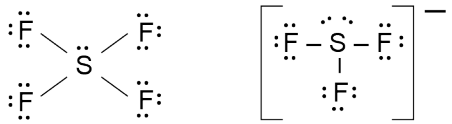
Assessment Schedule – 2019

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

Evidence Statement

Q	Evidence	Achievement	Merit	Excellence
ONE (a)	Cr: **$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^5$** **or [Ar] $4s^1 3d^5$** Fe^{3+}: **$1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$** **or [Ar] $3d^5$** Ge: **$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^2$** **or [Ar]$3d^{10} 4s^2 4p^2$**	Two correct.		
(b)	 see-saw T-shaped	Any two correct.	Table correct.	
(c)(i)	Sulfur and the sulfur ion have the same number of proton/nuclear charge but when the sulfur atom gains two electrons to form the sulfur ion, there is increased electron-electron repulsion in the valence energy level. As a result, the electrons move further apart, and therefore the S^{2-} ion has a larger radius than the S atom.	Recognises the atom gains electrons to form ion / repulsion increases	Full explanation.	
(ii)	Electronegativity increases across a period, i.e. from Na to S. Both Na and S have the same number of energy levels and therefore the same shielding/electron-electron repulsion from inner levels. S has more protons/greater nuclear charge and therefore a greater attraction for valence/bonding electrons therefore greater electronegativity than Na. Electronegativity decreases down a group. Sulfur has one more energy level and therefore increased shielding/electron-electron repulsion. Even though S has greater nuclear charge/more protons than O, because the valence electrons are further from the nucleus, electronegativity is lower.	States that electronegativity increases across a period OR up a group. OR One correct statement relating to electronegativity.	Explains difference in electronegativity EITHER across a period OR up / down a group OR Partial explanation for both with some linking of ideas.	Fully accounts for difference in electronegativity for ALL three elements.
(d)	ClF_5 has six electron clouds about the central atom, including five bond pairs and one lone pair. The electron clouds repel as far apart as possible; this produces the square pyramidal shape. There is an electronegativity difference between Cl and F, so the Cl–F bonds are polar covalent. The square pyramidal shape arranges these dipoles asymmetrically due to the lone pair on the central atom. The dipoles do not cancel so ClF_5 is a polar molecule.	Names shape / 6 regions, 5 bonding, 1 not. OR Recognises influence of electronegativity difference.	Explains shape OR polarity. OR Explains shape and polarity with a minor omission in each part.	Fully explains shape and polarity of ClF_5.

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response; no relevant evidence.	1a	2a	3a	5a	3m	4m	e2m	2e

Q	Evidence	Achievement	Merit	Excellence
TWO (a)	Endothermic since energy is required to break the intermolecular forces between the molecules in the liquid state.	Correct answer with some reasoning.	Full explanation.	
(b)	Find $6C(s) + 7H_2(g) \rightarrow C_6H_{14}(\ell)$ $6C(s) + 6O_2(g) \rightarrow 6CO_2(g)$ $= 6 \times -394$ kJ mol^{-1} $= -2364$ kJ mol^{-1} $H_2(g) + ½\ O_2(g) \rightarrow H_2O(g)$ $= 7 \times -286$ kJ mol^{-1} $= -2002$ kJ mol^{-1} $6CO_2(g) + 7H_2O(\ell) \rightarrow C_6H_{14}(\ell) + 9½\ O_2(g)$ = (reverse) $= +4163$ kJ mol^{-1} $\Delta_f H°\ (C_6H_{14}) = -2364 + -2002 + 4163 = -203$ kJ mol^{-1}	Recognises need to multiply values.	Valid method with one minor error.	Valid method and answer with negative sign and unit. Answer to 3 s.f.
(c)(i)	$q = mc\Delta T$ $= 400 \times 4.18 \times (36.7 - 20.5)$ $= 27086$ J $= 27.086$ kJ $n(C_6H_{14}) = \frac{5.22}{86.0} = 0.0607$ mol $\Delta_r H = -\frac{q}{n}$ $= -\frac{27.086}{0.0607}$ $= -446$ kJ mol^{-1}	Up to TWO of: • correct q calculation • correct mol calculation • correct $\Delta_r H$ calculation.	Correct process to determine $\Delta_c H$, but one error.	Correct answer, with units and 3 s.f.
(ii)	Less negative as a result of heat loss to the surroundings / some incomplete combustion occurring / apparatus absorbing heat / not done in standard conditions resulting in less energy being transferred to the water.	Identifies ONE reason.	Explains a difference	

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No response; no relevant evidence.	1a	2a	3a	5a	3m	4m	1e + 2m	2e

Q	Evidence	Achievement	Merit	Excellence
THREE (a)	NH_3 Hydrogen bonding, (permanent dipoles), temporary dipoles. C_2H_6 Temporary dipoles / instantaneous dipoles. CH_3NH_2 Hydrogen bonding, permanent dipoles, temporary dipoles..	Two rows correct.		
b(i)(ii)	Methanamine and ethane have electron clouds of similar size / similar molar mass and would therefore have intermolecular temporary dipole attractions of similar strength. However, methanamine also has hydrogen bonding due to the N–H bond. As this is the strongest intermolecular force, it requires a larger amount of heat energy to break. Therefore, methanamine has a higher boiling point than ethane.	Identifies methanamine and presence of hydrogen bonding as the reason for the higher boiling point	Relates presence of temporary dipoles in both molecules and presence of H bonding in methanamine, creating stronger intermolecular forces in methanamine and hence a higher boiling point.	Fully justifies why methanamine has a higher boiling point than ethane and ammonia, including reference to relative sizes and causes of temporary dipoles and H bonding for all molecules related to energy requirements.
(iii)	Both methanamine and ammonia have intermolecular hydrogen bonding due to the N–H bond, which causes strongest type of intermolecular force. However, methanamine has a significantly larger electron cloud / larger molar mass. This means the temporary dipole attractions between methanamine molecules will be stronger, and will therefore require more heat energy to break. So, methanamine has a higher boiling point than ammonia.	Identifies increase in size of electron cloud / molar mass / strength of temporary dipoles as the reason for the higher boiling point of methanamine.	Relates presence of H bonding in both molecules and presence of greater temporary dipoles in methanamine than in ammonia, creating stronger intermolecular forces in methanamine and hence a higher boiling point.	
(c)	$\Delta_r H° = \Sigma\Delta_f H°$ (products) – $\Sigma\Delta_f H°$ (reactants) + 135 – (–74.9 + –45.9) = +256 kJ mol^{-1}	Attempts correct process.	Correct answer with units.	
(d)	The reaction has 9 moles of gaseous reactants and 10 moles of gaseous products. Increasing numbers of gaseous particles increases disorder, so the entropy of the system increases. Since the process is exothermic, heat energy is released into the surroundings increasing the disorder, so the entropy of the surroundings increases. Therefore, the total entropy increases due to an increase in both the entropy of the system and the surroundings, so the reaction is spontaneous.	Recognises increasing disorder / more particles. OR Reaction is exothermic so heat is released.	Entropy changes of the system OR surroundings is explained. OR Partial explanation for both with some linking of ideas.	Entropy changes of the system (reference to states) and surroundings explained and overall entropy change used to justify the spontaneous reaction.

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response; no relevant evidence.	1a	2a	3a	5a	3m	4m	e2m	2e

Cut Scores

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