F321 Atoms, Bonds and Groups

<table>
<tr><th colspan="3">Question</th><th>Expected Answers</th><th>Marks</th><th>Additional Guidance</th></tr>
<tr><td>1</td><td>(a)</td><td>(i)</td><td>
<table>
<tr><th></th><th>protons</th><th>neutrons</th><th>electrons</th></tr>
<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>
</table>
^{24}Mg line correct ✓
^{25}Mg line correct ✓</td><td>2</td><td>mark by row</td></tr>
<tr><td></td><td></td><td>(ii)</td><td><u>24 x 78.60 + 25 x 10.11 + 26 x 11.29</u>
100

OR 18.8640 + 2.5275 + 2.9354

OR 24.3269 ✓

A_r = 24.33 (to 4 sig figs) ✓</td><td>2</td><td>ALLOW two marks for A_r = 24.33 with no working out

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 ✓</td></tr>
<tr><td></td><td></td><td>(iii)</td><td>The (weighted) mean mass of an atom
OR (weighted) average mass of an atom ✓

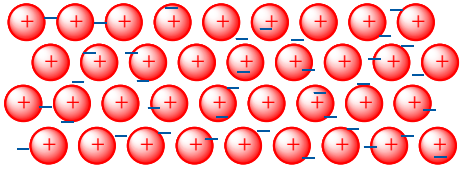
relative to 1/12th (the mass) ✓

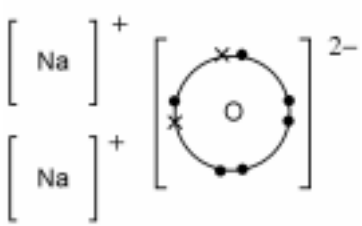
of (one atom of) ^{12}C ✓</td><td>3</td><td>ALLOW The (weighted) mean mass
OR (weighted) average mass of an atom
OR average atomic mass ✓
compared with (the mass of) carbon-12 ✓
which is 12 ✓

For 1st marking point, ALLOW mean mass of the isotopes
OR average mass of the isotopes
Do NOT ALLOW the singular: isotope

ALLOW mass of one mole of atoms ✓
compared to 1/12th ✓
(the mass) of one mole / 12 g of carbon-12 ✓</td></tr>
</table>

Question			Expected Answers	Marks	Additional Guidance
					mass of one mole of atoms ✓ 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)**	$M(MgSO_4)$ = 120.4 OR 120 (g mol^{-1}) ✓ mol $MgSO_4$ = $\frac{1.51}{120.4}$ = *0.0125 mol* ✓	**2**	**ALLOW** 0.013 up to calculator value of 0.012541528 correctly rounded (from M = 120.4 g mol^{-1}) **ALLOW** 0.013 up to calculator value of 0.012583333 correctly rounded (from M = 120 g mol^{-1}) **ALLOW** ecf from incorrect M i.e. 1.51 ÷ M
		(ii)	$\frac{1.57}{18.0}$ = 0.0872(2) (mol) ✓	**1**	**ALLOW** 0.09 up to calculator value of 0.08722222
		(iii)	***x*** = 7 ✓	**1**	**ALLOW** ecf i.e. answer to (ii) ÷ 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**	

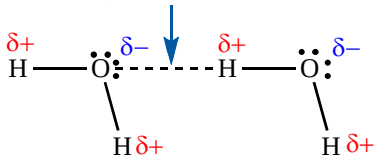
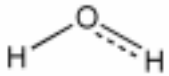
Question			Expected Answers	Marks	Additional Guidance
2	(a)		 regular arrangement of **labelled** + ions with some attempt to show electrons ✓ scattering of labelled electrons **between** other species **OR** a statement anywhere of **delocalised** electrons (can be in text below) ✓ metallic bond as (electrostatic) **attraction** between the electrons and the positive ions ✓	3	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 **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 **ALLOW** e^- **OR** e as label for electron **DO NOT ALLOW** '–' as label for electron
	(b)	**(i)**	$4\ Na + O_2 \longrightarrow 2\ Na_2O$ **OR** $2\ Na + ½\ O_2 \longrightarrow Na_2O$ ✓	**1**	**ALLOW** correct multiples including fractions **IGNORE** state symbols
		(ii)	(electrostatic) attraction between oppositely charged ions✓	**1**	

Question			Expected Answers	Marks	Additional Guidance
		(iii)	 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 ✓	**2**	**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 **IGNORE** inner shell electrons **ALLOW:** $2[Na^+]$ $2[Na]^+$ $[Na^+]_2$ (brackets not required) **DO NOT ALLOW** $[Na_2]^{2+}$ / $[Na_2]^+$ / $[2Na]^{2+}$ **DO NOT ALLOW**: $[Na_2]^{2+}$ $[Na_2]^+$ $[2Na]^{2+}$ $[Na]_2^+$
	(c)		sodium is a (good) conductor because it has mobile electrons **OR** delocalised electrons **OR** electrons can move ✓ sodium oxide does not conduct as a solid ✓ sodium oxide conducts when it is a liquid ✓ ions cannot move in a solid ✓ **ions** can move **OR** are mobile when liquid ✓	**5**	**Throughout this question, 'conducts' and 'carries charge' are treated as equivalent terms.** **DO NOT ALLOW** 'free electrons' for mobile electrons **ALLOW** poor conductor **OR** bad conductor 'Sodium oxide only conducts when liquid' is insufficient to award 'solid conductivity' mark **ALLOW** ions are fixed in place **IGNORE** electrons **IGNORE** charge carriers **IGNORE** 'delocalised ions' or 'free ions' for mobile ions Any mention of electrons moving is a **CON**
			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)		$CaCO_3(s) \longrightarrow CaO(s) + CO_2(g)$ 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)	$Ca(OH)_2$ ✓	1	**IGNORE** charges, even if wrong
		(ii)	$Ca(NO_3)_2$ ✓	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	**ALLOW** 3 marks for: the energy required to remove one mole of electrons ✓ from one mole of atoms ✓ atoms in the gaseous state ✓ 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
	(b)	(i)	outer electrons closer to nucleus **OR** radii decreases ✓ nuclear charge increases **OR** protons increase ✓ electrons added to the same shell **OR** screening **OR** shielding remains the same ✓	3	 **IGNORE** 'atomic number increases' **IGNORE** 'nucleus gets bigger' 'charge increases' is not sufficient **ALLOW** 'effective nuclear charge increases' **OR** 'shielded nuclear charge increases' **ALLOW** shielding is similar
		(ii)	atomic radii increase **OR** there are more shells ✓ there is **more** shielding **OR more** screening ✓	3	**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 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'

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)	Hydrogen bond  Shape of water with at least one H with δ+ and at least one O with δ– ✓ H-bond between H in one water molecule and a lone pair of an O in another water molecule✓ hydrogen bond labelled **OR** H_2O has hydrogen bonding ✓	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, *ie* 
		(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' (ie 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 ✓ $Cl_2 + 2I^- \longrightarrow I_2 + 2Cl^-$ ✓	2	**DO NOT ALLOW** formulae (*i.e.* 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	