# Assessment Schedule 2006

## Scholarship Chemistry (93102)

### Evidence Statement

| Question | Evidence | 1–4 marks | 5–6 marks | 7–8 marks |
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| 1(a) | $Cl_2$ are non-polar so held together by weak temporary dipole dipole attractions. Low size of $\Delta_{fus}H^o$ and $\Delta_{vao}H^o$ reflect small amount of energy required to break these forces and separate particles in both solid and liquid phases.<br>NaCl has strong ionic forces between the ions so a large amount of energy is needed to disrupt the lattice and even more to separate the ions and vaporise them.<br>Large difference between $\Delta_{fus}H^o$ and $\Delta_{vap}H^o$ in NaCl reflects energy needed to separate ions from each other when changing from liquid to gas.<br>Small difference between $\Delta_{fus}H^o$ and $\Delta_{vap}H^o$ in $Cl_2$ because forces between molecules of $Cl_2$ similar in both phases.<br>Ie solid to liquid – E needed to disrupt the lattice<br>Liquid to Gas – E- needed to completely separate particles. | Shows some understanding of forces involved and/or $\Delta_{fus}H^o$ and $\Delta_{vap}H^o$<br>And/or links between these<br>**AND / OR**<br>Correct method for calculation with limited errors | For 1(a)<br>Correct discussion of forces for both substances linked to $\Delta_{fus}H^o$ and $\Delta_{vap}H^o$ Part (i)<br>**AND**<br>For 1(b)<br>Correct method for calculation with small errors<br>**OR**<br>For 1(a)<br>Both correct forces identified OR definitions of $\Delta_{fus}H^o$ and $\Delta_{vap}H^o$<br>**AND**<br>For 1(b)<br>Correction calculations and discussions<br>1 mark – Correct calculation OR calculation error with correct follow on discussion<br>2 marks – Calculation and discussion correct | Correct discussion of forces for both substances and with comparison between $\Delta_{fus}H^o$ and $\Delta_{vap}H^o$<br>**AND**<br>Correction calculations and discussions for 1(b) |
| (b) (i) | $Na(g) \rightarrow Na^+(g) + e^-$  $\Delta H = 502$ kJ mol$^{-1}$<br>$Cl(g) + e^- \rightarrow Cl^-(g)$  $\Delta H = -355$ kJ mol$^{-1}$<br>Adding these:<br>$Na(g) + Cl(g) \rightarrow Na^+(g) + Cl^-(g)$ $\Delta H = 502 - 355$<br>$= 147$ kJ mol$^{-1}$<br>From (i) transfer of electrons to form ions is endothermic so reaction would not be spontaneous. | | | |
| (ii) | Lattice enthalpy: $\Delta H$ for $NaCl(s) \rightarrow Na^+(g) + Cl^-(g)$<br>$Na(g) + Cl(g) \rightarrow Na^+(g) + Cl^-(g)$ $\Delta H = 147$ kJ mol$^{-1}$<br>(OR $Na(g) \rightarrow Na^+(g) + e^-$  $\Delta H = 502$ kJ mol$^{-1}$<br>$Cl(g) + e^- \rightarrow Cl^-(g)$  $\Delta H = -355$ kJ mol$^{-1}$)<br>$NaCl(s) \rightarrow Na(s) + Cl_2(g)$  $\Delta H = +411$ kJ mol$^{-1}$<br>$Na(s) \rightarrow Na(l) \rightarrow Na(g)$  $\Delta H = 104 + 2.6 = 106.6$ kJ mol$^{-1}$<br>$\frac{1}{2} Cl_2(g) \rightarrow Cl(g)$  $\Delta H = \frac{1}{2} \times 242 = 121$ kJ mol$^{-1}$<br>Adding these: $NaCl(s) \rightarrow Na^+(g) + Cl^-(g)$<br>$\Delta H = 147 + 411 + 106.6 + 121 = 785.6$ kJ mol$^{-1}$(790) | | | |

| Question | Evidence | 1–4 marks | 5–6 marks | 7–8 marks |
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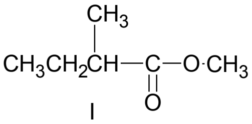
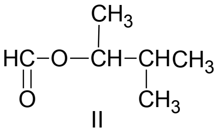
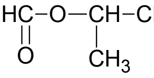
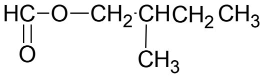
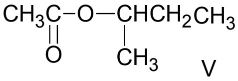
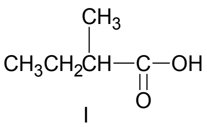
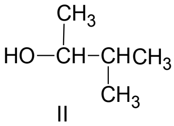
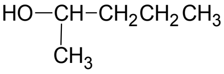
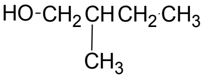
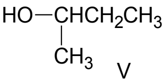
| 2(a) | Mg 2,8,2 Na 2,8,1<br>• Difference between II and III: third $e^-$ is removed from shell closer to nucleus.<br>• Large difference between × and XI because XI is E for $e^-$ in shell closer to the nucleus and so it is held more strongly.<br>• III to × (OR I to II) **increasing** because as $e^-$ removed the repulsions between the $e^-$s in the shell are reduced so $e^-$ are closer to the nucleus (or $e^-$ removed from a more positive particle).<br>• III to × (OR I to II) increase is gradual because successive $e^-$ removed are from the same E level.<br>• 1st I.E. for Mg is bigger than for Na as the increased nuclear charge will provide a stronger attraction for the $e^-$. (OR Energy required to remove the inner core $e^-$ from Mg will be higher because of the increased charge on the nucleus).<br>• I.E. similar for Na and Mg because they have similar e-arrangements and with the valence $e^-$ in same shell. | Some aspects of the following correct:<br>Relates changes to $e^-$ arrangement<br>**OR**<br>Recognises reasons for large changes **OR** gradual increase **OR** compares Na and Mg<br>**AND / OR**<br>Some of:<br>Structure of 6-carbon acid or ester with chiral carbon OR discussion of polarity<br>2 marks – At least one of Structure **A** with corresponding Structure **B**<br>3 marks | For 2(a)<br>Discussion shows some understanding of reasons for large changes and gradual increases in relation to the $e^-$ arrangement and compares and contrasts Mg and Na<br>**AND**<br>There is some recognition of the nature of Structure **A** and **B** | For 2(a)<br>Discussion shows understanding of reasons for large changes and gradual increases in relation to the $e^-$ arrangement and compares and contrasts Mg and Na<br>**AND**<br>Structure **A** with corresponding Structure **B** recognised **WITH** justification that includes link to solubility mark |
| 2(b) | Compound **A**: could be ester or acid.<br>As **B** is different from **A** the original compound is an ester.<br>Extraction of acidification product into the ether layer suggests a water insoluble compound is formed. This could be a long chain alcohol or carboxylic acid.<br>Possible structures for ester with chiral carbon:<br> $CH_3CH_2CH(CH_3)-C(=O)-O\cdot CH_3$ I<br> $HC(=O)-O-CH(CH_3)-CH(CH_3)CH_3$ II<br> $HC(=O)-O-CH(CH_3)-CH_2CH_2CH_3$ III<br> $HC(=O)-O-CH_2\cdot CH(CH_3)CH_2CH_3$ IV<br> $CH_3C(=O)-O-CH(CH_3)CH_2CH_3$ V<br>Possible structures for Compound **B** from I to V above:<br> $CH_3CH_2CH(CH_3)-C(=O)-OH$ I<br> $HO-CH(CH_3)-CH(CH_3)CH_3$ II<br> $HO-CH(CH_3)-CH_2CH_2CH_3$ III<br> $HO\cdot CH_2CH(CH_3)CH_2\cdot CH_3$ IV<br> $HO-CH(CH_3)CH_2CH_3$ V | | | |

| Question | Evidence | 1–4 marks | 5–6 marks | 7–8 marks |
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| 3 | **Functional group changes**:<br>Alcohol to ketone use $Cr_2O_7^{2-}/H^+$<br>Alcohol to acid use $Cr_2O_7^{2-}/H^+$<br>Alkene to alcohol use $H_2SO_4(aq)$ OR $H_3PO_4(aq)$ (heat)<br>Ester to alcohol use $H_2SO_4\ (aq)$<br>**Order:** Use $Cr_2O_7^{2-}/H^+$, then $H_2SO_4(aq)$<br>Otherwise alcohol that is created by the the hydrolysis of the ester would then be oxidized to a ketone with the $Cr_2O_7^{2-}/H^+$. (Note: the alcohol formed in the adition reaction is a tertiary alcohol and is not affected by the reaction with $Cr_2O_7^{2-}/H^+$.)<br>**By-products**:<br>Addition of $H_2O$ to alkene could result in –OH on other end of double bond (minor product).<br>Oxidation of alcohol to carboxylic acid could result in some aldehyde.<br>Hydrolysis of ester results in ethanoic acid. | Some aspects of reagents **AND / OR**, by-products recognised. | Most aspects of reactions recognised with small omissions. | All functional group changes correctly identified with correct and sensible discussion re order. By-products including second addition product recognised. |

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| 4(a) | Solution **A**: pH > 7. Solution reacts with water to produce $OH^-$. Weak base so only partial hydrolysis<br>$CH_3NH_2 + H_2O \rightarrow CH_3NH_3^+ + OH^-$<br>Solution **B**: pH < 7. $CH_3NH_3Cl$ dissolves in water to give $CH_3NH_3^+$ which reacts with water to produce $H_3O^+$. Weak acid so only partial hydrolysis<br>$CH_3NH_3^+ + H_2O \rightarrow CH_3NH_2 + H_3O^+$<br>Solution C: pH > 7 (= 10.6) Solution is a buffer as both acid and conjugate base are present. Equimolar amounts so pH = $pK_a$ | Some aspects of calculations or discussions correct. | At least one of calculations or discussions correct and some correct ideas/methods for at least two others correct. | Calculations carried out correctly and related discussion complete with correct equations where relevant. |
| (b) | $HCl + CH_3NH_2 \rightarrow CH_3NH_3^+ + Cl^-$<br>$n(HCl) = 0.1 \times 0.015 = 1.5 \times 10^{-3}$ mol<br>$n(CH_3NH_2) = 0.1 \times 0.025 = 2.5 \times 10^{-3}$ mol<br>After reaction: $n(CH_3NH_2) = 1.0 \times 10^{-3}$ mol<br>$c(CH_3NH_2) = 2.5 \times 10^{-2}$<br>$n(CH_3NH_3^+) = 1.5 \times 10^{-3}$ mol, $c(CH_3NH_3^+) = 3.75 \times 10^{-2}$<br>$K_a = 2.51 \times 10^{-11} = [CH_3NH_2]\,[H_3O^+] / [CH_3NH_3^+]$<br>$[H_3O^+] = 2.51 \times 10^{-11} \times 3.75 \times 10^{-2} / 2.5 \times 10^{-2}$<br>pH = 10.4 | | | |
| (c) | In solution **A** $Cu(OH)_2$ dissolves because $Cu^{2+}$ forms a complex ion and hence is removed from the solubility equilibrium and so more $Cu(OH)_2$ dissolves.<br>$Cu(OH)_2(s) \rightarrow Cu^{2+}(aq) + 2OH^-(aq)$<br>$Cu^{2+} + 4CH_3NH_2 \rightarrow [Cu(CH_3NH_2)_4]^{2+}$<br>In Solution **B** $Cu(OH)_2$ dissolves because $CH_3NH_3^+$ is a weak acid and will reacts to neutralise $OH^-$.Removing $OH^-$ from the equilibrium and causes more $Cu(OH)_2$ to dissolve.<br>$CH_3NH_3^+ + OH^- \rightarrow CH_3NH_2 + H_2O$ | | | |
| (d) | $Mg^{2+}(aq) + 2OH^-(aq) \rightarrow Mg(OH)_2(s)$<br>For precipitation $[Mg^{2+}]\,[OH^-]^2 > 1.5 \times 10^{-11}$<br>$[Mg^{2+}] = 0.1$ mol $L^{-1}$ $[OH^-]^2 = 1.5 \times 10^{-11} / 0.1 = 1.5 \times 10^{-10}$<br>$[OH^-] = 1.22 \times 10^{-5}$ and $[H_3O^+] = 8.2 \times 10^{-10}$<br>To achieve this pH need a buffer<br>$CH_3NH_3^+ + H_2O \rightarrow CH_3NH_2 + H_3O^+$<br>$K_a = 2.51 \times 10^{-11} = [CH_3NH_2]\,[H_3O^+] / [CH_3NH_3^+]$<br>$[CH_3NH_3^+] = 0.1 \times 8.2 \times 10^{-10} / 2.51 \times 10^{-11} = 3.27$ mol $L^{-1}$<br>$m(CH_3NH_3Cl) = 3.27 \times 67.5 = 221$ g | | | |

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| 5(a) | In solution: $Na^+$, $I^-$ $H_2O$<br>• At (+) electrode $2I^- \rightarrow I_2 + 2e^-$<br>• Observe brown colour of $I_2$<br>• At (–) electrode $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$<br>• Observe phenolphthalein will turn pink, bubbles of gas.<br>Reason: From $E^\circ$ data: $I^-$ is more easily oxidised than water as it is the reductant in the couple with the lower $E^\circ$ value.<br>And $H_2O$ is more easily reduced than $Na^+$ as it is the oxidant in the couple with the higher $E^\circ$ value. | For 5(a)<br>Some observations linked to species with some attempt at justification **OR** recognition of strongest oxidant and reductant based on $E^\circ$ values<br>**AND / OR**<br>Spontaneous reactions recognized with reasons | For 5(a) Some correct observations linked to $E^\circ$ data given<br>**AND**<br>One or two spontaneous reactions correctly identified with supporting evidence and attempts to correctly balance equations | For 5(a)<br>Principles of electrolysis correctly identified with correct observations linked to $E^\circ$ data given<br>**AND**<br>Two spontaneous reactions correctly identified with supporting evidence and balanced equations |
| (b) | For the reaction of $IO^-$ to form $IO_3^-$ and $I_2$<br>$E^\circ_{reaction} = E^\circ_{red} - E^\circ_{ox} = 0.45 - 0.14 > 0$ hence spontaneous<br>$5IO^- + 2H_2O \rightarrow IO_3^- + 2I_2 + 4OH^-$<br>For the reaction of $I_2$ to form $IO^-$ to form $I^-$<br>$E^\circ_{reaction} = E^\circ_{red} - E^\circ_{ox} = 0.54 - 0.45 > 0$ hence spontaneous<br>$I_2 + H_2O \rightarrow IO^- + I^- + 2H^+$<br>OR $I_2 + 2OH^- \rightarrow IO^- + I^- + H_2O$<br>For $IO_3^-$ $E^\circ_{ox} > E^\circ_{red}$ so not spontaneous | | | |

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| 6(a) | - Vigorous swirling (would assist in dissolving the iodine but) could cause it the reaction product ($I^-$) to be oxidized to $I_2$ so that more $I_2$ generated.<br>- Allowing solutions to stand could cause volatile $I_2$ to be lost.<br>- If sufficient iodide is added to convert the $I_2$ produced to $I_3^-$ then both solubility and volatility problems can be minimized.<br>- Increase n($S_2O_3^{2-}$) then n(Vit C) **less** than actual OR decrease n($S_2O_3^{2-}$) then n(Vit C) **more** than actual. | Some aspects of practical techniques correctly discussed<br>**AND / OR**<br>Some steps in calculation correct | Most aspects of practical techniques correctly discussed<br>**AND / OR**<br>Most steps in calculation correct | Correctly discusses most aspects of practical technique including the significance of the results<br>**AND**<br>Correctly carries out calculation with correct number of significant figures. |
| (b) | Standard solution:<br>c($BrO_3^-$) = 1.33 g /167 g mol$^{-1}$ × 1/0.5000 L × 1/5<br>**= 0.00319 mol L$^{-1}$**<br>n($BrO_3^-$)$_{added}$ =0 .01404 L × 0.00319 mol L$^{-1}$= **4.47 × 10$^{-5}$ mol**<br>n($S_2O_3^{2-}$) = 0.00238 mol L$^{-1}$ × 0.00236 L = **5.617 × 10$^{-6}$ mol**<br>n($BrO_3^-$)$_{excess}$ = n($S_2O_3^{2-}$) /6 = 9.38 × 10$^{-7}$<br>n($BrO_3^-$)$_{used}$ = 4.47 × 10$^{-5}$ – 9.38 × 10$^{-7}$= 4.38 × 10$^{-5}$ mol<br>n(Vit C) = 3 n($BrO_3^-$) = 1.31 × 10$^{-4}$ mol<br>m(Vit C) = 176 × 1.31 × 10$^{-4}$ = 23.1 mg in 50 mL<br>(46.2 mg per 100 mL)<br><br>Titre used to calculate excess bromine used is very small and hence **percentage error** would be large so accuracy of results is limited.<br><br>Alternative methods<br><br>n($Br_2$)$_{added}$ = 3 × n($BrO_3^-$)$_{added}$ = 3 × 4.47 × 10$^{-5}$ mol<br>= 1.341 × 10$^{-4}$ mol<br>n($I_2$) = n($S_2O_3^{2-}$)/2 = 5.617 × 10$^{-6}$ = 2.808 × $^{-6}$ = n($Br_2$)$_{excess}$<br>n($Br_2$)$_{reacted}$ = 1.341 × 10$^{-4}$ – 2.808 × 10$^{-6}$ = 1.338 × 10$^{-4}$ mol<br>= n(Vit C)<br>m(Vit C) = 1.313 × 10$^{-4}$ mol × 176 = 23.1 mg in 50mL<br><br>OR<br>n($Br_2$) = 3 × n($BrO_3^-$) = 3 × 4.47 × 10$^{-5}$ mol<br>= 1.341 × 10$^{-4}$ mol<br>Would give m(Vit C) = 1.341 × 10$^{-4}$ mol × 176 = 23.6 mg<br>n($Br_2$)$_{excess}$ = n($I_2$) = n($S_2O_3^{2-}$)/2 = 5.617 × 10$^{-6}$ = 2.808 × $^{-6}$<br>Would give m(Vit C) = 2.808 × $^{-6}$ × 176 = 0.494 mg<br>Actual Vit C = 23.6 – 0.5 mg = 23.1 mg in 50mL | | | |