Cambridge International AS & A Level

Cambridge Assessment International Education
Cambridge International Advanced Subsidiary and Advanced Level

CHEMISTRY **9701/41**

Paper 4 A Level Structured Questions **October/November 2018**

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.

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[Turn over

Generic Marking Principles

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GENERIC MARKING PRINCIPLE 1:

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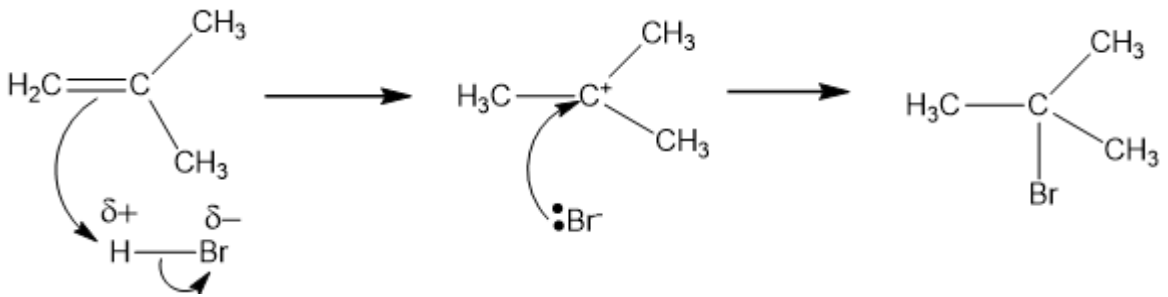
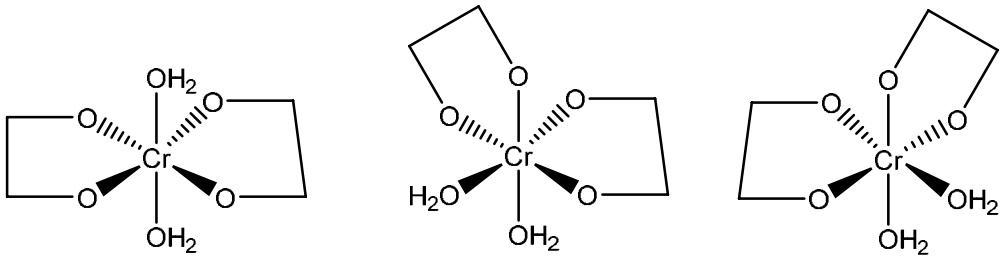
<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>1(a)(i)</td><td>
<table>
<tr><th>peak</th><th>organic compound</th><th>explanation</th></tr>
<tr><td>X</td><td>alkane</td><td>London forces only
OR no hydrogen bonding</td></tr>
<tr><td>Y</td><td>aldehyde</td><td>(Permanent dipole-dipole and London forces)</td></tr>
<tr><td>Z</td><td>carboxylic acid</td><td>(contains) hydrogen bonding</td></tr>
</table>
M1 peak assignments [1]
M2 explanation of Z OR X [1]
</td><td>2</td></tr>
<tr><td>1(a)(ii)</td><td>% of Z = 47/98 = 48%</td><td>1</td></tr>
<tr><td>1(b)(i)</td><td>^{37}Cl and ^{81}Br</td><td>1</td></tr>
<tr><td>1(b)(ii)</td><td>M peak $CH_2{}^{35}Cl^{79}Br$
M+2 peak $CH_2{}^{37}Cl^{79}Br$ OR $CH_2{}^{35}Cl^{81}Br$
M+4 peak $CH_2{}^{37}Cl^{81}Br$
two correct scores 1 mark
all 3 correct scores 2 marks</td><td>2</td></tr>
<tr><td>1(c)(i)</td><td>


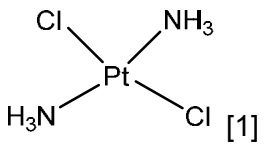
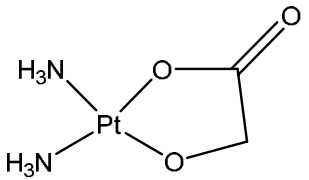
M1 correct dipole on HBr AND any correct curly arrow [1]
M2 two other correct curly arrows AND lone pair required on Br^- [1]
M3 intermediate [1]
</td><td>3</td></tr>
</table>

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

Question	Answer	Marks
2(a)	species that forms **dative bond**(s) to a (central) **metal atom / ion**	**1**
2(b)	 any two structures [1] × 2	**2**
2(c)(i)	K_{sp} = $[Ca^{2+}][C_2O_4^{2-}]$ [1] units $mol^2\ dm^{-6}$ [1]	**2**
2(c)(ii)	$[Ca^{2+}] = [C_2O_4^{2-}] = 6.65 \times 10^{-3}/128.1 = 5.19 \times 10^{-5}$ mol dm^{-3} [1] $K_{sp} = (5.19 \times 10^{-5})^2$ = **2.7×10^{-9}** $mol^2\ dm^{-6}$ [1]	**2**

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>3(a)</td><td>[1] for each column

<table><tr><th rowspan="2">element</th><th colspan="2">number of unpaired electrons in</th></tr><tr><th>3d</th><th>4s</th></tr><tr><td>Cr</td><td>5</td><td>1</td></tr><tr><td>Mn</td><td>5</td><td>0</td></tr><tr><td>Fe</td><td>4</td><td>0</td></tr></table></td><td>2</td></tr>
<tr><td>3(b)</td><td>$2KMnO_4 \rightarrow K_2MnO_4 + O_2 + MnO_2$
formulae of K_2MnO_4 and O_2 [1]
rest of the equation [1]</td><td>2</td></tr>
<tr><td>3(c)</td><td>M1 d orbitals split into two levels / lower and upper orbitals [1]
M2 visible light is absorbed and the complementary colour observed [1]
M3 electron(s) promoted / excited [1]</td><td>3</td></tr>
<tr><td>3(d)(i)</td><td>precipitate A $[Cu(H_2O)_4(OH)_2]$ OR $Cu(OH)_2$ [1]
solution B $[Cu(NH_3)_4(H_2O)_2]^{2+}$ [1]
solution C $Cu(CH_3CO_2)_2$ [1]</td><td>3</td></tr>
<tr><td>3(d)(ii)</td><td>Na_2CO_3 or CO_3^{2-}</td><td>1</td></tr>
<tr><td>3(d)(iii)</td><td>$CuCO_3 + 2CH_3CO_2H \rightarrow Cu(CH_3CO_2)_2 + CO_2 + H_2O$</td><td>1</td></tr>
<tr><td>3(d)(iv)</td><td>any two for one mark
• fizzing / bubbles / effervescence
• solid disappears
• green / blue solution (formed)</td><td>1</td></tr>
</table>

Question	Answer	Marks
3(e)	sum of the charges of the (four) ligands equals the oxidation number / charge of Pt **OR** a calculation Pt +2, NH_3 neutral / no charge, both Cl^-'s –1 (so no overall charge)	**1**
3(f)(i)	 [1] square planar **and** 180° [1]	**2**
3(f)(ii)	**M1** this can **bond / bind** with **DNA** [1] **M2** which prevents replication of the DNA / strand **OR** prevents cell division [1]	**2**
3(g)		**1**

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

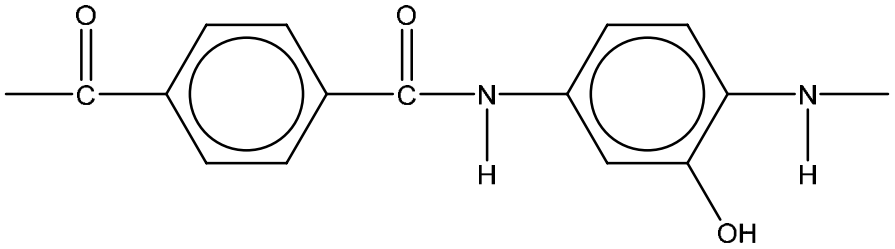
<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>4(b)(ii)</td><td>[1] or each correct tick
<table>
<tr><th>effect of increasing temperature</th><th>decreases</th><th>stay the same</th><th>increase</th></tr>
<tr><td>pH</td><td>✓</td><td></td><td></td></tr>
<tr><td>ratio of $[H^+]:[OH^-]$</td><td></td><td>✓</td><td></td></tr>
</table></td><td>2</td></tr>
<tr><td>4(c)</td><td>$[H^+] = 10^{-13.25} = 5.62 \times 10^{-14}$ [1]
$[OH^-] = K_w/[H^+] = 1.0 \times 10^{-14}/5.62 \times 10^{-14}$
$[OH^-]$ = 0.18 (0.178) (mol dm^{-3}) [1] ecf correct answer scores [2]</td><td>2</td></tr>
<tr><td>4(d)</td><td>$HCO_3^- + H^+ \rightarrow H_2CO_3$ OR $HCO_3^- + H^+ \rightarrow CO_2 + H_2O$ [1]
$H_2CO_3 + OH^- \rightarrow HCO_3^- + H_2O$ [1]</td><td>2</td></tr>
<tr><td>4(e)(i)</td><td>$\boldsymbol{CH_3COOH} + H_2O \rightleftharpoons CH_3COO^- + H_3O^+$ [1]
acid + base ⇌ base + acid [1]</td><td>2</td></tr>
<tr><td>4(e)(ii)</td><td>M1 moles NaOH = 0.15 × 20/1000 = 0.0030 AND initial moles CH_3COOH = 0.25 × 30/1000 OR 0.0075 [1]

M2 equilibrium moles CH_3COOH = 0.0045 AND equilibrium moles CH_3COONa = 0.0030 [1]

M3 $[CH_3COOH]$ = 0.0045/0.05 = 0.090 AND $[CH_3COONa]$ = 0.003/0.05 = 0.060
$[H^+] = K_a \times [CH_3COOH]/[CH_3COONa]$ = 2.625×10^{-5} [1]

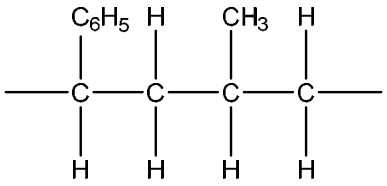
M4 pH = $-\log[H^+]$ = 4.6 [1] correct answer scores [4]</td><td>4</td></tr>
<tr><td>4(f)(i)</td><td>end point = 28 cm^3</td><td>1</td></tr>
<tr><td>4(f)(ii)</td><td>M1 reaction M bromothymol (blue) / bromocresol (green) AND reaction N bromothymol (blue) / thymolphthalein [1]

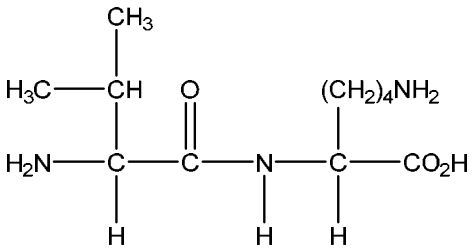
M2 (both indicators have) a pH range / colour change within / in end-point / vertical region / sharp fall of the graph [1]</td><td>2</td></tr>
</table>

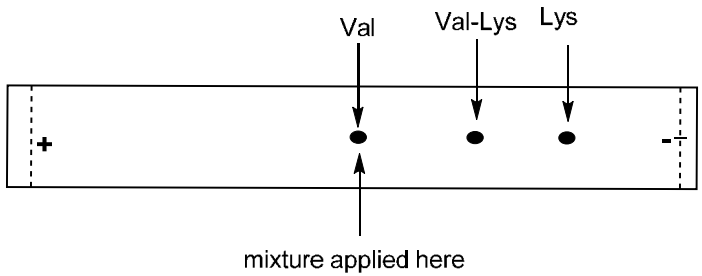
<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>5(a)(i)</td><td>[1] for each correct answer
<table>
<tr><th></th><th>number of peaks</th></tr>
<tr><td>F</td><td>3</td></tr>
<tr><td>G</td><td>6</td></tr>
</table></td><td>2</td></tr>
<tr><td>5(a)(ii)</td><td> 

one amide bond displayed in full [1]

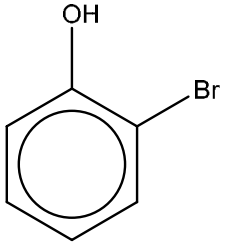
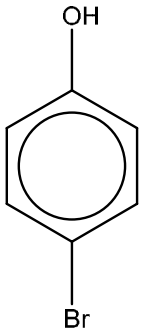
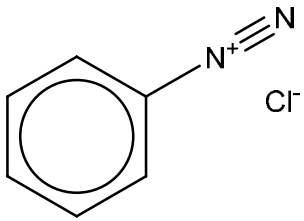
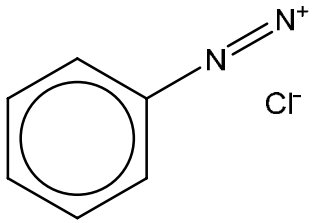
rest of the structure – one repeat unit only [1]</td><td>2</td></tr>
<tr><td>5(b)</td><td>[1] for each correct tick
<table>
<tr><th></th><th>σ-bonds only</th><th>π-bonds only</th><th>both σ- and π-bonds</th></tr>
<tr><td>bonds broken</td><td></td><td>✓</td><td></td></tr>
<tr><td>bonds formed</td><td>✓</td><td></td><td></td></tr>
</table></td><td>2</td></tr>
</table>

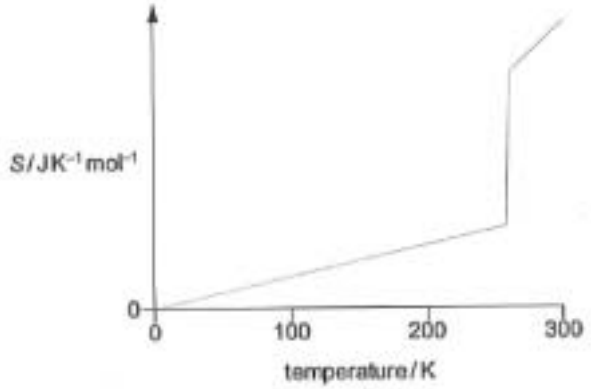
Question	Answer	Marks
5(c)	 **M1** length of chain with both monomers [1] **M2** continuation bonds [1]	**2**
5(d)(i)	C-C bonds are non-polar / have no dipole so cannot be hydrolysed [1]	**1**
5(d)(ii)	**M1** Hydrolysis using acid / base / alkali / enzymes [1] **M2** action of UV light [1]	**2**

Question	Answer	Marks
6(a)	 **M1** amide bond displayed [1] **M2** rest of the structure [1]	**2**

Question	Answer	Marks
6(b)	 **M1** valine on the cross [1] **M2** Val-Lys and Lys on the right of the cross (in any order) [1] **M3** relative order of Val-Lys and Lys (on the same side of the cross) [1] **Explanation** • Val does not move as it is a zwitterion / neutral (at pH6) **OR** Lys / Val-Lys move towards **negative** (pole) as they are **positively charged** • Lys moves the **furthest** as it has the **lowest** M_r (with the same positive charge) **OR** Val-Lys moves the **least** as it has the **largest** M_r (with the same positive charge) [1] × 2	**5**

Question	Answer	Marks
7(a)	**M1** C-X / C-C*l* / C-O bond is strong**er** (in chlorobenzene / phenol) [1] **M2** p-orbital / lone pair on C*l* / O(H) / X (in chlorobenzene / phenol) [1] **M3** electrons of the (C*l* / O / electronegative atom) **AND** overlap / delocalise with π-electron cloud / delocalise into ring [1]	**3**

Question	Answer	Marks
7(b)	 2-bromophenol  4-bromophenol structure and name correct [1]	**2**
7(c)(i)	step 1 **conc.** HNO_3 + H_2SO_4 (and temperare 50–55 °C) [1] step 2 Sn + HC*l* **AND one** of conc.HC*l* + heat [1] step 4 H_2O warm / heat [1]	**3**
7(c)(ii)	 **OR** 	**1**
7(c)(iii)	step 1 electrophilic substitution	**1**
7(c)(iv)	$C_6H_5NO_2$ + 6[H] → $C_6H_5NH_2$ + $2H_2O$	**1**

Question	Answer	Marks
8(a)	 **M1** continuous increase in *S* from 0–300 K (excluding m.p.) [1] **M2 steep** vertical increase in *S* **ONLY** at the m.p. **AND** continuous increase in *S* after m.p. [1]	**2**
8(b)	[1] for each correct tick <table><tr><td></td><td>negative $\Delta S^{\ominus}$</td><td>positive $\Delta S^{\ominus}$</td></tr><tr><td>solid dissolving in water</td><td></td><td>✓</td></tr><tr><td>water boiling to steam</td><td></td><td>✓</td></tr></table>	**1**
8(c)	$\Delta H^{\ominus}$ = (2 × C=O) + (3 × H-H) – (3 × C-H) – (C-O) – (3xO-H) $\Delta H^{\ominus}$ = (2 × 805) + (3 × 436) – (3 × 410)– (1 × 360) – (3 × 460) [1] $\Delta H^{\ominus}$ = 1610 + 1308 – 1230 – 360 – 1380 = **– 52** (kJ mol^{-1}) [1] ecf correct answer scores [2]	**2**
8(d)(i)	$\Delta S^{\ominus}$ = 127 + 70 – (214 + 3 × 131) [1] = – 410 (J K^{-1} mol^{-1}) [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 × –0.41) = **– 8.8(2)** (kJ mol^{-1}) [1] correct answer scores [2]	**2**

Question	Answer	Marks
8(d)(iii)	(as temperature increases) feasibility decreases	**1**
8(e)(i)	$2CH_3OH + 3O_2 \rightleftharpoons 2CO_2 + 4H_2O$ **OR** $2CH_3OH + 3O_2 \rightleftharpoons 2CO_2 + 4H^+ + 4OH^-$	**1**
8(e)(ii)	$E^{\ominus}_{cell}$ = 1.23 – 0.02 = **1.21** V	**1**

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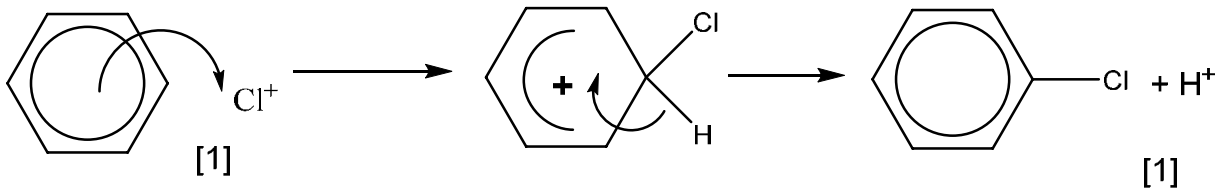
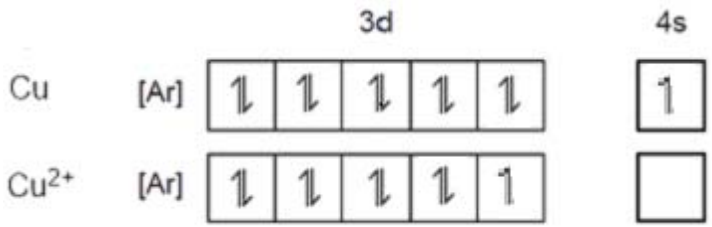
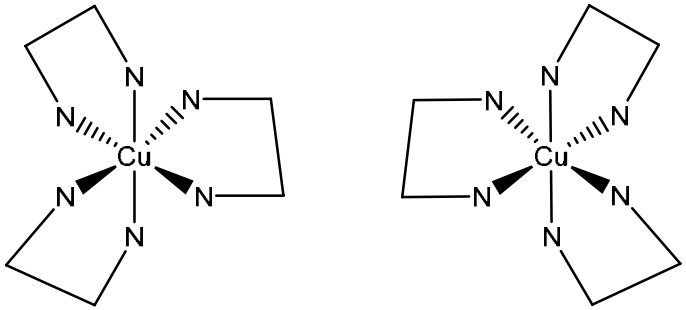
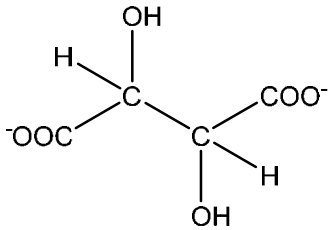
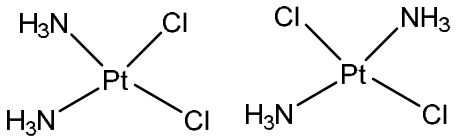
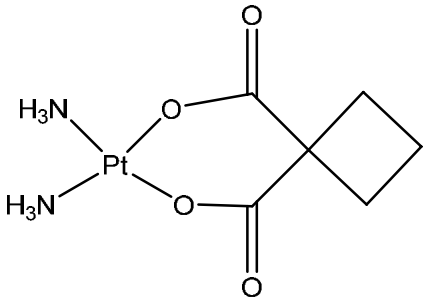
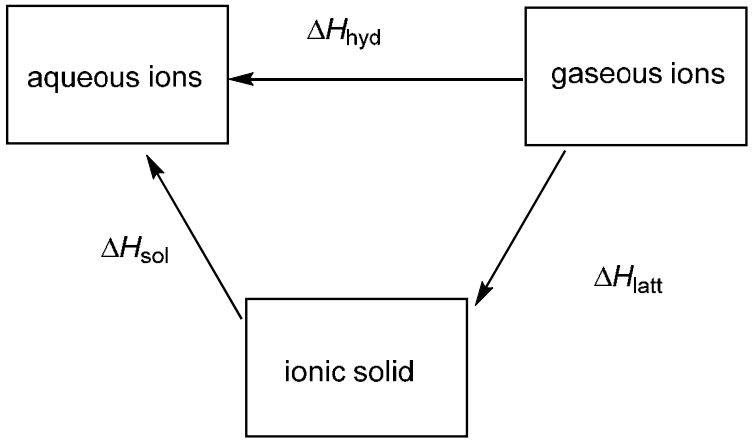
1(a)(i)	<table><tr><th>peak</th><th>organic compound</th><th>explanation</th></tr><tr><td>J</td><td>**carboxylic acid**</td><td>**most polar**</td></tr><tr><td>K</td><td>**ketone**</td><td>**polarity between J and L**</td></tr><tr><td>L</td><td>**alkene**</td><td>**most non-polar**</td></tr></table> peak assignments [1] explanation of J or L [1]	**2**
1(a)(ii)	% of K = 18 / 92 = **19.6%**	**1**
1(b)(i)	$Cl_2 + AlCl_3 \rightarrow Cl^+ + AlCl_4^-$	**1**
1(b)(ii)	 [1] intermediate [1] curly arrow [1] [1]	**4**
1(b)(iii)	$H^+ + AlCl_4^- \rightarrow AlCl_3 + HCl$	**1**
1(c)(i)	catalyst and the reactants are in the same phase / state	**1**
1(c)(ii)	(Rh) heterogeneous **AND** (Fe^{3+}) homogeneous	**1**

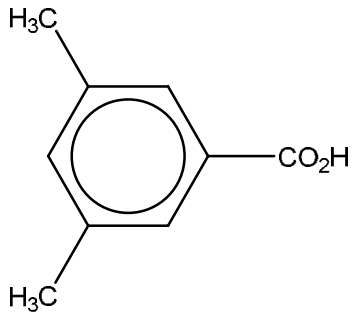
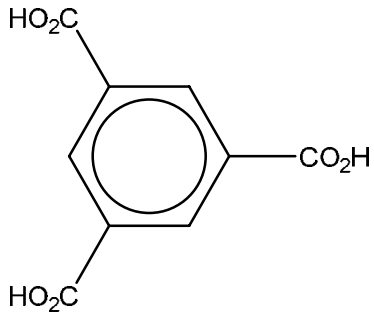
Question	Answer	Marks
2(a)	 [1] × 2	**2**
2(b)(i)	orbitals have the same energy	**1**
2(b)(ii)	d-d splitting seen, leading to 2 upper and 3 lower orbitals	**1**
2(c)	an ion / molecule that donates two pairs of electrons	**1**
2(d)	 one correct [1] two correct and mirror images of each other [1]	**2**

Question	Answer	Marks
3(a)(i)	solution of **A** $[Co(NH_3)_6]^{2+}$ [1] precipitate **B** $CoCO_3$ [1]	**2**
3(a)(ii)	NaOH(aq) / OH^-(aq)	**1**
3(a)(iii)	$[Co(H_2O)_4(OH)_2] + 6NH_3 \rightarrow [Co(NH_3)_6]^{2+} + 4H_2O + 2OH^-$	**1**

Question	Answer	Marks
3(a)(iv)	$[Co(H_2O)_6]^{2+} + CO_3^{2-} \rightarrow CoCO_3 + 6H_2O$	**1**
3(b)(i)	variable oxidation states	**1**
3(b)(ii)		**1**
3(b)(iii)	$C_4H_4O_6^{2-} + 3[O] \rightarrow 2HCO_2^{-} + 2CO_2 + H_2O$	**1**
3(c)(i)	 cis trans square planar shape of one isomer [1] both isomers drawn and assigned as cis and trans correctly [1]	**2**
3(c)(ii)	this can react / bond / bind with <u>DNA</u> [1] which prevents replication of the strand / prevents cell division / prevents mitosis [1]	**2**
3(d)		**1**

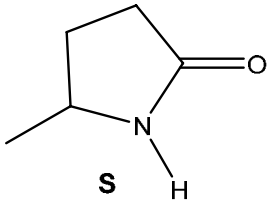
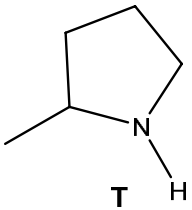
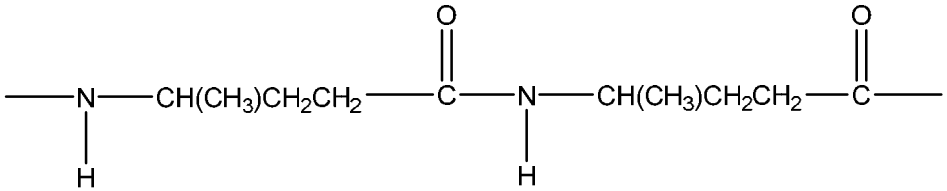
Question	Answer	Marks
4(a)	$Ca_3N_2 + 6H_2O \rightarrow 3Ca(OH)_2 + 2NH_3$ products are $Ca(OH)_2$ **and** NH_3 [1] rest of the equation, balanced [1]	**2**
4(b)	**M1**: solubility increases (down the Group) [1] **M2**: because lattice energy and hydration energy **decreases or** lattice energy and hydration energy become **less exothermic / (more) endothermic**[1] **M3**: because lattice energy decreases to a **greater extent** (than does ΔH_{hyd}) [1]	**3**
4(c)	 arrow label and direction correct [1] x 3	**3**
4(d)(i)	$K_{sp} = [Ca^{2+}][F^-]^2$ [1] units = $mol^3\ dm^{-9}$ [1]	**2**
4(d)(ii)	$K_{sp} = 4x^3 = 3.45 \times 10^{-11}$ x= $\mathbf{2.05 \times 10^{-4}}$ ($mol\ dm^{-3}$)	**1**

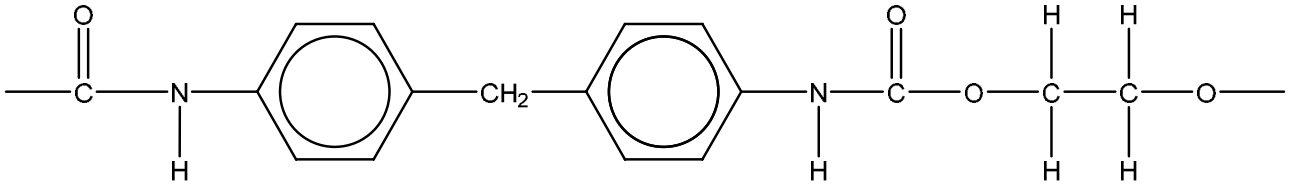
Question	Answer	Marks
5(a)	ionic radius / ion size **increases OR** charge density **decreases** (down the group) [1] less polarisation / distortion of anion / nitrate ion / NO_3^- / nitrate group **OR** N-O / N=O bond is less weakened / distorted / polarised **OR** more energy to break N-O / N=O bond [1]	**2**
5(b)	• moles of Ce^{4+} = 0.0400 × 21.8 / 1000 = 8.72×10^{-4} (moles of Ce^{4+}) • moles of NO_2^- = 8.72×10^{-4} / 2 = 4.36×10^{-4} in 25 cm^3 (use of 2:1 ratio correctly) • moles of NO_2^- = $4.36 \times 10^{-4} \times 4$ = $1.74(4) \times 10^{-3}$ in 100 cm^3 (use of 4:1 ratio correctly) • mass $NaNO_2$ = $1.74(4) \times 10^{-3} \times (23.0 + 14.0 + 32.0)$ = 0.120 g (use of M_r correctly) • % purity = 0.120 / 0.138 = 86.96% (use of 0.0138 correctly) two points = [1] four points = [2] all five points = [3]	**3**
5(c)(i)	$5NO_2^- + 2MnO_4^- + 6H^+ \rightarrow 2Mn^{2+} + 5NO_3^- + 3H_2O$ **OR** $5HNO_2 + 2MnO_4^- + H^+ \rightarrow 2Mn^{2+} + 5NO_3^- + 3H_2O$ all species correct [1] balanced [1]	**2**
5(c)(ii)	$E^{\ominus}_{cell}$ = 1.52 – 0.94 = **0.58** (V)	**1**
5(d)(i)	weak acid is partly ionised **and** strong acid is completely ionised	**1**
5(d)(ii)	$K_a = \frac{[H^+][NO_2^-]}{[HNO_2]}$	**1**
5(d)(iii)	$K_a = [H^+]^2 / [HNO_2]$ $[H^+] = \sqrt{0.00069} \times 0.15 = 1.02 \times 10^{-2}$ [1] pH = –log$[H^+]$ = **2.0 (1.99)** [1] minimum 2 sigificant figures	**2**
5(d)(iv)	% ionisation = $100 \times 1.02 \times 10^{-2} / 0.15$ = **6.7–6.8 %**	**1**

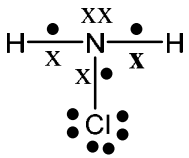
Question	Answer	Marks
5(e)(i)	**M1** A solution that resists changes in pH [1] **M2** when small amounts of acid or alkali are added to it [1]	**2**
5(e)(ii)	**M1** $HNO_2 + OH^- \rightarrow NO_2^- + H_2O$ [1] **M2** $NO_2^- + H^+ \rightarrow HNO_2$ [1]	**2**
5(f)(i)	CuCN / copper(I) cyanide	**1**
5(f)(ii)	 **Y**  **Z** [1] × 2	**2**
5(g)		**2**

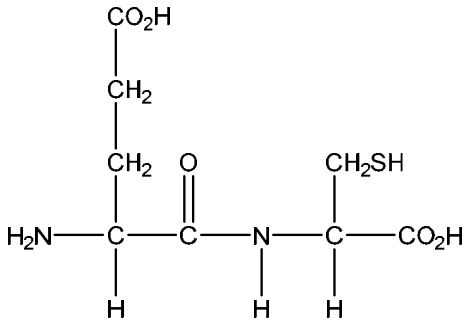
	number of peaks
W	6
Z	3

[1] × 2

Question	Answer	Marks
6(a)(i)	KCN / NaCN / CN^-	**1**
6(a)(ii)	step 1 PCl_3 + heat / PCl_5 / $SOCl_2$ [1] step 4 $NaBH_4$ [1]	**2**
6(b)(i)	 **S**  **T**	**2**
6(b)(ii)	step I condensation [1] step II reduction [1]	**2**
6(c)	 • amide bond (CO-NH) • structure of polymer with exactly two repeat units • continuation bonds • hydrocarbon portions correct two points = [1] four points = [1]	**2**

Question	Answer	Marks
7(a)(i)	$C_{15}H_{10}N_2O_2$	**1**
7(a)(ii)	 -NH-CO-O- linkage [1] whole molecule correct [1]	**2**
7(a)(iii)	intermolecular force: hydrogen bonding; group(s) involved: NH intermolecular force: VDW forces / Induced dipole-dipole forces / polar forces; group(s) involved: $-C_6H_4CH_2-$ **allow** benzene / aromatic rings **M1** hydrogen bonding [1] **M2** NH group for hydrogen **AND** second correct IMF [1]	**2**
7(b)	type of polymer: synthetic polyamide; example: nylon / Kevlar type of polymer: synthetic polyester; example: Terylene type of polymer: conducting polymer; example: polyacetylene / polyethyne type of polymer: non-solvent based adhesive; example: epoxyresins / superglue one mark [1] for each correct answer up to a maximum of [3]	**3**

Question	Answer	Marks
8(a)(i)	species with an unpaired electron	**1**
8(a)(ii)	$NH_2 + Cl \rightarrow NH_2Cl$	**1**
8(b)(i)		**1**
8(b)(ii)	sp^3 **AND** 100–107°	**1**
8(c)(i)	(entropy) is a measure of the disorder/randomness of a system	**1**
8(c)(ii)	$\Delta S^{\ominus}$ = 237 + 187 – (241 + 198) = –15.0 (J K^{-1} mol^{-1})	**1**
8(c)(iii)	$\Delta H^{\ominus}$ = 95.4–92.3 – (80.1–45.9) = –31.1 (kJ mol^{-1})	**1**
8(c)(iv)	$\Delta G^{\ominus} = \Delta H^{\ominus} - T\Delta S^{\ominus}$ [1] $\Delta G^{\ominus}$ = -31.1 – (298 × -0.015) = –26.6 (kJ mol^{-1}) [1]	**2**
8(c)(v)	(at higher temperatures) $T\Delta S^{\ominus}$ becomes more negative so $\Delta G^{\ominus}$ becomes more positive **OR** (at high temperatures) $-T\Delta S^{\ominus}$ is becomes more positive so $\Delta G^{\ominus}$ becomes more positive	**1**
8(d)	ethylamine > ammonia > phenylamine [1] ethyl group is electron donating group [1] p-orbital from N in phenylamine overlaps with π-ring system **OR** lone pair on N is delocalised into benzene ring [1] basicity linked to ability of N to accept a proton [1]	**4**

Question	Answer	Marks
9(a)	 **M1** peptide link [1] **M2** rest of the structure [1]	**2**
9(b)	spot / identity **E** / Glu **F** / Glu-Cys **G** / Cys **M1** correct table [1] **M2** Explanation of why Cys moves the least – because it exists as a zwitterion / it is almost neutral [1] **M3** Explanation of why Glu-Cys moves a smaller distance than Glu – a comparitive statement that Glu-Cys has a greater M_r than Glu [1]	**3**

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Cambridge International Advanced Subsidiary and Advanced Level

CHEMISTRY **9701/43**

Paper 4 A Level Structured Questions **October/November 2018**

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

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

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[Turn over

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.

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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.

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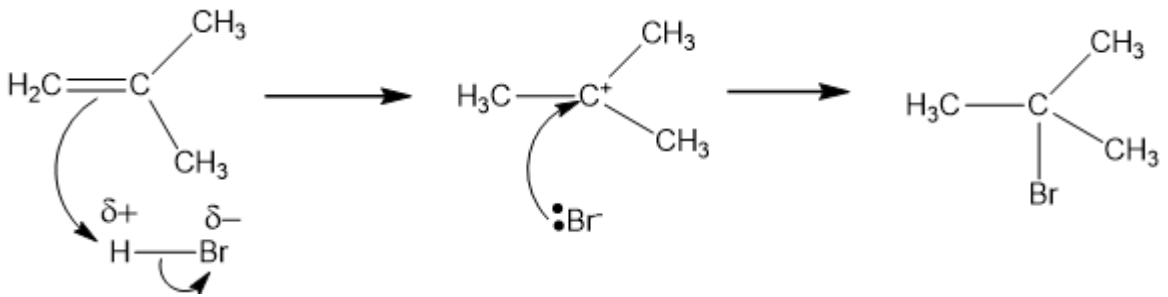
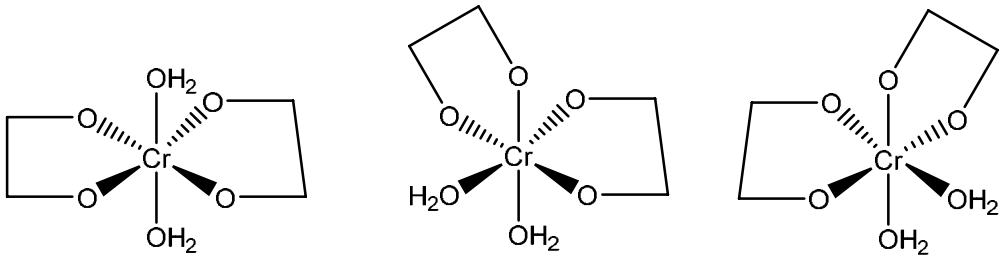
<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>1(a)(i)</td><td>
<table>
<tr><th>peak</th><th>organic compound</th><th>explanation</th></tr>
<tr><td>X</td><td>alkane</td><td>London forces only
OR no hydrogen bonding</td></tr>
<tr><td>Y</td><td>aldehyde</td><td>(Permanent dipole-dipole and London forces)</td></tr>
<tr><td>Z</td><td>carboxylic acid</td><td>(contains) hydrogen bonding</td></tr>
</table>
M1 peak assignments [1]
M2 explanation of Z OR X [1]
</td><td>2</td></tr>
<tr><td>1(a)(ii)</td><td>% of Z = 47/98 = 48%</td><td>1</td></tr>
<tr><td>1(b)(i)</td><td>^{37}Cl and ^{81}Br</td><td>1</td></tr>
<tr><td>1(b)(ii)</td><td>M peak $CH_2{}^{35}Cl^{79}Br$
M+2 peak $CH_2{}^{37}Cl^{79}Br$ OR $CH_2{}^{35}Cl^{81}Br$
M+4 peak $CH_2{}^{37}Cl^{81}Br$
two correct scores 1 mark
all 3 correct scores 2 marks</td><td>2</td></tr>
<tr><td>1(c)(i)</td><td>


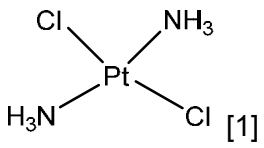
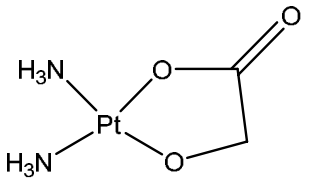
M1 correct dipole on HBr AND any correct curly arrow [1]
M2 two other correct curly arrows AND lone pair required on Br^- [1]
M3 intermediate [1]
</td><td>3</td></tr>
</table>

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

Question	Answer	Marks
2(a)	species that forms **dative bond**(s) to a (central) **metal atom / ion**	**1**
2(b)	 any two structures [1] × 2	**2**
2(c)(i)	K_{sp} = $[Ca^{2+}][C_2O_4^{2-}]$ [1] units $mol^2\ dm^{-6}$ [1]	**2**
2(c)(ii)	$[Ca^{2+}] = [C_2O_4^{2-}] = 6.65 \times 10^{-3}/128.1 = 5.19 \times 10^{-5}$ mol dm^{-3} [1] $K_{sp} = (5.19 \times 10^{-5})^2$ = **2.7×10^{-9}** $mol^2\ dm^{-6}$ [1]	**2**

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>3(a)</td><td>[1] for each column

<table><tr><th rowspan="2">element</th><th colspan="2">number of unpaired electrons in</th></tr><tr><th>3d</th><th>4s</th></tr><tr><td>Cr</td><td>5</td><td>1</td></tr><tr><td>Mn</td><td>5</td><td>0</td></tr><tr><td>Fe</td><td>4</td><td>0</td></tr></table></td><td>2</td></tr>
<tr><td>3(b)</td><td>$2KMnO_4 \rightarrow K_2MnO_4 + O_2 + MnO_2$
formulae of K_2MnO_4 and O_2 [1]
rest of the equation [1]</td><td>2</td></tr>
<tr><td>3(c)</td><td>M1 d orbitals split into two levels / lower and upper orbitals [1]
M2 visible light is absorbed and the complementary colour observed [1]
M3 electron(s) promoted / excited [1]</td><td>3</td></tr>
<tr><td>3(d)(i)</td><td>precipitate A $[Cu(H_2O)_4(OH)_2]$ OR $Cu(OH)_2$ [1]
solution B $[Cu(NH_3)_4(H_2O)_2]^{2+}$ [1]
solution C $Cu(CH_3CO_2)_2$ [1]</td><td>3</td></tr>
<tr><td>3(d)(ii)</td><td>Na_2CO_3 or CO_3^{2-}</td><td>1</td></tr>
<tr><td>3(d)(iii)</td><td>$CuCO_3 + 2CH_3CO_2H \rightarrow Cu(CH_3CO_2)_2 + CO_2 + H_2O$</td><td>1</td></tr>
<tr><td>3(d)(iv)</td><td>any two for one mark
• fizzing / bubbles / effervescence
• solid disappears
• green / blue solution (formed)</td><td>1</td></tr>
</table>

Question	Answer	Marks
3(e)	sum of the charges of the (four) ligands equals the oxidation number / charge of Pt **OR** a calculation Pt +2, NH_3 neutral / no charge, both Cl^-'s –1 (so no overall charge)	**1**
3(f)(i)	 [1] square planar **and** 180° [1]	**2**
3(f)(ii)	**M1** this can **bond / bind** with **DNA** [1] **M2** which prevents replication of the DNA / strand **OR** prevents cell division [1]	**2**
3(g)		**1**

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

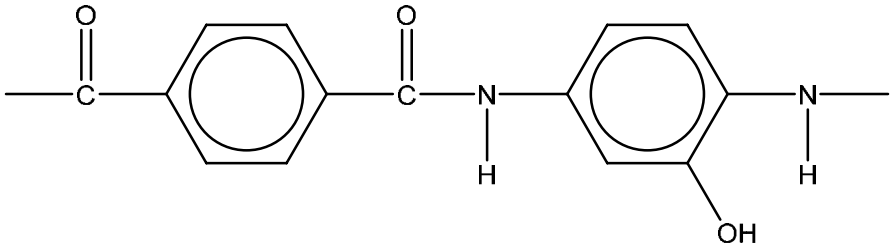
<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>4(b)(ii)</td><td>[1] or each correct tick
<table>
<tr><th>effect of increasing temperature</th><th>decreases</th><th>stay the same</th><th>increase</th></tr>
<tr><td>pH</td><td>✓</td><td></td><td></td></tr>
<tr><td>ratio of $[H^+]$:$[OH^-]$</td><td></td><td>✓</td><td></td></tr>
</table></td><td>2</td></tr>
<tr><td>4(c)</td><td>$[H^+] = 10^{-13.25} = 5.62 \times 10^{-14}$ [1]
$[OH^-] = K_w/[H^+] = 1.0 \times 10^{-14}/5.62 \times 10^{-14}$
$[OH^-]$ = 0.18 (0.178) (mol dm^{-3}) [1] ecf correct answer scores [2]</td><td>2</td></tr>
<tr><td>4(d)</td><td>$HCO_3^- + H^+ \rightarrow H_2CO_3$ OR $HCO_3^- + H^+ \rightarrow CO_2 + H_2O$ [1]
$H_2CO_3 + OH^- \rightarrow HCO_3^- + H_2O$ [1]</td><td>2</td></tr>
<tr><td>4(e)(i)</td><td>$\boldsymbol{CH_3COOH} + H_2O \rightleftharpoons CH_3COO^- + H_3O^+$ [1]
acid + base ⇌ base + acid [1]</td><td>2</td></tr>
<tr><td>4(e)(ii)</td><td>M1 moles NaOH = 0.15 × 20/1000 = 0.0030 AND initial moles CH_3COOH = 0.25 × 30/1000 OR 0.0075 [1]

M2 equilibrium moles CH_3COOH = 0.0045 AND equilibrium moles CH_3COONa = 0.0030 [1]

M3 $[CH_3COOH]$ = 0.0045/0.05 = 0.090 AND $[CH_3COONa]$ = 0.003/0.05 = 0.060
$[H^+] = K_a \times [CH_3COOH]/[CH_3COONa]$ = 2.625×10^{-5} [1]

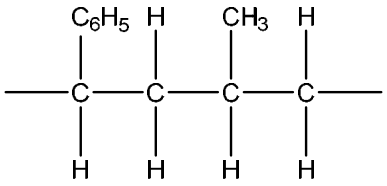
M4 pH = $-\log[H^+]$ = 4.6 [1] correct answer scores [4]</td><td>4</td></tr>
<tr><td>4(f)(i)</td><td>end point = 28 cm^3</td><td>1</td></tr>
<tr><td>4(f)(ii)</td><td>M1 reaction M bromothymol (blue) / bromocresol (green) AND reaction N bromothymol (blue) / thymolphthalein [1]

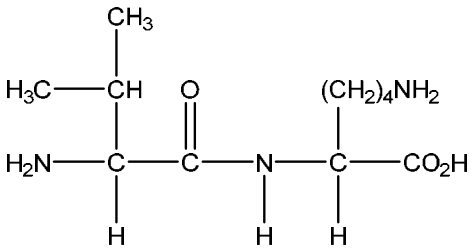
M2 (both indicators have) a pH range / colour change within / in end-point / vertical region / sharp fall of the graph [1]</td><td>2</td></tr>
</table>

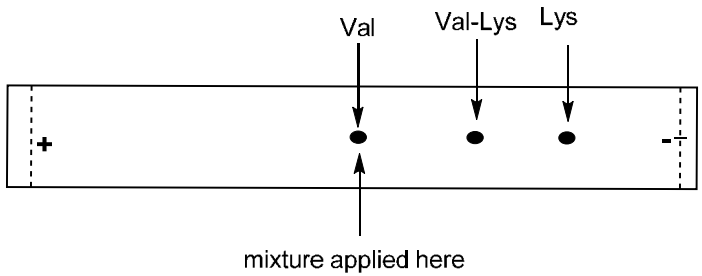
<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>5(a)(i)</td><td>[1] for each correct answer
<table>
<tr><th></th><th>number of peaks</th></tr>
<tr><td>F</td><td>3</td></tr>
<tr><td>G</td><td>6</td></tr>
</table></td><td>2</td></tr>
<tr><td>5(a)(ii)</td><td> 

one amide bond displayed in full [1]

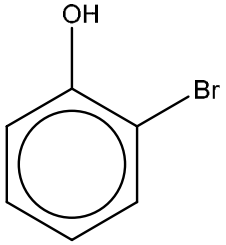
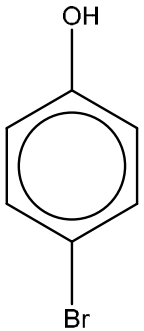
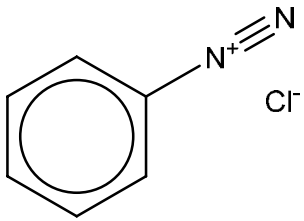
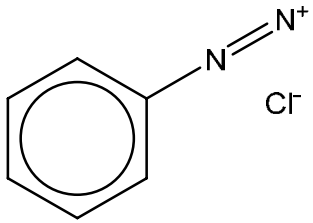
rest of the structure – one repeat unit only [1]</td><td>2</td></tr>
<tr><td>5(b)</td><td>[1] for each correct tick
<table>
<tr><th></th><th>σ-bonds only</th><th>π-bonds only</th><th>both σ- and π-bonds</th></tr>
<tr><td>bonds broken</td><td></td><td>✓</td><td></td></tr>
<tr><td>bonds formed</td><td>✓</td><td></td><td></td></tr>
</table></td><td>2</td></tr>
</table>

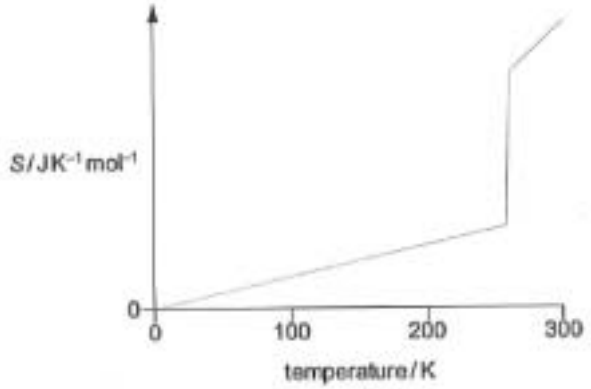
Question	Answer	Marks
5(c)	 **M1** length of chain with both monomers [1] **M2** continuation bonds [1]	**2**
5(d)(i)	C-C bonds are non-polar / have no dipole so cannot be hydrolysed [1]	**1**
5(d)(ii)	**M1** Hydrolysis using acid / base / alkali / enzymes [1] **M2** action of UV light [1]	**2**

Question	Answer	Marks
6(a)	 **M1** amide bond displayed [1] **M2** rest of the structure [1]	**2**

Question	Answer	Marks
6(b)	 **M1** valine on the cross [1] **M2** Val-Lys and Lys on the right of the cross (in any order) [1] **M3** relative order of Val-Lys and Lys (on the same side of the cross) [1] **Explanation** • Val does not move as it is a zwitterion / neutral (at pH6) **OR** Lys / Val-Lys move towards **negative** (pole) as they are **positively charged** • Lys moves the **furthest** as it has the **lowest** M_r (with the same positive charge) **OR** Val-Lys moves the **least** as it has the **largest** M_r (with the same positive charge) [1] × 2	**5**

Question	Answer	Marks
7(a)	**M1** C-X / C-C*l* / C-O bond is strong**er** (in chlorobenzene / phenol) [1] **M2** p-orbital / lone pair on C*l* / O(H) / X (in chlorobenzene / phenol) [1] **M3** electrons of the (C*l* / O / electronegative atom) **AND** overlap / delocalise with π-electron cloud / delocalise into ring [1]	**3**

Question	Answer	Marks
7(b)	 2-bromophenol  4-bromophenol structure and name correct [1]	**2**
7(c)(i)	step 1 **conc.** HNO_3 + H_2SO_4 (and temperare 50–55 °C) [1] step 2 Sn + HC*l* **AND one** of conc.HC*l* + heat [1] step 4 H_2O warm / heat [1]	**3**
7(c)(ii)	 **OR** 	**1**
7(c)(iii)	step 1 electrophilic substitution	**1**
7(c)(iv)	$C_6H_5NO_2$ + 6[H] → $C_6H_5NH_2$ + $2H_2O$	**1**

Question	Answer	Marks
8(a)	 **M1** continuous increase in *S* from 0–300 K (excluding m.p.) [1] **M2 steep** vertical increase in *S* **ONLY** at the m.p. **AND** continuous increase in *S* after m.p. [1]	**2**
8(b)	[1] for each correct tick <table><tr><td></td><td>negative $\Delta S^{\ominus}$</td><td>positive $\Delta S^{\ominus}$</td></tr><tr><td>solid dissolving in water</td><td></td><td>✓</td></tr><tr><td>water boiling to steam</td><td></td><td>✓</td></tr></table>	**1**
8(c)	$\Delta H^{\ominus}$ = (2 × C=O) + (3 × H-H) – (3 × C-H) – (C-O) – (3xO-H) $\Delta H^{\ominus}$ = (2 × 805) + (3 × 436) – (3 × 410)– (1 × 360) – (3 × 460) [1] $\Delta H^{\ominus}$ = 1610 + 1308 – 1230 – 360 – 1380 = **– 52** (kJ mol^{-1}) [1] ecf correct answer scores [2]	**2**
8(d)(i)	$\Delta S^{\ominus}$ = 127 + 70 – (214 + 3 × 131) [1] = – 410 (J K^{-1} mol^{-1}) [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 × –0.41) = **– 8.8(2)** (kJ mol^{-1}) [1] correct answer scores [2]	**2**

Question	Answer	Marks
8(d)(iii)	(as temperature increases) feasibility decreases	**1**
8(e)(i)	$2CH_3OH + 3O_2 \rightleftharpoons 2CO_2 + 4H_2O$ **OR** $2CH_3OH + 3O_2 \rightleftharpoons 2CO_2 + 4H^+ + 4OH^-$	**1**
8(e)(ii)	$E^{\ominus}_{cell}$ = 1.23 – 0.02 = **1.21** V	**1**

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