A-Level Chemistry

Shapes of Molecules

Mark Scheme

Time available: 63 minutes
Marks available: 54 marks

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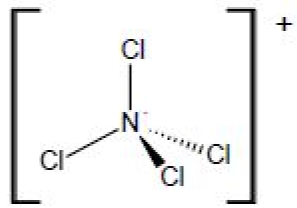
Mark schemes

1. Shapes:

Must show lp on NCl_3

1



Must have some indication that shape is 3D

1

Name of shape of NCl_3 = Pyramidal

Allow tetrahedral

1

Bond Angle = 109.5°

Allow 109 – 109.5°

1

(4 bp and 0 lp) electron pairs repel equally / electron pairs repel to be as far apart as possible

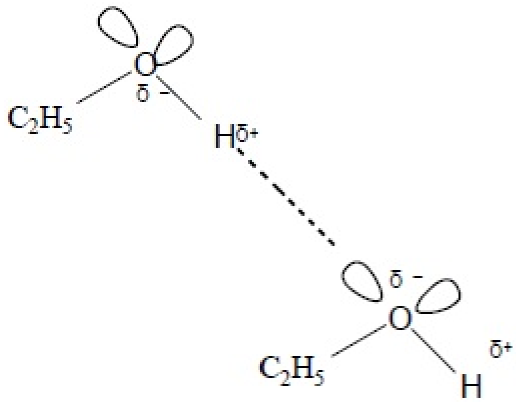
Do not allow atoms repel equally

Allow bonds repel equally

1

[5]

2.



***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

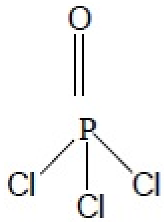
Hydrogen bonds are stronger/est intermolecular force

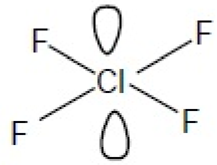
Allow more energy to break/overcome hydrogen bonding

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]

3. (a) $S_2O_3^{2-} + 2\,H^+ \rightarrow SO_2 + S + H_2O$

Allow $S_2O_3^{2-} + 2H_3O+ \rightarrow SO_2 + S + 3H_2O$

Allow ½$S_2O_3^{2-} + H^+ \rightarrow$ ½SO_2 + ½S + ½H_2O

Allow ½$S_2O_3^{2-} + H_3O + \rightarrow$ ½SO_2 + ½S + 1½H_2O

Ignore state symbols

NOT multiples

NOT if any spectator ions included (unless crossed out)

1

(b) **M1** acid(ic) / acidity / produces H^+

***M1** Allow low(ers) pH*

Ignore toxic / soluble

Ignore sulfurous / sulfuric / H_2SO_4

Ignore rain

Ignore proton donor (unless qualified, e.g. reacts with water to form a proton donor)

NOT any other named acid

1

M2 $SO_2 + H_2O \rightarrow H_2SO_3$ / $H^+ + HSO_3^-$

***M2** Allow $SO_2 + H_2O \rightarrow 2\,H^+ + SO_3^{2-}$*

Allow $SO_2 + 2\,H_2O \rightarrow H_3O^+ + HSO_3^-$

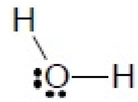
Allow $SO_2 + 3\,H_2O \rightarrow 2\,H_3O^+ + SO_3^{2-}$

Allow multiples

Ignore state symbols

1

(c) **M1**



__M1__ bent shape and 2 lone pairs on O

Allow any suitable representation of lone pairs (e.g. dots, crosses, lobes with/without dots/crosses)

1

M2 104½°

__M2__ Allow 104-105°

1

M3 lone pairs repel more (strongly) than bond(ing) pairs

__M3__ Allow non-bonding pair for lone pair

Allow covalent bond for bond(ing) pair

Allow shared pair for bond(ing) pair

Allow OH bond for bond(ing) pair

Allow bond for bond(ing) pair

NOT OH or O-H without the word bond for bond(ing) pair

1

M4 so bond angle reduced from/less than 109½° / tetrahedral

__M4__ Allow bond angle reduced from 120° if bent with one lone pair in __M1__

Allow reduced from 109°

Allow reduced by 2.5° per lone pair or 5° if __M2__ correct

1

(d)

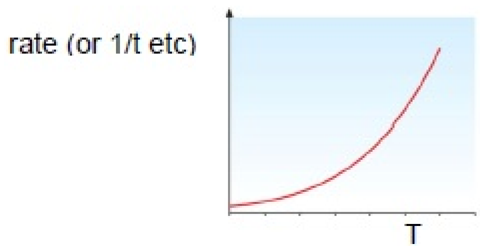
This question is marked using levels of response. Refer to the Mark Scheme Instructions for examiners for guidance on how to mark this question	
Level 3 **5-6 marks**	**All stages are covered and the explanation of each stage is correct and virtually complete.** (6 v 5) Answer is well structured, with no repetition or irrelevant points. Accurate and clear expression of ideas with no errors in use of technical terms.
Level 2 **3-4 marks**	**All stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies OR two stages covered and the explanations are generally correct and virtually complete** (4 v 3) Answer has some structure. Ideas are expressed with reasonable clarity with, perhaps, some repetition or some irrelevant points. If any, only minor errors in use of technical terms.
Level 1 **1-2 marks**	**Two stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies OR only one stage is covered but the explanation is generally correct and virtually complete** (2 v 1) Answer includes statements which are presented in a logical order and/or linked.
0 marks	Insufficient correct Chemistry to warrant a mark

Indicative Chemistry content

Stage 1 Method
(1a) Idea of using disappearing cross or colorimetry
(1b) Puts acid or thiosulfate into container on/with cross or in colorimeter
(1c) Add second reactant and start timing

Stage 2 Measurements
(2a) Repeat at different temperatures (if number of temperatures stated, must be more than two)
(2b) Record time, t, for cross to disappear / defined reading on colorimeter
(2c) Idea of ensuring other variables (cross, volumes, concentrations) kept constant (apart from T)

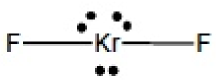
Stage 3 Use of Results
(3a) 1/t (or 1000/time, etc) is a measure of rate
(3b) plot of rate (or 1/t etc) (y-axis) against T (x-axis) (can come from labelled axes on sketch) (IGNORE T against rate)
(3c) sketch of plot as shown (Allow 3c if axes not labelled but NOT if incorrectly labelled)



6

[13]

4. (a)



Allow diagram with 2 bonds <u>and</u> 3 lone pairs

1

<u>Linear</u>

1

<u>180°</u>

1

(b) Lone pairs repel more than bond pairs

1

Allow idea of reducing bond angle

bond angle will be lower (than regular tetrahedral angle) / bond angle of 103-106°

1

(c) Van der Waals forces

Allow London forces, dispersion forces, induced dipole-dipole

Apply List for M1.

Allow M2 if vdW mentioned in M1, otherwise CE=0

1

(Uneven distribution of electrons in) one molecule <u>induces</u> dipole in neighbouring/another /nearby <u>molecule</u>

1

symmetrical molecule / dipoles cancel

OR

no hydrogens bonded to F (N or O), therefore no hydrogen bonding

1

[8]

5. (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) Difference in electronegativity 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 ∂+ on one molecule and ∂− 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]

6. (a) $Al + 1.5Cl_2 \rightarrow AlCl_3$

Accept multiples.

Also $2Al + 3Cl_2 \rightarrow Al_2Cl_6$

Ignore state symbols.

1

(b) Coordinate / dative (covalent)

If wrong CE=0/2 if covalent mark on.

1

Electron pair on Cl^- donated to Al(Cl_3)

QoL

Lone pair from Cl^- *not just Cl*

Penalise wrong species.

1

(c) Al_2Cl_6 or $AlBr_3$

Allow Br_3Al or Cl_6Al_2

Upper and lower case letters must be as shown.

Not $2AlCl_3$

1

(d) $SiCl_4$ / silicon tetrachloride

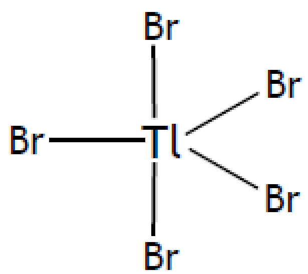
Accept silicon(4) chloride or silicon(IV) chloride.

Upper and lower case letters must be as shown.

Not silicon chloride.

1

(e)



Accept shape containing 5 bonds and no lone pairs from Tl to each of 5 Br atoms.

Ignore charge.

1

Trigonal bipyramid(al)

1

(f) (i) Cl — Tl — C

Accept this <u>linear</u> structure only with no lone pair on Tl

1

(ii) (Two) bonds (pairs of electrons) repel equally / (electrons in) the bonds repel to be as far apart as possible

Dependent on linear structure in (f)(i).

Do not allow electrons / electron pairs repel alone.

1

(g) Second

1

[10]