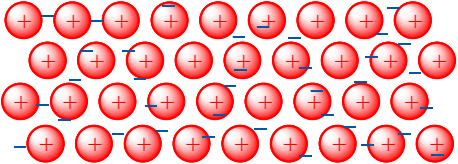


F321 Atoms, Bonds and Groups

Question			Expected Answers	Marks	Additional Guidance												
1	(a)	(i)	<table border="1"> <thead> <tr> <th></th> <th>protons</th> <th>neutrons</th> <th>electrons</th> </tr> </thead> <tbody> <tr> <td>^{24}Mg</td> <td>12</td> <td>12</td> <td>12</td> </tr> <tr> <td>^{25}Mg</td> <td>12</td> <td>13</td> <td>12</td> </tr> </tbody> </table> <p>^{24}Mg line correct ✓ ^{25}Mg line correct ✓</p>		protons	neutrons	electrons	^{24}Mg	12	12	12	^{25}Mg	12	13	12	2	mark by row
	protons	neutrons	electrons														
^{24}Mg	12	12	12														
^{25}Mg	12	13	12														
		(ii)	$\frac{24 \times 78.60 + 25 \times 10.11 + 26 \times 11.29}{100}$ <p>OR $18.8640 + 2.5275 + 2.9354$</p> <p>OR 24.3269 ✓</p> <p>$A_r = 24.33$ (to 4 sig figs) ✓</p>	2	<p>ALLOW two marks for $A_r = 24.33$ with no working out</p> <p>ALLOW one mark for ecf from incorrect sum provided final answer is between 24 and 26 and is to 4 significant figures, e.g. 24.3235 * gives ecf of 24.32 ✓</p>												
		(iii)	<p>The (weighted) mean mass of an atom OR (weighted) average mass of an atom ✓</p> <p>relative to $1/12^{\text{th}}$ (the mass) ✓</p> <p>of (one atom of) ^{12}C ✓</p>	3	<p>ALLOW The (weighted) mean mass OR (weighted) average mass of an atom OR average atomic mass ✓ compared with (the mass of) carbon-12 ✓ which is 12 ✓</p> <p>For 1st marking point, ALLOW mean mass of the isotopes OR average mass of the isotopes Do NOT ALLOW the singular: isotope</p> <p>ALLOW mass of one mole of atoms ✓ compared to $1/12^{\text{th}}$ ✓ (the mass) of one mole / 12 g of carbon-12 ✓</p>												

Question		Expected Answers	Marks	Additional Guidance
				$\frac{\text{mass of one mole of atoms}}{12}$ ✓ 1/12th ✓ the mass of one mole / 12 g of carbon-12 ✓
(b)	(i)	Mg ✓ oxidation number changes from 0 to (+)2 OR oxidation number increases by 2 ✓	2	ALLOW correct oxidation numbers shown in equation 2nd mark is dependent on identification of Mg IGNORE electrons
	(ii)	Mg/solid dissolves OR Mg/solid disappears OR (Mg/solid) forms a solution ✓ bubbles OR fizzes OR effervesces OR gas produced ✓	2	IGNORE metal reacts IGNORE temperature change IGNORE steam produced DO NOT ALLOW carbon dioxide gas produced DO NOT ALLOW hydrogen produced without gas
(c)	(i)	$M(\text{MgSO}_4) = 120.4 \text{ OR } 120 \text{ (g mol}^{-1}\text{)} \checkmark$ $\text{mol MgSO}_4 = \frac{1.51}{120.4} = 0.0125 \text{ mol } \checkmark$	2	ALLOW 0.013 up to calculator value of 0.012541528 correctly rounded (from $M = 120.4 \text{ g mol}^{-1}$) ALLOW 0.013 up to calculator value of 0.012583333 correctly rounded (from $M = 120 \text{ g mol}^{-1}$) ALLOW ecf from incorrect M i.e. $1.51 \div M$
	(ii)	$\frac{1.57}{18.0} = 0.0872(2) \text{ (mol)} \checkmark$	1	ALLOW 0.09 up to calculator value of 0.08722222
	(iii)	$x = 7 \checkmark$	1	ALLOW ecf i.e. answer to (ii) \div answer to (i) ALLOW correctly calculated answer from 1 significant figure up to calculator value, ie, x does not have to be a whole number. Likely response = 6.95 ✓
		Total	15	

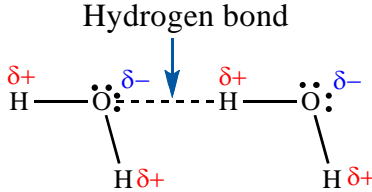
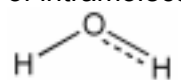
Question	Expected Answers	Marks	Additional Guidance
2 (a)	 <p>regular arrangement of labelled + ions with some attempt to show electrons ✓</p> <p>scattering of labelled electrons between other species OR a statement anywhere of delocalised electrons (can be in text below) ✓</p> <p>metallic bond as (electrostatic) attraction between the electrons and the positive ions ✓</p>	3	<p>Lattice must have at least 2 rows of positive ions If a metal ion is shown (e.g. Na⁺), it must have the correct charge</p> <p>ALLOW for labels: + ions, positive ions, cations If '+' is unlabelled in diagram, award the label for '+' from a statement of 'positive ions' in text below DO NOT ALLOW as label or text positive atom OR protons OR nuclei</p> <p>ALLOW e⁻ OR e as label for electron DO NOT ALLOW '- ' as label for electron</p>
(b) (i)	$4 \text{ Na} + \text{O}_2 \longrightarrow 2 \text{ Na}_2\text{O}$ <p>OR</p> $2 \text{ Na} + \frac{1}{2} \text{ O}_2 \longrightarrow \text{Na}_2\text{O} \checkmark$	1	<p>ALLOW correct multiples including fractions IGNORE state symbols</p>
(ii)	(electrostatic) attraction between oppositely charged ions ✓	1	

Question	Expected Answers	Marks	Additional Guidance
(iii)	<p>Na shown with either 8 or 0 electrons AND O shown with 8 electrons with 6 crosses and 2 dots (or vice versa) ✓ Correct charges on both ions ✓</p>	2	<p>For 1st mark, if 8 electrons shown around cation then 'extra' electron(s) around anion must match symbol chosen for electrons in cation Shell circles not required</p> <p>IGNORE inner shell electrons</p> <p>ALLOW: 2[Na⁺] 2[Na]⁺ [Na⁺]₂ (brackets not required) DO NOT ALLOW [Na₂]²⁺ / [Na₂]⁺ / [2Na]²⁺ DO NOT ALLOW: [Na₂]²⁺ [Na₂]⁺ [2Na]²⁺ [Na]₂⁺</p>
(c)	<p>sodium is a (good) conductor because it has mobile electrons OR delocalised electrons OR electrons can move ✓</p> <p>sodium oxide does not conduct as a solid ✓</p> <p>sodium oxide conducts when it is a liquid ✓</p> <p>ions cannot move in a solid ✓</p> <p>ions can move OR are mobile when liquid ✓</p>	5	<p>Throughout this question, 'conducts' and 'carries charge' are treated as equivalent terms.</p> <p>DO NOT ALLOW 'free electrons' for mobile electrons</p> <p>ALLOW poor conductor OR bad conductor 'Sodium oxide only conducts when liquid' is insufficient to award 'solid conductivity' mark</p> <p>ALLOW ions are fixed in place IGNORE electrons IGNORE charge carriers</p> <p>IGNORE 'delocalised ions' or 'free ions' for mobile ions Any mention of electrons moving is a CON</p>
	Total	12	

Question			Expected Answers	Marks	Additional Guidance
3	(a)	(i)	mol HCl = 1.50×10^{-2} ✓ volume HCl(aq) = 75.0 ✓	2	ALLOW answers to 2 significant figures ALLOW ecf from wrong number of moles i.e. $\frac{\text{moles of HCl} \times 1000}{0.200}$ ALLOW one mark for 37.5 (from incorrect 1:1 ratio)
		(ii)	180 ✓	1	No other acceptable answer
	(b)		$\text{CaCO}_3(\text{s}) \longrightarrow \text{CaO}(\text{s}) + \text{CO}_2(\text{g})$ equation ✓ state symbols ✓	2	state symbols are dependent on correct formulae of CaCO_3 , CaO and CO_2 DO NOT ALLOW the 'equation mark' if O_2 is seen on both sides (but note that the 'state symbol mark' may still be accessible)
	(c)	(i)	$\text{Ca}(\text{OH})_2$ ✓	1	IGNORE charges, even if wrong
		(ii)	$\text{Ca}(\text{NO}_3)_2$ ✓	1	IGNORE charges, even if wrong
			Total	7	

Question		Expected Answers	Marks	Additional Guidance
4	(a) (i)	the energy required to remove one electron ✓ from each atom in one mole ✓ of gaseous atoms ✓	3	<p>ALLOW 3 marks for: the energy required to remove one mole of electrons ✓ from one mole of atoms ✓ atoms in the gaseous state ✓</p> <p>If no definition, ALLOW one mark for the equation below, including state symbols. $X(g) \rightarrow X^+(g) + e^-$ / $X(g) - e^- \rightarrow X^+(g)$ ALLOW e for electron IGNORE state symbol for electron</p>
	(b) (i)	<p>outer electrons closer to nucleus OR radii decreases ✓</p> <p>nuclear charge increases OR protons increase ✓</p> <p>electrons added to the same shell OR screening OR shielding remains the same ✓</p>	3	<p>IGNORE 'atomic number increases' IGNORE 'nucleus gets bigger' 'charge increases' is not sufficient ALLOW 'effective nuclear charge increases' OR 'shielded nuclear charge increases'</p> <p>ALLOW shielding is similar</p>
	(ii)	<p>atomic radii increase OR there are more shells ✓</p> <p>there is more shielding OR more screening ✓</p>	3	<p>ALLOW electrons in higher energy level ALLOW electrons are further from the nucleus DO NOT ALLOW more orbitals OR more sub-shells DO NOT ALLOW different shell or new shell</p> <p>There must be a clear comparison: e.g. 'more shielding', 'increased shielding'. i.e. DO NOT ALLOW just 'shielding'. ALLOW 'more electron repulsion from inner shells'</p>

Question		Expected Answers	Marks	Additional Guidance
		the nuclear attraction decreases OR Increased shielding / distance outweigh the increased nuclear charge ✓		Nuclear OR proton(s) OR nucleus spelt correctly ONCE ALLOW 'nuclear pull' IGNORE any reference to 'effective nuclear charge'
	(c) (i)	$O^+(g) \longrightarrow O^{2+}(g) + e^-$ ✓	1	answer must have state symbols ALLOW e for electron ALLOW $O^+(g) - e^- \rightarrow O^{2+}(g)$ DO NOT ALLOW $O^+(g) + e^- \longrightarrow O^{2+}(g) + 2e^-$ IGNORE state symbol for electron
	(ii)	the O^+ ion, is smaller than the O atom OR the electron repulsion/shielding is smaller OR the proton : electron ratio in the 2+ ion is greater than in the 1+ ion ✓	1	ALLOW the outer electrons in an O^+ ion are closer to the nucleus than an O atom DO NOT ALLOW 'removed from next shell down'
		Total	11	

Question		Expected Answers	Marks	Additional Guidance
5	(a)	(i) number of protons (in the nucleus) ✓	1	ALLOW proton number ALLOW number of protons in an atom IGNORE reference to electrons
		(ii) $(1s^2)2s^22p^63s^23p^63d^24s^2$ ✓	1	ALLOW $1s^2$ written twice ALLOW subscripts ALLOW $4s^2$ before $3d^2$
		(iii) Mn / manganese and d ✓	1	ALLOW D
	(b)	(i) <p style="text-align: center;">Hydrogen bond</p>  <p>Shape of water with at least one H with $\delta+$ and at least one O with $\delta-$ ✓</p> <p>H-bond between H in one water molecule and a lone pair of an O in another water molecule ✓</p> <p>hydrogen bond labelled OR H_2O has hydrogen bonding ✓</p>	3	all marks can be awarded from a labelled diagram If HO_2 shown then DO NOT ALLOW 1st mark Dipole could be described in words so it does not need to be part of diagram. At least one hydrogen bond must clearly hit a lone pair Lone pair interaction could be described in words so it does not need to be part of diagram. DO NOT ALLOW hydrogen bonding if described in context of intramolecular bonding, <i>ie</i> 
		(ii) no hydrogen bonding OR weaker intermolecular forces ✓	1	DO NOT ALLOW 'weaker' / 'weak' hydrogen bonding ALLOW weaker van der Waals' forces ALLOW weaker dipole-dipole interactions DO NOT ALLOW 'weak intermolecular forces' (<i>ie</i> comparison essential here) DO NOT ALLOW 'no intermolecular forces'

Question	Expected Answers	Marks	Additional Guidance
(c)	van der Waals' forces OR induced dipole interactions ✓ number of electrons increases ✓ Down the group , intermolecular forces / van der Waals' forces increase OR Down the group , more energy needed to break intermolecular / van der Waals' forces ✓	3	electron(s) must be seen and spelt correctly ONCE ALLOW number of electron shells increases ALLOW iodine has most electrons ALLOW chlorine has the least electrons For ' Down the group ' ALLOW 'Increase in boiling points' or 'Molecules get bigger'
(d) (i)	goes brown ✓	1	ALLOW yellow OR orange OR any shade of yellow, orange and brown, e.g. reddish-brown IGNORE precipitate
(ii)	iodine and (potassium) chloride ✓ $\text{Cl}_2 + 2\text{I}^- \longrightarrow \text{I}_2 + 2\text{Cl}^-$ ✓	2	DO NOT ALLOW formulae (<i>i.e.</i> names essential) ALLOW any correct multiple including fractions IGNORE state symbols
(iii)	chlorine / Cl_2 is more reactive (than iodine) OR chlorine / Cl_2 is a more powerful oxidising agent ✓	1	ALLOW chlorine is better at electron capture OR chlorine attracts electrons more ALLOW iodine is less reactive (than chlorine) ALLOW iodide (ion) / I^- is a stronger reducing agent DO NOT ALLOW Cl is more reactive DO NOT ALLOW explanation in terms of displacement DO NOT ALLOW chlorine is more electronegative
(iv)	goes purple / violet / lilac / pink ✓	1	ALLOW pink OR any combination of purple, violet, lilac and pink
	Total	15	