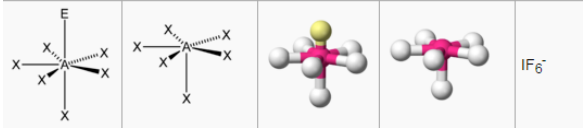
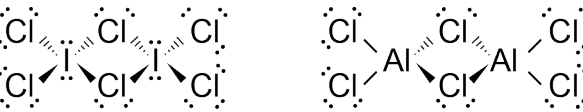


Assessment Schedule – 2015

Scholarship Chemistry (93102)

Evidence Statement

Q	Evidence	Level 3	Scholarship	Outstanding
<p>ONE (a)(i)</p> <p>(ii)</p>	<p>Shape about the central atom is determined by the number of regions of electrons which are arranged as far apart as possible to minimise repulsion. (VSEPR)</p> <p>From the Lewis diagrams:</p> <p>IF_4^+ has five regions of electrons which take up a trigonal bipyramid arrangement. There are four bonding and one non-bonding pair so the observed shape is a see saw with bond angles of around 120° and 90°.</p> <p>IF_6^- has seven regions of electrons. The suggested shape is a distorted octahedron (name is not necessary but some attempt to describe or draw a shape that has 7 regions of electrons that repel equally). Since there are 6 bonds, the lone pair will go in the “axial” position so the observed shape will be a pentagonal pyramid (suggested answer is an extension of a square pyramid but other sensible answers based on VSEPR should be accepted), with the expected bond angles in the plane to be less than $90^\circ / 72^\circ$ ($360^\circ \div 5$).</p>   <p>I_2Cl_6 – each iodine has 6 electron regions (octahedral) and only 4 bonding with the bonds taking a square planar shape so the molecules will be flat.</p> <p>Al_2Cl_6 – each Al will have 4 electron regions (tetrahedral) and 4 bonds so bonding around each Al is tetrahedral. (Some distortion for Al–Cl–Al.)</p> <p>The I_2Cl_6 molecules will have a higher molar mass and hence greater electron cloud so the instantaneous-induced dipole forces will be greater than for Al_2Cl_6. Hence the intermolecular forces between these molecules will be greater. Also the flat / planar nature of the I_2Cl_6 molecules will make it easier for the molecules to pack together / get close to each other than for the more angular shaped Al_2Cl_6 molecules. Both of these factors would suggest that I_2Cl_6 will have a higher melting point.</p>	<ul style="list-style-type: none"> Shapes, bond angles and reason linked to Lewis structures. 	<ul style="list-style-type: none"> Logical development and clarity of ideas (IF_4^+) and comparison of shapes and melting points of I_2Cl_6 and Al_2Cl_6. 	<ul style="list-style-type: none"> Comprehensive communication of ideas about shape linked to Lewis structures and melting points, including extrapolation of VSEPR to SEVEN regions of electrons.

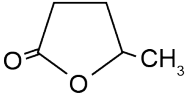
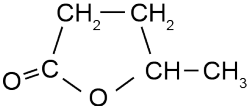
<p>(b)</p>	$n(\text{IO}_3^-) = \frac{0.5466 \text{ g}}{214.0 \text{ g mol}^{-1}} = 0.002554 \text{ mol}$ $c(\text{IO}_3^-) = \frac{0.002554 \text{ mol}}{0.250 \text{ L}} = 0.01022 \text{ mol L}^{-1}$ <p>Balanced equation for the reaction</p> $\text{IO}_3^- + 5\text{I}^- + 6\text{H}^+ \rightarrow 3\text{I}_2 + 3\text{H}_2\text{O}$ $6\text{S}_2\text{O}_3^{2-} + 3\text{I}_2 \rightarrow 3\text{S}_4\text{O}_6^{2-} + 6\text{I}^-$ <hr/> $\text{IO}_3^- + 6\text{H}^+ + 6\text{S}_2\text{O}_3^{2-} \rightarrow 3\text{H}_2\text{O} + 3\text{S}_4\text{O}_6^{2-} + \text{I}^-$ $\frac{n(\text{IO}_3^-)}{1} = \frac{n(\text{S}_2\text{O}_3^{2-})}{6}$ $n(\text{IO}_3^-) = c(\text{IO}_3^-) \times V(\text{IO}_3^-) = 0.01022 \text{ mol L}^{-1} \times 0.0100 \text{ L} = 1.022 \times 10^{-4} \text{ mol}$ $n(\text{S}_2\text{O}_3^{2-}) = 6 \times 1.022 \times 10^{-4} \text{ mol} = 6.130 \times 10^{-4} \text{ mol}$ $c(\text{S}_2\text{O}_3^{2-}) = \frac{n(\text{S}_2\text{O}_3^{2-})}{V(\text{S}_2\text{O}_3^{2-})} = \frac{6.130 \times 10^{-4} \text{ mol}}{0.02548 \text{ L}} = 0.02406 \text{ mol L}^{-1}$ $5\text{CO} + \text{I}_2\text{O}_5 \rightarrow \text{I}_2 + 5\text{CO}_2$ $\text{I}_2 + 2\text{S}_2\text{O}_3^{2-} \rightarrow 2\text{I}^- + \text{S}_4\text{O}_6^{2-}$ $n(\text{S}_2\text{O}_3^{2-}) = 0.02406 \times 0.01723 = 4.1453 \times 10^{-4} \text{ mol}$ $n(\text{I}_2) = 2.073 \times 10^{-4} \text{ mol}$ $n(\text{CO}) = 5 \times 2.073 \times 10^{-4} = 1.036 \times 10^{-3} \text{ mol}$ $c(\text{CO}) = \frac{1.036 \times 10^{-3}}{23.20} = 4.466 \times 10^{-5} \text{ mol L}^{-1}$ $= 0.001250 \text{ g L}^{-1}$	<ul style="list-style-type: none"> • Correct use of titration data. 	<ul style="list-style-type: none"> • Integration and synthesis involving calculations using the correct method throughout, but 1–2 errors introduced. 	<ul style="list-style-type: none"> • Sophisticated integrations involving calculations using correct methods to produce the correct answer, which includes correct significant figures and units.
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Q	Evidence	Level 3	Scholarship	Outstanding
TWO (a)(i)	<p>From the graph: $pK_a = 4.8$ ($K_a = 1.58 \times 10^{-5}$).</p> <p>After 5 mL of NaOH added – assume no H^+ from weak acid.</p> <p>Initial $n(\text{HCl}) = 0.015 \times 0.200 = 0.003 \text{ mol}$ $n(\text{NaOH}) \text{ added} = 0.005 \times 0.100 = 0.0005 \text{ mol}$ $n(\text{HCl}) \text{ left} = 0.003 - 0.0005 = 0.0025 \text{ mol}$ $V_{\text{total}} = 30 \text{ mL} = 0.0300 \text{ L}$ $c(\text{HCl}) = \frac{0.0025}{0.030} = 0.0833 \text{ mol L}^{-1}$</p> <p>so pH = 1.08</p> <p>(Check assumption – at this pH $\frac{[\text{CH}_3\text{COO}^-]}{[\text{CH}_3\text{COOH}]} = 2 \times 10^{-4}$ so the reaction of CH_3COOH with water is not significant.)</p> <p>After 29 mL NaOH added – assume no dissociation of CH_3COOH at this pH.</p> <p>Initial $n(\text{HCl}) = 0.015 \times 0.200 = 0.003 \text{ mol}$ $n(\text{NaOH}) \text{ added} = 0.029 \times 0.100 = 0.0029 \text{ mol}$ $n(\text{HCl}) \text{ left} = 0.003 - 0.0029 = 0.0001 \text{ mol}$ $V_{\text{total}} = 54 \text{ mL} = 0.0540 \text{ L}$ $c(\text{HCl}) = \frac{0.0001}{0.054} = 1.85 \times 10^{-3} \text{ mol L}^{-1}$</p> <p>so pH = 2.73</p> <p>Checking the assumption outlined above:</p> $c(\text{HA}) = 0.010 \times \frac{0.2}{0.054} = 3.70 \times 10^{-2} \text{ mol L}^{-1}$ $1.74 \times 10^{-5} = \frac{0.00185 \times [\text{A}^-]}{0.0370}$ <p>$[\text{A}^-] = 3.48 \times 10^{-4} = [\text{H}_3\text{O}^+]$ from weak acid dissociation $[\text{H}_3\text{O}^+]_{\text{TOT}} = 1.85 \times 10^{-3} + 3.48 \times 10^{-4} = 2.198 \times 10^{-3}$, so pH = 2.66.</p>	<ul style="list-style-type: none"> • TWO calculations. 	<ul style="list-style-type: none"> • TWO calculations correct and recognises assumptions. 	<ul style="list-style-type: none"> • All calculations consider whether assumptions are valid.

	<p>After 50 mL NaOH added – assume no dissociation of water. All HCl is used up and the second equivalence point is reached. $n(\text{CH}_3\text{COOH}) = 0.010 \times 0.200 = 0.002 \text{ mol} = n(\text{CH}_3\text{COO}^-)$ $V_{\text{total}} = 75 \text{ mL} = 0.0750 \text{ L}$ $c(\text{CH}_3\text{COO}^-) = \frac{0.002}{0.0750} = 0.02667 \text{ mol L}^{-1}$ $\text{p}K_{\text{b}} = 9.2 \quad K_{\text{b}} = 6.31 \times 10^{-10}$ $6.31 \times 10^{-10} = \frac{[\text{OH}^-] \times [\text{HA}]}{0.02667}$ $[\text{OH}^-]^2 = 1.683 \times 10^{-11}$, so $[\text{OH}^-] = 4.10 \times 10^{-6}$, so $\text{pOH} = 5.39$, thus $\text{pH} = 14.0 - 5.39$ so pH = 8.61</p>			
(ii)	<p>First equivalence point is at 30 mL where all of the strong acid has been reacted. The pH at this point is determined by the concentration and dissociation of the unreacted weak acid. Since the $\text{p}K_{\text{a}}$ is small, the reaction with water will be reactant-favoured and only a small dissociation occurs. $\text{HCl} + \text{NaOH} \rightarrow \text{NaCl} + \text{H}_3\text{O}^+ \quad \text{CH}_3\text{COOH} + \text{H}_2\text{O} \rightleftharpoons \text{CH}_3\text{COO}^- + \text{H}_3\text{O}^+$ As NaOH continues to be added, acid is reacted to form the conjugate base and a buffer solution is created by the presence of significant quantities of the acid and its conjugate base. The pH of the solution is dependent on the ratio of acid to conjugate base. $\text{CH}_3\text{COOH} + \text{OH}^- \rightleftharpoons \text{CH}_3\text{COO}^- + \text{H}_2\text{O}$ When the concentration of acid is equal to the concentration of conjugate base the pH is equal to $\text{p}K_{\text{a}}$. This will occur when 40 mL of NaOH (10 mL after all the strong acid has been neutralised) has been added, as it requires 20 mL of NaOH to neutralise all of the weak acid. When 50 mL of NaOH has been added, all of the weak acid has been consumed, and the species present in solution is CH_3COO^-, which will react with water to produce a basic solution. The pH here depends on the concentration of the base and the extent of the reaction, as reflected in the size of $\text{p}K_{\text{a}}$ (of the conjugate acid) or $\text{p}K_{\text{b}}$. $\text{CH}_3\text{COO}^- + \text{H}_2\text{O} \rightleftharpoons \text{CH}_3\text{COOH} + \text{OH}^-$ After 50 mL of NaOH has been added, any additional NaOH put into the reaction solution will have no further acid to react with, so the pH will be dependent on the concentration of the OH^- in solution.</p>	<p>Some of:</p> <ul style="list-style-type: none"> Species linked to equations. pH linked to species present. Buffer region accounted for. pH at equivalence point accounted for. 	<ul style="list-style-type: none"> Logically developed discussion incorporating at least three of the four sections. 	<ul style="list-style-type: none"> pH changes from 30 to 60 mL related to the species present and their concentration with discussions, including equations.

(b)	<p>The equivalence points of the titration are turning points on the graph. The slope is dependent on the nature and concentration of the ions present. As one ionic species is used up, it is replaced by another with a different conductivity. Hence the change of gradient at each equivalence point.</p> <p>During the addition of the first 30 mL of NaOH, the reaction occurring is:</p> $\text{Na}^+ + \text{OH}^- + \text{H}^+ + \text{Cl}^- \rightarrow \text{Na}^+ + \text{Cl}^- + \text{H}_2\text{O}$ <p>Initially in the solution, there is a high concentration of H^+ and Cl^- ions. The H^+ ions have a particularly high conductivity. As these are replaced by Na^+ ions and H_2O molecules, the concentration of H^+ decreases resulting in a drop in conductivity since the Na^+ ions have a lower conductivity than H^+.</p> <p>At the first equivalence point (30 mL added) all the H^+ ions from HCl have been replaced by Na^+, so there is mostly just Na^+ and Cl^- ions (and a small number of CH_3COO^- from the acid dissociation) present, and hence the conductivity is low. From 30 to 50 mL, the conductivity rises a small amount as the ion concentration increases.</p> $\text{CH}_3\text{COOH} + \text{Na}^+ + \text{OH}^- \rightarrow \text{CH}_3\text{COO}^- + \text{Na}^+ + \text{H}_2\text{O}$ <p>The rise is only small because the ions formed have relatively low conductivity and the solution is diluted by the added NaOH solution.</p> <p>After 50 mL has been added, the conductivity increases to a greater extent and one of the ions being added to the solution (OH^-) has a relatively higher conductivity than those in the solution at the equivalence point (50 mL added).</p>	<p>Some of:</p> <ul style="list-style-type: none"> • Links conductance to the species of ions present. • Links conductance to concentration of ions present. 	<ul style="list-style-type: none"> • Discussion that shows recognition of the species present in solution (and their relative concentration) that contribute to the conductance. 	<ul style="list-style-type: none"> • Well developed discussion of how the shape of the graph is linked to the relative concentrations of the species present, including appropriate equations.
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Q	Evidence	Level 3	Scholarship	Outstanding
THREE (a)	$\text{RCHO} + 2\text{Ag}^+ + \text{H}_2\text{O} \rightarrow \text{RCOOH} + 2\text{Ag} + 2\text{H}^+$ $n(\text{Ag}) = \frac{4.64}{107.9} = 0.0430 \text{ mol} \quad n(\text{aldehyde}) = 0.0215 \text{ mol}$ $m(\text{et}) + m(\text{met}) = 42.69 \text{ g.}$ <p>In 2.18 g sample, $m_{\text{tot}} = 0.7802 \text{ g}$ so $m(\text{et}) = 0.7802 - m(\text{met})$</p> $\frac{m(\text{et})}{44.05} + \frac{m(\text{met})}{30.03} = 0.0215 \text{ mol}$ $\frac{(0.7802 - m(\text{et}))}{30.03} + \frac{m(\text{et})}{44.05} = 0.0215 \text{ mol}$ $44.05(0.7802 - m(\text{et})) + 30.03 m(\text{et}) = 0.0215 \times 30.03 \times 44.05 = 28.44$ $34.37 - 44.05 m(\text{et}) + 30.03 m(\text{et}) = 28.44$ $34.37 - 28.44 = 14.02 m(\text{et})$ $m(\text{et}) = \frac{5.93}{14.02} = 0.4230 \text{ g}$ $m(\text{met}) = 0.7802 - 0.4230 = 0.3572 \text{ g}$ <p>In the original sample:</p> $m(\text{ethanal}) = \frac{0.4230}{0.7802} \times 42.69 = \mathbf{23.15 \text{ g}}$ $m(\text{methanal}) = 42.69 - 23.14 = \mathbf{19.54 \text{ g}}$ <p>Note: If calculated mass of aldehydes in 2.18 g, then: $m(\text{ethanal}) = 0.4230 \text{ g}$ $m(\text{methanal}) = 0.3572 \text{ g.}$</p>	<ul style="list-style-type: none"> Recognises some steps of calculation. 	<ul style="list-style-type: none"> Calculation is mostly correct. 	<ul style="list-style-type: none"> Both aldehydes identified with correct working.

	<p>Compound A</p> <p>Isomer 5</p> <p>A</p> <p>E</p> <p>F</p> <p>Compound B</p> <p>Isomer 4</p> <p>B</p> <p>G</p> <p>F</p> <p>Compound C</p> <p>Isomer 1</p> <p>C</p> <p>H</p> <p>I</p> <p>J</p> <p>OR</p> <p>K</p> <p>L</p>			
	$\begin{array}{c} \text{CH}_3\text{CCH}_3 \\ \parallel \\ \text{O} \end{array}$	$\begin{array}{c} \text{CH}_3 \\ \\ \text{CH}_3\text{CCH}_2\text{COH} \\ \quad \parallel \\ \text{OH} \quad \text{O} \end{array}$		
	$\begin{array}{c} \text{CH}_3\text{CCH}_2\text{COH} \\ \parallel \quad \parallel \\ \text{O} \quad \text{O} \end{array}$	$\begin{array}{c} \text{CH}_3 \\ \\ \text{CH}_3\text{CCH}_2\text{COH} \\ \quad \parallel \\ \text{OH} \quad \text{O} \end{array}$		
	$\begin{array}{c} \text{HOCCH}_2\text{CH}_2\text{COH} \\ \parallel \quad \parallel \\ \text{O} \quad \text{O} \end{array}$	$\begin{array}{c} \text{CH}_3\text{CHCH}_2\text{CH}_2\text{COH} \\ \quad \parallel \\ \text{OH} \quad \text{O} \end{array}$		
		<p>OR</p> 		
	$\begin{array}{c} \text{CH}_3\text{COH} \\ \parallel \\ \text{O} \end{array}$	$\begin{array}{c} \text{O} \\ \parallel \\ \text{CH}_3\text{CCOH} \\ \parallel \\ \text{O} \end{array}$		

Q	Evidence	Level 3	Scholarship	Outstanding
FOUR (a)	<p>In order for two substances to dissolve the solute-solute and the solvent-solvent intermolecular forces must be disrupted and the solute-solvent intermolecular forces formed. For solutions of high solubility the solute-solvent intermolecular forces will be stronger than the sum of the solute-solute and the solvent-solvent forces. (There must be sufficient energy released from the bond making to balance the energy needed for bond breaking).</p> <p>In aqueous solutions the intermolecular forces are hydrogen bonds.</p> <p>In the pain killers, the predominate intermolecular forces will be instantaneous-induced dipoles between the hydrocarbon parts of the molecules with some dipole-dipole attractions and hydrogen bonding between the functional groups of different molecules.</p> <p>The low solubility of all these compounds in water is due to the hydrocarbon portion in each molecule that cannot form hydrogen bonds with water molecules.</p> <p>Ibuprofen molecules have the largest hydrocarbon portion and are the least soluble. Aspirin and paracetamol molecules have similar sized hydrocarbon groups relative to their functional groups. Their solubility will be based on the ability of the molecules to hydrogen bond through the N – H and O – H, and C = O groups in paracetamol molecules, and the O – H and C = O groups in aspirin molecules.</p> <p>The greater solubility of paracetamol is probably related to the position of the polar OH group in the molecule. The acidic nature of the aspirin and ibuprofen molecules will also contribute to their solubility.</p> <p>When calcium salts of aspirin and ibuprofen are used the negative charge of the conjugate base of the acid functional groups will create even stronger ion-dipole attractions to the water molecules, thus enhancing the solubility.</p>	<p>Some discussion of:</p> <ul style="list-style-type: none"> • Factors that affect solubility. • Recognition of the intermolecular forces between any two molecules. • Links solubility to intermolecular forces. 	<ul style="list-style-type: none"> • Logical concise discussion of factors which affect solubility. 	<ul style="list-style-type: none"> • Convincing discussion of trends in solubility for the three given compounds.

<p>(b)</p>	<p>Reaction: $\text{N}_2(\text{g}) + 8\text{H}^+(\text{aq}) + 8\text{e}^- \rightarrow 2\text{NH}_3(\text{g}) + \text{H}_2(\text{g})$</p> <p>Endothermic processes:</p> $\text{N}_2 \rightarrow 2\text{N} \quad \Delta H = 945$ $8\text{H}^+(\text{aq}) \rightarrow 8\text{H}^+(\text{g}) \quad \Delta H = 8 \times +1150 = 9200 \text{ kJ mol}^{-1}$ $8\text{H}^+(\text{g}) + 8\text{e}^- \rightarrow 8\text{H} \quad \Delta H = 8 \times -1312 = -10496 \text{ kJ mol}^{-1}$ <p>Exothermic processes:</p> $8\text{H}^+(\text{g}) + 8\text{e}^- \rightarrow 8\text{H} \quad \Delta H = 8 \times -1312 = -10496 \text{ kJ mol}^{-1}$ $2\text{H} \rightarrow \text{H}_2 \quad \Delta H = -436 \text{ kJ mol}^{-1}$ $2\text{H} + 2\text{N} \rightarrow 2\text{NH} \quad \Delta H = 2 \times -351 = -702 \text{ kJ mol}^{-1}$ $2\text{H} + 2\text{NH} \rightarrow 2\text{NH}_2 \quad \Delta H = 2 \times -385 = -770 \text{ kJ mol}^{-1}$ $2\text{H} + 2\text{NH}_2 \rightarrow 2\text{NH}_3 \quad \Delta H = 2 \times -444 = -888 \text{ kJ mol}^{-1}$ <p style="text-align: center;">Total enthalpy change = -3147 kJ mol⁻¹</p> <p>This indicates a favourable change from an enthalpy point of view</p> <p>From an entropy point of view, the reaction appears to involve combining a large number of particles to form only a few molecules, which would mean that the products are more ordered than the reactants which would be unfavourable.</p> <p>However, the three product molecules are in the gas phase, which is favourable from a disorder point of view (more disordered, entropically favourable). Also the dehydration of the H^+ ions will release many water molecules from being ordered around the ion, leading to greater entropy and more disorder.</p>	<p>Some of:</p> <ul style="list-style-type: none"> • Endothermic / exothermic reactions recognised in an attempt towards the calculation of ΔH. • Enthalpy ideas correct. • Entropy changes recognised. 	<ul style="list-style-type: none"> • Enthalpy calculations correct and some discussion of the thermodynamics of the reaction. 	<ul style="list-style-type: none"> • Comprehensive discussion of both enthalpy changes and entropy changes.
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