**M1.** (a) before any KOH added: $K_a = \frac{[H^+][A^-]}{[HA]}$ **or** $\frac{[H^+][CH_3COO^-]}{[CH_3COOH]}$ **(1)**

$\therefore$ $K_a = \frac{[H^+]^2}{[CH_3COOH]}$ **(1)**

$\therefore$ $[H^+] = \sqrt{1.74 \times 10^{-5} \times 0.160} = 1.67 \times 10^{-3}$ **(1)**

$\therefore$ pH = 2.78 **(1)**

4

(b) at 8 $cm^3$ KOH:
Moles KOH added = $(8 \times 10^{-3}) \times 0.210 = 1.68 \times 10^{-3}$ **(1)**
$\therefore$ moles of $CH_3COO^-$ formed = $1.68 \times 10^{-3}$ **(1)**

Original moles of $CH_3COOH$ = $(25 \times 10^{-3}) \times 0.160 = 4.0 \times 10^{-3}$ **(1)**

$\therefore$ moles of $CH_3COOH$ left = $(4.0 \times 10^{-3}) - (1.68 \times 10^{-3})$
$= 2.32 \times 10^{-3}$ **(1)**

$[H^+] = K_a \times \frac{[CH_3COOH]}{[CH_3COO^-]}$ **(1)**

$= 1.74 \times 10^{-5} \times \frac{2.32 \times 10^{-3} / V}{1.68 \times 10^{-3} / V} = 2.40 \times 10^{-5}$ **(1)**

$\therefore$ <u>pH = 4.62</u> **(1)**

*It forget subtraction : max 5*
*If $K_a$ expression not used max 5*
*if moles of $CH_3COOH$ wrong but substitution used max 5*

7

(c) at 40 $cm^3$ of KOH:
Total moles of KOH = $(40 \times 10^{-3}) \times 0.21 = 8.4 \times 10^{-3}$ **(1)**
$\therefore$ excess moles of KOH = $(8.4 \times 10^{-3}) - (4.0 \times 10^{-3})$
$= 4.4 \times 10^{-3}$ **(1)**
in total volume = 40 + 25 = 65 $cm^3$ **(1)**

$\therefore$ $[OH^-] = 4.4 \times 10^{-3} \times \frac{1000}{65} = 0.0677$ **(1)**

$\therefore$ $[H^+] = \frac{10^{-14}}{0.0677}$

*OR pOH =1.17*

= $1.477 \times 10^{-13}$ **(1)**

$\therefore$ pH = 12.8<u>3</u> **(1)**

*If volume missed : max 4*

*If moles of acid wrong but method includes subtraction : max 5*

*If no subtraction : max 4*

6

**[Max 16]**

**M2.** (a) (i) $K_a = \frac{[H^+][CH_3COO^-]}{[CH_3COOH]}$ **(1)** ($[H^+]$ or $H_3O^+$)

(ii) (1) $K_a = \frac{[H^+]^2}{[CH_3COOH]}$ **(1)**

(2) $[H^+] = \sqrt{1.74 \times 10^{-5} \times 0.220}$ = $1.96 \times 10^{-3}$ **(1)**

(3) pH = $-\log_{10}[H^+]$ **(1)**

*can score independently*

(4) pH = 2.<u>71</u> **(1)**

*2 d.p. essential*

*If forget √ can score (1) and (3) for pH = 5.42*

5

(b) (i) moles acid = $\frac{25}{1000} \times 0220$ **(1)** = $5.50 \times 10^{-3}$

= $\frac{x}{10^3} \times 0.150$

$\therefore$ $x = 25 \times \frac{0.220}{0.150}$ **or** $5.50 \times 10^{-3} \times \frac{1000}{0.150}$

= 36.7 (or 37) $cm^3$ (or 36.6) **(1)**

*NOT 36 NOR 37.0 units must match*

(ii) *Indicator*: thymol blue **(1)**
*Explanation*: weak acid – strong base **(1)**
equivalent at pH > 7 **(1)**
or high pH

5

(c) (1) mol NaOH added = $\frac{2.0}{40.0}$ = 0.050 **(1)**

*If wrong $M_r$: CE ∴ lose marks (1) and (2) then mark on consequentially → max 4*

(2) mol $CH_3COOH$ left = 0.220 – 0.050 = 0.170 **(1)**

(3) mol $CH_3COO^-$ formed = 0.050 **(1)**

(4) $[H^+] = Ka \frac{[acid]}{[salt]}$ OR $pH = pKa + \log\frac{[A^-]}{[HA]}$ etc **(1)**

*If expression wrong no marks for 4 / 5 / 6*

**can score (1) to (4) in (5)**

(5) $[H^+] = 1.74 \times 10^{-5} \times \frac{(0.170)}{(0.05)}$ OR $pH = 4.76 + \log\left(\frac{0.05}{0.17}\right)$ **(1)**

(6) pH = 4.23 **(1)**

*Correct answer gets* ***(1)(1)(1)(1)(1)(1)***
*Mark (5) is for use of correct values of (acid moles) and (salt moles)*
*if one wrong allow pH conseq*
*if both wrong, no further marks*
*e.g. if candidate forgets substitution in (2)*
*he loses (2) and (5) but can score (1) (3) (4) (6) = max 4*

*for pH = 4.12 if* $\frac{[acid]}{[salt]}$ *upside down; answer 5.29 scores 3* *for (1) (2) (3)*

6

**[16]**