

CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International Advanced Level

MARK SCHEME for the October/November 2015 series

9701 CHEMISTRY

9701/41

Paper 4 (A2 Structured Questions), maximum raw mark 100

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Page 2	Mark Scheme	Syllabus	Paper
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Question	Marking point	Marks
1 (a)	Ca $3s^2 3p^6 4s^2$ and Ca ²⁺ $3s^2 3p^6$	1
(b)	Ca(OH) ₂ + 2HNO ₃ → Ca(NO ₃) ₂ + 2H ₂ O or CaO + 2HNO ₃ → Ca(NO ₃) ₂ + H ₂ O	1
(c) (i)	CaO and brown gas	1
(ii)	the (cat)ion size / radii increases decreasing its ability to polarise the nitrate ion / N-O bond	2
(d) (i)	(energy change when) 1 mole of ions gaseous (ions) dissolve in water (to form an infinitely dilute solution) or gaseous (ions) form an aqueous solution	2
(ii)	$\Delta H_{\text{latt}}^{\ominus} \text{Ca(NO}_3)_2 + \Delta H_{\text{sol}}^{\ominus} \text{Ca(NO}_3)_2 = \Delta H_{\text{hyd}}^{\ominus} \text{Ca}^{2+} + 2\Delta H_{\text{hyd}}^{\ominus} \text{NO}_3^-$ $\Delta H_{\text{latt}}^{\ominus} - 19 = -1650 + (2x - 314)$ $-2259 \text{ kJ mol}^{-1}$	3
1	Ca ⁽²⁺⁾ is a smaller (ion) or Ca ⁽²⁺⁾ has a larger charge density Ca ⁽²⁺⁾ has a stronger attraction / bond to H ₂ O	2
		12

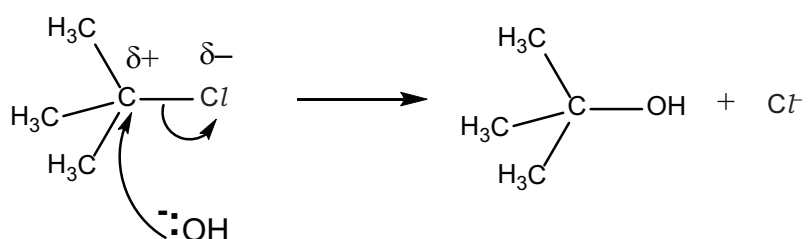
Page 3	Mark Scheme	Syllabus	Paper
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Question	Marking point	Marks																
2 (a)	<table><tr><td>Na</td><td>Mg</td><td>Al</td><td>Si</td><td>P</td><td>S</td><td>Cl</td><td>Ar</td></tr><tr><td>1</td><td>0</td><td>1</td><td>2</td><td>3</td><td>2</td><td>1</td><td>0</td></tr></table>	Na	Mg	Al	Si	P	S	Cl	Ar	1	0	1	2	3	2	1	0	3
	Na	Mg	Al	Si	P	S	Cl	Ar										
	1	0	1	2	3	2	1	0										
(b) (i)	SiCl ₄ white solid /ppt or misty /white / steamy fumes pH 0–3 PCl ₅ misty /white / steamy fumes pH 0–3	3																
(ii)	SiCl ₄ + 2H ₂ O → SiO ₂ + 4HCl	1																
		<u>7</u>																

Page 4	Mark Scheme	Syllabus	Paper
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Question	Marking point	Marks															
3 (a)	forms (one or more) ions with incomplete d orbital(s)/sub-shells/shells	1															
(b) (i)	dative (covalent) or co-ordinate	1															
(ii)	<table border="1"> <thead> <tr> <th>species</th><th>can act as a ligand</th><th>cannot act as a ligand</th></tr> </thead> <tbody> <tr> <td>NO₃⁻</td><td>✓</td><td></td></tr> <tr> <td>BF₃</td><td></td><td>✓</td></tr> <tr> <td>H₂NCH₂CH₂NH₂</td><td>✓</td><td></td></tr> <tr> <td>NH₄⁺</td><td></td><td>✓</td></tr> </tbody> </table>	species	can act as a ligand	cannot act as a ligand	NO ₃ ⁻	✓		BF ₃		✓	H ₂ NCH ₂ CH ₂ NH ₂	✓		NH ₄ ⁺		✓	2
species	can act as a ligand	cannot act as a ligand															
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(c) (i)	<table border="1"> <thead> <tr> <th></th><th>formula of manganese species formed</th><th>type of reaction</th></tr> </thead> <tbody> <tr> <td>Mn²⁺ (aq) + NaOH (aq)</td><td>Mn(OH)₂ Mn(H₂O)₄(OH)₂ Mn(OH)₃</td><td>precipitation</td></tr> <tr> <td>Mn²⁺ (aq) + concentrated HCl</td><td>MnCl₄²⁻ MnCl₆⁴⁻</td><td>ligand exchange / substitution</td></tr> <tr> <td>Mn²⁺ (aq) + aqueous H₂O₂</td><td>Mn³⁺</td><td>redox / oxidation</td></tr> </tbody> </table>		formula of manganese species formed	type of reaction	Mn ²⁺ (aq) + NaOH (aq)	Mn(OH) ₂ Mn(H ₂ O) ₄ (OH) ₂ Mn(OH) ₃	precipitation	Mn ²⁺ (aq) + concentrated HCl	MnCl ₄ ²⁻ MnCl ₆ ⁴⁻	ligand exchange / substitution	Mn ²⁺ (aq) + aqueous H ₂ O ₂	Mn ³⁺	redox / oxidation	5			
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		9															

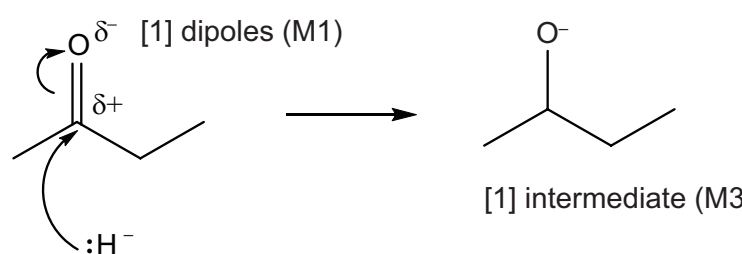
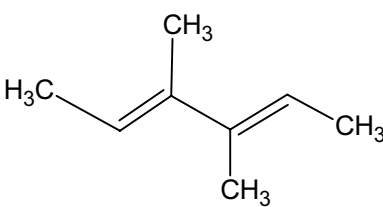
Page 5	Mark Scheme	Syllabus	Paper
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Question	Marking point	Marks
4 (a)	M1: dipole on C–Cl bond M2: curly arrow breaking C–Cl bond M3: curly arrow from the oxygen on OH^- (lone pair needs to be shown) to carbon in C–Cl bond and Cl^- (ion) formed in the mechanism 	3
(b) (i)	time taken for the concentration of a reactant(s) to fall to half its original value	1
(ii)	evidence of a pair of construction lines on graph and $t_{1/2} = 49\text{--}53\text{ s}$	1
(iii)	no effect/change	1
(c) (i)	evidence of tangent at 80 s and data used, e.g. $0.42 / 152 = 0.00263$ units $\text{mol dm}^{-3} \text{s}^{-1}$	2
(ii)	correct use of answer to (i)/0.19 and s^{-1}	1
		<u>9</u>

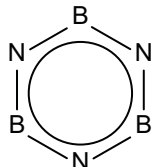
Page 6	Mark Scheme	Syllabus	Paper
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Question	Marking point	Marks
5 (a) (i)	M1: salt bridge and voltmeter/ M2: method of H ₂ gas delivery M3: X and Pt electrode labelled M4: solution H ⁺ /HCl(aq)/H ₂ SO ₄ and X ²⁺ labelled	4
(ii)	25 °C/298 K and 1 atm/101 kPa pressure and 1 mol dm ⁻³ (solution)	1
(iii)	solution – ions or H ⁺ and X ²⁺ and wires – electrons/e ⁻	1
(b) (i)	$X + 2Ag^+ \rightarrow 2Ag + X^{2+}$	1
(ii)	moles Ag = 1.30 / 107.9 = 0.0120 1 moles of X react with 2 moles Ag ⁺ moles of X lost = 0.012 × 0.5 = 0.00602 A _r of X = 0.67/0.006 = 111–112 and X = Cd	4
		<u>11</u>

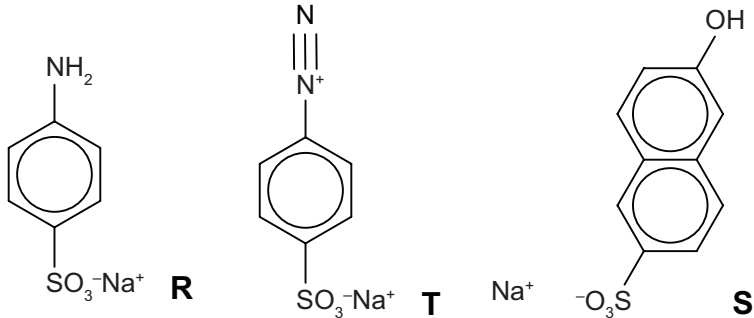
Page 7	Mark Scheme	Syllabus	Paper
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Question	Marking point	Marks
6 (a)	$4\text{BF}_3 + 3\text{NaBH}_4 \rightarrow 2\text{B}_2\text{H}_6 + 3\text{NaBF}_4$	1
(b)	 [1] dipoles (M1) [1] both curly arrows (M2) arrow <u>must</u> come from lone pair [1] intermediate (M3)	3
(c) (i)	(electrophilic) addition	1
(ii)		1

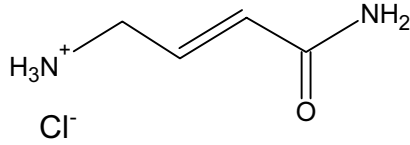
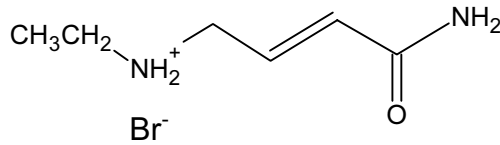
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Question	Marking point	Marks
(d) (i)	<i>any four of</i> M1: σ-bonds between C–C or C–H M2: π-bonds formed from overlap of p-orbitals M3: (π-bonds/electrons) above and below the ring M4: bonds/electrons are delocalised M5: bond angle 120° M6: intermediate C–C bond length / all C–C same length / strength M7: carbons are sp^2 hybridised	3
(ii)	correct delocalised structure of borazine 	1
		10

Page 9	Mark Scheme	Syllabus	Paper
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Question	Marking point	Marks
7 (a) (i)	 R T S	3
(ii)	Sn + HCl HNO₂ or NaNO₂ + HCl step 1 (linked to a reduction) reflux/heat/>50 °C or conc/6M (HCl) and step 2 ≤10 °C	3
(iii)	diazonium (group)	1
(b) (i)	σ-bonds = 14 π-bonds = 2	2

Page 10	Mark Scheme	Syllabus	Paper
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Question	Marking point			Marks
7	reagent	structure of product	type of reaction	3
	HCl		acid-base or neutralisation	
	CH ₃ CH ₂ Br		(nucleophilic) substitution	
				<u>12</u>

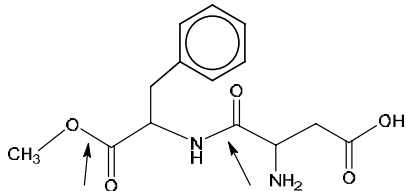
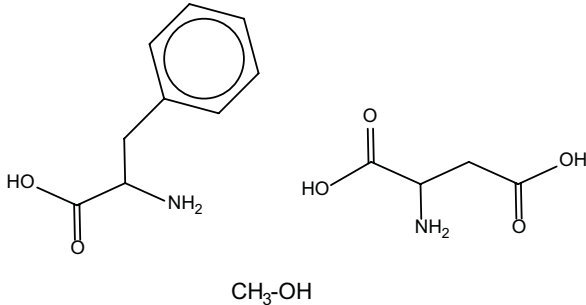
Page 11	Mark Scheme	Syllabus	Paper
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Question	Marking point	Marks
8 (a) (i)	A = mRNA B ₁ and B ₂ , etc. = tRNA or tRNA-amino acid complex	2
(ii)	stage 1 = transcription and stage 3= translation	1
(b) (i)	C ₅ H ₅ N ₅	1
(ii)	cytosine, thymine, guanine	1
(iii)	covalent hydrogen bonding	2
(c)	hydrolysis	1
(d) (i)	Phosphorus / P	1
(ii)	H atoms have insufficient electron density or electrons (to show up) or H atoms contain one e ⁻	1
		<u>10</u>

Page 12	Mark Scheme	Syllabus	Paper
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Question	Marking point	Marks
9 (a)	iron/Fe (= haemoglobin) sodium/Na or potassium/K (= transmission of nerve impulses) Zn or Cu or Mg or Mn or Mo or Ni or Fe or Co (= enzyme co-factor)	2
(b)	any three of: M1: substrate binds to/fits into the active site of the enzyme M2: Interaction with site causes a specific bond to be weakened, (which breaks) M3: lowers activation energy M4: products released from the enzyme/active site	3
(c) (i)	Tertiary	1
(ii)	$2 -SH \rightarrow -S - S- (+ 2H)$	1
(iii)	oxidation	1
(d) (i)	E = CH and F = CH ₂	1
(ii)	E = triplet and adjacent 2H F = doublet and adjacent 1H	2
		<u>11</u>
10 (a) (i)		1

Page 13	Mark Scheme	Syllabus	Paper
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Question	Marking point	Marks
(ii)		2
(iii)		3
(b)	M1: hydrogen bonding M2: between the NH ₂ groups and water or CO ₂ /C=O/-OH groups and water (allow names) or lone pair on N/O with water	2
(c)	allow range 1–200 nm or 1–200 × 10 ⁻⁹ m	1
		<u>9</u>