**M1.** (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

*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

*Allow H bonds*

*Do not allow 'hydrogen' only but mark on*

**1**

(ii) Van der Waals'/VdW

*Allow London forces, dispersion forces, temporary induced dipole forces*

**1**

(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

*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

**1**

(trigonal) pyramid(al)/(distorted) tetrahedral

*do not insist on the + sign*

*Allow triangular pyramid*

*Not square pyramid*

*Ignore bond angles in structure*

*M2 independent of M1*

1

(ii) 107°

*Allow range 106 – 108°*
*Ignore °(C)*

1

(iii) $NH_3$/ammonia

*Contradictions (eg $NH_4$ ammonia) CE = 0*

1

(d) 3

*Allow three/III/3 lone pairs/3lp/3 lone pairs of electrons*

1

**[9]**

**M2.** (a) (i) shared <u>pair of electrons</u>

*Can have one electron from each atom contributes to the bond*
*Not both electrons from one atom*

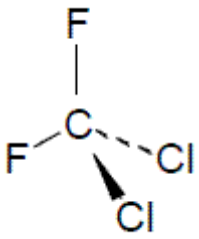
1

(ii) $\frac{1}{2}Cl_2 + \frac{3}{2}F_2 \rightarrow ClF_3$

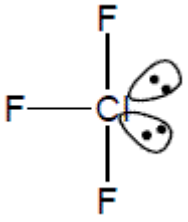
1

*Only*
*Ignore state symbols even if wrong*

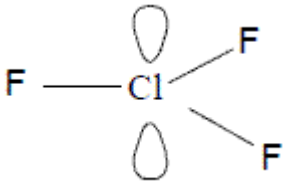
(b)




1




**OR**

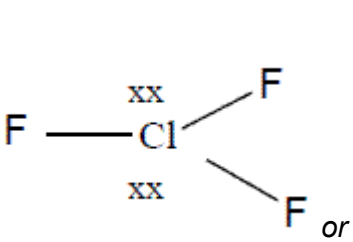



*Allow any structure with 4 bp*

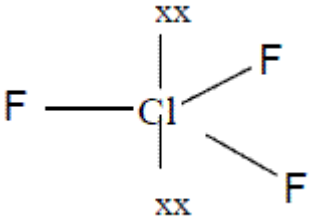
*In $CClF_2$, watch for Cl in centre- it must be C*

*Ignore wrong bond angles*

*Representations of lone pairs allowed are the two examples shown with or without the electrons in the lobe.*
*Also they can show the lone pair for either structure by two crosses/dots or a line with two crosses/dots on it e.g.*




*or*




*Or a structure with 3 bp and 2 lp*

1

(c) Dipole – dipole

*Allow van der Waals/vdw/London/dispersion/temporary dipole – induced dipole*
*Not dipole alone*

1

(d) (i) Coordinate/dative (covalent)

*If wrong CE = 0/3 but if 'covalent' or left top line blank, mark on.*

1

(Lone) pair of electrons/both electrons (on $F^-$)

*CE if lone pair is from B*

1

Donated from $F^-$/fluoride or donated to the $BF_3$

*Must have the – sign on the F ie $F^-$*
*Ignore $Fl^-$*
*M3 dependent on M2*

1

(ii) 109° to 109.5°

1

(e) $\frac{238 \times 100}{438}$

*For 1 mark allow 238 as numerator and 438 as denominator or correct strings*

1

= 54.3%

*2 marks if correct answer to 3 sig figs.*
*54% or greater than 3 sig figs = 1 mark*

1

**[11]**

**M3.** (a) (i) Covalent;

*If not covalent CE = 0.*
*If blank, mark on.*

1

Shared <u>pair of electrons</u> (one from each atom);

*Not shared electrons.*

1

(ii) Hydrogen bonds / H bonds;

*Not just hydrogen.*

1

Van der Waals/London/dispersion forces/temporary induced dipole;

1

(b) Showing all the lone pairs on both molecules;

*Allow showing both lone pairs on the O involved in the H-bond.*

**1**

Showing the partial charges on O and H on both molecules;

*Allow showing both partial charges on the O and H of the other molecule involved in the H bond.*

**1**

Showing the Hydrogen bond from the lone pair on O of one molecule to the delta + on the H of the other molecule;

**1**

(c) (i) $C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$;

*Accept multiples.*
*Allow $C_2H_6O$.*

**1**

(ii) CO is (produced which is) toxic/ poisonous/C (may be produced) which is toxic/ C is a respiratory irritant/ C (particles) exacerbate asthma/C causes global dimming/ smog;

*Must relate to C or CO.*
*Any mention of $SO_2$ $NO_2$ or other pollutants CE = 0.*

**1**

(iii) More fuel needed (which costs more)/Wastes fuel/ less fuel burnt (so need more to buy more)/engine gets sooty so need to pay for engine to be cleaned/Have to fit catalytic converter;

*Not just costs more.*
*Not engine gets sooty unless qualified.*

**1**

(d) (i) (React) with CaO/ calcium oxide/quicklime/lime;

*Accept $CaCO_3$/ calcium carbonate/limestone.*
*Not chalk.*

**1**

All the sulfur dioxide may not react with the CaO or $CaCO_3$ / may not have time to react/ incomplete reaction;

*Accept incomplete reaction.*

**1**

(ii) Occupies a (much) smaller volume;

*Not easier to store or transport.*

**1**

**[13]**

**M4.** (a) Hydrogen/H bonds

*Not just hydrogen*

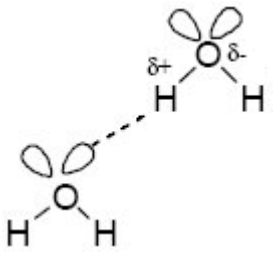
**1**

van der Waals/vdw/dipole-dipole/London/temporarily induced dipole/dispersion forces

*Not just dipole*

**1**

(b)




*M1 for partial charges as indicated in diagram (correct minimum)*
*M2 for all four lone pairs*
*M3 for H bond from the lp to the H (δ+) on the other molecule*
*Lone pair on hydrogen CE = 0*
*OHO CE = 0*
*If only one molecule of water shown*
*CE = 0*

**3**

(c) Hydrogen bonds/IMF (in water) stronger

***OR***

IMF/VDW/dipole-dipole forces (in $H_2S$) are weaker

***OR***

H bonding is the strongest IMF

*Ignore energy references*
*Comparison must be stated or implied*

**1**

(d) Atoms/molecules get larger/more shells/more electrons/more surface area

*Not heavier/greater Mr*

**1**

therefore increased Van der Waals/IMF forces

*Ignore references to dipole-dipole forces*

**1**

(e) Dative (covalent)/coordinate

*If not dative/coordinate CE = 0/2*
*If covalent or blank read on*

**1**

(Lone) pair/both electrons/two electrons on $O(H_2)$ donated (to $H^+$)
OR pair/both electrons come from $O(H_2)$

*Explanation of a coordinate bond specific to oxygen or water required*
*Not just H+ attracted to lone pair since that is nearer to a H bond*

**1**

(f) ionic

**1**

*if not ionic CE = 0*

oppositely charged ions/+ and – ions or particles

*atoms or molecules loses M2 and M3*

**1**

ions attract strongly OR strong/many (ionic) bonds must be broken

*$S^-$ loses M2*
*Reference to IMF loses M2 and M3*

**1**

**[13]**