# Answers to 3.7 Paper 1

## Question One

**a** $HCN + H_2O \rightleftharpoons CN^- + H_3O^+$ A

**b** $CH_3COOH$ A

**c** $K_a = \dfrac{[H_3O^+][CN^-]}{HCN}$

$[H_3O^+]^2 = 6.17 \times 10^{-10} \times 0.0100$

$= 6.17 \times 10^{-12}$

$[H_3O^+] = 2.48 \times 10^{-6}$

pH = 5.60

A = correct equation and substitution, M = correct pH

## Question Two

**a** **i** 7 A

**ii** HCl is a strong acid with complete dissociation or proton transfer, while $CH_3COOH$ is a weak acid that has less dissociation or proton transfer hence fewer $H_3O^+$ and a higher pH.

A = idea of strong and weak acids, M = complete explanation

**iii** $[Al(H_2O)_6]^{3+}(aq) + H_2O(l) \rightarrow [Al(H_2O)_5OH]^{2+}(aq) + H_3O^+(aq)$

A = minor error, M = completely correct (states not needed)

**iv** $Cl^- = NH_4^+ >> NH_3 = H_3O^+ >> OH^-$

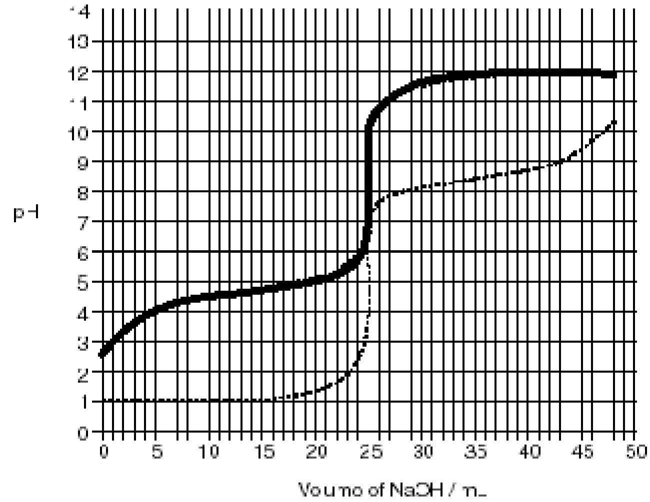
A = correct ions but 2 out of order, M = all correct

**v** $NH_4Cl$ solution is a better conductor than $NH_3$ solution. $NH_4Cl$ is a soluble salt and completely dissociates in water giving a greater number of ions which are charge carriers. $NH_3$ is a weak base and forms fewer ions in water making the solution a poorer conductor.

A = idea of different dissociations, M = plus idea of relative amounts of ions, E = complete answer linking conductivity to charge carriers

**b** **i** Add a suitable indicator. A

**ii**



Correct curve drawn A

**iii** The titration is of a weak acid versus a strong base so at the start the pH > 1 and the shape is not flat, while at the equivalence point the pH > 7 (salt of a weak acid formed so solution is basic), and at the end it is strongly basic (pH = 12).

A = 2 of the 3 points mentioned, M = all 3 points mentioned

**iv** $n(\text{OH}^-) = 0.025\text{ L} \times 0.100\text{ mol L}^{-1}$

$= 0.0025\text{ mol}$

$$c(\text{CH}_3\text{COOH}) = \frac{0.0025\text{ mol}}{0.020\text{ L}}$$

$= 0.125\text{ mol L}^{-1}$

A = correct volume from graph, M = correct concentration

**v** Correct region shown ≈ 5 – 20 mL of NaOH added A

**vi** Both acid and conjugate base are present so there will be a relatively small change in pH when a relatively large amount of $\text{OH}^-$ (or $\text{H}_3\text{O}^+$) is added.

A = mention of small change in pH, M = linked to acid and conjugate base being present

**vii** At the equivalence point $\text{CH}_3\text{COONa}$ is present. Hence:

$$\text{CH}_3\text{COO}^- + \text{H}_2\text{O} \rightleftharpoons \text{CH}_3\text{COOH} + \text{OH}^-$$

This is basic, thus $K_b$ has to be used. $K_b = 5.75 \times 10^{-10}$

$$K_b = \frac{[\text{CH}_3\text{COOH}][\text{OH}^-]}{[\text{CH}_3\text{COO}^-]}$$

Assumption: $[\text{CH}_3\text{COOH}] = [\text{OH}^-]$

$$5.75 \times 10^{-10} = \frac{[\text{OH}^-]^2}{0.0556}$$

$[\text{OH}^-] = 5.718 \times 10^{-6}$

$\text{pOH} = 5.24$

$\text{pH} = 8.76$

A = correctly uses $K_b$, M = correct calculation with 1 minor error, E = pH correctly found

**vii** Find an indicator whose colour changes at the steepest part of the curve ie. $\text{p}K_a$ of indicator matches the vertical part of the curve and changes colour in this region.

A =one point made, M = both points made

**Question Three**

**a** $M(\text{AgBr}) = 188\text{ g mol}^{-1}$

$$\text{Solubility} = \frac{1.33 \times 10^{-4}\text{ g L}^{-1}}{188\text{ g mol}^{-1}}$$

$= 7.07 \times 10^{-7}\text{ mol L}^{-1}$ A

**b** $\text{AgBr(s)} \rightleftharpoons \text{Ag}^+\text{(aq)} + \text{Br}^-\text{(aq)}$ A

**c** $K_s = [\text{Ag}^+][\text{Br}^-]$ A

**d** $[\text{Ag}^+] = [\text{Br}^-] = 7.07 \times 10^{-7}\text{ mol L}^{-1}$

$K_s = (7.07 \times 10^{-7}\text{ mol L}^{-1})^2$

$= 5.00 \times 10^{-13}\text{ mol L}^{-1}$

A = correct method with minor error, M = correct calculation and answer

**Question Four**

**a i** $\text{BaSO}_4\text{(s)} \rightleftharpoons \text{Ba}^{2+}\text{(aq)} + \text{SO}_4^{2-}\text{(aq)}$

$K_s = [\text{Ba}^{2+}][\text{SO}_4^{2-}]$ but $[\text{Ba}^{2+}] = [\text{SO}_4^{2-}]$ which becomes $[\text{Ba}^{2+}]^2$

$[\text{Ba}^{2+}] = \sqrt{1.1 \times 10^{-10}}$

$= 1.05 \times 10^{-5}\text{ mol L}^{-1}$

A = correct answer, but no (or wrong) units, M = correct answer

**ii** Because $\text{MgSO}_4$ is soluble it means there are more $\text{SO}_4^{2-}$ ions. More $\text{BaSO}_4\text{(s)}$ is formed (the equilibrium shifts to the left) thus reducing its solubility (common ion effect).

A = idea of more sulfate ions reducing solubility, M = full answer

**iii** $[Ba^{2+}] = [SO_4^{2-}] = 0.0005 \text{ mol L}^{-1}$ (remember that volume has doubled)

Ionic product = $(0.0005)^2$

$= 2.5 \times 10^{-7} \text{ mol}^2 \text{ L}^{-2}$

Ionic product > $K_s$ ($1.1 \times 10^{-10}$), hence precipitate will form.

A = correct method, M = correct calculation with minor error, E = correct calculation and argument

**b** **i** $K_a = \dfrac{[C_6H_5COO^-][H_3O^+]}{[C_6H_5COOH]}$ A

**ii** pH = 4, hence $[H_3O^+] = 1.0 \times 10^{-4} \text{ mol L}^{-1}$ and $Ka = 6.3 \times 10^{-5}$. Substitute in above equation.

$$6.3 \times 10^{-5} = \frac{[C_6H_5COO^-][1 \times 10^{-4}]}{[C_6H_5COOH]}$$

$$\frac{[C_6H_5COO^-]}{[C_6H_5COOH]} = \frac{6.3 \times 10^{-5}}{1 \times 10^{-4}}$$

Hence, [benzoic acid] > [benzoate ion]

A = correct answer without backing, M = correct method with minor error, E = correct relation calculated and correct answer argument

## Judgement Statement

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|---|---|
| **Achievement** | **11 questions answered correctly.**<br>**A minimum of 11 × A** |
| **Merit** | **14 questions answered correctly with 8 at Merit level**<br>**A minimum of 6 × A + 8 × M** |
| **Excellence** | **16 questions answered correctly with 10 at Merit level and 3 at Excellence level.**<br>**A minimum of 3 × A + 10 × M + 3 × E** |