Question Number	Answer	Mark
9	**The only correct answer is C** (polar liquid towards the rod and non-polar liquid no deflection) *A is not correct because non-polar liquids are not deflected* *B is not correct because polar liquids are not deflected away from the rod* *D is not correct because non-polar liquids are not deflected*	**(1)** **Computer**

Question Number	Answer	Mark
12	**The only correct answer is C** (Sc^{3+}) *A is incorrect because this has no electrons so cannot be isoelectronic with a noble gas* *B is incorrect because this has one electron fewer than neon* *D is incorrect because though it has no s-electrons it has 10 d-electrons, 10 more than argon*	**(1)**

Question Number	Answer	Mark
19	**The only correct answer is C** (further substitution products are formed) *A is not correct because this is not true* *B is not correct because ultraviolet radiation is used in industrial reactions* *D is not correct because termination products are formed in low concentrations*	**(1)**

Question Number	Answer	Mark
9	**The only correct answer is D** (fluorine has more protons) *A is not correct because although this is true, it is not a reason for the ionisation energy being higher* *B is not correct because fluorine and oxygen have the same number of shells of electrons* *C is not correct because although this is true, it is not a reason for the ionisation energy being higher*	**(1)**

Question Number	Answer	Mark
4	**The only correct answer is C** (13 900 Pa) *A is not correct because the volume is converted into dm^3* *B is not correct because the temperature has been converted into degrees Celsius* *D is not correct because the nRT has been multiplied by the volume instead of divided*	**(1)**

Question Number	Answer	Mark
10	**The only correct answer is C** ([Ar] ↑↑↑↑↑ ↑) *A is not correct because the electrons in 4s and 3d have been paired before all the orbitals had been occupied* *B is not correct because the electrons in the 4s orbital has been paired before all the 3d orbitals had been occupied* *D is not correct because 4s orbital is doubly filled and these electrons have parallel spins*	**(1)**

Question Number	Answer	Mark
10	**The only correct answer is B** ($Mg^+(g) \rightarrow Mg^{2+}(g) + e^-$) *A is not correct because Mg is the first and second ionisation energies combined* *C is not correct because Mg^+ is a solid* *D is not correct because this is the first ionisation energy for Mg*	**(1)** **Computer**

Question Number	Answer	Mark
3	**The only correct answer is A** (a molecule of ethene, $^{12}C_2\ ^{1}H_4$) ***B*** *is incorrect because it contains 16 neutrons* ***C*** *is incorrect because it contains 16 neutrons* ***D*** *is incorrect because it contains 16 neutrons*	**(1)**

Question Number	Answer	Mark
7	**The only correct answer is C** (3.00 dm^3) ***A*** *is incorrect because this is the volume if oxygen were the only gas produced* ***B*** *is incorrect because this is the volume if oxygen were the only gas and 1 mol of calcium nitrate gave 1 mol of oxygen* ***D*** *is incorrect because this is the volume of gas if 1 mol of calcium nitrate gave 5 mol of gas*	**(1)**

Question Number	Answer	Mark
12	**The only correct answer is A** (beryllium ions are smaller than barium ions) ***B*** *is incorrect because the number of electrons does not affect the melting temperature* ***C*** *is incorrect because the beryllium ion has a larger charge density than the barium ion* ***D*** *is incorrect because electronegativity does not affect the melting temperature*	**(1)** **Computer**

Question Number	Answer	Mark
7	**The only correct answer is C** (91.2) ***A*** *is not correct because this only takes into account the base peak* ***B*** *is not correct because this does not take into account the peak at 96* ***D*** *is not correct because this is the unweighted mean*	**(1)**

Question Number	Answer	Mark
5	**The only correct answer is C** (x = 2, y = 7, z = 4) ***A*** *is incorrect because x must be 2 to match the 4 P in* P_4O_{10} ***B*** *is incorrect because z must be 4 to give 8 H to match the H in* $2P_2H_4$ ***D*** *is incorrect because x must be 2 to match the 4 P in* P_4O_{10}	**(1)**

Question Number	Answer	Mark
4	**The only correct answer is A** (argon) ***B*** *is incorrect because this would have a mass of 176 mg* ***C*** *is incorrect because this would have a mass of 16 mg* ***D*** *is incorrect because neon is monatomic not diatomic*	**(1)**

Question Number	Answer	Mark
18	**The only correct answer is D** ($C_3H_7^{\bullet} + HCl \rightarrow C_3H_7Cl + H^{\bullet}$) *A is not correct because this is a termination step in the reaction* *B is not correct because this is a termination step in the reaction* *C is not correct because this is a propagation step in the reaction*	**(1)**

Question Number	Answer	Mark
12	**The only correct answer is C** (touch screens) *A is not correct because this is a use of diamonds* *B is not correct because this is a use of graphite* *D is not correct because this use relies on graphene's strength*	**(1)**

Question Number	Answer	Mark
1	**The only correct answer is A** ($C_{10}H_8$) *B is incorrect because there are only 8 hydrogens, one on each of the carbons which are not linking the two rings* *C is incorrect because there are only 10 carbons and 8 hydrogen atoms* *D is incorrect because there are only 10 carbons and 8 hydrogen atoms*	**(1)**

Question Number	Answer	Mark
7(a)	**The only correct answer is D** (120°) *A is not correct because the answer is based on a square planar shape* *B is not correct because this is based on the shape for ammonia* *C is not correct because the answer is based on a tetrahedral shape*	**(1)** **Computer**

Question Number	Answer	Mark
7(b)	**The only correct answer is D** (109.5°) *A is not correct because the answer is based on a square planar shape* *B is not correct because this is based on the shape for water* *C is not correct because this is based on the shape for ammonia*	**(1)** **Computer**

Question Number	Answer	Mark
7(c)	**The only correct answer is B** (104.5°) *A is not correct because the answer is based on a square planar shape* *C is not correct because the answer is based on a tetrahedral shape* *D is not correct because the answer is based on a linear shape*	**(1)** **Computer**

Question Number	Answer	Mark
15	**The only correct answer is C** ($CH_3^{\bullet} + H^{\bullet} \rightarrow CH_4$) *A is incorrect because methyl free radicals are present* *B is incorrect because the chlorine free radical and the methyl free radical are present* *D is incorrect because chlorine free radicals are present*	**(1)** **Computer**

Question Number	Answer	Mark
8	**The only correct answer is B** (0.09 mol aluminium) ***A** is incorrect because that is the number of moles of aluminium that has reacted* ***C** is incorrect because the reacting ratio of aluminium to acid has been taken as 1:1* ***D** is incorrect because the limiting reagent has not been recognised and the reacting ratio has been reversed*	**(1)** **Computer**

Question Number	Answer	Mark
14(a)	**The only correct answer is A** ( ***B** is incorrect because hydrogen peroxide is not concentrated enough to be toxic, nor is it flammable* ***C** is incorrect because hydrogen peroxide is not flammable* ***D** is incorrect because hydrogen peroxide is not concentrated enough to be toxic*	**(1)**

Question Number	Answer	Mark
14(b)	**The only correct answer is C** (II and III) ***A** is incorrect because using an alternative method that involves less hazardous materials would not work* ***B** is incorrect because working on a smaller scale has not been included* ***D** is incorrect because using an alternative method that involves less hazardous materials is not appropriate*	**(1)**

Question Number	Answer	Mark
4	**The only correct answer is B** (92) ***A** is incorrect because this is the molecular mass of NO_4 which has 82.05% oxygen* ***C** is incorrect because this is the molecular mass of N_3O_4 which has 60.38% oxygen* ***D** is incorrect because this is $69.57 \div 64 \times 100$ instead of $64 \div (69.57 \div 100)$*	**(1)**

Question Number	Answer	Mark
14	**The only correct answer is C** (SO_2) ***A** is incorrect because although the bonds are polar, the dipoles cancel because the molecule is linear* ***B** is incorrect because although the bonds are polar, the dipoles cancel because the molecule is octahedral* ***D** is incorrect because although the bonds are polar, the dipoles cancel because the molecule is tetrahedral*	**(1)** **Computer**

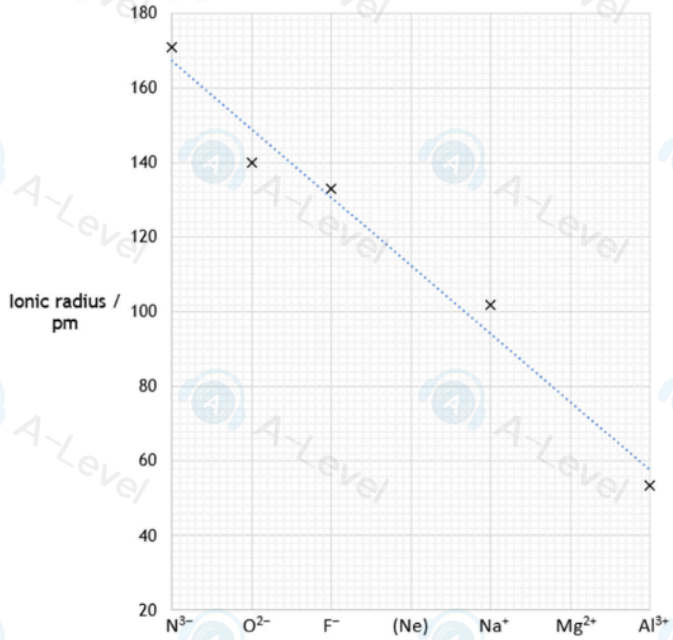
Question Number	Answer	Mark
14	**The only correct answer is A** (1,1-dibromopropane) ***B** is not correct because the electronegative atoms are arranged symmetrically cancelling the dipoles* ***C** is not correct because the electronegative atoms are arranged symmetrically cancelling the dipoles* ***D** is not correct because the electronegative atoms are arranged symmetrically cancelling the dipoles*	**(1)**

Question Number	Answer	Mark
9	**The only correct answer is B** ($CH_4 + H_2O \rightarrow 3H_2 + CO$) *A is incorrect because atom economy is 11.1%* *C is incorrect because atom economy is 4.35%* *D is incorrect because atom economy is 12.0%*	**(1)**

Question Number	Answer	Mark
11(a)	**The only correct answer is A** ($Na^+ > Mg^{2+} > Al^{3+}$) *B is not correct because the ions are in a random order* *C is not correct because the ions are in a random order* *D is not correct because the ions are in reverse order*	**(1)** **Computer**

Question Number	Answer	Mark
11(b)	**The only correct answer is A** ($F^- < O^{2-} < N^{3-}$) *B is not correct because the ions are in a random order* *C is not correct because the ions are in a random order* *D is not correct because the ions are in reverse order*	**(1)** **Computer**

Question Number	Answer	Mark
2	**The only correct answer is B** (Mg^{2+}) *A is incorrect because the fluoride anion has fewer protons than magnesium* *C is incorrect because the sodium cation has fewer protons than magnesium* *D is incorrect because the oxide ion has fewer protons than magnesium*	**(1)** **Computer**

Question Number	Answer	Additional Guidance	Mark
24(a)(i)	• axis labelled with unit **and** allowing the data to fill over half of y-axis **(1)** • 5 **points** in the table correctly plotted to within half a small square **(1)**	An example of the graph:  A scale of 30pm per large square does not score M1 Non-linear axes negate M1 **and** M2 – but an axis break is allowed NB trend line does not need to be present for M1 or M2 Ignore x-axis label even if incorrect Ignore point for Neon even if not on the line	**(2)**

Question Number	Answer	Additional Guidance	Mark
24(a)(ii)	• appropriate straight best fit line on graph **(1)** • value for Mg radius (read from graph) **(1)**	At least one point above and below the line Allow a line connecting N^{3-}, F^-, Al^{3+} Allow 70 – 80 (pm) Marks are independent	**(2)**

Question Number	Answer	Additional Guidance	Mark
24(a)(iii)	An explanation that makes reference to the following points: • (ionic) radius decreases (with (increasing) atomic number) **(1)** • because there are more protons (in the nucleus) **(1)** • and the ions are isoelectronic **(1)**	Must be a trend not a comparison for M1 Ignore "across the period" Do not award atomic radius Allow nuclear charge increases Ignore mass to charge ratio Ignore atomic number Ignore electrostatic force between electrons and nucleus is increasing (if no mention of protons) Accept there is no variation in shell/shielding / all have 10 electrons / the same number of electrons / same electronic configuration	**(3)**

Question Number	Answer	Additional Guidance	Mark
24(b)(i)	An answer that makes reference to the following point: • **giant ionic** lattice	Allow crystal for lattice Allow giant ionic structure Do not award linear shape Do not award references to covalency or molecules Allow this answer given in 24(b)(ii) provided this is not negated by the 24(b)(i) answer	**(1)**

Question Number	Answer	Additional Guidance	Mark
24(b)(ii)	A description that makes reference to the following points: • sodium fluoride does not conduct electricity when **solid** **(1)** • sodium fluoride does conduct when in aqueous solution / molten **(1)** • because the ions cannot move (in a solid) **and** the ions are free to move when the substance is in solution / molten **(1)**	Allow poor conductor / insulator Ignore carry charge Allow because the ions are in fixed positions Do not award M3 if there is reference to sodium fluoride having delocalised electrons Must mention solutions **and** molten to gain all three marks	**(3)**

Question Number	Answer	Additional Guidance	Mark
24(b)(iii)	An explanation that makes reference to the following points: • the fluoride ion has a single charge **and** a small (ionic) radius / size **(1)** • so the electron cloud is difficult to **distort** **(1)**	Allow opposite argument i.e. ions that are large and bigger charges are easy to polarise, but you can't polarise fluoride due to its size and charge for M1 Allow small/low charge Allow small size Ignore low size Do not award M1 for atomic radius Ignore comments about electronegativity Allow "it is difficult to **distort**" Marks are independent	**(2)**

(Total for Question 24 = 13 marks)

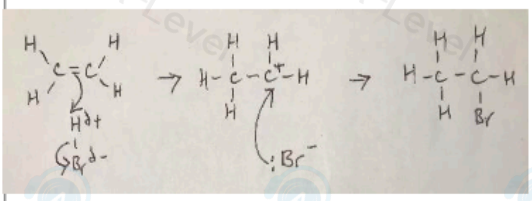
Question Number	Answer	Additional Guidance	Mark
22(c)(ii)	An answer that makes reference to the following points: • fossil fuels are non-renewable/ will run out/ are finite / biofuels are renewable **(1)** • fossil fuels contribute to global warming / biofuels release the carbon dioxide absorbed while growing **(1)**	Do not award biodegradable Allow fossil fuels contribute to climate change Allow biofuels (don't release net carbon dioxide so) are carbon neutral/ net zero Allow biofuels have a lower carbon footprint Ignore references to acid rain / NOx / Do not award references to hydrogen	**(2)** **Expert**

Question Number	Answer	Additional Guidance	Mark
22(c)(iii)	An answer that makes reference to the following point: • (catalytic) reforming/reformation	Allow isomerisation Do not award catalytic conversion	**(1)** **Clerical**

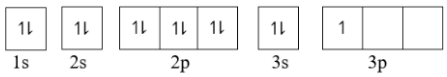
Question Number	Answer	Additional Guidance	Mark
22(c)(iv)	An answer that makes reference to the following point: • 	Allow structural methyl groups shown on branches and ignore vertical connectivity Ignore bond angles Ignore molecular / structural / displayed formulae Ignore state symbols even if incorrect Ignore references to reaction conditions/ catalysts	**(1)** **Graduate**

Question Number	Answer	Additional Guidance	Mark
22(d)(i)	An answer that makes reference to the following point: • to prevent combustion/ oxidation / explosion (of the mixture) or oxygen reacts with hydrocarbons/ ethene /hydrogen	Allow hydrocarbons are flammable/ can catch fire Allow to prevent formation of CO_2/ CO /C/ alcohols/diols/aldehydes Ignore references to side reactions/ (unwanted) products/ incorrect / toxic products Do not award (oxygen) reacts with steam	**(1)** **Expert**

Question Number	Answer	Additional Guidance	Mark
22(d)(ii)	An answer that makes reference to one of the following points: • **making** polymers / poly(ethene) / polythene / polyethylene/ plastics • ripening / maturing fruit e.g. bananas • **making** ethanol / ethane-1,2-diol / antifreeze/ haloethane /	Ignore to make alcohol Ignore polymerisation Ignore references to fuels Do not award making bioethanol	**(1)** **Expert**

Question Number	Answer	Additional Guidance	Mark
22(e)	An answer that makes reference to the following points: • dipole on HBr • curly arrow from C=C bond to H $^{(\delta+)}$ • curly arrow from H−Br bond to Br or just beyond • correct intermediate • lone pair on Br^- • curly arrow from lone pair (if shown) on Br^- to C+	Do not award partial charge on C=C Do not award partial charge on Br Penalise incorrect or missing charge on Br once only If lp shown and M5 scored, arrow must come from lp Penalise half arrows once only  All 6 points scores 3 4 or 5 points scores 2 2 or 3 points scores 1	(3) Expert

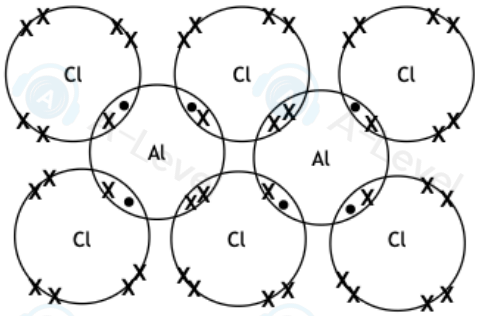
(Total for Question 22 = 20 marks)

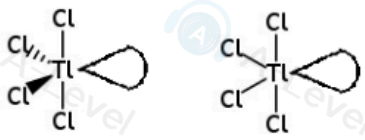
Question Number	Answer	Additional Guidance	Mark
21(a)(i)	An answer that makes reference to the following point: • $1s^2 2s^2 2p^6 3s^2 3p^1$	Allow  Allow double headed arrows Ignore $[Ne]3s^2\ 3p^1$ Ignore 2,8,3	(1)

Question Number	Answer	Additional Guidance	Mark
21(a)(ii)	An answer that makes reference to the following points: • they have the same number of / 3 outershell electrons **(1)** • they have different numbers of shells of electrons / boron has two shells, aluminium 3 shells and thallium 6 shells **(1)**	Ignore reference to d-electrons in thallium Allow all (n) $s^2\ p^1$ Allow electron configurations Allow number of shells increase down the group Ignore different number of sub-shells	(2)

Question Number	Answer	Additional Guidance	Mark
21(a)(iii)	An answer that makes reference to the following points: • all three will be the same shape (because they have the same number of outer shell electrons to form bonds with chlorine) **(1)** • trigonal planar **(1)** • because there are three bonding pairs of electrons and no lone pairs of electrons which are at maximum separation / minimum repulsion **(1)**	**M2 and M3 may be scored for any one molecule identified as trigonal planar** Allow any of the three stated as trigonal planar Allow triangular planar / planar triangle Allow this explanation for any one of the three. No TE from incorrect shape	**(3)**

Question Number	Answer	Additional Guidance	Mark
21(b)(i)	• calculation of moles of aluminium chloride **(1)** • rearrangement of $pV = nRT$ **(1)** • calculation of number of moles **(1)** **and** number of moles are the same (so consistent with Al_2Cl_6) OR • Calculation of M_r or moles **(1)** • Use of PV=nRT correctly rearranged for n or V **(1)** • Evaluated answer **and** comparison with Al_2Cl_6 data **(1)**	<u>Example of calculation:</u> $5.00 \div 267 = 0.018727 / 1.8727 \times 10^{-2}$ (mol) $= 0.0187 / 1.87 \times 10^{-2} / 0.019 / 1.9 \times 10^{-2}$ $n = pV \div RT$. May be seen in the expression in M3 $(0.000700 \times 101000) \div (8.31 \times 455) = 0.018699 / 1.8699 \times 10^{-2}$ $= 0.0187 / 1.87 \times 10^{-2} / 0.019 / 1.9 \times 10^{-2}$ Allow alternative method Ignore SF except 1 SF $V = nRT/p$ Ignore SF except 1 SF	**(3)**

Question Number	Answer	Additional Guidance	Mark
21(b)(ii)	An answer that makes reference to the following point: • 3 covalent bonds, one dot, one cross, between each Al and 3 Cl atoms **(1)** • 2 dative covalent bonds with two crosses between one Al and one Cl **(1)** • 3 lone pairs of electrons on the terminal Cl atoms, two pairs on the bridging Cl atoms **(1)**	Example of diagram  OR  OR  If all dots or all crosses are used allow M2 and M3 for the correct numbers of electrons marked as dots or crosses. No TE anywhere	**(3)**

Question Number	Answer	Additional Guidance	Mark
21(c)	• a diagram of the $TlCl_4^{3-}$ ion including one lone pair of electrons on Tl **(1)** • an estimated bond angle of ≤ 120° shown between the two equatorial Cls **(1)** • at least one estimated bond angle of ≤ 90° shown between two Cl (an axial and an equatorial Cl) **(1)**	Examples of diagrams Allow diagrams without dots and wedges Ignore absence of charge (as in the diagrams below) Ignore estimated bond angles, even if incorrect for M1.  Ignore 180° No TE on M2 or M3 for incorrect shape	**(3)**

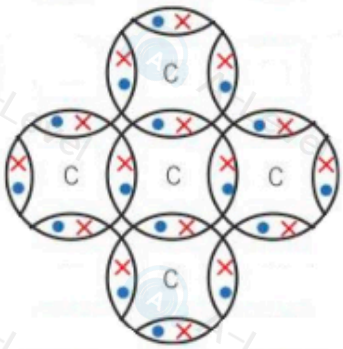
(Total for Question 21 = 15 marks)

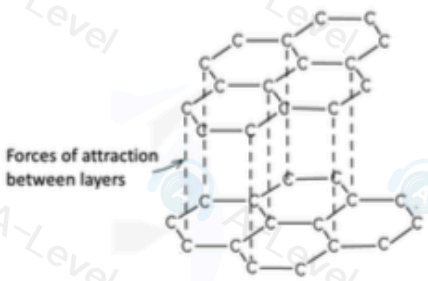
Question Number	Answer	Additional Guidance	Mark
22(a)	• conversion of dm^3 to m^3 **(1)** • conversion of temperature to K **(1)** • rearrangement of ideal gas equation **(1)** • evaluation to give number of moles **(1)** • calculation of molar mass **(1)**	Example of calculation $1 \div 1000 = 0.0010 / 1.0 \times 10^{-3}$ (m^3) $273 + 20 = 293$ $n = \frac{pV}{RT}$ $\frac{101000 \times 1.0 \times 10^{-3}}{8.31 \times 293} = 0.04148 / 4.148 \times 10^{-2}$ (mol) $\frac{0.656}{0.04148} = 15.81 = 16$ (g mol^{-1}) Ignore SF except 1SF Allow TE throughout Allow conversion of Pa to kPa and use of dm^3 Do not award a TE on a molar mass less than 2 Correct answer with some working scores 5	**(5)**

	Alternative method • conversion of any volume in dm^3 to m^3 by dividing by 1000 (e.g. 24 in this case) • conversion of temperature to K • rearrangement of ideal gas equation • evaluation to give number of moles • calculation of mass in volume chosen in M1 (eg 24 dm^3 as shown) **and** calculation of molar mass	$24 \div 1000 = 0.024$ (m^3) $273 + 20 = 293$ $n = \frac{pV}{RT}$ $\frac{101000 \times 0.024}{8.31 \times 293} = 0.99556$ (mol) $0.656 \times 24 = 15.744$ (g) **and** $15.744 \div 0.99556$ (mol) $= 15.81$(g mol^{-1})	

Question Number	Answer	Additional Guidance	Mark
22(b)	An answer that makes reference to the following point: • methane/CH_4	TE on a hydrocarbon that fits the molar mass from (a)	**(1)**

(Total for Question 22 = 6 marks)

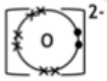
Question Number	Answer	Additional Guidance	Mark
17 (a)	An answer that makes reference to the following points: • 4 pairs of electrons around central carbon atom (1) • 3 more pairs of electrons around each of the 4 outer carbons (1)	 Accept all dot, all crosses in any combination Accept the diagram with no circles Allow the electrons not to be paired	(2)

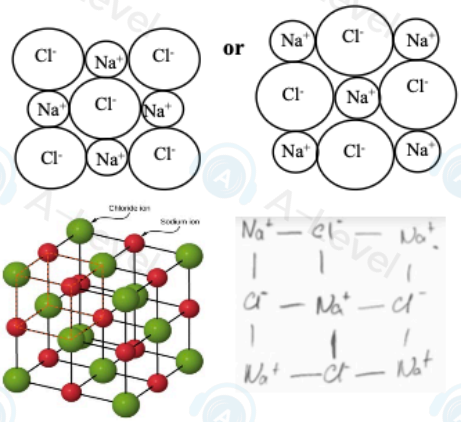
Question Number	Answer	Additional Guidance	Mark
17(b)	An answer that makes reference to the following points: • at least two layers of hexagons (with or without Cs) (containing at least 3 hexagons per layer) (1) • labelled (electrostatic) forces of attraction between the layers (1)	drawing of graphite  Ignore delocalised electrons Allow any form of intermolecular forces	(2)

Question Number	Answer	Additional Guidance	Mark
17(c)	An answer that makes reference to the following points: • in diamond all the carbons are bonded to each other, (with no gaps). (1) • in graphite there are layers that are further apart than the carbon to carbon bonds in diamond (1)	Mention of molecules negates one mark Allow each C bonded to 4 other C atoms, or tetrahedral lattice Allow there is empty space / large distance between the layers in graphite Do not award air is trapped between the layers	(2)

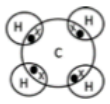
Question Number	Answer	Additional Guidance	Mark
23(a)(i)	An answer that makes reference to the following point: • (electrostatic force of) **attraction** between oppositely charged ions	Allow attraction between cations / positively charged metal ions and anions	(1)

Question Number	Answer	Additional Guidance	Mark
23(a)(ii)	An explanation that makes reference to the following points: • magnesium **ions** have a higher charge. **(1)** • magnesium ions have a smaller radius. **(1)**	Allow ORA about sodium ions Allow Mg^{2+} and Na^{+} Allow magnesium has a smaller ionic radius / magnesium ions are smaller If no other mark awarded allow one mark for Mg^{2+} / magnesium ion has a greater charge density Penalise any mention of covalent bonding or intermolecular forces once only.	(2)

Question Number	Answer	Additional Guidance	Mark
23(a)(iii)	An answer that makes reference to the following points: •  (1) •  (1)	**Mark independently** Allow eight electrons on outer shell instead of no electrons or no circle Allow single sodium ion Do not award Na^{+}_{2} Allow transferred electrons in any pattern Do not award all dots or all crosses for the oxide ion Ignore omission of square brackets	(2)

Question Number	Answer	Additional Guidance	Mark
23(a)(iv)	An answer that makes reference to the following points: • At least 9 correctly labelled sodium **and** chloride ions (1) • The correct structure of alternating sodium / positive and chloride / negative (ions) either in rows or 3D lattice (1)	 Ignore size of ions Do not award M1 if suggestion that sodium chloride is not NaCl	(2)

Question Number	Answer	Additional Guidance	Mark
23(b)(i)	An answer that makes reference to the following point: • (electrostatic force of) **attraction** between the **shared pair** of electrons and the nuclei (of two atoms)		**(1)**

Question Number	Answer		Additional Guidance	Mark
23(b)(ii)	An answer that makes reference to the following points:			**(3)**
	• structure of methane	**(1)**		
	• structure of ammonia	**(1)**		
	• structure of water	**(1)**		

Question Number	Answer		Additional Guidance	Mark
23(b)(iii)	An answer that makes reference to the following points:			**(3)**
	• shape and bond angle for methane	**(1)**		
	• shape and bond angle for ammonia	**(1)**		
	• shape and bond angle for water	**(1)**		

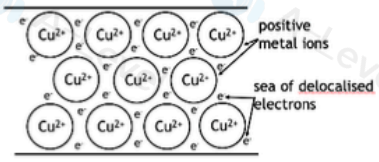
molecule	shape	bond angle
methane	tetrahedral	109.5°
ammonia	(trigonal) pyramidal	107°
water	non-linear / bent / V-shaped	104.5°

If no other mark scored 1 mark for either three correct bond angles or three correct shapes

Question Number	Answer		Additional Guidance	Mark
23(b)(iv)	An answer that makes reference to the following points: (Both ammonia and water have four pairs of electrons around the central atom)			**(2)**
	• ammonia has one lone pair and water has two lone pairs	**(1)**	Allow water has an extra lone pair	
	• lone pairs (of electrons) repel more than bonded pairs.	**(1)**	Ignore bond angles even if incorrect.	

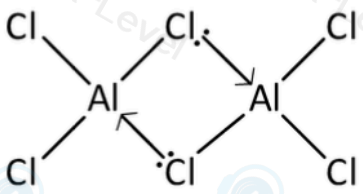
Question Number	Answer	Additional Guidance	Mark
23(b)(v)	An answer that makes reference to the following points: • ethene is a simple molecule • ethene has weak intermolecular forces • poly(ethene) is a polymer • poly(ethene) strong intermolecular forces All four bullet points scores 2 Two or three bullet points scores 1	Allow London / van der Waals / dispersion forces for intermolecular forces Ignore monomer Do not award reference to breaking covalent bonds Allow poly(ethene) is a macromolecule / giant molecule for polymer Do not award reference to breaking covalent bonds	(2)

Question Number	Answer	Additional Guidance	Mark
23(c)(i)	An answer that makes reference to the following point: • **electrostatic** (force of) **attraction** between the positive / metal ions and the (sea of delocalised) electrons.		(1)

Question Number	Answer	Additional Guidance	Mark
23(c)(ii)	An explanation that makes reference to the following points: • **delocalised** electrons are able to move / flow (through the lattice and carry a charge) **(1)** • diagram showing lattice of Cu^{2+} ions and (sea of) electrons interspersed within the structure – approximately twice as many electrons as ions **(1)**	Delocalised electrons may be labelled in the diagram  Do not award ions move	(2)

(Total for Question 23 = 21 marks)

Question Number	Answer	Additional Guidance	Mark
25(a)(i)	• trigonal planar	Allow triangular planar	**(1)**

Question Number	Answer	Additional Guidance	Mark
25(a)(ii)	An answer that makes reference to the following points: • eight correct covalent bonds **(1)** • correctly identifying the two dative covalent bonds between the monmoers by means of arrow from chlorine to aluminium **(1)**	An example of a diagram:  Bonds between aluminium atoms lose M1 Ignore bond angles and lengths Ignore dot-cross diagrams Ignore missing lone pair electrons on arrow Do not award lone pair on aluminium for M2	**(2)**

Question Number	Answer	Additional Guidance	Mark
25(b)	• balanced equation	$AlCl_3 + 3H_2O \rightarrow 3HCl + Al(OH)_3$ Allow equation with Al_2Cl_6 Allow multiples Ignore state symbols even if incorrect	**(1)**

Question Number	Answer	Additional Guidance	Mark
25(c)	• calculation of moles of sodium hydroxide **(1)** • use of ratio **(1)** • M_r of aluminium hydroxide **and** mass of aluminium hydroxide **(1)**	An example of a calculation: $0.15 \times 1.5 = 0.225$ mol $0.225 \div 3 = 0.075$ $27.0 + (3 \times (16 + 1)) = 78$ $78 \times 0.075 = 5.85$ (g) Correct answer scores 3 marks TE throughout Ignore SF except 1SF **Common incorrect answer:** 17.55(g) scores 2 (M1 and M3)	**(3)**

Question Number	Answer		Additional Guidance	Mark
25(d)(i)	A description that makes reference to the following points: • **strong** electrostatic (attraction) • between cations and delocalised electrons • Al^{3+} **and** 3 electrons per ion	**(1)** **(1)** **(1)**	Do not award references to covalent bonding for M1 Allow "positively charged ions" for cations Allow aluminium ions for cations Do not award nuclei / protons Do not award M2 for reference to intermolecular forces Allow +3 charge M2 and M3 may be shown in a diagram	**(3)**

Question Number	Answer		Additional Guidance	Mark
25(d)(ii)	An explanation that makes reference to the following points: • **delocalised** electrons flow (under a potential difference) • layers/ions/atoms slide over each other (while still being held together by delocalised electrons)	**(1)** **(1)**	Allow voltage is applied Allow **delocalised** electrons can move (and conduct/carry charge) Do not award mobile ions Do not award reference to intermolecular forces for M2	**(2)**

(Total for Question 25 = 12 marks)