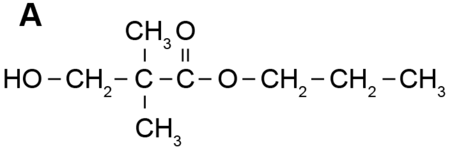
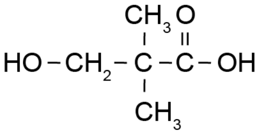
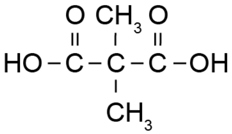
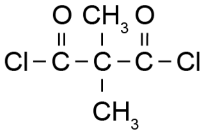
Assessment Schedule – 2024

Scholarship Chemistry (93102)

Evidence Statement

Q	Evidence	Scholarship Not Awarded	Scholarship	Outstanding Scholarship
ONE (a)(i)	Mass of hydrated salt = 3.792 g Mass of anhydrous salt = 1.855 g Mass of water = 1.937 g Moles of salt = $\frac{1.855\text{ g}}{120.4\text{ g mol}^{-1}}$ = 0.015407 mol Moles of water = $\frac{1.937\text{ g}}{18.0\text{ g mol}^{-1}}$ = 0.10761 mol Mole ratio salt:water = 1:6.98 (1:7), so formula is $MgSO_4.7H_2O$ $n(Mg^{2+}) = cV = 0.255\text{ mol L}^{-1} \times 0.250\text{ L} = 0.06375\text{ mol}$ $M(MgSO_4.7H_2O) = 120.4 + (7 \times 18.0) = 246.4\text{ g mol}^{-1}$ $m = 0.06375\text{ mol} \times 246.4\text{ g mol}^{-1} = 15.71\text{ g}$	Any of the following: • Determines a formula for hydrated $MgSO_4$ crystals. • Calculates the mass for the standard solution. • Explains surroundings entropy changes during rehydration. • Explains system entropy changes during rehydration. • Explains potential functional groups present in Compound **A**. • Relates, with reasons, a proposed compound to one of the three ^{13}C NMR spectra. • Determines the structural formula for any of Compounds **A**–**F**.	A range of the following: • Determines a formula for hydrated $MgSO_4$ crystals with minor errors and explains the entropy changes occurring during the rehydration of the anhydrous crystals. • Accurately relates aspects of IR and ^{13}C NMR data to different proposed compounds from the reaction scheme. • Determines the structural formula for four of Compounds **A**–**F**.	A range of the following: • Correctly determines the formula for $MgSO_4.7H_2O$, the mass required for the standard solution, and justifies the thermochemical changes occurring as the anhydrous crystals rehydrate. • Discusses IR spectral data in relation to Compound **A** and clearly links ^{13}C NMR data to Compounds **B, D/E**, and **C**. • Determines the structural formula for all of Compounds **A**–**F**.
(ii)	Process is $MgSO_4(s) + 7H_2O(g) \rightarrow MgSO_4.7H_2O(s)$ For the mass of the crucible to have increased, the anhydrous salt must have reabsorbed some water from the atmosphere. The removal of water is endothermic, requiring heating, therefore the reabsorption of water, and formation of new attractive forces between the ions and the water molecules, is exothermic. This results in a positive increase in the entropy of the surroundings. The entropy change of the system is negative because the random motion of the H_2O molecules is much lower in the lattice. This results in a decrease in entropy of the system. As the process is spontaneous at room temperature, the increase in entropy of the surroundings must be greater than the decrease in the entropy of the system.			

(b)(i)	The IR spectra for Compound **A** shows a strong sharp peak at about 1750 cm^{-1} from a C=O stretch. This suggests a carboxylic acid, amide, ketone, aldehyde, ester, or acyl chloride functional group. The strong peak at 3400–3600 cm^{-1} indicates an O–H stretch, consistent with carboxylic acid or alcohol functional groups. Due to the lack of peaks indicating N–H or C–Cl bonds, amide and acyl chloride functional groups can be reasonably eliminated.			
(ii)	**A**  $HO-CH_2-C(CH_3)_2-C(=O)-O-CH_2-CH_2-CH_3$ **B**  $HO-CH_2-C(CH_3)_2-C(=O)-OH$ **C** $HO-CH_2-CH_2-CH_3$ **D**  $HO-C(=O)-C(CH_3)_2-C(=O)-OH$ **E** $Cl-CH_2-CH_2-CH_3$ **F**  $Cl-C(=O)-C(CH_3)_2-C(=O)-Cl$			

(iii)	*The candidate answer will be assessed on the quality of the arguments made, which will include discussion of the peaks present in the ^{13}C NMR spectra.* *The candidate may have made mistakes in their compound structures in (ii), and thus argue incorrect structures for the ^{13}C NMR spectra. This is acceptable, provided the spectral arguments are sound.* **Spectra 1 matches Compound B** The peak at 182 ppm indicates a COOH carbon-bonding environment. The peak at 70 ppm indicates a C–OH carbon bonding environment. The molecule must have two different functional groups. Four peaks in total indicates four unique carbon-bonding environments. Compound **B**. **Spectra 2 matches Compound D or F** The peak at 174 ppm indicates a COOH or COCl carbon-bonding environment. The peak at 49 ppm indicates a C atom bonded to a nearby C=O carbon. Three peaks in total indicates symmetry in the molecule, and three unique carbon-bonding environments. Compound **D** or **F** could produce this spectrum. **Spectra 3 matches Compound C** The peak at 64 ppm indicates a C–OH bonding environment. There are three peaks, indicating three unique carbon bonding environments. The only structure without a C=O bonding environment, and three unique carbon-bonding environments, is Compound **C**.			

Q	Evidence	Scholarship Not Awarded	Scholarship	Outstanding Scholarship
TWO (a)	When these compounds are dissolved into water, the processes occurring vary depending on the particles involved. Water is a polar molecule in which the oxygen atom has a partial negative charge and the hydrogens have a partial positive charge. Solid sodium chloride is an ionic salt, with strong electrostatic attractions between the oppositely charged Na^+ and Cl^- ions in the lattice structure. When dissolving in water, the water-ion forces of attraction are strong enough to overcome existing ionic bonds in the lattice, and hydrogen bonds in the water, enabling the salt to dissolve. Glucose is a molecular solid, with numerous –OH functional groups available for hydrogen bonding with water. These interactions are stronger than intermolecular attractions between the glucose molecules, and hydrogen bonding in water. Citric acid is a molecular solid, with three –COOH and one –OH functional groups. When dissolving in water, the water molecules can form hydrogen bonds with these functional groups, enabling strong water-citric acid attractions to form, which are strong enough to overcome existing intermolecular attractions in the citric acid, and hydrogen bonding in water. In addition, citric acid ($C_6H_8O_7$) is a weak acid that reacts with water, forming $C_6H_7O_7^-$, $C_6H_6O_7^{2-}$, and $C_6H_5O_7^{3-}$ to a tiny extent. Dissociating to form ions in solution, which can then form strong ion-water attractions, further aids in the high solubility of the citric acid in water. All have strong intermolecular / ionic forces in the lattice structures, but these are all overcome in the dissolving process.	Any of the following: • Describes the role of ion-water attractions in dissolving of NaCl. • Describes the role of hydrogen bonding in dissolving of citric acid and glucose. • Describes the role of ionisation of citric acid in dissolving. • Explains pH of any two of the four solutions. • Gives the correct relative concentration of ions for two of the four solutions. • Calculates pH of final solution with minor error. • Explains observations for Solution **A** or **B**. • Writes balanced chemical equations for equilibrium reactions occurring during qualitative analysis. • Uses calculations to determine the cation in **B** with minor error.	A range of the following: • Discusses the changes occurring when two of the substances dissolve in water, or explains all three with minor omissions. • Correctly compares the pH of three of the four solutions to pure water, with correct relative concentrations, and calculates pH of final solution with minor error. • Discusses the equilibrium changes occurring for Solution **A** or **B**, and uses calculations to justify the identity of the cation in **B**.	A range of the following: • Fully discusses the changes occurring when all three substances are dissolved in water with clear links to particles and attractive forces. • Compares the pH of all four solutions to pure water, with relevant equations and comparative concentrations described, alongside calculating the correct pH of the final solution in (ii). • Uses equilibrium principles and balanced chemical equations to justify the observations made during the qualitative analysis of **A** and **B**, and uses calculations to justify the identity of the cation in **B.**

(b)(i)	**Solution A** • Contains ethanol, which is a non-ionising molecular substance. The pH of the solution will be 7, the same as pure water. $CH_3CH_2OH(\ell) \rightarrow CH_3CH_2OH(aq)$ $[CH_3CH_2OH] > [H_3O^+] = [OH^-]$ **Solution B** • Contains ethanoic acid, a weak acid, which will dissociate into ethanoate ions and hydronium ions. The pH of the solution will be less than 7 as a result. $CH_3COOH(aq) + H_2O(\ell) \rightarrow CH_3COO^-(aq) + H_3O^+(aq)$ $[CH_3COOH] > [CH_3COO^-] = [H_3O^+] > [OH^-]$ **Solution C** • Contains sodium ethanoate, a basic conjugate salt of a weak acid. This salt will dissolve in water to form ethanoate ions, which will then go on to react with water to form ethanoic acid molecules and hydroxide ions. The pH of the solution will be greater than 7 as a result. $CH_3COONa(s) \rightarrow CH_3COO^-(aq) + Na^+(aq)$ $CH_3COO^-(aq) + H_2O(\ell) \rightarrow CH_3COOH(aq) + OH^-(aq)$ $[Na^+] > [CH_3COO^-] > [CH_3COOH] = [OH^-] > [H_3O^+]$ **Solution D** • Contains an equimolar mixture of CH_3COOH and CH_3COO^- ions. When the concentration of a weak acid and its conjugate base are equal, the pH of the solution equals the p*K*a of the acid. The pH will be equal to 4.76 $[Na^+] > [CH_3COOH] = [CH_3COO^-] > [H_3O^+] > [OH^-]$			

(ii)	$n(\text{NaOH}) = 0.460\ \text{mol L}^{-1} \times 0.010\ \text{L} = 0.0046\ \text{mol}$ $n(\text{CH}_3\text{COOH})_{\text{initial}} = 0.350\ \text{mol L}^{-1} \times 0.045\ \text{L} = 0.01575\ \text{mol}$ $n(\text{CH}_3\text{COO}^-)_{\text{initial}} = 0.350\ \text{mol L}^{-1} \times 0.045\ \text{L} = 0.01575\ \text{mol}$ $n(\text{CH}_3\text{COOH})_{\text{final}} = n(\text{CH}_3\text{COOH})_{\text{initial}} - n(\text{NaOH})$ $= 0.01575\ \text{mol} - 0.0046\ \text{mol} = 0.01115\ \text{mol}$ $n(\text{CH}_3\text{COO}^-)_{\text{final}} = n(\text{CH}_3\text{COO}^-)_{\text{initial}} + n(\text{NaOH})$ $= 0.01575\ \text{mol} + 0.0046\ \text{mol} = 0.02035\ \text{mol}$ $\text{pH} = \text{p}K_\text{a} + \log \dfrac{n(\text{CH}_3\text{COO}^-)}{n(\text{CH}_3\text{COOH})}$ $= 4.76 + \log \dfrac{0.02035\ \text{mol}}{0.01115\ \text{mol}}$ **= 5.02 (3 s.f)** **Or** $10^{-pK_\text{a}} = \dfrac{\left[\text{H}_3\text{O}^+\right]\left[\text{CH}_3\text{COO}^-\right]}{\left[\text{CH}_3\text{COOH}\right]}$ $10^{-4.76} = \dfrac{\left[\text{H}_3\text{O}^+\right](0.02035\ \text{mol})}{(0.01115\ \text{mol})}$ $\left[\text{H}_3\text{O}^+\right] = 9.86 \times 10^{-6}$ $\text{pH} = 5.02$			

(c)(i)	**Solution A** • Following the procedure, the anions present in the solution were carbonate, CO_3^{2-} ions. • Addition of Ag^+ ions resulted in the formation of a Ag_2CO_3 precipitate, the white solid in the test tube. $2Ag^+(aq) + CO_3^{2-}(aq) \rightleftharpoons Ag_2CO_3(s)$ • Addition of dilute nitric acid, the H^+ ions in the acid reacted with the CO_3^{2-} ions in the solution, forming CO_2 gas and water. $2H^+(aq) + CO_3^{2-}(aq) \rightarrow CO_2(g) + H_2O(l)$ • The removal of CO_3^{2-} ions from the solution caused the Ag_2CO_3 equilibrium to favour the reverse reaction, producing more CO_3^{2-} ions in solution, and causing the Ag_2CO_3 precipitate to dissolve. $Ag_2CO_3(s) \rightarrow 2Ag^+(aq) + CO_3^{2-}(aq)$ **Solution B** • Following the procedure, the anions present in the solution were chloride, Cl^- ions. • Addition of Ag^+ ions resulted in the formation of a AgCl precipitate, the white solid in the test tube. $Ag^+(aq) + Cl^-(aq) \rightleftharpoons AgCl(s)$ • Addition of excess dilute ammonia to the new sample containing the AgCl precipitate, the NH_3 molecules in the solution combined with the Ag^+ ions in the solution, forming $[Ag(NH_3)_2]^+$ complex ions. $Ag^+(aq) + 2NH_3(aq) \rightleftharpoons [Ag(NH_3)_2]^+(aq)$ • The removal of Ag^+ ions from the solution caused the AgCl equilibrium to favour the reverse reaction, producing more Ag^+ ions in solution, and causing the AgCl precipitate to dissolve. $AgCl(s) \rightarrow Ag^+(aq) + Cl^-(aq)$			

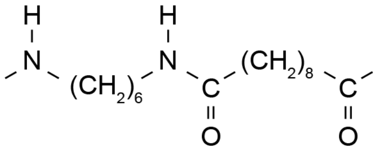
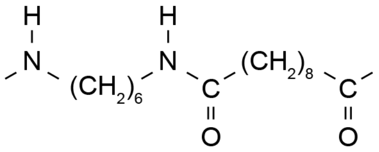
(ii)	$c(\text{X}^{2+})_{\text{dropper}} = 0.100 \text{ mol L}^{-1} \times \frac{30 \text{ mL}}{150 \text{ mL}}$ $= 0.0200 \text{ mol L}^{-1}$ $c(\text{X}^{2+})_{\text{test tube}} = 0.0200 \text{ mol L}^{-1} \times \frac{2 \text{ mL}}{7 \text{ mL}}$ $= 0.005714 \text{ mol L}^{-1}$ $c(\text{OH}^{-})_{\text{test tube}} = 0.0875 \text{ mol L}^{-1} \times \frac{5 \text{ mL}}{7 \text{ mL}}$ $= 0.0625 \text{ mol L}^{-1}$ $Q(\text{X(OH)}_2) = [\text{X}^{2+}][\text{OH}^{-}]^2$ $= 0.005714 \text{ mol L}^{-1} \times (0.0625 \text{ mol L}^{-1})^2$ $= \mathbf{2.232 \times 10^{-5}}$ $Q(\text{X(OH)}_2) > K_s(\text{Mg(OH)}_2)$ Therefore, it cannot be Mg^{2+}, as if it was, then a precipitate would have formed in the test tube. The cation must be Ba^{2+}, but the solution was too dilute for $\text{Q} > K_s$ and form a precipitate. $\text{Q}(\text{X(OH)}_2) < K_s(\text{Ba(OH)}_2)$			

Q	Evidence	Scholarship Not Awarded	Scholarship	Outstanding Scholarship
THREE (a)	Possible oxidations: $Cl^- \rightarrow Cl_2$, $H_2O \rightarrow O_2$. Of these, the oxidation of water is the most likely to occur (least positive E°), however the question indicated that at high salt concentrations, Cl_2 will be produced instead. This will occur at the anode, and a pale green gas (or formation of a pale green solution) will be observed. $2Cl^- \rightarrow Cl_2 + 2e^-$ Possible reductions: $Na^+ \rightarrow Na$, $H_2O \rightarrow H_2$. Of these, the reduction of water has the most positive E_o, and therefore water will be reduced to hydrogen gas at the cathode. This will occur at the cathode, and a colourless gas will be observed. $2H_2O + 2e^- \rightarrow 2OH^- + H_2$ or $2H^+ + 2e^- \rightarrow H_2$ The overall reaction will be: $2H_2O + 2Cl^- \rightarrow Cl_2 + 2OH^- + H_2$ The solution will become increasingly more alkaline as the process progresses. The cell potential to produce chlorine at the anode, and hydrogen at the cathode is: $E_{cell} = E°_{reduction} - E°_{oxidation}$ $= -0.83\text{ V} - +1.36\text{ V}$ $= -2.19\text{ V}$ The modification required is to exchange the 1.50 V AA battery with a power source that produces a voltage greater than 2.19 V.	Any of the following: • Calculates the cell potential for electrolysis. • Explains observations at anode, cathode, or in the solution during electrolysis. • Writes balanced redox half and full equations for the electrolysis process. • Calculates sodium thiosulfate concentration with minor error. • Calculates sodium hypochlorite concentration with errors. • Acid hydrolysis discussed. • Base hydrolysis discussed. • Monomer for one nylon identified. • One correct structure of one product.	A range of the following: • Discusses the changes occurring in the electrolysis of salt water, with links to a range of observations, balanced equations, cell potential calculations, and modifications to the demonstration. • Calculates the concentration of sodium thiosulfate and sodium hypochlorite with minor error. • Discusses acidic and basic hydrolysis of nylon-6,10, with correct product structures, or accounts for the correct monomers needed to make nylon-6,6 and nylon-6.	A range of the following: • Justifies the required change in energy source for electrolysis to occur, with support of a cell potential calculation, and fully discusses the changes occurring at the anode, cathode, and to the solution, during the electrolytic process, with support of balanced equations. • Correctly calculates the concentration of sodium thiosulfate, and the concentration of sodium hypochlorite in the pool chlorine in $g\ L^{-1}$. • Discusses the hydrolysis of nylon-6,10 under acidic and basic conditions, and the formation of nylon-6,6 and nylon-6, all with support of structural equations.

(b)	**Standardisation of $Na_2S_2O_3$** $n(IO_3^-) = \frac{0.533\text{ g}}{214\text{ g mol}^{-1}}$ $= 0.002490\text{ mol}$ $c(IO_3^-) = \frac{0.002490\text{ mol}}{0.100\text{ L}}$ $= 0.02490\text{ mol L}^{-1}$ $n(IO_3^-)_{\text{aliquot}} = 0.02490\text{ mol L}^{-1} \times 0.010\text{ L}$ $= 0.0002490\text{ mol}$ $n(S_2O_3^-) = 0.0002490\text{ mol} \times 6$ $= 0.001494\text{ mol}$ $c(S_2O_3^-) = \frac{0.001494\text{ mol}}{0.01645\text{ L}}$ $= 0.09084\text{ mol L}^{-1}$ (4 s.f.) **Pool chlorine analysis** $n(S_2O_3^-) = 0.09084\text{ mol L}^{-1} \times 0.01810\text{ L}$ $= 0.001644\text{ mol}$ $n(OCl^-) = \frac{0.001644\text{ mol}}{2}$ $= 0.000822\text{ mol}$ $c(OCl^-) = \frac{0.000822\text{ mol}}{0.0250\text{ L}}$ $= 0.03288\text{ mol L}^{-1}$ (4 s.f.) $c(OCl^-) = 0.03288\text{ mol L}^{-1} \times \frac{250\text{ mL}}{5\text{ mL}}$ $= 1.644\text{ mol L}^{-1}$ $c(OCl^-) = 1.644\text{ mol L}^{-1} \times 74.4\text{ g mol}^{-1}$ $= 122.3\text{ g L}^{-1}$ (4 s.f.)			

(c)(i)

Nylon-6,10 can be chemically degraded by exposure to acids and bases. These catalyse hydrolysis, resulting in the amide functional groups reacting with water, and producing chains terminating in amine and carboxylic acid functional groups (or salts, depending on the pH).

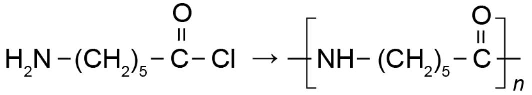
Reactants	**Conditions**	**Products**
	H_2O / H^+	$^+H_3N(CH_2)_6NH_3^+$ $HOOC(CH_2)_8COOH$
	H_2O / OH^-	$H_2N(CH_2)_6NH_2$ $^-OOC(CH_2)_8COOH^-$

(ii)

Condensation polymerisation requires monomers with two functional groups that can react to form the repeating links needed for polymer formation.

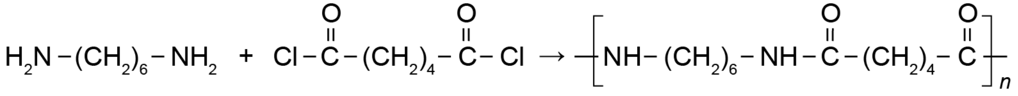
Compound **U** has alcohol groups and Compound **X** has amide groups already formed, so neither would be suitable.

Compound **W** could be used as it contains two functional groups that can react with each other, and this would result in Nylon 6.

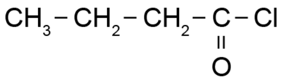
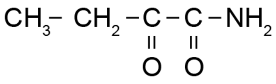


$$H_2N-(CH_2)_5-\overset{\overset{O}{\|}}{C}-Cl \rightarrow -\!\!\left[NH-(CH_2)_5-\overset{\overset{O}{\|}}{C}\right]_n\!\!-$$

Compounds **Y** and **Z** OR compounds **V** and **Z** could be used to synthesise nylon-6,6.



$$H_2N-(CH_2)_6-NH_2 + Cl-\overset{\overset{O}{\|}}{C}-(CH_2)_4-\overset{\overset{O}{\|}}{C}-Cl \rightarrow -\!\!\left[NH-(CH_2)_6-NH-\overset{\overset{O}{\|}}{C}-(CH_2)_4-\overset{\overset{O}{\|}}{C}\right]_n\!\!-$$

Q	Evidence	Scholarship Not Awarded	Scholarship	Outstanding Scholarship
FOUR (a)(i)	Errors in the scheme which the candidates may discuss include: • In the scheme for **B**, NaOH(*alc*) will facilitate elimination over substitution, and the reagent should be NaOH(*aq*). • In the scheme for **B**, HCl(*alc*) is not a reagent, and it should be HCl. • In the scheme for **B**, NH_3(*conc*) cannot undergo substitution with the –OH functional group, so **B** would not form. • In the scheme for **D**, H^+ / MnO_4^- would oxidise both the primary and secondary alcohol groups into aldehyde / ketone groups. • In the scheme for **D**, the PCl_5 will substitute both the alcohol –OH group, and the carboxylic acid–OH group, forming haloalkane and acyl chloride functional groups. • In the scheme for **D**, the NH_3(*conc*) will not substitute the –OH group of the carboxylic acid without heat and removal of water. • The major and minor products given in the scheme to **B** are labelled incorrectly. *Alternative steps proposed can vary, but should be logical and use appropriate reagents to yield the correct products **A**–**D**.*	Any of the following: • Identifies an error in the reaction scheme. • Proposes an alternative reagent or step for the reaction scheme. • Correctly identifies one of the final products if the scheme was followed. • Calculates enthalpy change for reaction with minor error. • Calculates energy release for reaction with multiple errors. • Explains state of one substance at room temperature. • Identifies PCl_3 is the only liquid at room temperature.	A range of the following: • Discusses a range of errors from the reaction scheme, and suitable alternative steps, or has determined the correct structures for the products if the synthesis scheme was followed. • Calculates the energy released when black powder is reacted with minor error. • Justifies the state of two of the four substances at room temperature, with links to particles and attractive forces present.	A range of the following: • Comprehensively discusses a range of errors from the synthesis scheme, with appropriate suitable alternative reagents or steps outlined, and has identified the correct structures for the final compounds. • Correctly calculates the energy released when the black powder is reacted. • Justifies the state of all four substances at room temperature, with clear links to particles and attractive forces present in each.
(ii)	**A**  $CH_3-CH_2-CH_2-\underset{\underset{\displaystyle O}{\|}}{C}-Cl$ **B** $CH_3-CH_2-CH=CH_2$ **or** $CH_3-CH=CH-CH_3$ **D**  $CH_3-CH_2-\underset{\underset{\displaystyle O}{\|}}{C}-\underset{\underset{\displaystyle O}{\|}}{C}-NH_2$ Compound **C** would not be formed.			

(b)	Required equation: $10KNO_3(s) + 8C(s) + 3S(s) \rightarrow 2K_2CO_3(s) + 3K_2SO_4(s) + 6CO_2(g) + 5N_2(g)$ Using the equations given: $K(s) + 1\frac{1}{2}N_2(g) + 1\frac{1}{2}O_2(g) \rightarrow KNO_3(s)$ (Reverse, ×10) $2K(s) + C(s) + 1\frac{1}{2}O_2(g) \rightarrow K_2CO_3(s)$ (×2) $S(s) + O_2(g) \rightarrow SO_2(g)$ (×3) $SO_2(g) + \frac{1}{2}O_2(g) \rightarrow SO_3(g)$ (×3) $SO_3(g) + K_2O(s) \rightarrow K_2SO_4(s)$ (×3) $C(s) + O_2(g) \rightarrow CO_2(g)$ (×6) $2K(s) + \frac{1}{2}O_2(g) \rightarrow K_2O(s)$ (×3) Energy change: $(-493.0 \times 10 \times -1) + (-1146 \times 2) + (-296.8 \times 3) + (-98.9 \times 3) + (-635.0 \times 3)$ $+ (-393.0 \times 6) + (-361.0 \times 3) =$ **-3896.0 kJ mol^{-1}** $n(KNO_3) = \frac{200.0\text{ g}}{101.1\text{ g mol}^{-1}} = 1.978\text{ mol}$ energy released $= -3896.0\text{ kJ mol}^{-1} \times \frac{1}{10} \times 1.978\text{ mol} =$ **-770.6 kJ**			

(c)	**Silicon dioxide, SiO_2 – Solid** • Silicon dioxide is a covalent network solid. • The silicon and oxygen atoms in the SiO_2 lattice are joined by a strong network of covalent bonds. These covalent bonds require high amounts of energy to be overcome; therefore SiO_2 has a very high melting point, and is a solid at room temperature. **Ethanamide, CH_3CONH_2 – Solid** • Ethanamide is a molecular substance. Amides are known for being solids at room temperature, including low-mass amides. • The ethanamide molecules are polar, and have atoms that can engage in hydrogen bonding with nearby molecules. The molecules are therefore held together in a lattice structure by temporary dipole forces, permanent dipole forces, and strong hydrogen bonds. Whilst a molecular solid, with weak intermolecular forces between the molecules, these forces overall still require more energy to be overcome than is available at room temperature, so ethanamide is a solid at room temperature. **Methylammonium chloride, CH_3NH_3Cl – Solid** • Methylammonium chloride is an ionic solid. It is the ionic salt formed in the reaction between methanamine and hydrogen chloride (hydrochloric acid). • The methylammonium cations and chloride anions are held together in an ionic lattice, with strong ionic bonds between the oppositely charged ions. Ionic bonds are strong and require high amounts of energy to be overcome; therefore the salt has a high melting point, and is a solid at room temperature. **Phosphorus trichloride, PCl_3 – Liquid** • Phosphorus trichloride is a molecular substance. • The phosphorus trichloride molecules are polar but cannot form hydrogen bonds with nearby molecules. The molecules are therefore held together by only temporary dipole forces and permanent dipole forces. There is enough energy in the environment at room temperature to overcome these intermolecular attractive forces, causing the substance to be a liquid at room temperature.			

Cut Scores

Scholarship	Outstanding Scholarship
17–24	25–32