Equilibria

Mark Scheme 1

Level	International A Level
Subject	Chemistry
Exam Board	Edexcel
Topic	Rates, Equilibria & Further Organic Chemistry
Sub Topic	Equilibria
Booklet	Mark Scheme 1

Time Allowed: **52 minutes**

Score: **/43**

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
1	B		1

Question Number	Correct Answer	Mark
2	A	

Question Number	Correct Answer	Mark
3(a)	D	

Question Number	Correct Answer	Mark
3(b)	C	

Question Number	Correct Answer	Mark
3(c)	A	

Question Number	Correct Answer	Mark
4(a)	B	

Question Number	Correct Answer	Mark
4(b)	A	

Question Number	Correct Answer	Mark
4(c)	B	

Question Number	Correct Answer	Reject	Mark
5	**B**		**(1)**

Question Number	Correct Answer	Reject	Mark
6	**C**		**(1)**

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

Question Number	Acceptable Answers	Reject	Mark
8a	Proton/ H^+ donor		1

Question Number	Acceptable Answers	Reject	Mark
8b	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
8c(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
8c(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
8d	$[H^+] = (1 \times 10^{-14} / [OH^-])$ $= 2 \times 10^{-13}$ (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
8e(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
8e(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
8e(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 8 = 15 marks)

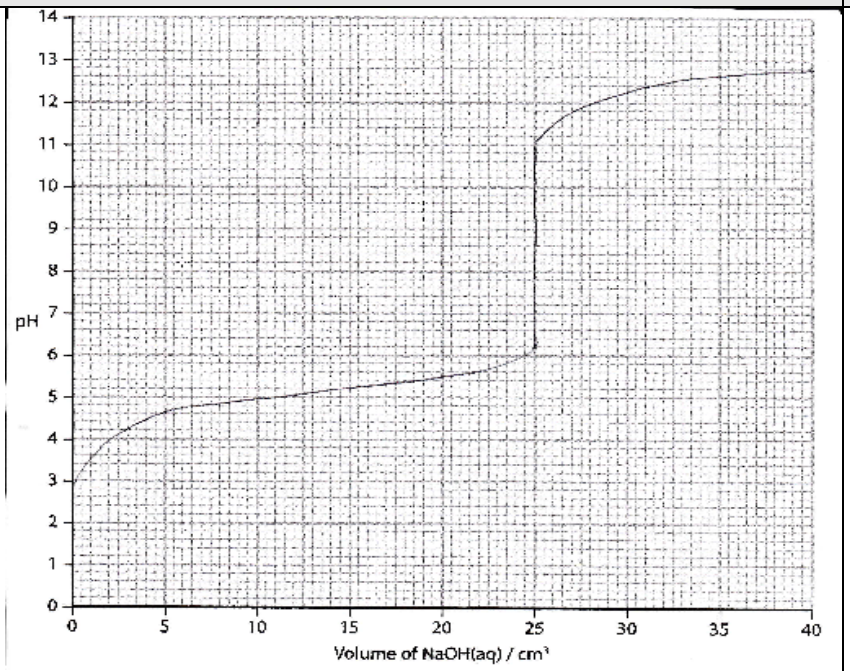
Question Number	Acceptable Answers	Reject	Mark
9(a)(i)	**AL OW** answers written on either set of dotted lines **Weak:** dissociates/ionizes to a small extent / partially /incompletely **ALLOW** does not ionise completely **(1)** **Acid:** proton donor **ALLOW** produces/forms /releases H^+ ions / H_3O^+ ions / oxonium ions / hydroxonium ions / hydronium ions **ALLOW** electron pair acceptor **(1)** **IGNORE** just 'accepts electrons' **IGNORE** contains H^+ ions **IGNORE** reference to typical acid reactions	'not easily dissociated' / few H^+ ions	**(2)**

Question Number	Acceptable Answers	Reject	Mark
9(a)(ii)	(K_a =) $\frac{[CHCl_2COO^-][H^+]}{[CHCl_2COOH]}$ **OR** $[H_3O^+]$ for $[H^+]$ **ALLOW** $[CHCl_2CO_2^-]$ / $[CHCl_2CO_2H]$ **IGNORE** $[]_{eq}$ and state symbols, even if incorrect	No /round brackets	**(1)**

Question Number	Acceptable Answers	Mark
9(a)(iii)	weakest ethanoic acid chloroethanoic acid dichloroethanoic acid strongest trichloroethanoic acid **OR** correct formulae all four correct **(1)** **Reason** the weakest acid has the lowest K_a/ acid dissociation constant **OR** the weakest acid has the highest pK_a **OR** the strongest acid has the highest K_a/ acid dissociation constant **OR** the strongest acid has the lowest pK_a **OR** K_a increases/pK_a decreases from ethanoic acid to trichloroethanoic acid/ weakest to strongest acid **ALLOW** acid that dissociates least has the smallest Ka/highest pKa ORA **(1)** **IGNORE** references to the effect of the chlorine atoms on K_a/stability of anion/strength of the O-H bond **IGNORE** references to pH	**(2)**

Question Number	Acceptable Answers	Reject	Mark
9(b)(i)	**IGNO** SF except 1 SF throughout **FIRST CHECK THE FINAL ANSWER,** **IF** answer pH = 2.88/2.9, award **2** marks IF pH = 2.89, decide which route has been followed and award **1** mark for routes 1 and 2 (rounding error) and **3** marks for route 3 IF answer is not correct, award the following marks: **Route 1** $[H^+] = \sqrt{K_a} \times [CH_3COOH]$ $= \sqrt{1.7 \times 10^{-5}} \times 0.1$ $= 1.3038 \times 10^{-3}$ (mol dm^{-3}) **(1)** pH = 2.8848 **(1)** consequential on their $[H^+]$, provided pH is less than 7 **Route 2** $[H^+] = \sqrt{K_a} \times [CH_3COOH]$ pH = ½ pKa – ½ log$[CH_3COOH]$ **(1)** = 2.88 **(1)** consequential on their expression for pH		**(4)**

	Assumption 1 $[H^+] = [CH_3COO^-]$ **OR** no H^+ from the (ionization of) water **OR** H^+ all comes from the acid **(1)** **Assumption 2** Ionization of the (weak) acid is negligible / very small / insignificant **OR** $[CH_3COOH]_{initial} = [CH_3COOH]_{eqm}$ **OR** $[CH_3COOH]_{eqm} = 0.1$ mol dm^{-3} **OR** $[CH_3COOH]$ remains constant **(1)** **Route 3** using $[CH_3COOH]_{eqm} = 0.1 - [H^+]$ **(1)** $[H^+] = 1.2954 \times 10^{-3}$ (mol dm^{-3}) **(1)** pH = 2.8876 **(1)** **Assumption** $[H^+] = [CH_3COO^-]$ **OR** no H^+ from the (ionization of) water **OR** H^+ all comes from the acid **(1)** **ALLOW** [HA]/[HX]/[acid]/$[A^-]$/$[X^-]$/[base] for formulae of acid and base	'no dissociation' **OR** 'partial'/'incomplete' dissociation	

Question Number	Acceptable Answers	Mark
9(b) (ii)	 Graph starting at 2.9 (allow 2.8-3.0) or answer to (b)(i) **(1)** Initial rise **and** buffering region to 25 cm^3 **(1)** Vertical rise at 25 cm^3, starting from pH 5.5-7 **and** ending at pH 10-12 **(1)** Finishing (asymptotically) between pH 12-13 inclusive and reaching at least 38 cm^3 **(1)** **Note:** If graph is sketched as if ethanoic acid is added to NaOH, the only mark available is the vertical jump down at 25 cm^3, starting from 10-12 and ending at 5.5-7	**(4)**

Question Number	Acceptable Answers	Reject	Mark
9(b)(iii)	any correct indicator that has the complete pH range within the vertical jump on their titration curve **Note:** expected indicators numbers 14 to 17 from Data Booklet ie phenol red (6.8-8.4) thymol blue ((base)) (8.0-9.6) phenolphthalein (8.2-10.0) thymolphthalein (8.3-10.6) **ALLOW** bromothymol blue (6.0-7.6) if their vertical range starts at or below 6.0 **(1)** **Justification – conditional on a correct indicator** pH range (of indicator) lies (completely)within the vertical jump (on the titration curve) **OR** indicator will change colour in the vertical section of the graph **OR** pH range of indicator and pH range of vertical section of the graph stated as long as they overlap **ALLOW** pK_{in} (±1) is in the mid-point of the vertical jump **ALLOW** pKin is nearest to the pH at the end/equivalence point **ALLOW** indicator will change colour at the end/equivalence point **(1)** **IGNORE** (because it is a) titration of a weak acid with strong alkali	If no titration curve **(0)** litmus/azolitmin universal indicator	**(2)**

Question Number	Acceptable Answers	Reject	Mark
9(c)	(CH_3COOH + CCl_3COOH →) base (2) acid (1) $CH_3COOH_2^+$ + CCl_3COO^- conjugate acid / acid 2 co ugate base /base 2 **First marking point** both formulae correct **(1)** **Second marking point** both conjugate acid-base pairs correctly identified **(1)** **ALLOW** any indication of the correct pairs they may be linked together eg lines or arrows, provided they have been labelled correctly as acid or base **Note:** If equation is CH_3COOH + CCl_3COOH →) acid (2) base (1) CH_3COO^- + $CCl_3COOH_2^+$ conjugate base / base 2 conjugate acid /acid 2 **ALLOW** 1 mark for the consequential acid/base pairs	HCH_3COOH^+ for first mark only Just 'acid' and 'base' with no link	**(2)**

(Total for Question 9 = 17 marks)