Assessment Schedule – 2019

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

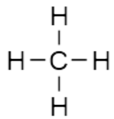
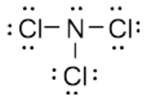
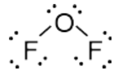
Evidence Statement

<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>Na(s) (sodium)</td><td>metal / metallic</td><td>atoms /cations (or metal nuclei) in sea of delocalised electrons</td><td>metallic bond</td></tr>
<tr><td>NaI(s) (sodium iodide)</td><td>ionic</td><td>ions</td><td>ionic bond / electrostatic attraction between (oppositely charged) ions</td></tr>
<tr><td>$I_2(s)$ (iodine)</td><td>(covalent) molecular</td><td>molecules</td><td>(weak) intermolecular (forces)</td></tr>
</table>
</td><td>• Two rows or two columns correct.</td><td></td><td></td></tr>
<tr><td>(b)</td><td>Sodium is a metallic solid made up of atoms in 3D lattice held together by non-directional metallic bonds (or cations non-directionally electrostatically attracted to a surrounding sea of electrons). When a force (or pressure) is applied, the atoms / layers can move without breaking / disrupting these non-directional bonds; thus the structure can change shape.
NaI is made up of alternating positive ions / Na^+ ions, and negative ions / I^- ions, ionically bonded in a 3D lattice. NaI is not malleable because if pressure is applied to an ionic lattice, it forces ions with the same charge next to each other; they repel each other and break the structure.</td><td>• Describes structure of sodium.
OR
Recognises metallic bonding as non-directional.
• Describes structure of sodium iodide.
OR
Describes ionic bonding is directional.</td><td>• Describes malleability and Links this to non-directional metallic bonding of sodium.
• Describes brittleness of sodium iodide and links it to directional ionic bonding / repulsion of like charged ions.</td><td>• Comprehensively explains malleability of sodium and brittleness of sodium iodide.</td></tr>
</table>

(c)	Iodine is a non-polar (covalent) molecular substance made up of I_2 molecules held together by weak intermolecular forces. Iodine is soluble in cyclohexane, but does not easily dissolve in water. For iodine in water, the iodine-water attractions are not strong enough to overcome both the iodine-iodine / solute-solute and the strong water-water / solvent-solvent attractions. For iodine in cyclohexane, the iodine-cyclohexane attractions are strong enough to overcome iodine-iodine / solute-solute and cyclohexane-cyclohexane / solvent-solvent attractions because all attractive forces are similar (nonpolar).	• Recognises I_2 as a non-polar molecule. • Identifies iodine as (more) soluble in cyclohexane and insoluble/less soluble in water.	• Links attractions (or lack of) of water OR cyclohexane for non-polar iodine to solubility.	• Comprehensively explains iodine's solubility in cyclohexane and insolubility (low solubility) in water linking polarity, strength of attraction and overcoming / not overcoming existing bonding within the solvent or solid.
(d)	The melting of ice is endothermic, as (intermolecular) bonds are being broken as water changes from solid to liquid. This requires energy to be absorbed from the surroundings/the drink. This causes the temperature of the drink to decrease.	• Identifies the melting of ice is endothermic / absorbs or requires energy / breaks bonds.	• Links bond breaking to energy being absorbed from the surroundings / drink / environment.	• Full explanation that links to the cooling of the drink.

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

<table>
<tr><th>Q</th><th>Evidence</th><th>Achievement</th><th>Merit</th><th>Excellence</th></tr>
<tr><td>TWO
(a)(i)

(ii)</td><td>
<table>
<tr><th>Molecule</th><th>CH_4</th><th>NCl_3</th><th>OF_2</th></tr>
<tr><td>Lewis Structure</td><td></td><td></td><td></td></tr>
<tr><td>Name of Shape</td><td>tetrahedral</td><td>trigonal pyramidal</td><td>bent / v-shaped / angular</td></tr>
</table>
Bond angle is determined by the number of electron density regions around the central atom, which are arranged into a position to minimise repulsion by having maximum separation.
All molecules have 4 electron density regions / areas of negative charge around the central atom which arrange with maximum separation into a tetrahedral shape / geometry with a bond angle of (approx.) 109.5° / 109°.
In CH_4 all of the electron pairs are bonded, and so the shape of the molecule is also tetrahedral.
In NCl_3 three of the electron pairs are bonded and one is non-bonding. The observed shape of the molecule is trigonal pyramidal.
In OF_2, due to the presence of two non-bonding pairs of electrons / regions (or two bonding regions) on the central atom, OF_2 has an observed shape that is bent / v-shaped / angular.</td>
<td>• Two Lewis structures correct.
OR
Two shapes correct.

• Identifies the 4 regions of negative charge for each molecule.
OR
Identifies the bonding and non-bonding pairs for one molecule.
• Recognises that electrons density regions are arranged in a position of maximum separation / minimal repulsion.</td>
<td>• Links number of areas of negative charge (including bonding / nonbonding) around the central atom to the shape of TWO molecules using minimise repulsion / maximum separation.
OR
Links four regions on the central atom for two or more molecules to a bond angle of 109.5° using minimise repulsion / maximum separation.</td>
<td>• Justifies the shape of all molecules by referring to all factors that influence shape and bond angle.</td></tr>
<tr><td>(b)(i)

(ii)</td><td>$CHCl_3$ is polar.
$NH_3$is polar.
In $CHCl_3$, there are two types of bond, C–H and C–Cl, each polar, due to the difference in electronegativity between C and H and C and Cl atoms. These dipoles have different polarities / sizes as H and Cl have different electronegativities. (Despite the tetrahedral arrangement appearing symmetrical) the different (sized) bond dipoles do not cancel each other out, so $CHCl_3$ is polar.
In NH_3, the three N–H bonds are polar, i.e. have a dipole, due to the difference in electronegativity between N and H atoms. These (equally sized) dipoles are arranged in a non-symmetrical trigonal pyramidal shape, resulting in the bond dipoles not cancelling each other out, so NH_3 is polar.</td>
<td>• Identifies polarity of both molecules.

• Identifies bonded atoms have different electronegativity (values).</td>
<td>• Links bond polarity to electronegativity differences between bonded atoms for all bonds in one molecule.
OR
Uses lack of symmetry for NH_3 OR differing bond dipoles for $CHCl_3$ to link molecule polarity to dipoles not cancelling in one molecule.</td>
<td>• Justifies polarity of both molecules by referring to differences in electronegativity, dipoles, and non-symmetrical arrangement of NH_3 dipoles.</td></tr>
</table>

(c)	Bond breaking $2 \times C-C = 348 \times 2 = 696$ $8 \times C-H = 413 \times 8 = 3304$ $5 \times O=O = 495 \times 5 = 2475$ Total = **6475** Bond making $8 \times O-H = 463 \times 8 = 3704$ $6 \times C=O = 6x$ $\Delta_r H = \Sigma$Bond energies (bonds broken) – ΣBond energies (bonds formed) $6475 - 3704 - 6x = -2056$ kJ mol^{-1} $6x = +2056 + 6475 - 3704 = 4827$ $x = 805$ kJ mol^{-1}	• Correctly calculates total bonds broken. OR Correctly identifies bonds made in a formula.	• Correct process with minor error / omission.	• Correct answer with unit.

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

Q	Evidence	Achievement	Merit	Excellence
THREE (a)(i) (ii)	Exothermic as $\Delta_r H$ is negative. To be able to conduct electricity, there needs to be mobile/free moving charged particles. Graphite, C(*s*), is an extended covalent network solid. Each carbon atom is covalently bonded to 3 other carbon atoms in hexagonal layers. This leaves one delocalised electron per carbon atom that is mobile and able to carry a charge, so graphite conducts electricity. Carbon dioxide is a covalent molecule. The molecules are held together by weak intermolecular forces, so it is a gas at room temperature. There are no free moving ions or electrons in their structure. Therefore, it can't conduct electricity.	• Correct term with reason in (i). accept energy/heat is lost OR ΔH/enthalpy change is negative. • Recognises mobile charged particles needed for conductivity. OR Identifies graphite is a covalent network made of atoms and $CO_2(g)$ consists of molecules.	• Links 2D network/layered covalent **network** structure of graphite to free moving electrons which conduct electricity OR molecules of CO_2 to being uncharged / not having a free moving charged particle and therefore not conducting electricity.	• Justifies the conductivity of graphite and carbon dioxide in terms of structure and bonding providing / not providing free moving charged particles.
(b)(i) (ii)	$n(O_2(g)) = \frac{1804.5}{1203} = 1.5$ moles $m = n \times M = 1.5 \times 32 = 48.0$ g $n = \frac{m}{M} = \frac{100}{40.3} = 2.48$ $\text{Energy} = \Delta_r H \times n = \frac{-1203}{2} \times 2.48 = -1492.5 \text{ kJ} / -1493 \text{ kJ}$ -1490 kJ (3 sf) (either positive or negative values accepted)	• ONE step of calculation correct. • ONE step of calculation correct.	• Correct answer. • Correct answer.	BOTH correct answers with units.

(c)	$65\,000 \times 60 = 3\,900\,000$ g $n(\text{Al}) = \frac{3\,900\,000}{27} = 144\,444$ moles $\Delta_r H = \frac{144\,444}{4} \times 3350$ $= 121\,000\,000$ kJ $= 1.21 \times 10^8$ kJ (rounded to 3sf) OR $\frac{65000}{27} = 2407$ moles $\Delta_r H = \frac{2407}{4} \times 3350 = 2\,015\,862$ kJ $\times 60$ $= 121\,000\,000$ kJ $= 1.21 \times 10^8$ kJ (rounded to 3sf)	• ONE step of process correct.	• Process correct with minor error.	• Calculates energy with units (kJ or kJ h^{-1}) and 3 sf.

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