Acids, Bases + Buffers Questions MS.

3. (a) $H^+(aq) + OH^-(aq) \longrightarrow H_2O(l)$ ✓ [1]

(b) $[H^+(aq)] = K_w / [OH^-(aq)] = 1.0 \times 10^{-14}/0.00750 = 1.33 \times 10^{-12}$ mol dm^{-3} ✓

pH = $-\log[H^+(aq)]$ ✓ = $-\log 1.33 \times 10^{-12} = 11.9$ ✓ [3]

(c) moles NaOH = $0.00750 \times 20/1000 = 1.50 \times 10^{-4}$ mol ✓ [1]

moles HCOOH = 1.50×10^{-4} mol ✓ [1]

(d) mass of formic acid in 20 ants = $1.50 \times 10^{-4} \times 46 = 6.9 \times 10^{-3}$ g ✓

mass of formic acid in 1 ant = $6.9 \times 10^{-3}/20$ g = 3.45×10^{-4} 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)

$$K_a = \frac{[H^+(aq)] \times [HCOO^-(aq)]}{[HCOOH(aq)]}$$ ✓ [1]

(iii)

$$K_a = \frac{[H^+(aq)]^2}{[HCOOH(aq)]} \quad \therefore 1.6 \times 10^{-4} = \frac{[H^+(aq)]^2}{6.0 \times 10^{-3}}$$ ✓

$[H^+(aq)] = \sqrt{\{(1.6 \times 10^{-4}) \times (6.0 \times 10^{-3})\}} = 9.8 \times 10^{-4}$ mol dm^{-3} ✓

pH = $-\log[H^+(aq)] = -\log 9.8 \times 10^{-4} = 3.0$ ✓ [3]

(f) baking powder must be an alkali/base OR baking powder neutralises acid in ant bite ✓

$HCOOH + NaHCO_3 \longrightarrow HCOONa + CO_2 + H_2O$ ✓ [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 ✓

= CH_2O ✓

mass CH_2O = 30; M_r = 90 ∴ molecular formula = $C_3H_6O_3$ ✓

[3]

(b)

$$K_a = \frac{[H^+(aq)]\,[A^-(aq)]}{[HA(aq)]} \;/\; \frac{[H^+(aq)]^2}{[HA(aq)]}$$ ✓

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

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

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

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... ✓✓✓×

[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]

(ii) $CH_3COOH \rightleftharpoons H^+ + CH_3COO^-$ /
$CH_3COOH + H_2O \rightleftharpoons H_3O^+ + CH_3COO^-$ ✓ [1]

(iii) The weak acid or CH_3COOH reacts with added alkali / added alkali reacts with H^+ ✓

The base or CH_3COO^- 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 CH_3COO^- ✓

[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)

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

[1]

(ii)

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

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

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

(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)

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

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

[3]

moles **NaOH** in 25.00 cm^3 = moles NaOH = 0.0125 mol ✓

moles **A** in 21.40 cm^3 = moles NaOH = 0.0125 mol ✓

moles **A** in 250 cm^3 = 0.0125 x 250/21.40 = 0.146 mol / [A] = 0.584 mol dm^{-3} ✓

0.146 mol **A** has a mass of 10.8 g

molar mass of **A** = 10.8/0.146 = 74 g mol^{-1} ✓

Therefore **A** is propanoic acid / CH_3CH_2COOH ✓

[5]

[Total: 14]

3. (a) (i) $H_2 + Cl_2 \longrightarrow 2HCl$ ✓

[1]

(ii) $C_6H_{14} + Cl_2 \longrightarrow C_6H_{13}Cl + HCl$ ✓

[1]

(b) (i) moles HCl = 8 x 15 = 120 mol ✓

volume HCl(g) = 120 x 24 = 2880 (dm^3) ✓

[2]

(ii) solution must be diluted by 8.00/0.0200 = 400 times ✓

To 2.50 cm^3 of 8.00 mol dm^{-3} HCl✓ add sufficient water to make 1 dm^3 of solution.

[2]

(iii) pH= $-\log[H^+]$ ✓ = 1.70 ✓

[2]

(c) (i) Final pH is approx 11 / equivalence point <7 ✓

[1]

(ii) volume of NH_3(aq) that reacts is 15 cm^3 ✓

amount of HCl used = 0.0200 x 20.00/1000 = 4 x 10^{-4}

concentration of NH_3(aq) = 4 x 10^{-4} x 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) ✓

equilibrium: $HCOOH \rightleftharpoons HCOO^- + H^+$

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

HCOOH reacts with added alkali / $HCOOH + OH^- \longrightarrow H_2O + COO^-$/

added alkali reacts with H^+ / $H^+ + OH^- \longrightarrow H_2O$✓

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

$HCOO^-$ reacts with added acid or H^+ ✓

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

[6]

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

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

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

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

OR

$pH = pK_a - \log [HCOOH]/[HCOO^-]$ ✓

$pK_a = 3.8$ ✓

$pH = 3.8 + 0.4 = 4.2$ ✓

NOTES

3.19 worth ✓✓ (incorrect power of 10)

3.4 worth ✓✓ (use of $[HCOOH]/[HCOO^-]$)

[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 x 31.3/100 = 0.626 g ✓
moles of Ca in kidney stone = 0.626/40.1 = 0.0156 mol ✓
number of Ca^{2+} ions removed = 6.02 x 10^{23} x 0.0156 = 9.39 x 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 x 10^{23} x 0.0156 = 9.39 x 10^{21} ions ✓
For consequential marking of last point, must be evidence of ***moles*** *x L*

[3]

Molecular formula of **X** = $H_2C_2O_4$ ✓
Structural formula = $(COOH)_2$ ✓

[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]