moved by solvent	1
(ii)	they have similar R_f values/similar solubilities (AW) ✓	1
(iii)	run another chromatogram with a different solvent/use two way chromatography ✓ because it is unlikely that two substances have similar R_f values in two different solvents ✓	2
(iv)	distribution/relative solubility of the solute/spot/component / differences in solubility ✓ between the mobile and the stationary phase ✓	2
(b)	uses (an applied) voltage ✓ movement depends on mass & charge ✓ pH controlled by buffer ✓ pH must be controlled because charge changes with pH ✓ example of how charge changes by showing cation ($-NH_3^+$) at low pH or anion ($-COO^-$) at high pH ✓ pH changes may affect direction of movement of amino acids ✓ **6** marking points - maximum = **5**	5
QWC	At least two sentences that shows legible text with accurate spelling, punctuation and grammar so that the meaning is clear. ✓	1
	Total	**12**

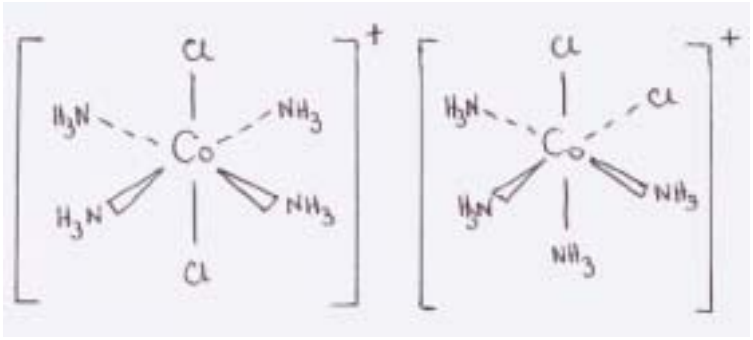
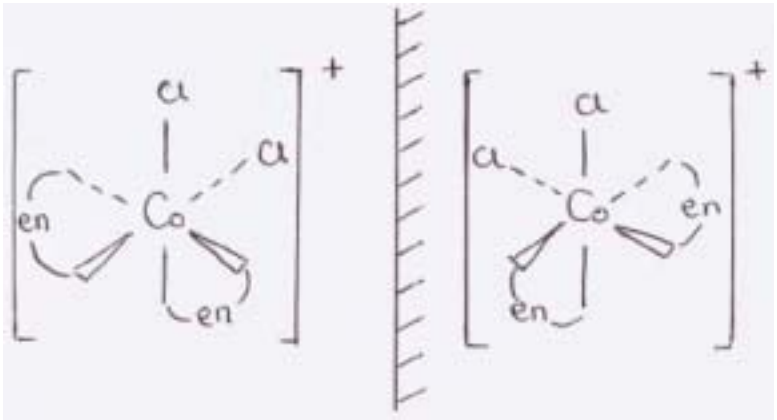
Question	Expected Answers	Marks
4(a)	$CH_3CH_2NH_2$ yes due to lone pair on N ✓ $C_6H_5CH_3$ yes due to delocalised benzene ring ✓ $CH_3CH_2CH_3$ no because contains no lone pairs or multiple bonding/is a saturated molecule ✓ CH_3CH_2CN yes due to C≡N/ unsaturated/π-bonding ✓	4
(b) (i)	**more** conjugation / larg**er** chromophore ✓ decreases energy gap ✓ shifts absorption (to longer λ) into visible region ✓	3
(ii)	likely to absorb in UV region ✓	1
	Total	**8**

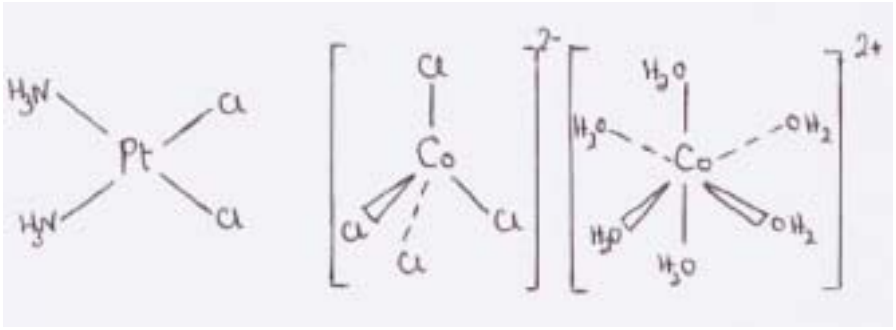
Question	Expected Answers	Marks
5(a) (i)	*M* = 164 (from mass spec) ✓ empirical mass of C_5H_6O = 82 , therefore molecular formula = $C_{10}H_{12}O_2$ ✓	2
(ii)	carbonyl identified from IR (at about 1700cm^{-1}) ✓ ring identified from nmr: C_6H_5 at δ = 7.3 ppm or from peak *m*/*e* = 77 in mass spectrum ✓ methyl groups identified from nmr: 2 x CH_3s at δ = 1.2 ppm ✓ Single H identified from nmr by peak at δ = 4.0 ppm/ doublet at δ = 1.2 ppm indicates next to a CH ✓  ✓	5
	Total	**7**

2815/06 Transition Elements

Question	Expected Answers	Marks
1 (a) (i)	+6 / 6+ / 6	1
(ii)		
	H_2 and H^+ (state symbols not required)	1
	Voltmeter and salt bridge [if no liquid levels lose this mark]	
	Both Platinum electrodes labelled	1
	$Cr_2O_7^{2-}$ / Cr^{3+}(/ H^+ not needed for mark)	1
	Temp 298K or 25°C + Pressure 1 Atm / 100 kPa/ 101 KPa / 1 bar / 10^5 Pa	1
	+ concentration 1 mol dm^{-3} (can take from diagram) or equimolar mixture of $Cr_2O_7^{2-}$ / Cr^{3+}	1
(b)	$E^{\ominus}$ would be lower than +1.33 V	1
	Equilibrium would move from right to left / backwards	1
	Total	**8**
2 (a)	$[Co(H_2O)_6]^{3+}$	1
	$E^{\ominus}$ for $[Co(H_2O)_6]^{3+} + e^- \rightleftharpoons [Co(H_2O)_6]^{2+}$ is more positive	1
	This reaction is more likely to proceed from left to right / $[Co(H_2O)_6]^{3+}$ is more likely to accept electrons / be reduced	1
(b)	Pink	1
(c)	$2[Co(NH_3)_6]^{3+} + Fe \rightarrow 2[Co(NH_3)_6]^{2+} + Fe^{2+}$	1
	idea that $E^{\ominus}$ is positive / idea of cobalt complex equilibrium tending to go from left to right whilst Fe^{2+} / Fe equilibrium goes from right to left / calculation of cell emf ((+)0.55V).	1
	Total	**6**

Question	Expected Answers	Marks
3 (a) (i)	$1s^2 2s^2 2p^6 \mathbf{3s^2 3p^6 3d^{10}}$	**1**
(ii)	Colour requires electrons in d-orbitals and a space for promotion / colour results from transitions of electrons between d-orbitals / colour results from a partially filled d-subshell	**1**
	Cu^+ has a full set of 3d orbitals / is $3d^{10}$ / has a full d-subshell	**1**
(b)	Energy levels of d-orbitals are split	**1**
	Different ligands interact differently with d-orbitals / ΔE changes for different ligands	**1**
	Size of ΔE determines frequency / wavelength / colour of visible light absorbed	**1**
(c)	Disproportionation or explained eg copper(I) goes to copper(II) and copper / copper(I) is oxidised and reduced.	**1**
	$2CuCl \rightarrow CuCl_2 + Cu$ / $2Cu^+ \rightarrow Cu^{2+} + Cu$	**1**
	$CuCl_2$ / Cu^{2+} / $[Cu(H_2O)_6]^{2+}$ and $CuCl_4^{2-}$ is blue-green and Cu is reddish-pink (both needed for 1 mark)	**1**
(d)	Moles $S_2O_3^{2-}$ = 0.00198 mol	**1**
	1 mole $S_2O_3^{2-}$ = 1 mole Cu^{2+} / 25 cm^3 Cu^{2+} contains 0.00198 moles	**1**
	250 cm^3 of Cu^{2+} contains 0.0198 moles	**1**
	0.0198 moles Cu has a mass of 0.0198 x 63.5 g = 1.26 g (1.2573)	**1**
	% Cu = 1.26/1.65 x 100 = 76.2% (allow 76.0% - 76.4%)	**1**
	Allow ecf after each stage of the calculation	
	Total	**14**

Question	Expected Answers	Marks
4 (a)	Geometric or *cis* and *trans*	1
(b)		
	Accept other possible projections. Brackets and charge are NOT required for the mark	2
(c)	Optical	1
	cis isomer	1
	correct mirror images (allow ecf)	1
		
	Accept other projections. Brackets and charge are not required. Accept a loop for en If optical given in (a) allow *cis*/*trans* and correct structures in (c) unless *cis*/*trans* drawn in (b) Reverse names but correct structures = 4 marks for (a), (b) and (c) combined. NB only two marks available for *cis*/*trans* diagrams regardless of labels	
	Total	**6**

Question	Expected Answers	Marks
5	Co-ordination number is the number of dative covalent / co-ordinate bonds formed (with central transition metal / ion)	1
		
	Suitable charge / brackets needed for these examples Square planar tetrahedral octahedral 90^O 109.5^O 90^O	
	Two marks for each type with suitable example and correct name of shape and bond angle. Clear 3-D diagram with correct bond angle for a correct complex will receive 2 marks	6
	$[Co(H_2O)_6]^{2+} + 4Cl^- \rightleftharpoons [CoCl_4]^{2-} + 6H_2O$ / other suitable correct equations	1
	Shape changes from octahedral to tetrahedral	1
	Co-ordination number changes from 6 to 4 } } 1 mark for both Charge changes from +2 to -2 }	1
	(Mark for co-ordination number and charge can be taken from equation	
	Quality of Written Communication: 1 mark awarded for the correct use in context of at least 2 of the following terms; Square planar, tetrahedral, octahedral, dative, covalent, co-ordinate,	1
	Total	**11**

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

Question	Expected Answers	Marks
1(a)	$K_c = \frac{[H_2]\,[I_2]}{[HI]^2}$ ✓	1
1(b)(i)	HI: 0.28 ✓ H_2: 0.11 ✓	2
1(b)(ii)	Use of $K_c = \frac{0.11 \times 0.11}{0.28^2}$ to generate a calculated value ✓ = 0.15 ✓ (2 significant figures) (calc. value: 0.154336735) no units ✓ *There must be some response here, not left blank.* If [HI] = 0.39 mol dm^{-3} (common mistake), K_c = 0.07955292571 (calc value) = 0.080 to 2 sig figs Do **NOT** accept 0.08 mol dm^{-3} (1 significant figure)	3
1(c)	K_c doesn't change ✓ Composition stays the same **OR** equilibrium does not move ✓	2
1(d)	K_c increases ✓ (forward) reaction is endothermic **OR** reverse reaction is exothermic ✓	2
1(e)	I : Cl = $\frac{78.15}{127}$: $\frac{21.85}{35.5}$ **OR** 0.615 : 0.615 ✓ **A**: ICl **OR** any multiple, eg I_2Cl_2, etc ✓ *ICl with no working scored 2 marks.* $HI + Cl_2 \longrightarrow ICl + HCl$ ✓ **ACCEPT** $2HI + Cl_2 \longrightarrow 2ICl + H_2$ *Accept multiples from identification of* **A**. *Accept equation based on an incorrect formula for A but ONLY if a compound of I and Cl* **B**: I_2Cl_6 ✓ $2HI + 4Cl_2 \longrightarrow I_2Cl_6 + 2HCl$ ✓ **ACCEPT** $2HI + 3Cl_2 \longrightarrow I_2Cl_6 + H_2$ ✓ *Accept equation based on an incorrect formula for B but ONLY if a compound of I and Cl*	5
	Total:	**15**

Question	Expected Answers	Marks
2(a)	3 ✓	1
2(b)	$k = \frac{6.90 \times 10^{-7}}{(2.80 \times 10^{-4})^2 \times 1.44 \times 10^{-3}}$ ✓ = 6.11 x 10^3 ✓ (calculator 6.111819728 × 10^3) units: $dm^6\ mol^{-2}\ s^{-1}$ ✓ **ACCEPT** 6.1 × 10^3 up to calculator value If expression is upside down, calculated value = 1.636173913 1.6 up to calculator value would score 1 mark for the numerical value **ECF** units $dm^{-6}\ mol^2\ s^1$ If square is missed, calculated value = 1.711309524 1.7 up to calculator value would score 1 mark for the numerical value **ECF** units $dm^3\ mol^{-1}\ s^{-1}$	3
2(c)(i)	Curve downwards with slope gradually levelling off ✓	1
2(c)(ii)	Measure its gradient **OR** slope ✓ (Tangent) at t = 0 **OR** at start ✓ *Either mark could be from triangle shown on graph with y/x*	2
2(c)(iii)	Half-life is constant ✓	1
2(d)(i)	Curve upwards with slope gradually getting steeper ✓	1
2(d)(ii)	rate × 9 **OR** 3^2 ✓ order = 2 (with respect to NO) ✓ *Each marking point is independent*	2
2(d)(iii)	rate × 2^2 × 3 = × 12 ✓	1
	Total:	**12**

Question	Expected Answers	Marks
3(a)	pK_a = 2.82 ✓ calculated value = 2.823908741 **ACCEPT** 2.8 up to calculator value	1
3(b)(i)	$K_a = \frac{[H^+]\,[HSO_3^-]}{[H_2SO_3]}$ ✓	1
3(b)(ii)	$1.50 \times 10^{-3} \approx \frac{[H^+]^2}{0.0265}$ ✓ *('=' sign is acceptable)* $[H^+] = \sqrt{1.50 \times 10^{-3} \times 0.0265}$ = 6.30 × 10^{-3} mol dm^{-3} ✓ pH = –log$[H^+]$ = –log 6.30 × 10^{-3} = 2.20 ✓ *(Stand alone mark; ie* pH –log(0.0265) = 1.58 can be awarded 1 mark*)* If all figures kept in calculator, value = 2.200331434 **ACCEPT** 2.2 up to calculator value If no square root, pH =. 4.40	3
3(b)(iii)	a small amount of second dissociation **OR** it is a diprotic acid ✓ **ACCEPT** equilibrium concentration H_2SO_3 is less than the initial concentration.	1
3(c)(i)	ionic product (of water) ✓	1
3(c)(ii)	$K_w = [H^+]\,[OH^-]$ ✓	1
3(d)	$[H^+] = \frac{1.0 \times 10^{-14}}{0.0265}$ **OR** 3.77 × 10^{-13} **OR** pOH –log(0.0265) = 1.58 ✓ pH = –log(3.77 × 10^{-13}) **OR** 14 – 1.58 = 12.42 ✓ calculated value = 12.42324587 **ACCEPT** 12.4 up to calculator value	2
3(e)	**C**: $KHSO_3$ ✓ $KOH + H_2SO_3 \longrightarrow KHSO_3 + H_2O$ ✓ **D**: K_2SO_3 ✓ $2KOH + H_2SO_3 \longrightarrow K_2SO_3 + 2H_2O$ / $KOH + KHSO_3 \longrightarrow K_2SO_3 + H_2O$ ✓ If **C** and **D** are the wrong way around award 3 max by **ECF** If H_2SO_4 used throughout, award 3 max by **ECF**	4
	Total:	**14**

Question	Expected Answers	Marks
4(a)	$C_2H_4O_3$ ✓	1
4(b)	**Stage 1:** $ClCH_2COOH + 2NaOH \longrightarrow HOCH_2COONa + NaCl + H_2O$ scores two marks ✓✓ $ClCH_2COOH + NaOH \longrightarrow HOCH_2COONa + HCl$ scores one mark ✓ $ClCH_2COOH + NaOH \longrightarrow ClCH_2COONa + H_2O$ scores one mark ✓ $ClCH_2COOH + NaOH \longrightarrow HOCH_2COOH + NaCl$ scores one mark ✓ **Stage 2:** $HOCH_2COONa + H^+ \longrightarrow HOCH_2COOH + Na^+$ ✓ **ACCEPT ECF** from $ClCH_2COONa$ forming $ClCH_2COOH$	3
4(c)	buffer minimises **OR** resists pH changes ✓ $HOCH_2COOH \rightleftharpoons HOCH_2COO^- + H^+$ ✓ **For explanation below, accept HA and A^- OR other weak acid** added alkali reacts with H^+ / $H^+ + OH^- \rightarrow H_2O$ ✓ $\rightarrow HOCH_2COO^-$ / Equil $\rightarrow$ right (to counteract change) ✓ $HOCH_2COO^-$ reacts with added acid or H^+ ✓ $\rightarrow HOCH_2COOH$ / Equil $\rightarrow$ left (to counteract change) ✓ $[H^+] = 10^{-pH} = 10^{-4.4} = 3.98 \times 10^{-5}$ ✓ $\frac{[HOCH_2COOH]}{[HOCH_2COO^-]} = \frac{[H^+]}{K_a}$ **OR** $\frac{[HOCH_2COO^-]}{[HOCH_2COOH]} = \frac{K_a}{[H^+]}$ ✓ $\frac{[HOCH_2COOH]}{[HOCH_2COO^-]} = \frac{3.98 \times 10^{-5}}{1.48 \times 10^{-4}}$ **OR** 0.27 **OR** $\frac{[HOCH_2COO^-]}{[HOCH_2COOH]} = \frac{1.48 \times 10^{-4}}{3.98 \times 10^{-5}}$ **OR** 3.7 ✓ **QWC:** Buffer explanation includes discussion of equilibrium shift ✓	2 4 3 1

Question	Expected Answers	Marks
4(d)	moles CO_2 = $\frac{5.119}{44}$ = 0.116 ✓ moles H_2O = $\frac{1.575}{18}$ = 0.0875 **OR** moles H = 2 x 0.0875 = 0.175 ✓ moles **A** = $\frac{4.362}{150}$ = 0.0291 ✓ Molar ratio **A** : C : H = 1 : $\frac{0.116}{0.0291}$: $\frac{0.175}{0.0291}$ = 1 : 4 : 6 ✓ O = 150 – (4 x 12 + 6 x 1) = 96 moles O = $\frac{96}{16}$ = 6 molecular formula = $C_4H_6O_6$ ✓ **ACCEPT** suitable alternatives methods e.g. moles C = $\frac{5.119}{44}$ = 0.116 ✓ moles H = $2 \times \frac{1.575}{18}$ = 0.175 ✓ (mass C = 1.396 g; mass H = 0.175 g; mass O = 2.791 g) moles O = $\frac{2.791}{16}$ = 0.174 ✓ empirical formula = C : H : O = $C_2H_3O_3$ ✓ molecular formula = $C_4H_6O_6$ (related to 150) ✓	5
	Total:	**19**

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

Skill P: 16 marks (out of up to 19 available)

The "expected" solution to the problem involves the following two stage procedure.
$KMnO_4$ titration (for $H_2C_2O_4$) followed by adding Mg and gas collection, or precipitation (for both acids)

T Titration - 6 marks

T1 Equation for the redox reaction **[1]**
$2MnO_4^- + 16H^+ + 5C_2O_4^{2-} \rightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$
or $2KMnO_4 + 3H_2SO_4 + 5H_2C_2O_4 \rightarrow 2MnSO_4 + 10CO_2 + 8H_2O + K_2SO_4$

T2 Use $KMnO_4$ of concentration 0.0250 - 0.0500 mol dm^{-3} in the burette
and a verbal statement that $KMnO_4$ is an oxidising agent (*owtte*) **[1]**
If 10 cm^3 pipette is used for acid, then concentration is 0.0100 - 0.0200 mol dm^{-3}
Concentration does not need to be justified, but must give a titre 15 – 40 cm^3

T3 Pipette a known volume of acid mixture into a [conical] flask
and acidify with extra sulphuric acid (***or*** reference to sulphuric acid in the mixture)
and heat the mixture. **[1]**

T4 No indicator is required (implied)
and end colour change in titration is from colourless/decolorised to [pale] pink **[1]**
Allow pink or <u>pale</u> purple as the final colour

T5 Titrate until two consistent/concordant accurate titres are obtained **[1]**
Accept "titres within 0.1 cm^3" (unit needed).

T6 Calculate concentration of $H_2C_2O_4$ in the solution from specimen titration data. **[1]**

G Gas collection – 9 marks

G1 Pipette known volume of acid mixture ***and*** add Mg **[1]**
No mark for selection of any other metal or of a metal carbonate
Thereafter mark ecf for other metals or a metal carbonate or $NaHCO_3$

G2 **Precaution**: Use Mg in excess
and in the form of powder/turnings ***or*** sandpaper/remove oxide layer before use
Reason: to ensure that both acids in the mixture react completely
or speed reaction up ***or*** reference to MgO reacting to produce no gas **[1]**
*Two precautions **and** one reason are required*

G3 Equations for reaction of **both** acids **[1]**
$Mg + H_2SO_4 \rightarrow MgSO_4 + H_2$ ***and*** $Mg + H_2C_2O_4 \rightarrow MgC_2O_4 + H_2$
No G3 if metal carbonate produces an insoluble sulphate (eg $CaCO_3$)

G4 Calculation of suitable maximum volume of acid mixture to use **[1]**
Calculation must relate explicitly to the capacity of the syringe/collecting vessel.

G5 Calculation of suitable minimum mass of Mg (or other reagent) to use **[1]**

G6 Collect gas in a gas syringe/ inverted burette/ inverted measuring cylinder
and use of inner tube (or similar arrangement) to keep reagents apart at start **[1]**
Marks can be scored from a neat labelled diagram, if drawn
If a metal carbonate was used, collection must be in a gas syringe

G7 Record final volume of gas (when fizzing ceases/when syringe stops moving) **[1]**
Visual observation to indicate completion of reaction is required

G8 Repeat procedure ***and*** take mean of gas volumes/until volumes are consistent **[1]**

G9 Specimen calculation of the concentration of H_2SO_4 in mixture **[1]**
Calculation must use volume of gas collected and the answer from strand T

P **Precipitation (P) – 7 marks (maximum)**

P1 Add excess aqueous barium nitrate/chloride
to known volume (measured by pipette/ burette) of mixed acid. **[1]**

P2 Equation for precipitation reaction(s), with state symbols
and justification of volume (***or*** mass) of aq barium compound used **[1]**

P3 Filter using reduced pressure filtration with pre-weighed filter paper **[1]**

P4 **Two** precautions from
- Wash all solid on to the filter funnel with distilled water
- Use of fine grade (or multiple sheets of) filter paper
- Wash solid on filter paper [to remove impurities]
- Repeat whole experiment and take mean results **[1]**

P5 Dry in desiccator ***or*** in an oven until constant mass is achieved **[1]**

P6 Specimen calculation of concentration of sulphuric acid **[1]**
M_r of sulphate (for Ba =233; Ca = 136) must be shown in working

P7 A clear discussion of the solubility of barium ethanedioate
or calculation of mass of barium ethanedioate precipitated **[1]**

S **Safety, Sources and QWC - 4 marks**

S1 **Safety**:
Sulphuric acid is irritant/corrosive (*depending on context of use in Plan*):
use safety spectacles or lab coat ***or*** wash with plenty of water if spilt **[1]**

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 "Hazcards" without any qualification*

S3 **QWC**: text is legible and spelling, punctuation and grammar are accurate **[1]**
Allow no more than five different errors 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?*
- *Are scientific language used and chemical formulae quoted correctly?*
- *Are both experiments described in a logical sequence?*

Practical Test (B)

Page 3 : Part 1 **[17 marks]**

Presentation of titration data **[2]**

- Table grid drawn (at least three lines) ***and*** all burette data shown in the table, including first/trial.
- One correctly labelled table - three burette volumes clearly indicated and recorded
  "Reversed" data (eg final = 0.00 and initial = 27.30) forfeits this bullet
- Three (or more) sets of titration readings are shown
- All "accurate" burette data are quoted to **two** decimal places, ending in .00 or .05
  *The 2 d.p. rule does not apply to the trial (if labelled as trial) but it **does** apply to "0.00 cm^3"*
- No readings recorded above 50 cm^3
- All subtractions are shown and are correct

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

Self-consistency of titres **[2]**

- The two selected titres are within 0.10 cm^3 at the **first** end-point
- The two selected **total** titres are within 0.10 cm^3 at the **second** end-point
  *If 3 titres are used to calculate mean, assess on the spread of **all** three accurate titres.*
  For incorrect subtraction, award these marks using the candidate's own values.
  The candidate may choose the trial titre if its value makes it appropriate to do so
- **Units**, cm^3 or ml, must be given somewhere *(**once** in the table is sufficient).*

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

Mean titres (A, B and C) calculated **[2]**

- **A** *may be calculated using either the closest two titres **or** the two accurate titres.*
  A candidate may use three titres if all are within 0.10 cm^3.
  ***e.g.** if titres are 26.00, 26.10, 26.00 - means of 26.00, 26.03, or 26.05 are all correct*
  Give the candidate the benefit of any legitimate doubt.
- **B** *may be calculated using either the closest two titres **or** the two accurate titres.*
  *A candidate may use different experiments to calculate **A** and **B***
- *Correct subtraction to give* **C**
- *Units are shown at least once in this section*
- *The means must be quoted correctly to 1 or 2 d.p (**or** to 3 d.p. only for .025 or .075)*

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

Accuracy **[10]**

Write down the supervisor's mean titres (A and B) next to the candidate's table.
Check the candidate's mean titres (A and B).

- *Use the candidate's own means to assess accuracy, where suitable.*
- *Round the candidate's mean to the nearest 0.05 cm^3*
- *Compare the mean supervisor's titres with the candidate's titres.*
- *Use the conversion chart below to award the marks for accuracy.*

The accuracy for each mean titre is marked out of 5
(A is phenolphthalein end-point and B is methyl orange end-point)

A/B is within **0.25** cm^3 of mean supervisor's value	[5]
A/B is within **0.40** cm^3 of mean supervisor's value	[4]
A/B is within **0.60** cm^3 of mean supervisor's value	[3]
A/B is within **0.90** cm^3 of mean supervisor's value	[2]
A/B is within **1.20** cm^3 of mean supervisor's value	[1]

Spread penalty
("Spread" is defined by the titres used by the candidate to calculate the mean)
If the titres have a spread of 0.40 cm^3 or more, deduct 1 mark.
If the titres have a spread of 0.90 cm^3 or more, deduct 2 marks (max on each titration).

Safety **[1]**
Phenolphthalein contains ethanol since it has flammable hazard symbol
or phenolphthalein, since methyl orange contains water which is not flammable.

Pages 4 - 6: Part 2 **[13 marks]**

*Mark **ecf** wherever possible from one part of an answer to the next.*
*Answers should be quoted to **three** significant figures (if the answer is a marking point)*

(a) Concentration = $2.50^{\times 10}/_{250}$ = 0.100 mol dm^{-3} **[1]**

(b) Answer (a) is multiplied by $^{\text{difference between mean titres}}/_{1000}$ **[1]**
*This is a method mark but the correct mean **C** must be used*

(c) Answer quoted must be the same as that given in **(b)** **[1]**

(d) **1 mark**
Second chemical equation shows that 1 mol Na_2CO_3 gives 1 mol $NaHCO_3$ **[1]**

(e)(i) Answer is 40 times that given in **(c)** **[1]**

(e)(ii) **2 marks**
M_r of sodium carbonate = 106 **[1]**

Correct answer obtained by candidate **[1]**
***No** ecf allowed*

(f)(i) Volume correctly calculated, (A – C), to one ***or*** two d.p. **[1]**

(f)(ii) No of moles of HCl used = $^{\text{answer (i) x answer (a)}}/_{1000}$ **[1]**

(f)(iii) Concentration of NaOH = no of moles of HCl *x* 40 **[1]**

Concentration of NaOH used, correctly worked out **[1]**

(f)(iv) M_r of NaOH is 40 **[1]**

Mass of NaOH (= 40 x iii), correctly calculated **[1]**

Pages 7 + 8: Part 3 (Skill E) **[14 marks]**

(a)(i) 3 marks

Correct volumes used in both calculations – 10 cm^3 and 250 cm^3 **[1]**

% error in pipette = 0.30 % (***or*** 99.70% accuracy) **[1]**

% error in vol flask = 0.080 % (***or*** 99.92% accuracy), so flask is more accurate **[1]**

(ii) 2 marks

Burette reads to 0.05/ 0.1 cm^3 so is less accurate than pipette [reads to 0.03] **[1]**

Burette must be read twice, so error is increased/ accuracy reduced further **[1]**

(b) 2 marks

Idea that reliable end points are consistent *(or vice versa)* **[1]**
This mark not awarded if accuracy ideas are discussed (apparatus or indicator)

Candidate uses his/her own titre values appropriately to decide which end-point was more reliable ***or*** less reliable (***or*** justifies that both were equally reliable) **[1]**

(c) 5 marks (max) – but only 4 on question paper
Mark the best two strands

- Methyl orange ***or*** phenolphthalein end-point is indistinct /difficult to judge **[1]**

  Colour change at the end of each stage is gradual **[1]**
  Reference to specific end colour of chosen indicator is needed

- Double indicator titration involves more burette readings **[1]**

  There is cumulative error ***or*** increased % error in the titration **[1]**

  Sensible attempt made to calculate a combined % error in expt **[1]**

- Volume C is small/ only c13 cm^3 [compared to a normal mean titre] **[1]**

  The % error in measuring this volume is higher than in a titre of about 25 cm^3 **[1]**

- Indicators interfere with each other **[1]**

(d) 3 marks (max) *Credit any **three** points from the following*

Sodium carbonate is a base/ alkali ***or*** both chemicals contain OH^- ions **[1]**

The pH of the mixed solution is higher than that of NaOH alone **[1]**

However, the effect on pH is small since Na_2CO_3 is a weak alkali
or $CO_3^{2-} + H_2O \Leftrightarrow HCO_3^- + OH^-$ **[1]**

Correct concentration of NaOH corresponding to any stated pH value
or equation(s) linking the pH to the hydroxide ion concentration
or logarithmic scale increases % error in measurement of concentration **[1]**

Grade Thresholds

Advanced GCE Chemistry (3882/7882)
January 2009 Examination Series

Unit Threshold Marks

Unit		Maximum Mark	a	b	c	d	e	u
2811	Raw	60	51	45	40	35	30	0
	UMS	90	72	63	54	45	36	0
2812	Raw	60	49	44	39	34	29	0
	UMS	90	72	63	54	45	36	0
2813A	Raw	120	98	88	78	69	60	0
	UMS	120	96	84	72	60	48	0
2813B	Raw	120	98	88	78	69	60	0
	UMS	120	96	84	72	60	48	0
2813C	Raw	120	94	84	74	64	55	0
	UMS	120	96	84	72	60	48	0
2814	Raw	90	73	65	57	49	42	0
	UMS	90	72	63	54	45	36	0
2815A	Raw	90	74	68	62	56	50	0
	UMS	90	72	63	54	45	36	0
2815C	Raw	90	75	68	61	54	47	0
	UMS	90	72	63	54	45	36	0
2815E	Raw	90	77	70	63	56	49	0
	UMS	90	72	63	54	45	36	0
2816A	Raw	120	100	90	80	70	61	0
	UMS	120	96	84	72	60	48	0
2816B	Raw	120	100	90	80	70	61	0
	UMS	120	96	84	72	60	48	0
2816C	Raw	120	92	82	72	62	53	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	10.0	35.9	60.7	84.1	98.4	100	1206
7882	14.9	49.3	78.0	92.9	98.1	100	288

1694 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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