M1.(a) Silicon / Si

If not silicon then CE = 0 / 3

1

covalent (bonds)

M3 dependent on correct M2

1

Strong or many of the (covalent) bonds need to be broken / needs a lot of energy to break the (covalent) bonds

Ignore hard to break

1

(b) Argon / Ar

If not argon then CE = 0 / 3. But if Kr chosen, lose M1 and allow M2+M3

1

Large(st) number of protons / large(st) nuclear charge

Ignore smallest atomic radius

1

Same amount of shielding / same number of shells / same number of energy levels

Allow similar shielding

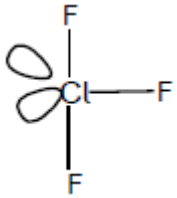
1

(c) Chlorine / Cl

*Not Cl_2, Not C**L**, Not Cl^2*

1

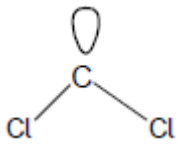
(d) (i)



Or any structure with 3 bonds and 2 lone pairs

Ignore any angles shown

1



Or a structure with 2 bonds and 1 lone pair

1

(ii) Bent / v shape

Ignore non-linear, angular and triangular

Apply list principle

1

(iii) $\frac{1}{2}Cl_2 + \frac{3}{2}F_2 \longrightarrow ClF_3$

No multiples

Ignore state symbols

1

[11]

M2.(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 $AlCl_3$

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

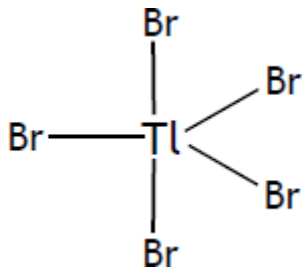
Accept silicon(4) chloride or silicon(IV) chloride.

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 — Cl

Accept this linear 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.

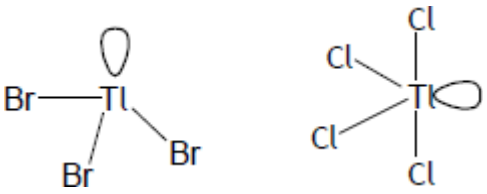
1

(g) Second

1

[10]

M3.(a)



Mark is for correct number of bonds and lone pair in each case.

Ignore charges if shown.

2

Pyramidal / trigonal pyramid

Allow tetrahedral.

1

107°

Allow 107 to 107.5°.

1

(b) M1 Ionic

CE = 0 / 3 if not ionic.

1

M2 Oppositely charged ions / Tl^+ and Br^- ions

If molecules / intermolecular forces / metallic bonding, CE=0.

1

M3 <u>Strong attraction</u> between ions

M3 dependent on M2.

Allow 'needs a lot of energy to break / overcome' instead of 'strong'.

1

(c) $Tl + \frac{1}{2}Br_2 \longrightarrow TlBr$

Allow multiples.

Ignore state symbols even if incorrect.

1

[8]

M4.(a) 94−105.5°

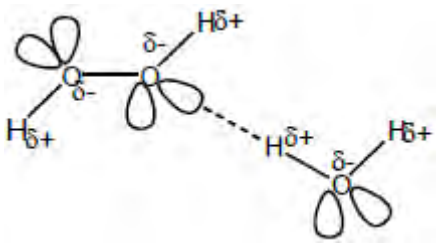
1

(b) (i) Hydrogen bond(ing) / H bonding / H bonds

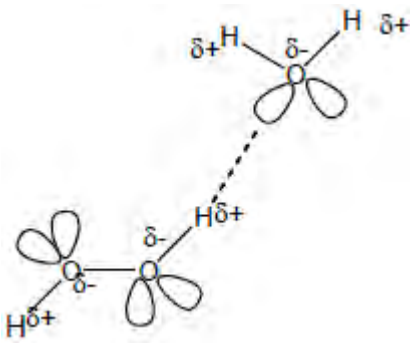
Not just hydrogen

1

(ii)



OR



1 mark for all lone pairs

1 mark for partial charges on the O and the H that are involved in H bonding

1 mark for the H-bond, from Hδ+ on one molecule to lone pair on O of other molecule

3

(c) Electronegativity of S lower than O or electronegativity difference between H and S is lower

Mark independently

1

No hydrogen bonding between H_2S_2 molecules

Or only van der Waals / only dipole-dipole forces between H_2S_2 molecules

If breaking covalent bonds CE = 0

1

[7]

M5.(a) $C(s) + 2F_2(g) \longrightarrow CF_4(g)$

State symbols essential

1

(b) Around carbon there are 4 bonding pairs of electrons (and no lone pairs)

1

Therefore, these repel equally and spread as far apart as possible

1

(c) $\Delta H = \Sigma\ \Delta_f H$ products $- \Sigma\ \Delta_f H$ reactants or a correct cycle

1

Hence = (2 × –680) + (6 × –269) – (x) = –2889

1

x = 2889 – 1360 – 1614 = –85 (kJ mol^{-1})

1

Score 1 mark only for +85 (kJ mol^{-1})

(d) Bonds broken = 4(C–H) + 4(F–F) = 4 × 412 + 4 × F–F

Bonds formed = 4(C–F) + 4(H–F) = 4 × 484 + 4 × 562

Both required

1

$-1904 = [4 \times 412 + 4(F–F)] – [4 \times 484 + 4 \times 562]$

$4(F–F) = –1904 – 4 \times 412 + [4 \times 484 + 4 \times 562] = 632$

1

$F–F = 632 / 4 = 158$ (kJ mol^{-1})

1

The student is correct because the F–F bond energy is much less than the C–H or other covalent bonds, therefore the F–F bond is weak / easily broken

Relevant comment comparing to other bonds

(Low activation energy needed to break the F–F bond)

1

[10]

M6.(a) This question is marked using levels of response. Refer to the Mark Scheme Instructions for Examiners for guidance on how to mark this question.

All stages are covered and the explanation of each stage is generally correct and virtually complete.

Answer is communicated coherently and shows a logical progression from stage 1 to stage 2 then stage 3.

Level 3
5 – 6 marks

All stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies OR two stages are covered and the explanations are generally correct and virtually complete.

Answer is mainly coherent and shows progression from stage 1 to stage 3.

Level 2
3 – 4 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

Answer includes isolated statements but these are not presented in a logical order or show confused reasoning.

Level 1
1 – 2 marks

Insufficient correct chemistry to gain a mark.

Level 0
0 marks

Indicative chemistry content

Stage 1: Electrons round P
- P has 5 electrons in the outside shell
- With 3 electrons from 3 fluorine, there are a total of 8 electrons in outside shell
- so 3 bond pairs, 1 non-bond pair

Stage 2: Electron pair repulsion theory
- Electron pairs repel as far as possible
- Lone pair repels more than bonding pairs

Stage 3: Conclusions
- Therefore, tetrahedral / trigonal pyramidal shape
- With angle of 109(.5)° decreased to 107°

6

(b) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^7$

Allow correct numbers that are not superscripted

1

(c) Too many electrons in d sub-shell / orbitals

1

(d) Tetrahedral (shape)

1

109.5°

Allow 109°

1

[10]

M7.B

[1]