

Assessment Schedule – 2018**Chemistry: Demonstrate understanding of equilibrium principles in aqueous systems (91392)****Evidence Statement**

Q	Evidence	Achievement	Merit	Excellence
ONE (a)	$\text{CH}_3\text{COO}^- + \text{H}_2\text{O} \rightleftharpoons \text{CH}_3\text{COOH} + \text{OH}^-$ $\text{H}_3\text{O}^+ = \sqrt{\frac{K_a \times K_w}{[\text{CH}_3\text{COO}^-]}}$ $= \sqrt{\left(\frac{1.74 \times 10^{-5} \times 1 \times 10^{-14}}{0.420}\right)}$ $= 6.44 \times 10^{-10}$ $\text{pH} = -\log 6.44 \times 10^{-10}$ $= 9.19$	<ul style="list-style-type: none"> • Correct process to determine pH. 	<ul style="list-style-type: none"> • Correct answer, including significant figures. 	
(b)(i) (ii)	$\text{CaF}_2 \rightleftharpoons \text{Ca}^{2+} + 2\text{F}^-$ $K_s = [\text{Ca}^{2+}] [\text{F}^-]^2$ <p>Let solubility be 's':</p> $[\text{Ca}^{2+}] = s$ $[\text{F}^-] = 2s$ $K_s = 4s^3$ $s = \sqrt[3]{\left(\frac{3.20 \times 10^{-11}}{4}\right)}$ $= 2.00 \times 10^{-4} \text{ mol L}^{-1}$	<ul style="list-style-type: none"> • Correct equilibrium equation. • Method correct for determining solubility. 	<ul style="list-style-type: none"> • Correct solubility of CaF₂ calculated, including unit, including significant figures. 	

(c)(i)	<p>In a saturated solution: $\text{Fe}(\text{OH})_3 \rightleftharpoons \text{Fe}^{3+} + 3\text{OH}^-$ As the pH is lowered, $[\text{H}_3\text{O}^+]$ increases. The H_3O^+ will remove and neutralise OH^- / $\text{H}_3\text{O}^+ + \text{OH}^- \rightarrow 2\text{H}_2\text{O}$ A decrease in $[\text{OH}^-]$ will result in the forward reaction being favoured, to restore equilibrium / minimise the change. This causes more solid $\text{Fe}(\text{OH})_3$ to dissolve, i.e. the solubility of $\text{Fe}(\text{OH})_3$ increases / so that $[\text{Fe}^{3+}][\text{OH}^-]$ will again equal K_s.</p>	<ul style="list-style-type: none"> Recognises $\text{Fe}(\text{OH})_3$ is more soluble when the pH is lowered. 	<ul style="list-style-type: none"> Explains that the solubility of $\text{Fe}(\text{OH})_3$ increases due to removal of OH^- from the equilibrium. 	<ul style="list-style-type: none"> Fully explains, using equilibrium principles, how the solubility of $\text{Fe}(\text{OH})_3$ increases when the pH is lowered. Must include neutralisation equation.
(ii)	<p>The SCN^- ions can form a complex ion with Fe^{3+} ions: $\text{Fe}^{3+} + \text{SCN}^- \rightarrow [\text{FeSCN}]^{2+}$ Since the Fe^{3+} are removed from the equilibrium, more $\text{Fe}(\text{OH})_3$ dissolves to replace some of the Fe^{3+}, i.e. equilibrium will shift towards the products / speed up the forward reaction. As a result, the solubility of $\text{Fe}(\text{OH})_3$ increases.</p>	<ul style="list-style-type: none"> Identifies that the solubility of $\text{Fe}(\text{OH})_3$ will increase when KSCN is added. 	<ul style="list-style-type: none"> Explains that the solubility of $\text{Fe}(\text{OH})_3$ will increase due to removal of Fe^{3+} from the equilibrium / formation of a complex ion. 	<ul style="list-style-type: none"> Fully explains, using equilibrium principles, how the solubility of the $\text{Fe}(\text{OH})_3$ solid increases when KSCN is added. Must include complex ion equation.

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response; no relevant evidence.	1a	2a	3a	4a	3m	4m	2e, with a minor error	2e

Q	Evidence	Achievement	Merit	Excellence
TWO (a)(i) (ii)	<p>Volume from curve at pH 10.0 = 15 – 16.0 mL</p> <p>As the HCl is added, the H_3O^+ ions are neutralised by the basic component of the buffer, CH_3NH_2, according to the equation below:</p> $\text{CH}_3\text{NH}_2 + \text{H}_3\text{O}^+ \rightarrow \text{CH}_3\text{NH}_3^+ + \text{H}_2\text{O}$ <p>OR</p> $\text{CH}_3\text{NH}_2 + \text{HCl} \rightarrow \text{CH}_3\text{NH}_3^+ + \text{Cl}^-$ <p>Since the H_3O^+ are removed from the solution, the pH of the solution does not significantly change.</p>	<ul style="list-style-type: none"> Correct volume measured from curve (15 – 16 mL). Identifies the acid / H_3O^+ is removed / neutralised by the buffer. 	<ul style="list-style-type: none"> Explains that the CH_3NH_2 neutralises the H_3O^+, with supporting equation. 	
(b)(i) (ii)	<p>$\text{Cl}^- > \text{CH}_3\text{NH}_3^+ > \text{CH}_3\text{NH}_2 = \text{H}_3\text{O}^+ > \text{OH}^-$</p> $\text{CH}_3\text{NH}_3^+ + \text{H}_2\text{O} \rightleftharpoons \text{CH}_3\text{NH}_2 + \text{H}_3\text{O}^+$ $K_a = 2.51 \times 10^{-11} = \frac{[\text{H}_3\text{O}^+]^2}{\left(0.168 \times \frac{25}{45}\right)}$ <p>$[\text{H}_3\text{O}^+] = 1.53 \times 10^{-6} \text{ mol L}^{-1}$</p> <p>$\text{pH} = -\log 1.53 \times 10^{-6} = 5.82$</p>	<ul style="list-style-type: none"> Four correct species. Recognises the solution at the equivalence point is acidic. 	<ul style="list-style-type: none"> Correct order for all. Correct process to determine pH, but minor error, e.g. incorrect dilution of CH_3NH_3^+. 	<ul style="list-style-type: none"> Correct pH, including significant figures.
(c)	<p>Electrical conductivity in solution requires ions.</p> <p>The initial solution is the weak base, methanamine. It only partially dissociates to produce a lower [ions], i.e. CH_3NH_3^+ and OH^- ions. This means there is mainly CH_3NH_2 present, which has no charge. The solution is therefore a poor conductor of electricity compared to the solution at the equivalence point.</p> $\text{CH}_3\text{NH}_2 + \text{H}_2\text{O} \rightleftharpoons \text{CH}_3\text{NH}_3^+ + \text{OH}^-$ <p>The solution at the equivalence point is made up of the products from the titration / CH_3NH_3^+ and Cl^-. As there are more ions in solution / higher [ions] the solution at the equivalence point is a better conductor.</p>	<ul style="list-style-type: none"> Recognises electrical conductivity in solution requires ions. 	<ul style="list-style-type: none"> Links the identified [ions] to the electrical conductivity of ONE solution. 	<ul style="list-style-type: none"> Full explanation of the electrical conductivity of BOTH solutions, i.e. links [ions] to electrical conductivity, including supporting equation.

N0	N1	N2	A3	A4	M5	M6	E7	E8
No response; no relevant evidence.	1a	2a	3a	4a	2m	3m	1e + 1m	2e, with minor error or omission.

Q	Evidence	Achievement	Merit	Excellence
THREE (a)(i) (ii) (iii)	$K_s = [Ag^+][Cl^-]$ The Ag^+ is a common ion. By increasing $[Ag^+]$, the equilibrium will shift towards the reactants to use up some of the extra Ag^+ , so more solid $AgCl$ will form, i.e. the solubility of $AgCl$ will decrease. $\text{Final } [Ag^+] = \frac{70}{120} \times 0.0220 = 0.0128 \text{ mol L}^{-1}$ $\text{Final } [Cl^-] = \frac{50}{120} \times 0.0550 = 0.0229 \text{ mol L}^{-1}$ $Q = [Ag^+][Cl^-] = 0.0128 \times 0.0229 = 2.94 \times 10^{-4}$ Since $Q > K_s$, $AgCl$ will form a precipitate.	<ul style="list-style-type: none"> Correct K_s expression. Identifies Ag^+ is a common ion / $[Ag^+]$ increases. Correct substitution into Q expression. OR Correct $[Ag^+]$ or $[Cl^-]$. 	<ul style="list-style-type: none"> Explains the effect of increasing $[Ag^+]$ using equilibrium principles. Correct process to determine Q and compare with K_s. 	<ul style="list-style-type: none"> Correct calculation and comparison with K_s to determine whether $AgCl$ will form a precipitate.
(b)(i) (ii) (iii)	The solution will function as a buffer over a pH range 2.74 – 4.74 ($pK_a \pm 1$). $n(\text{HCOONa}) = \frac{m}{M} = \frac{5.11}{68} = 0.0751 \text{ mol}$ $c(\text{HCOO}^-) = \frac{n}{V} = \frac{0.0751}{0.125} = 0.601 \text{ mol L}^{-1}$ $K_a = 1.82 \times 10^{-4} = \frac{[\text{HCOO}^-][\text{H}_3\text{O}^+]}{[\text{HCOOH}]}$ $= \frac{0.601 \times [\text{H}_3\text{O}^+]}{0.105}$ $[\text{H}_3\text{O}^+] = 3.18 \times 10^{-5} \text{ mol L}^{-1}$ $\text{pH} = -\log [\text{H}_3\text{O}^+] = 4.50$ Since the pH of the solution falls within the buffer zone (2.74 – 4.74), it will function as a buffer. However, as the $\text{pH} > pK_a$, / this means $[\text{HCOO}^-] > [\text{HCOOH}]$, so the buffer will be more effective against added strong acid.	<ul style="list-style-type: none"> Identifies pH range for buffer. Determines $n(\text{HCOO}^-)$. OR Correct substitution into K_a expression. Buffer is more effective against acid. 	<ul style="list-style-type: none"> Correct pH. Evaluates ability of solution to function as a buffer (could have an incorrect pH). 	<ul style="list-style-type: none"> Correct calculation of the buffer’s pH. AND A full evaluation of the ability of the solution to function as a buffer.

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response; no relevant evidence.	1a	2a	3a	4a	2m	3m	2e, with minor error or omission.	2e

Cut Scores

Not Achieved	Achievement	Achievement with Merit	Achievement with Excellence
0 – 8	9 – 13	14 – 19	20 – 24