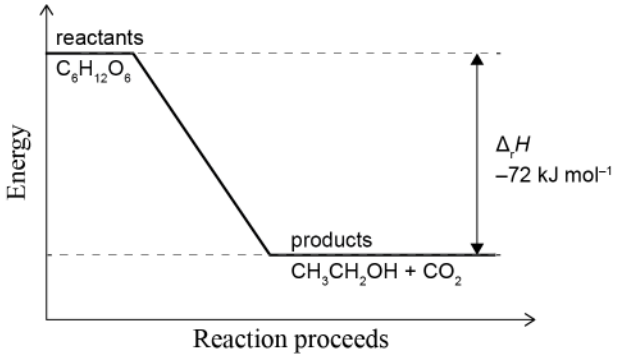
Assessment Schedule – 2023

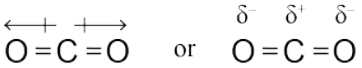
Chemistry: Demonstrate understanding of bonding, structure, properties and energy changes (91164)

Evidence

Q	Evidence	Achievement	Merit	Excellence
ONE (a)(i)	Exothermic – the negative change in enthalpy ($\Delta_r H$) value means that the reaction releases heat energy / enthalpy of products is less than that of reactants.	• Reaction type correct with reason.		
(ii)		• Diagram correct shape with reactants and products labelled.	• Diagram correctly drawn and enthalpy change, reactants, and products labelled.	
(iii)	$n(CH_3CH_2OH) = \frac{161}{46} = 3.5$ mol Energy = $3.5 \times \frac{72}{2} = 126$ kJ (released)	• One step correct.	• Correct answer with unit and -sign or released.	
(b)	Both the carbon and oxygen atoms in ethanol have four total regions of electron density about them. These regions arrange themselves with maximum separation in order to minimise repulsion. This gives each a tetrahedral parent geometry and a bond angle of 109.5°. As the carbon atoms have four bonding regions and zero non-bonding regions, the overall shape about each carbon is tetrahedral, while the two bonding and two non-bonding regions about the oxygen atom give an overall shape of bent.	• Identifies the total number of electron clouds around ONE atom. OR Identifies the number of bonding and non-bonding regions for ONE atom.	• Links repulsion of electron clouds to parent geometry for BOTH atoms. OR Links number of bonding and non-bonding regions to shape for BOTH atoms.	• Fully compares and contrasts the shape and bond angles of BOTH atoms.

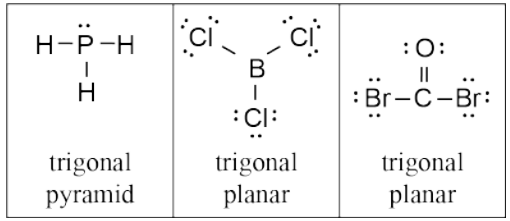
(c)(i)	Positive $\Delta_r H$	• Positive sign.	• Positive sign.	• Full answer.
(ii)	Ethanol is a molecular substance. This means that there are weak intermolecular forces between molecules. These forces only require a small amount of heat energy to be broken, therefore ethanol readily evaporates. As the evaporation is endothermic, this heat energy is absorbed from the student's hand, therefore making their hand feel cool.	AND Ethanol has weak forces of attraction. OR Energy is absorbed.	AND Links weak intermolecular forces to small energy requirement. OR Links absorption of heat energy to making hand feel cool.	

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

Q	Evidence		Achievement	Merit	Excellence
TWO (a)	Bonds broken: 1 × C–C = 348 5 × C–H = 5 × 413 = 2065 1 × C–O = 358 1 × O–H = 463 3 × O=O = 3x Total: 3234 + 3x kJ mol^{-1} $\Delta_r H = \Sigma_{\text{bonds broken}} - \Sigma_{\text{bonds formed}}$ –1370 = 3234 + 3x – 5998 –1370 = –2764 + 3x 1394 = 3x x = 465 kJ mol^{-1}	Bonds formed: 4 × C=O = 4 × 805 = 3220 6 × O–H = 6 × 463 = 2778 Total: 5998 kJ mol^{-1}	• Correctly calculates bonds broken. OR Bonds formed.	• Correct process with minor error	• Correct answer with unit.
(b)(i)	 or		• Draws bond dipoles correctly. **AND**		
(ii)	CO_2 – non-polar H_2O – polar		Identifies polarity of both molecules correctly.		
(iii)	Both molecules contain polar bonds due to the difference in electronegativity between atoms. (O is more electronegative than H) In CO_2, due to the linear shape, the bond dipoles are arranged symmetrically and therefore cancel out, making the molecule non-polar. In H_2O, the bent shape means the bond dipoles are arranged asymmetrically, the dipoles do not cancel, and the molecule is polar.		• Identifies the difference in electronegativity between atoms in the bonds of a molecule. OR Identifies symmetry of molecule responsible for polarity.	• Links symmetry / asymmetry of molecules to dipole cancellation / non-cancellation in ONE molecule.	• Compares and contrasts the polarity of both molecules with reference to electronegativity, bond polarity, and symmetry of dipole arrangement.

(c)(i)	<table><tr><th>Substance</th><th>Type of solid</th><th>Type of particles</th><th>Attractive forces</th></tr><tr><td>CO(s)</td><td>Molecular</td><td>Molecules</td><td>Inter-molecular forces</td></tr><tr><td>Pd(s)</td><td>Metallic</td><td>Metal atoms / Metal cations and delocalised electrons</td><td>Metallic bonds</td></tr></table>	• One row correct.		
(ii)	Palladium is a metallic substance which consists of (a lattice) of metal cations surrounded by a sea of delocalised valence electrons, held together by strong metallic bonds. As the metallic bonds are strong, a lot of heat energy is required to break them, giving palladium a high melting point.	• Describes structure of palladium OR Identifies bonds must be broken to melt substance.	• Links structure and bonding in palladium to the high energy requirement to break bonds and melt substance.	

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

Q	Evidence	Achievement	Merit	Excellence
THREE (a)	 trigonal pyramid | trigonal planar | trigonal planar	• TWO correct Lewis structures with shapes.		
(b)(i)	$n(COBr_2) = \frac{1150}{145/2} = 15.86$ mol $m = 15.86 \times 187.8 = 2980$ g	• ONE step correct from (i) or (ii).	• TWO steps correct from (i) or (ii).	• Correct answer with statement about whether the volume of $COBr_2$ will fit in flask.
(ii)	$\frac{2980}{2.52} = 1182$ mL $= 1.18$ L No this amount will not fit within a 1 L flask. OR Maximum mass in 1 L = $1000 \times 2.52 = 2520$ g. As 2520 g is less than 2980 g, it will not fit within the flask.			
(c)	Carbonic dibromide is a molecular substance which consists of molecules held together by weak intermolecular forces. There are no free moving charged particles, meaning carbonic dibromide is unable to conduct electricity in any state. Lithium bromide is an ionic compound. It consists of a (3D lattice) of alternating lithium and bromide ions, held together by strong ionic bonds. In the solid state, the ions are held firmly in the lattice and cannot move to conduct electricity. When molten, the lattice / ionic bonds are broken, allowing the ions to move, and pass electrical current.	• Identifies mobile charged particles are required for electrical conductivity • Describes structure of lithium bromide or $COBr_2$	• Links structure of ONE compound to presence / absence of mobile charge particles.	• Justifies the conductivity of both substances in both the solid and liquid states.

(d)	In order for a substance to dissolve, the solute and solvent particles need to form sufficiently strong attractive forces to overcome the already existing forces of attraction. As cyclohexane is a non-polar molecule, the attractive forces it forms with the ions in the ionic lattice of lithium fluoride are insufficiently strong to overcome the strong ionic bonds. This means the ionic lattice remains intact, and the lithium fluoride does not dissolve. However, as water is a polar molecule, it has a negative pole, which can attract the positive ions in the lattice, and a positive pole, which can attract the negative ions in the lattice. These attractive forces are strong enough to overcome the ionic bonds present, allowing the substance to dissolve.	• Identifies solubility is governed by the strength of the attractive forces between solute and solvent particles.	• Links strength of attractive forces between solute (named) and solvent (named) particles to the solubility / insolubility of LiBr in ONE solvent.	• Fully explains the solubility of lithium bromide in both cyclohexane and water.

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

Cut Scores

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