1 (Calibrate) meter with solution(s) of known pH/buffer(s)

Do not accept 'repeat reading'

1

Adjust meter/plot calibration curve

1

[2]

2 (a) (i) $-\log[H^+]$

or $\log 1/[H^+]$
penalise ( )

1

(ii) $[H^+] = 0.56$

mark for the answer; allow 2dp or more

1

$[H_2SO_4] = ½ \times 0.56 = 0.28$

1

(b) (i) $CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$

OR

$CH_3COOH + OH^- \rightarrow CH_3COO^- + H_2O$

Allow CH_3CO_2H *etc*

1

(ii) mol acid = $(25.0 \times 10^{-3}) \times 0.41 = 1.025 \times 10^{-2}$ or 1.03×10^{-2}

1

$[NaOH] = 1.025 \times 10^{-2}/22.6 \times 10^{-3} = 0.45(4)$

mark for answer
if not 0.454 look back for error

1

OR

$[NaOH] = 1.03 \times 10^{-2}/22.6 \times 10^{-3} = 0.456$ or 0.46

(iii) cresol purple

1

(iv) NaOH reacts with <u>carbon dioxide</u> (in the air)

1

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

allow molecular formulae or minor slip in formulae

penalise ( )

allow H_3O^+

not allow HA etc

1

(ii) $K_a = \frac{[H^+]^2}{[CH_3COOH]}$ or with numbers

1

allow HA etc here

This can be scored in part (c)(i) but doesn't score there.

$[H^+] = (\sqrt{(1.74 \times 10^{-5} \times 0.410)} = \sqrt{(7.13 \times 10^{-6})}) = 2.67 \times 10^{-3}$

1

mark for 2.67×10^{-3} or 2.7×10^{-3} either gives 2.57

pH = 2.57 can give three ticks here for (c)(ii)
penalise decimal places < 2 >

1

pH mark conseq on their $[H^+]$

so 5.15 gets 2 marks where square root not taken

(iii) **M1** mol OH^- = $(10.0 \times 10^{-3}) \times 0.10 = 1.0 \times 10^{-3}$

If no subtraction or other wrong chemistry the max score is 3 for M1, M2 and M4

1

M2 orig mol HA = $(25.0 \times 10^{-3}) \times 0.41 = 0.01025$

1

or 1.025×10^{-2} or 1.03×10^{-2}

M3 mol HA in buffer = orig mol HA – mol OH^-

1

= 0.00925 or 0.0093

If A^- is wrong, max 3 for M1, M2 and M3 or use of

pH = pKa – log [HA]/[A^-]

M4 mol A^- in buffer = mol OH^- = 1.0×10^{-3}

Mark is for insertion of correct numbers in correct expression for $[H^+]$

1

M5 $[H^+] = \left(\frac{K_a \times [CH_3COOH]}{[CH_3COO^-]} = \right)$

1

$\frac{(1.74 \times 10^{-5})(0.00925)}{0.0010}$ or $\frac{(1.74 \times 10^{-5})(0.00930)}{0.0010}$

(= 1.61×10^{-4} or 1.62×10^{-4})

M6 pH = 3.79 can give six ticks for 3.79

if [HA]/[A⁻] upside down lose M5 & M6

If wrong method e.g. $[H^+]^2/[HA]$ max 3 for M1, M2 and M3

Some may calculate concentrations

[HA] = 0.264 and [A⁻] = 0.0286 and rounding this to 0.029 gives pH = 3.80 (which is OK)

NB Unlike (c)(ii), this pH mark is NOT awarded conseq to their $[H^+]$ unless following AE

BEWARE: using 0.01025 wrongly instead of 0.00925 gives pH = 3.75
(this gets 3 for M1, M2 & M4)

1

[18]

3 (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^+] = √ 1.74 × 10^{-5} × 0.15 (or 1.62 × 10^{-3})

1

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

1

[8]

4 (a) (i) addition of small amounts of acid send eqm to left or extra H^+ removed by reaction with HCO_3^-

1

ratio $[H_2CO_3]/[HCO_3^-]$ remains constant hence [H^+] and pH remain const

1

(ii) pH = 7.41 ∴ [H^+] = 3.89 × 10^{-8} mol dm^{-3}

1

$K_a = \frac{[H^+][HCO_3^-]}{[H_2CO_3]}$

1

$= \frac{(3.89 \times 10^{-8})(2.5 \times 10^{-2})}{1.25 \times 10^{-2}}$ = 7.78 × 10^{-8} mol dm^{-3}

allow error carried forward mark. Do not penalise twice.

1

(b) (i) moles H^+ added = 10 × 10^{-3} × 1.0 = 0.01

1

(ii) moles ethanoic acid after addition = 0.15 + 0.01 = 0.16

1

moles ethanoate ions after addition = 0.10 – 0.01 = 0.09

1

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

1

$= 1.74 \times 10^{-5} \times \frac{0.16/V}{0.09/V}$

1

pH = 4.51

1

[11]

5 C

[1]

6 (a) –log $[H^+]$

ecf if [ ] wrong and already penalised

1

4.57×10^{-3}

allow 4.6×10^{-3}

ignore units

1

(b) (i) $K_a = \frac{[H^+][X^-]}{[HX]}$ allow HA etc

not $\frac{[H^+]^2}{[HX]}$ but mark on

If expression wrong allow conseq units in (ii)
but no other marks in (ii)

1

(ii) $\frac{[H^+]^2}{[HX]} = \frac{(4.57 \times 10^{-3})^2}{[0.150]}$

If use 4.6×10^{-3}

1

$K_a = 1.4(1) \times 10^{-4}$ and pKa = 3.85

$= 1.39 \times 10^{-4}$

allow $1.39 – 1.41 \times 10^{-4}$ mol dm^{-3}

1

(iii) $pK_a = 3.86$

Penalise dp of final answer < or > 2 in pH once in paper

1

(c) (i) $\frac{30}{1000} \times 0.480 = 0.0144$ or $1.4(4) \times 10^{-2}$

Mark is for answer (M1)

1

(ii) $\frac{18}{1000} \times 0.350 = 0.0063$ or 6.3×10^{-3}

Mark is for answer (M2)

1

(iii) $0.0144 - 2(0.0063) = 1.80 \times 10^{-3}$

M3 is for (i) – 2(ii)

If x 2 missed, CE i.e. lose M3 and the next mark gained

1

(iv) $1.80 \times 10^{-3} \times \frac{1000}{48} = 0.0375$ (0.038)

M4 is for answer

If vol is not 48×10^{-3} (unless AE) lose M4 and next mark gained
If multiply by 48 - this is AE - i.e. lose only M4
If multiply by 48×10^{-3} this is AE - i.e. lose only M4

1

(v) $10^{-14} / 0.0375$ ($10^{-14} / 0.038$)

M5 for $K_w/[OH^-]$

1

($= 2.66 \times 10^{-13}$) ($= 2.63 \times 10^{-13}$)

or pOH

or pOH = 1.426 (or pOH = 1.420)

If no attempt to use K_w or pOH lose both M5 and M6

1

pH = 12.57 (12.58) M6

Allow M6 conseq on AE in M5 if method OK

1

[13]

7 (a) k = rate/$[CH_3CH_2COOCH_3][H^+]$

1

or

$$= \frac{1.15 \times 10^{-4}}{(0.150)(0.555)}$$

= 1.38×10^{-3} to 1.4×10^{-3}

1

$mol^{-1}\ dm^3\ s^{-1}$

1

(b) ans = rate constant × (½ × 0.150) × (½ × 0.555)

ignore units

= rate constant × 0.0208

2.88×10^{-5} (1.38×10^{-3} gives 2.87×10^{-5})

Allow 2.87 – 2.91 × 10^{-5} (1.4×10^{-3} gives 2.91×10^{-5})

1

(c) $[H^+]$ = rate/ $k[CH_3COOCH_2CH_3]$

1

$$= \frac{4.56 \times 10^{-5}}{(8.94 \times 10^{-4})(0.123)}$$

= 0.415 (0.4146)

1

pH = 0.38 mark independently

$[H^+]$ = 0.41 gives pH = 0.39

1

[7]

8 C

[1]

9 (a) (i) $[H^+][OH^-]$

1

– log $[H^+]$

1

(ii) $[H^+] = [OH^-]$

1

(iii) $(2.0 \times 10^{-3}) \times 0.5 = 1.0 \times 10^{-3}$

1

(iv) $[H^+] = \frac{4.02 \times 10^{-14}}{1.0 \times 10^{-3}}$ $(= 4.02 \times 10^{-11})$

1

pH = 10.40

1

(b) (i) $K_a = \frac{[H^+][CH_3CH_2COO^-]}{[CH_3CH_2COOH]}$

1

$= \frac{[H^+]}{[CH_3CH_2COOH]}$

1

$[H^+] = \sqrt{(1.35 \times 10^{-5}) \times 0.125}$ $(= 1.30 \times 10^{-3})$

1

pH = 2.89

1

(c) (i) $(50.0 \times 10^{-3}) \times 0.125 = 6.25 \times 10^{-3}$

1

(ii) $(6.25 \times 10^{-3}) – (1.0 \times 10–3) = 5.25 \times 10^{-3}$

1

(iii) mol salt formed $= 1.0 \times 10^{-3}$

1

$[H^+] = K_a \times \frac{[CH_3CH_2COOH]}{[CH_3CH_2COO–)}$

1

$= (1.35 \times 10^{-5}) \times \frac{(5.25 \times 10^{-3})/V}{(1.0 \times 10^{-3})/V}$ $(= 7.088 \times 10^{-5})$

1

pH = 4.15

1

[16]

10 (a) (i) B;

1

C;

1

A;

1

(ii) cresolphthalein

OR

thymolphthalein;

1

(b) (i) –log[H^+];

1

(ii) [H^+] = 1.259 × 10^{-12} (or 1.26 or 1.3)

OR

OH = 14 – pH;

1

$$[OH^-] = \frac{10^{-14}}{1.258 \times 10^{-12}}$$

OR

= 2.10;

1

= 7.9(4) × 10^{-3};

(if [H^+] is wrong allow 1 for [OH] = K_W/[H^+] or as numbers)

1

(c) (i) $K_a = [H^+]^2/[CH_3CH_2COOH]$

OR

$[H+]^2/[HA]$

OR

$[H^+] = [A^-]$ etc;

1

$[H^+] = \sqrt{1.35 \times 10^{-5} \times 0.117}$ or expression without numbers;

1

$= 1.257 \times 10^{-3}$

pH = 2.90;

1

(iii) $K_a = [H^+]$

OR

$pK_a = pH$;

1

pH = 4.87;

(penalise 1dp once)

1

[13]