Assessment Schedule – 2025

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

Evidence

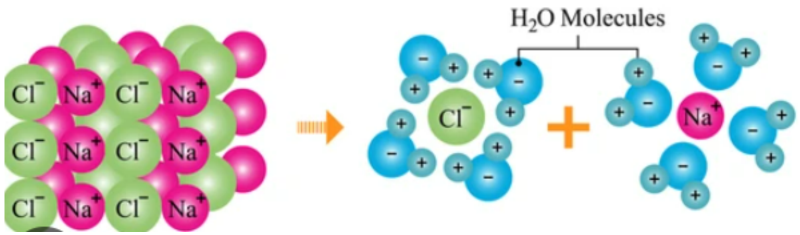
<table>
<tr><th>Q</th><th>Evidence</th><th>Achievement</th><th>Merit</th><th>Excellence</th></tr>
<tr><td>ONE (a)</td><td>$n(\text{NaCl}) = \frac{73.0}{58.4} = 1.25 \text{ mol}$
$\Delta_r H = \frac{-81.8}{1.25} = -65.4 \text{ kJ mol}^{-1}$</td><td>• One step correct.</td><td>• Correct answer with unit.</td><td></td></tr>
<tr><td>(b)(i)</td><td><table><tr><th>Solid type</th><th>Melting point (°C)</th><th>Substance selected</th></tr><tr><td>3D Covalent Network</td><td>3550</td><td>Diamond (C)</td></tr><tr><td>Ionic</td><td>801</td><td>Sodium chloride (NaCl)</td></tr><tr><td>Metallic</td><td>420</td><td>Zinc (Zn)</td></tr><tr><td>Molecular</td><td>–78</td><td>Ammonia (NH_3)</td></tr></table></td><td>• THREE of four correct.</td><td></td><td></td></tr>
<tr><td>(ii)</td><td>The higher the melting point of a substance, the stronger the forces of attraction between the substance's particles. The melting point indicates how much energy is required to overcome the forces of attraction between its particles.
Ionic solids are made of positive and negative ions arranged in an alternating 3D lattice structure held together with strong directional ionic bonds between the cations and anions. These strong bonds require a large amount of energy to be overcome, therefore ionic solids have relatively higher melting points than molecular solids.
Molecular solids are made of molecules held together with weak intermolecular forces of attraction that require only small amounts of energy to be overcome. Therefore, molecular solids have relatively lower melting points than ionic solids.</td><td>• Recognises the relationship between melting point and the forces between a substance's particles.
OR
Identifies that forces between particles must be broken for a solid to melt.
OR
Describes structure of either substance.</td><td>• Describes structures and bonding of one solid type and links it to the energy/heat required for melting.</td><td>• Links structure and bonding in each type of solid to the difference in energy required for melting.</td></tr>
</table>

(c)	Diamond is very hard due to the four covalent bonds that connect each of the carbon atoms that are very strong and directional. It is a covalent network. This means a large amount of force is required to overcome these bonds, making diamond a very hard substance. Gold is a metallic solid held together by non-directional strong metallic bonds between cations / atoms / nuclei and delocalised electrons. It is arranged in layers that, under force, can slide over one another due to the non-directional bonding. This enables gold to be drawn out / stretched and moulded into shape without breaking.	• Recognises that type (in gold) or strength (in diamond) of bonding influences different properties of the substances.	• Links the bonding and structure of ONE solid to properties.	• Explains how the bonding in both solids results in their comparative properties.
(d)	Bonds broken: $1 \times N{\equiv}N = x$ $3 \times H–H = 3 \times 436 = 1308$ Total: $1308 + x$ kJ mol^{-1} Bonds formed: $6 \times N\text{-}H = 6 \times 391 = 2346$ Total: 2346 kJ mol^{-1} $\Delta_r H = \Sigma_{\text{bonds broken}} - \Sigma_{\text{bonds formed}}$ $-93.0 = (1308 + x) - 2346$ $2253 = 1308 + x$ $x = -945$ kJ mol^{-1}	• Correctly calculates total bonds broken or bonds formed.	• Correct process with minor error.	• Correct answer with units.

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
TWO (a)(i)	Endo The products have more energy than the reactants. Exo Energy is released to the surroundings. Endo The change in enthalpy (Δ*H*) for the reaction is positive.	• TWO of three correct.	• (ii) including reason.	
(ii)	Exothermic Changing state from gas to liquid, the particles have less energy. This energy has been released to the surroundings as a result of bond making, and so the process is exothermic.	OR Exothermic and correct reason.		
(iii)	Absorbing energy from the surroundings.	OR (iii) correct.		
(iv)	Positive	OR (iv) correct.		
(b)(i)	A polar bond is a covalent bond with a dipole, as a result of the atoms in the bond having a big enough difference in electronegativity (the atoms ability to attract bonding electrons). Any relevant example e.g. $O^{\delta-}$-$H^{\delta+}$.	• Basic definition and example. OR Selects Tetrachloromethane.		
(ii)	Tetrachloromethane		• Links symmetry of molecules to dipole cancellation using using CCl_4 and C–Cl polar bonds.	• All parts correct (i, ii, iii) including full explanation addressing both size of dipoles and symmetry for tetrachloromethane.
(iii)	Both polar and non-polar molecules can contain polar bonds. If polar bonds are both equal in size of polarity and symmetrically arranged around the central atom, then the dipoles cancel and the molecule is non-polar. For example, tetrachloromethane has four polar bonds, but they are all equally polar C–Cl, and they are arranged symmetrically around the carbon atom; therefore the four dipoles cancel out and the overall molecule is non-polar.	• Identifies that symmetry of molecule is responsible for polarity. OR Identifies that size of dipole influences polarity of the molecule.		
(c)	See table below.	• Two correct.	• Three correct.	

Solute and solvent combination	Soluble?	Insoluble?
Tetrachloromethane, CCl_4, in water, H_2O		✓
Magnesium bromide, $MgBr_2$, in hexane, C_6H_{14}		✓
Bromine, Br_2, in hexane, C_6H_{14}	✓	

(d)	The attraction between solute and solvent needs to be enough to overcome the attractions between water molecules themselves. Sodium chloride is an ionic compound; in water the partially negative O atoms of the water are attracted to the positive Na ions (Na^+), and the partially positive hydrogen atoms in water is attracted to the negative chloride ions (Cl^-). This attraction between solute and solvent is enough to overcome those within water and between the ions, and therefore sodium chloride is soluble. However, as iodine is a non-polar molecular solid, there are no charges or partial charges for the water molecules to be attracted towards. Therefore, there is no force of attraction to overcome the existing attractions between water molecules, hence iodine is insoluble in water.  Source: https://www.shutterstock.com/image-vector/illustration-chemical-water-solubility-sodium-chloride-1713324574	• Identifies attractions (or lack of) are required between water and the solute for a substance to be soluble / insoluble. OR Good diagram.	• Links relative strength of attractive forces between solute and solvent particles to solubility for ONE compound.	• Justifies the solubility of both compounds with reference to polarity, relative strength of attractive forces and need to overcome existing forces. AND Includes diagram of NaCl dissolving in H_2O.

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)	Diamond is a 3D covalent network solid made of carbon atoms covalently bonded to four other carbon atoms in a tetrahedral arrangement. Graphite is a 2D covalent network solid made of carbon atoms covalently bonded to three other carbon atoms in hexagonal rings. There is a delocalised valence electron from each carbon atom that is free to move. These hexagonal rings form layers with weak intermolecular forces between them. To conduct electrically, a substance must contain free-moving charged particles. The delocalised electrons in graphite can move freely throughout the structure and carry a negative charge, therefore graphite can conduct. Diamond does not have any free-moving delocalised electrons as all carbons are bonded to four other carbons. Therefore, diamond does not conduct while graphite does.	• Describes the structure of diamond covalent network with a tetrahedral arrangement/each C bonded to 4 others. OR Describes the structure of graphite covalent network solid in layers/each C bonded to 3 others OR Defines conductivity.	• Explains bonding and structure of both carbon allotropes (diamond A + 3D each carbon is bonded to 4 other carbon atoms, 2D graphite A+, bonded to 3 others delocalised electrons). • Links conductivity, A+ to presence of delocalised valence e for graphite to carry a current or lack of mobile charged particles/delocalised electrons for diamond so no current can flow.	• Comprehensively explains the structure and bonding of both solids and relates this to the conductivity of both diamond and graphite. *Relevant aspects of drawn structures can contribute to answer.*
(b)(i) (ii)	$n(C_2H_5OH) = \frac{17500}{1370} = 12.8$ mol $m = 12.8 \times 46.7 = 597$ g $n(\text{ZnO}) = \frac{187}{81.4} = 2.297$ mol $\text{Energy} = 2.297 \times \frac{-696}{2} = -799$ kJ	• One step correct. OR One step correct.	• Correct answer with unit. OR Correct answer with unit.	• Both calculations correct (i) and (ii).

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<td>(c)</td>
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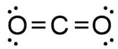
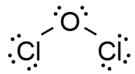
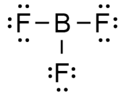
<tr><td>Compound</td><td>CO_2</td><td>Cl_2O</td><td>BF_3</td></tr>
<tr><td>Lewis structure</td><td></td><td></td><td></td></tr>
<tr><td>Name of shape</td><td>linear</td><td>bent</td><td>trigonal planar</td></tr>
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<td>• TWO correct Lewis structures with shapes.</td>
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<tr>
<td>(d)</td>
<td>In methane, there are four regions of electron density around the central C atom. These are repelled at maximum separation to give minimum repulsion with bond angles of 109.5° and an arrangement that is tetrahedral. As all regions are bonded, the shape is also tetrahedral.
Whereas, in ammonia, there are four regions of electron density surrounding the N atom. As each of these regions has a negative charge, they repel as far apart as possible into maximum separation; this is what determines the arrangement and the associated bond angle. For ammonia, this is tetrahedral with angles of 109.5°. As only three of the four regions are bonded, the final shape is trigonal pyramid. The presence of the lone pair (unbonded electrons) around the central N atom means the arrangement and the final shape are different.
It is acceptable to give the bond angle first and then state that this angle maximises separation to minimise repulsion.</td>
<td>• Identifies the correct number of bonding and non-bonding regions / lone pairs for ammonia or methane.
• Recognises electron density regions are arranged in positions of maximum separation / minimum repulsion.</td>
<td>• Links the number of areas of electron density around the central atom AND the number of lone pairs to the molecular shape for ONE compound.</td>
<td>• Fully explains each molecular substance, including that number of areas of electron density AND number of lone pairs determine molecular shape.</td>
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</table>

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