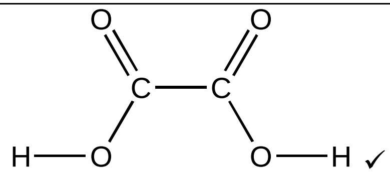
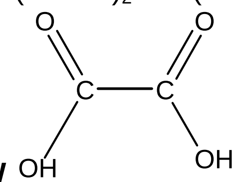
Question			er	Mark	Guidance
1	(a)	(i)	proton donor ✓	1	**ALLOW** H^+ donor
		(ii)	(the proportion of) dissociation ✓ Correct equation for **any** of the four acids: $C_6H_5COOH \rightleftharpoons H^+ + C_6H_5COO^-$ **OR** $CH_3COOH \rightleftharpoons H^+ + CH_3COO^-$ **OR** $CH_3COCOOH \rightleftharpoons H^+ + CH_3COCOO^-$ **OR** $CH_3CHOHCOOH \rightleftharpoons H^+ + CH_3CHOHCOO^-$ ✓	2	**ALLOW** a weak acid partly dissociates **ALLOW** a strong acid totally dissociates **ALLOW** ionisation for dissociation **ALLOW** the ability to donate a proton Equilibrium sign **required** **ALLOW** equilibria involving H_2O and H_3O^+ e.g. $C_6H_5COOH + H_2O \rightleftharpoons H_3O^+ + C_6H_5COO^-$, etc **DO NOT ALLOW** $HA \rightleftharpoons H^+ + A^-$
		(iii)	weakest: CH_3COOH — acetic acid C_6H_5COOH — benzoic acid $CH_3CHOHCOOH$ — lactic acid strongest: $CH_3COCOOH$ ✓ — pyruvic acid	1	**ALLOW** correct order using **any** identifier from the table, *ie*, common name, systematic name, structural formula **OR** pK_a value
		(iv)	$C_6H_5COOH_2^+ + CH_3CHOHCOO^-$ ✓	1	**BOTH** products **AND** correct charges required for mark Mark **ECF** from incorrect order in **(iii)** See response from **(iii)** below response to **(iv)**

Question			er	Mark	Guidance
	(b)	(i)	$2CH_3COCOOH + Ca(OH)_2 \rightarrow (CH_3COCOO)_2Ca + 2H_2O$ ✓ **Note:** pyruvic acid must have been used here and formula of pyruvic acid and pyruvate **must** be correct	1	All species **AND** balancing required for the mark **ALLOW** $(CH_3COCOO^-)_2Ca^{2+}$ **ALLOW** equation showing $2CH_3COCOO^- + Ca^{2+}$ **IF** charges shown, charges **must** balance, e.g. **DO NOT ALLOW** $(CH_3COCOO^-)_2Ca$ **IGNORE** state symbols if shown **ALLOW** multiples **ALLOW** equilibrium sign
		(ii)	$H^+ + OH^- \longrightarrow H_2O$	1	**ALLOW** multiples but **not** same species on both sides **ALLOW** equilibrium sign **IGNORE** state symbols if shown **ALLOW** $H_3O^+ + OH^- \longrightarrow 2H_2O$ **ALLOW** $CH_3COCOOH + OH^- \longrightarrow CH_3COCOO^- + H_2O$
	(c)		**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF** answer = 2.11, award **4 marks** --- $K_a = 10^{-pKa}$ $= 10^{-2.39}$ **OR** 0.00407 ✓ $K_a = \frac{[H^+]\,[CH_3COCOO^-]}{[CH_3COCOOH]}$ (**ALLOW** use of HA,H^+ and A^-) **OR** $[H^+] = \sqrt{(K_a \times [HA])}$ **OR** $[H^+]$ **=** $\sqrt{0.00407 \times 0.0150}$ ✓ (subsumes 1st marking point) $[H^+] =$ 0.00782 (mol dm^{-3}) ✓ pH = –log 0.00782 = **2.11** ✓	4	**IF** there is an alternative answer, check to see if there is any **ECF** credit possible using working below --- **IF ECF, ANNOTATE WITH TICKS AND CROSSES, etc** **ALLOW** 0.0041 to calculator value: 0.004073802 **IF** the pK_a of a different weak acid has been used use **ECF** from 2nd marking point **ALLOW** 0.0078 to calculator value (depending on previous rounding) **ALLOW ONLY 2.11** **(This is to take into account poor previous rounding)** **IF** candidate has used 0.0150 mol dm^{-3} (*ie* assumes strong acid) **ALLOW** final mark **ONLY** by **ECF** for a pH of 1.82 **IF** no square root used, pH = 4.21 3 marks

Question			er	Mark	Guidance
	(d)	(i)		1	**ALLOW** correct structural **OR** displayed **OR** skeletal formula **OR** recognisable mixture of formulae **DO NOT ALLOW** molecular formula but **ALLOW** $(COOH)_2$ **OR** $(CO_2H)_2$ **ALLOW**  **BUT not** O–H–C
		(ii)	$C_2H_2O_4 \rightleftharpoons H^+ + C_2HO_4^-$ ✓ $C_2HO_4^- \rightleftharpoons H^+ + C_2O_4^{2-}$ ✓	2	**ALLOW** in **either** order **ALLOW** arrow instead of equilibrium sign **ALLOW** molecular formulae for this part **ALLOW** equilibria involving H_2O and H_3O^+ **ALLOW** equations using structures

Question			er	Mark	Guidance
	(e)		***Chemicals (1 mark)*** lactic acid / $CH_3CHOHCOOH$ **AND** (sodium) lactate / $CH_3CHOHCOO^-$ (Na^+) ✓ ***Concentrations (4 marks)*** **EITHER** $[H^+(aq)] = 10^{-3.55}$ **OR** 2.8×10^{-4} **OR** 2.82×10^{-4} (mol dm^{-3})✓ *separate marking point* $K_a = 10^{-3.86}$ **OR** 1.4×10^{-4} **OR** 1.38×10^{-4} (mol dm^{-3}) ✓ *separate marking point* $\frac{[HA]}{[A^-]} = \frac{[H^+]}{K_a}$ **OR** $\frac{[A^-]}{[HA]} = \frac{K_a}{[H^+]}$ ✓ $\frac{[HA]}{[A^-]} = \frac{2.8\times10^{-4}}{1.4\times10^{-4}}$ **OR** $\frac{2}{1}$ **OR** 2 **OR** $\frac{[A^-]}{[HA]} = \frac{0.5}{1}$ **OR** 0.5✓ This marking point subsumes previous marking point **ONLY** ***Comment (1 mark)*** Magic tang/taste could come from other chemicals/substances in the sweet **OR** The buffer would have the same taste/tang as the magic tang ✓	**6**	**ANNOTATE WITH TICKS AND CROSSES, etc** **ALLOW** any lactate salt **ALLOW** lactic acid **AND** NaOH **OR** lactic acid **AND** OH^- -- **FOR ALTERNATIVE** using Henderson–Hasselbalch equation, **SEE PAGE 11** --- If another weak acid has been selected and salt has been selected, allow **ECF** for remainder of question **SEE PAGE 12** --- **ALLOW** 2.8×10^{-4} up to calculator value of 2.81838×10^{-4} **ALLOW** 0.00028, etc **ALLOW** 1.4×10^{-4} up to calculator value of 1.38038×10^{-4} **ALLOW** 0.00014, etc **ALLOW** use of $CH_3CHOHCOOH$ **AND** $CH_3CHOHCOO^-(Na^+)$ **ALLOW** use of acid **AND** salt **ALLOW** value from $\frac{\text{calculated value of }[H^+]}{\text{calculated value of }K_a}$ **ALLOW** 2SF up to calculator value of 2.041742129 correctly rounded but **ALLOW** 2 if 2.8×10^{-4} and 1.4×10^{-4} used **ALLOW** 2 mol dm^{-3} HA **AND** 1 mol dm^{-3} A^- **OR** any concentration ratio of 2(acid) : 1(salt) **ALLOW** 2SF up to calculator value of 0.489778819 correctly rounded but **ALLOW** 0.5 if 2.8×10^{-4} and 1.4×10^{-4} used

Question			er	Mark	Guidance
			ALTERNATIVE approach for concentrations using Henderson–Hasselbalch equation ***(4 marks)*** $pH = pK_a + \log\frac{[A^-]}{[HA]}$ **OR** $-\log K_a + \log\frac{[A^-]}{[HA]}$ ✓ $\log\frac{[A^-]}{[HA]}$ = 3.55 – 3.86 ✓ (subsumes previous mark) $\log\frac{[A^-]}{[HA]}$ = –0.31 ✓ (subsumes previous mark) $\frac{[A^-]}{[HA]} = 10^{-0.31} = \frac{0.490}{1}$ **OR** 0.490 ✓		**ALLOW** use of $CH_3CHOHCOOH$ **AND** $CH_3CHOHCOO^-(Na^+)$ **ALLOW** use of acid **AND** salt **ALLOW** $pH = pK_a - \log\frac{[HA]}{[A^-]}$ **OR** $-\log K_a - \log\frac{[HA]}{[A^-]}$ **ALLOW** $\log\frac{[HA]}{[A^-]}$ = 3.86 –3.55 (subsumes previous mark) **ALLOW** $\log\frac{[HA]}{[A^-]}$ = 0.31 (subsumes previous mark) **ALLOW** $\frac{[HA]}{[A^-]} = 10^{0.31} = \frac{2.04}{1}$ **OR** $\frac{2}{1}$ **OR** 2 For $\frac{[A^-]}{[HA]}$, **ALLOW** 2 SF up to calculator value of 0.48978819 For $\frac{[HA]}{[A^-]}$, **ALLOW** 2 SF up to calculator value of 2.041737945 but **ALLOW** 2 if $10^{-0.31}$ used

Question			er	Mark	Guidance
	(e)		**SUMMARY OF 4(e) MARKING POINTS FOR EACH POSSIBLE ACID CHOSEN**		

SUMMARY OF 4(e) MARKING POINTS FOR EACH POSSIBLE ACID CHOSEN
FIRST, CHECK THE ANSWER ON ANSWER LINE: IF answer is correct for weak acid chosen, award MP2–MP5
IF there is an alternative answer, check to see if there is any **ECF** credit possible using working below

	lactic	**yruvic**	**acetic**	**benzoic**
pK_a	3.86			4.19
MP1	lactic **AND** lactate **OR** lactic acid **AND** OH^-	No mark	No mark	No mark
MP2: $[H^+]$	$10^{-3.55}$ **OR** 2.82×10^{-4} (**calc**: 2.81838×10^{-4})			
MP3: K_a **calc:**	$10^{-3.86}$ **OR** 1.38×10^{-4} $1.380384265 \times 10^{-4}$	$10^{-2.39}$ **OR** 4.07×10^{-3} $4.073802778 \times 10^{-3}$	$10^{-4.76}$ **OR** 1.74×10^{-5} $1.737800829 \times 10^{-5}$	$10^{-4.19}$ **OR** 6.46×10^{-5} $6.45654229 \times 10^{-5}$
MP4: ratio expression	$\frac{[HA]}{[A^-]} = \frac{[H^+]}{K_a}$ **OR** $\frac{[A^-]}{[HA]} = \frac{K_a}{[H^+]}$			
MP5: $\frac{[HA]}{[A^-]}$ **calc:**	$\frac{2.82\times10^{-4}}{1.38\times10^{-4}}$ **OR** 2.04 2.041737945	$\frac{2.82\times10^{-4}}{4.07\times10^{-3}}$ **OR** 0.0693 **calc:** 0.069183097	$\frac{2.82\times10^{-4}}{1.74\times10^{-5}}$ **OR** 16.2 **calc:** 16.21810097	$\frac{2.82\times10^{-4}}{6.46\times10^{-5}}$ **OR** 4.37 **calc:** 4.365158322
OR $\frac{[A^-]}{[HA]}$ **calc:**	$\frac{1.38\times10^{-4}}{2.82\times10^{-4}}$ **OR** 0.489 0.489778819	$\frac{4.07\times10^{-3}}{2.82\times10^{-4}}$ **OR** 14.4	$\frac{1.74\times10^{-5}}{2.82\times10^{-4}}$ **OR** 0.0617 0.0616595	$\frac{6.46\times10^{-5}}{2.82\times10^{-4}}$ **OR** 0.229 0.229086765

TAKE CARE: Calc values are completely unrounded and may differ between brands of calculator
Use **actual** candidate values at each stage using rounding to 2 or more SF.
MP5: calculated using 3 SF from MP2 and MP3
calc values for MP5 are completely unrounded (using calculator values from MP2 and MP3)

Be slightly flexible as candidates may have written down rounded values but carried on with calculator values
– This appr ach is **ACCEPTABLE**

			Total	**20**	

Question			Expected Answers	Marks	Additional Guidance
2	a		measured pH > 1 **OR** $[H^+] < 0.1$ (mol dm^{-3}) ✓ $[H^+] = 10^{-pH}$ ✓ $K_a = \frac{[H^+][CH_3CH_2COO^-]}{[CH_3CH_2COOH]}$ **OR** $\frac{[H^+]^2}{[CH_3CH_2COOH]}$ ✓ Calculate K_a from $\frac{[H^+]^2}{0.100}$ ✓	4	**ALLOW** C_2H_5 throughout question **ALLOW** $[H^+] < [CH_3CH_2COOH]$ **OR** $[H^+] < [HA]$ **ALLOW** measured pH is higher than expected **ALLOW** measured pH is not as acidic as expected **ALLOW** a quoted pH value or range > 1 and < 7 **OR** between 1 and 7 **ALLOW** $[H^+]$ = antilog –pH **OR** $[H^+]$ = inverse log –pH **ALLOW** $\frac{[H^+][A^-]}{[HA]}$ **OR** $\frac{[H^+]^2}{[HA]}$ **IF** K_a is **NOT** given and $K_a = \frac{[H^+]^2}{0.100}$ is shown, award mark for K_a also (i.e. $K_a = \frac{[H^+]^2}{0.100}$ is automatically awarded the last 2 marks)
	b		**Marks are for correctly calculated values. Working shows how values have been derived.** $[H^+] = 10^{-13.46} = 3.47 \times 10^{-14}$ (mol dm^{-3}) ✓ $[OH^-] = \frac{1.0 \times 10^{-14}}{3.47 \times 10^{-14}} = 0.29$ (mol dm^{-3}) ✓	2	**ALLOW** $3.467368505 \times 10^{-14}$ and correct rounding to 3.5×10^{-14} **ALLOW** 0.28840315 and correct rounding to 0.29, i.e. **ALLOW** 0.288 **ALLOW** alternative approach using pOH: pOH = 14 – 13.46 = 0.54 ✓ $[OH^-] = 10^{-0.54}$ = 0.29 (mol dm^{-3}) ✓ Correct answer gets **BOTH** marks

Question			Expected Answers	Marks	Additional Guidance
	c		Propanoic acid reacts with sodium hydroxide forming propanoate ions/sodium propanoate **OR** $CH_3CH_2COOH + NaOH \rightarrow CH_3CH_2COONa + H_2O$ ✓ Some propanoic acid remains **OR** propanoic acid **AND** propanoate (ions) / sodium propanoate present ✓ equilibrium: $CH_3CH_2COOH \rightleftharpoons H^+ + CH_3CH_2COO^-$ ✓ **Added alkali** CH_3CH_2COOH reacts with added alkali **OR** $CH_3CH_2COOH + OH^- \rightarrow$ **OR** added alkali reacts with H^+ **OR** $H^+ + OH^- \rightarrow$ ✓ $\rightarrow CH_3CH_2COO^-$ **OR** Equilibrium $\rightarrow$ right ✓ **Added acid** $CH_3CH_2COO^-$ reacts with added acid **OR** $[H^+]$ increases ✓ $\rightarrow CH_3CH_2COOH$ **OR** Equilibrium $\rightarrow$ left ✓	7 **5**	***ANNOTATIONS MUST BE USED*** **ALLOW** C_2H_5 throughout question **ALLOW** Adding NaOH forms propanoate ions/sodium propanoate (imples that the NaOH is added to the propanoic acid) **ALLOW**: weak acid **AND** its conjugate base/salt present Throughout, do not penalise comments that imply that pH is constant in presence of buffer **DO NOT ALLOW** HA and A^- in this equilibrium expression For description of action of buffer below, **ALLOW** HA for CH_3CH_2COOH; **ALLOW** A^- for $CH_3CH_2COO^-$ Equilibrium responses must refer back to a written equilibrium. **IF** no equilibrium shown, use the equilibrium as written in expected answers (which is also written on page 6 of the paper) **ALLOW** weak acid reacts with added alkali **ALLOW** conjugate base reacts with added acid **DO NOT ALLOW** salt reacts with added acid

Question			Expected Answers	Marks	Additional Guidance
	d		$HNO_3 + CH_3CH_2COOH \rightleftharpoons CH_3CH_2COOH_2^+ + NO_3^-$ ✓ acid 1 base 2 acid 2 base 1 ✓	2	State symbols **NOT** required **ALLOW** 1 **AND** 2 labels the other way around. **ALLOW** 'just acid' and 'base' labels throughout if linked by lines so that it is clear what the acid–base pairs are. **IF** proton transfer is wrong way around then **ALLOW** 2nd mark for idea of acid–base pairs, i.e. $HNO_3 + CH_3CH_2COOH \rightleftharpoons CH_3CH_2COO^- + H_2NO_3^+$ ✗ base 2 acid 1 base 1 acid 2 ✓
	e	i	$2CH_3CH_2COOH + Mg \rightarrow (CH_3CH_2COO)_2Mg + H_2$ ✓	1	**IGNORE** state symbols **ALLOW** ionic equation: $2H^+ + Mg \rightarrow Mg^{2+} + H_2$ **IGNORE** any random charges in formula of $(CH_3CH_2COO)_2Mg$ as long as the charges are **correct (charges are treated as working)** i.e. $(CH_3COO^-)_2$ Mg **OR** $(CH_3COO)_2^-$ Mg should **not** be penalised However, Mg^{2+} instead of Mg on the left side of equation is obviously wrong
		ii	$2H^+ + CO_3^{2-} \longrightarrow H_2O + CO_2$ **OR** $2H^+ + CO_3^{2-} \longrightarrow H_2CO_3$ **OR** $H^+ + CO_3^{2-} \longrightarrow HCO_3^-$ ✓	1	State symbols **NOT** required
			Total	**17**	

Question			Expected answers	Marks	Additional guidance
3	a		A strong acid completely dissociates **AND** a weak acid partially dissociates ✓	1	**ALLOW** ionises for dissociates
		ii	$(K_a =)\ \dfrac{[H^+]\,[NO_2^-]}{[HNO_2]}$ ✓	1	**DO NOT ALLOW** $\dfrac{[H^+]^2}{[HNO_2]}$ Square brackets **are required**
		iii	**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF** answer = 1.89 award **2 marks** **IF** answer = 1.9 award **1 mark** --- pH = –log 0.0129 = **1.89** ✓✓ **OR** pH = –log 0.0129 = **1.9** ✓ ***not*** *two decimal places*	2	**IF** there is an alternative answer to more decimal places, check calculator value -- **Working to get to 0.0129 (mol dm^{-3})** **Not required and no credit** $[H^+] = \sqrt{K_a \times [HNO_2]}$ **=** $\sqrt{4.43 \times 10^{-4} \times 0.375}$ **ALLOW 1 mark** for an answer with more than 2 decimal places that rounds back to 1.89
		iv	HNO_3 + HNO_2 ⇌ NO_3^- + $H_2NO_2^+$ ✓ Acid 1 Base 2 Base 1 Acid 2 ✓	2	State symbols **NOT** required **ALLOW** 1 **AND** 2 labels the other way around. **ALLOW** 'just acid' and 'base' labels if linked by lines so that it is clear what the acid–base pairs are **IF** proton transfer is wrong way around **ALLOW** 2nd mark for idea of acid–base pairs, *i.e.* HNO_3 + HNO_2 ⇌ $H_2NO_3^+$ + NO_2^- ✗ Base 2 Acid 1 Acid 2 Base 1 ✓ **NOTE** For the 2nd marking point (acid–base pairs), this is the **ONLY** acceptable **ECF**

Question			Expected answers	Marks	Additional guidance
					*i.e., **NO ECF** from impossible chemistry*
	b		Proton acceptor ✓	1	**ALLOW** H^+ acceptor
		ii	**Marks are for correctly calculated values.** **Working shows how values have been derived.** $[OH^-] = 2 \times 0.04(00) = 0.08(00)$ (mol dm^{-3}) ✓ $[H^+] = \frac{1.00 \times 10^{-14}}{0.08(00)}$ **OR** 1.25×10^{-13} (mol dm^{-3}) ✓ pH = –log 1.25×10^{-13} = **12.90** ✓ --- **pOH variation (also worth 3 marks)** $[OH^-] = 2 \times 0.04(00) = 0.08(00)$ (mol dm^{-3}) ✓ pOH –log 0.08(00) = 1.10 ✓ pH = 14.00 – 1.10 = 12.90 ✓	3	**ALLOW** by **ECF** $\frac{1.00 \times 10^{-14}}{\text{calculated value of } [OH^-]}$ **DO NOT ALLOW** 12.9 *not **two** decimal places* --------------------------------------- **COMMON ERRORS** 12.60 ✓✓ *no × 2 for [OH⁻]* 12.6 ✓ *no × 2 for [OH⁻] **AND** 1 DP only* 12.30 ✓✓ *÷ 2 [OH⁻]* 12.3 ✓ *÷ 2 [OH⁻] **AND** 1 DP only* 1.40 **NO** marks
	c		$Ca(OH)_2 + 2HNO_2 \rightarrow Ca(NO_2)_2 + 2H_2O$ ✓ $H^+ + OH^- \longrightarrow H_2O$ ✓	2	**ALLOW**: $2H^+ + 2OH^- \rightarrow 2H_2O$

Question			Expected answers	Marks	Additional guidance
	d		**Equilibrium** $H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$ ✓		***ANNOTATIONS MUST BE USED*** **Equilibrium sign is required** **IGNORE** $HA \rightleftharpoons H^+ + A^-$ **DO NOT ALLOW** $H_2CO_3 \rightleftharpoons 2H^+ + CO_3^{2-}$ **DO NOT ALLOW** $NaHCO_3 \rightleftharpoons Na^+ + HCO_3^-$ **IGNORE** $H_2O + CO_2 \rightleftharpoons H_2CO_3$
			Action of buffer **Added alkali** H_2CO_3 reacts with added alkali **OR** $H_2CO_3 + OH^- \rightarrow$ **OR** added alkali reacts with H^+ **OR** $H^+ + OH^- \rightarrow$ ✓ Equilibrium $\rightarrow$ right **OR** equilibrium shifts forming H^+ **OR** HCO_3^- ✓		**IF** $HA \rightleftharpoons H^+ + A^-$ **OR** $H_2CO_3 \rightleftharpoons 2H^+ + CO_3^{2-}$ have been used above: **ALLOW** all marks that meet marking alternatives as written **NOTE** The 1st '**added acid**' mark **cannot** then be accessed Equilibrium responses **must** refer back to a written equilibrium **BUT IF** $H_2CO_3 \rightarrow H^+ + HCO_3^-$ shown above, assume that any equilibrium comments apply to the correct equilibrium **IF** more than one equilibrium shown, it **must** be clear which equilibrium is being referred to **ALLOW** added alkali reacts with weak acid ***Quality of Written Communication*** Mark is for linking the action of the buffer in controlling added alkali and hence pH

Question			Expected answers	Marks	Additional guidance
			Added acid HCO_3^- reacts with added acid ✓ Equilibrium → left **OR** equilibrium shifts forming H_2CO_3 ✓	5	**HCO_3^-** is **required** for this mark **BUT** … **ALLOW** added acid reacts with conjugate base **ONLY** if HCO_3^- is present in equilibrium with H_2CO_3 **DO NOT ALLOW** salt reacts with added acid
	d	ii	**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF** answer = **6.6 : 1** **OR** **1 : 0.15** **CHECK** ratio is HCO_3^- : H_2CO_3 and award **5 marks.** **IF** answer = **0.15 : 1** , **CHECK** ratio is H_2CO_3 : HCO_3^- and award **4 marks** -- In blood at pH 7.40, $[H^+] = 10^{-pH} = 10^{-7.40} = 3.98 \times 10^{-8}$ (mol dm^{-3}) ✓ $K_a = \frac{[H^+]\,[HCO_3^-]}{[H_2CO_3]} = \frac{3.98 \times 10^{-8} \times 10.5}{1}$ **OR** $K_a = 4.18 \times 10^{-7}$ (mol dm^{-3}) ✓ In blood at pH 7.20, $[H^+] = 10^{-pH} = 10^{-7.20} = 6.31 \times 10^{-8}$ (mol dm^{-3}) ✓ $\frac{[HCO_3^-]}{[H_2CO_3]} = \frac{K_a}{[H^+]}$ **OR** $\frac{4.18 \times 10^{-7}}{6.31 \times 10^{-8}}$ ✓ $= \frac{6.6}{1}$ **OR** 6.6 : 1 ✓ (up to calc. value, see below) **ALLOW** any answer with > 1 decimal place that rounds back to 6.62 **OR** 6.63	5	**IF** there is an alternative answer, check to see if there is any **ECF** credit possible using working below -- ***ANNOTATIONS MUST BE USED*** **FOR ALTERNATIVE** using Henderson–Hasselbalch equation below --- **ALLOW** 3.98×10^{-8} up to calculator value of $3.981071706 \times 10^{-8}$ correctly rounded **ALLOW** 6.31×10^{-8} up to calculator value of $6.309573445 \times 10^{-8}$ correctly rounded -- **Common errors** 0.15 : 1 ✓✓✓✓ *Inverse ratio of H_2CO_3 : HCO_3^-* 16.6 : 1 **OR** 0.06 : 1 ✓✓✓✓ *10.5/1 swapped over in 2nd mark giving K_a value of 3.79×10^{-9}* ***ALLOW** answer with > 1 decimal place that rounds back to 16.64 **OR** 16.65*
			ALTERNATIVE approach for concentrations using Henderson–Hasselbalch equation ***(5 marks)*** $pH = pK_a + \log\frac{[HCO_3^-]}{[H_2CO_3]}$ **OR** $-\log K_a + \log\frac{[HCO_3^-]}{[H_2CO_3]}$ ✓ $pK_a = pH - \log\frac{[HCO_3^-]}{[H_2CO_3]} = 7.40 - \log\frac{10.5}{1} = 6.38$ ✓ (subsumes previous mark) Calculator: 6.378810701		

Question			Expected answers	Marks	Additional guidance
			At pH = 7.20, $\log \frac{[HCO_3^-]}{[H_2CO_3]}$ = pH – pK_a = 7.20 – 6.38 = 0.82 ✓ (subsumes previous mark) $\frac{[HCO_3^-]}{[H_2CO_3]} = 10^{0.82}$ ✓ = $\frac{6.6}{1}$ **OR** 6.6 : 1 ✓		
			Total	**22**	