Marking scheme for AHL Worksheet – Chapter 8

1 **a** $0.063\ \text{mol dm}^{-3}$ [1]

b $1.6 \times 10^{-6}\ \text{mol dm}^{-3}$ [1]

c $2.51 \times 10^{-14}\ \text{mol dm}^{-3}$ [1]

2 $K_a = \dfrac{[CH_3CH_2COO^-][H^+]}{[CH_3CH_2COOH]}$ [1]

3 **a** $K_a = 10^{-4.35} = 4.37 \times 10^{-5}$ [1]

$4.37 \times 10^{-5} = \dfrac{[H^+]^2}{0.100}$ [1]

$[H^+] = 2.09 \times 10^{-3}\ \text{mol dm}^{-3}$ [1]

pH = 2.68 [1]

b $K_a = 10^{-5.98} = 1.05 \times 10^{-6}$ [1]

$1.05 \times 10^{-6} = \dfrac{[H^+]^2}{0.220}$ [1]

$[H^+] = 4.80 \times 10^{-4}\ \text{mol dm}^{-3}$ [1]

pH = 3.32 [1]

c $K_a = 10^{-7.68} = 2.09 \times 10^{-8}$ [1]

$2.09 \times 10^{-8} = \dfrac{[H^+]^2}{0.150}$ [1]

$[H^+] = 5.60 \times 10^{-5}\ \text{mol dm}^{-3}$ [1]

pH = 4.25 [1]

4 **a** $CH_3NH_2 + H_2O \rightarrow CH_3NH_3^+ + OH^-$ [1]

b $K_b = \dfrac{[CH_3NH_3^+][OH^-]}{[CH_3NH_2]}$ [1]

5 **a** $H_2O(l) \rightarrow H^+(aq) + OH^-(aq)$ [1]

or $2H_2O(l) \rightarrow H_3O^+(aq) + OH^-(aq)$ [1]

b $K_w = [H^+(aq)][OH^-(aq)]$ [1]

c **i** $pK_w = 2 \times pH$ [1]

pH = 6.70 [1]

ii pH = 7.10 at 15 °C, acidic [1]

pH = 7.46 at 35 °C, alkaline [1]

pH = 6.81 at 50 °C, alkaline [1]

pH = 7.47 at 0 °C, neutral [1]

6 **a** pOH = 1 [1]

pH = 13 [1]

b pOH = 0.561 [1]

pH = 13.439 [1]

c $[OH^-] = 0.500 \text{ mol dm}^{-3}$ [1]

pOH = 0.301 [1]

pH = 13.699 [1]

7 **a** **i** $K_b = 10^{-6.78} = 1.66 \times 10^{-7}$ [1]

$$1.66 \times 10^{-7} = \frac{[OH^-]^2}{0.400}$$ [1]

$[OH^-] = 2.58 \times 10^{-4} \text{ mol dm}^{-3}$ [1]

pOH = 3.59 [1]

pH = 10.41 [1]

ii $K_b = 10^{-4.95} = 1.12 \times 10^{-5}$ [1]

$$1.12 \times 10^{-5} = \frac{[OH^-]^2}{0.200}$$ [1]

$[OH^-] = 1.50 \times 10^{-3} \text{ mol dm}^{-3}$ [1]

pOH = 2.82 [1]

pH = 11.18 [1]

iii $K_b = 10^{-9.65} = 2.24 \times 10^{-10}$ [1]

$$2.24 \times 10^{-10} = \frac{[OH^-]^2}{0.150}$$ [1]

$[OH^-] = 5.79 \times 10^{-6} \text{ mol dm}^{-3}$ [1]

pOH = 5.24 [1]

pH = 8.76 [1]

b $B_3 < B_1 < B_2$ [1]

8 **a** alkaline [1]

salt of a strong base and a weak acid [1]

$CH_3COO^-(aq) + H_2O(l) \rightarrow CH_3COOH(aq) + OH^-(aq)$ [1]

b alkaline [1]

salt of a strong base and a weak acid [1]

$HCO_3^-(aq) + H_2O(l) \rightarrow H_2CO_3(aq) + OH^-(aq)$ [1]

c acidic [1]

salt of a weak base and a strong acid [1]

$NH_4^+(aq) \rightarrow NH_3(aq) + H^+(aq)$ [1]

d neutral [1]

salt of a strong acid and a strong base [1]

9 **a** $CN^-(aq) + H_2O(l) \rightarrow HCN(aq) + OH^-(aq)$ [1]

b **i** $A^-(aq) + H_2O(l) \rightarrow HA(aq) + OH^-(aq)$ [1]

pK_b for A^- is $14 - 8.70 = 5.30$ [1]

$K_b = 10^{-5.30} = 5.01 \times 10^{-6}$ [1]

$5.01 \times 10^{-6} = \frac{[OH^-]^2}{0.100}$ [1]

$[OH^-] = 7.08 \times 10^{-4}$ mol dm^{-3} [1]

pOH = 3.15 [1]

pH = 10.85 [1]

ii $X^-(aq) + H_2O(l) \rightarrow HX(aq) + OH^-(aq)$ [1]

pK_b for A^- is $14 - 6.35 = 7.65$ [1]

$K_b = 10^{-7.65} = 2.24 \times 10^{-8}$ [1]

$2.24 \times 10^{-8} = \frac{[OH^-]^2}{0.120}$ [1]

$[OH^-] = 5.18 \times 10^{-5}$ mol dm^{-3} [1]

pOH = 4.29 [1]

pH = 9.71 [1]

10 **a** 8.5 ± 0.5 [1]

b weak [1]

pH at the equivalence point is > 7 [1]

c volume of NaOH at equivalence point = 20.0 cm^3 [1]

moles of NaOH = $\frac{20.0}{1000} \times 0.100 = 2.00 \times 10^{-3}$ mol [1]

moles of HA = 2.00×10^{-3} mol [1]

concentration of HA = $2.00 \times 10^{-3} \times \frac{1000}{25} = 0.0800$ mol dm^{-3} [1]

d 4.1 (from half equivalence point) [1]

e phenolphthalein [1]

11 **a** pH = pK_a [1]

pH = 4.76 [1]

b $pH = 4.87 + \log\frac{0.0200}{0.0400}$ [1]

pH = 4.57 [1]

c moles of ethanoic acid = $\frac{50.0}{1000} \times 0.500 = 0.0250$ mol [1]

moles of sodium ethanoate = $\frac{100.0}{1000} \times 0.300 = 0.0300$ mol [1]

$pH = 4.76 + \log\frac{0.0300}{0.0250}$ [1]

pH = 4.84 [1]

d [salt] = [acid] [1]

pH = 4.76 [1]

e moles of ammonia = $\frac{50.0}{1000} \times 0.200 = 0.0100$ mol [1]

moles of ammonium chloride = $\frac{150.0}{1000} \times 0.100 = 0.0150$ mol [1]

$pH = pK_w - pK_b + \log\frac{[base]}{[salt]}$ [1]

$pH = 14 - 4.75 + \log\frac{0.0100}{0.0150}$ [1]

pH = 9.07 [1]