

M1. Penalise pH given to 1 dp first time it would have scored only

(a) (i) $K_w = [H^+][OH^-]$ **(1)**

(ii) $pH = -\log [H^+]$ **(1)**

or in words or below unless contradiction

(iii) *Calculation:* $[H^+] = \sqrt{5.48 \times 10^{-14}}$ **(1)**

$$= 2.34 \times 10^{-7}$$

$$\therefore pH = 6.63 \text{ or } 6.64$$
 (1)

Explanation: pure water $\therefore [H^+] = [OH^-]$ **(1)**

5

(b) (i) $[OH^-] = 0.150$ $\therefore [H^+] = 10^{-14}/0.15 = 6.66 \times 10^{-14}$

$$\text{or } pOH = 0.82$$

$$\therefore pH = 13.18$$
 (1)

$$\text{or } pH = 13.17$$

(ii) moles $OH^- = (35 \times 10^{-3}) \times 0.150 = 5.25 \times 10^{-3}$ **(1)^a**

$$\text{moles } H^+ = (40 \times 10^{-3}) \times 0.120 = 4.8(0) \times 10^{-3}$$
 (1)^b

$$\therefore \text{excess moles of } OH^- = 4.5 \times 10^{-4}$$
 (1)^c

$$\therefore [OH^-] = (4.5(0) \times 10^{-4}) \times 1000/75^d$$
 (1)^e

$$= 6.0(0) \times 10^{-3}$$

$$[H^+] = \frac{10^{-14}}{6.00 \times 10^{-3}} = 1.66 \times 10^{-12} \text{ or } pOH = 2.22$$

$$\therefore pH = 11.78$$
 (1)^f

$$\text{or } 11.77$$

8

(c) (i) $K_a = \frac{[H^+][X^-]}{[HX]}$ **(1)**

(ii) $[H^+] = 1.80 \times 10^{-2} \times 0.150 = 2.70 \times 10^{-3} \text{ (1)}$

$$K_a = \frac{[H^+]^2}{[HX]} (1) = \frac{(2.70 \times 10^{-3})^2}{0.150} = 4.86 \times 10^{-6} \text{ (1) mol dm}^{-3} \text{ (1)}$$

$$\text{or } \frac{(2.70 \times 10^{-3})^2}{0.1473} = 4.95 \times 10^{-6}$$

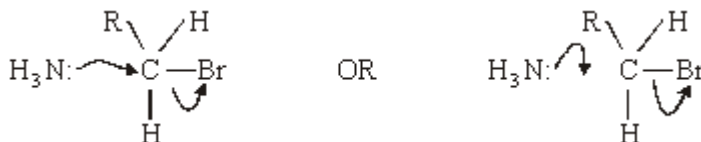
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Notes

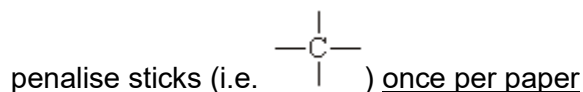
- (a) If K_w includes H_2O allow 6.63 if seen otherwise no marks likely
- (b) (ii) If no vol, max 4 for a, b, c, f answer = 10.65
 If wrong volume max 5 for a, b, c, e, f
 If no subtraction max 3 for a, b, d
 If missing 1000 max 5 for a, b, c, d, f answer = 8.78
 If uses excess as acid, max 4 for a, b, d, f answer = 2.22
 If uses excess as acid and no volume, max 2 for a, b answer = 3.35
- (c) If wrong K_a in (i) max 2 in part (ii) for $[H^+]$ **(1)** and conseq units **(1)**
but mark on fully from minor errors
eg no [] or charges missing

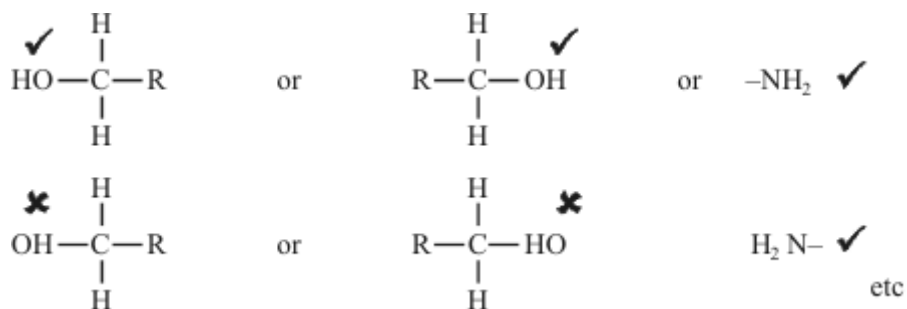
Organic points

- (1) Curly arrows: must show movement of a pair of electrons, i.e. from bond to atom or from lp to atom / space e.g.



- (2) Structures





Penalise once per paper

allow CH_3- or $-\text{CH}_3$ or $\begin{array}{c} \text{CH}_3 \\ | \end{array}$ or CH_3
 or $\text{H}_3\text{C}-$

[18]

M2.B

[1]

M3.B

[1]

M4.C

[1]

M5.D

[1]

M6. (a) before any KOH added: $K_a = \frac{[\text{H}^+][\text{A}^-]}{[\text{HA}]}$ or $\frac{[\text{H}^+][\text{CH}_3\text{COO}^-]}{[\text{CH}_3\text{COOH}]}$ (1)

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

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

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

4

(b) at 8 cm³ KOH:

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

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

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

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

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

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

$$\therefore pH = 4.62 \quad (1)$$

It forget subtraction : max 5

If K_a expression not used max 5

if moles of CH₃COOH wrong but substitution used max 5

7

(c) at 40 cm³ of KOH:

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

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

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

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

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

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

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

$$\therefore pH = 12.83 \quad (1)$$

If volume missed : max 4

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

If no subtraction : max 4

6

