A-Level Chemistry

Intermolecular Forces

Mark Scheme

Time available: 68 minutes
Marks available: 65 marks

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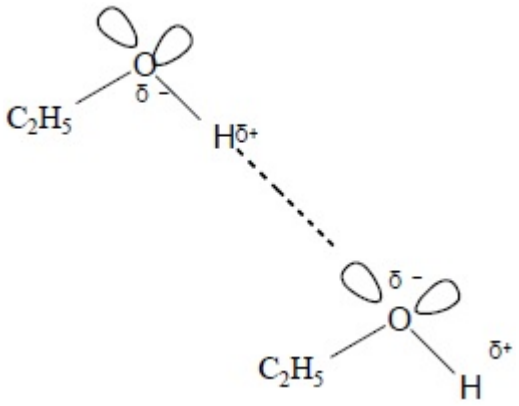
1.



M1 *two lone pairs on each O atom*
<u>and</u>
δ+ and δ- on each H-O bond

1

M2 *<u>dotted/broken</u> line shown between lone pair on one molecule and the correct H on another*

1

M3 *O·····H–O in straight line, dependent on* ***M2***

Ignore any partial charges on C–H or C–O bonds

For straight line in ***M3****, allow a deviation of up to 15°*

1

If a different molecule containing hydrogen bonding due to O–H bond drawn (e.g. methanol, water) or an incorrect attempt at the structure of ethanol, then maximum of 2 marks (i.e. only penalise if would score all three marks otherwise)

(b) Hydrogen bonds (between ethanol molecules)

1

(permanent) dipole-dipole <u>OR</u> van der Waals force (between methoxymethane molecules)

Allow vdW

1

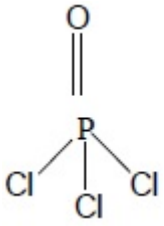
Hydrogen bonds are stronger/est intermolecular force

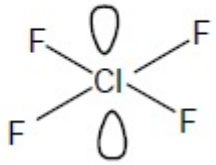
Allow more energy to break/overcome hydrogen bonding

Allow converse arguments

1

(c)





$POCl_3$: allow any shape showing 1 double bond between P and O and 3 P-Cl bonds

1

ClF_4^-: allow any shape showing 4 Cl ⁻F bonds and 2 lone pairs

1

(distorted) Tetrahedral

1

Square planar

1

90°

1

[11]

2. (a) Power of an atom to attract a pair of electrons in a covalent bond.

Allow power of an atom to attract a bonding/shared pair of electrons

Allow power of an atom to withdraw electron density from a covalent bond

Not lone pair Not Element

1

(b) <u>Difference in electronegativity</u> leads to bond polarity

If chloride (ions) mentioned then CE = 0

1

(dipoles don't cancel therefore the molecule has an overall permanent dipole) and there is an attraction between $\partial+$ on one molecule and $\partial-$ on another

partial charges should be correct if shown and can score M2 from diagram

1

(c)

SiH_4	**Tetrahedral**		1 shape & no tick
PH_3	**Pyramidal (trigonal)** **Allow tetrahedral**	✓	1 shape & tick
$BeCl_2$	**Linear**		1 shape & no tick
CH_3Cl	**(Distorted)Tetrahedral**	✓	1 shape & tick

If shapes are drawn rather than named then penalise first mark gained

4

[7]

3.

(a) $SrCl_2$> ICl > Br>

If wrong can award 1 for one in the correct 'position'

2

$SrCl_2$ strong ionic bonds / (strong electrostatic attraction between opposite ions)

1

Lattice so many strong bonds to overcome

1

ICl has dipole-dipole between molecules – weaker than ionic bonds

1

Br_2 has van der Waals forces between molecules – much weaker

Accept London / dispersion / induced dipole forces

1

(b) $Cl_2 + H_2O \rightleftharpoons HCl + HClO$

OR $2Cl_2 + 2H_2O \rightleftharpoons O_2 + 4HCl$

OR $Cl_2 + H_2O \rightleftharpoons 2H^+ + Cl^- + ClO^-$

1

Kills bacteria

1

Wasteful as most potable water not used for drinking - used in washing clothes etc

OR Some people suffer eye irritation / Some people find the taste unpleasant

OR can react with organic compounds to produce harmful substances

Allow 'it is potentially toxic as it can be if over concentrated'

1

(c) $6Br_2 + P_4 \longrightarrow 4PBr_3$

Accept 4P for P_4

1

Pyramidal shown in a diagram (but the name of the shape isn't needed)

1

100–108°

Actual value is 101° (hence larger range of values allowed)

1

(d) Tetrahedral shown in a diagram (but the name of the shape isn't needed)

1

109.5°

Accept 109° or 109°28'

1

[14]

4. (a) Electron movement in first molecule / temporary dipole

Allow description

1

Induces a dipole in another molecule

Allow description

1

(Induced-temporary) attraction or δ+ attracts δ- in different/adjacent molecules

M3 dependent on M1 and M2

Allow electrostatic attraction

M3 could be scored in diagram

If other type of force / metallic / ionic / polar bonds / permanent dipoles / difference in electronegativity mentioned CE = 0

1

(b) (i) (Methanol) H-bonds / hydrogen bonding

1

(Methanethiol) dipole-dipole forces or van der Waals

1

H-bonds are a stronger / are the strongest IMF

Allow H-bonds require more energy to overcome

If M1 and M2 not scored, allow 1 for methanol has stronger IMFs

If breaking covalent bonds then CE=0

1

(ii) (Fractional) distillation

Allow description

Do not allow heating unqualified

1

(c) (Methaneselenol is a) bigger molecule / larger Mr / larger no of electrons / Se bigger atom

1

With stronger/more vdw forces between molecules

If breaking covalent bonds then CE=0

1

(d) (i)

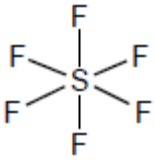


Diagram showing 6 bond pairs

1

(Bond angle) 90° for SF_6

Ignore 180°

1

Octahedral

1

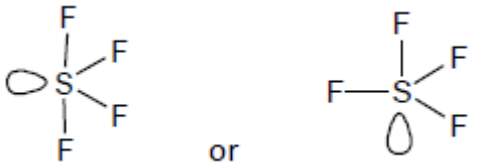


Diagram showing 4 bond pairs and 1 lone pair

1

(Bond angles) for SF_4

If shape of SF_4 is not based on 4 bond pairs and 1 lone pair cannot score M4 or M5

Any **two** from:
Allow 85 – 89°

Do not allow 90°

Allow 100 – 119°

Do not allow 120°

Allow 170 – 179°

Do not allow 180°

2

(ii) NaCl (as product in any equation)

1

$3\ SCl_2 + 4\ NaF \rightarrow SF_4 + S_2Cl_2 + 4\ NaCl$

Allow multiples

Ignore states

1

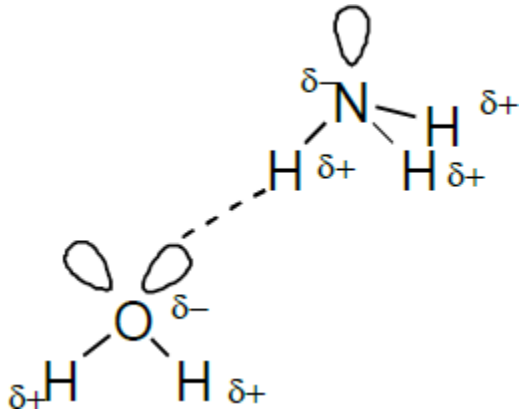
[17]

5. (a) Hydrogen bonding / hydrogen bonds / H-bonding / H-Bonds

Not just hydrogen.

1

(b)

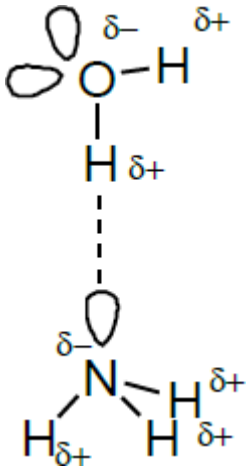


One mark for minimum of 4 correct partial charges shown on the N-H and O-H

One mark for the 3 lone pairs.

One mark for H bond from the lone pair on O or N to the $H^{\delta+}$

OR



The N-H-O should be linear but can accept if the lone pair on O or N hydrogen bonded to the H

If wrong molecules or wrong formula, CE = 0/3

3

(c) (Phosphine) does not form hydrogen bonds (with water)

1

[5]

6. (a) tendency / strength / ability / power of an <u>atom</u> / <u>element</u> / <u>nucleus</u> to attract / pull / withdraw electron<u>s</u> / e - density / bonding pair / shared pair

1

in a <u>covalent</u> bond

1

(b) (i) F_2 = van der Waals' / induced/temporary dipole-dipole / dispersion / London forces

1

CH_3F dipole-dipole

(not just 'dipole')

1

HF = hydrogen bonding

(not just 'H' / 'hydrogen')

1

(ii) large difference in electronegativity between H and F / F most/very/much more electronegative / values '4' & '2.1' quoted

(not just 'high <u>er</u>')

1

$^{\delta+}H\text{-}F^{\delta-}$ dipole created or dipole clearly implied

(accept arguments such as 'uneven charge in bond'/ 'polar bond' ∴ F slightly negative / H slightly positive)

1

attraction/bond formed between δ+H and lone pair on F

(M2 / M3 may be scored from a diagram)

(CE if full charges shown - lose M2 and M3)

1

(c) (i) van der Waals' / induced/temporary dipole-dipole / dispersion / London forces / attractions

(ignore references to dipole-dipole)

1

increase with the increasing M_r / size / mass / N^0 of e^- / size of e^- cloud (in the hydrogen halides)

(if ionic, or if 'covalent bonds broken' = CE = 0)

(mark M1 and M2 separately)

1

(ii) hydrogen bonding stronger than van der Waals' attraction/forces

(accept hydrogen bonding is very strong / strongest)

(accept arguments such as 'HF has H-bonds, others <u>only</u> have van der Waals')

(not just 'HF has H-bonding')

1

[11]