

## Assessment Schedule – 2020

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

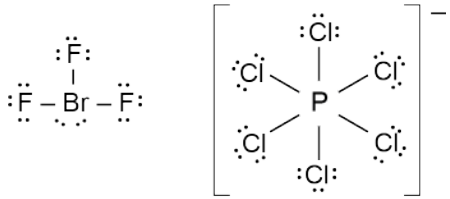
## Evidence Statement

Q1	Evidence	Achievement	Merit	Excellence
(a)(i)	CH <sub>3</sub> Br( <i>l</i> ): Permanent dipole, temporary dipole Br <sub>2</sub> ( <i>l</i> ): Temporary dipole CaBr <sub>2</sub> ( <i>l</i> ): Ionic bonds	<ul style="list-style-type: none"> <li>Two rows correct.</li> </ul>	<ul style="list-style-type: none"> <li>Explains with reference to ions and ionic bonding why calcium bromide has a higher boiling point than both bromomethane and bromine.</li> </ul>	<ul style="list-style-type: none"> <li>Fully justifies differences in boiling points for ALL three compounds in terms of strength of attractive forces. (Must include idea of TD in Br<sub>2</sub> being greater than sum of TD and PD in CH<sub>3</sub>Br and refer to energy/heat required.</li> </ul>
(ii)	Calcium bromide has strong ionic bonding <b>between ions</b> , whereas both CH <sub>3</sub> Br and Br <sub>2</sub> only have weak (intermolecular) attractions between molecules. Therefore, a lot more heat energy is required to overcome the ionic bonds compared to the intermolecular bonds, so calcium bromide has a higher boiling point than both bromomethane and bromine.	<ul style="list-style-type: none"> <li>Recognises ionic bonds are stronger than intermolecular attractions.</li> </ul>	<ul style="list-style-type: none"> <li>Explains with reference to molecules and intermolecular forces why bromine has a higher boiling point than bromomethane.</li> </ul>	
(iii)	Br <sub>2</sub> has a larger molar mass, and therefore a larger electron cloud than CH <sub>3</sub> Br. Since more heat energy is required for Br <sub>2</sub> to reach its boiling point, this means the temporary dipole attractions between Br <sub>2</sub> molecules must be stronger than the sum of the temporary dipole and permanent dipole attractive forces between CH <sub>3</sub> Br molecules.	<p>OR</p> <p>Relates boiling point to strength of attractive forces.</p> <ul style="list-style-type: none"> <li>Identifies Br<sub>2</sub> has stronger temporary dipole attractions / larger molar mass / electron cloud than CH<sub>3</sub>Br.</li> </ul>		
(b)	$-q = \Delta H \times n = -44.5 \times \frac{1.70}{40.0}$ $q = 1.891 \text{ kJ} = 1891 \text{ J} \quad (n = 0.0425 \text{ mol})$ $\Delta T = \frac{q}{mc} = \frac{1891}{36.7 \times 4.18} = 12.3 \text{ }^\circ\text{C}$	<ul style="list-style-type: none"> <li>ONE step of calculation correct / correct process with two errors.</li> </ul>	<ul style="list-style-type: none"> <li>Correct process for calculation one error. (13.4 / 14.2 / 12.9 / 0.0123)</li> </ul>	<ul style="list-style-type: none"> <li>Correct temperature change, including unit and significant figures (accept 2 – 4 significant figures for final answer).</li> </ul>

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response; no relevant evidence.	1a	2a	3a Part b e	4a Part b eaa	2m	3m	em	2e

Q2	Evidence	Achievement	Merit	Excellence
(a)(i)  (ii)	<p><math>\text{SbH}_3(\ell) \rightarrow \text{SbH}_3(\text{g})</math></p> <p>Between A and B, stibine molecules (in liquid state) gain kinetic energy, so the temperature increases. Due to the increase in kinetic energy, the molecules are moving to a greater extent (and the intermolecular forces between them become weaker).</p> <p>Between B and C, the added heat energy is used to break intermolecular attractions between the stibine molecules and therefore separate the stibine molecules from one another in the change of state from a liquid to a gas. Since the kinetic energy of the stibine molecules remains constant, the temperature also remains constant.</p> <p>Between C and D, stibine molecules (in gas state) gain kinetic energy, so the temperature increases. Due to the increase in kinetic energy, the stibine molecules are moving very fast.</p>	<ul style="list-style-type: none"> <li>• Correct equation, including state symbols.</li> <li>• Identifies particles gain kinetic energy / moving faster between A and B / C and D.</li> <li>OR</li> <li>• Energy is absorbed to breakdown intermolecular forces in B–C.</li> </ul>	<ul style="list-style-type: none"> <li>• Links change in kinetic energy to particle movement.</li> <li>OR</li> <li>Explains why the temperature does not change between B and C.</li> </ul>	<p>Fully explains changes in particle movement, kinetic energy, and intermolecular attractions, as stibine is heated from A to D.</p>
(b)(i)  (ii)	<p><math>-1868 = [-720 + (3 \times -286)] - 2\Delta_f H^\circ(\text{SbH}_3)</math></p> <p><math>-1868 = -1578 - 2\Delta_f H^\circ(\text{SbH}_3)</math></p> <p><math>2\Delta_f H^\circ(\text{SbH}_3) = +290</math></p> <p><math>\Delta_f H^\circ(\text{SbH}_3) = +145 \text{ kJ mol}^{-1}</math></p> <p>The enthalpy change would be less negative / less exothermic / <math>\Delta_f H^\circ</math> increase. Energy is absorbed / required to break the intermolecular attractions when changing liquid water into gaseous water. As a result, less heat energy will be released in the reaction.</p> <p>OR Less energy is released when forming gaseous water rather than liquid water because fewer intermolecular attractions are formed.</p>	<ul style="list-style-type: none"> <li>• Correct process with error.</li> <li>• Recognises energy is absorbed to change water from a liquid to a gas.</li> <li>OR</li> <li><math>\Delta_f H^\circ</math> increases / less negative with some explanation.</li> </ul>	<ul style="list-style-type: none"> <li>• Correct answer.</li> <li>• Correctly explains effect on enthalpy change (but does not relate to intermolecular forces).</li> </ul>	<ul style="list-style-type: none"> <li>• Correct calculation, including unit and significant figures (accept 2 – 4 significant figures for final answer), and explanation for (ii).</li> </ul>
(c)	<p>The entropy of the system increases since the ordered solid Ca particles produce disordered hydrogen gas molecules. So, there is a greater dispersal of matter and energy in the system.</p> <p>The reaction is exothermic (as evidenced by the test tube becoming hot). This means heat energy is released into the surroundings, so the air particles gain heat energy / kinetic energy. As a result the entropy of the surroundings increases.</p> <p>Since the entropy of both the system and the surroundings increases, this means the total entropy change will be positive and therefore the reaction will be spontaneous.</p>	<ul style="list-style-type: none"> <li>• Recognises entropy increases when there is: EITHER</li> <li>An increase in disorder / increased dispersal of matter / produces gas.</li> <li>OR</li> <li>Energy / exothermic reaction.</li> </ul>	<ul style="list-style-type: none"> <li>• Explains entropy change of: EITHER</li> <li>The system.</li> <li>OR</li> <li>The surroundings.</li> <li>OR</li> <li>Partial explanation for both with omissions.</li> </ul>	<ul style="list-style-type: none"> <li>• Justifies the spontaneous nature of the reaction in terms of the entropy changes in the system and surroundings.</li> </ul>

<b>NØ</b>	<b>N1</b>	<b>N2</b>	<b>A3</b>	<b>A4</b>	<b>M5</b>	<b>M6</b>	<b>E7</b>	<b>E8</b>
No response	1a	2a	3a/2m	4a	3m/em	4m	2e	3e

Q3	Evidence	Achievement	Merit	Excellence
(a)(i)	Mn: [Ar] 3d <sup>5</sup> 4s <sup>2</sup> As: [Ar] 3d <sup>10</sup> 4s <sup>2</sup> 4p <sup>3</sup> Cu <sup>2+</sup> : [Ar] 3d <sup>9</sup>	<ul style="list-style-type: none"> <li>Two electron configurations correct.</li> </ul>	<ul style="list-style-type: none"> <li>Full explanation.</li> </ul>	
(ii)	<p>The Mg atom and Mg<sup>2+</sup> ion both have the same number of protons. The Mg atom loses its two valence electrons when it forms the Mg<sup>2+</sup> ion. Whereas the Mg atom has three occupied energy levels, the Mg<sup>2+</sup> ion only has two occupied energy levels. As a result, the Mg<sup>2+</sup> ion is smaller.</p>	<ul style="list-style-type: none"> <li>Recognises the atom loses electrons to form ion.</li> </ul>		
(b)(i)	<p>BrF<sub>3</sub>:                      PCl<sub>6</sub><sup>-</sup>:</p>  <p>T-shaped                      octahedral</p>	<ul style="list-style-type: none"> <li>One correct Lewis diagram AND shape.</li> <li>OR</li> <li>TWO correct Lewis diagrams.</li> <li>OR</li> <li>TWO correct shapes.</li> </ul>	<ul style="list-style-type: none"> <li>Table correct.</li> </ul>	
(ii)	<p>For both AsF<sub>3</sub> and AsF<sub>5</sub>, F and As have different electronegativities, so the As – F bonds are polar covalent.</p> <p>However, AsF<sub>3</sub> has four electron clouds / areas of electron density around the central atom, including three bond pairs and one lone pair / non-bonding pair. Repulsion between these four electron clouds results in the trigonal pyramidal shape to maximise separation. Due to the lone pair on the central atom, the dipoles are asymmetrically arranged and therefore do not cancel, so AsF<sub>3</sub> is a polar molecule.</p> <p>In contrast, AsF<sub>5</sub> has five electron clouds / areas of electron density around the central atom, all of which are bond pairs. Repulsion between these five electron clouds results in the trigonal bipyramidal shape to maximise separation. The dipoles are symmetrically arranged and therefore cancel out to make AsF<sub>5</sub> a non-polar molecule.</p>	<ul style="list-style-type: none"> <li>Recognises influence of: EITHER</li> <li>Electronegativity difference on polarity.</li> <li>OR</li> <li>Numbers of electron pairs on shape.</li> </ul>	<ul style="list-style-type: none"> <li>Explains the shape and polarity of ONE molecule.</li> <li>OR</li> <li>Both shape explanations correct.</li> </ul>	<ul style="list-style-type: none"> <li>Compares and contrasts the shape and polarity of AsF<sub>3</sub> and AsF<sub>5</sub>.</li> </ul>

(c)(i)	$\text{As}(g) \rightarrow \text{As}^+(g) + e^-$	<ul style="list-style-type: none"> <li>• Correct equation, including state symbols.</li> <li>• Recognises that the (electrostatic) attraction between the nucleus and the valence electron affects the element's ionisation energy.</li> </ul>	<ul style="list-style-type: none"> <li>• Explains trend in first ionisation energy EITHER across a period OR down a group. OR Partial explanation for both with omissions.</li> </ul>	<ul style="list-style-type: none"> <li>• Fully justifies the difference in first ionisation energy for all three elements.</li> </ul>
((ii)	<p>Nitrogen and arsenic are in the same group. Ionisation energy decreases down a group because the valence electron to be removed is in an energy level further from the nucleus with greater repulsion/shielding from inner energy levels. Although the number of protons increases down a group, this effect is offset by the increasing distance between the nucleus and the valence electron to be removed. So, the electrostatic attraction between the positive nucleus and the valence electrons decreases, and therefore ionisation energy decreases down a group.</p> <p>Potassium and arsenic are in the same period. Ionisation energy increases across a period. Although the valence electron to be removed is in the same energy level with the same repulsion/shielding from inner energy levels, the number of protons increases across a period. So, the electrostatic attraction between the positive nucleus and the valence electrons increases, and therefore ionisation energy increases across a period.</p>			

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

### Cut Scores

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