



A-Level Chemistry
Weak Acids Dissociation
Constant (K_a)
Mark Scheme

Time available: 64 minutes
Marks available: 62 marks

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Mark schemes

1.

- (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, $[NH_3] = [H^+]$

Therefore $K_a = \frac{[H^+]^2}{[NH_4^+]}$

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]

2.

- (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

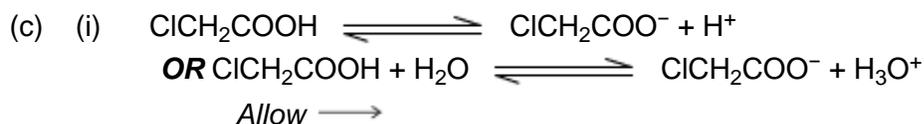
$$= \frac{(2.042 \times 10^{-3})^2}{1.75 \times 10^{-5}}$$

If M2 wrong no further marks.

1

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

1



Allow $\text{ClCH}_2\text{CO}_2\text{H}$ and $\text{ClCH}_2\text{CO}_2^-$

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

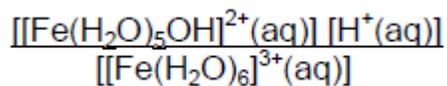
- (d) (i) **A** 1
- (ii) **C** 1
- (iii) **D** 1
- (e) M1 Mol NaOH = mol OH⁻ = (19.6 × 10⁻³) × 0.720 = 1.41(1) × 10⁻²
Mark for answer. 1
- M2 Mol H₂SO₄ = (26.4 × 10⁻³) × 0.550 = 1.45(2) × 10⁻²
Mark for answer. 1
- M3 Mol H⁺ added = **2** × (1.452 × 10⁻²) = 2.90(4) × 10⁻²
OR
 XS mol H₂SO₄ = 7.46(4) × 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

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3.

- (a) Idea that over time / after storage meter does not give accurate readings
*Do not accept 'to get an accurate reading' without further qualification.
 Allow 'temperature variations affect reading'.* 1

(b)



Allow without (aq) symbols.

Need at least one set of square brackets around complex ions

1

(c) $\text{pH} = -\log [\text{H}^+]$

1

$$[\text{H}^+] = 0.0240$$

Do not penalise precision of $[\text{H}^+]$

Correct answer scores M1 and M2.

1

$$K_a = (0.0240)^2 / 0.1 = 5.75 \times 10^{-3} \text{ or } 5.76 \times 10^{-3}$$

Correct answer without working loses M1 and M2.

Allow 7.58×10^{-3}

1

Answer, even if incorrect, given to 3 sig figs

1

(d) Oxygen (in the air) / O_2

Ignore 'air' or 'the atmosphere' or 'chemicals in soil'.

List principle.

1

(e) 4.0 – 6.9

Do not penalise precision.

[7]

4.

(a) $-\log [\text{H}^+]$

ecf if [] wrong and already penalised

1

$$4.57 \times 10^{-3}$$

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 $pK_a = 3.85$

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

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

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

(= 2.66×10^{-13}) (= 2.63×10^{-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 consequ on AE in M5 if method OK

1

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5.

(a) $K_a = \frac{[H^+][A^-]}{[HA]}$

(All three sets of square brackets needed, penalise missing brackets or missing charge once in the question)

(Don't penalise extra $[H^+]^2/[HA]$)

1

(b) $K_a = \frac{[H^+]^2}{[HA]}$ or $[H^+] = [A^-]$

$[H^+] = \sqrt{(1.45 \times 10^{-4}) \times 0.25}$

= 6.02×10^{-3} pH = 2.22

(must be to 2dp)

(allow 4th mark consequential on their $[H^+]$)

1

(c) (i) pH (almost) unchanged

(Must be correct to score explanation)

1

H⁺ removed by A⁻ forming HA

or acid reacts with salt

or more HA formed

1

(ii) $[H^+] = 10^{-3.59} = 2.57 \times 10^{-4}$ or 2.6×10^{-4}

1

$$[A^-] = \frac{K_a [HA]}{[H^+]}$$

1

$$= \frac{(1.45 \times 10^{-4}) \times 0.25}{2.57 \times 10^{-4}}$$

1

$$= 0.141 \text{ (mol dm}^{-3}\text{)}$$

(Allow 0.139 to 0.141 and allow 0.14)

(If not used 3.59, to find $[H^+]$ can only score M2 for working)

(If 3.59 used but $[H^+]$ is wrong, can score M2 for correct method and conseq M4)

If wrong method and wrong expression, can only score M1)

1

(ii) *Alternative scheme for first three marks of part (c)(ii)*

$$pH = pK_a - \log \frac{[HA]}{[A^-]}$$

1

$$pK_a = 3.84$$

1

$$3.59 = 3.84 - \log \frac{0.250}{[A^-]}$$

1

[11]