

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 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
		<u>12</u>

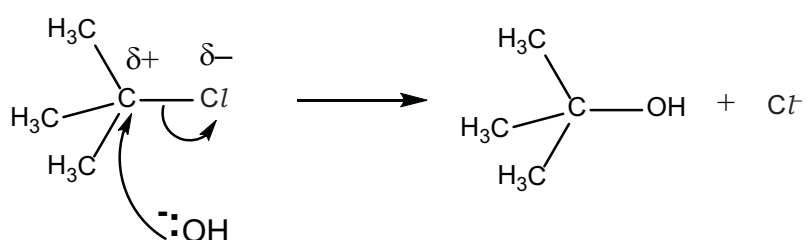
Page 3	Mark Scheme	Syllabus	Paper
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Question	Marking point	Marks																
2 (a)	<table border="1"> <tr> <td>Na</td> <td>Mg</td> <td>Al</td> <td>Si</td> <td>P</td> <td>S</td> <td>Cl</td> <td>Ar</td> </tr> <tr> <td>1</td> <td>0</td> <td>1</td> <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																
		7																

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) <i>or</i> 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
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NH ₄ ⁺		✓															
(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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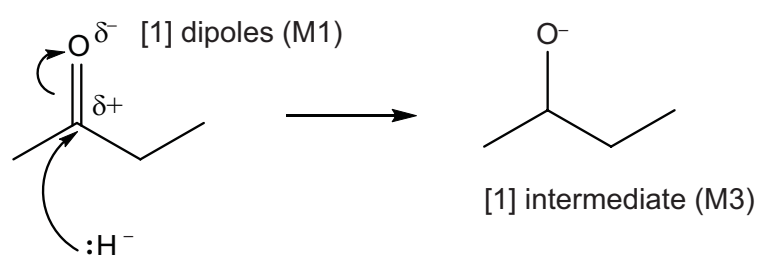
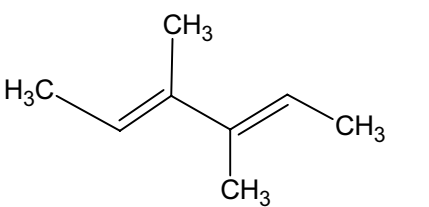
Page 5	Mark Scheme	Syllabus	Paper
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Question	Marking point	Marks
4 (a)	<p>M1: dipole on C–Cl bond</p> <p>M2: curly arrow breaking C–Cl bond</p> <p>M3: curly arrow from the oxygen on OH^- (lone pair needs to be shown) to carbon in C–Cl bond and Cl^- (ion) formed in the mechanism</p> 	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>

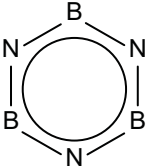
Page 6	Mark Scheme	Syllabus	Paper
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Question	Marking point	Marks
5 (a) (i)	M1: salt bridge and voltmeter/ M2: method of H ₂ gas delivery M3: X and Pt electrode labelled M4: solution H ⁺ /HCl(aq)/H ₂ SO ₄ and X ²⁺ labelled	4
(ii)	25 °C/298 K and 1 atm/101 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>

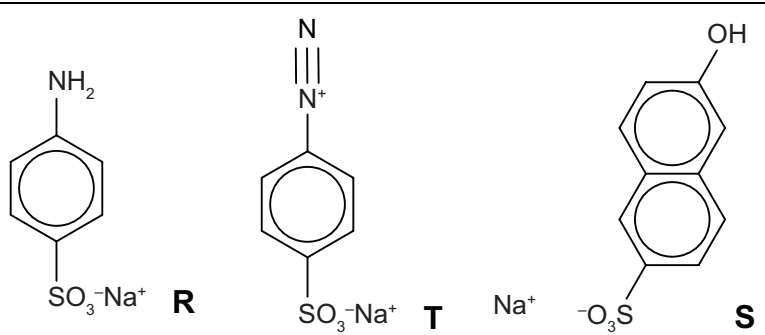
Page 7	Mark Scheme	Syllabus	Paper
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Question	Marking point	Marks
6 (a)	$4\text{BF}_3 + 3\text{NaBH}_4 \rightarrow 2\text{B}_2\text{H}_6 + 3\text{NaBF}_4$	1
(b)	 <p>[1] dipoles (M1)</p> <p>[1] intermediate (M3)</p> <p>[1] both curly arrows (M2) arrow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

Page 8	Mark Scheme	Syllabus	Paper
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Question	Marking point	Marks
(d) (i)	<p>any four of</p> <p>M1: σ-bonds between C–C or C–H</p> <p>M2: π-bonds formed from overlap of p-orbitals</p> <p>M3: (π-bonds/electrons) above and below the ring</p> <p>M4: bonds/electrons are delocalised</p> <p>M5: bond angle 120°</p> <p>M6: intermediate C–C bond length / all C–C same length / strength</p> <p>M7: carbons are sp^2 hybridised</p>	3
(ii)	<p>correct delocalised structure of borazine</p> 	1
		10

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Question	Marking point	Marks
7 (a) (i)		3
(ii)	<p>$\text{Sn} + \text{HCl}$</p> <p>HNO_2 or $\text{NaNO}_2 + \text{HCl}$</p> <p>step 1 (linked to a reduction) reflux/heat/$>50\text{ }^\circ\text{C}$ or conc/6M (HCl) and step 2 $\leq 10\text{ }^\circ\text{C}$</p>	3
(iii)	diazonium (group)	1
(b) (i)	<p>σ-bonds = 14</p> <p>π-bonds = 2</p>	2

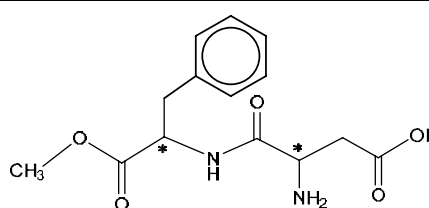
Page 10	Mark Scheme	Syllabus	Paper
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Question	Marking point	Marks									
7	<table border="1"> <thead> <tr> <th>reagent</th> <th>structure of product</th> <th>type of reaction</th> </tr> </thead> <tbody> <tr> <td>HCl</td> <td> </td> <td>acid-base or neutralisation</td> </tr> <tr> <td>CH₃CH₂Br</td> <td> </td> <td>(nucleophilic) substitution</td> </tr> </tbody> </table>	reagent	structure of product	type of reaction	HCl		acid-base or neutralisation	CH ₃ CH ₂ Br		(nucleophilic) substitution	3
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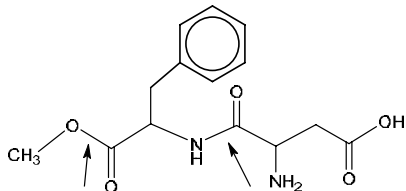
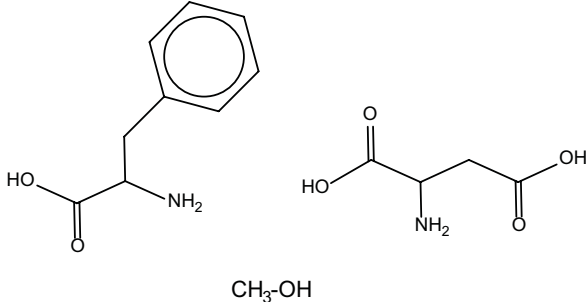
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Question	Marking point	Marks
8 (a) (i)	A = mRNA B ₁ and B ₂ , etc. = tRNA or tRNA-amino acid complex	2
(ii)	stage 1 = transcription and stage 3= translation	1
(b) (i)	C ₅ H ₅ N ₅	1
(ii)	cytosine, thymine, guanine	1
(iii)	covalent hydrogen bonding	2
(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>

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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 = CH₂	1
(ii)	E = triplet and adjacent 2H F = doublet and adjacent 1H	2
		<u>11</u>
10 (a) (i)		1

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Question	Marking point	Marks
(ii)	 <p>The diagram shows a chemical structure of a dipeptide derivative. On the left, a methyl ester group (CH₃O-C(=O)-) is attached to a carbon atom. This carbon is also bonded to a hydrogen atom and a benzyl group (a CH₂ group attached to a benzene ring). This carbon is further bonded to a nitrogen atom (NH) which is part of an amide linkage (-C(=O)-). This amide nitrogen is bonded to a hydrogen atom and a CH₂ group. This CH₂ group is bonded to another carbon atom, which is also bonded to a hydrogen atom and an amino group (-NH₂). This carbon is further bonded to a CH₂ group, which is finally bonded to a carboxylic acid group (-COOH). Two arrows point to the oxygen atom of the ester group and the hydrogen atom of the amide group.</p>	2
(iii)	 <p>The diagram shows three chemical structures. On the left is a dipeptide derivative: a benzyl group is attached to a CH₂ group, which is attached to a carbon atom bonded to a hydrogen atom, an amino group (-NH₂), and a carboxylic acid group (-COOH). In the middle is the constituent amino acid glycine: a CH₂ group is attached to a carbon atom bonded to a hydrogen atom, an amino group (-NH₂), and a carboxylic acid group (-COOH). On the right is the constituent amino acid phenylalanine: a benzene ring is attached to a CH₂ group, which is attached to a carbon atom bonded to a hydrogen atom, an amino group (-NH₂), and a carboxylic acid group (-COOH). Below the structures is the chemical formula CH₃-OH.</p>	3
(b)	<p>M1: hydrogen bonding M2: between the NH₂ groups and water or CO₂/C=O/-OH groups and water (allow names) or lone pair on N/O with water</p>	2
(c)	allow range 1–200 nm or 1–200 × 10 ⁻⁹ m	1
		<u>9</u>