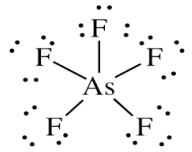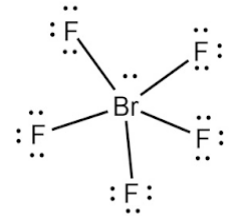## Assessment Schedule – 2018

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

Evidence Statement

Q	Evidence	Achievement	Merit	Excellence
ONE (a)	[Ar] $3d^3\,4s^2$ or $1s^22s^22p^63s^23p^63d^3\,4s^2$ [Ar] $3d^{10}$ or $1s^22s^22p^63s^23p^63d^{10}$ [Ar] $3d^{10}\,4s^2\,4p^6$ or $1s^22s^22p^63s^23p^63d^{10}\,4s^2\,4p^6$	• Two rows correct.		
(b)	The first ionisation energy increases across the second period. There is an increase in the number of protons therefore the nuclear charge / attractive force of the nucleus increases. As the electrons are added to the same energy level across the second period, the electrostatic attraction for the valence electrons increases. This means more energy is required to remove an electron from the valence shell. The atomic radius decreases across the second period. There is an increase in the number of protons therefore the nuclear charge / attractive force of the nucleus increases. Electrons are added to the same energy level as well. This causes the electrostatic attraction between the positive nucleus and the valence electrons to increase across the period pulling the valence electrons closer to the nucleus, so the atomic radius decreases. As the ionisation energy increases, the atomic radius decreases, this is due to the same factor of increased nuclear charge due to more protons in the nucleus going across the period whilst electrons are adding to the same energy level. This decreased radius means more energy is required to remove the valence electron due to stronger attractive forces.	• Identifies both trends correctly. • Recognises one factor influencing trends.	• Explains trend in first ionisation energy across a period. • OR Explains trend in atomic radius across a period.	• Full explanation of trends in first ionisation energy and atomic radius across a period, including relating the two trends to each other.

| (c)(i) | **AsF$_5$:**

trigonal bipyramidal

BrF$_5$:

square-based pyramid | • One correct shape AND one Lewis diagram (does not have to be for same molecule) OR TWO correct Lewis diagrams. | • All correct. | |
| (ii) | There are six electrons clouds about the central atom; four bond pairs and two lone pairs of electrons. The six electron pairs about the central Xe atom are arranged as far apart as possible in an octahedral geometry to minimise repulsion, but due to the two lone pairs, XeF$_4$ has a square planar shape. There is an electronegativity difference between Xe and F, so the Xe-F bonds are polar covalent. This molecule is symmetrical due to the position of the two lone pairs around Xe being above and below the plane, so the effect of the bond dipoles cancel, i.e. there is an even spread of charge. Therefore, XeF$_4$ is a non-polar molecule. | • TWO correct statements. | • Links shape to arrangement of electron pairs about central atom.

OR

Links polarity to shape and electronegativity. | • Fully explains shape and polarity for XeF$_4$. |

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response; no relevant evidence.	1a	2a	3a	4a	2m	3m	1e	2e with minor error or omission.

Q	Evidence	Achievement	Merit	Excellence
TWO (a)(i)	Methanol: hydrogen bonding, permanent dipole attractions, temporary dipole attractions. Propan-1-ol: hydrogen bonding, permanent dipole attractions, temporary dipole attractions. Propanal: permanent dipole attractions, temporary dipole attractions.	• TWO rows correct.		
(ii)	Both methanol and propan-1-ol have temporary dipoles, permanent dipoles, and hydrogen bonding between the molecules. Since propan-1-ol has a larger electron cloud than methanol, it has stronger temporary dipole attractions. As a result, propan-1-ol has a higher enthalpy of vaporisation/ requires more energy to separate the molecules than methanol. Propanal has temporary dipoles and permanent dipoles between the molecules. Permanent dipole attractions are weaker than hydrogen bonding, so propanal has a lower enthalpy of vaporisation/requires less energy to separate the molecules than methanol and propan-1-ol. Even though propanal and propan-1-ol have electron clouds of similar size and would therefore have temporary dipole attractions of similar strength, the hydrogen bonding in propan-1-ol has more influence on the enthalpy of vaporisation of/energy required to separate than the permanent dipole attractions.	• Recognises that the magnitude of the enthalpy of vaporisation is related to the strength of the intermolecular attractions.	• Links the enthalpy of vaporisation to attractive forces for the three molecules	• Fully compares and contrasts the enthalpy of vaporisation of the three molecules.
(b)(i) (ii)	$\Delta_cH° = [(3 \times -394) + (4 \times -286)] - (-255) = -2071$ kJ mol^{-1} The enthalpy change would be less negative / less exothermic. Energy is absorbed/required to break the intermolecular attractions when changing liquid water into gaseous water / less bonds are formed when gaseous water is produced As a result, less heat energy will be released in the reaction.	• Correct process with minor error, e.g. incorrect sign, incorrect unit. • ONE correct statement	• Correct enthalpy change, including unit. • Correctly identifies effect on enthalpy change with full explanation.	
(c)	$2Al(s) + 6HCl (aq) \rightarrow Al_2Cl_6(aq) + 3H_2(g)$ -1003 $3H_2(g) + 3Cl_2(g) \rightarrow 6HCl(g)$ -552 $6HCl(g) \rightarrow 6HCl(aq)$ -434.4 $\underline{Al_2Cl_6(aq) \rightarrow Al_2Cl_6(s) \qquad +643}$ $2Al(s) + 3Cl_2(g) \rightarrow Al_2Cl_6(s)$ -1346.4 kJ mol^{-1} (-1350kJmol^{-1})	• Correct process.	• Correct numerical answer.	• Correct answer with correct unit, sign and significant figures.

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response; no relevant evidence.	1a	2a	3a	4a	3m	4m	2e with minor error or omission	2e

Q	Evidence	Achievement	Merit	Excellence
THREE (a)(i) (ii)	$H_2O(s) \rightarrow H_2O(\ell)$ The enthalpy of vaporisation is larger than the enthalpy of fusion since much more heat energy is required to break all the attractive forces between liquid particles to form a gas. When a solid changes into a liquid, only some of the attractive forces are overcome, so less heat energy is required.	• Correct equation. OR Recognises that attractive forces are broken during state change OR that more energy is required.	• Explains that more attractive forces are broken when a liquid changes to a gas compared to a solid turning into a liquid using a correct equation.	
(b)	$q = mc\Delta T$ $q = 75.6 \times 4.18\ (11.5 - 20.9)$ $q = -2970.5$ J $q = -2.9705$ kJ $n(NH_4Cl) = \dfrac{m}{M}$ $= \dfrac{10.6}{53.5}$ $= 0.1981$ mol $\Delta H = \dfrac{-q}{n}$ $= -\dfrac{-2.9705}{0.198}$ $= +15.0$ kJ mol^{-1}	• ONE step of calculation correct.	• Correct process for calculation with minor error or omission, e.g. incorrect sign, using 65 g mass, answer of 15 000 kJ mol^{-1}.	• Correct $\Delta_rH°$, including unit, sign and significant figures.
(c)	When ammonium chloride dissolves in water, the entropy of the system increases. This is because there are more moles of particles formed / the ions / particles in the solution are more disordered than the solid / greater random movement of products particles / a greater dispersal of matter and energy. Since the process is endothermic, the entropy of the surroundings decreases because heat energy has been transferred from the surroundings so there is decreased random motion of the / decrease in the dispersal of matter and energy. However, since the NH$_4$Cl readily dissolves in water / process occurs spontaneously, the total entropy change is positive / total entropy increases/ increase in entropy of system outweighs decrease of entropy in the surroundings.	• Identifies change in entropy for BOTH the system and the surroundings. • Recognises entropy is a measure of the random motion of particles / dispersal of matter and energy / measure of disorder.	• Explains entropy change for the system. OR Explains entropy change for the surroundings.	• Full justification why NH$_4$Cl dissolves in water in terms of entropy changes of the system AND the surroundings.

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

Cut Scores

Not Achieved	Achievement	Achievement with Merit	Achievement with Excellence
0 – 8	9 – 13	14 – 19	20 – 24