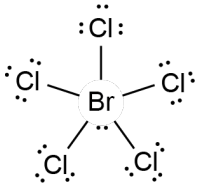
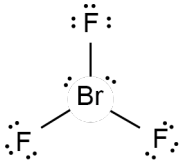
Assessment Schedule – 2022

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

Evidence Statement

Q	Evidence	Achievement	Merit	Excellence
ONE (a)	$BrCl_5$:  Square pyramidal BrF_3:  T-shaped	• One correct Lewis diagram AND shape. OR TWO correct Lewis diagrams. OR TWO correct shapes.	• Table correct.	
(b)	TeF_4 has five areas of electron density around the central atom. Repulsion between these five areas of electron density results in a trigonal bipyramid base shape to maximise separation / as far apart as possible. There are four bond pairs and one lone pair. So the molecular shape is seesaw. F is more electronegative than Te, so the Te–F bonds are polar covalent. Due to the lone pair on the central atom / seesaw shape the dipoles are asymmetrically arranged and therefore do not cancel, so TeF_4 is a polar molecule.	• Recognises influence of number of electron pairs / areas of electron density on shape. • Recognises influence of electronegativity difference on polarity.	• Explains EITHER shape OR polarity of molecule.	• Fully justifies the polarity of TeF_4 in terms of electronegativity, shape, and arrangement of dipoles.

(c)(i)	$n(CH_3OH) = \frac{m}{M} = \frac{2.28}{32.0} = 0.07125$ mol $-q = \Delta H \times n = -68.6 \times 0.07125 = -4.89$ kJ Therefore $q = 4.89$ kJ = 4890 J $q = mc\Delta T$ $\Delta T = \frac{q}{mc} = \frac{4890}{100 \times 4.18}$ $\Delta T = 11.7$ °C Therefore final temperature = 20.6 + 11.7 = 32.3 °C	• ONE step of calculation correct / correct process with two errors.	• Correct process for calculation with one error.	• Correct final temperature, including unit and significant figures (accept 2 – 4 significant figures for final answer).
(ii)	The beaker is not insulated / no lid / heat escaping round the sides therefore less heat is transferred to the water than should be. Some incomplete combustion occurred therefore less heat energy is released than complete combustion. Not done at standard conditions	• Identifies ONE reason.	• Explains one reason.	

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 in one part.	2e

Q	Evidence	Achievement	Merit	Excellence
TWO (a)	Br: [Ar] $3d^{10}4s^24p^5$ V: [Ar] $3d^34s^2$ Ni^{2+}: [Ar] $3d^8$	• TWO electron configurations correct.		
(b)(i)	$NH_3(s) \rightarrow NH_3(l)$	• Correct equation with state symbols.		
(ii)	Between A and B, ammonia molecules (in solid state) gain kinetic energy, so the temperature increases. Due to the increase in kinetic energy, the molecules are vibrating / moving to a greater extent (and the intermolecular forces between them become weaker). Between B and C, the added heat energy is used to break some of the intermolecular attractions between the ammonia molecules when changing state from a solid to a liquid / melting. Since the kinetic energy of the ammonia molecules remains constant, the temperature also remains constant. Between C and D, ammonia molecules (in liquid state) gain kinetic energy, so the temperature increases. Due to the increase in kinetic energy, the ammonia molecules move faster (and further apart.)	• Identifies particles gain kinetic energy / moving faster between A and B / C and D. • Recognises in B-C energy is absorbed to break / weaken intermolecular forces.	• Links change in kinetic energy to particle / molecular movement. • Links why the temperature does not change between B and C to melting	• Fully explains changes in particle movement, kinetic energy, and intermolecular attractions, as ammonia is heated from A to D.

(c)(i)	$\Delta_r H° = [(-1274) + (3 \times -286)] - (+41.0)$ $= -2173$ kJ mol^{-1} (-2170)	• Correct process with one error or omission.	• Correct answer with correct unit and significant figures (2 – 4).	
(ii)	The entropy of the system decreases since four highly randomised, disordered gaseous molecules produce four more ordered solid and liquid molecules. So, there is less dispersal of matter and energy in the system. Since the reaction is exothermic (borane catches fire when it reacts with oxygen), 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.	• Explains entropy change of EITHER the system OR the 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	4m	2e, with minor error / omission in one part.	2e

Q	Evidence	Achievement	Merit	Excellence
THREE (a)	When the Cl atom gains one electron in its valence energy level to become the Cl^- ion, there is increased electron-electron repulsion in the valence energy level while nuclear charge / number of protons remains the same. This causes the valence electrons to move further away from the nucleus, so the Cl^- ion is larger than the Cl atom.	• Recognises the atom gains an electron to form the ion.	• Full explanation.	
(b)	Across a period, the valence electrons / bonding electrons are both found in the same energy level with the same repulsion (shielding) from inner energy levels. The number of protons increases across a period / nuclear charge increases. This means the electrostatic attraction between the positive nucleus and the valence electrons / bonding electrons increases across a period, and therefore • the atomic radius decreases. • more energy is required to remove the outermost valence electrons, so the first ionisation energy increases. • bonding electrons are more strongly attracted to the nucleus, so the electronegativity increases.	• Recognises that the (electrostatic) attraction between the nucleus and the valence / bonding electrons affects an element's ionisation energy / electronegativity / atomic radius.	• Explains at least ONE trend in terms of two of the following: number of energy levels, shielding, number of protons, electrostatic attraction between positive nucleus and valence / bonding electrons.	• Fully justifies the three trends in terms of number of energy levels, repulsion (shielding) from inner energy levels, number of protons, and electrostatic attraction between positive nucleus and valence electrons (IE & radius) and bonding electrons (EN).

(c)(i)	N_2H_4: Hydrogen bonding, permanent dipole, temporary dipole BF_3: Temporary dipole NOCl: Permanent dipole, temporary dipole	• TWO rows correct.		
(ii)	Due to the large electronegativity difference between N and H / N_2H_4 has strong N – H dipoles, so there is strong hydrogen bonding between hydrazine molecules. This is why hydrazine has the highest boiling point because the other two molecules only have weaker permanent and temporary dipole attractions / don't have hydrogen bonds.	• Recognises hydrogen bonding is stronger than other intermolecular attractions. OR Relates boiling point to strength of attractive forces.	• Explains why hydrazine has the highest boiling point by linking the presence of the N–H bond to hydrogen bonding.	• Fully justifies differences in boiling points for ALL three molecules in terms of strength of attractive forces.
(iii)	BF_3 and NOCl have similar size electron clouds, so similar strength temporary dipole attractions. NOCl is a polar molecule, so also has stronger permanent dipole attractions present, so a higher boiling point than BF_3. BF_3 is a non-polar molecule, so has only the weak temporary dipole attractions between molecules and therefore has the lowest boiling point.	• Recognises BF_3 and NOCl have similar strength temporary dipole attractions / similar size electron clouds. OR Recognises NOCl has stronger PD's while BF_3 only has weaker TDs.	• Recognises BF_3 and NOCl have similar strength temporary dipole attractions / similar size electron clouds AND recognises NOCl has stronger PD's while BF_3 only has weaker TDs.	

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 in one part.	2e

Cut Scores

Not Achieved	Achievement	Achievement with Merit	Achievement with Excellence
0 – 8	9 – 14	15 – 18	19 – 24