Assessment Schedule – 2013

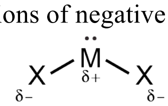
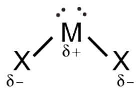
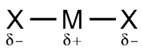
Chemistry: Demonstrate understanding of bonding, structure, properties and energy changes (91164)

Assessment Criteria

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding involves describing, identifying, naming, drawing, calculating, or giving an account of bonding, structure and properties of different substances and the energy involved in physical and chemical changes. This requires the use of chemistry vocabulary, symbols and conventions.	*Demonstrate in-depth understanding* involves making and explaining links between the bonding, structure and properties of different substances and the energy involved in physical and chemical changes. This requires explanations that use chemistry vocabulary, symbols and conventions.	*Demonstrate comprehensive understanding* involves elaborating, justifying, relating, evaluating, comparing and contrasting, or analysing links between bonding, structure and properties of different substances and the energy involved in physical and chemical changes. This requires the consistent use of chemistry vocabulary, symbols and conventions.

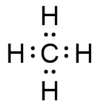
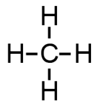
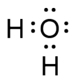
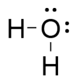
Evidence Statement

Q	Evidence	Achievement	Merit	Excellence
ONE (a)	Lewis diagrams shown (Appendix One).	• In (a) TWO Lewis structures correct.		
(b)	BF_3: trigonal planar: 120° bond angles. PF_3: trigonal pyramidal; ≈ / < 109.5° (107°). Shape is determined by the number of regions of electron density / electron clouds and whether they are bonding / non-bonding. BF_3 has three regions of electron density / electron clouds around the central B atom. The regions of electrons are arranged as far apart as possible from each other / to minimise repulsion, which results in a trigonal planar arrangement with a bond angle of 120°. All three regions of electrons are bonding, so the overall shape is trigonal planar. PF_3 has four regions of electron density / electron clouds around the central P atom. The regions of electrons make a tetrahedral arrangement with a bond angle of 109.5°. Only three regions of electrons are bonding and one is non-bonding, so the overall shape is trigonal pyramidal. *The non-bonding electrons have increased repulsion, therefore decreasing the bond angle to < 109.5°*	• In (b) TWO shapes correct. • In (b) TWO bond angles correct.	• In (b) the arrangement of electrons around the central atom is used to explain the **shape** of the molecule. • In (b) the arrangement of electrons around the central atom is used to explain the **bond angle**.	In (b) the arrangement of the electron density / electron clouds around the central atom is used to explain the shapes and angles of the molecules. Includes a comparison of the different shape and bond angles.

(c)(i)	The NH_3 molecule is polar. The N–H bond is polar due to differences in electronegativity of N and H. The shape of the molecule is trigonal pyramidal, therefore the N–H polar bonds are not arranged symmetrically around the N atom. This means that the dipoles will not cancel. This results in a molecule which is polar.	• In (c) N–H bond is polar. • Predicts polarity of NH_3 correctly with one piece of supporting evidence.	• In (c)(i) the difference in electronegativities between N and H is used to explain the N–H bonds are polar. OR In (c)(i) links spread of charge to overall molecule polarity.	In (c)(i) the polarity of molecule is explained and justified in terms of the regions of bond polarity and asymmetry.
(c)(ii)	Polar: bent Non-polar: linear If MX_2 is polar, this indicates that the polar M–X bonds are not spread symmetrically around the central M atom. There must be either three or four regions of negative charge with only two bonded atoms therefore the shape must be bent. Three regions of negative charge:  Four regions of negative charge:  If MX_2 is non-polar this means that the polar M-X bonds are spread symmetrically around the central M atom. There must be only two regions of negative charge around the M atom, both bonded by X atoms in a linear shape. Two regions of negative charge: 	• Predicts one possible shape for MX_2. • Polarity depends upon the symmetry of the molecule.	• In (c)(ii) links the asymmetric spread of polar bonds to the shape.	In (c)(ii) the predicted shapes of the molecules are explained and diagrams are drawn showing labelled dipoles.

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response or no relevant evidence.	1a	2a	4a	5a	3m	4m	3e with minor error / omission / additional information.	3e

Appendix One: Question One (a)

Molecule	Lewis structure
CH_4	 or 
H_2O	 or 
N_2	 or 

<table>
<tr><th>Q</th><th>Evidence</th><th>Achievement</th><th>Merit</th><th>Excellence</th></tr>
<tr><td>TWO
(a)</td><td><table>
<tr><th>Type of substance</th><th>Type of particle</th><th>Attractive forces between particles</th></tr>
<tr><td>Covalent network</td><td>Atom</td><td>Covalent (and weak intermolecular forces)</td></tr>
<tr><td>Molecular</td><td>Molecules</td><td>Weak intermolecular forces</td></tr>
<tr><td>Ionic</td><td>Ion</td><td>Ionic bonds / electrostatic attraction</td></tr>
<tr><td>Metal</td><td>Atom / cations and electrons</td><td>Metallic bonds / electrostatic attraction</td></tr>
</table></td><td>• ONE row or ONE column correct.</td><td>• Table completely correct.</td><td></td></tr>
<tr><td>(b)(i)</td><td>Chlorine is a molecular substance composed of chlorine molecules held together by weak intermolecular forces. The weak intermolecular forces do not require much heat energy to break, so the boiling point is low (lower than room temperature); therefore chlorine is a gas at room temperature.
Copper chloride is an ionic substance. It is composed of a lattice of positive copper ions and negative chloride ions held together by electrostatic attraction between these positive and negative ions. These are strong forces, therefore they require considerable energy to disrupt them and melt the copper chloride; hence copper chloride is a solid at room temperature.</td><td>• Chlorine:
low melting point
OR
is a gas at room temperature
AND
because it has weak intermolecular forces
OR
little energy is needed to turn it into a gas.
• Copper chloride:
High melting point
OR
is a solid at room temperature
AND
because it has strong ionic bonds
OR
a lot of energy would be needed to change it from a solid.</td><td>• Explains and links why chlorine is a gas and copper chloride is a solid at room temperature.
Eg: Chlorine:
has low melting point <u>and</u> is a gas at room temperature
<u>because</u> it has weak intermolecular forces <u>and</u> little energy is needed to turn it into a gas
Eg: $CuCl_2$:
High melting point and is a solid at room temperature because it has strong ionic bonds and
a lot of energy would be needed to change it from a solid.</td><td>Contrasts with reference to bonding and structure why chlorine is a gas at room temperature and copper chloride is a solid at room temperature.</td></tr>
<tr><td>(b)(ii)</td><td>For a substance to conduct electricity, it must have charged particles which are free to move.
Graphite is a covalent network solid composed of layers of C atoms covalently bonded to three other C atoms. The remaining valence electron is delocalised (ie free to move) between layers; therefore these delocalised electrons are able to conduct electricity.
Copper is a metallic substance composed of copper atoms packed together. Valence electrons are loosely held and are attracted to the nuclei of the neighbouring Cu atoms; ie the bonding is non-directional. These delocalised valence electrons are able to conduct an electrical current.
For a substance to be made into wires, it needs to be stretched or drawn out without breaking.</td><td>• For something to conduct there must be free moving charged particles.
• Graphite conducts because it has free moving electrons
• Copper conducts because it has free moving electrons.
• For something to be made into wires it needs to be able to be stretched without breaking / ductile</td><td>• Explains why both graphite and copper conduct electricity.
• Explains why copper is ductile but graphite is not.</td><td>Contrasts with reference to bonding and structure why both graphite and copper can conduct electricity, however only copper is ductile.</td></tr>
</table>

<table>
<tr>
<td></td>
<td>In graphite, the attractive forces holding the layers together are very weak and are broken easily, so the layers easily slide over one another, but the attraction is not strong enough to hold the layers together and allow it to be drawn into wires or although the layers can slide due to weak forces, if graphite was to be made into a wire the very strong covalent bonds within the layers would have to be broken.
Copper metal can easily be drawn into wires since, as it is stretched out, the non-directional metallic bonding holds the layers together, allowing it to be stretched without breaking.</td>
<td>• Graphite cannot be stretched since weak forces are easily broken or because the very strong covalent bonds have to be broken
• Copper able to be stretched into wires because non directional bonding of valence electrons holds it together or because the metallic bonds can stretch without breaking.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(c)</td>
<td>
<table>
<tr><th>Bonds broken:</th><th>Bonds formed:</th></tr>
<tr><td>C–H × 1
Cl–Cl × 1</td><td>C–Cl × 1
H–Cl × 1</td></tr>
<tr><td>414 + 242 = 656</td><td>324 + 431= –755</td></tr>
</table>
656 kJ + (–755 kJ) = –99.0 kJ mol^{-1}
OR
<table>
<tr><th>Bonds broken:</th><th>Bonds formed:</th></tr>
<tr><td>C–H × 4
Cl–Cl × 1</td><td>C–Cl × 1
C–H x 3
H–Cl × 1</td></tr>
<tr><td>1656+ 242 = 1898</td><td>324 + 1242+ 431= 1997</td></tr>
</table>
1898 kJ + (–1997 kJ) = –99.0 kJ mol^{-1}
</td>
<td>• Identifies bonds broken and formed.</td>
<td>• Process for calculating $\Delta_r H°$ correct, however one minor error</td>
<td>Correctly calculates $\Delta_r H°$, with units and negative sign.</td>
</tr>
</table>

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response or no relevant evidence.	1a	2a	5a	7a	3m	4m	2e	3e

Q	Evidence	Achievement	Merit	Excellence
THREE (a)	Endothermic Gets colder The process is endothermic since the enthalpy change ($\Delta_r H°$) is positive, which indicates that energy is absorbed by the system as the ammonium nitrate dissolves. Since heat energy is absorbed by the system from the surroundings (water & beaker), the **water or beaker** will get cooler as they lose heat energy.	• In (a) the reaction is endothermic because the value is positive OR because the ammonium nitrate is absorbing energy from the surroundings OR products have more energy than reactants. • In (a) beaker gets colder as heat energy is absorbed by ammonium nitrate.	• Explains that since reaction is endothermic heat energy is absorbed by the system from the surroundings (water / beaker) so the beaker feels colder.	In (d) calculations correct with units and statement made about which iron oxide produces more heat energy. AND two bullet points from Merit.
(b)(i) (b)(ii)	Exothermic The reaction is exothermic because the enthalpy change ($\Delta_r H°$) is negative; indicating that heat energy is produced during the reaction. 9800 kJ / 2820 kJ mol^{-1} = 3.48 mol	• In (b)(i) exothermic since value is negative or because glucose reacting is releasing energy OR products have less energy than reactants. • In (b)(ii) calculation is correct.		
(c)(i) (c)(ii)	Endothermic. Heat energy is needed to change the butane from a liquid to a gas; the energy is used to break the weak intermolecular forces between the butane molecules. n(C_4H_{10}) = 100 g / 58.1 g mol^{-1} = 1.7212 mol –4960 kJ / 1.7212 mol = –2882 kJ mol^{-1}	• In (c) the process is endothermic since energy isneeded to boil butane. • In (c)(ii) one step correct in the calculation.	• In (c)(i) explains the use of heat energy to break the **weak intermolecular forces between** butane molecules. • In (c)(ii) calculation is correct.	
(d)	n(Fe) = 2000 g / 55.9 g mol^{-1} = 35.78 mol Fe_3O_4: 3348 kJ / 9 = 372 kJ mol^{-1} 372 kJ mol^{-1} × 35.78 mol = 13 310.16 kJ = (–)1.33×10^4 kJ	• In (d) one step correct.	• In (d) two steps correct	

	Fe_2O_3: 851 kJ / 2 = 425.5 kJ mol^{-1} 425.5 kJ mol^{-1} × 35.78 mol = 15 224.4 kJ = (–)1.52×10^4 kJ Therefore Fe_2O_3 produces more heat energy when 2 kg iron is formed.			

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response or no relevant evidence.	1a	2a	4a	5a	2m	3m	e with minor error / incorrect unit / only 1m.	e

Judgement Statement

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