

Assessment Schedule – 2013**Chemistry: Demonstrate understanding of equilibrium principles in aqueous systems (91392)****Evidence Statement**

Q	Evidence	Achievement	Achievement with Merit	Achievement with Excellence
ONE (a)	<p>$\text{HCl} < \text{CH}_3\text{NH}_3\text{Cl} < \text{CH}_3\text{NH}_2$</p> <p>HCl, a strong acid, reacts completely with water to form $1 \text{ mol L}^{-1} \text{H}_3\text{O}^+$ and hence a low pH. $\text{HCl} + \text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^+ + \text{Cl}^-$</p> <p>$\text{CH}_3\text{NH}_3\text{Cl}$ dissociates completely in water to form CH_3NH_3^+ and Cl^-. CH_3NH_3^+, a weak acid, partially reacts with water to form less than $1 \text{ mol L}^{-1} \text{H}_3\text{O}^+$ and hence a higher pH than HCl. $\text{CH}_3\text{NH}_3\text{Cl} \rightarrow \text{CH}_3\text{NH}_3^+ + \text{Cl}^-$ $\text{CH}_3\text{NH}_3^+ + \text{H}_2\text{O} \rightleftharpoons \text{CH}_3\text{NH}_2 + \text{H}_3\text{O}^+$</p> <p>$\text{CH}_3\text{NH}_2$, a weak base, partially reacts with water to form OH^- ions. So there are more OH^- ions than H_3O^+ ions and the pH is thus high. $\text{CH}_3\text{NH}_2 + \text{H}_2\text{O} \rightleftharpoons \text{CH}_3\text{NH}_3^+ + \text{OH}^-$</p>	<ul style="list-style-type: none"> • Correct order. • TWO equations correct. • Recognises that HCl dissociates completely in water. <p>OR</p> <p>Recognises that CH_3NH_3^+ OR CH_3NH_2 only partially react with water.</p>	<ul style="list-style-type: none"> • THREE correct equations. • Recognises that HCl dissociate completely in water. <p>AND</p> <p>Recognises that CH_3NH_3^+ or CH_3NH_2 only partially react with water.</p>	<ul style="list-style-type: none"> • Discusses all the reactions correctly including concentrations of OH^- and H_3O^+ ions.
(b)	<p>$\text{HCl} = \text{CH}_3\text{NH}_3\text{Cl} > \text{CH}_3\text{NH}_2$</p> <p>$\text{CH}_3\text{NH}_3\text{Cl}$ and HCl will dissociate completely in water to produce 2 mol L^{-1} ions.</p> <p>CH_3NH_2 will only partially react with water to produce less than 1 mol L^{-1} of ions.</p>	<ul style="list-style-type: none"> • CH_3NH_2 written last. • Links concentration of ions to degree of conductivity. 	<ul style="list-style-type: none"> • CH_3NH_2 written last and discusses HCl / $\text{CH}_3\text{NH}_3\text{Cl}$ AND CH_3NH_2. Links concentration of ions to degree of conductivity. 	<ul style="list-style-type: none"> • Correct order with valid discussion. Links concentration of ions to degree of conductivity.

<p>(c)(i)</p>	$K_a = \frac{[\text{CH}_3\text{NH}_2][\text{H}_3\text{O}^+]}{[\text{CH}_3\text{NH}_3^+]}$ $[\text{H}_3\text{O}^+] = \frac{K_a[\text{CH}_3\text{NH}_3^+]}{[\text{CH}_3\text{NH}_2]}$ $[\text{CH}_3\text{NH}_2] = \frac{30 \times 10^{-3} \times 1}{50 \times 10^{-3}} = 0.600 \text{ mol L}^{-1}$ $[\text{CH}_3\text{NH}_3^+] = \frac{20 \times 10^{-3} \times 1}{50 \times 10^{-3}} = 0.400 \text{ mol L}^{-1}$ $[\text{H}_3\text{O}^+] = 1.52705 \times 10^{-11} \text{ mol L}^{-1}$ <p>pH = 10.8</p> <p>Candidates should not be penalised for using ratio of volume and getting correct answer.</p>	<ul style="list-style-type: none"> • Correct K_a expression. <p>OR</p> <ul style="list-style-type: none"> • $\text{pH} = \text{p}K_a + \log \frac{[\text{base}]}{[\text{acid}]}$ <p>OR</p> <p>Correct concentrations or number of moles.</p>	<ul style="list-style-type: none"> • Correct process with minor error. 	<ul style="list-style-type: none"> • Correct answer.
<p>(ii)</p>	<p>When a small amount of acid (H_3O^+) ions are added, they will react with the $\text{CH}_3\text{NH}_2(aq)$ molecules to form $\text{CH}_3\text{NH}_3^+(aq)$ ions.</p> $\text{CH}_3\text{NH}_2(aq) + \text{H}_3\text{O}^+(aq) \rightarrow \text{CH}_3\text{NH}_3^+(aq) + \text{H}_2\text{O}(\ell)$ <p>The added acid (H_3O^+), is mostly consumed, and the pH of the solution changes very little.</p>	<ul style="list-style-type: none"> • Correct equation. <p>OR</p> <p>Shows understanding that $\text{CH}_3\text{NH}_2(aq)$ reacts with added acid.</p> <p>OR</p> <p>Discusses minor reaction of $\text{OH}^- + \text{H}_3\text{O}^+$.</p>	<ul style="list-style-type: none"> • Correct equation. <p>AND</p> <p>Shows understanding that $\text{CH}_3\text{NH}_2(aq)$ reacts with added acid.</p>	<p>Correct equation and correct discussion of reaction.</p>

Not Achieved	N0	No response or no relevant evidence
	N1	2a
	N2	3a
Achievement	A3	4a
	A4	5a
Merit	M5	3m
	M6	4m
Excellence	E7	3e with minor error / omission / additional information.
	E8	4e

Q	Evidence	Achievement	Achievement with Merit	Achievement with Excellence
TWO (a)	$K_s = [\text{Ag}^+]^2[\text{CrO}_4^{2-}]$	<ul style="list-style-type: none"> • Correct K_s expression. 		
(b)(i)	$n(\text{Ag}_2\text{CrO}_4) = \frac{1.44 \times 10^{-3}}{332}$ $= 4.33 \times 10^{-6} \text{ mol in 50 mL}$ $[\text{Ag}_2\text{CrO}_4] = \frac{4.33 \times 10^{-6}}{50 \times 10^{-3}}$ $= 8.67 \times 10^{-5} \text{ mol L}^{-1}$ $[\text{Ag}^+] = 8.67 \times 10^{-5} \times 2 = 1.73 \times 10^{-4} \text{ mol L}^{-1}$ $[\text{CrO}_4^{2-}] = 8.67 \times 10^{-5} \text{ mol L}^{-1}$	<ul style="list-style-type: none"> • Correct process OR Correct answer with limited working • Correct ratio of $[\text{Ag}^+] : [\text{CrO}_4^{2-}]$ 	<ul style="list-style-type: none"> • Correct concentration of silver chromate calculated. 	<ul style="list-style-type: none"> • Correct solubility concentration values for each ion and K_s value.
(ii)	$K_s = (1.73 \times 10^{-4})^2 (8.67 \times 10^{-5})$ $= 2.61 \times 10^{-12}$	<ul style="list-style-type: none"> • Uses $4s^3$ with incorrect answer. 		
(c)	<p>Dissolving 0.0100g of silver chromate in 50 mL water will result in solid being present, as the required amount to make a saturated solution is 1.44×10^{-3} g in 50 mL, so any more than this will form a solid.</p> <p>If the same mass is added to 50 mL of ammonia, more will dissolve and less solid will be present due to the formation of a complex ion. The Ag_2CrO_4 will dissociate completely and form an equilibrium.</p> $\text{Ag}_2\text{CrO}_4 \rightleftharpoons 2\text{Ag}^+ + \text{CrO}_4^{2-}$ $\text{Ag}^+ + 2\text{NH}_3 \rightleftharpoons [\text{Ag}(\text{NH}_3)_2]^+$ <p>The silver ion will then react further with NH_3, removing it from the above equilibrium. Thus, more Ag_2CrO_4 will dissolve to re-establish equilibrium.</p>	<ul style="list-style-type: none"> • Recognises that more dissolves in B. • Recognises that a complex ion forms. 	<ul style="list-style-type: none"> • Recognises that more dissolves in beaker B with link to an equation. • Recognises that in ammonia a silver complex ion will form. 	<ul style="list-style-type: none"> • Links equilibrium of silver chromate with silver & ammonium complex ion removal and hence more dissolves. • Recognises $0.0100 \text{ g} > 1.44 \times 10^{-3}$, therefore solid Ag_2CrO_4 is present. • Correct equation of formation of complex ion.

Not Achieved	NØ	No response; no relevant evidence.
	N1	1a
	N2	2a
Achievement	A3	3a
	A4	4a
Merit	M5	2m
	M6	3m
Excellence	E7	2e
	E8	3e

Q	Evidence	Achievement	Achievement with Merit	Achievement with Excellence
THREE (a)	$K_a = \frac{[\text{H}_3\text{O}^+][\text{CH}_3\text{COO}^-]}{[\text{CH}_3\text{COOH}]}$ $\bullet \text{ pH} = \text{p}K_a + \log \frac{[\text{base}]}{[\text{acid}]}$ $[\text{H}_3\text{O}^+] = \sqrt{1.74 \times 10^{-5} \times 0.0896} \text{ mol L}^{-1}$ $= 1.25 \times 10^{-3} \text{ mol L}^{-1}$ $\text{pH} = -\log[\text{H}_3\text{O}^+] = 2.90$	<ul style="list-style-type: none"> • Correct process. 	<ul style="list-style-type: none"> • Correct pH. 	(a) & (b) correct.
(b)	<p>Halfway to equivalence point, half of the ethanoic acid has been used up. There are now equimolar quantities of ethanoic acid and sodium ethanoate.</p> $\text{As } K_a = \frac{[\text{H}_3\text{O}^+][\text{CH}_3\text{COO}^-]}{[\text{CH}_3\text{COOH}]}$ <p>According to the equation when $[\text{CH}_3\text{COOH}] = [\text{CH}_3\text{COO}^-]$ then $K_a = [\text{H}_3\text{O}^+]$ So $\text{p}K_a = \text{pH}$.</p>	<ul style="list-style-type: none"> • Recognises that there are equimolar quantities of ethanoic acid and sodium ethanoate. 	<ul style="list-style-type: none"> • Relates equation correctly to explanation. 	
(c)(i)	$\text{NaOH}(aq) + \text{CH}_3\text{COOH}(aq) \rightarrow \text{NaCH}_3\text{COO}(aq) + \text{H}_2\text{O}(l) \quad (1)$ <p>$[\text{CH}_3\text{COO}^-]$ increases as it is formed in reaction (1). $[\text{Na}^+]$ increases as NaOH is added (1). $[\text{CH}_3\text{COOH}]$ decreases as it reacts with NaOH (1). $[\text{H}_3\text{O}^+]$ decreases because $[\text{CH}_3\text{COO}^-] / [\text{CH}_3\text{COOH}]$ increases and K_a is a constant. $[\text{OH}^-]$ increases because $[\text{H}_3\text{O}^+]$ decreases and $[\text{H}_3\text{O}^+][\text{OH}^-]$ is constant.</p>	<ul style="list-style-type: none"> • Correct equation <i>minor error</i>. • Correct statement relating to change in concentration of 1 species. 	<p>Correct equation and correctly describes the change in concentration of 2 species.</p>	<ul style="list-style-type: none"> • Correct equation. AND Correctly describes the change in concentration of the 4 species.

(c)(ii)	$n(\text{CH}_3\text{COOH at start}) = 0.0896 \times 20 \times 10^{-3}$ $= 1.79 \times 10^{-3} \text{ mol}$ $n(\text{NaOH added}) = 0.1 \times 5 \times 10^{-3}$ $= 5 \times 10^{-4} \text{ mol}$ After 5 mL NaOH added: $n(\text{CH}_3\text{COOH}) = 1.29 \times 10^{-3} \text{ mol}$ $n(\text{CH}_3\text{COO}^-) = 5 \times 10^{-4} \text{ mol}$ $[\text{CH}_3\text{COOH}] = 0.0516 \text{ mol L}^{-1}$ $[\text{CH}_3\text{COO}^-] = 0.0200 \text{ mol L}^{-1}$ $[\text{H}_3\text{O}^+] = 4.48 \times 10^{-5} \text{ mol L}^{-1}$ pH = 4.35 Candidates will not be penalised for not calculating concentrations.	<ul style="list-style-type: none"> • Correct n for CH₃COOH OR NaOH at the start. 	<ul style="list-style-type: none"> • Correct process to identify either of the species after 5 mL has been added (mol or mol L⁻¹). 	<ul style="list-style-type: none"> • Correct answer.
Not Achieved	NØ	No response; no relevant evidence.		
	N1	1a		
	N2	2a		
Achievement	A3	3a		
	A4	4a		
Merit	M5	2m		
	M6	3m		
Excellence	E7	2e		
	E8	3e with one minor error		

Judgement Statement

	Not Achieved	Achievement	Achievement with Merit	Achievement with Excellence
Score range	0 – 6	7 – 12	13 – 18	19 – 24