

CHEMISTRY**9701/43**

Paper 4 A Level Structured Questions

October/November 2016

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.

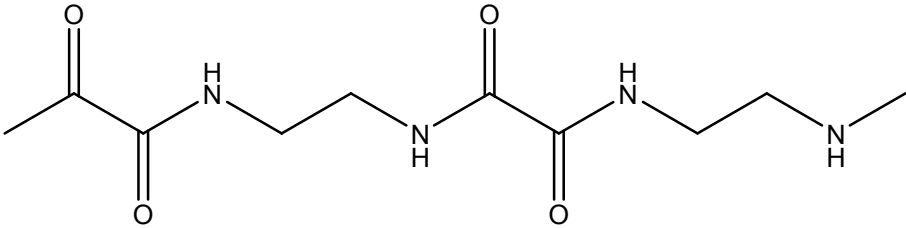
Cambridge will not enter into discussions about these mark schemes.

Cambridge is publishing the mark schemes for the October/November 2016 series for most Cambridge IGCSE[®], Cambridge International A and AS Level components and some Cambridge O Level components.

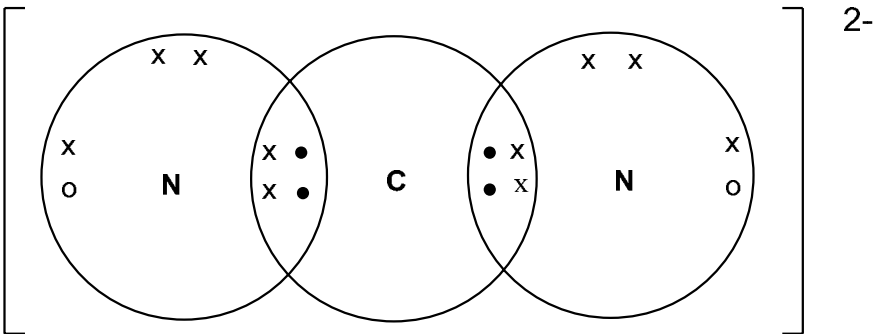
| | | | |
|---------------|---|-----------------|--------------|
| Page 2 | Mark Scheme | Syllabus | Paper |
| | Cambridge International AS/A Level – October/November 2016 | 9701 | 43 |

| Question | Answer | Mark |
|-----------------|--|--------------------|
| 1(a) | Cu [Ar] 3d ¹⁰ 4s ¹ Cu ²⁺ [Ar] 3d ⁹ (4s ⁰) | 1 1 2 |
| 1(b)(i) | ligand exchange / replacement / displacement / substitution | 1 1 |
| 1(b)(ii) | [Cu(H ₂ O) ₆] ²⁺ blue and [CuCl ₄] ²⁻ yellow OR yellow / green OR green / yellow | 1 1 |
| 1(b)(iii) | tetrahedral | 1 1 |
| 1(b)(iv) | $K_{\text{stab}} = \frac{[\text{CuCl}_4^{2-}]}{[\text{Cu}(\text{H}_2\text{O})_6^{2+}][\text{Cl}]^4}$ | 1 1 |
| 1(c)(i) | a species that contains two lone pairs that (each) form a co-ordinate / dative bond OR are donated (to a metal ion / atom) | 1 1 2 |
| 1(c)(ii) | equilibrium 2 lies more to the RHS / favours forward reaction more | 1 1 |
| 1(d)(i) | optical | 1 1 |
| 1(d)(ii) | 3D correct for octahedral one correct structure with 3D second correct with 3D | 1 1 1 |

| | | | |
|--------|--|----------|-------|
| Page 3 | Mark Scheme | Syllabus | Paper |
| | Cambridge International AS/A Level – October/November 2016 | 9701 | 43 |

| Question | Answer | Mark |
|-----------|--|--------------------|
| | | 3 |
| 1(e)(i) | lone pair receive / accepts a proton / H ⁺ | 1 1 2 |
| 1(e)(ii) | H ₂ NCH ₂ CH ₂ NH ₂ + 2HCl → ClH ₃ NCH ₂ CH ₂ NH ₃ Cl OR H ₂ NCH ₂ CH ₂ NH ₂ + 2H ⁺ → H ₃ N ⁺ CH ₂ CH ₂ N ⁺ H ₃ | 1 1 |
| 1(f)(i) | amide bond, displayed or –CONH– rest of the molecule with continuation bonds  | 1 1 2 |
| 1(f)(ii) | condensation / addition – elimination | 1 1 |
| 1(f)(iii) | any named polyalkene / eg polyethene, PVC allow Bakelite or Kevlar | 1 1 |
| | Total: | 20 |

| | | | |
|--------|--|----------|-------|
| Page 4 | Mark Scheme | Syllabus | Paper |
| | Cambridge International AS/A Level – October/November 2016 | 9701 | 43 |

| Question | Answer | Mark |
|----------|---|-------------------------|
| 2(a) | solid remains | 1 1 |
| 2(b) | stability increases (down the group) as size / radius of (metal) ion / M²⁺ increases so polarisation / distortion of anion / carbonate ion decreases | 1 1 1 3 |
| 2(c)(i) |  | 2 |
| 2(c)(ii) | $\text{CaCN}_2 + 3\text{H}_2\text{O} \rightarrow \text{CaCO}_3 + 2\text{NH}_3$ CaCO_3 correct equation | 1 1 2 |
| | Total: | 8 |

| | | | |
|---------------|---|-----------------|--------------|
| Page 5 | Mark Scheme | Syllabus | Paper |
| | Cambridge International AS/A Level – October/November 2016 | 9701 | 43 |

| Question | Answer | Mark |
|-----------------|---|-------------------------|
| 3(a)(i) | (entropy) increases/is positive and H ₂ /gas is formed | 1 1 |
| 3(a)(ii) | (entropy) increases/is positive and (KCl (aq)) solution has (free) moving/mobile ions/aqueous ions | 1 1 |
| 3(a)(iii) | (entropy) decreases/is negative and decrease in gas | 1 1 |
| 3(b)(i) | $\Delta S^\circ = 26.9 + 214 - 65.7 = (+) 175.2 \text{ (J K}^{-1} \text{ mol}^{-1}\text{)}$ $\Delta G^\circ = 117 - (298 \times 175.2 / 1000)$ OR $\Delta G^\circ = 117\,000 - (298 \times 175.2)$ $\Delta G^\circ = +64.8 \text{ (kJ mol}^{-1}\text{)}$ | 1 1 1 3 |
| 3(b)(ii) | T ΔS is more positive than ΔH /T ΔS increases/–T ΔS more negative and ΔG is negative/decrease/less positive | 1 1 |
| 3(c) | use of $\Delta G = 0$ or $\frac{T\Delta S}{\Delta H} = 1$ $T = 130 / (316 / 1000) = \mathbf{410 / 411 / 412 / 411.4}$ (K) | 1 1 2 |

| | | | |
|---------------|---|-----------------|--------------|
| Page 6 | Mark Scheme | Syllabus | Paper |
| | Cambridge International AS/A Level – October/November 2016 | 9701 | 43 |

| Question | Answer | Mark |
|-----------------|---|-------------|
| 3(d) | hydration enthalpy and lattice energy both more endothermic / more positive / less exothermic / less negative (down the group) | 1 |
| | ΔH_{hyd} decreases more / faster and ΔH_{sol} becomes (more) endothermic / (more) positive / less exothermic / less negative | 1 |
| | | 2 |
| | Total: | 11 |

| Question | Answer | Mark |
|-----------------|--|-------------|
| 4(a) | (an element) forming one or more (stable) ions or compounds or oxidation states with partially filled / incomplete d orbitals | 1 |
| 4(b)(i) | A $\text{Co}(\text{OH})_2$ OR $\text{Co}(\text{H}_2\text{O})_4(\text{OH})_2$ B $[\text{CoCl}_4]^{2-}$ C $[\text{Co}(\text{NH}_3)_6]^{2+}$ OR $[\text{Co}(\text{NH}_3)_6]^{3+}$ two correct = 1 mark three correct = 2 marks | 2 |
| 4(b)(ii) | $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$ pink solution of B blue solution of C brown/yellow/orange | |

| | | | |
|---------------|---|-----------------|--------------|
| Page 7 | Mark Scheme | Syllabus | Paper |
| | Cambridge International AS/A Level – October/November 2016 | 9701 | 43 |

| Question | Answer | Mark |
|-----------------|---|-------------|
| | two correct = 1 mark three correct = 2 marks | 2 |

| | | | |
|--------|--|----------|-------|
| Page 8 | Mark Scheme | Syllabus | Paper |
| | Cambridge International AS/A Level – October/November 2016 | 9701 | 43 |

| Question | Answer | Mark | | | | | | |
|-----------------------------------|--|----------------------------|-----------|------------------------------|-----------|-----------------------------------|--------------------|-------------------|
| 4(c) | (emf/potential/ E) of an electrode OR a half-cell compared to/connected to (S)HE which can be called a "hydrogen half-cell" at concentration of 1 mol dm^{-3} and pressure of 1 atm (or in Pa) OR 298 K | 1 1 2 | | | | | | |
| 4(d)(i) | <table border="1"> <tr> <td>half-cell</td> <td>electrode</td> </tr> <tr> <td>$\text{Co}^{2+} / \text{Co}$</td> <td>Co/cobalt</td> </tr> <tr> <td>$\text{Fe}^{3+} / \text{Fe}^{2+}$</td> <td>Pt/carbon/graphite</td> </tr> </table> | half-cell | electrode | $\text{Co}^{2+} / \text{Co}$ | Co/cobalt | $\text{Fe}^{3+} / \text{Fe}^{2+}$ | Pt/carbon/graphite | 1 1 |
| half-cell | electrode | | | | | | | |
| $\text{Co}^{2+} / \text{Co}$ | Co/cobalt | | | | | | | |
| $\text{Fe}^{3+} / \text{Fe}^{2+}$ | Pt/carbon/graphite | | | | | | | |
| 4(d)(ii) | $\text{Co} + 2\text{Fe}^{3+} \rightarrow \text{Co}^{2+} + 2\text{Fe}^{2+}$ | 1 1 | | | | | | |
| 4(d)(iii) | $E_{\text{cell}}^{\ominus} = 0.77 - (-0.28) = (+ \text{ or } -) 1.05 \text{ (V)}$ | 1 1 | | | | | | |
| 4(e)(i) | $E_{\text{electrode}} = -0.28 + (0.059/2) \log [0.05] = \mathbf{-0.32 / -0.318 \text{ (V)}}$ | 1 1 | | | | | | |
| 4(e)(ii) | more positive | 1 1 | | | | | | |
| 4(f) | $4\text{Fe}^{3+} + \text{V} + \text{H}_2\text{O} \rightarrow \text{VO}^{2+} + 4\text{Fe}^{2+} + 2\text{H}^+$ VO^{2+} correct equation | 1 1 | | | | | | |

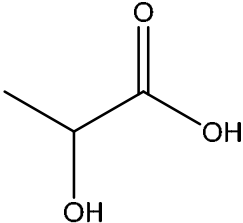
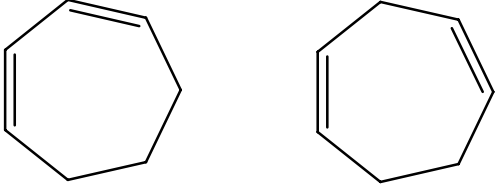
| | | | |
|---------------|---|-----------------|--------------|
| Page 9 | Mark Scheme | Syllabus | Paper |
| | Cambridge International AS/A Level – October/November 2016 | 9701 | 43 |

| Question | Answer | Mark |
|-----------------|---------------|-------------|
| | | 2 |
| | Total: | 14 |

| | | | |
|---------|--|----------|-------|
| Page 10 | Mark Scheme | Syllabus | Paper |
| | Cambridge International AS/A Level – October/November 2016 | 9701 | 43 |

| Question | Answer | | | | Mark | | | | | | | | | | | | | | | | |
|-------------------------------|--|--------------|---------------------------------------|--|-------------------------------|------------------------|--------------|------------------|------|------------------|-----------|---------------|------|-----------------------|-----------|---------------------------------------|------|--------|-----|---------------------------------------|----------|
| 5(a)(i) | $(100/22.1) \times (0.7/1.1)$ or $\frac{100 \times 0.7}{22.1 \times 1.1}$ or 2.87/2.88/2.9 3 carbon atoms | | | | 1 1 2 | | | | | | | | | | | | | | | | |
| 5(a)(ii) | C ₃ H ₆ O ₃ | | | | 1 1 | | | | | | | | | | | | | | | | |
| 5(b) | <table border="1"> <thead> <tr> <th>absorption / cm⁻¹</th> <th>appearance of the peak</th> <th>type of bond</th> <th>functional group</th> </tr> </thead> <tbody> <tr> <td>3350</td> <td>broad and strong</td> <td>OH or O–H</td> <td>alcohol / ROH</td> </tr> <tr> <td>2680</td> <td>very broad and strong</td> <td>OH or O–H</td> <td>(carboxylic) acid / CO₂H</td> </tr> <tr> <td>1725</td> <td>strong</td> <td>C=O</td> <td>(carboxylic) acid / CO₂H</td> </tr> </tbody> </table> | | | | absorption / cm ⁻¹ | appearance of the peak | type of bond | functional group | 3350 | broad and strong | OH or O–H | alcohol / ROH | 2680 | very broad and strong | OH or O–H | (carboxylic) acid / CO ₂ H | 1725 | strong | C=O | (carboxylic) acid / CO ₂ H | 2 |
| absorption / cm ⁻¹ | appearance of the peak | type of bond | functional group | | | | | | | | | | | | | | | | | | |
| 3350 | broad and strong | OH or O–H | alcohol / ROH | | | | | | | | | | | | | | | | | | |
| 2680 | very broad and strong | OH or O–H | (carboxylic) acid / CO ₂ H | | | | | | | | | | | | | | | | | | |
| 1725 | strong | C=O | (carboxylic) acid / CO ₂ H | | | | | | | | | | | | | | | | | | |

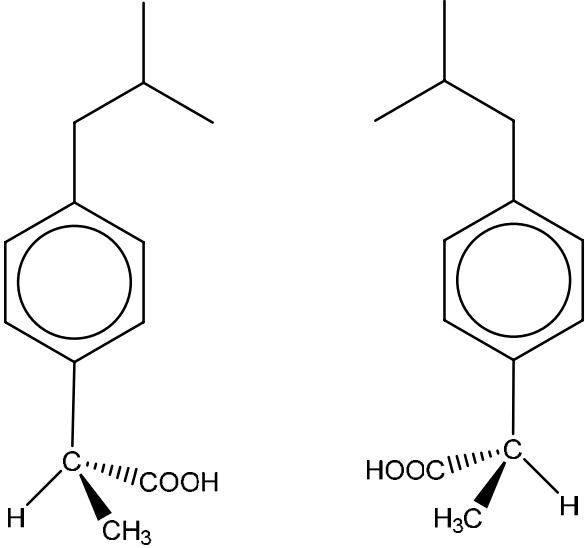
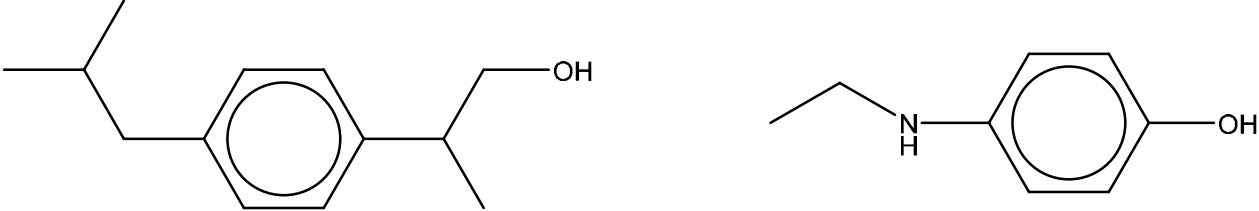
| | | | |
|---------|--|----------|-------|
| Page 11 | Mark Scheme | Syllabus | Paper |
| | Cambridge International AS/A Level – October/November 2016 | 9701 | 43 |

| Question | Answer | | | Mark | | | | | | | | | | | | | | | |
|---------------|--|--------------------|----------------|--------------------|-----|---|---|-----|---|---|-----|----------------|---|------|--|---|--|--|----------|
| 5(c)(i) | <table border="1"> <thead> <tr> <th>δ/ppm</th> <th>type of proton</th> <th>relative peak area</th> </tr> </thead> <tbody> <tr> <td>1.4</td> <td>-CH₃ or -CH₂ or -CH or alkane</td> <td>3</td> </tr> <tr> <td>3.9</td> <td>-OCH or -OCH₂ or -OCH₃ or CH or alkyl next to electronegative atom / oxygen</td> <td>1</td> </tr> <tr> <td>4.7</td> <td>-OH or alcohol</td> <td>1</td> </tr> <tr> <td>12.9</td> <td>-OH or -CO₂H or carboxylic acid</td> <td>1</td> </tr> </tbody> </table> | δ /ppm | type of proton | relative peak area | 1.4 | -CH ₃ or -CH ₂ or -CH or alkane | 3 | 3.9 | -OCH or -OCH ₂ or -OCH ₃ or CH or alkyl next to electronegative atom / oxygen | 1 | 4.7 | -OH or alcohol | 1 | 12.9 | -OH or -CO ₂ H or carboxylic acid | 1 | | | 4 |
| δ /ppm | type of proton | relative peak area | | | | | | | | | | | | | | | | | |
| 1.4 | -CH ₃ or -CH ₂ or -CH or alkane | 3 | | | | | | | | | | | | | | | | | |
| 3.9 | -OCH or -OCH ₂ or -OCH ₃ or CH or alkyl next to electronegative atom / oxygen | 1 | | | | | | | | | | | | | | | | | |
| 4.7 | -OH or alcohol | 1 | | | | | | | | | | | | | | | | | |
| 12.9 | -OH or -CO ₂ H or carboxylic acid | 1 | | | | | | | | | | | | | | | | | |
| 5(c)(ii) | doublet and 1 / one H / proton on neighbouring OR adjacent carbon | | | 1 1 | | | | | | | | | | | | | | | |
| 5(c)(iii) | 4.7 and 12.9 OR -OH and -CO ₂ H | | | 1 1 | | | | | | | | | | | | | | | |
| 5(c)(iv) |  | | | 1 1 | | | | | | | | | | | | | | | |
| 5(d)(i) |  both required for 1 mark | | | 1 1 | | | | | | | | | | | | | | | |

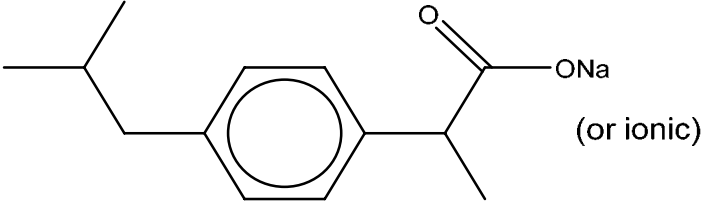
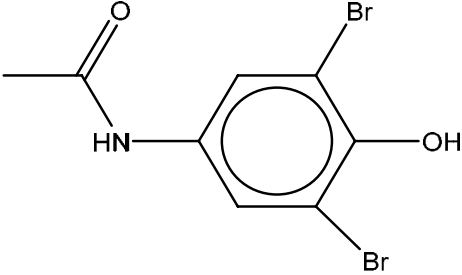
| | | | |
|---------|--|----------|-------|
| Page 12 | Mark Scheme | Syllabus | Paper |
| | Cambridge International AS/A Level – October/November 2016 | 9701 | 43 |

| Question | Answer | Mark |
|----------|-----------------|------------------|
| 5(d)(ii) | isomer | |
| | number of peaks | |
| | P | 4 |
| | Q | 4 |
| | | 1 |
| | | 1 |
| | | 2 |
| | | Total: 15 |

| Question | Answer | Mark |
|----------|---|----------|
| 6(a) | ibuprofen: carboxylic acid / carboxyl paracetamol: phenol and amide any two = 1 mark all three = 2 marks | 2 |
| 6(b)(i) | (chiral centre is a) carbon OR atom that has four different groups / atoms / species attached to it | 1 |
| | | 1 |

| Question | Answer | Mark |
|----------|--|-----------------------------|
| 6(b)(ii) |  <p>one correct isomer second diagram shows second isomer</p> | <p>1 1 2</p> |
| 6(c) |  <p>with ibuprofen with paracetamol</p> | <p>1 1 2</p> |

| | | | |
|---------|--|----------|-------|
| Page 14 | Mark Scheme | Syllabus | Paper |
| | Cambridge International AS/A Level – October/November 2016 | 9701 | 43 |

| Question | Answer | Mark |
|-----------|---|--------------------|
| 6(d)(i) | (reagent D) Na_2CO_3 / any carbonate (reagent E) Cl_2/Br_2 | 1 1 2 |
| 6(d)(ii) |  (or ionic) | 1 1 |
| 6(d)(iii) |  | 1 1 |
| 6(e)(i) | $\text{CH}_3\text{COCl} + \text{AlCl}_3 \rightarrow \text{CH}_3\text{CO}^+ + \text{AlCl}_4^-$ | 1 1 |

| Question | Answer | Mark |
|-----------|---|--|
| 6(e)(ii) | <p>curly arrow from ring system to CH_3CO^+</p> <p>correct intermediate</p> <p>curly arrow from C–H bond into ring</p> | <p>1</p> <p>1</p> <p>1</p> <p>3</p> |
| 6(e)(iii) | electrophilic substitution | <p>1</p> <p>1</p> |
| | Total: | 16 |

| | | | |
|---------|--|----------|-------|
| Page 16 | Mark Scheme | Syllabus | Paper |
| | Cambridge International AS/A Level – October/November 2016 | 9701 | 43 |

| Question | Answer | Mark |
|-----------|--|-------------------------|
| 7(a) | moles of thiosulfate = $0.1 \times 20.8 / 1000 = 2.08 \times 10^{-3}$ moles of ClO^- in 25 cm^3 portion = $2.08 \times 10^{-3} / 2 = 1.04 \times 10^{-3}$ (moles of ClO^- in $250 \text{ cm}^3 = 1.04 \times 10^{-2}$) concentration of $\text{ClO}^- = 1.04 \times 10^{-2} / (10 / 1000) = 1.04 \text{ (mol dm}^{-3}\text{)}$ | 1 1 1 3 |
| 7(b)(i) | starch | 1 1 |
| 7(b)(ii) | blue OR black to colourless | 1 1 |
| 7(b)(iii) | towards/ close to the end-point of the titration/when the solution goes yellow | 1 1 |
| 7(c) | moles of $\text{O}_2 = 82 / 24\,000 = 3.42 \times 10^{-3} = \text{moles } \text{ClO}^- \text{ ions}$ concentration of $\text{ClO}^- = 3.42 \times 10^{-3} / (5 / 1000) = 0.68 / 0.683 / 0.684 \text{ (mol dm}^{-3}\text{)}$ | 1 1 2 |
| 7(d)(i) | $K_c = \frac{[\text{C}_3\text{H}_3\text{N}_3\text{O}_3][\text{HClO}_3]^3}{[\text{C}_3\text{Cl}_3\text{N}_3\text{O}_3][\text{H}_2\text{O}]^3}$ | 1 1 |
| 7(d)(ii) | (position of eqm) moves to the right/ forward reaction predominates/ more HClO made (as $[\text{HClO}]$ decreases) no effect on K_c | 1 1 2 |

| | | | |
|---------|--|----------|-------|
| Page 17 | Mark Scheme | Syllabus | Paper |
| | Cambridge International AS/A Level – October/November 2016 | 9701 | 43 |

| Question | Answer | Mark |
|-----------|---|-----------------------------------|
| 7(d)(iii) | $2\text{HClO} \rightarrow 2\text{HCl} + \text{O}_2$ OR $2\text{HClO} \rightarrow \text{H}_2 + \text{Cl}_2 + \text{O}_2$ | <p>1</p> <p>1</p> |
| 7(e)(i) | addition of acid: $\text{H}^+ + \text{HCO}_3^- \rightarrow \text{H}_2\text{CO}_3$ OR $\text{H}^+ + \text{HCO}_3^- \rightarrow \text{H}_2\text{O} + \text{CO}_2$ addition of base: $\text{OH}^- + \text{H}_2\text{CO}_3 \rightarrow \text{HCO}_3^- + \text{H}_2\text{O}$ OR $\text{H}^+ + \text{OH}^- \rightarrow \text{H}_2\text{O}$ and position of eqm moves to the right OR $\text{OH}^- + \text{HCO}_3^- \rightarrow \text{CO}_3^{2-} + \text{H}_2\text{O}$ | <p>1</p> <p>1</p> <p>2</p> |
| 7(e)(ii) | $K_a = \frac{[\text{H}^+][\text{HCO}_3^-]}{[\text{H}_2\text{CO}_3]}$ $[\text{H}^+] = (7.94 \times 10^{-7}) \times 1/9.5 = 8.36 \times 10^{-8}$ $\text{pH} = -\log[\text{H}^+] = \mathbf{7.08}$ | <p>1</p> <p>1</p> <p>2</p> |
| | Total: | 16 |