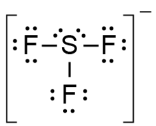
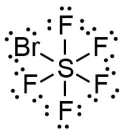
Assessment Schedule – 2025

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)	 T-shaped  Octahedral	• Two correct.	• All correct.	
(b)(i)	Polar. F is more electronegative than S, so the S–F bonds are polar covalent. Due to the seesaw shape, the dipoles are not symmetrically arranged around the S atom. As a result, the dipoles do not cancel out, and therefore SF_4 is a polar molecule.	• Identifies SF_4 as polar and recognises the influence of electronegativity / symmetry on polarity.	• Explains the polarity of SF_4.	• Fully justifies the polarity of SF_4 in terms of electronegativity and arrangement of dipoles. AND
(ii)	SF_4 has five areas of electron density around the central S atom. Repulsion between these areas of electron density maximise separation, and therefore minimise repulsion. Repulsion between five areas of electron density results in the trigonal bipyramidal electron geometry, with 90° and 120° bond angles. In contrast, $SBrF_5$ has six areas of electron density around the central S atom. Repulsion between these results in octahedral electron geometry, with smaller bond angles than the trigonal bipyramidal electron geometry, that is, all bond angles are 90°.	• SF_4 has S–F–S bond angles of 90° and 120°. OR $SBrF_5$ has S–F–S bond angles of 90°. • Recognises that SF_4 and $SBrF_5$ have different numbers of electron density.	• Explains that SF_4 has bond angles of 90° and 120° / trigonal bipyramid (electron) geometry. OR $SBrF_5$ has bond angles of 90° / octahedral electron geometry.	Justifies the difference in bond angle and electron geometry as being due to five and six regions of electron density around the S atom.

(c)	The entropy of the system decreases since three highly randomised, disordered gaseous molecules and one more ordered solid produce only one gas molecule. So, there is less dispersal of matter and energy in the system. Since the reaction is exothermic, this means heat energy is released into the surroundings, so the particles in the surroundings gain heat energy / kinetic energy. As a result, there is greater dispersal of matter and energy in the surroundings, so the entropy of the surroundings increases. Because the reaction is spontaneous, the increase in entropy of the surroundings must outweigh the decrease in entropy of the system, making the overall entropy change positive.	• Recognises entropy increases when there is an increase in disorder / increased dispersal of matter (vice versa). • Recognises that the entropy of the system has decreased and the entropy of the surroundings has increased.	• Explains entropy change for the system. OR • Explains entropy change for surroundings.	• Justifies the spontaneous nature of the reaction in terms of the entropy changes in the system and surroundings.

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

Q	Evidence	Achievement	Achievement with Merit	Achievement with Excellence
TWO (a)(i)	Cl $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$ Cu [Ar] $3d^{10}\ 4s^1$ Fe^{3+} [Ar] $3d^5$	• Two correct.		
(ii)	Both ions have the same nuclear charge. However, the greater number of electrons in the outermost shell of Fe^{2+} results in greater electron-electron repulsion within that valence shell, leading to a larger radius.	• Identifies same nuclear charge or same number of protons. OR There are different numbers of valence electrons in Fe^{3+} and Fe^{2+}.	• There is greater electron-electron repulsion due to more electrons in the valence shell of Fe^{2+}, leading to a larger radius.	
(b)(i)	HBr(ℓ): TD-TD attractions, PD-PD attractions HF(ℓ): TD-TD attractions, PD-PD attractions, hydrogen bonding Br_2(ℓ): TD-TD attractions	• Two rows correct.		
(ii)	HF and HBr have permanent dipole attractions between their molecules, but HF also has strong hydrogen bonding due to large electronegativity difference between H and F, explaining its higher $\Delta_{vap}H$ than HBr (despite HBr having a larger electron cloud).	• Recognises hydrogen bonding is stronger than permanent / temporary dipole attractions.	• Explains differences in enthalpy of vaporisation for HBr and HF molecules, in terms of strength of attractive forces.	• Fully justifies differences in enthalpy of vaporisation for all three molecules, in terms of strength of the attractive forces and relative sizes of electron clouds.
(iii)	The temporary dipole attractions between the molecules are of different strengths because all three molecules have different sized electron clouds. The much larger electron cloud of Br_2 means there are much stronger temporary dipole attractions between Br_2 molecules, outweighing permanent dipole attractions and hydrogen bonding between the smaller HBr and HF molecules.	• Recognises that a larger electron cloud / larger molar mass affects the strength of the attractive forces.	• Br_2 has a higher $\Delta_{vap}H$, due to stronger temporary dipoles, despite permanent dipole attractions and hydrogen bonding between HBr and HF, respectively.	

(c)(i)	(–54.1 × 4) + (–394 × 4) + (20.0 × 5) + (–286 × 12) + (40.7 × 12) = –4636 = –4640 kJ mol^{-1}	• Correctly manipulates one equation / enthalpy change (e.g. one correct enthalpy). OR	• Correct process with one error. OR	• Correct answer with correct unit, sign, and significant figures (2–4).
(ii)	The enthalpy change would be more exothermic / negative 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.	

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

Q	Evidence	Achievement	Achievement with Merit	Achievement with Excellence
THREE (a)(i)	$\frac{1}{2}N_2(g) + 1\frac{1}{2}H_2(g) \rightarrow NH_3(g)$	• Correct enthalpy of formation equation.		
(ii)	$-1172 = ((4 \times 90.3) + (6 \times -286)) - (4 \times x)$ $\Delta_f H°(NH_3(g)) = -45.7\ kJ\ mol^{-1}$	• Correct process with one error or omission.	• Correct answer, including unit and significant figures (accept 2–4).	
(b)(i)	Going up a group, the number of energy levels decreases, as does repulsion / shielding from inner energy levels. Magnesium is the smaller atom with a smaller number of protons, however its valence electrons are closer to the nucleus. This means there is a stronger electrostatic attraction between the positive nucleus of magnesium and its outermost electron to be removed compared to strontium, hence the first IE of magnesium is higher than that of strontium.	• Recognises distance from nucleus affects attraction for electrons. OR Recognises Mg has fewer energy levels than Sr vice-versa.	• Explains trend in first ionisation energy up / down a group. Reference should be made to at least TWO of: energy levels / shells / distance, repulsion / shielding, the number of protons, and strength of electrostatic attraction.	• Explains the trends in first ionisation energy and atomic radii. Reference should be made to ALL of: energy levels / shells / distance, repulsion / shielding, the number of protons, and strength of electrostatic attraction.
(ii)	Although the valence electrons are in the same energy level with the same repulsion / shielding from inner energy levels, the number of protons increases across a period and therefore the valence electrons are pulled closer to the nucleus. So, the electrostatic attraction between the positive nucleus and its valence electrons increases, and therefore the atomic radius decreases across a period.	• Recognises that the nuclear charge affects the atomic radius.	• Explains trend in atomic radii across a period. Reference should be made to at least TWO of: energy levels / shells / distance, repulsion / shielding, the number of protons, and strength of electrostatic attraction.	

(c)	$q = 68.0 \times 4.18 \times (23.2 - 20.4)$ $= 795.9$ J $= 0.7959$ kJ $n = \frac{-q}{\Delta H} = \frac{-0.7959}{-81.3} = 9.79 \times 10^{-3}$ mol $m(CaCl_2) = n \times M$ $= 9.79 \times 10^{-3} \times 111$ $= 1.09$ g	• Calculates heat energy released when $CaCl_2$ dissolves.	• Correct process to determine mass with minor error.	• Calculates mass of $CaCl_2$, including unit and 2–4 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 / omission.	2e

Cut Scores

Not Achieved	**Achievement**	**Achievement with Merit**	**Achievement with Excellence**
0 – 7	8 – 13	14 – 18	19 – 24