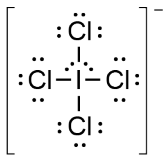
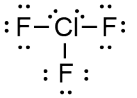
Assessment Schedule – 2016

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

Evidence Statement

Q	Evidence	Achievement	Achievement with Merit	Achievement with Excellence
ONE (a)	Cl: $1s^2 2s^2 2p^6 3s^2 3p^5$ Zn: [Ar] $3d^{10} 4s^2$ Cr^{3+}: [Ar] $3d^3$	• Two correct.		
(b)(i)	The Cl atom gains one electron to complete its valence shell to form the Cl^- ion, the nuclear charge remains the same. The increased inter-electron repulsion in the outer energy level causes the valence electrons to move further from the nucleus, so the Cl^- ion is larger than the Cl atom.	• Cl^- is larger as it gained an electron when formed / more repulsion.	• Full explanation.	
(ii)	**Electronegativity** decreases down a group. Electronegativity is a measure of how strongly an atom attracts bonding electrons. Although the nucleus will become increasingly positive down a group (number of protons increases), the atomic radius increases down a group as more energy levels are added and shielding / repulsion from inner shells increases. Therefore, the bonding electrons in the valence shell will be further from the positive nucleus, resulting in a weaker electrostatic attraction between the nucleus and the bonding electrons. **First ionisation energy** is a measure of how easily the first mole of electrons is removed from one mole of gaseous atoms. It becomes easier to remove an electron down a group / first IE decreases down a group as the valence electrons are further from nucleus with greater repulsion / shielding from inner shells, so there is less electrostatic attraction between protons in the nucleus and valence electron to be removed. For both EN and first IE, the attraction between the positive nucleus and bonding / valence electrons in the outer shell is decreasing down a group, so both EN and first IE decrease down a group.	• Trend in electronegativity and first ionisation energy correctly identified. OR Correct definitions for electronegativity and first ionisation energy. OR Both the definition AND the trend are correct for either electronegativity or first ionisation energy.	• Links trend in electronegativity AND ionisation energy to EITHER the size of atom / shielding OR to the electrostatic attraction between the nucleus and bonding electrons.	• Full explanation, including the relationship between electronegativity and first ionisation energy.

(c)(i)	 ICl_4^-: Square planar  ClF_3: T-shaped	• One correct shape or Lewis diagram.	• One correct Lewis diagram with corresponding shape.	
(ii)	No. There is an electronegativity difference between Se and F, so the Se-F bonds are polar covalent. The six bond pairs around the central Se atom arrange themselves as far apart as possible to minimise repulsion, so SeF_6 has an octahedral shape. Since this is a symmetrical shape, the bond dipoles cancel out, so SeF_6 is a non-polar molecule. Water is a polar solvent. Non-polar molecules like SeF_6 are not attracted to polar molecules like water, i.e. the intermolecular attraction between the water molecules and the SeF_6 molecules is insufficient to overcome the attraction between the water molecules. Therefore, SeF_6 is insoluble in water.	• Recognises SeF_6 is insoluble in water AND states shape or polarity of molecule.	• Links the shape of SeF_6 to the arrangement of electron pairs around the central atom. OR Links the polarity of SeF_6 to its shape.	• Full explanation of shape and polarity of SeF_6 linked to its solubility in water as a polar solvent.

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

Q	Evidence	Achievement	Achievement with Merit	Achievement with Excellence
TWO (a)	NaCl: Ionic bonds. HCl: Permanent dipole-dipole attractions, temporary dipole-dipole attractions. CH_3Cl: Permanent dipole-dipole attractions, temporary dipole-dipole attractions.	• Any two significant forces correct.		
(b)(i)	Much more heat energy is required to overcome the attraction between its particles and convert NaCl from a liquid to a gas than HCl and CH_3Cl, because NaCl has strong ionic bonding between its ions compared to weak intermolecular bonding between the HCl and CH_3Cl molecules.	• Recognises that NaCl has strong ionic bonding so requires more energy	• Links forces of NaCl and the two molecules to the energy required.	• Full explanation for both (i) and (ii) which links to a correct table in (a).
(ii)	Both HCl and CH_3Cl are polar molecules and therefore have permanent dipole-dipole attractions and temporary dipole-dipole attractions between their molecules. However, CH_3Cl has a larger molar mass and therefore more electrons, so its temporary dipole-dipole attractions are stronger than between the HCl molecules. This means more heat energy is required to overcome the attractions between liquid CH_3Cl molecules, so it has a higher $\Delta_{vap}H°$.	• Recognises that CH_3Cl has a larger molar mass / stronger intermolecular attractions (stronger temporary dipole forces).	• Links the larger molar mass of CH_3Cl to its stronger intermolecular attractions.	
(c)(i)	Enthalpy of fusion is the energy required to change 1 mol of a substance (NaCl) from a solid to a liquid.	• Defines enthalpy of fusion.		
(ii)	Fusion of NaCl only requires sufficient heat energy to break / overcome some of the ionic bonds, whereas vaporisation requires much more heat energy to overcome all the ionic bonds, therefore the $\Delta_{vap}H°$ of NaCl is much greater than its $\Delta_{fus}H°$.		• Links the difference in $\Delta_{vap}H°$ and $\Delta_{fus}H°$ to the number of bonds broken.	• Full explanation for both (ii) an (iii). (Both enthalpy and entropy discussed with correct conclusion given in (iii))
(iii)	When solid NaCl dissolves in water, there is an increase in the entropy of the system since the ions in solution have greater entropy than in the solid lattice, i.e. more random / disordered arrangement. Although the ions in solution have more energy / energetically less stable than in the solid lattice (since the process is endothermic), the increase in entropy makes the process spontaneous.	• Identifies entropy of system increases / positive entropy change.	• Links an increase in entropy to an increased random arrangement of particles.	

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 / omission.

Q	Evidence	Achievement	Achievement with Merit	Achievement with Excellence
THREE (a)	$\Delta_c H° = –394 + (2 \times –286) – (–240)$ $\Delta_c H° = –966 + 240$ $\Delta_c H° = –726$ kJ mol$^{–1}$	• Uses a recognised process but errors made in the calculation.	• Correct answer. May have poor rounding / incorrect units / sign / minor error causing incorrect answer.	• Calculation correct with correct units, sign, and an appropriate number of sig. figs.
(b)(i)	$q = mc\Delta T$ $q = 500$ g $\times$ 4.18 J ºC$^{–1}$ g$^{–1}$ $\times$ (34.5ºC – 21.2ºC) $q = 27\,797$ J = 27.797 kJ $n(CH_3OH) = \frac{m}{M} = \frac{2.56}{32} = 0.08$ mol $\Delta_c H = \frac{-q}{n} = \frac{-27.797}{0.08} = –347$ kJ mol$^{–1}$	• Calculates energy correctly. OR Calculates number of moles correctly.	• Correct answer. May have poor rounding / incorrect units / incorrect sign.	• Calculation correct with correct units, sign, and an appropriate number of sig. figs.
(ii)	Heat loss to surroundings / incomplete combustion which means the temperature of the water doesn't increase as much leading to a less negative enthalpy / the experiment wasn't insulated.	• A valid reason is stated.	• Links the reason to why it is a less negative enthalpy.	
(iii)	**Entropy** There is an increase in entropy since gaseous particles are formed; gaseous particles have a more random / disordered arrangement (greater dispersal of matter) than liquid particles. The enthalpy of the surroundings decreases as the alcohol evaporates as energy is absorbed from the surroundings to break the intermolecular forces between methanol molecules; thus the entropy of the surroundings decreases.	• ONE correct statement.	• Explains the entropy changes of the system / surroundings. OR a partial explanation of both.	• Explains the entropy changes of both the system and the surroundings.

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

Cut Scores

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