

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

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

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

$$\therefore \text{pH} = 2.78 \quad (1)$$

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(b) at 8 cm³ KOH:

$$\text{Moles KOH added} = (8 \times 10^{-3}) \times 0.210 = 1.68 \times 10^{-3} \quad (1)$$

$$\therefore \text{moles of } CH_3COO^- \text{ formed} = 1.68 \times 10^{-3} \quad (1)$$

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

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

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

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

$$\therefore \text{pH} = 4.62 \quad (1)$$

It forget subtraction : max 5

If K_a expression not used max 5

if moles of CH₃COOH wrong but substitution used max 5

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(c) at 40 cm³ of KOH:

$$\text{Total moles of KOH} = (40 \times 10^{-3}) \times 0.21 = 8.4 \times 10^{-3} \quad (1)$$

$$\therefore \text{excess moles of KOH} = (8.4 \times 10^{-3}) - (4.0 \times 10^{-3}) \\ = 4.4 \times 10^{-3} \quad (1)$$

$$\text{in total volume} = 40 + 25 = 65 \text{ cm}^3 \quad (1)$$

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

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

$$\text{OR } \text{pOH} = 1.17$$

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

$$\therefore \text{pH} = 12.83 \text{ (1)}$$

If volume missed : max 4

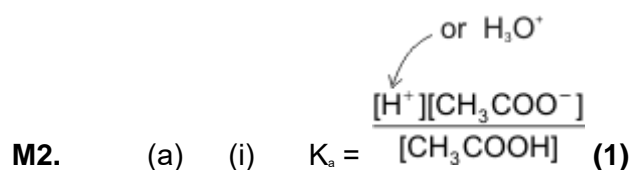
If moles of acid wrong but method includes subtraction : max

5

If no subtraction : max 4

6

[Max 16]



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

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

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

can score independently

(4)
$$\text{pH} = 2.71 \text{ (1)}$$

2 d.p. essential

If forget $\sqrt{\quad}$ can score (1) and (3) for pH = 5.42

5

(b) (i) moles acid =
$$\frac{25}{1000} \times 0.220 \text{ (1)} = 5.50 \times 10^{-3}$$

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

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

$$= 36.7 \text{ (or 37) cm}^3 \text{ (or 36.6) (1)}$$

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 CH₃COOH left = 0.220 – 0.050 = 0.170 (1)

(3) mol CH₃COO⁻ formed = 0.050 (1)

(4) $[H^+] = K_a \frac{[acid]}{[salt]}$ OR $pH = pK_a + \log \frac{[A^-]}{[HA]}$ 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]