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**CHEMISTRY**

**9701/41**

Paper 4 A Level Structured Questions

**October/November 2018**

MARK SCHEME

Maximum Mark: 100

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**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 2018 series for most Cambridge IGCSE™, Cambridge International A and AS Level components and some Cambridge O Level components.

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This document consists of **14** printed pages.

**PUBLISHED****Generic Marking Principles**

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptors for a question. Each question paper and mark scheme will also comply with these marking principles.

**GENERIC MARKING PRINCIPLE 1:**

Marks must be awarded in line with:

- the specific content of the mark scheme or the generic level descriptors for the question
- the specific skills defined in the mark scheme or in the generic level descriptors for the question
- the standard of response required by a candidate as exemplified by the standardisation scripts.

**GENERIC MARKING PRINCIPLE 2:**

Marks awarded are always **whole marks** (not half marks, or other fractions).

**GENERIC MARKING PRINCIPLE 3:**

Marks must be awarded **positively**:

- marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate
- marks are awarded when candidates clearly demonstrate what they know and can do
- marks are not deducted for errors
- marks are not deducted for omissions
- answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.

**GENERIC MARKING PRINCIPLE 4:**

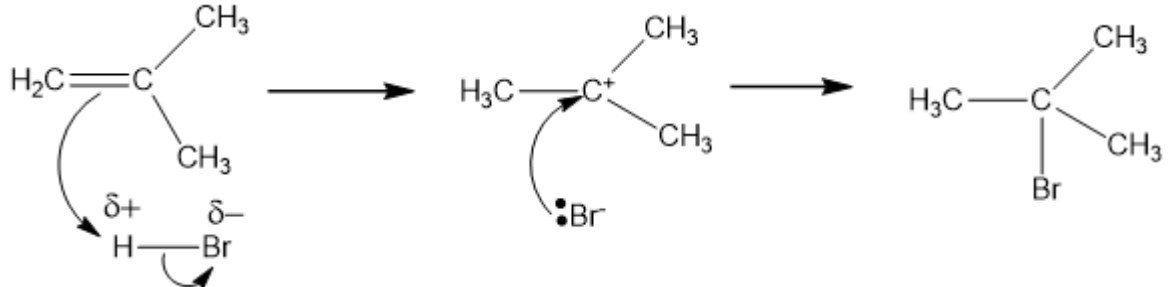
Rules must be applied consistently e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors.

**GENERIC MARKING PRINCIPLE 5:**

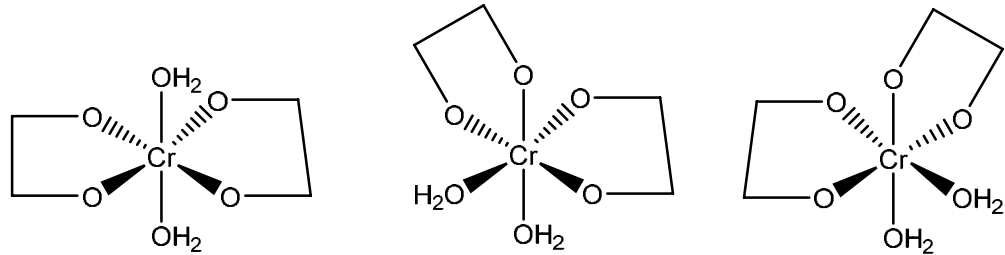
Marks should be awarded using the full range of marks defined in the mark scheme for the question (however; the use of the full mark range may be limited according to the quality of the candidate responses seen).

**GENERIC MARKING PRINCIPLE 6:**

Marks awarded are based solely on the requirements as defined in the mark scheme. Marks should not be awarded with grade thresholds or grade descriptors in mind.

Question	Answer			Marks
1(a)(i)	peak	organic compound	explanation	2
X	alkane	London forces <b>only</b> <b>OR</b> no hydrogen bonding		
Y	aldehyde	(Permanent dipole-dipole and London forces)		
Z	carboxylic acid	(contains) hydrogen bonding		
<p><b>M1</b> peak assignments [1] <b>M2</b> explanation of <b>Z OR X</b> [1]</p>				
1(a)(ii)	% of <b>Z</b> = 47/98 = <b>48%</b>			1
1(b)(i)	<sup>37</sup> Cl and <sup>81</sup> Br			1
1(b)(ii)	<p>M peak CH<sub>2</sub><sup>35</sup>Cl<sup>79</sup>Br  M+2 peak CH<sub>2</sub><sup>37</sup>Cl<sup>79</sup>Br <b>OR</b> CH<sub>2</sub><sup>35</sup>Cl<sup>81</sup>Br  M+4 peak CH<sub>2</sub><sup>37</sup>Cl<sup>81</sup>Br  two correct scores 1 mark  all 3 correct scores 2 marks</p>			2
1(c)(i)	 <p><b>M1</b> correct dipole on HBr <b>AND</b> any correct curly arrow [1]  <b>M2</b> two <b>other</b> correct curly arrows <b>AND</b> lone pair required on Br<sup>-</sup> [1]  <b>M3</b> intermediate [1]</p>			3

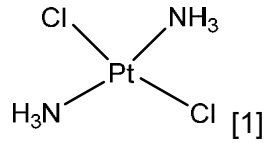
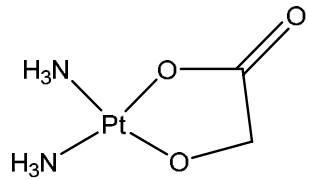
Question	Answer	Marks
1(c)(ii)	(major product is) formed via the most <b>stable tertiary carbocation / intermediate</b> <b>OR tertiary</b> halogenoalkane formed via more <b>stable carbocation / intermediate</b>	1
1(d)(i)	<b>M1 ratio</b> of the concentrations of <b>solute</b> in two (immiscible) solvents [1] <b>M2</b> at equilibrium [1]	2
1(d)(ii)	$K_{\text{partition}} = (x/10)/(1.25-x/50)$ [1] $4.75(1.25-x) = 5x$ $x = 5.9375/9.75 = \mathbf{0.61 \text{ g}}$ [1] correct answer scores [2]	2

Question	Answer	Marks
2(a)	species that forms <b>dative bond(s)</b> to a (central) <b>metal atom / ion</b>	1
2(b)	 <p>any two structures [1] × 2</p>	2
2(c)(i)	$K_{\text{sp}} = [\text{Ca}^{2+}][\text{C}_2\text{O}_4^{2-}]$ [1] units $\text{mol}^2 \text{dm}^{-6}$ [1]	2
2(c)(ii)	$[\text{Ca}^{2+}] = [\text{C}_2\text{O}_4^{2-}] = 6.65 \times 10^{-3}/128.1 = 5.19 \times 10^{-5} \text{ mol dm}^{-3}$ [1] $K_{\text{sp}} = (5.19 \times 10^{-5})^2 = \mathbf{2.7 \times 10^{-9} \text{ mol}^2 \text{dm}^{-6}}$ [1]	2

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Question	Answer	Marks															
3(a)	<p>[1] for each column</p> <table border="1" data-bbox="403 319 969 679"> <thead> <tr> <th data-bbox="403 319 591 416">element</th> <th colspan="2" data-bbox="591 319 969 416">number of unpaired electrons in</th> </tr> <tr> <th data-bbox="403 416 591 483"></th> <th data-bbox="591 416 781 483">3d</th> <th data-bbox="781 416 969 483">4s</th> </tr> </thead> <tbody> <tr> <td data-bbox="403 483 591 550">Cr</td> <td data-bbox="591 483 781 550">5</td> <td data-bbox="781 483 969 550">1</td> </tr> <tr> <td data-bbox="403 550 591 617">Mn</td> <td data-bbox="591 550 781 617">5</td> <td data-bbox="781 550 969 617">0</td> </tr> <tr> <td data-bbox="403 617 591 684">Fe</td> <td data-bbox="591 617 781 684">4</td> <td data-bbox="781 617 969 684">0</td> </tr> </tbody> </table>	element	number of unpaired electrons in			3d	4s	Cr	5	1	Mn	5	0	Fe	4	0	2
element	number of unpaired electrons in																
	3d	4s															
Cr	5	1															
Mn	5	0															
Fe	4	0															
3(b)	$2\text{KMnO}_4 \rightarrow \text{K}_2\text{MnO}_4 + \text{O}_2 + \text{MnO}_2$ formulae of $\text{K}_2\text{MnO}_4$ and $\text{O}_2$ [1] rest of the equation [1]	2															
3(c)	<b>M1</b> d orbitals split into two levels / lower and upper orbitals [1] <b>M2</b> visible light is <b>absorbed</b> and the complementary colour observed [1] <b>M3</b> electron(s) promoted / excited [1]	3															
3(d)(i)	precipitate <b>A</b> $[\text{Cu}(\text{H}_2\text{O})_4(\text{OH})_2]$ <b>OR</b> $\text{Cu}(\text{OH})_2$ [1] solution <b>B</b> $[\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+}$ [1] solution <b>C</b> $\text{Cu}(\text{CH}_3\text{CO}_2)_2$ [1]	3															
3(d)(ii)	$\text{Na}_2\text{CO}_3$ <b>or</b> $\text{CO}_3^{2-}$	1															
3(d)(iii)	$\text{CuCO}_3 + 2\text{CH}_3\text{CO}_2\text{H} \rightarrow \text{Cu}(\text{CH}_3\text{CO}_2)_2 + \text{CO}_2 + \text{H}_2\text{O}$	1															
3(d)(iv)	any <b>two</b> for one mark <ul style="list-style-type: none"> <li>• fizzing / bubbles / effervescence</li> <li>• solid <b>disappears</b></li> <li>• green / blue solution (formed)</li> </ul>	1															

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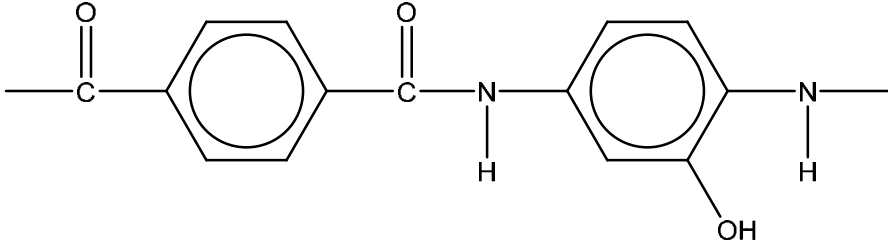
Question	Answer	Marks
3(e)	sum of the charges of the (four) ligands equals the oxidation number / charge of Pt <b>OR</b> a calculation Pt +2, NH <sub>3</sub> neutral / no charge, both Cl <sup>-</sup> 's -1 (so no overall charge)	1
3(f)(i)	 <p>square planar <b>and</b> 180° [1]</p>	2
3(f)(ii)	<b>M1</b> this can <b>bond / bind</b> with <b>DNA</b> [1] <b>M2</b> which prevents replication of the DNA / strand <b>OR</b> prevents cell division [1]	2
3(g)		1

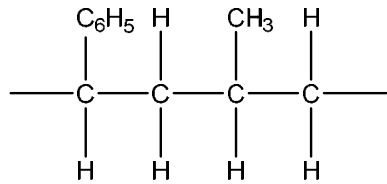
Question	Answer	Marks
4(a)	<b>M1</b> solubility decreases (down the Group) [1] <b>M2</b> because lattice energy and hydration energy <b>decreases</b> <b>OR</b> lattice energy and hydration energy become <b>less exothermic / more endothermic</b> [1] <b>M3</b> because hydration energy decreases to a <b>greater extent</b> (than does $\Delta H_{\text{Latt}}$ ) [1]	3
4(b)(i)	$(K_w = ) [H^+][OH^-]$	1

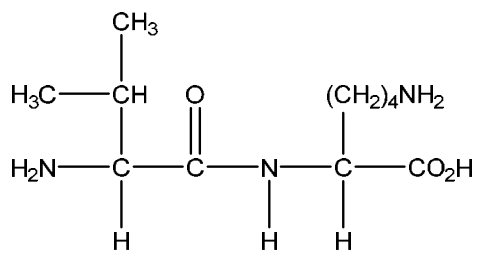
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Question	Answer	Marks												
4(b)(ii)	<p>[1] or each correct tick</p> <table border="1" data-bbox="338 277 1238 507"> <tr> <td data-bbox="338 277 647 376">effect of increasing temperature</td> <td data-bbox="647 277 826 376">decreases</td> <td data-bbox="826 277 1068 376">stay the same</td> <td data-bbox="1068 277 1238 376">increase</td> </tr> <tr> <td data-bbox="338 376 647 440">pH</td> <td data-bbox="647 376 826 440">✓</td> <td data-bbox="826 376 1068 440"></td> <td data-bbox="1068 376 1238 440"></td> </tr> <tr> <td data-bbox="338 440 647 507">ratio of [H<sup>+</sup>]:[OH<sup>-</sup>]</td> <td data-bbox="647 440 826 507"></td> <td data-bbox="826 440 1068 507">✓</td> <td data-bbox="1068 440 1238 507"></td> </tr> </table>	effect of increasing temperature	decreases	stay the same	increase	pH	✓			ratio of [H <sup>+</sup> ]:[OH <sup>-</sup> ]		✓		2
effect of increasing temperature	decreases	stay the same	increase											
pH	✓													
ratio of [H <sup>+</sup> ]:[OH <sup>-</sup> ]		✓												
4(c)	<p>[H<sup>+</sup>] = 10<sup>-13.25</sup> = 5.62 × 10<sup>-14</sup> [1]  [OH<sup>-</sup>] = K<sub>w</sub>/[H<sup>+</sup>] = 1.0 × 10<sup>-14</sup>/5.62 × 10<sup>-14</sup>  [OH<sup>-</sup>] = <b>0.18</b> (0.178) (mol dm<sup>-3</sup>) [1] ecf correct answer scores [2]</p>	2												
4(d)	<p>HCO<sub>3</sub><sup>-</sup> + H<sup>+</sup> → H<sub>2</sub>CO<sub>3</sub> <b>OR</b> HCO<sub>3</sub><sup>-</sup> + H<sup>+</sup> → CO<sub>2</sub> + H<sub>2</sub>O [1]  H<sub>2</sub>CO<sub>3</sub> + OH<sup>-</sup> → HCO<sub>3</sub><sup>-</sup> + H<sub>2</sub>O [1]</p>	2												
4(e)(i)	<p><b>CH<sub>3</sub>COOH</b> + H<sub>2</sub>O ⇌ CH<sub>3</sub>COO<sup>-</sup> + H<sub>3</sub>O<sup>+</sup> [1]  acid + base ⇌ base + acid [1]</p>	2												
4(e)(ii)	<p><b>M1</b> moles NaOH = 0.15 × 20/1000 = <b>0.0030</b> <b>AND</b> initial moles CH<sub>3</sub>COOH = 0.25 × 30/1000 <b>OR 0.0075</b> [1]  <b>M2</b> equilibrium moles CH<sub>3</sub>COOH = <b>0.0045</b> <b>AND</b> equilibrium moles CH<sub>3</sub>COONa = <b>0.0030</b> [1]  <b>M3</b> [CH<sub>3</sub>COOH] = 0.0045/0.05 = <b>0.090</b> <b>AND</b> [CH<sub>3</sub>COONa] = 0.003/0.05 = <b>0.060</b>  [H<sup>+</sup>] = K<sub>a</sub> × [CH<sub>3</sub>COOH]/[CH<sub>3</sub>COONa] = <b>2.625 × 10<sup>-5</sup></b> [1]  <b>M4</b> pH = -log[H<sup>+</sup>] = <b>4.6</b> [1] correct answer scores [4]</p>	4												
4(f)(i)	end point = 28 cm <sup>3</sup>	1												
4(f)(ii)	<p><b>M1</b> reaction <b>M</b> bromothymol (blue) / bromocresol (green) <b>AND</b> reaction <b>N</b> bromothymol (blue) / thymolphthalein [1]  <b>M2</b> (both indicators have) a pH range / colour change <b>within</b> / <b>in</b> end-point / vertical region / sharp fall of the graph [1]</p>	2												

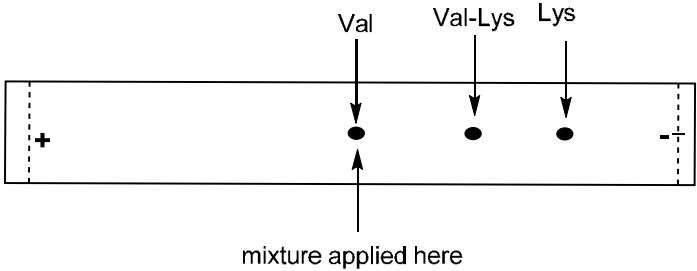


Question	Answer	Marks												
5(a)(i)	<p>[1] for each correct answer</p> <table border="1" data-bbox="336 296 730 493"> <thead> <tr> <th></th> <th>number of peaks</th> </tr> </thead> <tbody> <tr> <td><b>F</b></td> <td>3</td> </tr> <tr> <td><b>G</b></td> <td>6</td> </tr> </tbody> </table>		number of peaks	<b>F</b>	3	<b>G</b>	6	2						
	number of peaks													
<b>F</b>	3													
<b>G</b>	6													
5(a)(ii)	 <p>one amide bond displayed in full [1]</p> <p>rest of the structure – one repeat unit only [1]</p>	2												
5(b)	<p>[1] for each correct tick</p> <table border="1" data-bbox="336 1013 1391 1211"> <thead> <tr> <th></th> <th><math>\sigma</math>-bonds only</th> <th><math>\pi</math>-bonds only</th> <th>both <math>\sigma</math>- and <math>\pi</math>-bonds</th> </tr> </thead> <tbody> <tr> <td>bonds broken</td> <td></td> <td>✓</td> <td></td> </tr> <tr> <td>bonds formed</td> <td>✓</td> <td></td> <td></td> </tr> </tbody> </table>		$\sigma$ -bonds only	$\pi$ -bonds only	both $\sigma$ - and $\pi$ -bonds	bonds broken		✓		bonds formed	✓			2
	$\sigma$ -bonds only	$\pi$ -bonds only	both $\sigma$ - and $\pi$ -bonds											
bonds broken		✓												
bonds formed	✓													

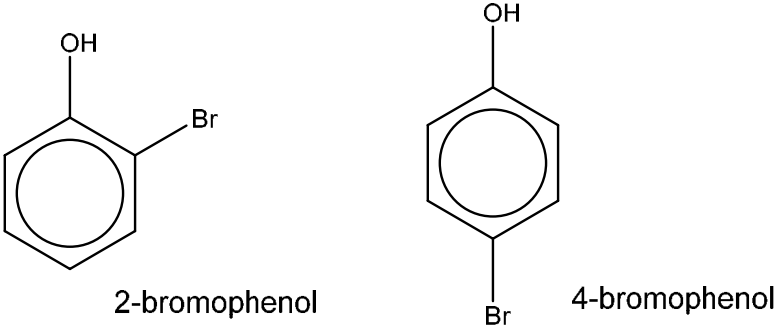
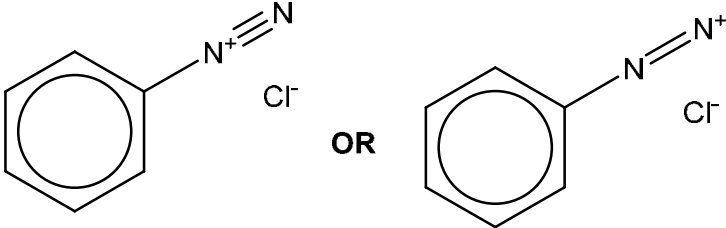
Question	Answer	Marks
5(c)	 <p><b>M1</b> length of chain with both monomers [1] <b>M2</b> continuation bonds [1]</p>	2
5(d)(i)	C-C bonds are non-polar / have no dipole so cannot be hydrolysed [1]	1
5(d)(ii)	<b>M1</b> <u>Hydrolysis</u> using acid / base / alkali / enzymes [1] <b>M2</b> action of UV light [1]	2

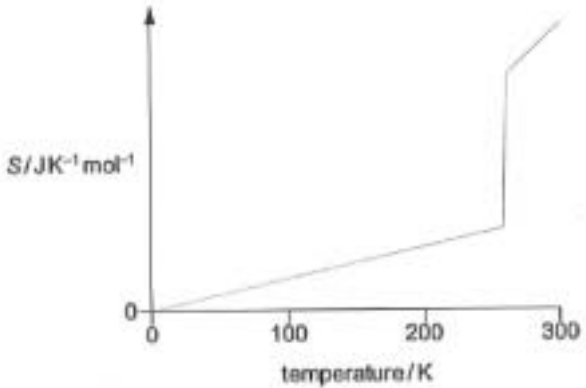
Question	Answer	Marks
6(a)	 <p><b>M1</b> amide bond displayed [1] <b>M2</b> rest of the structure [1]</p>	2

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Question	Answer	Marks
6(b)	<div style="text-align: center;">  </div> <p><b>M1</b> valine on the cross [1]  <b>M2</b> Val-Lys and Lys on the right of the cross (in any order) [1]  <b>M3</b> relative order of Val-Lys and Lys (on the same side of the cross) [1]</p> <p><b>Explanation</b></p> <ul style="list-style-type: none"> <li>Val does not move as it is a zwitterion / neutral (at pH6)  <b>OR</b> Lys / Val-Lys move towards <b>negative</b> (pole) as they are <b>positively charged</b></li> <li>Lys moves the <b>furthest</b> as it has the <b>lowest <math>M_r</math></b> (with the same positive charge)  <b>OR</b> Val-Lys moves the <b>least</b> as it has the <b>largest <math>M_r</math></b> (with the same positive charge)</li> </ul> <p>[1] × 2</p>	<b>5</b>

Question	Answer	Marks
7(a)	<p><b>M1</b> C-X / C-Cl / C-O bond is stronger (in chlorobenzene / phenol) [1]  <b>M2</b> p-orbital / lone pair on Cl / O(H) / X (in chlorobenzene / phenol) [1]  <b>M3</b> electrons of the (Cl / O / electronegative atom) <b>AND</b> overlap / delocalise with <math>\pi</math>-electron cloud / delocalise into ring [1]</p>	<b>3</b>

Question	Answer	Marks
7(b)	 <p style="text-align: center;">2-bromophenol                      4-bromophenol</p> <p>structure and name correct [1]</p>	<b>2</b>
7(c)(i)	<p>step 1 <b>conc.</b> HNO<sub>3</sub> + H<sub>2</sub>SO<sub>4</sub> (and temperare 50–55 °C) [1]</p> <p>step 2 Sn + HCl <b>AND one</b> of conc.HCl + heat [1]</p> <p>step 4 H<sub>2</sub>O warm / heat [1]</p>	<b>3</b>
7(c)(ii)	 <p style="text-align: center;">OR</p>	<b>1</b>
7(c)(iii)	step 1 electrophilic substitution	<b>1</b>
7(c)(iv)	$C_6H_5NO_2 + 6[H] \rightarrow C_6H_5NH_2 + 2H_2O$	<b>1</b>

Question	Answer	Marks									
8(a)	 <p><b>M1</b> continuous increase in <math>S</math> from 0–300 K (excluding m.p.) [1]  <b>M2</b> <b>step</b> vertical increase in <math>S</math> <b>ONLY</b> at the m.p. <b>AND</b> continuous increase in <math>S</math> after m.p. [1]</p>	2									
8(b)	<p>[1] for each correct tick</p> <table border="1" data-bbox="336 842 1111 1046"> <thead> <tr> <th></th> <th>negative <math>\Delta S^{\ominus}</math></th> <th>positive <math>\Delta S^{\ominus}</math></th> </tr> </thead> <tbody> <tr> <td>solid dissolving in water</td> <td></td> <td>✓</td> </tr> <tr> <td>water boiling to steam</td> <td></td> <td>✓</td> </tr> </tbody> </table>		negative $\Delta S^{\ominus}$	positive $\Delta S^{\ominus}$	solid dissolving in water		✓	water boiling to steam		✓	1
	negative $\Delta S^{\ominus}$	positive $\Delta S^{\ominus}$									
solid dissolving in water		✓									
water boiling to steam		✓									
8(c)	$\Delta H^{\ominus} = (2 \times \text{C}=\text{O}) + (3 \times \text{H}-\text{H}) - (3 \times \text{C}-\text{H}) - (\text{C}-\text{O}) - (3 \times \text{O}-\text{H})$ $\Delta H^{\ominus} = (2 \times 805) + (3 \times 436) - (3 \times 410) - (1 \times 360) - (3 \times 460)$ [1] $\Delta H^{\ominus} = 1610 + 1308 - 1230 - 360 - 1380 = -52 \text{ (kJ mol}^{-1}\text{)}$ [1] ecf correct answer scores [2]	2									
8(d)(i)	$\Delta S^{\ominus} = 127 + 70 - (214 + 3 \times 131)$ [1] $= -410 \text{ (J K}^{-1}\text{ mol}^{-1}\text{)}$ [1] ecf correct answer scores [2]	2									
8(d)(ii)	$\Delta G^{\ominus} = \Delta H^{\ominus} - T\Delta S^{\ominus}$ [1] $\Delta G^{\ominus} = -131 - (298 \times -0.41) = -8.8(2) \text{ (kJ mol}^{-1}\text{)}$ [1] correct answer scores [2]	2									

<b>Question</b>	<b>Answer</b>	<b>Marks</b>
8(d)(iii)	(as temperature increases) feasibility decreases	<b>1</b>
8(e)(i)	$2\text{CH}_3\text{OH} + 3\text{O}_2 \rightleftharpoons 2\text{CO}_2 + 4\text{H}_2\text{O}$ <b>OR</b> $2\text{CH}_3\text{OH} + 3\text{O}_2 \rightleftharpoons 2\text{CO}_2 + 4\text{H}^+ + 4\text{OH}^-$	<b>1</b>
8(e)(ii)	$E^\ominus_{\text{cell}} = 1.23 - 0.02 = \mathbf{1.21\text{ V}}$	<b>1</b>