
CHEMISTRY

9701/41

Paper 4 A Level Structured Questions

October/November 2017

MARK SCHEME

Maximum Mark: 100

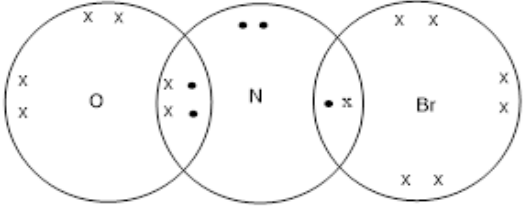
Published

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

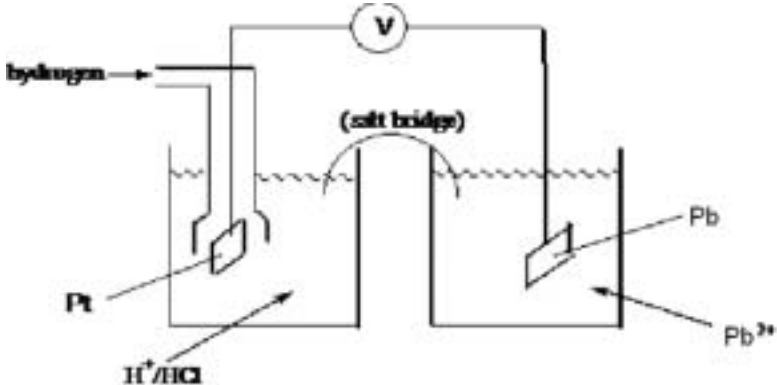
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Question	Answer	Marks
1(a)	N +2 to +3 (and oxidised)	1
	Br ₂ /Br 0 to –1 (and reduced)	1
1(b)		
	3 bonding pairs around N (in a structure involving NOBr)	1
	rest of molecule correct	1
1(c)(i)	the power to which a concentration of a reactant is raised in the rate equation	1
1(c)(ii)	using expt. 2 and 3 a = 2 or [NO] 2 nd order and conc × 3 rate × 9 or $6.1 \times 10^{-2} / 6.8 \times 10^{-3} = (0.09/0.03)^a$	1
	using expt. 1 and 2 b = 1 or [Br ₂] 1 st order and conc × 2 rate × 2 or $6.8 \times 10^{-3} / 3.4 \times 10^{-3} = (0.04/0.02)^b$	1
(c)(iii)	initial rate = 0.16(32)	1
1(c)(iv)	$(0.0034 = k(0.03)^2(0.02))$ k = 188.9	1
	mol ⁻² dm ⁶ s ⁻¹	1
1(c)(v)	k decreases (as rate decreases)	1

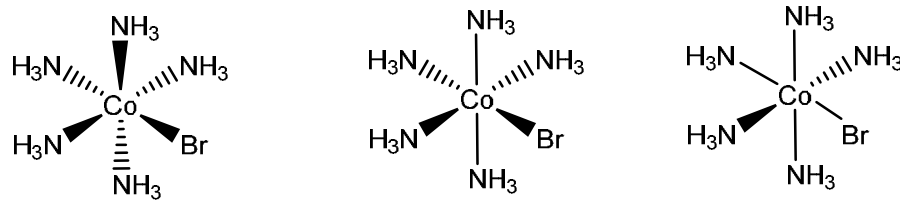
Question	Answer	Marks
1(d)	m = 2 and n = 0	1

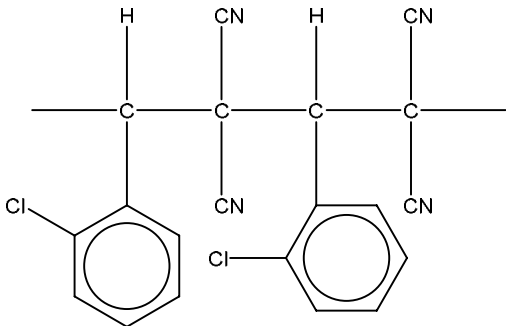
Question	Answer	Marks
2(a)	it / solubility decreases down the group and K_{sp} decreases	1
2(b)(i)	$\text{MgCO}_3(\text{s}) \rightleftharpoons \text{Mg}^{2+}(\text{aq}) + \text{CO}_3^{2-}(\text{aq})$	1
2(b)(ii)	(white) solid appears / precipitation (of MgCO_3)	1
	as $[\text{CO}_3^{2-}]$ increases shifting equilibrium to the LHS (precipitating out MgCO_3)	1
2(c)	solubility = $\sqrt{1.0 \times 10^{-5}} = 3.16 \times 10^{-3} \text{ mol dm}^{-3}$	1
	solubility = $3.2 \times 10^{-3} \times 84.3 = \mathbf{0.27} \text{ g dm}^{-3}$	1
2(d)(i)	Mg^{2+} ion is smaller than Ba^{2+} ion or ionic radii increase down group ora	1
	(Mg^{2+}) distorts / polarises / the anion / nitrate group / nitrate ion / $\text{NO}_3^{(1)-}$ / NO_3 ion more easily (than Ba^{2+}) ora	1
2(d)(ii)	$\text{Ba}(\text{NO}_3)_2 \rightarrow \text{BaO} + 2\text{NO}_2 + \frac{1}{2}\text{O}_2$	1
2(d)(iii)	$\text{BaO} + \text{H}_2\text{O} \rightarrow \text{Ba}(\text{OH})_2$	1
	$\text{Ba}(\text{OH})_2 + \text{H}_2\text{SO}_4 \rightarrow \text{BaSO}_4 + 2\text{H}_2\text{O}$	1

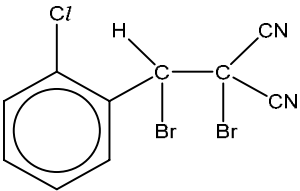
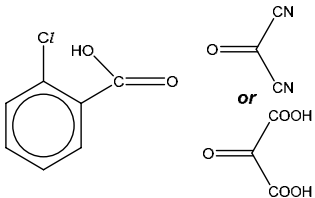
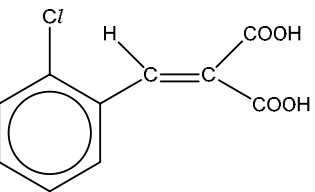
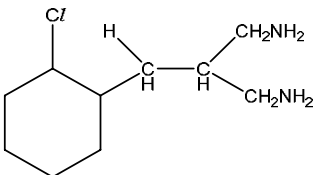
Question	Answer	Marks
3(a)	the potential difference between two half-cells / two electrodes (in a cell)	1
	under standard conditions of 1 atm., 298 K, (all) solutions being 1 mol dm ⁻³	1
3(b)(i)	 8 marking points, any 2 points for each mark H₂ / hydrogen correct delivery system for H₂ Pb²⁺ (aq) Pb electrode Pt electrode H⁺(aq) solution salt bridge voltmeter / V labelled	4
3(b)(ii)	more negative	1
	shifts Pb ²⁺ (+ 2e ⁻) ⇌ Pb equilibrium / reaction to the left	1

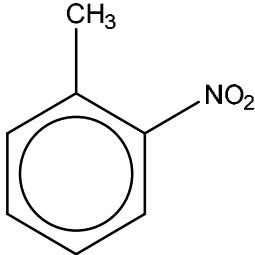
Question	Answer	Marks
3(c)(i)	$Q = 0.4 \times 80 \times 60 = \mathbf{1920\text{ C}}$ and use of 96500 / 193000 Moles of Pb = $1920 / 193000 = 9.95 \times 10^{-3}$ Mass of Pb = $207.2 \times 9.95 \times 10^{-3} = \mathbf{2.1\text{ g}}$ OR $Q = 0.4 \times 80 \times 60 = \mathbf{1920\text{ C}}$ and use of $1.6 \times 10^{-19} / 1.2 \times 10^{22}$ atoms Pb = 6×10^{21} ; moles of Pb = $6 \times 10^{21} / 6 \times 10^{23} = 0.01$ Mass of Pb = $207.2 \times 0.01 = \mathbf{2.1\text{ g}}$	2
3(c)(ii)	$\text{PbO}_2(\text{s}) + \text{SO}_4^{2-}(\text{aq}) + \mathbf{4\text{H}^+ + 2\text{e}^-} \rightarrow \text{PbSO}_4(\text{s}) + \mathbf{2\text{H}_2\text{O}}$	1
3(d)	reagents / PbO_2 / H_2SO_4 and used up / concentration decreases	1
	as fuel / hydrogen is being continuously supplied / fuel has not run out	1

Question	Answer	Marks
4(a)	density is higher and melting point is higher	1
	(density) due to A_r being larger and smaller atomic radii or (Co) atoms / ions heavier and smaller	1
	(melting point) due to stronger attraction to cations as more delocalised electrons	1
4(b)	(a molecule or ion) formed by a central metal atom / ion surrounded by (one or more) ligands	1
4(c)(i)	same number and type of <u>atoms</u> and different structural formula	1

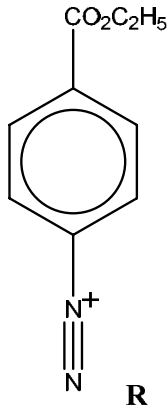
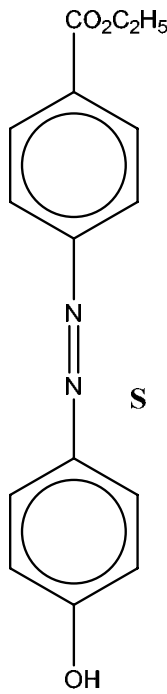
Question	Answer	Marks															
4(c)(ii)	octahedral AND 3D structure of $[\text{Co}(\text{NH}_3)_5\text{Br}]^{2+}$ e.g. 	1															
4(c)(iii)	co-ordinate / dative covalent	1															
4(c)(iv)	+3 for both	1															
4(d)	$(\text{HNO}_3) \text{ Ag}^+ / \text{AgNO}_3$ cream(–yellow) ppt. (of AgBr) and no reaction / white ppt. for other isomer	1															
	$\text{Ba}(\text{OH})_2 / \text{Ba}^{2+}(\text{aq}) / \text{BaCl}_2 / \text{Ba}(\text{NO}_3)_2$ white ppt. (of BaSO_4) and no reaction for other isomer	1															
4(e)	(d-d) energy gap / ΔE is different	1															
	absorb different wavelength / frequency (of light)	1															
4(f)	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th></th><th>heterogeneous</th><th>homogeneous</th></tr> </thead> <tbody> <tr> <td>Fe in the Haber process</td><td style="text-align: center;">✓</td><td></td></tr> <tr> <td>Fe^{2+} in the $\text{I}^- / \text{S}_2\text{O}_8^{2-}$ reaction</td><td></td><td style="text-align: center;">✓</td></tr> <tr> <td>NO_2 in the oxidation of SO_2</td><td></td><td style="text-align: center;">✓</td></tr> <tr> <td>V_2O_5 in the Contact process</td><td style="text-align: center;">✓</td><td></td></tr> </tbody> </table>		heterogeneous	homogeneous	Fe in the Haber process	✓		Fe^{2+} in the $\text{I}^- / \text{S}_2\text{O}_8^{2-}$ reaction		✓	NO_2 in the oxidation of SO_2		✓	V_2O_5 in the Contact process	✓		2
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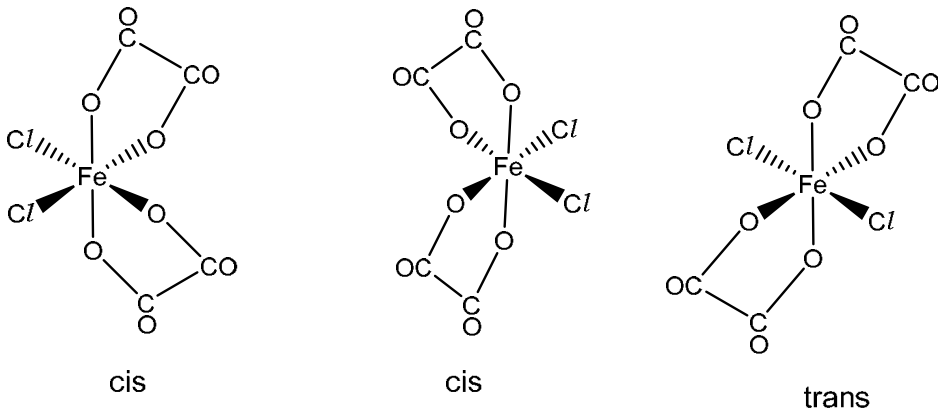
Question	Answer	Marks
5(a)	nitrile; alkene; chloro; benzene / arene	2
5(b)		1
	addition (polymerisation)	1

Question	Answer			Marks
5(c)	reagent	structure of product	type of organic reaction	8
	excess Br ₂ (aq)	 [1]	(electrophilic) addition	
	excess hot, conc. MnO ₄ ⁻ (aq)	 [1] + [1]	oxidation	
	excess hot, aqueous HCl	 [1]	hydrolysis	
	excess H ₂ /Pt catalyst	 both CH ₂ NH ₂ formed [1] both arene and alkene reduced [1]	reduction / hydrogenation	
		structures [6]	2 correct for 1 mark total [2]	

Question	Answer	Marks
6(a)(i)		1
6(a)(ii)	$\text{HNO}_3 + 2\text{H}_2\text{SO}_4 \rightarrow \text{H}_3\text{O}^+ + \text{NO}_2^+ + 2\text{HSO}_4^-$	1
6(a)(iii)	any three from: Point 1: bonds/electrons are partially delocalised in T or delocalised / π system / π bonding extends over only five carbons Point 2: four π-electrons in the (delocalised system of T) or methylbenzene has (two) more π-electrons / (two) more delocalised electrons Point 3: contains a carbon that is sp^3 hybridised in T or (all the) carbons are sp^2 hybridised in methylbenzene Point 4: one carbon has a bond angle of 109.5° / tetrahedral (in T) or (C-C) bond strengths / lengths are not all the same or not all the bond angles are 120° (in T)	3
6(b)(i)	4-aminobenzoic acid	1
6(b)(ii)	step 1 $\text{Sn} + \text{HCl}$ [1] concentrated / reflux / heat [1] step 2 CH_3COCl [1] step 3 KMnO_4 / manganate(<u>VII</u>) / MnO_4^- (acidified / alkaline) and heat [1] step 4 aqueous HCl and heat [1] step 5 ethanol, H_2SO_4, concentrated / reflux / heat [1]	6

Question	Answer	Marks																				
6(c)	(benzocaine) is less (basic than ethylamine) AND lone pair (on N) is less available to accept a proton / H^+ since (lone pair on N) is delocalised over the ring or phenyl ring is electron withdrawing group OR ethylamine is more basic (than benzocaine) AND lone pair (on N) is more available to accept a proton / H^+ since ethyl / alkyl group is electron-donating group	2																				
6(d)(i)	7 peaks	1																				
6(d)(ii)	$CDCl_3$ will produce no signal in the spectrum or $CHCl_3$ would produce a signal / would be detected	1																				
6(d)(iii)	<table><tr><th>δ/ppm</th><th>group responsible for the peak</th><th>number of H atoms responsible for the peak</th><th>splitting pattern</th></tr><tr><td>1.2</td><td>$CH_{(3)}$</td><td>3</td><td>triplet</td></tr><tr><td>3.5</td><td>$CH_{(2)}O$</td><td>2</td><td>quartet</td></tr><tr><td>5.5</td><td>NH_2</td><td>2</td><td>singlet (broad)</td></tr><tr><td>7.1–7.4</td><td>H attached to aromatic / benzene ring</td><td>4</td><td><i>multiplet</i></td></tr></table>	δ/ppm	group responsible for the peak	number of H atoms responsible for the peak	splitting pattern	1.2	$CH_{(3)}$	3	triplet	3.5	$CH_{(2)}O$	2	quartet	5.5	NH_2	2	singlet (broad)	7.1–7.4	H attached to aromatic / benzene ring	4	<i>multiplet</i>	4
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7.1–7.4	H attached to aromatic / benzene ring	4	<i>multiplet</i>																			
6(d)(iv)	neighbouring / adjacent carbon atom has two protons / H (attached to it) or there is an adjacent $CH_2(O)$ group	1																				
6(d)(v)	peak at 5.5 / NH_2 peak will disappear and NH_2 / protons exchange / swap with deuterium	1																				

Question	Answer	Marks
6(e)(i)	$\text{NaNO}_2 + \text{HCl}$ or HNO_2	1
6(e)(ii)	 R  S	
	structure of diazonium salt R	1
	structure of azo dye S	1

Question	Answer	Marks
7(a)	Fe atom = $(1s^2 2s^2 2p^6) 3s^2 3p^6 3d^6 4s^2$ Fe ³⁺ ion = $(1s^2 2s^2 2p^6) 3s^2 3p^6 3d^5$	1
7(b)	$([H^+]^2 = 8.9 \times 10^{-4} \times 0.25 \text{ or } 2.225 \times 10^{-4})$ $[H^+] = 0.0149$	1
	pH = $-\log(0.0149) = 1.83$	1
7(c)(i)	(K_{stab} is) the equilibrium constant for the formation of a complex (ion) (in a solvent from its constituent ions / molecules)	1
7(c)(ii)	$[\text{Fe}(\text{H}_2\text{O})_5\text{F}]^{2+}$ and $[\text{Hg}(\text{H}_2\text{O})_5\text{Cl}]^+$	1
7(d)	$K_{\text{stab}} = \frac{[\text{Fe}(\text{ed})_2\text{Cl}_2^{3-}]}{[\text{Fe}(\text{H}_2\text{O})_4\text{Cl}_2^+][\text{ed}]^2}$	1
	mol ⁻² dm ⁶	1
7(e)(i)	 cis cis trans	3

Question	Answer	Marks
7(e)(ii)	any cis isomer and the trans isomer identified	1
7(e)(iii)	both correct cis isomers identified	1
7(e)(iv)	trans isomer identified	1

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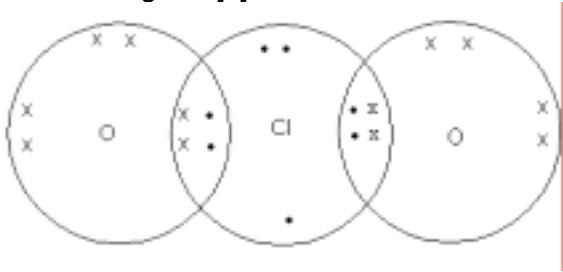
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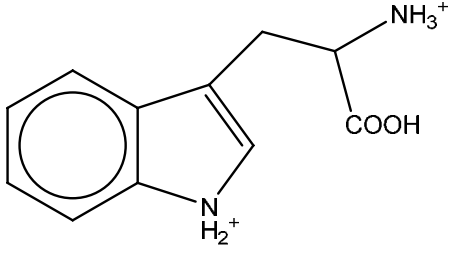
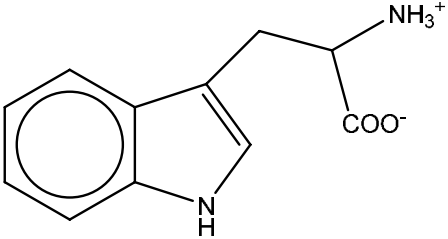
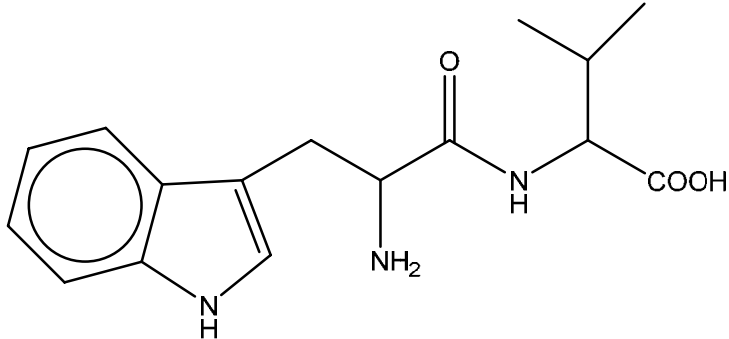
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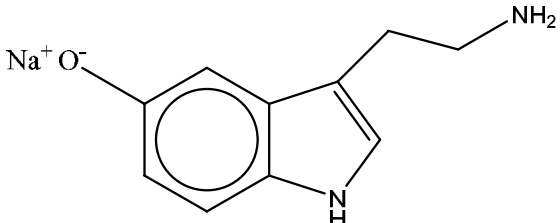
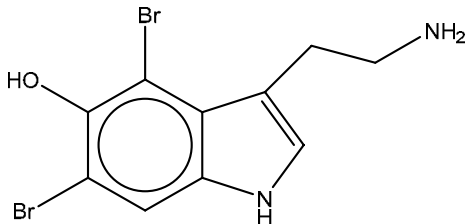
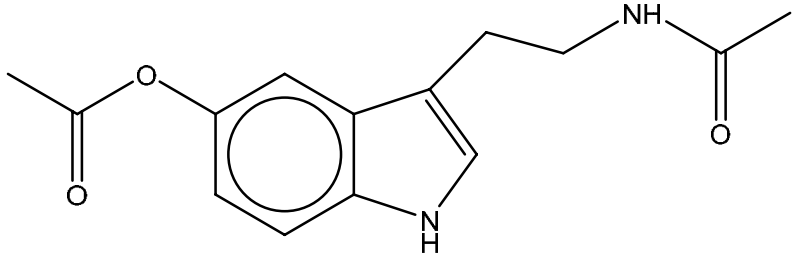
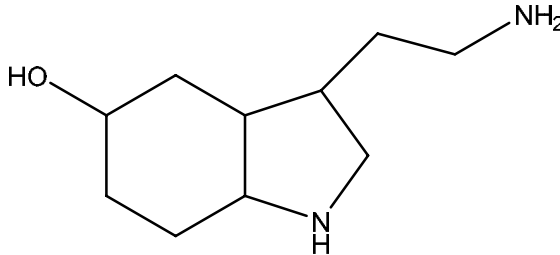
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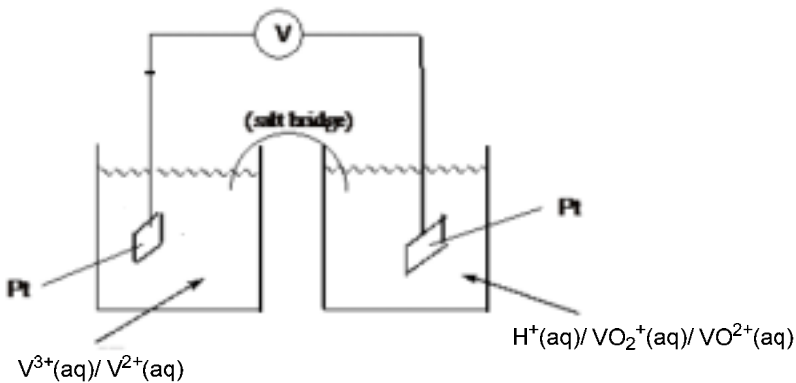
Question	Answer	Marks
1(a)	Cl +3 to +4 (and oxidised)	1
	Cl 0 to –1 (and reduced)	1
1(b)	19 electrons total [1] correct diagram [1] 	2
1(c)(i)	the exponent / power to which a concentration is raised in the rate equation	1
1(c)(ii)	$(0.0022 = k(0.01) \times (0.06))$ $k = 3.7 \text{ (3.67)}$	1
	$\text{mol}^{-1} \text{ dm}^3 \text{ s}^{-1}$	1
1(c)(iii)	initial rate = 5.50×10^{-3}	1
	$[\text{ClO}_2] = 0.048$	1
1(d)(i)	slowest step (in a multi-step reaction)	1
1(d)(ii)	1 mole of F_2 and 1 mole ClO_2 reacting in the rate-determining step	1
	1st step is rate-determining step and a balanced mechanism consistent with overall equation e.g. $\text{ClO}_2 + \text{F}_2 \rightarrow \text{ClO}_2\text{F}_2$ $\text{ClO}_2 + \text{ClO}_2\text{F}_2 \rightarrow 2\text{ClO}_2\text{F}$ or $\text{ClO}_2 + \text{F}_2 \rightarrow \text{ClO}_2\text{F} + \text{F}$ $\text{ClO}_2 + \text{F} \rightarrow \text{ClO}_2\text{F}$	1
1(e)	k increases (as rate increases)	1

Question	Answer	Marks
2(a)(i)	$\text{Mg}_3\text{N}_2 + 6\text{H}_2\text{O} \rightarrow 3\text{Mg}(\text{OH})_2 + 2\text{NH}_3$	1
2(a)(ii)	moles of $\text{Mg}_3\text{N}_2 = 2.52 / 100.9 = 0.025$ (0.0249)	1
	(moles of $\text{Mg}(\text{OH})_2 = 0.075$ (0.0749)) mass of $\text{Mg}(\text{OH})_2 = (0.075 \times 58.3) = 4.37$ g or 4.4 g	1
2(b)	solubility increases (down the group)	1
	ΔH_{latt} and ΔH_{hyd} both decrease / less exothermic / more endothermic	1
	but ΔH_{latt} decreases more (than ΔH_{hyd} decreases)	1
	ΔH_{sol} becomes more negative / more exothermic / less endothermic	1
2(c)(i)	$K_{\text{sp}} = [\text{Mg}^{2+}] [\text{OH}^-]^2$	1
2(c)(ii)	$K_{\text{sp}} = (1.7 \times 10^{-4}) \times (2 \times 1.7 \times 10^{-4})^2 = 2.0 \times 10^{-11}$ (1.97×10^{-11})	1
	$\text{mol}^3 \text{ dm}^{-9}$	1
2(d)	cations become bigger / ionic radius increases	1
	polarisation/distortion of anion / hydroxide ion decreases	1

Question	Answer	Marks
3(a)(i)	 pH 1  pH 5.9	2
3(a)(ii)	 peptide link [1] rest of the structure [1]	2

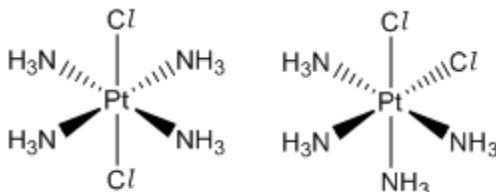
Question	Answer			Marks
3(b)	reagent	structure of product	type of organic reaction	8
	Na	 [1]	redox or reduction	
	excess Br ₂ (aq)	 [1]	(electrophilic) substitution	
	excess CH ₃ COCl	 acylated OH [1] acylated NH₂ [1]	condensation (or addition + elimination)	
	excess H ₂ / Pt catalyst	 [1]	reduction or hydrogenation or addition	

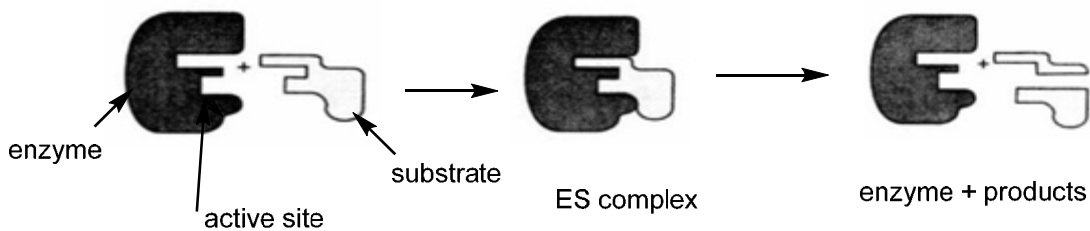
Question	Answer	Marks
3(c)(i)	(spectrum of M) contains a broad peak (for O–H) at 2500–3000 cm ⁻¹ or (spectrum of M) contains peak (for C=O) at 1640–1750 cm ⁻¹ or (spectrum of M) lacks (NH ₂ peak) at 3300–3500 cm ⁻¹	1
3(c)(ii)	5 or 6 peaks	1
	OH/NH protons exchange with deuterium or –OH / –NH + D ₂ O → –OD / –ND + DHO	1
3(d)	ester and hydrolysed	1

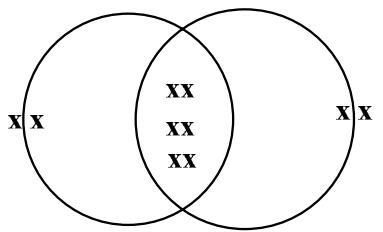
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4(a)(i)	$E^{\ominus}_{\text{cell}} = 1.00 - (-0.26) = (+)1.26 \text{ V}$	1
4(a)(ii)	$\text{VO}_2^+ + \text{V}^{2+} + 2\text{H}^+ \rightarrow \text{VO}^{2+} + \text{V}^{3+} + \text{H}_2\text{O}$	1
4(a)(iii)	 $\text{V}^{3+}(\text{aq}) / \text{V}^{2+}(\text{aq})$ $\text{H}^+(\text{aq}) / \text{VO}_2^+(\text{aq}) / \text{VO}^{2+}(\text{aq})$ solutions labelled correctly in one half-cell [1] solutions labelled correctly in both half-cells [1] two graphite or platinum electrodes [1] salt bridge and voltmeter [1]	4

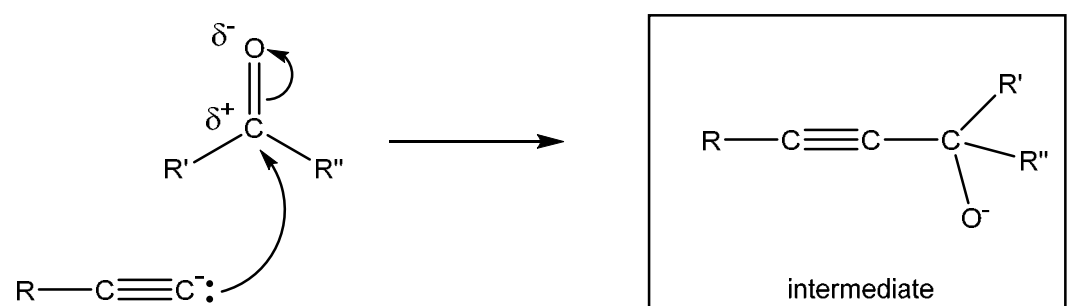
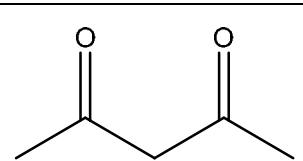
Question	Answer	Marks
4(b)	$V^{2+}(aq)$ and $Sn^{4+}(aq)$: yes and $E^{\circ}_{cell} = +0.15 - (-0.26) = +0.41 \text{ V}$ [1] $2V^{2+} + Sn^{4+} \rightarrow 2V^{3+} + Sn^{2+}$ [1] $VO^{2+}(aq)$ and $Fe^{3+}(aq)$ no reaction [1]	3

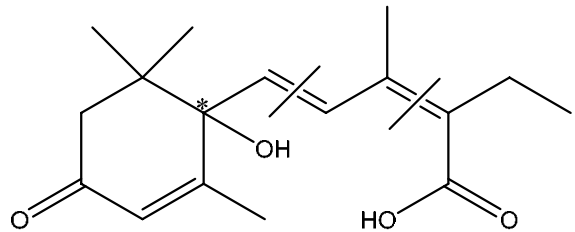
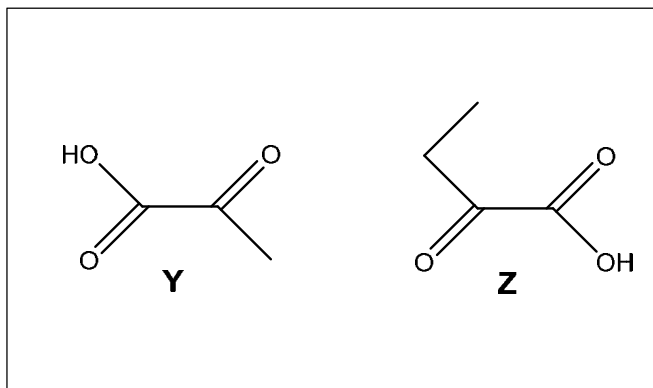
Question	Answer	Marks
5(a)	$(Na^+) 0.095 / 0.181 = 0.525$ and octahedral and co-ordination no. = 6	1
	$(Mg^{2+}) 0.065 / 0.181 = 0.359$ and tetrahedral and co-ordination no. = 4	1
5(b)	enthalpy change = $(-642) - (2 \times -106) = -430$	1
5(c)(i)	$-106 = 147 + 121 + 736 + (-349) + \text{lattice energy}$ lattice energy = -761	3
5(c)(ii)	$MgCl_2$ more exothermic / negative / bigger than $MgCl$ and $NaCl$ more exothermic / negative / bigger than $MgCl$	1
	(reason for $MgCl_2$) higher charge / lower radius of Mg^{2+} cation	1
	(reason for $NaCl$) smaller radius of Na^+ cation	1
5(d)	energy change when 1 mole of atoms / ions each gain an electron or energy change when 1 mole of atoms / ions gain 1 mole of electrons	1
	gaseous	1

Question	Answer	Marks									
6(a)	central metal atom/ion surrounded by (one or more) ligands	1									
6(b)	<table border="1"> <tr> <td></td><td>co-ordination number</td><td>oxidation number</td></tr> <tr> <td>$[\text{Pt}(\text{NH}_3)_4\text{Cl}_2]^{2+}$</td><td>6</td><td>+4</td></tr> <tr> <td>$[\text{PtCl}_4]^{2-}$</td><td>4</td><td>+2</td></tr> </table>		co-ordination number	oxidation number	$[\text{Pt}(\text{NH}_3)_4\text{Cl}_2]^{2+}$	6	+4	$[\text{PtCl}_4]^{2-}$	4	+2	2
	co-ordination number	oxidation number									
$[\text{Pt}(\text{NH}_3)_4\text{Cl}_2]^{2+}$	6	+4									
$[\text{PtCl}_4]^{2-}$	4	+2									
6(c)		2									
6(d)	(HNO ₃ +) AgNO ₃ reagent	1									
	$[\text{Pt}(\text{NH}_3)_4\text{Cl}_2]\text{Br}_2$ with cream ppt. (of AgBr) and $[\text{Pt}(\text{NH}_3)_4\text{Br}_2]\text{Cl}_2$, with white ppt. (of AgCl) observation with both	1									
6(e)	octahedral: both	1									
	square planar: geometric	1									
	tetrahedral: neither	1									

Question	Answer	Marks
6(f)	diagrams  enzyme active site substrate ES complex enzyme + products Marks can be awarded from words or diagram. Any three marking points from: • substrate shape is complementary to active site • the substrate binds / bonds / fits into the active site • products are released • lower E_A / bonds weakened in substrate	3

Question	Answer	Marks
7(a)(i)	$\text{CaC}_2 + 2\text{H}_2\text{O} \rightarrow \text{C}_2\text{H}_2 + \text{Ca(OH)}_2$	1
7(a)(ii)		1
7(b)	$\text{C}_n\text{H}_{2n-2}$	1
7(c)(i)	delocalised electrons	1
7(c)(ii)	CH	1
7(c)(iii)	less dense	1

Question	Answer	Marks																				
7(d)(i)	 2 curly arrows [1] dipole [1] intermediate [1]	3																				
7(d)(ii)	nucleophilic addition	1																				
7(d)(iii)	$\text{C}_2\text{H}_5-\text{C}\equiv\text{C}-\text{H}$ [1] Q  [1] R	2																				
7(e)	<table><tr><td></td><td>CH₃CHO</td><td>HCO₂H</td><td>CH₃COCH₃</td><td>HO₂CCO₂H</td></tr><tr><td>hot acidified MnO₄⁻(aq)</td><td>✓</td><td>✓</td><td>✗</td><td>✓</td></tr><tr><td>alkaline I₂(aq)</td><td>✓</td><td>✗</td><td>✓</td><td>✗</td></tr><tr><td>Tollens' reagent</td><td>✓</td><td>✓</td><td>✗</td><td>✗</td></tr></table>		CH ₃ CHO	HCO ₂ H	CH ₃ COCH ₃	HO ₂ CCO ₂ H	hot acidified MnO ₄ ⁻ (aq)	✓	✓	✗	✓	alkaline I ₂ (aq)	✓	✗	✓	✗	Tollens' reagent	✓	✓	✗	✗	4
	CH ₃ CHO	HCO ₂ H	CH ₃ COCH ₃	HO ₂ CCO ₂ H																		
hot acidified MnO ₄ ⁻ (aq)	✓	✓	✗	✓																		
alkaline I ₂ (aq)	✓	✗	✓	✗																		
Tollens' reagent	✓	✓	✗	✗																		

Question	Answer	Marks								
8(a)(i)	 circle or asterisk on correct C atom only [1] lines through the two correct bonds only [1]	2								
8(a)(ii)	ketone, (tertiary) alcohol, alkene, carboxylic acid two for each mark	2								
8(a)(iii)	sp carbons = 0 sp ² carbons = 8 sp ³ carbons = 9	1								
8(a)(iv)		2								
8(b)(i)	<table><tr><th>compound</th><th>spot</th></tr><tr><td>J</td><td>2</td></tr><tr><td>K</td><td>3</td></tr><tr><td>L</td><td>1</td></tr></table>	compound	spot	J	2	K	3	L	1	1
compound	spot									
J	2									
K	3									
L	1									

Question	Answer	Marks
8(b)(ii)	The more polar the compound and stronger attractive forces to the (polar) stationary phase ora: less polar compound and weaker attractive forces to the (polar) stationary phase	1
8(b)(iii)	R_f = retardation factor or retention factor or R_f = distance moved by compound from baseline over distance travelled by solvent front	1

CHEMISTRY

9701/43

Paper 4 A Level Structured Questions

October/November 2017

MARK SCHEME

Maximum Mark: 100

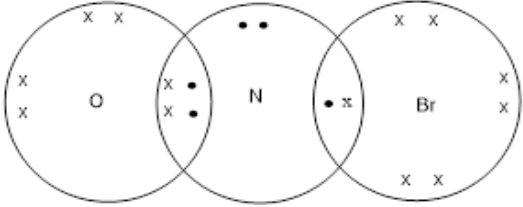
Published

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

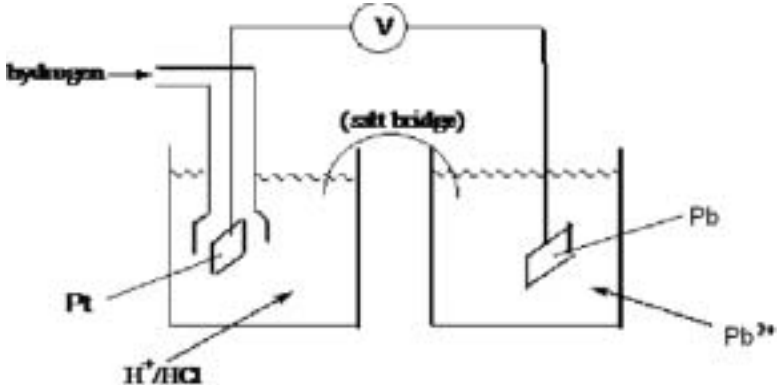
Cambridge International will not enter into discussions about these mark schemes.

Cambridge International is publishing the mark schemes for the October/November 2017 series for most Cambridge IGCSE[®], Cambridge International A and AS Level components and some Cambridge O Level components.

Question	Answer	Marks
1(a)	N +2 to +3 (and oxidised)	1
	Br ₂ /Br 0 to –1 (and reduced)	1
1(b)		
	3 bonding pairs around N (in a structure involving NOBr)	1
	rest of molecule correct	1
1(c)(i)	the power to which a concentration of a reactant is raised in the rate equation	1
1(c)(ii)	using expt. 2 and 3 a = 2 or [NO] 2 nd order and $\text{conc} \times 3 \text{ rate} \times 9$ or $6.1 \times 10^{-2} / 6.8 \times 10^{-3} = (0.09/0.03)^a$	1
	using expt. 1 and 2 b = 1 or [Br ₂] 1 st order and $\text{conc} \times 2 \text{ rate} \times 2$ or $6.8 \times 10^{-3} / 3.4 \times 10^{-3} = (0.04/0.02)^b$	1
(c)(iii)	initial rate = 0.16(32)	1
1(c)(iv)	$(0.0034 = k(0.03)^2(0.02))$ k = 188.9	1
	mol ⁻² dm ⁶ s ⁻¹	1
1(c)(v)	k decreases (as rate decreases)	1

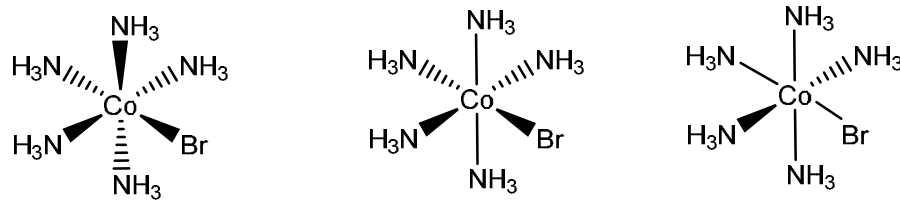
Question	Answer	Marks
1(d)	m = 2 and n = 0	1

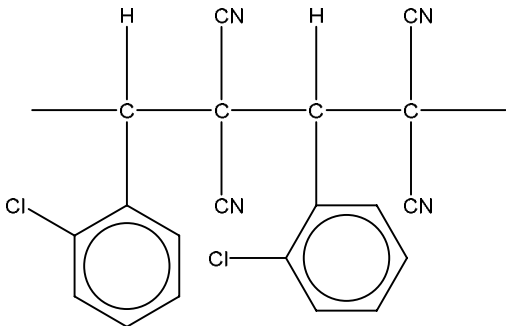
Question	Answer	Marks
2(a)	it / solubility decreases down the group and K_{sp} decreases	1
2(b)(i)	$\text{MgCO}_3(\text{s}) \rightleftharpoons \text{Mg}^{2+}(\text{aq}) + \text{CO}_3^{2-}(\text{aq})$	1
2(b)(ii)	(white) solid appears / precipitation (of MgCO_3)	1
	as $[\text{CO}_3^{2-}]$ increases shifting equilibrium to the LHS (precipitating out MgCO_3)	1
2(c)	solubility = $\sqrt{1.0 \times 10^{-5}} = 3.16 \times 10^{-3} \text{ mol dm}^{-3}$	1
	solubility = $3.2 \times 10^{-3} \times 84.3 = \mathbf{0.27} \text{ g dm}^{-3}$	1
2(d)(i)	Mg^{2+} ion is smaller than Ba^{2+} ion or ionic radii increase down group ora	1
	(Mg^{2+}) distorts / polarises / the anion / nitrate group / nitrate ion / $\text{NO}_3^{(1)-}$ / NO_3 ion more easily (than Ba^{2+}) ora	1
2(d)(ii)	$\text{Ba}(\text{NO}_3)_2 \rightarrow \text{BaO} + 2\text{NO}_2 + \frac{1}{2}\text{O}_2$	1
2(d)(iii)	$\text{BaO} + \text{H}_2\text{O} \rightarrow \text{Ba}(\text{OH})_2$	1
	$\text{Ba}(\text{OH})_2 + \text{H}_2\text{SO}_4 \rightarrow \text{BaSO}_4 + 2\text{H}_2\text{O}$	1

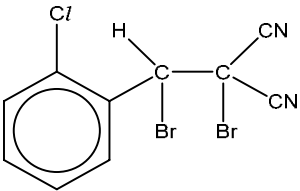
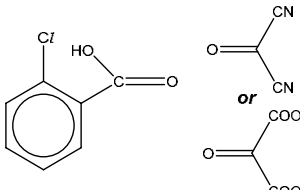
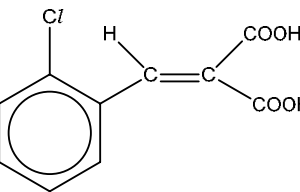
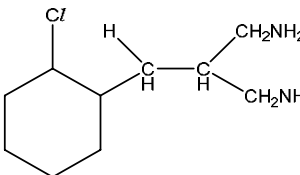
Question	Answer	Marks
3(a)	the potential difference between two half-cells / two electrodes (in a cell)	1
	under standard conditions of 1 atm., 298 K, (all) solutions being 1 mol dm ⁻³	1
3(b)(i)	 8 marking points, any 2 points for each mark H₂ / hydrogen correct delivery system for H₂ Pb²⁺ (aq) Pb electrode Pt electrode H⁺(aq) solution salt bridge voltmeter / V labelled	4
3(b)(ii)	more negative	1
	shifts Pb ²⁺ (+ 2e ⁻) ⇌ Pb equilibrium / reaction to the left	1

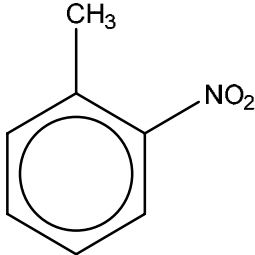
Question	Answer	Marks
3(c)(i)	$Q = 0.4 \times 80 \times 60 = \mathbf{1920\text{ C}}$ and use of 96500 / 193000 Moles of Pb = $1920 / 193000 = 9.95 \times 10^{-3}$ Mass of Pb = $207.2 \times 9.95 \times 10^{-3} = \mathbf{2.1\text{ g}}$ OR $Q = 0.4 \times 80 \times 60 = \mathbf{1920\text{ C}}$ and use of $1.6 \times 10^{-19} / 1.2 \times 10^{22}$ atoms Pb = 6×10^{21} ; moles of Pb = $6 \times 10^{21} / 6 \times 10^{23} = 0.01$ Mass of Pb = $207.2 \times 0.01 = \mathbf{2.1\text{ g}}$	2
3(c)(ii)	$\text{PbO}_2(\text{s}) + \text{SO}_4^{2-}(\text{aq}) + \mathbf{4\text{H}^+ + 2\text{e}^-} \rightarrow \text{PbSO}_4(\text{s}) + \mathbf{2\text{H}_2\text{O}}$	1
3(d)	reagents / PbO_2 / H_2SO_4 and used up / concentration decreases	1
	as fuel / hydrogen is being continuously supplied / fuel has not run out	1

Question	Answer	Marks
4(a)	density is higher and melting point is higher	1
	(density) due to A_r being larger and smaller atomic radii or (Co) atoms / ions heavier and smaller	1
	(melting point) due to stronger attraction to cations as more delocalised electrons	1
4(b)	(a molecule or ion) formed by a central metal atom / ion surrounded by (one or more) ligands	1
4(c)(i)	same number and type of <u>atoms</u> and different structural formula	1

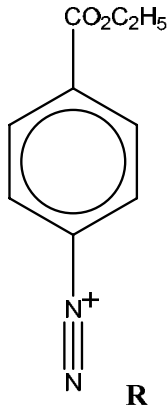
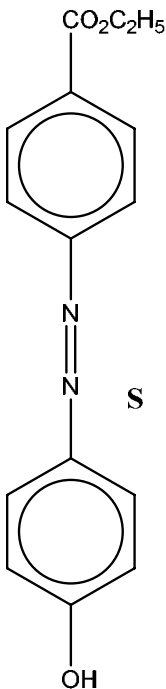
Question	Answer	Marks															
4(c)(ii)	octahedral AND 3D structure of $[\text{Co}(\text{NH}_3)_5\text{Br}]^{2+}$ e.g. 	1															
4(c)(iii)	co-ordinate / dative covalent	1															
4(c)(iv)	+3 for both	1															
4(d)	$(\text{HNO}_3) \text{ Ag}^+ / \text{AgNO}_3$ cream(–yellow) ppt. (of AgBr) and no reaction / white ppt. for other isomer	1															
	$\text{Ba}(\text{OH})_2 / \text{Ba}^{2+}(\text{aq}) / \text{BaCl}_2 / \text{Ba}(\text{NO}_3)_2$ white ppt. (of BaSO_4) and no reaction for other isomer	1															
4(e)	(d-d) energy gap / ΔE is different	1															
	absorb different wavelength / frequency (of light)	1															
4(f)	<table border="1"> <thead> <tr> <th></th><th>heterogeneous</th><th>homogeneous</th></tr> </thead> <tbody> <tr> <td>Fe in the Haber process</td><td>✓</td><td></td></tr> <tr> <td>Fe^{2+} in the $\text{I}^- / \text{S}_2\text{O}_8^{2-}$ reaction</td><td></td><td>✓</td></tr> <tr> <td>NO_2 in the oxidation of SO_2</td><td></td><td>✓</td></tr> <tr> <td>V_2O_5 in the Contact process</td><td>✓</td><td></td></tr> </tbody> </table>		heterogeneous	homogeneous	Fe in the Haber process	✓		Fe^{2+} in the $\text{I}^- / \text{S}_2\text{O}_8^{2-}$ reaction		✓	NO_2 in the oxidation of SO_2		✓	V_2O_5 in the Contact process	✓		2
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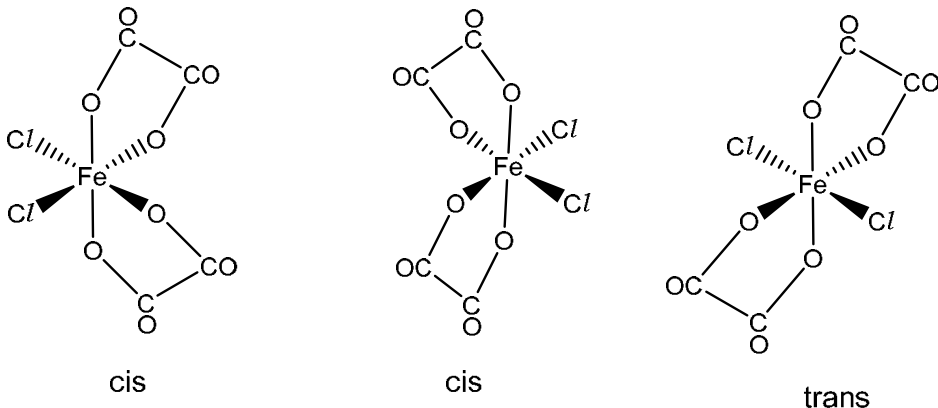
Question	Answer	Marks
5(a)	nitrile; alkene; chloro; benzene / arene	2
5(b)		1
	addition (polymerisation)	1

Question	Answer			Marks
5(c)	reagent	structure of product	type of organic reaction	8
	excess Br ₂ (aq)	 [1]	(electrophilic) addition	
	excess hot, conc. MnO ₄ ⁻ (aq)	 [1] + [1]	oxidation	
	excess hot, aqueous HCl	 [1]	hydrolysis	
	excess H ₂ /Pt catalyst	 both CH ₂ NH ₂ formed [1] both arene and alkene reduced [1]	reduction / hydrogenation	
		structures [6]	2 correct for 1 mark total [2]	

Question	Answer	Marks
6(a)(i)		1
6(a)(ii)	$\text{HNO}_3 + 2\text{H}_2\text{SO}_4 \rightarrow \text{H}_3\text{O}^+ + \text{NO}_2^+ + 2\text{HSO}_4^-$	1
6(a)(iii)	any three from: Point 1: bonds/electrons are partially delocalised in T or delocalised / π system / π bonding extends over only five carbons Point 2: four π-electrons in the (delocalised system of T) or methylbenzene has (two) more π-electrons / (two) more delocalised electrons Point 3: contains a carbon that is sp^3 hybridised in T or (all the) carbons are sp^2 hybridised in methylbenzene Point 4: one carbon has a bond angle of 109.5° / tetrahedral (in T) or (C-C) bond strengths / lengths are not all the same or not all the bond angles are 120° (in T)	3
6(b)(i)	4-aminobenzoic acid	1
6(b)(ii)	step 1 $\text{Sn} + \text{HCl}$ [1] concentrated / reflux / heat [1] step 2 CH_3COCl [1] step 3 KMnO_4 / manganate(<u>VII</u>) / MnO_4^- (acidified / alkaline) and heat [1] step 4 aqueous HCl and heat [1] step 5 ethanol, H_2SO_4, concentrated / reflux / heat [1]	6

Question	Answer	Marks																				
6(c)	(benzocaine) is less (basic than ethylamine) AND lone pair (on N) is less available to accept a proton / H⁺ since (lone pair on N) is delocalised over the ring or phenyl ring is electron withdrawing group OR ethylamine is more basic (than benzocaine) AND lone pair (on N) is more available to accept a proton / H⁺ since ethyl/alkyl group is electron-donating group	2																				
6(d)(i)	7 peaks	1																				
6(d)(ii)	CDCl ₃ will produce no signal in the spectrum or CHCl ₃ would produce a signal / would be detected	1																				
6(d)(iii)	<table><tr><td><i>δ/ppm</i></td><td>group responsible for the peak</td><td>number of H atoms responsible for the peak</td><td>splitting pattern</td></tr><tr><td>1.2</td><td>CH₍₃₎</td><td>3</td><td>triplet</td></tr><tr><td>3.5</td><td>CH₍₂₎O</td><td>2</td><td>quartet</td></tr><tr><td>5.5</td><td>NH₂</td><td>2</td><td>singlet (broad)</td></tr><tr><td>7.1–7.4</td><td>H attached to aromatic / benzene ring</td><td>4</td><td><i>multiplet</i></td></tr></table>	<i>δ/ppm</i>	group responsible for the peak	number of H atoms responsible for the peak	splitting pattern	1.2	CH ₍₃₎	3	triplet	3.5	CH ₍₂₎ O	2	quartet	5.5	NH ₂	2	singlet (broad)	7.1–7.4	H attached to aromatic / benzene ring	4	<i>multiplet</i>	4
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5.5	NH ₂	2	singlet (broad)																			
7.1–7.4	H attached to aromatic / benzene ring	4	<i>multiplet</i>																			
6(d)(iv)	neighbouring / adjacent carbon atom has two protons / H (attached to it) or there is an adjacent CH ₂ (O) group	1																				
6(d)(v)	peak at 5.5 / NH ₂ peak will disappear and NH ₂ / protons exchange / swap with deuterium	1																				

Question	Answer	Marks
6(e)(i)	$\text{NaNO}_2 + \text{HCl}$ or HNO_2	1
6(e)(ii)	 R  S	
	structure of diazonium salt R	1
	structure of azo dye S	1

Question	Answer	Marks
7(a)	Fe atom = $(1s^2 2s^2 2p^6) 3s^2 3p^6 3d^6 4s^2$ Fe ³⁺ ion = $(1s^2 2s^2 2p^6) 3s^2 3p^6 3d^5$	1
7(b)	$([H^+]^2 = 8.9 \times 10^{-4} \times 0.25 \text{ or } 2.225 \times 10^{-4})$ $[H^+] = 0.0149$	1
	pH = $-\log(0.0149) = 1.83$	1
7(c)(i)	(K_{stab} is) the equilibrium constant for the formation of a complex (ion) (in a solvent from its constituent ions / molecules)	1
7(c)(ii)	$[\text{Fe}(\text{H}_2\text{O})_5\text{F}]^{2+}$ and $[\text{Hg}(\text{H}_2\text{O})_5\text{Cl}]^+$	1
7(d)	$K_{\text{stab}} = \frac{[\text{Fe}(\text{ed})_2\text{Cl}_2^{3-}]}{[\text{Fe}(\text{H}_2\text{O})_4\text{Cl}_2^+][\text{ed}]^2}$	1
	mol ⁻² dm ⁶	1
7(e)(i)	 cis cis trans	3

Question	Answer	Marks
7(e)(ii)	any cis isomer and the trans isomer identified	1
7(e)(iii)	both correct cis isomers identified	1
7(e)(iv)	trans isomer identified	1