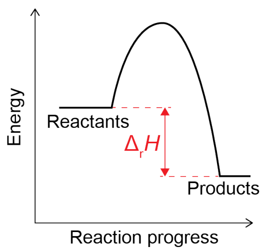
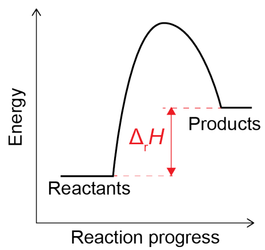
Assessment Schedule – 2021

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

Evidence

<table>
<tr><th>Q</th><th>Evidence</th><th>Achievement</th><th>Merit</th><th>Excellence</th></tr>
<tr><td>ONE (a)</td><td><table><tr><th>Solid</th><th>Type of solid</th><th>Type of particle</th><th>Attractive forces between particles</th></tr><tr><td>Oxygen $O_2(s)$</td><td>Molecular</td><td>Molecules</td><td>Intermolecular forces</td></tr><tr><td>Copper Cu(s)</td><td>Metallic</td><td>Atoms / cations (or metal nuclei) in sea of delocalised electrons</td><td>Metallic bonds</td></tr><tr><td>Graphite C(s)</td><td>Covalent network</td><td>Atoms</td><td>Covalent bonds</td></tr></table></td><td>• Two rows or two columns correct.</td><td>• Table correct.</td><td></td></tr>
<tr><td>(b)</td><td>Copper is a metallic solid made up of atoms in a 3D lattice held together by non-directional metallic bonds or cations in a sea of delocalised electrons held together by (non-directional) metallic bonds. Due to the non-directional nature of the metallic bonds, particles can move past one another / substance can change shape without disrupting the bonding, thus copper can be stretched into wires.
Due to the delocalised valence electrons in the structure, copper contains free-moving, charged particles, which allow it to conduct electricity.</td><td>• Describes structure of copper.
• Identifies non-directional bonds required for ductility.
OR
Free charged particles for conductivity.</td><td>• Links ductility to particles moving without breaking non-directional metallic bonds.
• Links conductivity to presence of delocalised valence electrons.</td><td>• Comprehensively explains conductivity and ductility of copper.</td></tr>
<tr><td>(c)</td><td>Oxygen is a molecular substance. The molecules are held together by weak intermolecular forces. These forces require only a little energy to overcome, turning oxygen into a gas; therefore the boiling point of oxygen is low.
Graphite is a 2D-extended covalent network substance. It consists of layers of carbon atoms, bonded into hexagonal rings by strong covalent bonds. These bonds require a large amount of heat energy to overcome and therefore graphite only turns into a gas (sublimes) at very high temperatures. The difference in the strength of attractive forces between particles in each substance is what leads to the large difference in temperature required to form gaseous substances.</td><td>• Describes structure of oxygen.
OR
Describes structure of graphite.
• Identifies that forces between particles must be broken to vaporise substance.</td><td>• Links strength of forces between particles to the temperature required for vaporisation of ONE substance.</td><td>• Fully links structure and bonding in each substance to the difference in temperature required for vaporisation.</td></tr>
</table>

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

Q	Evidence	Achievement	Merit	Excellence
TWO (a)(i) (ii)	Diagram A. The negative change in enthalpy indicates the reaction is exothermic. This means the reaction releases energy, so the products have less energy than the reactants as shown in diagram A. **Diagram A**  **Diagram B**  (Accept correct label on either diagram.)	• Identifies reaction as exothermic / energy is released. • Δ_rH correctly labelled on either diagram.	• Correctly links energy of products and reactants in an exothermic reaction to correct diagram.	
(b)	$m(C_{12}H_{26}) = 0.75 \times 2560 = 1920$ kg = 1 920 000 g $n(C_{12}H_{26}) = \dfrac{1\,920\,000}{170} = 11\,294$ mol Energy = $\Delta_rH \times n = \dfrac{15\,800}{2} \times 11\,294 = 89\,200\,000$ kJ (8.92×10^7 kJ)	• One step of process correct.	• Process correct with minor error.	• Calculates energy produced with correct units.
(c)	Insoluble in water. Soluble in cyclohexane. Water is a polar solvent, while cyclohexane is a non-polar solvent. As kerosene is non-polar, the attractive forces it forms with water molecules are weaker than the existing force of attraction found between particles within both the solvent and solute. However, as both kerosene and cyclohexane are non-polar molecules, the attractions that form between cyclohexane and kerosene particles are strong enough to overcome the existing attractive forces within each substance, allowing kerosene to dissolve.	• Identifies water as a polar solvent and cyclohexane as non-polar. OR Correctly identifies solubility of kerosene in each solvent.	• Links relative strength of attractive forces between solute and solvent particles to solubility in ONE solvent.	• Fully justifies solubility in both solvents with reference to polarity, relative strength of attractive forces, and need to overcome existing forces.

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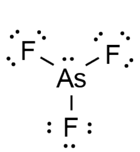
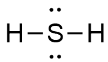
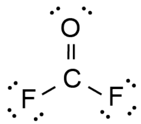
No response; no relevant evidence.	1a	2a	3a	4a	2m	3m	2e (minor error)	2e

Q	Evidence	Achievement	Merit	Excellence
THREE (a)	 Trigonal pyramid  Bent  Trigonal planar	• TWO Lewis structures. OR TWO shapes correct.	• TWO correct Lewis structures linked to correct shapes.	
(b)	N_2O has two regions of electron density around the central (red) N atom, while hydrazine has four regions of electron density around the (red) N atom. These regions arrange with maximum separation to minimise repulsion, giving N_2O a parent geometry of linear and a bond angle of 180°. N_2H_4 has a parent geometry of tetrahedral and a bond angle of 109.5° about each N atom. N_2O has two bonding and zero non-bonding regions so an overall shape of linear, while N_2H_4 has three bonding and one non-bonding regions about each nitrogen atom, giving an overall shape of trigonal pyramid.	• Identifies the correct number of bonding and non-bonding regions for ONE molecule. OR Recognises electron density regions arranged in position of max separation / min repulsion.	• Links total number of bonding regions to parent geometry and bond angle for ONE molecule using repulsion theory.	• Justifies shape and bond angle of both molecules, with reference to all relevant factors.
(c)(i)	Bond breaking: $4 \times$ C–H $= 4x$ $2 \times$ O=O $= 2 \times 495 = 990$ **Total: 990 + 4*x* kJ mol^{-1}** Bond making: $2 \times$ C=O $= 2 \times 805 = 1610$ $4 \times$ O–H $= 4 \times 463 = 1852$ **Total: 3462 kJ mol^{-1}** $\Delta_rH = \sum$bond energies (bonds broken) – $\sum$bond energies (bonds formed) $-802 = 990 + 4x - 3462$ $-802 = 4x - 2472$ $1670 = 4x$ $\boldsymbol{x = 418}$ **kJ mol^{-1}**	• Correctly calculates total bonds formed. OR Gives a correct expression for bonds broken.	• Correct process with minor error (e.g. counting bonds).	• Correct answer with unit.
(ii)	$n(CH_4) = \dfrac{1660}{802} = 2.07$ mol $m(CH_4) = n \times M = 2.07 \times 16 = 33.1$ g	• One correct step.	• Correct answer.	

(d)(i)	PCl_3 – Polar BCl_3 – Non-polar	• Identifies polarity of both molecules.		
(ii)	Both the P–Cl and B–Cl bonds in each molecule are polar due to the difference in electronegativity between atoms. In PCl_3, the bond dipoles are arranged asymmetrically due to the trigonal pyramid shape / presence of a lone pair of electrons, meaning the dipoles do not cancel and the molecule is polar. In contrast, due to the symmetrical nature of the trigonal planar BCl_3, the bond dipoles do cancel, and the molecule is non-polar.	• Identifies a difference in electronegativity between atoms in bonds.	• Links symmetry / asymmetry of molecule to cancellation / non-cancellation of dipoles in ONE molecule.	• Compares and contrasts polarity of both molecules, with reference to electronegativity differences, bond polarity, and symmetry of dipole arrangement.

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

Cut Scores

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