

Chemistry

Advanced GCE **A2 7882**

Advanced Subsidiary GCE **AS 3882**

Mark Schemes for the Units

January 2010

3882/7882/MS/R/10J

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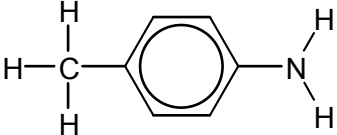
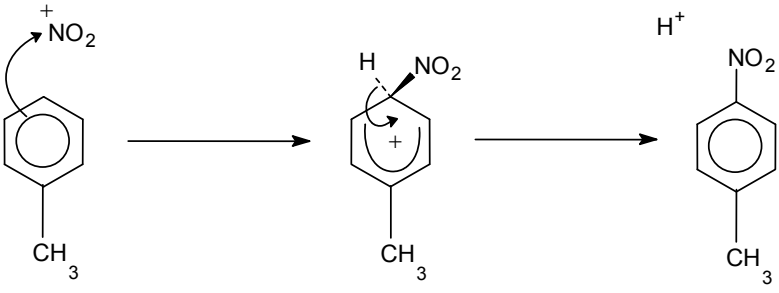
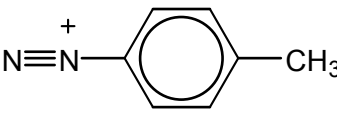
Advanced GCE Chemistry (7882)

Advanced Subsidiary GCE Chemistry (3882)

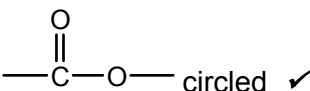
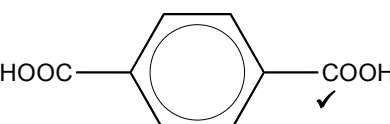
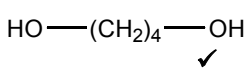
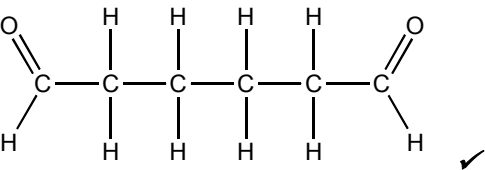
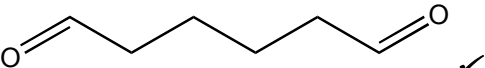
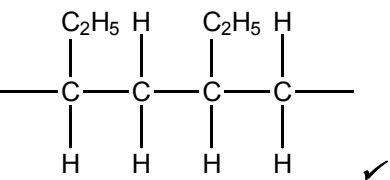
MARK SCHEME FOR THE UNITS

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2814 Chains, Rings and Spectroscopy


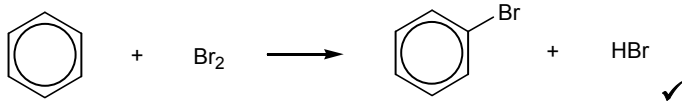
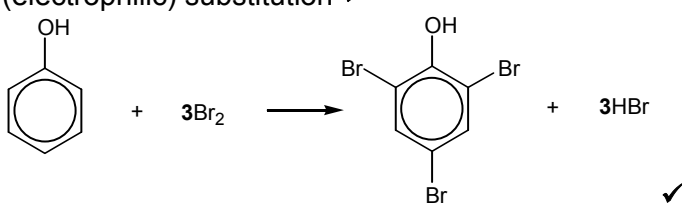
Qu.	Expected answers	Marks
1 (a)	 <p>allow -NH_2 and -CH_3 not fully displayed here</p>	1
(b)	<p>Stage 2</p> <p>reagents: conc. HNO_3 and conc H_2SO_4 ✓</p> <p>conditions: warm / reflux / stated temp (allow 30 – 60 °C) ✓</p> <p>balanced equation: $\text{HNO}_3 + \text{C}_6\text{H}_5\text{CH}_3 \longrightarrow \text{CH}_3\text{C}_6\text{H}_4\text{NO}_2 + \text{H}_2\text{O}$ ✓</p> <p>allow NO_2 to give H</p> <p>Stage 3</p> <p>reagents: Sn / Fe and conc HCl ✓</p> <p>conditions: heat/reflux ✓</p> <p>balanced equation:</p> $\text{CH}_3\text{C}_6\text{H}_4\text{NO}_2 + 6[\text{H}] \longrightarrow \text{CH}_3\text{C}_6\text{H}_4\text{NH}_2 + 2\text{H}_2\text{O} \checkmark$ <p>Mechanism for stage 2</p> <p>$\text{HNO}_3 + \text{H}_2\text{SO}_4 \longrightarrow \text{NO}_2^+ + \text{H}_2\text{O} + \text{HSO}_4^-$ ✓</p>  <p>curly arrow from π ring to NO_2^+ ✓</p> <p>correct intermediate ✓ (no methyl group loses this mark)</p> <p>curly arrow from C–H bond back to re-form π ring ✓</p> <p>correct products ✓ (allow ECF on no methyl group here)</p> <p>Quality of Written Communication</p> <p>Answer is well organised and clearly identifies: stage 1 as substitution / nitration and stage 2 as reduction / redox (allow hydrogenation) ✓</p>	11
(c) (i)	 <p>allow $^+\text{N}=\text{N}^+ \text{N}_2$ or N_2Cl but not $^+\text{N}\equiv\text{N}$</p>	1
(ii)	<p>C atoms: 17 H atoms: 14</p>	2
		16

Qu.	Expected answers	Marks
2 (a)	$\text{H}_2\text{NCH(R)COOH}$ ✓ (allow any order as long as CH not split)	1
(b)	glutamic acid has / glycine does not have ... a chiral carbon / four different groups attached to a carbon ✓ glutamic acid forms two non-superimposable (mirror images) / is asymmetric ✓ <div style="display: flex; align-items: center; justify-content: space-around;"> <div style="text-align: center;"> $\begin{array}{c} \text{COOH} \\ \\ \text{HOOC(CH}_2)_2\text{---C---} \\ \quad \quad \quad \diagup \quad \diagdown \\ \quad \quad \quad \text{H} \quad \text{NH}_2 \end{array}$ </div> <div style="text-align: center;"> $\begin{array}{c} \text{COOH} \\ \\ \text{H}_2\text{N---C---(CH}_2)_2\text{COOH} \\ \quad \quad \quad \diagdown \quad \diagup \\ \quad \quad \quad \text{H} \quad \text{H} \end{array}$ </div> </div> <p>correct 3-D diagram of one isomer of glutamic acid ✓ attempt at a 3-D diagram to show the other isomer ✓</p> <p style="text-align: right;">allow ECF on side group errors allow poor connectivity here</p>	4
(c) (i)	$\begin{array}{c} \text{H} \\ \\ \text{H}_3\text{N}^+\text{---C---COOH} \\ \\ \text{H} \end{array}$ ✓	1
(ii)	$\begin{array}{c} \text{H} \\ \\ \text{H}_2\text{N---C---COO}^- \\ \\ (\text{CH}_2)_2 \\ \\ \text{COO}^- \end{array}$ <p style="text-align: center;">one COO^- ✓ rest of the molecule ✓</p>	2
(d)	<p>at least one peptide linkage ✓</p> <div style="display: flex; align-items: center; justify-content: space-around;"> <div style="text-align: center;"> $\begin{array}{c} \text{H} \quad \quad \text{O} \\ \quad \quad \\ \text{H}_2\text{N---C---C---N---CH}_2\text{---COOH} \\ \quad \quad \\ (\text{CH}_2)_2 \quad \text{H} \\ \\ \text{COOH} \end{array}$ ✓ </div> <div style="text-align: center;"> $\begin{array}{c} \text{O} \quad \quad \text{H} \\ \quad \quad \\ \text{H}_2\text{N---CH}_2\text{---C---N---C---COOH} \\ \quad \quad \quad \\ \quad \quad \text{H} \quad (\text{CH}_2)_2 \\ \quad \quad \quad \\ \quad \quad \quad \text{COOH} \end{array}$ ✓ </div> </div> <p style="text-align: right;">allow CONH or the dipeptide formed using the glutamic acid side chain</p>	3
(e) (i)	(conc) H_2SO_4 ✓ allow HCl or H^+ but not anything with H_2O present	1
(ii)	$\begin{array}{c} \text{H} \\ \\ \text{H}_2\text{N---C---COOC}_2\text{H}_5 \\ \\ (\text{CH}_2)_2 \\ \\ \text{COOC}_2\text{H}_5 \end{array}$ <p style="text-align: center;">one ester group ✓ rest of the structure ✓</p>	2
		14

Qu.	Expected answers	Marks
3 (a)	 <p>allow the right hand carbon included</p>	1
(b) (i)	hexan(e)dioic acid	1
(ii)	  <p>do not allow C₆H₄ here do not allow OH here</p>	2
(c) (i)	  <p>must be fully displayed here allow one mark for two correct structures of hexanal</p>	2
(ii)	$\text{C}_6\text{H}_{10}\text{O}_2 + 2[\text{O}] \rightarrow \text{C}_6\text{H}_{10}\text{O}_4$ <p>allow correct structural / displayed / skeletal formula</p>	1
(iii)	(O-H) absorption appears at 2500–3300 (cm ⁻¹)	1
(d)		1
(e)	ecoflex® = condensation and poly(but-1-ene) = addition	1
(f)	<p>atactic has side chains on <u>random</u> sides ✓</p> <p>isotactic has side chains on the same side AW ✓</p> <p>do not allow just 'regular' / 'irregular', nor just 'groups'</p> <p>allow one mark for a correct (2D or 3D) diagram of isotactic with at least 6C if not scored in words</p>	2
		12

Qu.	Expected answers	Marks
5 (a)	alkene / C=C double bond ✓ aldehyde / carbonyl ✓ do not allow just C=C / CHO	2
(b) (i)	same structural/displayed formula but different 3D/spatial arrangement ✓ allow same order of bonds if same atoms specified	1
(ii)	circles alkene at position 2 ✓ (double bond has) restricted rotation ✓ (allow 'does not rotate') both C in the double bond must be bonded to 2 different atoms / groups / this molecule has four distinguishable groups AW ✓	3
(c)	$C_{10}H_{16}O + 13\frac{1}{2}O_2 \longrightarrow 10CO_2 + 8H_2O$	1
(d) (i)	NaBH ₄ / LiAlH ₄ (in ether)	1
(ii)	$C_{10}H_{16}O + 2[H] \longrightarrow C_{10}H_{18}O$	1
(e) (i)	CN ⁻ ✓ curly arrow from lone pair of :CN ⁻ to C of carbonyl ✓ dipoles on carbonyl and curly arrow to show breaking of the π-bond ✓ intermediate ✓ curly arrow from O ⁻ to H in HCN/ H ⁺ / H ₂ O ✓ allow use of R or a bond to represent the side chain	5
(ii)	type of reaction: hydrolysis ✓ reagent: suitable named acid – e.g. H ₂ SO ₄ / HCl ✓ contidtions: evidence of water – e.g. (aq)/dil and heat/reflux ✓	3
		17

Qu.	Expected answers	Marks
6	<p>$M_r = 72$ ✓ correct peak shown on diagram or described ✓</p> <p>Compound A</p> <p>is a ketone (because positive test with 2,4-DNPH and negative result with Tollens') ✓</p> <p>A must be $\text{CH}_3\text{CH}_2\text{COCH}_3$ / butanone ✓</p> <p>Compound B</p> <p>n.m.r has all Hs in the same environment/equivalent/one type AW ✓</p> <p>molecular formula is C_5H_{12} / any valid structure ✓</p> <p>B must be $\text{C}(\text{CH}_3)_4$ / 2,2-dimethylpropane ✓ (subsumes previous mark)</p> <p>Compound C</p> <p>is a carboxylic acid / contains COOH AW (because i.r. shows O-H / COOH at $2500\text{--}3300\text{ cm}^{-1}$ and C=O at $1680\text{--}1750\text{ cm}^{-1}$) ✓</p> <p>structure of any carboxylic acid shown ✓</p> <p>C is $\text{CH}_2=\text{CHCOOH}$ ✓ (subsumes previous mark)</p>	<p>allow minor errors in naming(e.g. missing 'di' '2,2' if the structure is correct)</p> <p>allow ECF from the wrong M_r only where it still makes chemical sense</p> <p>10</p>
		10

Qu.	Expected answers	Marks
7	<p>reaction with cyclohexene</p> <p>(electrophilic) addition ✓</p>  <p>(π-)electrons are localised / not delocalised ✓</p> <p>reaction with benzene</p> <p>(electrophilic) substitution ✓</p>  <p>(π-)electrons are delocalised ✓</p> <p>reaction with phenol</p> <p>(electrophilic) substitution ✓</p>  <p>lone pair of electrons from O are delocalised around the ring ✓</p> <p>explaining reactivity in the context of any compound</p> <p>valid discussion of relative electron density (around the ring) ✓</p> <p>valid discussion of relative polarisation of the bromine or the (electrostatic) attraction of electrophiles to the ring ✓</p> <p style="text-align: right;">any 10 out of 11 marks</p>	<p>allow 'added', 'adds' etc</p> <p>allow molecular formulae in the equations</p> <p>allow Br^+ to give H^+ in the equation</p> <p style="text-align: right;">10</p>
QWC	<p>Mark for at least two sentences or bullet points in context with correct spelling, punctuation and grammar ✓</p>	1
		11

2815/01 Trends and Patterns

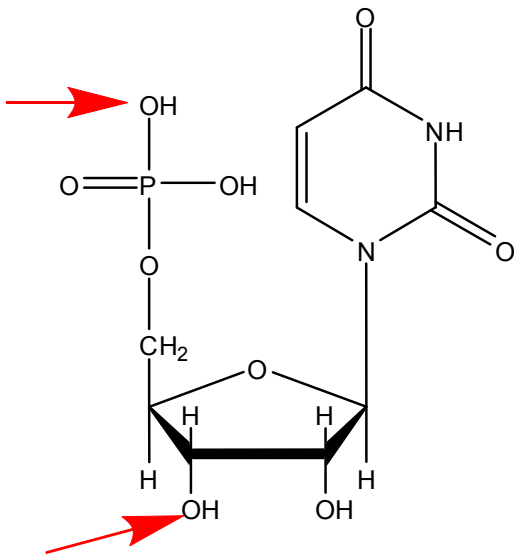
Qu.	Expected answers	Marks	Additional guidance
1 (a)	<p>6 correct labels: 3 marks 4 correct labels: 2 marks 3 correct labels: 1 mark</p>	3	Allow values (except A)
(b)	$= -443 = +76 + 376 + 122 + -349 + \text{Lattice enthalpy} \checkmark$ $\text{Lattice enthalpy} = -668 \text{ (kJ mol}^{-1}\text{)} \checkmark$	2	Allow ECF from (a) 668 = 1 mark
(c)	<p>Lattice enthalpy of NaCl would be more exothermic than that of CsCl / lattice enthalpy is greater in magnitude / ORA \checkmark</p> <p>Na^+ is smaller than Cs^+ / Na^+ has a larger charge density than Cs^+ / ORA \checkmark</p> <p>NaCl has stronger ionic bonding / stronger attraction between the positive and negative ion \checkmark</p>	3	<p>Not bigger or smaller lattice enthalpy</p> <p>NOT larger charge</p> <p>Correct particles must be used e.g. not Na has a smaller radius</p> <p>All comparative</p>
		8	

Qu.	Expected answers	Marks	Additional guidance
2 (a)	Number of outer shell electrons increases (by one) / uses (one) more outer electron in bonding / (maximum) oxidation number increases (by one) ✓	1	
(b)	Bonding NaCl and MgCl ₂ – ionic AND Structure NaCl and MgCl ₂ – giant ✓ Bonding AlCl ₃ and SiCl ₄ – covalent AND Structure AlCl ₃ and SiCl ₄ – simple ✓	2	
(c)	NaCl has a higher melting point than SiCl ₄ ✓ ORA SiCl ₄ has intermolecular forces / van der Waals forces of attraction / instantaneous dipole–induced dipole attractions ✓ NaCl has attraction between positive ion and negative ion / NaCl has electrostatic attraction between ions ✓ Forces that are broken are stronger in NaCl than in SiCl ₄ ✓	4	ONLY on correct forces
(d)	NaCl gives a colourless solution AND with a pH of 7 ✓ NaCl(s) → Na ⁺ (aq) + Cl ⁻ (aq) / NaCl(aq) ✓ NaCl dissolves or dissociates in water ✓ SiCl ₄ white precipitate formed / steamy fumes AND with a pH of 0–6 ✓, SiCl ₄ + 2H ₂ O → SiO ₂ + 4HCl / SiCl ₄ + 4H ₂ O → Si(OH) ₄ + 4HCl ✓ SiCl ₄ is hydrolysed ✓	6	Allow neutral NOT react Allow value between 0 and 6 Allow variants on hydrated SiO ₂
		13	

Qu.	Expected answers	Marks	Additional guidance
3 (a)	Oxidation: oxidation number of O changes from -1 to 0 ✓ Reduction: oxidation number of O changes from -1 to -2 ✓	2	Allow 1 mark for either 2 correct ON changes (1 ox 1 red) OR correct ref to ox and red from their ON changes
(b) (i)	$2\text{MnO}_4^- + 6\text{H}^+ + 5\text{H}_2\text{O}_2 \longrightarrow 2\text{Mn}^{2+} + 8\text{H}_2\text{O} + 5\text{O}_2$ Correct reactants and products and balanced (but can include e^- on both sides and H^+ on both sides. ✓ Correct balanced equation with no electrons shown and H^+ only on left hand side ✓	2	Allow correct multiples of equation Ignore state symbols
(ii)	Moles of $\text{MnO}_4^- = \frac{23.35 \times 0.0150}{1000} / 3.5025 \times 10^{-4} / 3.50 \times 10^{-4} / 3.5 \times 10^{-4}$ ✓ Moles of $\text{H}_2\text{O}_2 = 2.5 \times \text{moles of } \text{MnO}_4^- / 8.75 \times 10^{-4} / 8.76 \times 10^{-4}$ ✓ Concentration of $\text{H}_2\text{O}_2 = \frac{8.75 \times 10^{-4} \times 1000}{25.0} = 0.035(0)$ (mol dm^{-3}) ✓ correct answer = 3 marks	3	Allow ECF within the question
(c)	sodium hydroxide / potassium hydroxide / hydroxide ions / potassium thiocyanate / ammonium thiocyanate / thiocyanate ions ✓ observation: orange-red / brown / brown-red / foxy-red ppt with NaOH(aq) or (blood) red with $\text{KSCN} / \text{NH}_4\text{SCN} / \text{SCN}^-$ ✓	2	Allow formulae Colour AND ppt needed (not red or orange) Not ppt
		9	

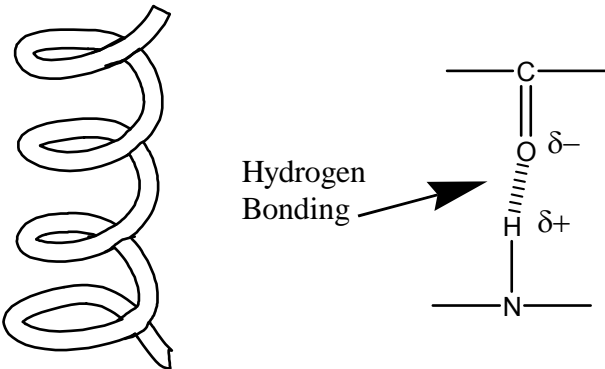
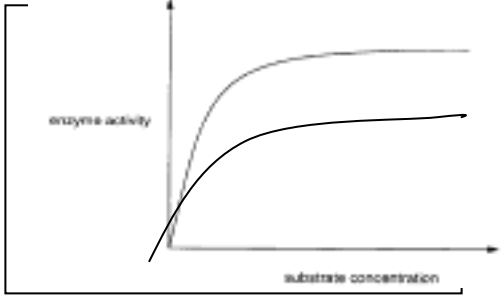
2815/02 Biochemistry

Qu.	Expected answers	Marks
1(a)(i)	Empirical formula = CH_2O ✓ accept COH_2	1
1(a)(ii)	<p>α-mannose has the OH on carbon 1 below the plane of the ring whereas β-mannose has the OH on carbon 1 above the plane of the ring structure. ✓</p> <p>or alternative diagram</p>	1
1(a)(iii)	<p>Correct orientation of OH groups is not required.</p>	1
1(a)(iv)	<p>Carbonyl (or aldehyde) ✓ ECF from (iii) for ketone but not carboxylic acid</p> <p>Hydroxyl (or alcohol) ✓</p>	2
(b)	<p>Mannose has many exposed –OH groups which can hydrogen bond with water ✓</p> <p>Hydrogen bond shown on diagram/ many hydrogen bonds possible ✓</p>	2
(c)(i)	<p>Correct atoms and bonds for two glycosidic links ✓</p> <p>Correct orientation for both β-glycosidic bond ✓</p> <p>Independent marks. Allow omission of ring C–Hs</p>	2
(c)(ii)	Cellulose fibres are the major structural component/support ✓ of plant stems	1
		10

Qu.	Expected answers	Marks
2(a)(i)	<p>positions 3 and 5 One mark for each correct position ✓✓</p> 	2
2(a)(ii)	<p>The monomer would be found in RNA (NO MARK) The base is uracil ✓ and the sugar is D-Ribose ✓</p>	2
2(a)(iii)	<p>Hydrogen bonding ✓ between complementary base pairs or (A/T and C/G) ✓ allows the two DNA strands to form a double helix ✓. The bases are held inside ✓ the helix and hence protected. (ANY THREE POINTS FROM THE FOUR POSSIBLE)</p>	3

2(b)	<p>mRNA synthesised from DNA in the nucleus leaves the nucleus via a nuclear pore.</p> <p>The mRNA carries the codes for individual amino acids in triplets of bases ① (Mark – The role of mRNA)</p> <p>Protein synthesis takes place at a ribosome in the cytoplasm ② (Mark – The site of protein synthesis)</p> <p>The ribosome binds to the mRNA at a start codon / the codon AUG initiates the chain/ the chain is terminated when the ribosome reaches a stop codon ③ (Mark – Chain initiation or start codon / Chain termination or stop codon)</p> <p>t-RNA binds an amino acid at one end of its structure and has a <u>triplet of bases</u> at the other.</p> <p>④ (Mark – structure of tRNA)</p> <p>At the ribosome t-RNA molecules provide the amino acids for each mRNA triplet code <u>in turn</u>/there are six exposed bases at any one time/two tRNA molecules at a time attached in the ribosome so two amino acids can be joined together.) This mark can be earned from a clear diagram.</p> <p>⑤ (Mark - role of tRNA)</p> <p>The t-RNA molecules bind to the mRNA strand by complementary base pairing involving hydrogen bonds Or The amino acids are joined together by the formation of peptide linkages ⑥ (Mark – bonding between complementary bases or amino acids)</p> <p>Quality and organization of scientific terms</p> <p>Use of 4 suitable scientific terms such as codon / triplet / amino acids / ribosomes / cytoplasm / bases / hydrogen bonds</p>	<p>6</p> <p>1</p> <p>14</p>
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Qu.	Expected answers	Marks
3(a)	<p>Ester bond drawn out correctly in at least one case ✓ Rest of the structure correct ✓</p> $ \begin{array}{c} \text{H} \\ \\ \text{H}-\text{C}-\text{O}-\text{C}(=\text{O})-(\text{CH}_2)_{14}\text{CH}_3 \\ \\ \text{H}-\text{C}-\text{O}-\text{C}(=\text{O})-(\text{CH}_2)_{14}\text{CH}_3 \\ \\ \text{H}-\text{C}-\text{O}-\text{C}(=\text{O})-(\text{CH}_2)_{14}\text{CH}_3 \\ \\ \text{H} \end{array} $	2
3(b)	<p>There are van der Waals' (or induced dipole – induced dipole) forces ✓ between triglycerides.</p> <p>Van der Waals' forces can form between the long triglyceride chains ✓ and non polar solvents like hexane – making them soluble.</p> <p>Triglycerides are non polar ✓ and so cannot form hydrogen bonds ✓ with water making them insoluble in polar solvents.</p> <p>Any three of the four marking points.</p>	3
3(c)	<p>in animalsprotection round organs / insulation / energy storage / hormone function ✓</p> <p>in plants.....food storage in seeds / waxy cuticles on leaves / cell membranes ✓</p>	2
		7

Qu.	Expected answers	Marks
4(a)	Four ✓	1
4(b)(i)	Protease enzyme ✓	1
4(b)(ii)	aqueous hydrochloric acid and heat ✓	1
4(b)(iii)	$ \begin{array}{c} \text{O} \\ \parallel \\ +\text{H}_3\text{N}-\text{CH}-\text{C}-\text{OH} \\ \\ \text{CH}_2 \\ \\ \text{CH}_2 \\ \\ \text{CH}_2 \\ \\ \text{CH}_2 \\ \\ \text{NH}_3^+ \end{array} $ ✓	1
4(c)	 <p>The α-helix ✓ is stabilised by hydrogen bonds ✓ between C=O on one part of chain and N-H lower down structure.</p> <p>Or suitable labelled diagram(s)</p>	2
4d(i)	X = Hydrogen bonding ✓ Y = Disulphide bridge ✓ Z = van der Waals' ✓	3
4d(ii)	van der Waals' ✓ or Z	1
4e(i)	Active sites are saturated with substrate ✓	1
4e(ii)	Curve less steep and flattens at lower activity ✓ 	1
4e(iii)	It binds to the enzyme outside of the active site ✓ It deforms the active site and prevents the substrate from binding ✓	2
		14

2815/04 Methods of Analysis and Detection

Qu.	Expected answers		Marks
1(a) (i)	molecular ion - caused by unfragmented molecular ion/ unfragmented molecule/ highest m/e value ✓ base peak – most abundant ion/ greatest intensity ✓ – not tallest/biggest		2
(ii)	unstable/completely fragmented/easily broken down ✓		1
(iii)	CH_2OH^+ / CH_3O^+ ✓		1
(b)	mass spec both will have a peak at m/e 31 (for CH_2OH^+) or M^+ at 76✓ different fragment ions/pattern/ identifies specific ion in one and not the other for e.g. Present in A but not propan-1,2-diol possible peaks at m/e OR Present in propan-1,2-diol but not A m/e 15 for CH_3^+ / 59 for $\text{CH}_3\text{CHOHCH}_2^+$ infra-red both have O–H peak between 3230–3550 OR both have C–O peak at 1000–1300 ✓ compound A has C=O peak at 1680–1750 or peak for OH in COOH at 2500–3300 ✓ n.m.r. both have OH in region 3.5–5.5 (ppm) ✓ propan-1,2-diol has 3 other peaks, compound A only two/ identifies a specific chemical shift found in one and not the other for example 11.7 for A for C=O – OH not in propan-1,2-diol /explains the difference in splitting patterns✓		2 2 2
			10

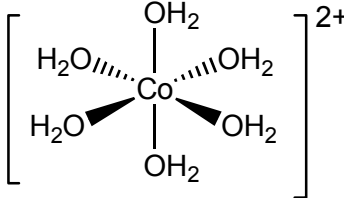
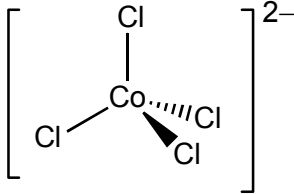
Qu.	Expected answers		Marks
2(a)	peak in UV/VIS region /~150–700 (nm) which tails off after visible region/low at ~800 (nm) ✓		1
(b) (i)	(groups of atoms/structural feature that) absorbs UV &/or visible radiation/light/energy ✓		1
(ii)	OH/ arene/NH/C=O or COOH/five-membered ring containing N/ double bonds - any 4 for 2 marks, any 2 for 1 mark ✓✓ Each Circle must not cover more than one group		2
(c) (i)	aqueous acid ✓ NOT conc H ₂ SO ₄ or conc HNO ₃ heat/reflux for ≥ 6 hours ✓		2
(ii)	chromatography/electrophoresis ✓		1
(iii)	use a known sample of tryptophan ✓ & compare <i>R_f</i> values✓/ use UV light✓ and it should absorb UV and appear as a dark spot/ ninhydrin/I ₂ i.e. locating agent✓	3	Max 2
			9

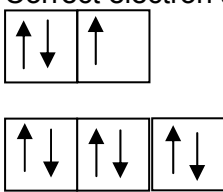
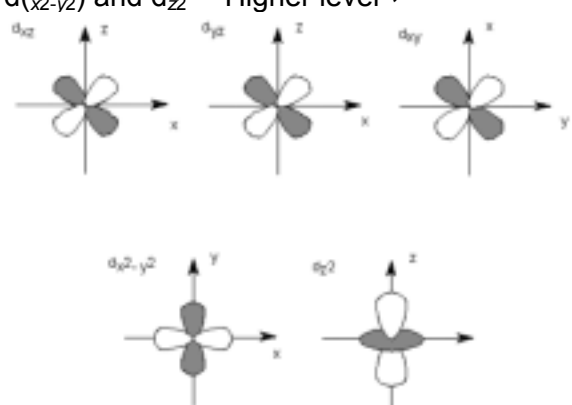
Qu.	Expected answers		Marks
3(a) (i)	Uses correct axes scales (using at least half of the available grid) and labels including units (axes can be either way around) ✓ all points correctly plotted within half a square with correct (straight) line ✓		2
(ii)	[K ⁺] in diluted sample = 4.5×10^{-3} (mol dm ⁻³) range of 4.3–4.6 ✓ ECF from graph [K ⁺] in patient's blood = $10 \times 4.5 \times 10^{-3} = 4.5 \times 10^{-2}$ (mol dm ⁻³) ✓ ECF from reading		2
(b)	$f = 7.43 \times 10^{14}$ ✓ i.e. use of c/λ $E = 4.92 \times 10^{-19}$ (J)/ 4.92×10^{-22} (kJ) ✓ ($E = hcL/\lambda$) answer = 296.38 (kJ mol ⁻¹) ✓ = 296 (kJ mol ⁻¹) ✓ Correct answer = 4 marks		4
			8

Qu.	Expected answers		Marks
4(a)	<p>partition solute moves/is distributed between mobile & stationary phases/solvents / the solute has different solubilities in the mobile phase and stationary phase ✓</p> <p>adsorption solute /sticks to stationary phase/ different components have different affinities towards the stationary phase ✓</p>		2
(b)	<ol style="list-style-type: none"> 1. DNA is broken into fragments by restriction enzymes✓ 2. fragments move through gel/porous material ✓ 3. fragments move to positive electrode (as all fragments are negative) ✓ 4. separation depends on mass of fragment ✓ 5. controlled by pH/buffer ✓ 6. bands transferred/blotted to (nylon) membrane ✓ 7. heat treated to give single strand ✓ 8. ³²P probes/isotopes added ✓ 9. sample exposed to X-rays (to make bands visible) <p style="text-align: right;">any 6 from 9</p>		6 max
QWC	At least two sentences, correctly used where the meaning is clear.		1
			9

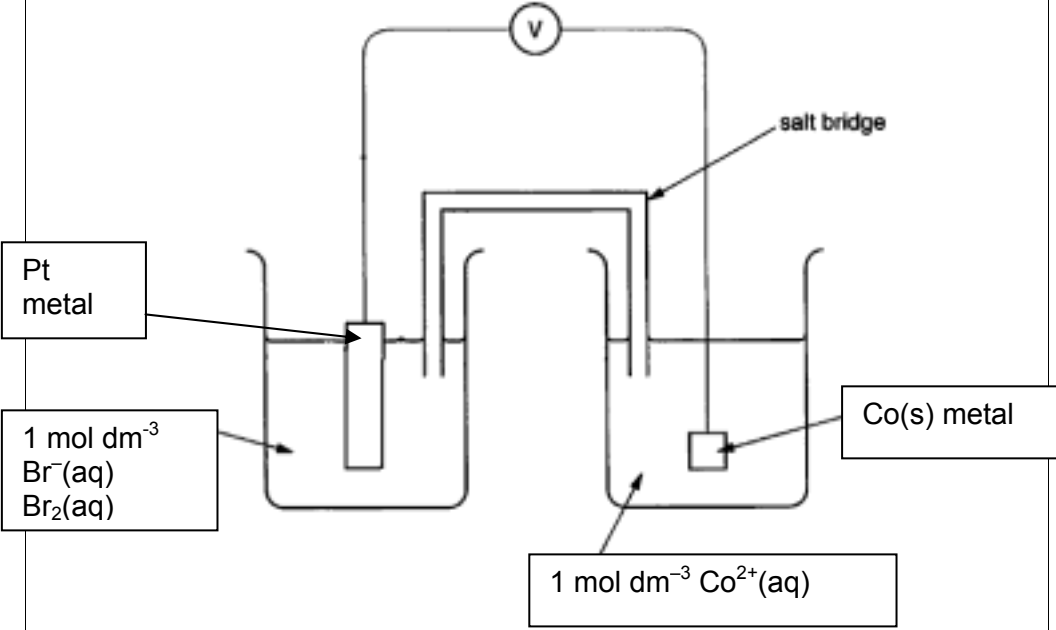
Qu.	Expected answers		Marks
5(a)	C_5H_{12} has mass = 72.0936 ✓ C_4H_8O has mass = 72.0573 ✓		2
(b)	i.r. shows strong C=O peak at 1720 cm^{-1} / between 1680 and 1750 ✓ n.m.r. show 3 proton environments ✓ Total number of protons = 8 ✓ Singlet at $\delta = 2.1$ ppm shows 3H / RCH_3CO (with no adjacent Hs) ✓ Triplet at $\delta = 1.0$ ppm shows 3H / RCH_3 (with no 2 adjacent Hs) ✓ Quartet at $\delta = 2.5$ ppm shows 2H / RCH_2CO (with 3 adjacent Hs) ✓ Any 1 correct splitting pattern explanation ✓ Compound T is $CH_3CH_2COCH_3$ ✓		7 max
			9

2815/06 Transition Elements

Qu.	Expected answers	Marks															
1(a)	A reaction in which one electron pair donor / ligand ✓ is replaced / displaced/swapped/exchanged ✓ by another (not substituted)	2															
1(b)	<div><div></div><div></div></div> <p>Charge not required Allow other 3-D representations.</p>	2															
1(c)(i)	$[\text{Co}(\text{NH}_3)_6]^{2+}$ ✓ E for forward reaction is less positive / more negative ✓ (not lower) Reverse reaction / oxidation is more likely to occur ✓	3															
1(c)(ii)	Ammonia is a <u>stronger ligand</u> than water / ammonia forms <u>stronger bonds</u> / ammonia is a <u>stronger base</u> / ammonia can donate its lone pair more easily ✓	1															
1(d)	<table><tr><td></td><td>$\text{VO}_2^+(\text{aq})$</td><td>$\text{VO}^{2+}(\text{aq})$</td><td>$\text{V}^{3+}(\text{aq})$</td><td>$\text{V}^{2+}(\text{aq})$</td></tr><tr><td>oxidation state of vanadium</td><td>+5 ✓</td><td>+4 ✓</td><td>+3</td><td>+2</td></tr><tr><td>colour</td><td>yellow</td><td>blue ✓</td><td>green</td><td>lilac/purple/ violet/mauve/ lavender ✓</td></tr></table>		$\text{VO}_2^+(\text{aq})$	$\text{VO}^{2+}(\text{aq})$	$\text{V}^{3+}(\text{aq})$	$\text{V}^{2+}(\text{aq})$	oxidation state of vanadium	+5 ✓	+4 ✓	+3	+2	colour	yellow	blue ✓	green	lilac/purple/ violet/mauve/ lavender ✓	4
	$\text{VO}_2^+(\text{aq})$	$\text{VO}^{2+}(\text{aq})$	$\text{V}^{3+}(\text{aq})$	$\text{V}^{2+}(\text{aq})$													
oxidation state of vanadium	+5 ✓	+4 ✓	+3	+2													
colour	yellow	blue ✓	green	lilac/purple/ violet/mauve/ lavender ✓													
					12												

Qu.	Expected answers	Marks
2(a)(i)	+2 / 2 ⁺ / 2 ✓	1
2(a)(ii)	Amount in moles = $cv/1000$ Amount of $S_2O_3^{2-}$ in moles = $\frac{0.500 \times 23.50}{1000} = 0.01175 / 0.0118 \text{ mol} \checkmark$ Lose mark if give answer as 0.012 but allow 5 ECF marks in (iii)	1
2(a)(iii)	Ratio is 2:1 Amount of I_2 in moles = $0.01175/2 = 0.0058765 \text{ mol} \checkmark$ Ratio is 2:1 Amount of Cu^{2+} in moles = $0.0058765 \times 2 = 0.01175 \text{ mol} \checkmark$ (Both steps not required can be combined into one step) Mass of copper in $25 \text{ cm}^3 = 0.01175 \times 63.5 / 0.746 \text{ g} \checkmark$ Mass of copper in $250 \text{ cm}^3 = 10 \times 0.746 \text{ g} = 7.46 \text{ g}$ % Copper = $\frac{7.46}{8.95} \times 100 = 83.36\% \checkmark$ Answer to 3 sig figs = 83.4% ✓ Answer is 83.7% if 0.0118 is used. Allow ECF from (ii) (Not all steps required final answer would score 5 marks, whereas 83.36% would score 4 marks)	5
2(b)(i)	Two boxes at higher energy ✓ Correct electron arrangement ✓ 	2
2(b)(ii)	d_{xy} , d_{yz} , d_{xz} – Lower level ✓ $d_{x^2-y^2}$ and d_{z^2} – Higher level ✓  NB d_{z^2} orbital must be shown on z axis	2

2(c)	Brass used for musical instruments / plumbing and electrical applications, rifle and pistol ammunition / coins / ornaments / door furniture OR Bronze used to make coins / statues / door furniture / medals OR Cupronickel used to make coins ✓ (Accept any reasonable use)	1
		12

Qu.	Expected answers	Marks
3(a)(i)	 <p>Co(s) and Co²⁺(aq) ✓ Br₂(aq) and Br⁻(aq) ✓ State symbols not needed but do not accept Br₂(g) Pt metal ✓ Salt bridge + voltmeter + complete circuit ✓ All solutions at 1 mol dm⁻³ ✓</p>	5
3(a)(ii)	1.37 V ✓ (Ignore sign)	1
3(a)(iii)	Co(s) + Br ₂ (aq) → Co ²⁺ (aq) + 2Br ⁻ (aq) ✓ (State symbols not needed)	1
3(a)(iv)	Reduction occurs at the Br ₂ / Br ⁻ electrode ✓ Bromine changes oxidation state from 0 to -1 ✓ or Bromine accepts / gains electrons so is being reduced ✓ or E is more positive so reaction more likely to occur from left to right / forwards	2
3(b)	MnO ₄ ⁻ only ✓ / acidified MnO ₄ ⁻ / H ⁺ and MnO ₄ ⁻ The standard cell potential has to be positive and with MnO ₄ ⁻ cell potential is +0.16 V whereas with Cr ₂ O ₇ ²⁻ cell potential is -0.03 V ✓ Allow idea that MnO ₄ ⁻ is a better oxidizing agent than Cl ₂ but Cr ₂ O ₇ ²⁻ is not	1 1
		11

Qu.	Expected answers	Marks																		
4	<table border="1"> <tr> <td></td><td>CrCl_3</td><td>H_2O</td></tr> <tr> <td>mass</td><td>2.380</td><td>1.62</td></tr> <tr> <td>Relative formula mass</td><td>158.5</td><td>18</td></tr> <tr> <td>Moles</td><td>0.015</td><td>0.09 ✓</td></tr> <tr> <td>Mole Ratio</td><td>= 0.015 / 0.015</td><td>= 0.09 / 0.015</td></tr> <tr> <td></td><td>1</td><td>6</td></tr> </table> <p>The value of x in the formula is 6 ✓</p>		CrCl_3	H_2O	mass	2.380	1.62	Relative formula mass	158.5	18	Moles	0.015	0.09 ✓	Mole Ratio	= 0.015 / 0.015	= 0.09 / 0.015		1	6	2
	CrCl_3	H_2O																		
mass	2.380	1.62																		
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Moles	0.015	0.09 ✓																		
Mole Ratio	= 0.015 / 0.015	= 0.09 / 0.015																		
	1	6																		
	<p>stereoisomers are molecules of the same structural formula but with a different spatial arrangement of their atoms ✓</p> <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;"> <p>cis-isomer ✓</p> </div> <div style="text-align: center;"> <p>trans-isomer ✓</p> </div> </div> <p>Isomers must be correctly labelled. ✓ Bond angles not required. Charges must be correct but if no charge or wrong charge allow ECF on second diagram. Ignore any reference to optical isomerism</p>	4																		
	<p>When a solution of chromate(VI) is reacted with acid ✓ the dichromate(VI) ion is formed.</p> $ \begin{array}{lcl} 2\text{CrO}_4^{2-}(\text{aq}) + 2\text{H}^+(\text{aq}) & \rightleftharpoons & \text{Cr}_2\text{O}_7^{2-}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \quad \checkmark \\ \text{or } 2\text{CrO}_4^{2-}(\text{aq}) + \text{H}^+(\text{aq}) & \rightleftharpoons & \text{Cr}_2\text{O}_7^{2-}(\text{aq}) + \text{OH}^-(\text{aq}) \\ \text{or } 2\text{CrO}_4^{2-}(\text{aq}) + \text{H}_2\text{O}(\text{l}) & \rightleftharpoons & \text{Cr}_2\text{O}_7^{2-}(\text{aq}) + 2\text{OH}^-(\text{aq}) \end{array} $ <p>State symbols not needed. Allow correct equations in either direction A colour change will occur in this reaction as the solution changes from yellow to orange. ✓ If colours are with equation, it must be clear that candidates know which is chromate(VI) and which is dichromate(VI)</p>	3																		
	Two complete sentences using correct spelling, punctuation and grammar, discussing the chemistry of chromium where the meaning is clear. ✓	1																		
		10																		

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

Qu.	Expected answers	Marks
1(a)(i)	$K_p = \frac{(p\text{SO}_3)^2}{(p\text{SO}_2)^2 \times (p\text{O}_2)} \checkmark$	1
(ii)	equilibrium is (well) to right \checkmark a lot more products than reactants \checkmark	2
1(b)(i)	effect on equilibrium position moves to left because forward reaction is exothermic / reverse reaction is endothermic / K_p decreases \checkmark effect on partial pressure of $\text{SO}_3(\text{g})$ decreases because equilibrium has moved to left OR reverse / K_p decreases \checkmark	2
(ii)	effect on equilibrium position moves to right because fewer gas moles on right \checkmark effect on partial pressure of $\text{SO}_3(\text{g})$ increases because equilibrium has moved to right / more products OR SO_3 \checkmark	2
1(c)	$3.0 \times 10^2 = \frac{p(\text{SO}_3)^2}{25^2 \times 125}$ OR $p(\text{SO}_3) = \sqrt{(3.0 \times 10^2 \times 25^2 \times 125)} \checkmark$ = 4841 kPa \checkmark (4841.1229183) Accept rounding back to 4800 kPa $\%(\text{SO}_3) = 100 \times 4841 / (4841 + 25 + 125) = 97\% \checkmark$	3
1(d)(i)	$2\text{ZnS} + 3\text{O}_2 \longrightarrow 2\text{ZnO} + 2\text{SO}_2 \checkmark\checkmark$ ZnS, O_2 as reactants and SO_2 as a product: 1st mark. ZnO and balance: 2nd mark	2
(ii)	ZnS is more available than S. \checkmark	1
		13

Qu.	Expected answers	Marks
2(a)	$\text{H}_2\text{O}_2 + 2\text{I}^- + 2\text{H}^+ \longrightarrow \text{I}_2 + 2\text{H}_2\text{O}$ equation includes H_2O_2 , I^- , H^+ as reactants and I_2 as product ✓ equation balanced ✓	2
2(b)(i)	order = 1 with respect to I^- ✓ When $[\text{I}^-]$ doubles, rate doubles ✓ order = 0 with respect to H^+ ✓ When $[\text{I}^-]$ doubles, rate doubles OR when $[\text{I}^-]$ quadruples, rate quadruples ✓	4
2(b)(ii)	rate = $k[\text{H}_2\text{O}_2][\text{I}^-]$ ✓ <i>[ECF from (i)]</i>	1
2(b)(iii)	From one of experiments, e.g. Experiment 1: $k = \frac{5.75 \times 10^{-6}}{0.05 \times 0.01}$ ✓ $= 1.15 \times 10^{-2}$ ✓ $\text{dm}^3 \text{mol}^{-1} \text{s}^{-1}$ ✓ <i>[ECF from (ii)]. Accept 1.2×10^{-2}</i>	3
2(c)(i)	$2\text{H}_2\text{O}_2 \longrightarrow 2\text{H}_2\text{O} + \text{O}_2$ ✓	1
2(c)(ii)	$1 \text{ dm}^3 \text{H}_2\text{O}_2 \longrightarrow 40 \text{ dm}^3 \text{O}_2$ ✓ amount of $\text{O}_2 = \frac{40}{24}$ OR 1.67 mol ✓ concentration of $\text{H}_2\text{O}_2 = \frac{2 \times 40}{24} = 3.3 \text{ mol dm}^{-3}$ OR $2 \times 1.67 = 3.34$ ✓ <i>Accept 3.3</i>	3
		14

Qu.	Expected answers	Marks
3(a)(i)	$\text{I}_2(\text{aq}) + \text{H}_2\text{S}(\text{g}) \longrightarrow 2\text{HI}(\text{aq}) + \text{S}(\text{s})$ species and balance ✓ state symbols: accept (s) for I_2 ; (aq) for H_2S ✓	2
(ii)	moles HI = $\frac{47.2}{128} = 0.36875 \text{ mol}$ ✓ <i>accept rounding back to 0.369 mol</i> $[\text{HI}] = \frac{0.36875 \times 1000}{225} = 1.64 \text{ mol dm}^{-3}$ $\text{pH} = -\log 1.64 = -0.21$ ✓	2
3(b)(i)	$\text{CH}_3\text{COOH} \rightleftharpoons \text{H}^+ + \text{CH}_3\text{COO}^-$ ✓ <i>Equilibrium sign is required</i>	1
(ii)	$K_a = \frac{[\text{H}^+(\text{aq})][\text{CH}_3\text{COO}^-(\text{aq})]}{[\text{CH}_3\text{COOH}(\text{aq})]}$ OR $[\text{H}^+] = \sqrt{([\text{CH}_3\text{COOH}][K_a])}$ ✓ $[\text{H}^+] = \sqrt{\{(1.70 \times 10^{-5}) \times (2.74 \times 10^{-3})\}} = 2.16 \times 10^{-4} \text{ mol dm}^{-3}$ ✓ <i>(or 2 marks if no expression given before)</i> $\text{pH} = -\log[\text{H}^+(\text{aq})] = -\log 2.16 \times 10^{-4} = 3.67$ ✓ <i>ECF: pH Must be from both $[\text{CH}_3\text{COOH}]$ AND K_a</i> DO NOT ALLOW 3.7 <i>If no square root, ECF answer = 7.33</i>	3
(iii)	$\text{HI} + \text{CH}_3\text{COOH} \rightleftharpoons \text{I}^- + \text{CH}_3\text{COOH}_2^+$ ✓ acid 1 base 2 base 1 acid 2 ✓ <i>Mark acid base pairs ECF from equation showing ethanoic acid as proton donor</i>	2
3(c)(i)	NaHCO_3 is an alkali or base / neutralises acid ✓ $\text{HCOOH} + \text{NaHCO}_3 \longrightarrow \text{HCOONa} + \text{CO}_2 + \text{H}_2\text{O}$ ✓ Allow H_2CO_3 instead of $\text{CO}_2 + \text{H}_2\text{O}$	2
(ii)	vinegar is acidic ✓ neutralises alkali in wasp sting ✓	2
(iii)	$[\text{H}^+] = \frac{K_a \times [\text{HCOOH}(\text{aq})]}{[\text{HCOO}^-(\text{aq})]} = \frac{1.60 \times 10^{-4} \times 0.75}{1.92}$ OR $6.25 \times 10^{-5} \text{ mol dm}^{-3}$ ✓ $\text{pH} = -\log[\text{H}^+] = -\log(7.5 \times 10^{-5}) = 4.20 / 4.2$ ✓ <i>ECF: pH Must be from $[\text{CH}_3\text{COOH}]$, $[\text{CH}_3\text{COO}^-]$ AND K_a</i> <i>If fraction inverted, ECF answer = 3.39</i>	2
		16

Qu.	Expected answers	Marks
4(a)	<p>moles of NaOH = $\frac{0.152 \times 19.80}{1000} / 3.01 \times 10^{-3} \text{ mol} \checkmark$</p> <p>moles of acid = $3.01 \times 10^{-3} \text{ mol} \checkmark$ (3.0096×10^{-3})</p> <p>moles of acid in flask = $4 \times 3.00 \times 10^{-3} = 1.20 \times 10^{-2} \text{ mol} \checkmark$ (0.0120384)</p> <p>molar mass of compound = $\frac{\text{mass}}{n} = \frac{1.368}{1.20 \times 10^{-2}} = 114 \checkmark$</p> <p>Molecular formula = $\text{C}_6\text{H}_{10}\text{O}_2 \checkmark$</p> <p>A six carbon carboxylic acid (e.g. hexanoic acid) shown (bod) \checkmark</p> <p>Any 2 possible structural isomers $\checkmark \checkmark$ eg: $\text{CH}_3\text{CH}_2\text{CH}_2=\text{CH}(\text{CH}_3)\text{COOH}$ $\text{CH}_3\text{CH}_2=\text{CH}(\text{CH}_3)\text{CH}_2\text{COOH}$ <i>Accept structural formulae or displayed formulae as long as they are unambiguous.</i></p>	8
4(b)	<p>Rate–concentration graphs Zero order: horizontal line \checkmark First order: straight rising line going through origin \checkmark Second order: curve rising upwards going through origin OR straight line in a rate vs conc² graph \checkmark correct labeled axes shown once \checkmark <i>Marks can be obtained by three clear sketch graphs</i></p> <p>pH curves Sketch graph with a sharp rise for strong acid and strong base with line vertical part of curve centred at about pH 7 Must be some indication of pH numbers fitting the vertical part of curve \checkmark</p> <p>Sketch graph with a sharp rise for strong acid and strong base with line vertical part of curve centred at a pH greater than 7 Must be some indication of pH numbers fitting the vertical part of curve \checkmark</p> <p>Vertical section in strong/strong graph is larger than vertical section for weak/strong graph AND pH curve for weak starts at higher pH than for strong \checkmark</p> <p>correct labeled axes shown once \checkmark (For x axis, accept 'volume OR amount of what is added')</p>	8
QWC	For pH titration pH curve, a statement that the colour change of suitable indicator range matches the vertical section \checkmark	1
		17

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

Plan: Skill P – 16 marks

Two methods are required.

One must be a titration (**T**) and the other based on a gravimetric procedure (**E or P**).

Measuring the volume of hydrogen is not permitted.

Both methods require the iron to be dissolved in acid to give $\text{Fe}^{2+}(\text{aq})$. (**D**)

D Dissolving the iron – 5 marks

- D1 Adds mixture to excess sulphuric acid of stated concentration [1]
Concentration used must be between $0.1 - 5.0 \text{ mol dm}^{-3}$ (incl)
- D2 Weighs solid mixture **and** reacts with acid until fizzing ceases
or weighs solid mixture **and** reacts with hot acid until reaction finishes [1]
- D3 Equation for reaction given ($\text{Fe} + \text{H}_2\text{SO}_4 \rightarrow \text{FeSO}_4 + \text{H}_2$)
and realises that copper does not react with (**or** dissolve in) the acid [1]
- D4 Calculates minimum volume of acid used needed for the reaction [1]
- D5 Filters [to remove copper] to obtain the iron(II) sulphate solution
and gives two precautions to ensure accuracy of procedure [1]
- washes all traces of the mixture into the funnel with distilled water
 - uses fine-grained filter paper (**or** multiple sheets)
 - reduced pressure/Buchner filtration
 - after filtration, uses distilled water to wash all aq FeSO_4 into the filtrate

T Titration method – 5 marks

- T1 Titrates with KMnO_4 used in burette
and gives correct balanced/ionic equation for reaction [1]
 KMnO_4 concentration must lie between 0.01 and 0.25 mol dm^{-3} (incl)
 $\text{MnO}_4^- + 5\text{Fe}^{2+} + 8\text{H}^+ \rightarrow \text{Mn}^{2+} + 5\text{Fe}^{3+} + 4\text{H}_2\text{O}$
- T2 Transfers all aqueous iron(II) salt into volumetric flask
and makes up to mark with distilled water [1]
- T3 Pipettes solution of Fe^{2+} into flask **and** adds excess H_2SO_4 [1]
- T4 States the end-point final colour (*pink or pale purple*)
and repeats to obtain consistent/concordant titres (**or** within 0.1 cm^3) [1]
- T5 Specimen calculation from titration to determine the % by mass of Fe [1]
Penalise use of $\text{Fe} = 56$ in the second calculation

E Evaporation method – 5 marks

- E1 Pipettes known volume of solution into a receptacle
or weighs metal mixture then reacts with named acid
and evaporates to remove all [solution] water
or evaporates until saturated (*owtte*) **and** leaves to crystallise [1]
- E2 Realises that residue /crystals are hydrated iron(II) sulphate
and quotes the " $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$ " formula [1]
- E3 Heating gently on water/steam bath or in oven to dry
and gives one reason for gentle heat **or** heats to constant mass [1]
 - *Gentle heat avoids spitting of solid*
 - *It avoids dehydration of hydrated iron(II) salt*
 - *It avoids decomposition of the anhydrous residue*
- E4 Weighs evaporating basin before use
and weighs the evaporating basin + residue/crystals at end [1]
- E5 Calculation to show how % of iron is calculated from mass of residue [1]
Allow a calculation that assumes residue is anhydrous iron(II) sulphate

P Precipitation method – 5 marks

- P1 Pipettes known volume of iron(II) salt solution into a beaker/flask
or weighs metal mixture then reacts with named acid
and adds excess of a suitable reagent (eg NaOH) to precipitate the Fe^{2+} [1]
- P2 Gives the [ionic] equation for the precipitation reaction
and calculates minimum volume (or mass) of reagent needed [1]
- P3 Weighs filter paper at start (before filtration)
and weighs filter paper + precipitated residue at end [1]
- P4 Dries the residue by heating gently **and** to constant mass [1]
Accept use of a desiccator as a suitable alternative drying method
- P5 Calculation to show how % of iron is calculated from mass of residue [1]

S Safety, Sources and QWC - 4 marks

- S1 Safety: One correct relevant hazard **and** a specific safety procedure described. [1]
Hazard quoted must be related to the reaction described
Precautions must be more than just specs/goggles/lab coats.
- 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 specific reference to "Hazcards"*

S3 **QWC**: text is legible and spelling, punctuation and grammar are accurate **[1]**

*Allow up to five different errors in legibility, spelling, punctuation or grammar.
Treat a type of ICT mistake in text (eg cm³) as one error.*

S4 **QWC**: information is organised clearly and coherently

[1]

Are the following three bullets all followed?

- *Is a word count given and within the limits 450 - 1050 words?
Photocopied/downloaded material counts in the total*
- *Is scientific language used correctly?
No S4 if there is more than one error - eg "strong" for "concentrated".*
- *Is most of the written material relevant to the task set?*

NOTE: 19 marks are available - maximum 16 awarded

Practical Test (Part B)

Part 1

(12 marks)

Mass readings

[1]

- Both mass readings must be listed, with unit (g) shown for each
- All three masses should be recorded consistently to two (or three) decimal places
- Labelling of masses must have minimum words, "bottle/container"
- Subtraction to give mass of **E** must be correct, and unit given.

Presentation of titration data

[2]

(8 bullets correct = 2 marks: 6 or 7 bullets correct = 1 mark)

- Table grid drawn
- Correctly labelled table (initial, final and difference *owtte*) used to record data
- All burette data quoted to 0.05 cm³ (including 0.00) (*integer loses extra "bullet"*)
- All subtractions are correct (*each error loses one "bullet"*)
- A minimum of three sets of burette readings are given
- Units, cm³ or ml, are given as headings (or with each reading)
- No burette readings above 50 cm³
- Titration readings are not inverted *and* initial reading is not shown as 50.00

Self-consistency of titres

[1]

- Two of candidate's **accurate** titres are within 0.10 cm³.

Mean titre

[1]

- Suitably calculated, with unit given, to 2 d.p. (*but allow 0.025 or 0.0725*)
A labelled trial reading may be used (if suitable) **or** ignored
If three readings are used, they must be within 0.1 cm³

Accuracy and Safety - 6 + 1 marks are available

Work out, using the steps below, what the adjusted candidate's titre (*T*) would have been if the candidate had used the same mass of **E** as the supervisor.

- Award the mark shown as follows.

$$T = \text{candidate's mean titre} \times \frac{\text{supervisor's mass}}{\text{candidate's mass}}$$

<i>T</i> is within 1.20 cm ³ of supervisor's mean value	[1]
<i>T</i> is within 1.00 cm ³ of supervisor's mean value	[2]
<i>T</i> is within 0.80 cm ³ of supervisor's mean value	[3]
<i>T</i> is within 0.60 cm ³ of supervisor's mean value	[4]
<i>T</i> is within 0.40 cm ³ of supervisor's mean value	[5]
<i>T</i> is within 0.25 cm ³ of supervisor's mean value	[6]

Spread penalty

This is based on the titres actually 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 0.80 cm^3 or more, deduct 2 marks.*
- *If the titres have a spread of 1.20 cm^3 or more, deduct 3 marks from accuracy.*

Safety

One sensible **safety precaution** stated **and** explained briefly

Accept any sensible precaution, such as use of spectacles or pipette filler.

*The precaution must be **related** to one of the irritant/harmful materials.*

Part 2 (Calculation)

(12 marks)

All answers are required to 3 sig fig, but penalise this once only

Page 5 - 6 marks

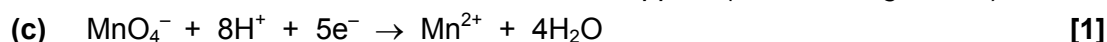
(a) M_r of $\text{KMnO}_4 = 158$ [1]

$[\text{KMnO}_4] = \frac{2.85}{158} = 0.0180 \text{ mol dm}^{-3}$ [1]

No ECF to wrong M_r within (a)

(b) $n(\text{KMnO}_4) = 0.0180 \times \frac{\text{mean titre}}{1000}$ (Method mark) [1]

Answer = $4.2 \times 10^{-4} \text{ mol}$ or 0.00042 approx (if no working shown)



Page 6 - 6 marks

(e) $n(\text{Fe}^{2+}) \text{ in } 250 \text{ cm}^3 = 5 \times 10 \times \text{"b"}$ [1]

Method mark.

Amount of $\text{Fe}^{2+} = 0.0210 \text{ mol}$ [1]

Correct answer scores this mark = $0.901 \times 10^{-4} \times \text{titre}$.

(f) $M_r = \frac{\text{mass of salt used}}{\text{moles of Fe}^{2+} \text{ used}}$ (correct numbers substituted) [1]

Method mark

M_r calculated correctly from data obtained (*should be 392*) [1]

(g) $[2X =] 392$ (**or** answer "f") $- 96 - 152 - 108 = 36$ [1]

$M_r - 356$ is sufficient to earn this mark

A_r of $X = \frac{36}{2} = 18.0$ [1]

This answer may be integral, without incurring the sig fig penalty

Part 3: Test-tube tests**(6 marks)****(a) 2 marks**

Green precipitate/solid formed [1]

**(b) 4 marks**No colour change (**or** solution goes slightly yellow) when adding peroxide to E [1]

Brown /rust coloured/red-brown /dark orange precipitate obtained with NaOH [1]

Iron(II)/ Fe^{2+} has been oxidised to iron(III)/ Fe^{3+} **or** $\text{Fe}^{2+} - \text{e}^- \rightarrow \text{Fe}^{3+}$
or hydrogen peroxide has oxidised Fe^{2+}
or fizzing due to oxygen liberated [1]

Final ppt is iron(III) hydroxide **or** $\text{Fe}^{3+} + 3\text{OH}^- \rightarrow \text{Fe}(\text{OH})_3$ [1]**Part 4: Evaluation****(14 marks)***18 marking points are available, but maximum 14 on the section.***(a) 4 marks**

$$n(\text{Fe}(\text{OH})_2) = 0.08/89.8 [= 0.00089(1) \text{ mol}]$$
 [1]

*Method mark. Use of 55.8 or 89.8 is required.**Allow all answers to 2,3 or 4 sig fig*

$$M_r \text{ of E} = 0.45/0.00089 = 505 \text{ (or 506)}$$
 [1]

$$M_r \text{ of X}_2 = 506 - 356$$
 [1]

$$A_r \text{ of X} = (75 \text{ or}) 74.5$$
 [1]

(b) 5 marks

A 2 d.p. balance is inaccurate for a small mass of solid
or calculates % error for the balance for any reading [1]

Suggests using a 3 or 4 dp balance (*not just 'more accurate'*) [1]

Use of the two measuring cylinders **is** sufficiently accurate [1]
*Reference to **both** is needed for this mark*

NaOH is in excess, so the exact volume does not matter [1]

 H_2O is not a reagent **or** extra water doesn't alter no of moles of reagent(s) [1]**(c) 4 marks (maximum)**

*Mark the best **two** ideas. Ignore all incorrect/irrelevant ideas
 Many marking parts in (c) and (d) are interchangeable*

Error in mass

Use larger mass of **E** to reduce [percentage] error [1]
 Calculations/words to explain reduced % error (in mass of **E** *or* of residue) [1]

Any two comments about problems of filtration

Use water to help transfer all solid into funnel during filtration [1]
 Use Buchner/suction filtration [1]
 Wash/rinse the residue in the funnel after filtration [1]
 Some solid may not be retained by filter paper [1]
 Use fine-grained filter paper [1]

Discussion of heating

Risk of decomposition of $\text{Fe}(\text{OH})_2$ to give FeO [during initial heating] [1]
 Heat gently/ keep temperature low [1]
 The paper and residue may not be dried completely [1]
 Re-heat the residue to constant mass [1]

Oxidation (any 2 points)

$\text{Fe}(\text{OH})_2$ can be oxidised [by air] to $\text{Fe}(\text{OH})_3$ (*owtte*) [1]
 This oxidation is quicker in alkaline conditions/ high pH [1]
 Carry out reaction in atmosphere of nitrogen *or* in vacuo [1]

(d) 5 marks (max) (but **two** marks awarded must relate to reliability)

Burette/pipette is more accurately calibrated [1]
 % error for either piece of equipment calculated correctly [1]
Do not allow a % error calculation for a measuring cylinder

Colour change gives accurate indication of the end of the reaction in the titration [1]

Three weighings in the gravimetric method lead to a high cumulative error [1]

A larger mass of solid was weighed in the titration [than in gravimetric expt].... [1]

.... % errors for weighing **E** compared in **both** experiments [1]

Titration experiment was repeated (*or* gravimetric experiment was not) [1]

Consistent titres (*or* within 0.1 cm^3) indicate reliability [1]
The word "reliability" must be used to earn this mark

Grade Thresholds

Advanced GCE Chemistry (3882/7882)
January 2010 Examination Series

Unit Threshold Marks

Unit		Maximum Mark	a	b	c	d	e	u
2814	Raw	90	69	61	54	47	40	0
	UMS	90	72	63	54	45	36	0
2815A	Raw	90	74	67	60	53	47	0
	UMS	90	72	63	54	45	36	0
2815C	Raw	90	74	67	60	54	48	0
	UMS	90	72	63	54	45	36	0
2815E	Raw	90	75	68	61	54	47	0
	UMS	90	72	63	54	45	36	0
2816A	Raw	120	97	86	76	66	56	0
	UMS	120	96	84	72	60	48	0
2816B	Raw	120	97	86	76	66	56	0
	UMS	120	96	84	72	60	48	0
2816C	Raw	120	89	78	68	58	48	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	4.5	9.1	27.3	54.5	100	100	23
7882	12.3	46.4	71.6	88.9	97.2	100	578

601 candidates aggregated this series.

For a description of how UMS marks are calculated see:

<http://www.ocr.org.uk/learners/ums/index.html>

Statistics are correct at the time of publication.

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