M1.(a) Proton donor or H^+ donor

1

(b) (i) $K_a = \frac{[CH_3COO^-][H^+]}{[CH_3COOH]}$ or $\frac{[CH_3COO^-][H_3O^+]}{[CH_3COOH]}$

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

1

M2 $CH_3COOH] = \frac{[H^+]^2}{K_a}$

Ignore ( )

Mark for correctly rearranged expression incl $[H^+]^2$

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

(c) (i) $ClCH_2COOH \rightleftharpoons ClCH_2COO^- + H^+$

OR $ClCH_2COOH + H_2O \rightleftharpoons ClCH_2COO^- + H_3O^+$

Allow $\longrightarrow$

Allow $ClCH_2CO_2H$ and $ClCH_2CO_2^-$

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 H_2SO_4 = $(26.4 \times 10^{-3}) \times 0.550 = 1.45(2) \times 10^{-2}$
Mark for answer.

1

M3 Mol H^+ added = **2 ×** $(1.452 \times 10^{-2}) = 2.90(4) \times 10^{-2}$
OR
XS mol H_2SO_4 = $7.46(4) \times 10^{-3}$
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
$[H^+]$ = 0.0149(3) × (1000 / 46.0) = 0.324 − 0.325 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]

M2.(a) $NH_4^+ \rightarrow NH_3 + H^+$

Accept multiples.

Accept $NH_4^+ + H_2O \rightarrow NH_3 + H_3O^+$

Ignore state symbols, even if incorrect.

1

(b) Test indicator / conc HCl

Do not accept 'smell'.

Do not accept precipitation reactions of aqueous ammonia.

1

Observation colour for an alkali / white fumes

If wrong test then lose second mark.

1

[3]

M3. (a) (i) **B** 1

C

1

A

1

(ii) cresolphthalein or thymolphthalein

1

(b) $pH = -\log[H^+]$

1

$K_a = \frac{[H^+]^2}{[CH_3COOH]}$ or $[H^+] = [A^-]$

1

$[H^+] = \sqrt{\square} 1.74 \times 10^{-5} \times 0.15$ (or 1.62×10^{-3})

1

pH = 2.79 (penalise 1 dp or more than 2dp once in the qu)

1

[8]

M4.(a) pH on the *y*-axis, volume of alkali on the *x*-axis

If axes unlabelled use data to decide that pH is on y-axis.

1

Uses sensible scales

*Lose this mark if plotted paths do not cover **half** of the paper.*
Lose this mark if the graph plot goes off the squared paper.

1

Labels the axes

Allow mark for axes labelled 'pH' and 'volume'.

1

Plots all of the points correctly

1

Line through the points is smooth and has the correct profile

Ignore 0–5 cm^3 section of the graph.

Lose this mark if graph is kinked or not a single line.

1

Line ignores the point at 12 cm^3

Lose this mark if point clearly not treated as an anomaly.

1

(b) (i) 24.4 cm^3 ± 0.2

If no answer in (i) allow answer written on the graph.

*Allow this answer **only**.*

Do not penalise precision.

1

(ii) 12.2 cm^3 ± 0.1

If no answer in (ii), allow answer written on the graph.

Allow answer to (i) divided by 2.

Do not penalise precision.

1

(iii) 3.9 ± 0.2

If no answer in (iii), allow answer written on the graph.

Consequential marking from (ii)

Lose this mark if answer not given to 1 dp.

1

(c) pK_a = – log K_a or $K_a = 10^x$, where x = – (answer to b(iii))

1

1.26×10^{-4}

3.7 to 4.1 gives $K_a = 7.9 \times 10^{-5}$ to 2.0×10^{-4}

Consequential marking from b(i).

Correct answer without working scores 1 mark only.

Do not penalise precision.

1

(d) Methanoic acid

Consequential marking from (c).

pK_a = 3.7 gives methanoic acid.

pK_a = 4.1 gives ethanoic acid.

No lucky guesses – candidates must apply answer from (c).

Do not allow answers based on data given in (f).

1

(e) Error in using pipette is 0.2% **and**
Error in using burette is 0.15 × 100 / (answer to b(i))

Using 24.4 for burette gives 0.6%

Do not penalise precision.

Allow if errors are given without working.

Lose mark if the burette error is not calculated on b(i).

*If the error being calculated is **not** stated, allow **if** the calculations are in the same order as in the question (pipette, burette).*

1

(f) Difference is $1.6 \times 10^{-4} - 1.26 \times 10^{-4} = 0.34 \times 10^{-4}$

Allow consequential answer from (c).

Do not penalise precision.

$0.34 \times 100 / 1.6$ is a 21% error

Correct final answer without working scores 1 mark.

Using 1.9×10^{-4} gives 0.3×10^{-4} and 18.8%.

1

(g) Calibrate meter **or** thermostat the mixture **or** maintain constant temperature

Do not allow 'repeat experiment'.

1

(h) Mixture is a <u>buffer</u>

1

[16]