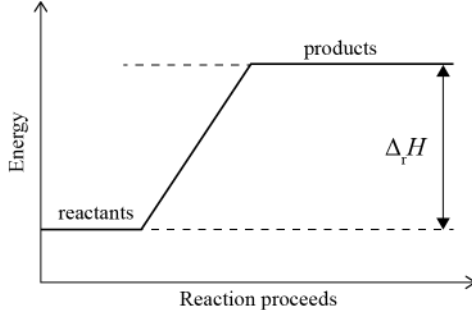


**Assessment Schedule – 2022****Chemistry: Demonstrate understanding of bonding, structure, properties and energy changes (91164)****Evidence**

Q	Evidence				Achievement	Merit	Excellence
ONE (a)	Molecule	NH <sub>3</sub>	CO <sub>2</sub>	N <sub>2</sub>	<ul style="list-style-type: none"> <li>Three Lewis structures.</li> <li>OR</li> <li>Three shapes correct.</li> </ul>		
Lewis diagram	$\begin{array}{c} \text{H}-\ddot{\text{N}}-\text{H} \\   \\ \text{H} \end{array}$	$\ddot{\text{O}}=\text{C}=\ddot{\text{O}}$	:N≡N:				
Name of shape	trigonal pyramid	linear	linear				
(b)	<p>Freon-11 has 4 regions of electron density around the central carbon atom, while sulfur dioxide has 3 regions around the central sulfur atom. In both molecules these regions of electron density repel to maximum separation. This gives freon-11 a tetrahedral parent geometry and bond angles of 109.5°, while sulfur dioxide has a parent geometry of trigonal planar and bond angles of 120°. As all regions in freon-11 are bonding regions the overall shape is tetrahedral, while in sulfur dioxide two of the regions are bonding regions, while one is non-bonding, giving it an overall shape of bent.</p>				<ul style="list-style-type: none"> <li>Identifies the correct number of bonding and non-bonding regions for ONE molecule.</li> <li>Recognises electron density regions arranged in position of max separation / min repulsion.</li> </ul>	<ul style="list-style-type: none"> <li>Links total number of bonding regions to parent geometry and bond angle for ONE molecule using repulsion theory.</li> </ul>	<ul style="list-style-type: none"> <li>Justifies shape of both molecules with reference to all relevant factors.</li> </ul>

<p>(c)(i)</p>		<ul style="list-style-type: none"> <li>• Diagram shows products with more energy than reactants.</li> </ul>	<ul style="list-style-type: none"> <li>• Diagram correct with labels</li> </ul>	
<p>(ii)</p>	<p>In order to evaporate, the attractive forces between freon-11 molecules need to be broken. The breaking of attractive forces is an endothermic process, so energy is absorbed for this to occur. This absorbed energy comes from the heat energy of the surroundings, causing the temperature of the refrigerator to decrease.</p>	<ul style="list-style-type: none"> <li>• Identifies attractive forces need to be broken.</li> </ul> <p>OR</p> <p>Heat energy is absorbed.</p>	<ul style="list-style-type: none"> <li>• Links breaking of attractive forces to absorption of heat energy.</li> </ul>	<ul style="list-style-type: none"> <li>• Fully explains cooling effect of freon-11 evaporation.</li> </ul>

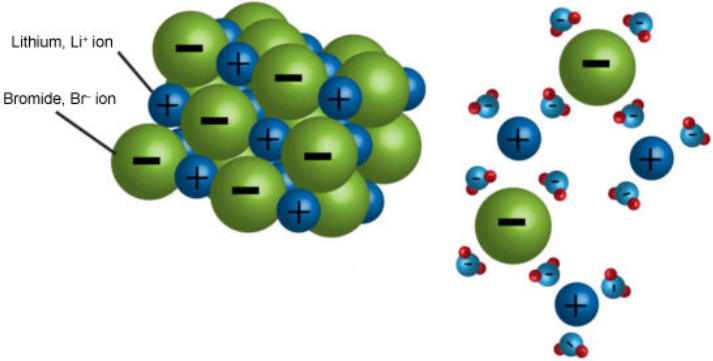
NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response. no relevant evidence.	1a	2a	3a	4a	2m	3m	2e with minor error	2e

Q	Evidence	Achievement	Merit	Excellence
<p>TWO (a)(i)</p> <p>(ii)</p> <p>(iii)</p>	<p>Bonds broken:  <math>4 \times \text{C-Cl} = 4x</math>  <math>1 \times \text{H-F} = 567</math>  <b>Total: <math>567 + 4x \text{ kJ mol}^{-1}</math></b></p> <p>Bonds formed:  <math>3 \times \text{C-Cl} = 3x</math>  <math>1 \times \text{C-F} = 485</math>  <math>1 \times \text{H-Cl} = 431 \text{ kJ mol}^{-1}</math>  <b>Total: <math>916 + 3x \text{ kJ mol}^{-1}</math></b></p> <p><math>\Delta_r H = \Sigma \text{bond energies (bonds broken)} - \Sigma \text{bond energies (bonds formed)}</math>  <math>-21 = 567 + 4x - (916 + 3x)</math>  <math>-21 = -349 + x</math>  <math>x = 328 \text{ kJ mol}^{-1}</math></p> <p><i>Can also be solved using net number of C-Cl bonds.</i></p> <p><math>\text{CCl}_3\text{F}</math> – polar    <math>\text{CCl}_4</math> – non-polar</p> <p>Both freon-11 and carbon tetrachloride have tetrahedral shapes. Both molecules contain polar C-Cl bonds due to the difference in electronegativity between the two atoms, while freon-11 also contains a polar C-F bond. Due to the symmetry of carbon tetrachloride, the dipoles cancel out and the molecule is non-polar. In freon-11, despite the tetrahedral shape, the difference in polarity of the C-Cl and C-F bonds mean the different (sized) bond dipoles cannot cancel out. This means freon-11 is a polar molecule.</p>	<ul style="list-style-type: none"> <li>• Correctly calculates bonds broken or bonds formed OR Correct process with a major error (e.g., rearranging equation, missing a bond type).</li> <li>• Identifies polarity of both molecules.</li> <li>• Identifies a difference in electronegativity between atoms. OR Identifies bond dipole cancellation in one molecule.</li> </ul>	<ul style="list-style-type: none"> <li>• Correct process with a minor error (e.g., counting bonds, incorrect sign).</li> <li>• Links symmetry / asymmetry of dipole arrangement to dipole cancellation in one molecule.</li> </ul>	<ul style="list-style-type: none"> <li>• Correct answer with unit.</li> <li>• Compares and contrasts polarity of both molecules, with reference to electronegativity differences between atoms</li> </ul>
(b)	$n(\text{O}_3) = \frac{m}{M} = \frac{126}{48} = 2.625 \text{ mol}$ $\text{Energy} = \Delta_r H \times n = \frac{285}{2} \times 2.625 = 374 \text{ kJ released}$	<ul style="list-style-type: none"> <li>• One step of process correct.</li> </ul>	<ul style="list-style-type: none"> <li>• Correct answer.</li> </ul>	

(c)(i)	Molecular	<ul style="list-style-type: none"> <li>Identifies molecular.</li> </ul> AND Identifies boiling point is related to strength of attractive forces. OR Identifies intermolecular forces present.	<ul style="list-style-type: none"> <li>Links strength of intermolecular forces to low energy requirement for evaporation</li> </ul>	
(ii)	Compound A is a molecular substance which has weak intermolecular forces existing between molecules. As these forces of attraction are weak, at room temperature there is sufficient heat energy to break them, allowing the substance to evaporate.			

<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. no relevant evidence.	1a	2a	3a	4a	3m	4m	2e with minor error	2e

Q	Evidence				Achievement	Merit	Excellence																
THREE (a)	<table border="1"> <thead> <tr> <th data-bbox="297 229 463 323">Solid</th> <th data-bbox="463 229 620 323">Type of solid</th> <th data-bbox="620 229 828 323">Type of particle</th> <th data-bbox="828 229 1039 323">Attractive forces between particles</th> </tr> </thead> <tbody> <tr> <td data-bbox="297 323 463 387">Freon-11 CCl<sub>3</sub>F(s)</td> <td data-bbox="463 323 620 387">Molecular</td> <td data-bbox="620 323 828 387">Molecules</td> <td data-bbox="828 323 1039 387">Intermolecular forces</td> </tr> <tr> <td data-bbox="297 387 463 451">Diamond C(s)</td> <td data-bbox="463 387 620 451">Covalent network</td> <td data-bbox="620 387 828 451">Atoms</td> <td data-bbox="828 387 1039 451">Covalent bonds</td> </tr> <tr> <td data-bbox="297 451 463 547">Lithium bromide LiBr(s)</td> <td data-bbox="463 451 620 547">Ionic</td> <td data-bbox="620 451 828 547">Ions</td> <td data-bbox="828 451 1039 547">Ionic bonds</td> </tr> </tbody> </table>				Solid	Type of solid	Type of particle	Attractive forces between particles	Freon-11 CCl <sub>3</sub> F(s)	Molecular	Molecules	Intermolecular forces	Diamond C(s)	Covalent network	Atoms	Covalent bonds	Lithium bromide LiBr(s)	Ionic	Ions	Ionic bonds	<ul style="list-style-type: none"> <li>Two rows or two columns correct.</li> </ul>	<ul style="list-style-type: none"> <li>Table correct.</li> </ul>	
Solid	Type of solid	Type of particle	Attractive forces between particles																				
Freon-11 CCl <sub>3</sub> F(s)	Molecular	Molecules	Intermolecular forces																				
Diamond C(s)	Covalent network	Atoms	Covalent bonds																				
Lithium bromide LiBr(s)	Ionic	Ions	Ionic bonds																				
(b)	<p>In order to conduct electricity, a substance must possess charged particles that are free to move.</p> <p>Diamond is made up of a 3D-network of carbon atoms covalently bonded to each other (in a tetrahedral array). Each carbon is bonded to 4 others. This means there are no valence electrons free to move throughout the structure, and diamond does not conduct electricity.</p> <p>Graphite is a 2D-covalent network substance. It consists of layers of carbon atoms, bound in hexagonal rings by strong covalent bonds. Each carbon is bonded to 3 others. This means there are (delocalised) valence electrons free to move throughout the structure, allowing graphite to conduct electricity.</p>				<ul style="list-style-type: none"> <li>Describes structure of diamond. OR Graphite.</li> <li>Identifies mobile free charged particles are required for conductivity.</li> </ul>	<ul style="list-style-type: none"> <li>Links conductivity / non-conductivity to presence / absence of free valence electrons in substance.</li> </ul>	<ul style="list-style-type: none"> <li>Comprehensively explains conductivity of diamond and graphite.</li> </ul>																

<p>(c)(i)</p> <p>(ii)</p> <p>(iii)</p> <p>(iv)</p>	<p>Exothermic. Because the change in enthalpy (<math>\Delta_r H</math>) is negative / heat energy is released / products have less energy than reactants / bonds broken.</p> <p><math>n(\text{LiBr}) = 20/86.8 = 0.230 \text{ mol}</math>  <math>\text{Energy} = n \times \Delta_r H = 0.230 \times 48.8 = 11.2 \text{ kJ}</math>  <math>n(\text{KBr}) = \frac{E}{\Delta_r H} = \frac{11.2}{19.9} = 0.563 \text{ mol}</math>  <math>m(\text{KBr}) = n \times M = 0.563 \times 119 = 67.0 \text{ g}</math></p> <p>The dissolution of LiBr is exothermic so the solution will be warm, while the dissolution of KBr is endothermic so the solution will be cool.</p> <p>Lithium bromide is an ionic compound. When placed in water, the negative pole of water molecules attract the positive lithium (<math>\text{Li}^+</math>) ions, and the positive pole attracts the negative bromide (<math>\text{Br}^-</math>) ions. The strength of this attractive force is sufficiently strong to overcome the ionic bonds within the ionic lattice, allowing the lattice to be broken down, and LiBr to dissolve.</p>  <p>Adapted from: <a href="http://www.saddlespace.org/whittaker/science/cms_page/view/7795247">www.saddlespace.org/whittaker/science/cms_page/view/7795247</a></p>	<ul style="list-style-type: none"> <li>• Correct reaction type with reason.</li> <li>• Correct number of moles of LiBr. OR Correct mass of KBr from incorrect number of moles.</li> <li>• Correctly identifies LiBr solution is warm while KBr is cool</li> <li>• Identifies attractions are required between water and the substance (LiBr) for it to be soluble. OR Diagram shows water dissolving ionic solid with hydrated ions.</li> </ul>	<ul style="list-style-type: none"> <li>• Correct energy change OR Correct mass of KBr from incorrect energy change.</li> <li>• Correctly links <b>endo</b> / <b>exothermic</b> nature of processes to temperature of solutions.</li> <li>• Links relative strength of the attractive forces between water and the ions in LiBr to solubility.</li> </ul>	<ul style="list-style-type: none"> <li>• Correct mass of KBr calculated.</li> <li>• Fully justifies solubility of LiBr with use of diagram to illustrate answer.</li> </ul>
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<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. no relevant evidence.	1a	2a	3a	4a	3m	4m	2e	3e

**Cut Scores**

<b>Not Achieved</b>	<b>Achievement</b>	<b>Achievement with Merit</b>	<b>Achievement with Excellence</b>
0 – 7	8 – 13	14 – 18	19 – 24