

Question Number	Acceptable Answers	Reject	Mark
1 (a)(i)	<p>Correct answer with or without working scores 2 marks</p> $[\text{H}^+] = (1.00 \times 10^{-14} / 0.250) = 4 \times 10^{-14} \quad (1)$ <p>pH = (13.39794 \Rightarrow) 13.4 (1)</p> <p>OR</p> <p>pOH = -log 0.250 = 0.602 (1)</p> <p>pH = (13.39794 \Rightarrow) 13.4 (1)</p> <p><i>ALLOW</i> TE in second mark if error in $[\text{H}^+]$ calculation gives pH more than 7 3 or more sf <i>IGNORE</i> rounding errors e.g. accept 13.39</p>		2

Question Number	Acceptable Answers	Reject	Mark
1 (a)(ii)	<p>$(K_a \Rightarrow) \frac{[\text{CH}_3\text{COO}^-][\text{H}^+]}{[\text{CH}_3\text{COOH}]} \quad (1)$</p> <p><i>ALLOW</i> H_3O^+ instead of H^+ $\frac{[\text{A}^-][\text{H}^+]}{[\text{HA}]}$ if key to symbols given <i>IGNORE</i> state symbols</p>	$\frac{[\text{H}^+]^2}{[\text{CH}_3\text{COOH}]}$	1

Question Number	Acceptable Answers	Reject	Mark
1 (a)(iii)	<p>Correct answer with or without working scores 2 marks</p> $1.7 \times 10^{-5} = \frac{[\text{H}^+]^2}{0.125} \quad (1)$ <p>$[\text{H}^+] = 1.46 \times 10^{-3}$ pH = 2.84/2.8 (1)</p> <p>no TE from an incorrect $[\text{H}^+]$</p>		2

Question Number	Acceptable Answers	Reject	Mark
1 (a)(iv)	<p>pH = 4.8 / 4.77 (1)</p> <p>pH = $pK_a / [H^+] = K_a$ (when acid is half neutralized) (1)</p>	$H^+ = K_a$	2

Question Number	Acceptable Answers	Reject	Mark
1 (a)(v)	<p>Sigmoid curve starting between pH 2 and 4 (2.8), ending between pH 12 and 14 inclusive (1)</p> <p>with steep rise (may be vertical or gently sloping) of between 3 - 7 units between pH 6 and 12. Sloping section should not extend over more than 5cm³. (1)</p> <p>When 12.5 cm³, NaOH added. (1) <i>ALLOW</i> tolerance for grid</p> <p>Reverse curves lose first mark</p>		3

Question Number	Acceptable Answers	Reject	Mark
1 (a)(vi)	<p>First mark Thymolphthalein more suitable as it changes (from colourless to blue) in steep region of titration (pH 8.3 to 10.6)/ at the equivalence point / at the end point OR thymolphthalein has pH range in steep region of titration (1)</p> <p>Second mark Methyl yellow changes (from red to yellow at pH 2.9 to 4) before equivalence point / before the end point / doesn't change in steep section OR Methyl yellow has pH range before / outside steep region of titration (1)</p> <p><i>ALLOW</i> 'Thymolphthalein more suitable as it changes at the equivalence point but methyl yellow does not.' This scores 2 marks</p> <p>OR</p> <p>First mark $pK_{in} \pm 1$ must lie within vertical region on titration curve (1)</p> <p>Second mark hence thymolphthalein is suitable and methyl yellow is not (1)</p>		2

Question Number	Acceptable Answers	Reject	Mark
1 (b)	<p>Sodium ethanoate/ CH_3COONa Potassium ethanoate / CH_3COOK</p> <p><i>ALLOW</i> other cations as alternatives to sodium</p>	Use of sodium hydroxide (because it's in food)	1

Question Number	Acceptable Answers	Reject	Mark
2(a)(i)	$K_w = [\text{H}^+] \times [\text{OH}^-]$ OR $K_w = [\text{H}_3\text{O}^+] \times [\text{OH}^-]$ State symbols are not required IGNORE any incorrect state symbols	Inclusion of $[\text{H}_2\text{O}]$	1

Question Number	Acceptable Answers	Reject	Mark
2(a)(ii)	<p>FIRST, CHECK THE FINAL ANSWER IF answer pH = 11.875 / 11.88 / 11.9 / 12 award 2 marks</p> <p>IGNORE sf except 1 sf</p> $[\text{H}^+] = \frac{K_w}{[\text{OH}^-]} = \frac{1.00 \times 10^{-14}}{0.00750}$ $= 1.3333 \times 10^{-12}$ $= 1.33 \times 10^{-12} \quad \text{(1)}$ <p style="text-align: center;">(mol dm⁻³)</p> <p>ALLOW first mark for just</p> $[\text{H}^+] = \frac{K_w}{[\text{OH}^-]}$ <p>pH = $-\log_{10} [\text{H}^+] = 11.875$ = 11.88 / 11.9 (1)</p> <p>OR</p> <p>pOH = $-\log_{10} [\text{OH}^-] = 2.12 \quad \text{(1)}$ pH = $pK_w - \text{pOH}$ pH = 11.88 / 11.9 (1)</p> <p>Second mark only awarded CQ if pH between 8 and 14</p>		2

Question Number	Acceptable Answers	Reject	Mark
2(b)	<p>First mark</p> $\text{Moles NaOH} = \frac{0.00750 \times 20.0}{1000}$ $= 1.50 \times 10^{-4} \text{ (mol)}$ <p style="text-align: right;">(1)</p> <p>(Since HCOOH : NaOH ratio is 1:1)</p> <p>Second mark</p> $[\text{HCOOH(aq)}] = \frac{1.50 \times 10^{-4}}{0.0250}$ <p>OR</p> $= 1.50 \times 10^{-4} \times \frac{1000}{25.0}$ <p style="text-align: right;">(1)</p> <p>(= $6.00 \times 10^{-3} \text{ mol dm}^{-3}$)</p> <p>ALTERNATIVE APPROACH:</p> <p>Use of an expression such as</p> $0.00750 \times 20.0 = 25 \times y$ <p style="text-align: right;">(1)</p> $y = \frac{0.00750 \times 20.0}{25}$ <p style="text-align: right;">(1)</p>		2

Question Number	Acceptable Answers	Reject	Mark
2(c)(i)	<p>(Weak) dissociates / ionizes to a small extent</p> <p>OR dissociate / ionizes partially</p> <p>OR dissociates / ionizes incompletely</p> <p>OR does not fully dissociate / ionize</p> <p>OR forms an equilibrium when reacted with water (1)</p> <p>(Acid) proton donor</p> <p>ALLOW 'proton donator'</p> <p>OR produces / releases H^+ ions</p> <p>OR produces / releases H_3O^+ ions (1)</p> <p>Ignore reference to typical acid reactions</p>	'not easily dissociated'	2

Question Number	Acceptable Answers	Reject	Mark
2(c)(ii)	$(K_a =) \frac{[\text{HCOO}^-][\text{H}^+]}{[\text{HCOOH}]}$ <p>State symbols are NOT required IGNORE any incorrect state symbols</p>	$(K_a =) \frac{[\text{H}^+]^2}{[\text{HCOOH}]}$ <p>Inclusion of $[\text{H}_2\text{O}]$</p>	1

Question Number	Acceptable Answers	Reject	Mark
2(c)(iii)	<p>IGNORE sf except 1 sf THROUGHOUT FIRST, CHECK THE FINAL ANSWER IF answer $K_a = 1.59 \times 10^{-4} \text{ (mol dm}^{-3}\text{)}$ award the first two 2 marks $[\text{H}^+] (= 10^{-\text{pH}} = 10^{-3.01})$ $= 9.77 \times 10^{-4} \text{ (mol dm}^{-3}\text{)}$ (1)</p> $K_a = \frac{[\text{H}^+]^2}{[\text{HCOOH}]}$ $K_a = \frac{(9.77 \times 10^{-4})^2}{6.00 \times 10^{-3}}$ $= 1.59 \times 10^{-4} \text{ (mol dm}^{-3}\text{)}$ (1) <p>Assumption 1 $[\text{H}^+] = [\text{HCOO}^-]$ OR no H^+ from the (ionization of) water OR H^+ only from the acid (1)</p> <p>Assumption 2 Ionization of the (weak) acid is negligible / very small / insignificant OR $[\text{HCOOH}]_{\text{initial}} - x = [\text{HCOOH}]_{\text{eqm}}$ OR $[\text{HCOOH}]_{\text{eqm}} = [\text{HCOOH}]_{\text{initial}}$ OR $[\text{HCOOH}]_{\text{eqm}} = 6.00 \times 10^{-3} \text{ (mol dm}^{-3}\text{)}$ OR $[\text{H}^+] \ll [\text{HA}]$ (1)</p> <p>Assumptions can be in either order</p>	<p>If incorrect units max 1</p> <p>Just 'partial' / 'incomplete' Or 'no dissociation'</p>	4

<p>2(c) (iii) cont'd</p>	<p>OR</p> $[H^+] (= 10^{-pH} = 10^{-3.01})$ $= 9.77 \times 10^{-4} \text{ (mol dm}^{-3}\text{)} \quad (1)$ $K_a = \frac{[H^+]^2}{[HCOOH]}$ $K_a = \frac{(9.77 \times 10^{-4})^2}{(6.00 \times 10^{-3} - 9.77 \times 10^{-4})} \quad (1)$ $= 1.90 \times 10^{-4} \text{ (mol dm}^{-3}\text{)} \quad (1)$ <p>Assumption $[H^+] = [HCOO^-]$ OR no $[H^+]$ from the (ionization of) water OR H^+ only from the acid (1)</p> <p>Ignore references to constant temperature</p>		
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Question Number	Acceptable Answers	Reject	Mark
3 (a)(i)	$(K_a =) [H^+][C_6H_5COO^-]/[C_6H_5COOH]$ Penalise missing charges ALLOW $[H_3O^+]$ in place of $[H^+]$ IGNORE state symbols and units even if incorrect	$K_a = [H^+]^2/[C_6H_5COOH]$	1

Question Number	Acceptable Answers	Reject	Mark
3(a)(ii)	$[H^+] = \sqrt{(6.3 \times 10^{-5} \times 0.0025)}$ (1) $pH = -\log \sqrt{(6.3 \times 10^{-5} \times 0.0025)}$ $= 3.4$ (1) Answer without working scores (2) marks 6.8 scores (1) IGNORE sf except 1	answer if units given	2

Question Number	Acceptable Answers	Reject	Mark
3(b)	(pH) range (of indicator) 3.8 to 5.4 OR $pK_{in} = 4.7$ (1) Bubble bath is (initially yellow since) pH less than 3.8 / is 3.4 (1) Adding of water/dilution (of acid) causes pH to rise/ means $[H^+]$ decreases (1) Hence pH rises to ≥ 5.4 so blue/changes colour (1) If a(ii) $pH > 3.8$ and < 5.4 then loses second marking point but can score other marking points. If a(ii) $pH > 5.4$ then can score first and third marking points only	Water neutralizes acid	4

Question Number	Acceptable Answers	Reject	Mark
18 (a)	pH = (-log 0.25) = 0.602 / 0.60 / 0.6 Ignore significant figures		1

Question Number	Acceptable Answers	Reject	Mark
18 (b) (i)	$(K_a =) \frac{[H^+][CH_3CH_2COO^-]}{[CH_3CH_2COOH]}$ ALLOW $[H_3O^+]$ for $[H^+]$ ALLOW C_2H_5 for CH_3CH_2 ALLOW $\frac{[H^+][A^-]}{[HA]}$ if HA and A ⁻ identified	Wrong / missing charge on $CH_3CH_2COO^-$ $K_a = \frac{[H^+]^2}{[CH_3CH_2COOH]}$ unless full expression also given	1

Question Number	Acceptable Answers	Reject	Mark
18 (b) (ii)	$1.3 \times 10^{-5} = \frac{[H^+]^2}{0.25}$ / rearrangement of this expression (1) $([H^+] = 1.8 \times 10^{-3})$ pH = 2.74 (1) Correct answer with no working scores (2) No TE for incorrect $[H^+]$ Ignore significant figures except 1 Minimum of 1 decimal place needed		2

Question Number	Acceptable Answers	Reject	Mark
18 (c) (i)	$CH_3CH_2COOH + NaOH \rightarrow CH_3CH_2COO^{(-)}Na^{(+)} + H_2O$ OR $CH_3CH_2COOH + OH^- \rightarrow CH_3CH_2COO^- + H_2O$ Accept $CH_3CH_2CO_2H$, C_2H_5COOH , $C_2H_5CO_2H$	Equations for ethanoic acid	1

Question Number	Acceptable Answers	Reject	Mark
18 (c) (ii)	<p>$1.3 \times 10^{-5} = \frac{[H^+][5 \times 10^{-2}]}{[7.5 \times 10^{-2}]}$ (concentration ratio)</p> <p>OR</p> <p>$1.3 \times 10^{-5} = \frac{[H^+](1 \times 10^{-3})}{(1.5 \times 10^{-3})}$ (ratio by moles)</p> <p>(ratio by moles allowed as volumes acid and salt equal) (1)</p> <p>($[H^+] = 1.95 \times 10^{-5}$)</p> <p>pH = 4.7 / 4.7099654 (1)</p> <p>Second mark dependent on first Correct answer with or without working (2)</p> <p>OR</p> <p>pH = pK_a -log $\frac{(1.5 \times 10^{-3})}{1 \times 10^{-3}}$</p> <p>OR</p> <p>pH = pK_a -log $\frac{(7.5 \times 10^{-2})}{5 \times 10^{-2}}$ (1)</p> <p>pH = 4.7 (1)</p> <p>Correct answer with or without working (2)</p> <p>Accept any value which rounds to 4.7</p>		2

Question Number	Acceptable Answers	Reject	Mark
*18 (c) (iii)	<p>Mixture is a buffer (1)</p> <p>EITHER</p> <p>OH⁻ combines with H⁺ in solution (1)</p> <p>Propanoic acid dissociates to replace H⁺ (1) <i>Correct equations could gain these marks</i></p> <p>OR</p> <p>OH⁻ reacts with propanoic acid (1) <i>Correct equation could gain this mark</i></p> <p>Significant quantities of weak acid and salt are both present /ratio of acid and salt does not change (1)</p> <p>ALLOW a reservoir of weak acid and salt are present: Allow conjugate base for salt</p>	NaOH combines	3

Question Number	Acceptable Answers	Reject	Mark
18 (c) (iv)	<p>S-shaped curve, vertical at 25 cm³ (with kink at start) (1)</p> <p>Starting at pH 2-3 (TE from (b)(ii), finishing at pH 12 -13 (1)</p> <p>Vertical section between 3 and 6 units high centred round a pH of between 8 and 9 (1)</p> <p>Vertical section should not extend over more than $\pm 2.5\text{cm}^3$ This section should start between 5.5 and 7.5 and finish between 9.5 and 11.5 but do not penalise for very small differences.</p> <p>Reverse curve maximum 2</p>		3

Question Number	Acceptable Answers	Reject	Mark
18 (c) (v)	<p>Either Need indicator changing in vertical region of curve / need indicator changing where pH changes sharply / bromocresol green changes before the vertical region (1)</p> <p>Not bromocresol green which changes at 3.8 - 5.4 (1)</p> <p>OR</p> <p>$pK_{in} \pm 1$ must be in vertical section / sharply changing section (1)</p> <p>Not bromocresol green because pK_{in} is 4.7 (1)</p> <p>TE from curve with vertical section including pH 3.7 - 5.7</p>	Just "the equivalence point is outside the bromocresol green range"	2

Question Number	Acceptable Answers	Reject	Mark
18 (d) (i)	Dilute acid / dilute strong named acid or formula / NaOH(aq) followed by dilute acid / water plus dilute acid / water plus H^+	NaOH alone water any weak acid concentrated sulfuric acid HCN acid hydrolysis alone	1

Question Number	Acceptable Answers	Reject	Mark
18 (d) (ii)	$CH_3CH_2COCl + H_2O \rightarrow CH_3CH_2COOH + HCl$ / $C_2H_5COCl + H_2O \rightarrow C_2H_5COOH + HCl$ Accept displayed formula	Equations with NaOH or OH^-	1

Question Number	Acceptable Answers	Reject	Mark
18 (d) (iii)	Colour change orange to green / blue		1

Question Number	Acceptable Answers	Reject	Mark
18 (e)	<p>Reducing agent /Reduction (of the acid) occurs (1)</p> <p>Li Al H₄ / lithium tetrahydridoaluminate / lithium aluminium hydride (1)</p> <p>Allow minor error in name if correct formula is given</p> <p>Ignore solvent</p> <p>ALLOW nucleophile AND H⁻ for 1 mark</p>	Lithal without correct name or formula	2

Question Number	Acceptable Answers	Reject	Mark
5 (a)(i)	<p>(pH =) -log [H⁺]</p> <p>OR</p> <p>(pH =) -log [H₃O⁺]</p> <p>OR</p> <p>Accept Definition in words (For example: "It is minus / negative log(arithm) of the hydrogen ion concentration")</p> <p>Base 10 does not have to be there, but reject "ln"</p>	<p>Just "concentration of hydrogen ions"</p> <p>{ } curly brackets</p> <p>-log H⁺</p>	1

Question Number	Acceptable Answers	Reject	Mark
5 (a)(ii)	(pH = -log 0.0100) = 2(.00)	If any units given	1

Question Number	Acceptable Answers	Reject	Mark
5 (b)(i)	$[\text{H}_3\text{O}^+] = \frac{K_a[\text{CH}_3\text{COOH}]}{[\text{CH}_3\text{COO}^-]}$ <p>OR</p> $[\text{H}_3\text{O}^+]^2 = K_a[\text{CH}_3\text{COOH}] \quad (1)$ <p>ALLOW</p> <p>[HA] for [CH₃COOH] and [A⁻] for [CH₃COO⁻] in rearranged expression</p> <p>Accept [H⁺] for [H₃O⁺]</p> <p>∴ [H₃O⁺] = √ 1.75 x 10⁻⁷</p> <p>OR</p> <p>∴ [H₃O⁺] = 4.18(3) x 10⁻⁴ (mol dm⁻³) (1)</p> <p>pH = 3.38 / 3.4 (1) ignore sf except one sf</p> <p>Third mark TE from [H⁺] only if pH less than 7</p> <p>N.B. CORRECT ANSWER, WITH OR WITHOUT WORKING, SCORES (3)</p> <p>Assumption assumes that degree of ionisation of the acid is very small/negligible</p> <p>OR</p> $[\text{CH}_3\text{COOH}]_{\text{eqm}} = [\text{CH}_3\text{COOH}]_{\text{initial}}$ <p>OR</p> $[\text{H}^+] = [\text{CH}_3\text{COO}^-]$ <p>OR</p> <p>all of the hydrogen ions come from the acid / ignore hydrogen ions from the water (1)</p> <p>IGNORE any references to temperature</p>	<p>3.37 / 3 / 3.39 / a correct pH value with units</p> <p>just “weak acid” / just “partially dissociates” / acid does not dissociate / [CH₃COOH] constant</p> <p>[H⁺] = [OH⁻] / [H⁺] = [salt]</p>	4

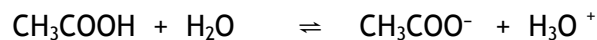
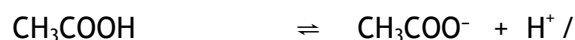
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5 (b)(ii)

First mark:

2

(Dilution/addition of water) shifts the equilibrium



to the **right**

OR

the above stated in words such as:
degree of dissociation increases/
proportion of dissociation increases/
more dissociation (as the ethanoic acid is diluted)

(1)

Second mark:

so the $[\text{H}^+]$ is greater than expected/
so the decrease in $[\text{H}^+]$ is less than expected /
so that the decrease in $[\text{H}^+]$ is less than that for hydrochloric acid

(1)

Reject just a reference to a 0.5 increase in pH for $\text{CH}_3\text{COOH}(\text{aq})$ compared with a 1.0 increase in pH for $\text{HCl}(\text{aq})$

Each mark is a stand alone mark.

ALTERNATIVE ROUTE:

First mark:

$$[\text{H}^+] = \sqrt{K_a \times [\text{HA}]} \quad \text{OR} \quad (K_a \times [\text{HA}])^{1/2}$$

OR

$$\text{pH} = \frac{1}{2}\text{p}K_a - \frac{1}{2}\log[\text{HA}]$$

(1)

Second mark:

use of mathematical expression given (e.g. $[\text{H}^+]$ affected by factor of $1/\sqrt{10}$ on dilution OR substitution of numerical values into the equation)

(1)

IGNORE: any comments or calculations relating to $\text{HCl}(\text{aq})$

Question Number	Acceptable Answers	Reject	Mark
5 (c)(i)	<p>These marks are stand alone.</p> <p>Maintains an almost constant pH / resists change(s) in pH (1)</p> <p>for small addition of H⁺ or OH⁻ ions (N.B. both ions needed) / for small additions of acid or alkali / for small additions of acid or base (1)</p> <p><i>IGNORE</i> any references to named buffer mixtures</p>	<p>“resists small change(s) in pH” OR “pH does not change”</p>	2

Question Number	Acceptable Answers	Reject	Mark
5 (c)(ii)	citric acid		1

Question Number	Acceptable Answers	Reject	Mark
5 (c)(iii)	<p>First mark:</p> <p>(buffer contains) reservoir of HA and A⁻ OR (buffer contains) large concentrations of [HA] and [A⁻] OR both equations: HA ⇌ A⁻ + H⁺ and NaA → Na⁺ + A⁻</p> <p>Second mark:</p> <p>(Addition of alkali/base)</p> <p>HA + OH⁻ → A⁻ + H₂O OR description/equations to show that H⁺ reacts with OH⁻ (to form H₂O) and more acid dissociates (to replace H⁺)</p> <p>Third mark:</p> <p>(Addition of acid)</p> <p>A⁻ + H⁺ → HA OR A⁻ reacting with H⁺ in any context described in words (e.g. by reference to weak acid equilibrium)</p> <p>Fourth mark:</p> <p>the ratio of [A⁻]:[HA] hardly changes / the ratio of [HA]:[A⁻] hardly changes OR [A⁻] nor [HA] changes significantly (1)</p>	<p>JUST NaA ⇌ Na⁺ + A⁻ and HA → H⁺ + A⁻ without correct description</p> <p>Just [H⁺] remains constant</p>	4