

Acids, Bases + Buffers Questions MS.

3. (a) $\text{H}^+(\text{aq}) + \text{OH}^-(\text{aq}) \longrightarrow \text{H}_2\text{O}(\text{l})$ ✓ [1]
- (b) $[\text{H}^+(\text{aq})] = K_w / [\text{OH}^-(\text{aq})] = 1.0 \times 10^{-14} / 0.00750 = 1.33 \times 10^{-12} \text{ mol dm}^{-3}$ ✓
 $\text{pH} = -\log[\text{H}^+(\text{aq})] = -\log 1.33 \times 10^{-12} = 11.9$ ✓ [3]
- (c) moles NaOH = $0.00750 \times 20/1000 = 1.50 \times 10^{-4} \text{ mol}$ ✓ [1]
 moles HCOOH = $1.50 \times 10^{-4} \text{ mol}$ ✓ [1]
- (d) mass of formic acid in 20 ants = $1.50 \times 10^{-4} \times 46 = 6.9 \times 10^{-3} \text{ g}$ ✓
 mass of formic acid in 1 ant = $6.9 \times 10^{-3} / 20 \text{ g} = 3.45 \times 10^{-4} \text{ g}$ ✓
 % of formic acid = $(3.45 \times 10^{-4} / 6.0 \times 10^{-4}) \times 100 = 57.5 \%$ ✓ [3]
- (e) (i) partially dissociates ✓ [1]
- (ii)
 $K_a = \frac{[\text{H}^+(\text{aq})] \times [\text{HCOO}^-(\text{aq})]}{[\text{HCOOH}(\text{aq})]}$ ✓ [1]
- (iii)
 $K_a = \frac{[\text{H}^+(\text{aq})]^2}{[\text{HCOOH}(\text{aq})]}$ ✓ $\therefore 1.6 \times 10^{-4} = \frac{[\text{H}^+(\text{aq})]^2}{6.0 \times 10^{-3}}$
 $[\text{H}^+(\text{aq})] = \sqrt{\{(1.6 \times 10^{-4}) \times (6.0 \times 10^{-3})\}} = 9.8 \times 10^{-4} \text{ mol dm}^{-3}$ ✓
 $\text{pH} = -\log[\text{H}^+(\text{aq})] = -\log 9.8 \times 10^{-4} = 3.0$ ✓ [3]
- (f) baking powder must be an alkali/base OR baking powder neutralises acid in ant bite ✓
 $\text{HCOOH} + \text{NaHCO}_3 \longrightarrow \text{HCOONa} + \text{CO}_2 + \text{H}_2\text{O}$ ✓ [2]
- (g) vinegar is acidic ✓ and neutralises alkali in wasp sting ✓ [2]

[Total: 18]

3. (a) Empirical formula = C : H : O = 40.0/12 : 6.7/1 : 53.3/16 = 3.33 : 6.7 : 3.33 ✓
 = CH₂O ✓

mass CH₂O = 30; M_r = 90 ∴ molecular formula = C₃H₆O₃ ✓

[3]

(b)

$$K_a = \frac{[\text{H}^+(\text{aq})][\text{A}^-(\text{aq})]}{[\text{HA}(\text{aq})]} = \frac{[\text{H}^+(\text{aq})]^2}{[\text{HA}(\text{aq})]} \quad \checkmark$$

$$\therefore 1.2 \times 10^{-5} = \frac{[\text{H}^+(\text{aq})]^2}{1.5}$$

$$[\text{H}^+(\text{aq})] = \sqrt{\{(1.2 \times 10^{-5}) \times (1.5)\}} = 4.2 \times 10^{-3} \text{ mol dm}^{-3} \quad \checkmark$$

$$\text{pH} = -\log[\text{H}^+(\text{aq})] \quad \checkmark = -\log 4.2 \times 10^{-3} = 2.4 / 2.37 \quad \checkmark$$

4 marks:

K_a expression ✓;[H⁺] ✓;

pH expression ✓;

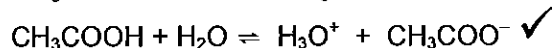
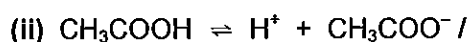
calculation of pH from [H⁺] (ecf) ✓

Common error. Without square root, answer is 4.7/ 4.7447... ✓✓✓x

[4]

(c) (i) A solution that minimises changes/resists change in pH after addition of acid/alkali ✓
 NOT 'maintains constant pH' or 'cancel out'

[1]



[1]

(iii) The weak acid or CH₃COOH reacts with added alkali / added alkali reacts with H⁺ ✓

The base or CH₃COO⁻ reacts with added acid ✓

Direction of movement indicated for one change / indication of the products formed for one change ✓

[3]

(d) effect on pH increases ✓

explanation equilibrium → left ✓

H⁺ removed by CH₃COO⁻ ✓

[3]

[Total: 15]

3. (a)

Acid is a proton/ H^+ donor ✓

Base is a proton/ H^+ acceptor ✓

Conjugate acid has H^+ more than conjugate base ✓

Equation showing acid-base pairs ✓

2 acid-base pairs labelled correctly ✓

Dilute acid has small number of moles dissolved per volume ✓

Weak acid has partial dissociation ✓

[7]

Quality of Written Communication

At least two complete sentences that are legible and where the spelling, punctuation and grammar allow the meaning to be clear. At least one equation shown. ✓

[1]

(b) (i)

$$K_a = \frac{[H^+(aq)][CN^-(aq)]}{[HCN(aq)]} \quad \checkmark$$

[1]

(ii)

$$K_a = \frac{[H^+(aq)]^2}{[HCN(aq)]} \quad \therefore 4.9 \times 10^{-10} = \frac{[H^+(aq)]^2}{0.010} \quad \checkmark$$

$$[H^+(aq)] = \sqrt{\{ (4.9 \times 10^{-10}) \times (0.010) \}} = 2.2 \times 10^{-6} \text{ mol dm}^{-3} \quad \checkmark$$

$$\text{pH} = -\log[H^+(aq)] = -\log 2.2 \times 10^{-6} = 5.65/5.66/5.7 \quad \checkmark$$

(accept calculator value)

[3]

[Total: 12]

4. (a) (i)

	C	:	H	:	O
=	66.7/12	:	11.1/1	:	22.2/16 ✓
=	5.56	:	11.1	:	1.39
=	4	:	8	:	1

empirical formula = C_4H_8O ✓

$48 + 8 + 16 = 72$ which is half of M_r

Therefore molecular formula = $C_8H_{16}O_2$ ✓

Structural formula = $CH_3(CH_2)_6COOH$ ✓

[4]

(ii) caprylic acid is a longer molecule/contains more electrons ✓

caprylic acid has more van der Waals forces between molecules ✓

caprylic acid has a higher boiling point / is less volatile ✓

[2 max]

(b)

$$[H^+(aq)] = K_w / [OH^-(aq)] \checkmark = 1.00 \times 10^{-14} / 0.500 = 2.00 \times 10^{-14} \text{ mol dm}^{-3} \checkmark$$

$$pH = -\log[H^+(aq)] = -\log 2 \times 10^{-14} = 13.699 / 13.7 \checkmark \text{ (calculator value: 13.69897)}$$

[3]

$$\text{moles NaOH in } 25.00 \text{ cm}^3 = \text{moles NaOH} = 0.0125 \text{ mol} \checkmark$$

$$\text{moles A in } 21.40 \text{ cm}^3 = \text{moles NaOH} = 0.0125 \text{ mol} \checkmark$$

$$\text{moles A in } 250 \text{ cm}^3 = 0.0125 \times 250/21.40 = 0.146 \text{ mol} / [A] = 0.584 \text{ mol dm}^{-3} \checkmark$$

0.146 mol A has a mass of 10.8 g

$$\text{molar mass of A} = 10.8/0.146 = 74 \text{ g mol}^{-1} \checkmark$$

Therefore A is propanoic acid / CH_3CH_2COOH ✓

[5]

[Total: 14]

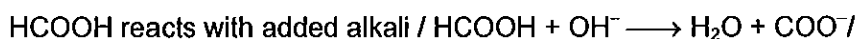
3. (a) (i) $\text{H}_2 + \text{Cl}_2 \longrightarrow 2\text{HCl}$ ✓ [1]
- (ii) $\text{C}_6\text{H}_{14} + \text{Cl}_2 \longrightarrow \text{C}_6\text{H}_{13}\text{Cl} + \text{HCl}$ ✓ [1]
- (b) (i) moles HCl = $8 \times 15 = 120$ mol ✓
volume HCl(g) = $120 \times 24 = 2880$ (dm³) ✓ [2]
- (ii) solution must be diluted by $8.00/0.0200 = 400$ times ✓
To 2.50 cm³ of 8.00 mol dm⁻³ HCl ✓ add sufficient water to make 1 dm³ of solution. [2]
- (iii) $\text{pH} = -\log[\text{H}^+] = 1.70$ ✓ [2]
- (c) (i) Final pH is approx 11 / equivalence point <7 ✓ [1]
- (ii) volume of NH₃(aq) that reacts is 15 cm³ ✓
amount of HCl used = $0.0200 \times 20.00/1000 = 4 \times 10^{-4}$
concentration of NH₃(aq) = $4 \times 10^{-4} \times 1000/15 = 0.0267$ mol dm⁻³ ✓ [2]
- (iii) chlorophenol red ✓
pH range coincides with pH change during sharp rise OR pH 4-7 /
coincides with equivalence point ✓ [2]

[Total: 13]

4. (a) A solution that minimises changes in pH (after addition of acid/alkali) ✓



/ HCOOH and HCOO^- / weak acid and its conjugate base ✓



$\longrightarrow \text{HCOO}^-$ / Equilibrium moves to right (to counteract change) ✓



$\longrightarrow \text{HCOOH}$ / Equilibrium moves to left (to counteract change) ✓

[6]

qwc: communicates in terms of relevant equilibrium ✓ [1]

- (b) For a buffer, $K_a = [\text{H}^+] \times [\text{HCOO}^-] / [\text{HCOOH}]$ ✓

$$[\text{H}^+] = K_a \times [\text{HCOOH}] / [\text{HCOO}^-] = 1.6 \times 10^{-4} \times 1/2.5 = 6.4 \times 10^{-5} \text{ mol dm}^{-3} \checkmark$$

$$\text{pH} = -\log[\text{H}^+] = -\log(6.4 \times 10^{-5}) = 4.19 / 4.2 \checkmark$$

OR

$$\text{pH} = \text{p}K_a - \log [\text{HCOOH}] / [\text{HCOO}^-] \checkmark$$

$$\text{p}K_a = 3.8 \checkmark$$

$$\text{pH} = 3.8 + 0.4 = 4.2 \checkmark$$

NOTES

3.19 worth ✓✓ (incorrect power of 10)

3.4 worth ✓✓ (use of $[\text{HCOOH}] / [\text{HCOO}^-]$)

[3]

[Total: 10]

5.

	Ca	:	C	:	O
=	31.3/40.1	:	18.7/12	:	50.0/16 ✓
=	0.78	:	1.56	:	3.125
=	1	:	2	:	4

Empirical formula of Y = CaC_2O_4 ✓

[2]

mass of Ca in kidney stone = $2 \times 31.3/100 = 0.626 \text{ g}$ ✓
 moles of Ca in kidney stone = $0.626/40.1 = 0.0156 \text{ mol}$ ✓
 number of Ca^{2+} ions removed = $6.02 \times 10^{23} \times 0.0156 = 9.39 \times 10^{21}$ ions ✓
0.0156 mol Ca is 2 marks (molar mass 128.1 g mol⁻¹)

OR

moles of Ca = $2/128.1$ ✓ = 0.0156 mol ✓
 number of Ca^{2+} ions removed = $6.02 \times 10^{23} \times 0.0156 = 9.39 \times 10^{21}$ ions ✓
For consequential marking of last point, must be evidence of moles x L

[3]

Molecular formula of X = $\text{H}_2\text{C}_2\text{O}_4$ ✓
 Structural formula = $(\text{COOH})_2$ ✓

[2]

Oxalic acid forms hydrogen bonds with water ✓
 2 x O–H in structure / 2 x COOH groups / no hydrocarbon chain / diagram showing at least 2 H bonds with water per oxalic acid molecule ✓

[2]

[Total: 9]