Question	Marking Guidance	Mark	Comments
1(a)	Water or H_2O or molecules (in ice) are held further apart (than in liquid water)/(more) space/gaps/holes in structure/ Water or H_2O or molecules (in ice) are more spread out	1	Allow water (liquid) is more compact / less space/gaps/holes CE if holes filled with air, O_2 etc CE if macromolecule CE if atoms further apart (since ambiguous) Ignore spaces filled with H_2O Ignore reference to H bonds Allow better tessellation in liquid water
1(b)(i)	Hydrogen bonding	1	Allow H bonds Do not allow 'hydrogen' only but mark on
1(b)(ii)	Van der Waals' / VdW	1	Allow London forces, dispersion forces, temporary induced dipole forces

1(b)(iii)	Hydrogen bonding is stronger (than van der Waals forces) / IMF in ice stronger (than IMF in methane)/ H bonds take more energy to break	1	Not H Bonds are strong (needs comparison)
			If (b)(i) OR (ii) is incorrect, cannot award (b)(iii)
			If (b)(i) and /or (ii) is blank, can score (b)(iii)

1(c)(i)	Structure showing 3 bonds to H and 1 lone pair (trigonal) pyramid(al) /(distorted) tetrahedral	1 1	do not insist on the + sign Allow triangular pyramid Not square pyramid Ignore bond angles in structure M2 independent of M1
1(c)(ii)	107°	1	Allow range106 - 108° Ignore ° (C)
1(c)(iii)	NH_3 /ammonia	1	Contradictions (eg NH_4 ammonia) CE = 0
1(d)	3	1	Allow three/ III/ 3 lone pairs/ 3lp/ 3 lone pairs of electrons

Question	Marking Guidance	Mark	Comments
2(a)	$4d^{10}5s^2\,5p^1$ in any order	1	Allow subscripts for numbers Allow capitals
2(b)(i)	Using an electron gun / (beam of) high energy/fast moving electrons	1	Ignore 'knocks out an electron'
2(b)(ii)	$In(g) + e^- \rightarrow In^+(g) + 2e^-$ ***OR*** $In(g) \rightarrow In^+(g) + e^-$ $In(g) - e^- \rightarrow In^+(g)$	1	The state symbols need not be present for the electron- but if they are they must be (g) No need to show charge on electron If I CE = 0 Ignore any equations using M
2(b)(iii)	So no more than 1 electron is knocked out/ so only one electron is knocked out/ prevent further ionisation	1	Allow stop 2+ and 3+/other ions being formed Not to get wrong m/z
2(b)(iv)	Any two processes from • Accelerate (owtte) • Deflect (owtte) • Detect (owtte)	2 max	Ignore wrong causes of process

2(c)(i)	Average/mean mass of (1) atom(s) (of an element) 1/12 mass of one atom of ^{12}C ***OR*** (Average) mass of one mole of atoms 1/12 mass of one mole of ^{12}C ***OR*** (Weighted) average mass of all the isotopes 1/12 mass of one atom of ^{12}C ***OR*** Average mass of an atom/isotope compared to C-12 on a scale in which an atom of C-12 has a mass of 12	1 1	Not average mass of 1 molecule Allow the wording Average mass of 1 atom of an element compared to 1/12 mass atom of ^{12}C (or mass 1/12 atom of ^{12}C) Allow if moles of atoms on both lines Accept answer in words Can have top line x 12 instead of bottom line ÷12 If atoms/moles mixed, max = 1
2(c)(ii)	$\frac{113x + 115y}{x + y} = 114.5$ ratio (113:115) = 1:3 **OR** 25:75 **OR** 0.5:1.5 etc	1 1	Allow idea that there are 4 x 0.5 divisions between 113 and 115 Correct answer scores M1 and M2 If 1:3 for In(115): In(113), max = 1
2(d)	None Same no of electrons (in the outer shell)/same electron configuration	1 1	 Ignore electrons determine chemical properties/ ignore protons M2 dependent on M1 being correct

2(e)	29.0% /29% O $\frac{69.2}{114.8/114.5}$ $\frac{1.8}{1}$ $\frac{29.0}{16}$ or 0.603 1.8 1.81 1 3 3 EF = InH_3O_3	1 1 1	If no O calculated, allow M2 if In and H divided by the correct A_r Allow $In(OH)_3$ Do not allow last mark just for ratio 1:3:3 If InO_3H_3 given with no working then allow 3 marks If I not In, lose M3

Question	Marking Guidance	Mark	Comments
3(a)(i)	$\underline{4.98 \times 10^{-3}}$	1	Only
3(a)(ii)	2.49×10^{-3}	1	Allow answer to 3(a)(i) ÷ 2 Allow answers to 2 or more significant figures
3(a)(iii)	2.49×10^{-2}	1	Allow 3(a)(ii) x 10 Allow answers to 2 or more significant figures
3(a)(iv)	138.2	1	3.44 divided by the candidate's answer to 3(a)(iii) 138.2 or 138.1 (i.e. to 1 d.p.)
3(a)(v)	(138 - 60) ÷ 2 = 39.1 K/ potassium	1 1	Allow 39 – 39.1 Allow ((a)(iv) – 60) ÷ 2 Allow consequential on candidate's answer to a(iv) and a(v) if a group 1 metal Ignore + sign
3(b)	PV = n RT or rearranged $T = \frac{0.022 \times 100000}{0.658 \times 8.31}$ 402(.3) K (or 129 ^{o}C)	1 1 1	If incorrectly rearranged CE = 0 Correct M2 also scores M1 allow 402- 403K or 129- 130^{o}C do not penalise ^{o}K M3 must include units for mark
3(c)	Pressure build up from gas/ may explode/ stopper fly out/glass shatters/breaks	1	Penalise incorrect gas
3(d)(i)	M_r =84.3 $\frac{6.27}{}$ = 0.074(4) 84.3	1 1	If 84 used, max 1 CE if not 84 or 84.3 Allow answers to 2 or more significant figures M2 = 0.074-0.075
3(d)(ii)	M1 M_r $MgSO_4$ = 120(.4) M2 Expected mass $MgSO_4$ =0.074(4) x120(.4)= 8.96 g M3 95% yield = $\frac{8.96 \times 95}{100}$ = 8.51 g Alternative method M2 0.074(4) x 95/100 = 0.0707 M3 0.0707 x 120(.4) = 8.51 g	1 1 1	allow 120.3 and 120.1 CE if wrong Mr Allow 8.8 – 9.0 or candidate's answer to 3(d)(i) x 120(.4) Allow 8.3 – 8.6 M3 dependent on M2 Allow 3d(i) x 95/100 Allow 8.3 – 8.6 M3 dependent on M2

4)

estion	Marking Guidance	Mark	Comments
(a)	Macromolecular/giant covalent/ giant molecular / giant atomic Many/strong covalent bonds Bonds must be broken/overcome	1 1 1	If IMF/H-bonds/Ionic/metallic CE =0/3 covalent bond between molecules CE = 0/3 If giant unqualified M1 = 0 but mark on M2 and M3 can only be scored if covalent mentioned in answer Ignore metalloid and carbon Ignore bp Ignore numbers of bonds and references to energy
(b)	(Simple) <u>molecular</u> S bigger <u>molecule</u> (than P) or S_8 and P_4 references So more/ stronger <u>van der Waals'</u> forces (to be broken or overcome)	1 1 1	QoL Do not allow simple covalent for M1 Giant covalent/ionic/metallic, CE = 0 If breaking covalent bonds CE= 0/3 QoL Allow more electrons in sulfur <u>molecule</u> or S_8 Do not allow S is bigger then P Allow S <u>molecule</u> has a bigger M_r Do not allow contradictions Not just more energy to break

(c)	Regular arrangement of minimum of 6 particles in minimum of 2 rows + charge in each one (of 6) Rows/planes/sheets/layers (of atoms/ions) can slide (owtte) over one another	1 1 1	Ignore e- Do not allow ring arrangements OR structures bonded with electrons Allow +, (1+, 2+ or 3+) in ions/or in words M3 independent If ionic bonding/molecules/IMF/vdw/covalent, penalise M3 Ignore layers of electrons sliding
(d)	Bigger charge (3+ compared to 1+) ***OR*** smaller atom/ion in Al / more protons/bigger nuclear charge More free /delocalised electrons (in Al)/bigger sea of electrons in Al Stronger metallic bonding/ stronger (electrostatic) attraction between the (+) ions or nuclei and the (delocalised) electrons (or implied)	1 1 1	CE = 0 if molecules, ionic, covalent, IMF (Allow Al^{2+}) Accept 2 or 3 delocalised electrons compared to 1 in Na Must be implied that the electrons are the delocalised ones not the electrons in the shells. Accept converse arguments

Question	Marking Guidance	Mark	Comments
5(a)(i)	$Cu + 4HNO_3 \longrightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$	1	Or multiples Ignore state symbols
5(a)(ii)	**M1** HNO_3 (+) **5** **M2** NO_2 (+) **4**	2	Ignore working out M1 Credit (V) M2 Credit (IV)
5(a)(iii)	$HNO_3 + H^+ + e^- \longrightarrow NO_2 + H_2O$ OR $NO_3^- + 2H^+ + e^- \longrightarrow NO_2 + H_2O$	1	Or multiples Ignore state symbols Ignore charge on the electron unless incorrect and accept loss of electron on the RHS
5(b)(i)	**In either order** **M1** Concentration(s) (of reactants and products) remain(s) constant / stay(s) the same / remain(s) the same / do(es) not change **M2** Forward rate = Reverse / backward rate	2	For M1 accept [ ] for concentration NOT "equal concentrations" and NOT "concentration(s) is/are the same" NOT "amount" Ignore "dynamic" and ignore "speed" Ignore "closed system" It is possible to score both marks under the heading of a single feature
5(b)(ii)	**M1** The (forward) reaction / to the right is endothermic or takes in / absorbs heat OR The reverse reaction / to the left is exothermic or gives out / releases heat **M2 depends on correct M1 and must refer to temperature/heat** The equilibrium shifts / moves left to right to oppose the increase in temperature	2	M2 depends on a correct statement for M1 For M2, the equilibrium shifts/moves to absorb the heat OR to lower the temperature OR to cool the reaction
5(b)(iii)	**M1 refers to number of moles** There are fewer moles (of gas) on the left OR more moles (of gas) on the right. OR there is one mole (of gas) on the left and 2 moles on the right. **M2 depends on correct M1 and must refer to pressure** The equilibrium shifts / moves right to left to oppose the increase in pressure	2	M2 depends on a correct statement for M1 For M2, the equilibrium shifts/moves to lower the pressure.

Question		Mark	Comments
6 (a)	Ti is not produced *OR* TiC / carbide is produced OR titanium reacts with carbon *OR* Product is brittle *OR* Product is a poor engineering material	1	Penalise "titanium carbonate" Ignore "impure titanium" Credit "it / titanium is brittle"
(b)(i)	$FeTiO_3 + 3½Cl_2 + 3C \longrightarrow FeCl_3 + TiCl_4 + 3CO$	1	Ignore state symbols Credit multiples
(b)(ii)	$FeCl_3 + TiCl_4 + 7Na \longrightarrow 7NaCl + Fe + Ti$ OR (for example) $2FeCl_3 + TiCl_4 + 10Na \longrightarrow 10NaCl + 2Fe + Ti$	1	Ignore state symbols Credit multiples including ratios other than 1:1 Ignore working
(c)	Either order **M1** The Cu^{2+} / copper(II) ions / they have gained (two) electrons *OR* $Cu^{2+} + 2e^- \longrightarrow Cu$ *OR* oxidation state / number decreases (or specified from 2 to 0) **M2** The Cu^{2+} / copper(II) ions / they have been reduced	2	Penalise reference to incorrect number of electrons in **M1** For **M1**, accept "copper" if supported by correct half-equation or simplest ionic equation Ignore charge on the electron For **M2** do **not** accept "copper" alone
(d)	$2O^{2-} \longrightarrow O_2 + 4e^-$	1	Or multiples including $3O^{2-} \longrightarrow 1.5\ O_2 + 6e^-$ Ignore state symbols Ignore charge on the electron Credit the electrons being subtracted on the LHS