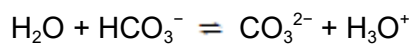


or



Must have equilibrium sign but mark on to (b)

Ignore state symbols

1

(b) Acid: Increase in concentration of H^+ ions, equilibrium moves to the left.

Allow H^+ ions react with carbonate ions (to form HCO_3^-)

1

Alkali: OH^- reacts with H^+ ions, equilibrium moves to the right (to replace the H^+ ions)

1

Concentration of H^+ remains (almost) constant

1

[4]

M2.(a) Burette

1

Because it can deliver variable volumes

1

(b) The change in pH is gradual / not rapid at the end point

1

An indicator would change colour over a range of volumes of sodium hydroxide

Allow indicator would not change colour rapidly / with a few drops of NaOH

1

(c) $[H^+] = 10^{-pH} = 1.58 \times 10^{-12}$ 1

$K_w = [H^+] [OH^-]$ therefore $[OH^-] = K_w / [H^+]$ 1

Therefore, $[OH^-] = 1 \times 10^{-14} / 1.58 \times 10^{-12} = 6.33 \times 10^{-3} \text{ (mol dm}^{-3}\text{)}$
Allow 6.31–6.33 $\times 10^{-3} \text{ (mol dm}^{-3}\text{)}$ 1

(d) At this point, $[NH_3] = [H^+]$
 $= \frac{[H^+]^2}{[NH_4^+]}$
Therefore K_a 1

$[H^+] = 10^{-4.6} = 2.51 \times 10^{-5}$ 1

$K_a = (2.51 \times 10^{-5})^2 / 2 = 3.15 \times 10^{-10} \text{ (mol dm}^{-3}\text{)}$
Allow 3.15 – 3.16 $\times 10^{-10} \text{ (mol dm}^{-3}\text{)}$ 1

(e) When $[NH_3] = [NH_4^+]$, $K_a = [H^+]$ therefore $-\log K_a = -\log [H^+]$
Answer using alternative value 1

Therefore $pH = -\log_{10}(3.15 \times 10^{-10}) = 9.50$
M2 pH = $-\log_{10}(4.75 \times 10^{-9}) = 8.32$
Allow consequential marking based on answer from part (d) 1

[12]

M3.(a) Proton donor or H^+ donor 1

(b) (i)
$$K_a = \frac{[\text{CH}_3\text{COO}^-][\text{H}^+]}{[\text{CH}_3\text{COOH}]} \text{ or } \frac{[\text{CH}_3\text{COO}^-][\text{H}_3\text{O}^+]}{[\text{CH}_3\text{COOH}]}$$

If K_a wrong, can only score M1 below.

Must be ethanoic acid not HA

Must have square brackets (penalise here only) but mark on in (b)(ii).

1

(ii) M1 $[\text{H}^+] = 10^{-2.69}$ **OR** 2.042×10^{-3} (mol dm⁻³)

1

M2
$$[\text{CH}_3\text{COOH}] = \frac{[\text{H}^+]^2}{K_a}$$

Ignore ()

Mark for correctly rearranged expression incl $[\text{H}^+]^2$

1

M3

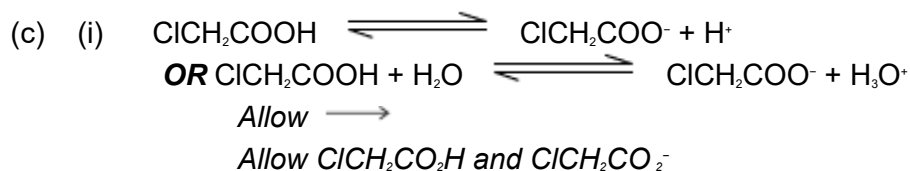
$$= \frac{(2.042 \times 10^{-3})^2}{1.75 \times 10^{-5}}$$

If M2 wrong no further marks.

1

M4 = 0.238 (mol dm⁻³) Allow 0.229 – 0.24

1



1

- (ii) M1 Cl is (more electronegative so) withdraws electrons
OR negative inductive effect of Cl
Ignore electronegativity.
Ignore chloroethanoic acid has a lower K_a value.

Allow Cl reduces +ve inductive effect of methyl group.

1

M2 Weakens O–H bond

OR O–H bond is more polar

OR reduces negative charge on COO⁻

OR stabilizes COO⁻ (more)

M1 & M2 are independent marks.

Ignore H⁺ lost more easily.

1

(d) (i) **A**

1

(ii) **C**

1

(iii) **D**

1

(e) M1 Mol NaOH = mol OH⁻ = $(19.6 \times 10^{-3}) \times 0.720 = 1.41(1) \times 10^{-2}$
Mark for answer.

1

M2 Mol H₂SO₄ = $(26.4 \times 10^{-3}) \times 0.550 = 1.45(2) \times 10^{-2}$
Mark for answer.

1

M3 Mol H⁺ added = **2** × $(1.452 \times 10^{-2}) = 2.90(4) \times 10^{-2}$

OR

XS mol H₂SO₄ = $7.46(4) \times 10^{-3}$

If factor × 2 missed completely (pH = 2.05)

or used wrongly later,

can score max 4 for M1, M2, M5 & M6

1

M4 XS mol H⁺ = 0.0149(3)

1

M5 For dividing by volume

$$[\text{H}^+] = 0.0149(3) \times (1000 / 46.0) = 0.324 - 0.325 \text{ mol dm}^{-3}$$

If no use or wrong use of volume lose M5 and M6

ie can score 4 for pH = 1.83 (no use of vol)

Treat missing 1000 as AE (-1) & score 5 for pH = 3.49

1

M6 pH = 0.49

2dp (penalise more or less).

If × 2 missed & vol not used, pH = 3.39 scores M1 & M2 only.

1

[18]

M4.(a) (only) slightly or partially dissociated / ionised

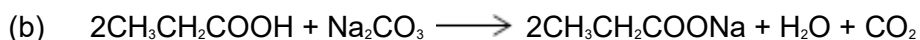
Ignore 'not fully dissociated'.

Allow low tendency to dissociate or to lose / donate a proton.

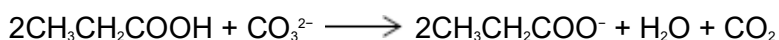
Allow shown equilibrium well to the left.

Otherwise ignore equations.

1



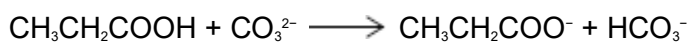
OR



OR



OR



Must be propanoic acid, allow C₂H₅COOH.

Not molecular formulae.

Allow multiples.

Ignore reversible sign.

Not H₂CO₃.

1

- (c) $[\text{OH}^-] = 2 \times 0.0120 = 0.0240$ M1
 Correct answer for pH with or without working scores 3.

1

$$[\text{H}^+] = \frac{1 \times 10^{-14}}{0.0240} = 4.166 \times 10^{-13} \text{ OR } \text{pOH} = 1.62 \quad \text{M2}$$

If $\times 2$ missed or used wrongly can only score M3 for correct calculation of pH from their $[\text{H}^+]$.

1

pH = 12.38 M3
 Lose M3 if not 2 decimal places: 12.4 scores 2.
 12.08 scores 1 (missing $\times 2$); 12.1 scores 0.
 11.78 scores 1 (dividing by 2) 11.8 scores 0.

1

(d) (i) $K_a = \frac{[\text{H}^+][\text{C}_6\text{H}_5\text{COO}^-]}{[\text{C}_6\text{H}_5\text{COOH}]}$

Ignore () here but brackets must be present.
 Must be correct acid and salt.
 If wrong, mark part (ii) independently.

1

(ii) M1 $K_a = \frac{[\text{H}^+]^2}{[\text{C}_6\text{H}_5\text{COOH}]}$ OR with numbers

Correct answer for pH with or without working scores 3.
 Allow HX, HA and ignore () here.
 May score M1 in part (i).

1

M2 $[\text{H}^+] = \sqrt{(6.31 \times 10^{-5} \times 0.0120)}$ or $\sqrt{(K_a \times [\text{C}_6\text{H}_5\text{COOH}])}$
 $(= \sqrt{(7.572 \times 10^{-7}} = 8.70 \times 10^{-4})$
 pH = 6.12 may score 2 if correct working shown and they show the square root but fail to take it.

But if no working shown or wrong $K^a = \frac{[H^+]}{[C_6H_5COOH]}$

used which also leads to 6.12, then zero scored.

1

M3 pH = 3.06

Must be 2 decimal places ie 3.1 loses M3.

1

(iii) M1 $[H^+] = 10^{-4.00} = 1.00 \times 10^{-4}$

Correct answer for mass with or without working scores 5.

Allow 1×10^{-4} .

1

M2 $[X^-] = \frac{K_a \times [HX]}{[H^+]}$

Ignore () here.

If $[HX] / [X^-]$ upside down, can score M1 plus M4 for 5.26×10^{-7} .

1

M3 $= \frac{6.31 \times 10^{-5} \times 0.0120}{1.00 \times 10^{-4}}$

And M5 for 7.57×10^{-5} g.

1

M4 $= 7.572 \times 10^{-3}$

1

M5 Mass $(C_6H_5COONa) = 7.572 \times 10^{-3} \times 144 = 1.09$ g
or 1.1 g

Wrong method, eg using $[H^+]^2$ may only score M1 and M5 for correct multiplication of their M4 by 144

(provided not of obviously wrong substance).

1

(e) M1 CO₂
Allow NO_x and SO₂. 1

M2 pH (It) falls / decreases
If M1 wrong, no further marks. 1

M3 mark M2 & M3 independently
acidic (gas)
OR reacts with alkali(ne solution) / OH⁻
OR CO₂ + 2OH⁻ → CO₃²⁻ + H₂O
OR CO₂ + OH⁻ → HCO₃⁻
Not forms H₂CO₃ H₂SO₃ H₂SO₄ etc OR H⁺ ions. 1

[17]

M5.C

[1]