Acid/Base Equilibria

Mark Scheme

Level	International A Level
Subject	Chemistry
Exam Board	Edexcel
Topic	Rates, Equilibria & Further Organic Chemistry
Sub Topic	Acid/Base Equilibria
Booklet	Mark Scheme

Time Allowed: **40 minutes**

Score: **/33**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

Question Number	Correct Answer	Reject	Mark
1a	A		1

Question Number	Correct Answer	Reject	Mark
1b	B		1

Question Number	Correct Answer	Reject	Mark
2	**D**		**(1)**

Question Number	Correct Answer	Reject	Mark
3	D		**1**

Question Number	Acceptable Answers	Reject	Mark
4a	Proton/ H^+ donor		1

Question Number	Acceptable Answers	Reject	Mark
4b	pH of HCl = 1 **and** pH of weak acid is greater /higher than 1 Allow any number >1 and <7	 Different (from 1)	1

Question Number	Acceptable Answers	Reject	Mark
4c(i)	HCOOH/ methanoic acid is stronger **because** its K_a is bigger/higher OR its pK_a is smaller / lower (The data: K_a pK_a Methanoic acid 1.6×10^{-4} 3.8 Propanoic acid 1.3×10^{-5} 4.9) IGNORE Discussion of inductive effect		1

Question Number	Acceptable Answers	Reject	Mark
4c(ii)	$(HCOOH + C_2H_5COOH) \rightleftharpoons$ **$HCOO^- + C_2H_5COOH_2^+$** ALLOW TE for equation with propanoic acid as proton donor giving $HCOOH_2^+$ and $C_2H_5COO^-$ if HCOOH is stated to be weaker	$COOH^-$ $C_2H_6COOH^+$	1

Question Number	Acceptable Answers	Reject	Mark
4d	$[H^+] = (1 \times 10^{-14} / [OH^-])$ $= 2 \times 10^{-13}$ (mol dm^{-3}) **(1)** pH = 12.7 **(1)** OR pOH / -log 0.05 = 1.3 **(1)** pH = (14 -1.3 =) 12.7 **(1)** Correct answer with no working scores 2 provided at least 3 SF Allow TE on first mark provided answer >7	 13 13	2

Question Number	Acceptable Answers	Reject	Mark
4e(i)	$C_2H_5COOH + NaOH \rightarrow C_2H_5COO^{(-)}\ Na^{(+)} + H_2O$ ALLOW $\rightleftharpoons$ for $\rightarrow$ $C_2H_5COO^-$ + Na^+ for $C_2H_5COO^{(-)}\ Na^{(+)}$ IGNORE State symbols even if incorrect		1

Question Number	Acceptable Answers	Reject	Mark
4e(ii)	Allow salt/ C_2H_5COONa/ propanoate ion/ $C_2H_5COO^-$/ base for A^- Allow propanoic acid/ C_2H_5COOH for HA **First mark** $K_a = \frac{[H^+][A^-]}{[HA]}$ OR $\log K_a = \log[H^+] + \log [A^-]/[HA]$ OR $pH = pK_a - \log [HA]/[A^-]$ ALLOW any of these equations re-arranged or used correctly **(1)** **Next four marks** Mol NaOH before mixing = (20 x 0.05/1000) = 0.001 **and** mol propanoic acid before mixing = (20 x 0.25/1000) = 0.005 **(1)** Mol propanoate in mixture = 0.001 OR [propanoate] = (0.001/40 x1000) = 0.025 (mol dm^{-3}) **(1)** Mol propanoic acid in mixture = 0.004 OR [propanoic acid] = (0.004/40 x 1000) = 0.1(mol dm^{-3}) **(1)** $[H^+] = \frac{(1.3 \times 10^{-5})(0.1)}{0.025}$ pH = 4.28/ 4.3 **(1)** Correct pH with no working scores last 4 marks ALLOW Other methods leading to 4.28 e.g. based on equal volumes being mixed so mol propanoate are in double the volume and so concentration is 0.025 mol dm^{-3}		5

Question Number	Acceptable Answers	Reject	Mark
4e(iii)	**First mark** The mixture contains a large amount/ reservoir of a (weak) acid/propanoic acid **and** its conjugate base/ propanoate ions /salt **(1)** **Second mark** Only awarded if at least one equation given Added OH^- combines with H^+ ($H^+ + OH^- \rightarrow H_2O$) from propanoic acid followed by dissociation of more propanoic acid $C_2H_5COOH \rightleftharpoons C_2H_5COO^- + H^+$ OR Added OH^- combines with propanoic acid $OH^- + C_2H_5COOH \rightarrow C_2H_5COO^- + H_2O$ **(1)** **Third mark** (pH is unchanged because added OH^- is removed) change in concentration of $C_2H_5COO^-$ **and** C_2H_5COOH is small / ratio [salt]/[acid] hardly changes **(1)**		3

(Total for Question 4 = 15 marks)

Question Number	Acceptable Answers	Reject	Mark
5(a) (i)	**1st mark: Identification of buffer** Any mention of buffer solution / buffering (region) **(1)** **2nd mark: Identification of species responsible for buffering action** ammonia/NH_3 **and** ammonium ions /NH_4^+ present (in significant concentrations) **OR** ammonia/NH_3 **and** ammonium chloride /NH_4Cl present (in significant concentrations) **OR** weak base **and** salt/conjugate acid present (in significant concentrations) **OR** B **and** BH^+ present (in significant concentrations) **Can be awarded from a correct equation** **(1)** **3rd mark: For mention of how this buffer works on addition of small amounts of H^+ ions** (relatively large concentration/reservoir of) ammonia molecules react with added hydrogen ions/ H^+ /(hydrochloric) acid **OR** (relatively large concentration /reservoir of weak) base reacts with added hydrogen ions / H^+ /(hydrochloric) acid **OR** $H^+ + NH_3 \rightarrow NH_4^+$ **Allow** reversible arrow **OR** Adding (hydrochloric) acid/H^+ /hydrogen ions has negligible effect on ratio $[NH_3]:[NH_4^+]$ **(1)** **Ignore** references to buffering action on addition of OH^- (not relevant here) **Ignore** general descriptions of buffer solution eg resists change in pH when small amounts of acid or alkali added	Acidic buffer Weak acid and its conjugate base HA and A^-	**3**

Question Number	Acceptable Answers	Mark
5(a) (ii)	**Note** – the equations $NH_4^+ + H_2O \rightarrow NH_3 + H_3O^+$ $NH_4^+ + H_2O \rightarrow NH_4OH + H^+$ score **all three marks** **Note** –the equation $NH_4^+ \rightarrow NH_3 + H^+$ scores 2 marks, but if (aq) state symbols are given, scores 3 marks **1st mark:** Ammonium ions /NH_4^+ present (at equivalence point) **OR** ammonium chloride/ammonium salt **(1)** **2nd mark** Ammonium (ions) / NH_4^+ react with water /hydrolysed by water /dissociate in water **Ignore** ammonium chloride reacts with water **(1)** **3rd mark** $NH_4^+ \rightarrow NH_3 + H^+$ **OR** $NH_4^+ + H_2O \rightarrow NH_3 + H_3O^+$ **Allow** $NH_4^+ + H_2O \rightarrow NH_4OH + H^+$ **(1)** **Note if no other mark awarded** Just 'strong acid – weak base (titration)' / ammonium chloride is the salt of a strong acid and a weak base scores **(1)** only	**3**

Question Number	Acceptable Answers	Mark
5(a) (iii)	**If final answer is 1.6(2), with correct working or without working, award 4 marks** Mol of ammonia used = (25/1000 x 0.024) = $6x10^{-4}$ mol **and** Mol of acid added = (40/1000 x 0.054) = $2.16x10^{-3}$ **(1)** Mol of excess acid = $2.16x10^{-3} - 6x10^{-4}$ = $1.56x10^{-3}$ mol **(1)** $[H^+] = 1.56x10^{-3}/(65/1000) = 0.024$ mol dm^{-3} **(1)** pH = $-\log [H^+] = 1.6(2)$ **(1)** **Ignore** SF except 1 SF **Allow** TE for 2nd, 3rd marks **Allow** TE for 4th mark provided pH is less than 7 and it is based on some use of data in question **Alternative method for 1st and 2nd marks** Mol of ammonia used = (25/1000 x 0.024) = $6x10^{-4}$ mol **and** Volume of acid used = $\frac{6x10^{-4} \times 1000}{0.054}$ = 11.111 cm^3 **(1)** Volume of acid left = 40 – 11.111 = 28.889 cm^3 Mol of excess acid = $\frac{28.889 \times 0.054}{1000}$ = $1.56x10^{-3}$ mol **(1)**	**4**

Question Number	Acceptable Answers	Reject	Mark
5(b)(i)	**EITHER** $[H^+]^2 = 5.5x10^{-13}$ or $[H^+] = \sqrt{5.5x10^{-13}}$ / $7.416x10^{-7}$ (mol dm^{-3}) **(1)** pH = $-\log\sqrt{5.5x10^{-13}}$ (= 6.12982 / 6.13) **(1)** **OR** pK_w = 12.26 **(1)** pH = ½ pK_w (= 6.130) **(1)**	6.13 with no working	**2**

Question Number	Acceptable Answers	Reject	Mark
5(b) (ii)	Neutral **(1)** $[H^+]$ = $[OH^-]$ /equal amounts of H^+ and OH^- ions **OR** **Both** $[H^+]$and $[OH^-]$ have increased by the same amount **(1)**	Acidic or alkaline for both marks	**2**

Total for Question 5 = 14 marks