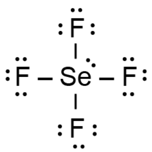
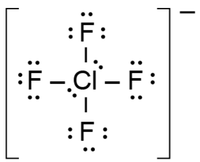
Assessment Schedule – 2021

Chemistry: Demonstrate understanding of thermochemical principles and the properties of particles and substances (91390)

Evidence Statement

Q	Evidence	Achievement	Merit	Excellence
ONE (a)	Sc: $[Ar]3d^1 4s^2$ Ga: $[Ar]\ 3d^{10} 4s^2 4p^1$ Fe^{3+}: $[Ar]\ 3d^5$	• TWO electron configurations correct.		
(b)(i)	SeF_4:  seesaw ClF_4^-:  square planar	• TWO correct.	• ALL correct.	
(ii)	Fusion (melting) requires only **some intermolecular forces** to be broken, whereas vaporisation requires **all intermolecular forces** to be overcome, so more heat energy is required.	• Recognises fusion and vaporisation require bonds to be broken.	• Full explanation.	

(c)(i)	The ordered K^+ ions and NO_3^- ions in the solid lattice form disordered K^+ ions and NO_3^- **ions in solution**. As a result, there is a greater dispersal of matter and energy in the system / **more disorder**, **so the entropy of the system increases** (positive entropy change) Since the reaction is endothermic, **heat energy is absorbed** from the surroundings. As a result, there is **a decrease in** the dispersal of matter and **energy / disorder** in the surroundings, **so the entropy of the surroundings decreases** (negative entropy change). Given potassium nitrate readily dissolves in water / reaction is spontaneous, the increase in entropy of the system must be greater than the decrease in entropy of the surroundings, therefore the total entropy change will be positive.	• Recognises that the entropy of the system increases due to the formation of ions / aqueous / liquid / solid to solution. • Recognises that the entropy of the surroundings decreases because the reaction is endothermic.	• Explains entropy change of EITHER the system OR the surroundings. OR Minor error in both parts.	• Justifies the spontaneous nature of the reaction in terms of the entropy changes in the system and surroundings.
(ii)	$q = mc\Delta T$ $= 135 \times 4.18 \times (14.2 - 21.3)$ $= -4007$ J $= -4.007$ kJ $\Delta H = -\frac{q}{n}$ $n = -\frac{-4.007}{34.9}$ $n = 0.115$ mol $m = nM$ $= 0.115 \times 101$ $= 11.6$ g	• ONE step of the calculation correct.	• Correct process with one error.	• Correct mass of potassium nitrate, including unit and significant figures (accept 2 – 4).

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response; no relevant evidence.	1a	2a	3a	4a / e+ m	2m	3m / e + m	E + 2m	2e

Q	Evidence	Achievement	Merit	Excellence
TWO (a)	Calcium and selenium are in the same period. Although the valence electrons are in the same energy level with the same repulsion / shielding from inner shells, the number of protons increases across a period. So, the electrostatic attraction between the positive nucleus and its valence electrons increases, and therefore the atomic radius of Se is smaller than the atomic radius of Ca.	• Recognises that the (electrostatic) attraction between the nucleus and the valence electrons affects the atomic radius.	• Partially explains difference in atomic radii by reference to increasing number of protons / nuclear charge and strength of electrostatic attraction.	• Fully explains difference in atomic radii. AND
(b)	Fluorine is at the top of Group 17. Going up a group, the number of energy levels decreases, as does repulsion / shielding from inner energy levels. Fluorine is the smallest atom with the valence electrons closest to the nucleus. This means there is a strong electrostatic attraction between the positive nucleus of fluorine and any bonding electrons, so it is the most electronegative element in Group 17.	• Recognises distance from nucleus affects attraction for electrons. • Recognises F has the fewest energy levels.	• Partially explains trend in electronegativity up / down a group. Reference should be made to energy levels / shells and at least TWO of: repulsion / shielding, distance, and strength of electrostatic attraction.	Fully justifies why fluorine is the most electronegative element in Group 17.
(c)(i)	$4NH_3(g) \rightarrow 2N_2(g) + 6H_2(g)$ $2 \times + 92 = +184$ $6H_2(g) + 3O_2(g) \rightarrow 6H_2O(g)$ $3 \times -572 = -1716$ $2N_2(g) + 2O_2(g) \rightarrow 4NO(g)$ $2 \times +180 = +360$ $\Delta_r H = (+184) + (-176) + (+360) = -1172\ kJ\ mol^{-1}$ (-1170 3sf)	• Correctly manipulates one equation / enthalpy change. E.g one correct enthalpy.	• Correct process with one error.	• Correct answer with correct unit, sign, and significant figures (2 – 4), PLUS explanation for (ii).
(ii)	The enthalpy change would be more exothermic because heat energy would be released as intermolecular forces form between liquid water molecules.	• Recognises energy is released when bonds are formed / gas changes to liquid.	• Explains that energy is released as intermolecular forces form between water molecules when changing state from a gas to a liquid.	

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No response; no relevant evidence.	1a	2a	3a	4a / e + a	2m	3m / e + m	e + 2m	2e

Q	Evidence	Achievement	Merit	Excellence
THREE (a)(i)	**Butanal:** temporary dipole, permanent dipole **Propanoic acid:** temporary dipole, permanent dipole, hydrogen bonding **Pentanoic acid:** temporary dipole, permanent dipole, hydrogen bonding	• TWO rows correct.		
(ii)	Butanal and propanoic acid both have electron clouds of a similar size (similar molar mass), and therefore the temporary dipole attractions between the molecules are of similar strength. Both propanoic acid and butanal have permanent dipole attractions between their molecules due to the C=O dipole. However, propanoic acid also has hydrogen bonding between its molecules due to the strong O – H dipole, caused by the large difference in electronegativity between O and H. As a result, more heat energy is required to overcome the intermolecular forces between propanoic acid, so it has a higher $\Delta_{vap}H°$ than butanal. Like propanoic acid, pentanoic acid has hydrogen bonding between its molecules. However, pentanoic acid has a larger electron cloud. As a result, there are stronger temporary dipole attractions between pentanoic acid molecules, and therefore more heat energy is required to overcome its intermolecular forces.	• Recognises hydrogen bonding is stronger than permanent / temporary dipole attractions. • Recognises pentanoic acid has stronger (temporary dipole) attractions / greater molar mass / more electrons than other molecules.	• Explains differences in enthalpy of vaporisation for TWO molecules in terms of strength of attractive forces. OR Propanoic acid has a higher $\Delta_{vap}H°$ than Butanal due to H bonding and Pentanoic acid has a higher $\Delta_{vap}H°$ Propanoic acid due to greater TD's / greater molar mass / larger molecule.	• Fully justifies differences in enthalpy of vaporisation for ALL three molecules in terms of strength of attractive forces and relative sizes of electron clouds / molar mass / size.
(b)(i)	$6C(s) + 6H_2(g) + 3O_2(g) \rightarrow C_6H_{12}O_6(s)$	• Correct equation, including state symbols.		
(ii)	$-2803 = [(6 \times -394) + (6 \times -286)] - \Delta_fH°(C_6H_{12}O_6)$ $-2803 = [(-2364) + (-1716)] - \Delta_fH°(C_6H_{12}O_6)$ $\Delta_fH°(C_6H_{12}O_6) = -1277$ kJ mol^{-1} (1280 3sf)	• Correct process with one error or omission.	• Correct answer, including unit and significant figures (accept 2 – 4).	
(c)	F and Cl are each more electronegative than S, so the S – F and S – Cl bonds are polar covalent. $SClF_5$ has six areas of electron density (six electron clouds) around the central S atom, all of which are bond pairs. Repulsion between these six areas of electron density results in the octahedral shape to maximise separation and therefore minimise repulsion. Although the dipoles are symmetrically arranged, the S – F dipoles have a differing strength from the S – Cl dipole. As a result, the dipoles do not cancel out, and therefore $SClF_5$ is a polar molecule. (Opposite S–F dipoles cancel, but the S–F and the opposite S–Cl dipoles do not cancel. Thus, the $SClF_5$ molecule has a dipole.)	• Recognises influence of either electronegativity difference or shape on polarity. OR Correct shape and recognises polar bonds are present.	• Fully explains polarity OR Fully explains shape. OR Minor errors in both parts.	• Fully explains the shape and polarity of $SClF_5$.

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response; no relevant evidence.	1a	2a	3a	4a / e + a	2m	3m / e + m	e + 2m	2e

Cut Scores

Not Achieved	Achievement	Achievement with Merit	Achievement with Excellence
0 – 7	8 – 13	14 – 19	20 – 24