

<p>(c)(i)</p> <p>Order of decreasing pH: CH₃NH₂, NH₄Cl, HBr.</p> <p>CH₃NH₂ is a weak base, and therefore partially dissociates to produce OH⁻.</p> $\text{CH}_3\text{NH}_2 + \text{H}_2\text{O} \rightleftharpoons \text{CH}_3\text{NH}_3^+ + \text{OH}^-$ <p>NH₄Cl is an acidic salt. The NH₄⁺ is a weak acid, and therefore partially dissociates to produce H₃O⁺.</p> $\text{NH}_4^+ + \text{H}_2\text{O} \rightleftharpoons \text{NH}_3 + \text{H}_3\text{O}^+$ <p>HBr is a strong acid, and therefore completely dissociates to produce a higher [H₃O⁺] than NH₄⁺.</p> $\text{HBr} + \text{H}_2\text{O} \rightarrow \text{Br}^- + \text{H}_3\text{O}^+$ <p>Since CH₃NH₂ is the only base, it has the lowest [H₃O⁺] and therefore the highest pH. Since HBr is a strong acid, it has the highest [H₃O⁺] and therefore the lowest pH.</p> <p>(ii)</p> $\text{NH}_4^+ + \text{H}_2\text{O} \rightleftharpoons \text{NH}_3 + \text{H}_3\text{O}^+$ $K_a = \frac{[\text{NH}_3][\text{H}_3\text{O}^+]}{[\text{NH}_4^+]}$ $5.75 \times 10^{-10} = \frac{(10^{-4.70})^2}{[\text{NH}_4^+]}$ $[\text{NH}_4^+] = 0.692 \text{ mol L}^{-1}$		<ul style="list-style-type: none"> Recognises [H₃O⁺] affects pH. Correct process for calculating [NH₄⁺]. 	<ul style="list-style-type: none"> Correct order, and some explanation of degree of dissociation and [H₃O⁺] linked to pH. Correct [NH₄⁺], including unit. 	<ul style="list-style-type: none"> Fully justifies order, including degree of dissociation and relative [H₃O⁺] linked to pH, with support from at least TWO correct equations, AND correct [NH₄⁺].
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N0	N1	N2	A3	A4	M5	M6	E7	E8
No response; no relevant evidence.	1a	2a	3a	4a	3m	4m	2e, but allow minor error / omission in one part.	2e

Q	Evidence	Achievement	Merit	Excellence
TWO (a)(i) (ii) (iii)	$\text{PbBr}_2 \rightleftharpoons \text{Pb}^{2+} + 2\text{Br}^-$ $K_s = [\text{Pb}^{2+}] [\text{Br}^-]^2$ Let solubility be s : $K_s = 4s^3$ $s = \sqrt[3]{\left(\frac{2.10 \times 10^{-6}}{4}\right)}$ $s = 8.07 \times 10^{-3} \text{ mol L}^{-1}$	<ul style="list-style-type: none"> • Correct equilibrium equation and K_s expression. • Method correct for determining solubility of PbBr_2. 	<ul style="list-style-type: none"> • Correct solubility of PbBr_2, including unit. 	
(b)	$[\text{Pb}^{2+}] = \frac{125}{300} \times 0.0365 = 1.52 \times 10^{-2} \text{ mol L}^{-1}$ $[\text{Br}^-] = \frac{175}{300} \times 2 \times 0.00262 = 3.06 \times 10^{-3} \text{ mol L}^{-1}$ $\text{IP} = [\text{Pb}^{2+}] [\text{Br}^-]^2 = (1.52 \times 10^{-2}) \times (3.06 \times 10^{-3})^2$ $= 1.42 \times 10^{-7}$ Since $\text{IP} < K_s$, no PbBr_2 precipitate will form.	<ul style="list-style-type: none"> • EITHER Correct $[\text{Pb}^{2+}]$ OR $[\text{Br}^-]$. • Correct comparison of Q_s (IP) with K_s 	<ul style="list-style-type: none"> • Correct process to determine Q_s (IP) and compare with K_s. 	<ul style="list-style-type: none"> • Correct calculation and comparison with K_s to determine whether PbBr_2 will form a precipitate.

(c)(i)	$\text{Ni(OH)}_2 \rightleftharpoons \text{Ni}^{2+} + 2\text{OH}^-$ <p>When ammonia solution is added, the Ni^{2+} ions are removed from the saturated solution to form a complex ion, as shown below:</p> $\text{Ni}^{2+} + 6\text{NH}_3 \rightarrow [\text{Ni}(\text{NH}_3)_6]^{2+}$ <p>To restore the equilibrium, more solid Ni(OH)_2 dissolves to replace some of the Ni^{2+} / increase $[\text{Ni}^{2+}]$. Therefore the solubility of Ni(OH)_2 increases.</p> <p>When the pH is decreased below pH 4, $[\text{H}_3\text{O}^+]$ increases. The H_3O^+ remove the OH^- from the equilibrium according to the neutralisation equation below:</p> $\text{H}_3\text{O}^+ + \text{OH}^- \rightarrow 2\text{H}_2\text{O}$ <p>To restore the equilibrium, more solid Ni(OH)_2 dissolves to replace some of the OH^- / increase $[\text{OH}^-]$. Therefore the solubility of Ni(OH)_2 increases.</p>	<ul style="list-style-type: none"> Recognises Ni^{2+} forms a complex ion with NH_3. <p>OR</p> <ul style="list-style-type: none"> Recognises $[\text{H}_3\text{O}^+]$ increases below pH 4. 	<ul style="list-style-type: none"> Explains that the formation of a complex ion removes Ni^{2+} from equilibrium / causes decrease in $[\text{Ni}^{2+}]$. Explains that H_3O^+ removes OH^- from equilibrium / causes decrease in $[\text{OH}^-]$. 	<ul style="list-style-type: none"> Fully explains, using equilibrium principles, how the solubility of Ni(OH)_2 increases due to both the addition of NH_3 and decreasing pH below 4.
(ii)	$\text{Ni(OH)}_2 \rightleftharpoons \text{Ni}^{2+} + 2\text{OH}^-$ $K_s = [\text{Ni}^{2+}][\text{OH}^-]^2$ $[\text{OH}^-] = \frac{1 \times 10^{-14}}{10^{-8.25}} = 1.78 \times 10^{-6} \text{ mol L}^{-1}$ $6.00 \times 10^{-16} = [\text{Ni}^{2+}] \times (1.78 \times 10^{-6})^2$ $[\text{Ni}^{2+}] = 1.90 \times 10^{-4} \text{ mol L}^{-1}$	<ul style="list-style-type: none"> Correctly calculates $[\text{OH}]^-$. 	<ul style="list-style-type: none"> Correctly calculates $[\text{Ni}^{2+}]$, i.e. solubility of Ni(OH)_2, including unit. 	

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response; no relevant evidence.	1a	2a	3a	4a	3m	4m	2e, but allow minor error / omission in one part.	2e

Q	Evidence	Achievement	Merit	Excellence
THREE (a)(i) (ii)	<p> Na^+, CH_3COO^-, CH_3COOH, OH^-, H_3O^+ </p> <p> For this solution: $\text{CH}_3\text{COO}^- + \text{H}_2\text{O} \rightleftharpoons \text{CH}_3\text{COOH} + \text{OH}^-$ $[\text{CH}_3\text{COO}^-] = 0.224 \text{ mol L}^{-1}$ </p> <p> For this solution: $[\text{CH}_3\text{COOH}] = [\text{OH}^-] = \frac{K_w}{[\text{H}_3\text{O}^+]}$ </p> <p> Using K_a to calculate pH: $K_a = \frac{[\text{H}_3\text{O}^+][\text{CH}_3\text{COO}^-]}{[\text{CH}_3\text{COOH}]}$ $1.74 \times 10^{-5} = \frac{0.224 \times [\text{H}_3\text{O}^+]^2}{10^{-14}}$ $[\text{H}_3\text{O}^+] = 8.81 \times 10^{-10} \text{ mol L}^{-1}$ pH = 9.05 </p>	<ul style="list-style-type: none"> THREE correct species identified. Correct process for determining pH of sodium ethanoate solution. 	<ul style="list-style-type: none"> Correctly calculates pH of sodium ethanoate solution. 	
(b)	<p> The electrical conductivity of a solution depends upon its concentration of mobile ions. </p> <p> HCl is a strong acid and therefore completely dissociates (evidence from equation) to produce a high concentration of Cl^- ions and H_3O^+ ions in solution. </p> <p> $\text{HCl} + \text{H}_2\text{O} \rightarrow \text{Cl}^- + \text{H}_3\text{O}^+$ </p> <p> Sodium ethanoate is a basic salt. It completely dissociates (evidence from equation) to produce a high concentration of Na^+ ions and CH_3COO^- ions in solution. </p> <p> $\text{CH}_3\text{COONa} \rightarrow \text{Na}^+ + \text{CH}_3\text{COO}^-$ </p> <p> Since both solutions produce a high concentration of ions, they are both good electrical conductors. </p>	<ul style="list-style-type: none"> Recognises a solution requires mobile ions for electrical conductivity. 	<ul style="list-style-type: none"> Explains why HCl is a good electrical conductor. <p>OR</p> <ul style="list-style-type: none"> Explains why sodium ethanoate is a good electrical conductor. 	Fully justifies why BOTH solutions are good electrical conductors, including equations.

<p>(c)(i)</p>	$\text{CH}_3\text{COOH} + \text{H}_2\text{O} \rightleftharpoons \text{CH}_3\text{COO}^- + \text{H}_3\text{O}^+$ $K_a = \frac{[\text{CH}_3\text{COO}^-][\text{H}_3\text{O}^+]}{[\text{CH}_3\text{COOH}]}$ $1.74 \times 10^{-5} = \frac{[\text{H}_3\text{O}^+]^2}{(0.224 \times \frac{25}{45})}$ $[\text{H}_3\text{O}^+] = 1.47 \times 10^{-3} \text{ mol L}^{-1}$ <p>pH = 2.83</p>	<ul style="list-style-type: none"> • Correct process for calculating pH at equivalence point. • Circles “Higher pH”. 	<ul style="list-style-type: none"> • Calculates correct pH at equivalence point. • Links the pH at the equivalence point to the pH of the weak acid and the magnitude of its K_a / pK_a. 	<ul style="list-style-type: none"> • Calculates correct pH at equivalence point AND Explains why the pH is higher at the equivalence point for (ii).
<p>(ii)</p>	<p>Circled “Higher pH”.</p> <p>At the equivalence point, the weak acid is present, i.e. either CH_3NH_3^+ or CH_3COOH. Since CH_3NH_3^+ has a smaller K_a (larger pK_a), it is a weaker acid than CH_3COOH and will therefore dissociate to a lesser extent to produce a lower $[\text{H}_3\text{O}^+]$. As a result, the pH at the equivalence point will be higher for CH_3NH_3^+.</p>			

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No response; no relevant evidence.	1a	2a	3a	4a	3m	4m	2e, but allow minor error / omission in one part.	2e

Cut Scores

Not Achieved	Achievement	Achievement with Merit	Achievement with Excellence
0 – 7	8 – 13	14 – 18	19 – 24