

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

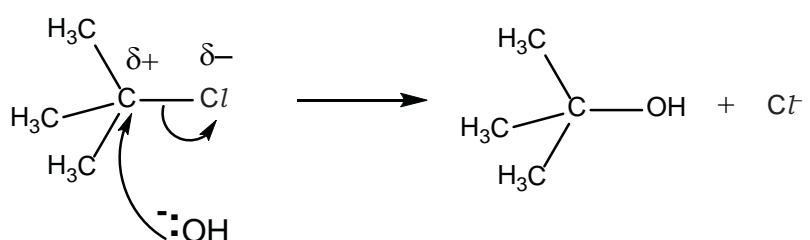
<b>Page 3</b>	<b>Mark Scheme</b>	<b>Syllabus</b>	<b>Paper</b>
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<b>Question</b>	<b>Marking point</b>	<b>Marks</b>																
<b>2 (a)</b>	<table border="1"> <tr> <td>Na</td> <td>Mg</td> <td>Al</td> <td>Si</td> <td>P</td> <td>S</td> <td>Cl</td> 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

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

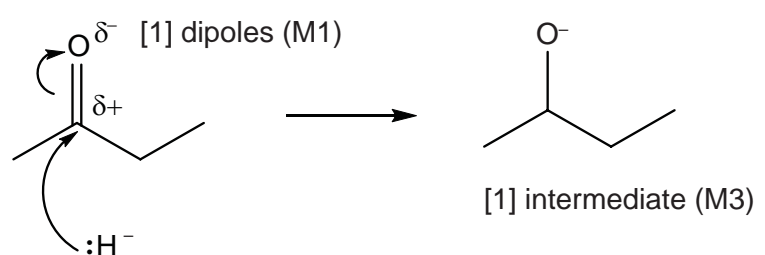
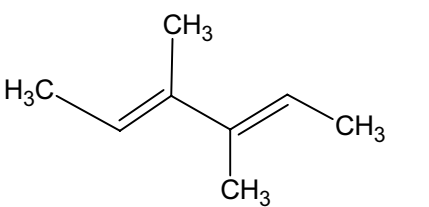
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Question	Marking point	Marks
4 (a)	<p>M1: dipole on C–Cl bond</p> <p>M2: curly arrow breaking C–Cl bond</p> <p>M3: curly arrow from the oxygen on <math>\text{OH}^-</math> (lone pair needs to be shown) to carbon in C–Cl bond <b>and</b> <math>\text{Cl}^-</math> (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 <b>and</b> $t_{1/2} = 49\text{--}53\text{ s}$	1
(iii)	no effect/change	1
(c) (i)	evidence of tangent at 80 s <b>and</b> 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 <b>and</b> $\text{s}^{-1}$	1
		<u>9</u>

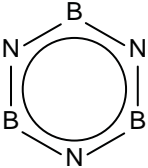
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<b>Question</b>	<b>Marking point</b>	<b>Marks</b>
<b>5 (a) (i)</b>	M1: salt bridge <b>and</b> voltmeter/ M2: method of H <sub>2</sub> gas delivery M3: X <b>and</b> Pt electrode labelled M4: solution H <sup>+</sup> /HCl(aq)/H <sub>2</sub> SO <sub>4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

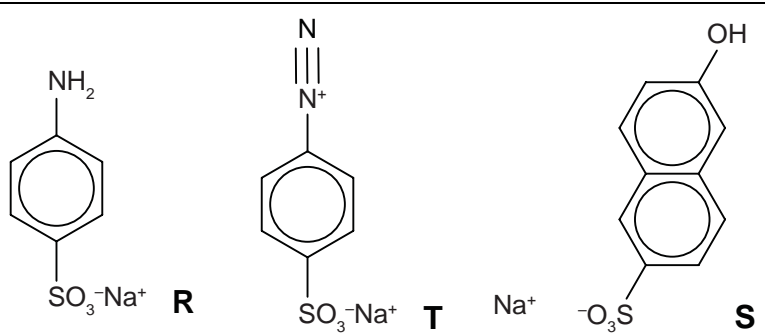
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Question	Marking point	Marks
6 (a)	$4\text{BF}_3 + 3\text{NaBH}_4 \rightarrow 2\text{B}_2\text{H}_6 + 3\text{NaBF}_4$	1
(b)	 <p>[1] dipoles (M1)</p> <p>[1] intermediate (M3)</p> <p>[1] both curly arrows (M2) arrow <u>must</u> come from lone pair</p>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

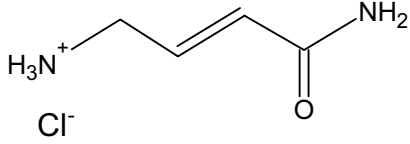
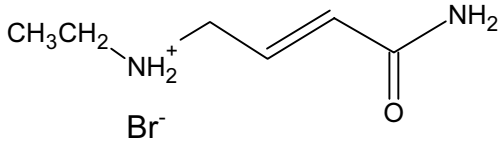
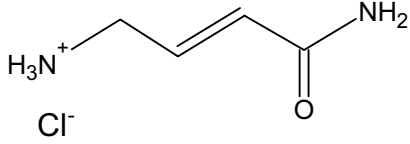
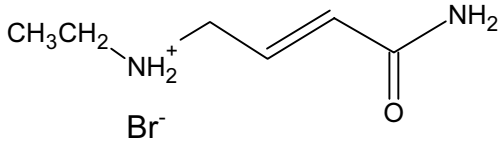
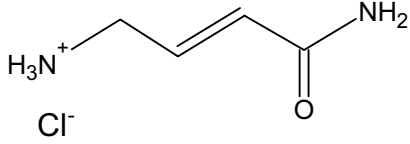
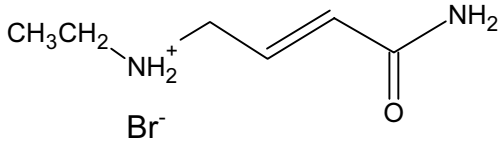
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<b>Question</b>	<b>Marking point</b>	<b>Marks</b>
<b>(d) (i)</b>	<p><i>any four of</i></p> <p>M1: <math>\sigma</math>-bonds between C–C <b>or</b> C–H</p> <p>M2: <math>\pi</math>-bonds formed from overlap of p-orbitals</p> <p>M3: (<math>\pi</math>-bonds/electrons)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

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Question	Marking point	Marks
7 (a) (i)	 <p> <chem>Nc1ccc(S(=O)(=O)[Na])cc1</chem> <b>R</b>     <chem>[N+]#Nc1ccc(S(=O)(=O)[Na])cc1</chem> <b>T</b>     <chem>[Na+].[O-]S(=O)(=O)c1ccc2cc(O)ccc2c1</chem> <b>S</b> </p>	3
(ii)	<p>Sn + HCl</p> <p>HNO<sub>2</sub> or NaNO<sub>2</sub> + HCl</p> <p>step 1 (linked to a reduction) reflux/heat/&gt;50 °C <b>or</b> conc/6M (HCl)  <b>and</b> step 2 ≤10 °C</p>	3
(iii)	diazonium (group)	1
(b) (i)	<p>σ-bonds = 14</p> <p>π-bonds = 2</p>	2

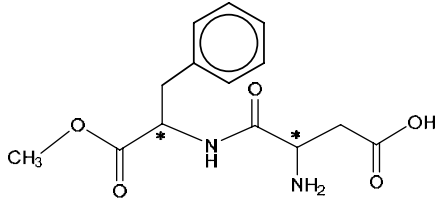
Page 10	Mark Scheme	Syllabus	Paper
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Question	Marking point	Marks									
7	<table border="1"> <thead> <tr> <th>reagent</th> <th>structure of product</th> <th>type of reaction</th> </tr> </thead> <tbody> <tr> <td>HCl</td> <td>  </td> <td>acid-base or neutralisation</td> </tr> <tr> <td>CH<sub>3</sub>CH<sub>2</sub>Br</td> <td>  </td> <td>(nucleophilic) substitution</td> </tr> </tbody> </table>	reagent	structure of product	type of reaction	HCl		acid-base or neutralisation	CH <sub>3</sub> CH <sub>2</sub> Br		(nucleophilic) substitution	3
reagent	structure of product	type of reaction									
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Question	Marking point	Marks
8 (a) (i)	<b>A</b> = mRNA <b>B</b> <sub>1</sub> and <b>B</b> <sub>2</sub> , etc. = tRNA <b>or</b> tRNA-amino acid complex	2
(ii)	stage 1 = transcription <b>and</b> stage 3= translation	1
(b) (i)	C <sub>5</sub> H <sub>5</sub> N <sub>5</sub>	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 <b>or</b> electrons (to show up) <b>or</b> H atoms contain one e <sup>-</sup>	1
		<b>10</b>

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Question	Marking point	Marks
9 (a)	iron/Fe (= haemoglobin) sodium/Na <b>or</b> potassium/K (= transmission of nerve impulses) Zn <b>or</b> Cu <b>or</b> Mg <b>or</b> Mn <b>or</b> Mo <b>or</b> Ni <b>or</b> Fe <b>or</b> Co (= enzyme co-factor)	2
(b)	any three of: M1: substrate binds to/fits into the <b>active site</b> 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)	<b>E = CH and F = CH<sub>2</sub></b>	1
(ii)	<b>E = triplet and adjacent 2H</b> <b>F = doublet and adjacent 1H</b>	2
		<b>11</b>
10 (a) (i)		1

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Question	Marking point	Marks
(ii)		2
(iii)	<p>CH<sub>3</sub>-OH</p>	3
(b)	<p>M1: hydrogen bonding  M2: between the NH<sub>2</sub> groups and water  or CO<sub>2</sub>/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 <sup>-9</sup> m	1
		<u>9</u>