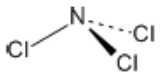
Shapes of Molecules - Mark Scheme

Q1.

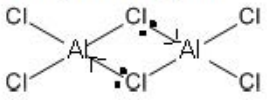
Question number	Answer	Additional guidance	Mark
(a)	An explanation that makes reference to the following points: • (I) is incorrect because the solutions are aqueous **or** ions are (in the) aqueous (state) the state symbols should be (aq) instead of (I) • silver ions should have one positive charge / Ag^+ **or** silver chloride is AgCl	Allow silver nitrate and sodium chloride are aqueous Do not award if incorrect state symbol for one of the species in the equation e.g. Ag is (s) / AgCl is (aq) Ignore just the charge on the silver ion is incorrect / the formula of silver chloride is incorrect	**(2)**

Question number	Answer	Additional guidance	Mark
(b)	• calculation of mol of C, H and Cl **(1)** • calculation of empirical formula **(1)** • calculation of molecular formula **(1)**	Example of calculation: C : H : Cl mol $\frac{3.09}{12} : \frac{0.26}{1} : \frac{9.15}{35.5}$ = 0.2575 : 0.26 : 0.2577 (ratio 1 : 1 : 1) Empirical formula is CHCl molar mass CHCl = 12 + 1 + 35.5 = 48.5 $\frac{\text{molar mass } (CHCl)_n}{\text{molar mass CHCl}} = \frac{97}{48.5} = 2$ Molecular formula is $C_2H_2Cl_2$ Allow symbols in any order Do not award 2CHCl Ignore SF in mol and ratio Correct molecular formula with some working scores (3) **Alternative method** scores (3) no. C atoms = $\frac{3.09 \times 97}{12.5 \times 12} = 2 / 1.9982$ no. H atoms = $\frac{0.26 \times 97}{12.5 \times 1} = 2(.0176)$ no. Cl atoms = $\frac{9.15 \times 97}{12.5 \times 35.5} = 2$	**(3)**

Question number	Answer	Additional guidance	Mark
(c)(i)	• all 4 ion formulae • all 4 (corresponding) *m* / *z* values	Example of answer: ions *m* / *z* $N(^{35}Cl)_3^+$ 119 $N(^{35}Cl)_2{}^{37}Cl^+$ 121 $N^{35}Cl(^{37}Cl)_2^+$ 123 $N(^{37}Cl)_3^+$ 125 Allow any other unambiguous way of representing the formulae e.g. in words Allow (1) for any two *m* / *z* values with corresponding ion formulae Ignore missing / incorrect charge on ion Ignore mass number on N Ignore bonds or + between Cl atoms / order of atoms e.g. $N\text{-}^{35}Cl\text{-}^{35}Cl\text{-}^{35}Cl$	(2)

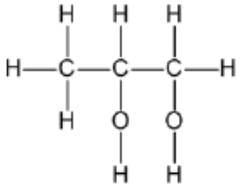
Question number	Answer	Additional guidance	Mark
(c)(ii)	• number of bonding pairs **and** number of lone pairs • shape • bond angle	Example of table: Number of bonding pairs of electrons on nitrogen: 3 Number of lone pairs on electrons on nitrogen: 1 Shape of molecule: trigonal pyramidal Bond angle: 107° **Shape:** Allow 3-dimensional drawing e.g.  There must be at least 1 dotted/dashed line or wedge for 3-d Allow just 'pyramidal' Allow pyramid for pyramidal Do not award tetrahedral **Bond angle:** Allow any number in the range 106-108° Ignore missing °	(3)

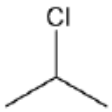
Question number	Answer	Additional guidance	Mark
(d)(i)	An explanation that makes reference to one of the following pairs of points: **Polarisation route** • an aluminium ion / cation is (very) small **and** highly charged **or** Al^{3+} has a small ionic radius / is small • so it polarises / distorts the chloride ion / Cl^- / anion **Allow Electronegativity route** • there is a (relatively) small difference in electronegativity between aluminium and chlorine • so the electrons are (partially) shared	Marks must come from the same route – maximum 1 mark if one point from one route and one point from the other route Allow the aluminium ion has a high charge density Allow a description of polarisation Allow chlorine anion / ion Ignore the aluminium chloride is polarised Ignore size of chloride ion	(2)

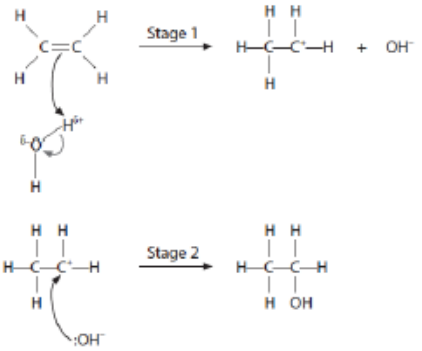
Question number	Answer	Additional guidance	Mark
(d)(ii)	A description including the following points: • diagram showing two $AlCl_3$ molecules joined through two chlorine atoms • dative (covalent) bonds **or** coordinate bonds	Example of diagram:  Allow dot-and-cross diagram Ignore missing arrow heads and lone pairs from diagram Do not award diagram with Al-Al / Cl-Cl bond(s) Allow dative covalent bonds labelled on diagram / shown as arrows from Cl to Al Allow description of dative bonds Allow M2 even if only 1 dative bond shown / mentioned Do not award M2 if dative bonds starting from aluminium Do not award M2 for any answer that mentions ions / ionic bonds	(2)

Q2.

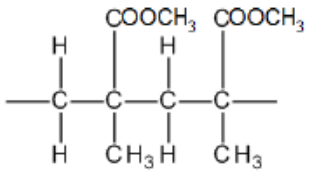
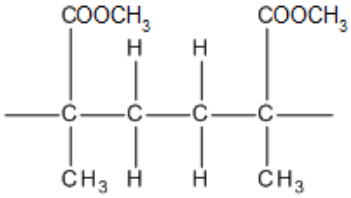
Question number	Answer		Additional guidance	Mark
(a)(i)	• (reagent W) hydrogen/H_2	(1)		2
	• (catalyst X) nickel	(1)	Allow nickel, Ni/platinum, Pt/palladium, Pd	

Question number	Answer	Additional guidance	Mark
(a)(ii)	• 	Allow OH Do not allow C-H-O	1

Question number	Answer	Additional guidance	Mark
(a)(iii)	• 		1

Question number	Answer		Additional guidance	Mark
(b)(i)	• correct dipole ($O^{\delta-} - H^{\delta+}$)	(1)	Example of mechanism: 	4
	• curly arrow from C=C to H in H_2O	(1)		
	• curly arrow from O-H bond to O	(1)		
	• curly arrow from lone pair on O of OH^- to C^+	(1)		

Question number	Answer		Additional guidance	Mark
(b)(ii)	• trigonal planar	(1)	Allow M1 and M2 shown on a diagram	3
	• 3 bond pairs/electron pairs (around the carbon atom)	(1)	Allow bond pairs/electron pairs as far apart as possible	
	• bond pairs/electron pairs arranged to minimise repulsion	(1)		

Question number	Answer	Additional guidance	Mark
(c)	• 4 carbon backbone with continuation bonds (1) • all side chains correct (1)	Example of polymer:  or  Allow CO_2CH_3 in side chains Allow CH_3 and $COOCH_3$ groups above or below the carbon chain Ignore square brackets and n Any structure with C=C scores 0	2

Q3.

Question number	Answer	Mark
	The only correct answer is C (ICl_4^-) **A** *is incorrect because CCl_4 is tetrahedral* **B** *is incorrect because CH_4 is tetrahedral* **D** *is incorrect because NH_4^+ is tetrahedral*	(1)

Q4.

Question number	Answer	Mark
	D $AlCl_3$ trigonal planar, PH_3 pyramidal	1