Pearson Edexcel

Mark Scheme (Results)

January 2022

Pearson Edexcel International Advanced Subsidiary Level
In Chemistry (WCH11)
Paper 01: Structure, Bonding and Introduction to Organic Chemistry

Section A

Question Number	Answer	Mark
1(a)	**The only correct answer is C** (XY_2) **A** *is not correct because Group 2 elements combine with Group 7 elements in the ratio 1:2* ***B*** *is not correct because Group 2 elements combine with Group 7 elements in the ratio 1:2* ***D*** *is not correct because Group 2 elements combine with Group 7 elements in the ratio 1:2*	**(1)**

Question Number	Answer	Mark
1(b)	**The only correct answer is D** (in the liquid state and in aqueous solution only) **A** *is not correct because the ions do not move in the solid state* **B** *is not correct because the ions do not move in the solid state* **C** *is not correct because the ions do not move in the solid state*	**(1)**

Question Number	Answer	Mark
2	**The only correct answer is B** (NaF) **A** *is not correct because the* Cl^- *ion is larger than* F^- *so ionic bonding is weaker in NaCl* **C** *is not correct because the* K^+ *ion is larger than* Na^+ *and the* Cl^- *ion is bigger than* F^- **D** *is not correct because the* K^+ *ion is larger than* Na^+	**(1)**

Question Number	Answer	Mark
3	**The only correct answer is C** (a yellow colour has moved to the positive end and a blue colour to the negative end) **A** *is not correct because the green colour is formed from yellow and blue ions* **B** *is not correct because the green colour is formed from yellow and blue ions* **D** *is not correct because the blue Cu^{2+} ions will move to the negative end and the yellow CrO_4^{2-} ions will move to the positive end*	**(1)**

Question Number	Answer	Mark
4	**The only correct answer is D** (Al^{3+}) **A** *is not correct because the N^{3-} ion has fewer protons so is larger* **B** *is not correct because the F^- ion has fewer protons so is larger* **C** *is not correct because the Na^+ ion has fewer protons so is larger*	**(1)**

Question Number	Answer	Mark
5	**The only correct answer is D** (small radius and large charge) ***A*** *is not correct because radius should be small* **B** *is not correct because the radius should be small and the charge should be large* **C** *is not correct because the charge should be large*	**(1)**

Question Number	Answer	Mark
6	**The only correct answer is A** (large radius and large charge) **B** *is not correct because the charge should be large* **C** *is not correct because the charge and radius should be large* ***D*** *is not correct because radius should be large*	**(1)**

Question Number	Answer	Mark
7	**The only correct answer is D** ($Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$) **A** *is not correct because $NaNO_3$ is soluble* **B** *is not correct because the charge on the barium ion is incorrect* **C** *is not correct because the charge on the sodium ion is incorrect*	**(1)**

Question Number	Answer	Mark
8	**The only correct answer is A** (CO_2) **B** *is not correct because HCl is a polar molecule* **C** *is not correct because H_2O is a polar molecule* **D** *is not correct because NH_3 is a polar molecule*	**(1)**

Question Number	Answer	Mark
9	**The only correct answer is C** (0.00005%) **A** *is not correct because the answer shows the percentage equal to ppm* **B** *is not correct because the answer shows the ppm divided by 100* **D** *is not correct because the correct answer has been divided by 100*	**(1)**

Question Number	Answer	Mark
10(a)	**The only correct answer is B** ($C_2H_6 + Br_2 \rightarrow C_2H_5Br + HBr$) **A** *is not correct because hydrogen is not produced* **C** *is not correct because CH_3Br is not a product* **D** *is not correct because neither CH_4 nor CH_2Br_2 are products*	**(1)**

Question Number	Answer	Mark
10(b)	**The only correct answer is A** (homolytic breaking of a Br—Br bond) **B** *is not correct because the Br-Br bond does not break heterolytically* **C** *is not correct because the C-H bond is not broken by UV light* **D** *not correct because the C-H bond is not broken by UV light*	**(1)**

Question Number	Answer	Mark
11	**The only correct answer is B** (general formula) **A** *is not correct because only the general formula is the same for all alkanes* **C** *is not correct because only the general formula is the same for all alkanes* **D** *is not correct because only the general formula is the same for all alkanes*	**(1)**

Question Number	Answer	Mark
12	**The only correct answer is D** (hexene and propane) **A** *is not correct because these products are possible* **B** *is not correct because these products are possible* **C** *is not correct because these products are possible*	**(1)**

Question Number	Answer	Mark
13	**The only correct answer is C** (4) **A** *is not correct because there are 4 isomers* **B** *is not correct because there are 4 isomers* **D** *is not correct because there are 4 isomers*	**(1)**

Question Number	Answer	Mark
14	**The only correct answer is B** (7.22×10^{21}) **A** *is not correct because a 1:1 ratio has been used instead of 1:6* **C** *is not correct because a 1:7 ratio has been used instead of 1:6* **D** *is not correct because this is the number of atomic mass units in the product*	**(1)**

Question Number	Answer	Mark
15	**The only correct answer is A** (hydrogen chloride) **B** *is not correct because sulfur is an impurity in alkane fuels and so sulfur dioxide can be produced during their combustion* **C** *is not correct because carbon particulates can be produced during the combustion of alkane fuels* **D** *is not correct because carbon monoxide can be produced during the combustion of alkane fuels*	**(1)**

Question Number	Answer	Mark
16	**The only correct answer is C** (27.90 tonnes) **A** *is not correct because the wrong ratio (2:1) has been used instead of 1:2* **B** *is not correct because the wrong ratio (1:1) has been used instead of 1:2* **D** *is not correct because the wrong ratio (1:3) has been used instead of 1:2*	**(1)**

Question Number	Answer	Mark
17	**The only correct answer is B** (0.40 dm^3 of 0.03 mol dm^{-3} KCl) **A** *is not correct because it contains 0.02 mol of ions* **C** *is not correct because it contains 0.018 mol of ions* **D** *is not correct because it contains 0.018 mol of ions*	**(1)**

Question Number	Answer	Mark
18	**The only correct answer is C** (39.2%) **A** *is not correct because the O on the right-hand side has been multiplied by 2, not 6* **B** *is not correct because the O on the right-hand side has been multiplied by 4, not 6* **D** *is not correct because the mass of oxygen has been divided by the mass of KCl*	**(1)**

(Total for Section A = 20 marks)

Section B

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>19(a)(i)</td><td>
<table>
<tr><th>Measurement</th><th>Mass / g</th></tr>
<tr><td>Mass of empty crucible</td><td>21.21</td></tr>
<tr><td>Mass of crucible and magnesium sulfate before heating</td><td>26.71</td></tr>
<tr><td>Mass of crucible and magnesium sulfate after heating for 2 mins</td><td>24.12</td></tr>
<tr><td>Mass of magnesium sulfate</td><td>2.91</td></tr>
<tr><td>Mass of water</td><td>2.59</td></tr>
</table>
</td><td>Both masses required</td><td>(1)</td></tr>
</table>

Question Number	Answer	Additional Guidance	Mark
19(a)(ii)	• M1 M_r of $MgSO_4$ **(1)** • M2 moles of $MgSO_4$ **(1)** • M3 moles of H_2O **(1)** • M4 ratio of moles of water to moles of magnesium sulfate: to the nearest whole number **(1)**	<u>Example of calculation</u> $(24.3 + 32.1 + (4 \times 16)) = 120.4$ Allow 120 $(2.91 \div 120.4) = 0.024169 / 2.4169 \times 10^{-2}$ (mol) Ignore SF except 1 TE from wrong mass in (a)(i) $(2.59 \div 18) = 0.14389 / 1.4389 \times 10^{-1}$ (mol) Ignore SF except 1 TE from wrong mass in (a)(i) No TE on wrong M_r of H_2O Alternative method for M3 and M4 M_r of hydrate = 26.71-21.21/0.024169 = 227.56 mass of water = 227.56 – 120.4 = 107.16 moles of water = 107.16/18 = 5.9533 x = 6 $(0.1438889 \div 0.0241694) = 5.9533:1$ $(MgSO_4.6H_2O)$ x = 6 TE from M2 and M3 Correct answer with some **relevant** working scores (4) Ignore SF throughout	**(4)**

Question Number	Answer	Additional Guidance	Mark
19(b)	An answer that makes reference to the following points: • heat to constant mass/ until mass does not change **(1)** • to ensure all the water is lost/ driven off **(1)**	Allow heat for longer Ignore any reference to repetition/ using a higher temperature/different flame/more magnesium sulfate/ any changes to the method Do not award heat under reflux for longer Allow more water is lost/given off Allow some water may have remained Allow all the water evaporated Ignore allow (reaction) to go to completion	**(2)**

(Total for Question 19 = 7 marks)

Question Number	Answer	Additional Guidance	Mark
20(a)	An answer that makes reference to the following points • Cu ([Ar]) $3d^{10}$ $4s^1$ **(1)** • Cu^{2+} ([Ar]) $3d^9$ **(1)**	ALLOW $4s^1$ $3d^{10}$ ALLOW $4s^0$ $3d^9$ Ignore $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ in both cases	**(2)**

Question Number	Answer	Additional Guidance	Mark
20(b)(i)	<table><tr><th>Isotope</th><th>Protons</th><th>Neutrons</th><th>Electrons</th></tr><tr><td>^{63}Cu</td><td>29</td><td>34</td><td>29</td></tr><tr><td>^{65}Cu</td><td>29</td><td>36</td><td>29</td></tr></table> **(1)** **(1)**	One mark for each correct row Four or five correct scores one mark Ignore working	**(2)**

Question Number	Answer	Additional Guidance	Mark
20(b)(ii)	An answer that makes reference to the following points: • (atoms/elements that have) same number of protons/same proton number/ quoted same number of protons even if wrong **(1)** • (but) different numbers of neutrons/neutron number **(1)**	Ignore any reference to electrons but do not award if different to the number of protons Ignore if they state the wrong number of neutrons in the 2 isotopes. If they fail to mention numbers of protons and neutrons 'same atomic number but different mass number' scores (1) Do not award atomic mass for mass number Do not award molecules but penalise once only	**(2)**

Question Number	Answer	Additional Guidance	Mark
20(b)(iii)	• (isotopes have) the same electronic configuration	Allow same electron arrangement/electron(ic) structure Allow the same number of electrons Ignore the same number of protons Ignore the same number of electrons in the outer shell/same number of valence electrons Ignore same period/same group Ignore any given electronic configurations/number of electrons even if wrong Ignore any reference to neutrons	**(1)**

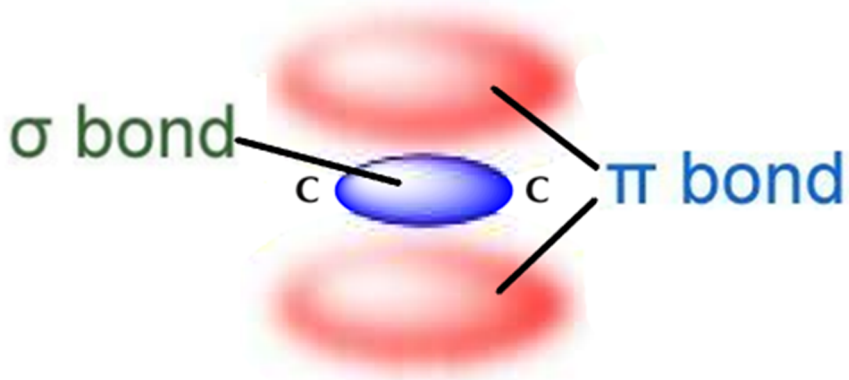
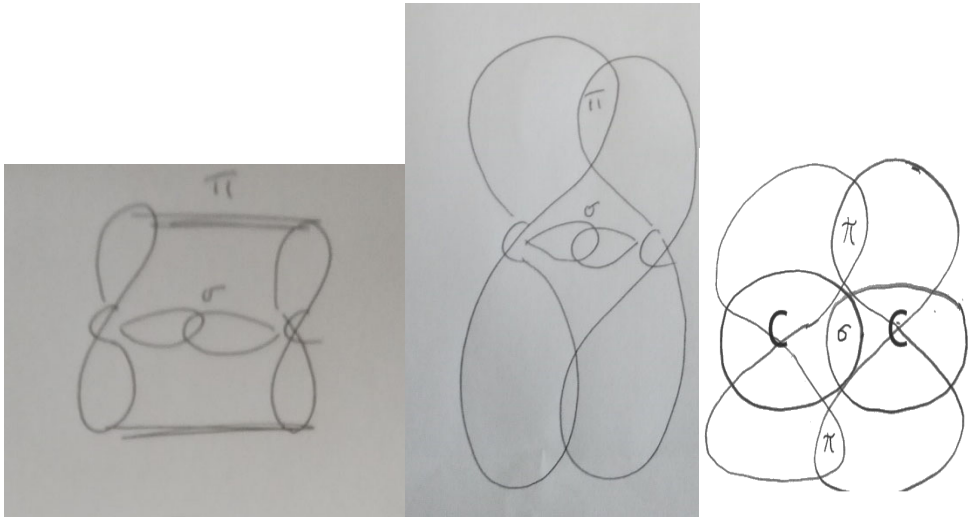
Question Number	Answer	Additional Guidance	Mark
20(b)(iv)	An explanation that makes reference to the following points: • expression relating isotopic masses A_r and X **(1)** • abundance of (Cu) 63 = 0.8 or 80% abundance of (Cu) 65 = 0.2 or 20% **(1)** Alternative method 65- 63.4 = 1.6 63.4-63 = 0.4 **(1)** 0.4/2.0 × 100 = 20% 65 1.6/2.0 × 100 = 80% 63 **(1)**	Example of calculation $63.4 = \frac{(1- X) \times 65) + (X \times 63)}{1}$ 63.4 = 65 – 65X + 63X 63.4 = 65 – 2X −1.6 = −2X X / 63 = 0.8 OR $63.4 = \frac{(1-X) \times 63) + (X \times 65)}{1}$ 63.4 = 63 – 63X + 65X 63.4 = 63 + 2X 0.4 = 2X X / 65 = 0.2	**(2)**

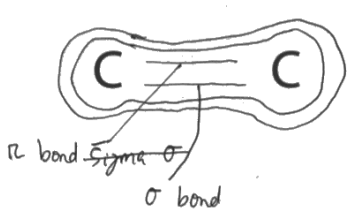
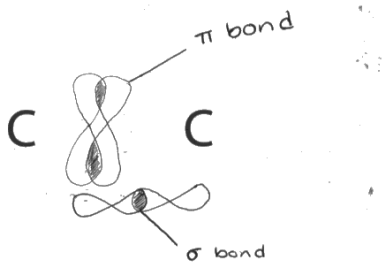
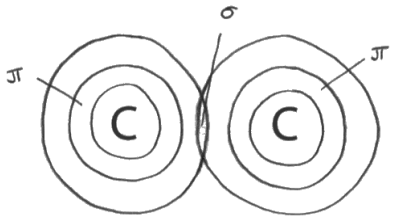
		OR $63.4 = \frac{(100- X) \times 65) + (X \times 63)}{100}$ $6340 = 6500 – 65X + 63X$ $6340 = 6500 – 2X$ $-160 = -2X$ $X / 63 = 80\%$ OR $63.4 = \frac{(100 -X) \times 63) + (X \times 65)}{100}$ $6340 = 6300 – 63X + 65X$ $6340 = 6300 + 2X$ $40 = 2X$ $X /65 = 20\%$ Correct answer with or without working scores (2)	

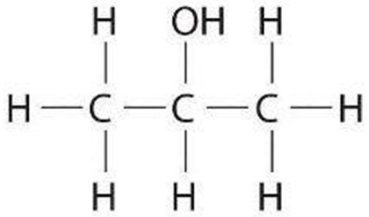
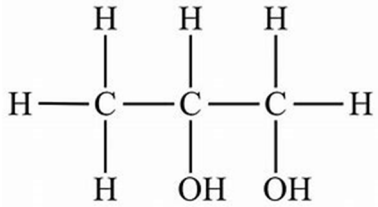
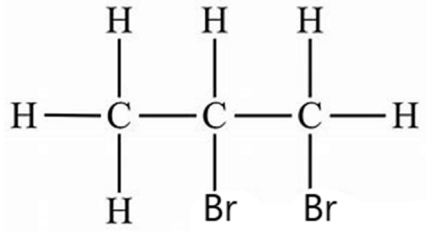
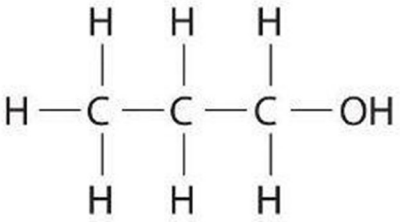
Question Number	Answer	Additional Guidance	Mark
20(c)(i)	• a correct balanced equation	$CuCO_3 + H_2SO_4 \rightarrow CuSO_4 + CO_2 + H_2O$ **or** $CuCO_3 + 2H^+ \rightarrow Cu^{2+} + CO_2 + H_2O$ Allow multiples Ignore state symbols even if incorrect Do not award H_2CO_3 as a product	**(1)**

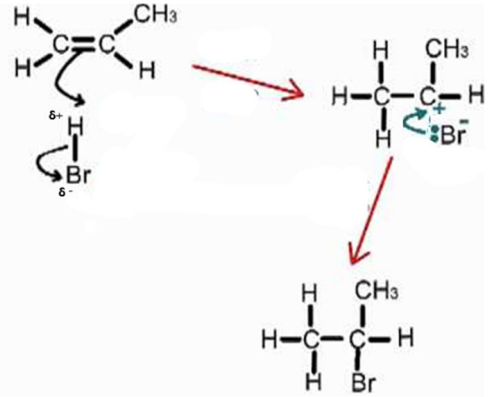
Question Number	Answer		Additional Guidance	Mark
20(c)(ii)	• M1moles of sulfuric acid • M2 maximum mass of copper(II) sulfate • M3 percentage yield calculation • M4 answer to 2 or 3 SF Correct answer with some working scores (4)	**(1)** **(1)** **(1)** **(1)**	<u>Example of calculation</u> $50 \times 1.00 \div 1000 = 0.05$ (mol) / 5×10^{-2} (mol) $0.05 \text{ (mol)} \times 249.6 = 12.48$ (g) Allow TE on M1 $100 \times 10.87 \div 12.48 = 87.099$ Allow TE on M2 unless over 100% 87(%) / 87.1(%) Alternative method $50 \times 1.00 \div 1000 = 0.05$ (mol) / 5×10^{-2} (mol) 10.87 (g) / 249.6 (g) = 0.04355 (mol) /4.355×10^{-2} (mol) $100 \times 4.355 \times 10^{-2} / 5 \times 10^{-2} = 87.099$ Allow TE on M1 and M2 unless over 100% 87(%) / 87.1(%) M4 dependent on a sensible calculation that involves either a mass or moles that has been calculated. Ignore incorrect rounding by truncating intermediate figures eg 0.435 (mol)	**(4)**

(Total for Question 20 = 14 marks)

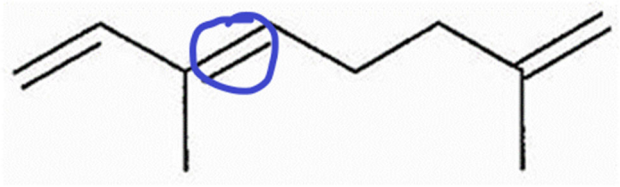
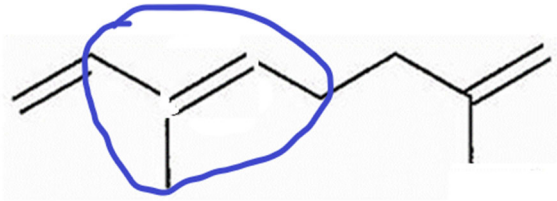
Question Number	Answer	Additional Guidance	Mark
21(a)	An answer that makes reference to the following points:  σ (1) π (1)  All three of the above score 2 marks	One mark for each of the bonds labelled. The π bond **must** be above **and** below the carbons but only one of the lobes of the π bond needs to be labelled Ignore overlap of orbitals where the sigma bond extends beyond the carbon atoms Ignore extra labelled sigma bonds to hydrogen	**(2)**

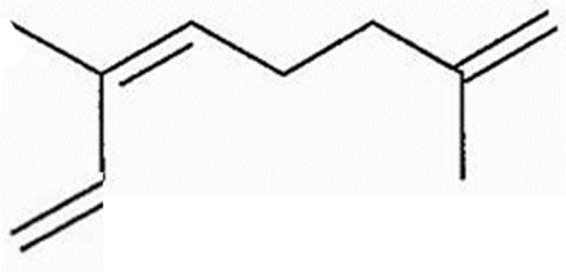
	 Scores 0	Do not award single lines as there must be an area of electron density.	
	 Scores 0	Do not award if the orbits are shown overlapping in a random position away from the Cs.	
	 Scores 0	Do not award electron rings or contour lines Allow if both bonds are correct and labelled the wrong way round score (1)	

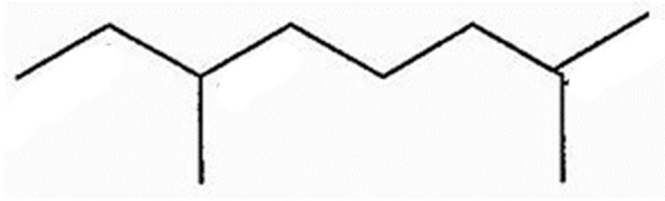
Question Number	Answer	Additional Guidance	Mark
21(b)(i)	Steam and catalyst  **(1)** Acidified potassium manganate(VII)  **(1)** Bromine  **(1)**	Accept skeletal / structural formulae/ or a combination Allow  Ignore connectivity of OH unless horizontal but penalise only once Ignore names even if incorrect If wrong number of carbon atoms penalise once only. Do not award any structure with missing bonds.	**(3)**

Question Number	Answer	Additional Guidance	Mark
21(b)(ii)	An explanation that makes reference to the following points:  • dipole on HBr and two correct curly arrows **(1)** • correct intermediate **(1)** • curly arrow from **lone pair** on Br^- to C^+ or the space between the Br^- to C^+ **(1)**	Arrows must start from the covalent bond. From the H—Br bond it must go to the Br or beyond. From the C=C bond is must go to the H or in the space. If Br_2 is added M2 and M3 can be scored If 1-bromopropane is the product the intermediate mark cannot be scored so Max 2 Penalise half curly arrows once only If wrong alkene Allow M1 and M3 only. Ignore the product even if incorrect	**(3)**

Question Number	Answer	Additional Guidance	Mark
21(c)(i)	• $C_{10}H_{16}$	$H_{16}C_{10}$ Ignore working and any names	(1)

Question Number	Answer	Additional Guidance	Mark
21(c)(ii)	 **or** 	Allow any circle that includes the correct double bond and does not extend beyond the OR answer.	(1)

Question Number	Answer	Additional Guidance	Mark
21(c)(iii)	• correct skeletal formula	Example of formula:  Ignore angles and lengths of bonds	**(1)**

Question Number	Answer		Additional Guidance	Mark
21(c)(iv)	An answer that makes reference to the following points: • moles of hydrogen / H_2 • ratio of moles hydrogen / H_2 to alpha-ocimene = number of C=C that react • Correct structure  If there is no calculation or calculation says H_2 is in excess M3 can be awarded.	**(1)** **(1)** **(1)**	<u>Example of calculation</u> 3.6 ÷ 24 = 0.15 (mol) 0.15 ÷ 0.05 = 3 Allow TE incorrect moles of H_2 Allow TE on incorrect ratio of 1 or 2. Ignore length of bonds/bond angles Allow structural or displayed formulae	**(3)**

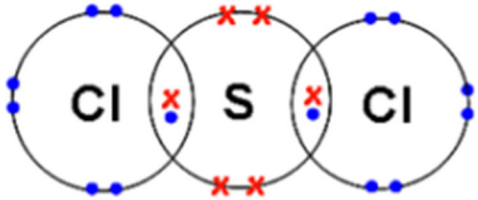
(Total for Question 21 = 14 marks)

Question Number	Answer	Additional Guidance	Mark
22(a)(i)	• (metallic bonding is) the **attraction** between positive ions/cations and **delocalised** electrons	Can be shown as a labelled diagram including the word **attraction.** Allow **electrostatic forces** as an alternative to **attraction** Allow **attraction** between metal ions and **delocalised** electrons Allow **attraction** between (positive) nuclei and **delocalised** electrons Ignore just 'ions' Ignore free moving electrons/ sea of electrons	**(1)**

Question Number	Answer		Additional Guidance	Mark
22(a)(ii)	An explanation that makes reference to three of the following points			**(3)**
	• M1 Mg has more **delocalised** electrons	**(1)**	Allow Mg loses two electrons **and** Na one to form **delocalised** electrons Ignore free moving electrons	
	• M2 **Mg^{2+}** is smaller (than Na^{+})	**(1)**	Allow Mg ion is smaller (than Na^{+}) Allow Mg smaller ionic radius Do not award atomic radius	
	• M3 **Mg^{2+}** has a higher charge (than Na^{+})	**(1)**	Allow Mg ion has a higher charge (than Na^{+}) Ignore the number of protons Just Mg^{2+} 'has a greater charge density' scores (1) for M2 & M3	
	• M4 Greater attraction between the **delocalised** electrons and the Mg^{2+} ions/ Mg^{2+} nuclei	**(1)**	Allow greater attraction between the delocalised electrons and Mg Ignore attraction to the protons Ignore outer shell electrons Allow reverse argument for all points	

Question Number	Answer	Additional Guidance	Mark
22(b)(i)	• (the electrostatic attraction between) the shared (pair of) electrons and the (two) nuclei (of the bonded atoms)	Allow single nucleus	**(1)**

Question Number	Answer	Additional Guidance	Mark
22(b)(ii)	An explanation that makes reference to the following points: • phosphorus (P) simple molecular **(1)** • silicon (Si) giant (covalent/molecular) structure **(1)** • when phosphorus melts weak London forces are broken **and** when silicon melts strong covalent bonds are broken **(1)**	Allow (small) molecules/ P_4/ just 'molecular'/simple covalent Allow lattice instead of giant Ignore macromolecular Do not award giant metallic/ionic Allow / dispersion /van der Waals forces/ instantaneous dipole-induced dipole/intermolecular forces Do not award if any mention of intermolecular forces for silicon.	**(3)**

Question Number	Answer	Additional Guidance	Mark
22(c)(i)	An explanation that makes reference to the following points: • dot-and-cross diagram showing two shared pairs of electrons between S and Cls **(1)** • rest of diagram correct **(1)**	Example of dot-and-cross diagram  Allow all dots/all crosses/dots crosses the wrong way round Allow the non-bonded pairs of electrons on S and Cl anywhere and allow non-bonding electrons unpaired. Ignore inner shells Charged species/ions scores 0	**(2)**

Question Number	Answer	Additional Guidance	Mark
22(c)(ii)	An answer that makes reference to the following points: • bond angle 104.5(º) **(1)** • four pairs of electrons/ 2 bonding pairs and 2 lone pairs occupy a position of minimum repulsion **(1)** • (2)lone pairs repel more than bonding pairs (so the angle is reduced from 109.5 (º)) **(1)**	Allow 102-105 (actual answer 103º) Allow just electron pairs occupying a position of minimum repulsion and do not penalise for an incorrect number of electron pairs if quoted. Allow maximum separation Ignore bonds/ areas of electron density/atoms Ignore any reference to shapes e.g. angular, V-shaped	**(3)**

(Total for Question 22 = 13 marks)

Question Number	Answer	Additional Guidance	Mark
23(a)(i)	• $Li(g) \rightarrow Li^{+}(g) + e^{(-)}$	Both species and states must be correct Allow $Li(g) - e^{(-)} \rightarrow Li^{+}(g)$ Ignore state symbol on e^{-}	**(1)**

Question Number	Answer	Additional Guidance	Mark
23(a)(ii)	An explanation that makes reference to the following points: • (on moving across the period) there is an increase in the number of protons/atomic number/nuclear charge **(1)** • (The electrons are in the same shell so there is a) greater attraction between the nucleus and electron(s) **(1)**	Allow effective nuclear charge Allow smaller atomic radius Allow same/similar shielding Allow attraction between protons and electrons	**(2)**

Question Number	Answer	Additional Guidance	Mark
23(a)(iii)	An explanation that makes reference to the following points: Oxygen (even though it has one more proton) • M1 the electron is being removed from a (2)**p orbital** that is **paired** / **full** **(1)** • M2 less energy is needed to remove a **paired** electron / there is repulsion between the **paired** electrons **(1)** OR Nitrogen (even though it has one fewer proton) • M1 the electron is being removed from a (2)**p orbital** that is **unpaired** **(1)** • M2 more energy is needed to remove an **unpaired** electron **(1)**	Allow the electron is being removed from the **pair** of electrons in the (2)**p sub-shell** Allow the **p orbital** contains **two electrons** Do not award p shell Do not award 3p Allow there is spin-pair repulsion Allow easier to remove a paired electron Allow there is repulsion between the electrons if pairing or 2 electrons of full orbital is mentioned in M1 Allow the electron is being removed from a half-filled (2)**p sub-shell** Allow the electron is being removed from a (2)**p orbital** that only contains **one** electron. Do not award p shell Do not award 3p Allow more energy is required to remove this electron if unpaired is mentioned in M1 Allow this arrangement is stable, so more energy is needed to remove the electron M1 can be scored with a diagram Ignore reference to shielding/lone pairs	**(2)**

Question Number	Answer	Additional Guidance	Mark
23(b)	An answer that makes reference to two of the following points: o M1 (General increase because there is the same positive charge) but fewer electrons/ less repulsion between elections/ electrons getting closer to the nucleus/ ion becoming increasingly more positive/increase in effective nuclear charge **(1)** o M2 there is a big jump between 5^{th}-6^{th} ionisation energies as the 6^{th} electron is removed from a new shell/ quantum shell/ energy level (closer to the nucleus) **(1)** o M3 there is a jump between 3^{rd} - 4^{th} ionisation energies as the 4^{th} electron is removed from a new sub shell/2s (closer to the nucleus) **(1)**	Allow there is a big jump between 5^{th}-6^{th} ionisation energies as nitrogen has 5 electrons in its outer shell Ignore it is in group 5 Allow there is a big jump between 5^{th}-6^{th} ionisation energies as the inner electrons have no shielding	**(2)**

(Total for Question 23 = 7 marks)

Question Number	Answer	Additional Guidance	Mark
24(a)	• M1conversion of volume to m^3 **(1)** • M2 rearrangement of Ideal Gas Equation **(1)** • M3 conversion of pressure and evaluation to give number of moles **(1)** • M4 calculation of molar mass **(1)**	Example of calculation $72.5 \times 10^{-6} = 7.25 \times 10^{-5}$ / 0.0000725 (m^3) $n = \frac{pV}{RT}$ $\frac{100000 \times 7.25 \times 10^{-5}}{8.31 \times 358} = 2.4370 \times 10^{-3}$ / 0.002437(mol) Allow TE on volume from M1 $\frac{0.210}{2.4370 \times 10^{-3}} = 86.172 = 86$ (g mol^{-1}) Allow TE on moles from M3 Ignore SF except 1SF Ignore units even if incorrect	**(4)**

Question Number	Answer	Additional Guidance	Mark
24(b)	• hexane or any alkane with the molecular formula of C_6H_{14}	Allow name or structural/displayed/skeletal formula Allow TE on sensible mass from (a) If no mass allow hexane If both name and formula/structure given they must match The name or formula must match the mass in (a)	**(1)**

(Total for Question 24 = 5 marks)
(Total for Section B = 60 marks)
TOTAL FOR PAPER = 80 MARKS