1

Structures

M1 Bromine is (simple) molecular / simple molecules

Chemical Error penalties

1

M2 Magnesium is metallic / consists of (positive) ions in a (sea) of delocalised electrons

If Br_2 (covalent) bonds broken lose M3 and M4

1

Strength

M3 Br_2 has weak (van der Waals) forces between the molecules / weak IMFs

If eg Mg molecules or Mg ionic bonds lose M2 and M4

1

M4 so more energy is needed to overcome the Stronger (metallic) bonds or converse. The comparison could be direct or implied.

1

Liquid range

M5 Mg has a much greater liquid range because forces of attraction in liquid / molten metal are strong(er) OR converse argument for Br_2

Must refer to liquid range to score M5

1

[5]

2

(a) Correct diagram of NH_3 including LP on N

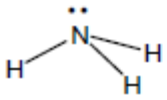
1

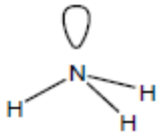
Correct diagram of $AlCl_3$

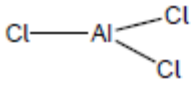
1

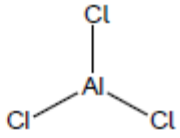
Bond angles in range 106-108° and bond angle of 120°

1









Ignore shape names

(b) Dative (covalent) /co-ordinate bond

Wrong bond CE=0 but mark on if covalent quoted

1

Shared pair of / both electrons come from the $N(H_3)$

1

(c) Aluminium is now surrounded by 4 electron pairs/bonds or is tetrahedral

Independent

1

Therefore Cl-Al-Cl bond angle decreases / changes
(from 120° in $AlCl_3$) to allow range 107-111° in H_3NAlCl_3

1

[7]

3 B

[1]

4 A

[1]

5 (a) M1 have the same molecular formula
or are C_3H_6O
or both have the same number/amount of each type of atom or same amount of each element
or are isomers

Not just the same atoms;

1

M2 <u>identical / exactly the same / same precise</u> (relative) molecular mass / formula mass / M_r

Same (relative) molecular mass / formula mass / M_r is NOT enough got score M2

Allow <u>same accurate</u> (relative) molecular mass / formula mass / M_r

Ignore reference to number of decimal places

1

(b) M1 prop-2-en-1-ol

Must refer to this compound clearly by name or structure (not to alcohol alone); ignore minor slips in name/structure

1

M2 <u>O</u>(-)<u>H</u> (alcohol) and 3230–3550 (cm^{-1}), or
<u>C=C</u> and 1620–1680 (cm^{-1})

Marked independently from M1

Could score from bond labelled on correct signal on spectrum

Allow any value within these ranges

If additional incorrect signals given penalise M2

Ignore signals below 1500 cm^{-1} and C-H signals

1

(c) (i) Determine the level by looking at the chemical content. (**NB** - If there is clear breakage of covalent bonds then max level 2 (max 3 marks).

(ii) The mark within that level is then determined by looking at how coherent and logical the answer is and by use of terminology; start at the higher mark and penalise poor terminology/explanation; examples of terminology that would reduce the mark to the lower one:

- reference to van der Waals 'bonds' or dipole-dipole 'bonds in relevant compounds that are being credited
- uncertainty about whether hydrogen bonds are the O-H bonds within or are forces/bonds between molecules (if the alcohol is being credited)
- use of 'vdw' or 'dip-dip' unless these terms 'van der Waals' for 'dipole-dipole' have been used elsewhere in answer (note that IMF and H-bond would not be penalised)

(iii) If the answer does not achieve level 1, then 1 mark maximum could be scored for any correct point from the list of indicative content

Level 3
- **Relative order** of boiling points of **all three** compounds
- Strongest intermolecular force of **all three** compounds identified
- Answer explains this coherently and logically and uses correct terminology for all **three** compounds

5-6 marks

Level 2
- **Relative** boiling points of **two** compounds correctly compared
- Strongest intermolecular force for these **two** compounds correctly identified
- Answer explains this coherently and logically and uses correct terminology for **these two** compounds

3-4 marks

Level 1
- **One** compound with the **highest** or **lowest** boiling point is correctly identified
- Strongest intermolecular force for that **one** compound identified
- Answer explains this coherently and logically and uses correct terminology for **this one** compound
- Allow 1 mark for individual correct point from indicative content on the right if no other mark scored

1-2 marks

Level 0
None of the indicative chemistry content given.

0 marks

Indicative chemistry content:

• Correct order (highest to lowest) = prop-2-en-1-ol > propanal > butane

• Prop-2-en-1-ol has hydrogen bonds

• Propanal has (permanent) dipole-dipole forces

• Butane has van der Waals' forces

• Strength of intermolecular forces:
hydrogen bonds > dipole-dipole > van der Waals

(Note - actual values for reference are prop-2-en-1-ol 97°C, propanal 46°C and butane −1°C)

[10]

6 (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

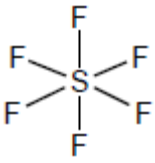
(d) (i) 

Diagram showing 6 bond pairs

1

(Bond angle) 90° for SF_6

Ignore 180°

1

Octahedral

1

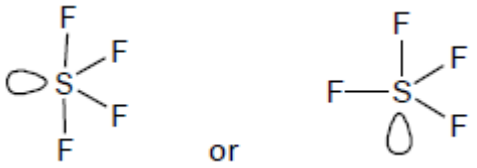


Diagram showing 4 bond pairs <u>and 1 lone pair</u>

1

(Bond angles) for SF_4

If shape of SF_4 is not based on 4 bond pairs <u>and 1 lone pair</u> 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]

7 (a) General increase

If not increase then CE

1

Greater nuclear charge / more protons

1

Same shielding / electrons added to same shell

Allow similar

1

Stronger <u>attraction</u> (from nucleus) for <u>outer electron(s)</u>

Allow electron in outer shell

1

(b) Aluminium / Al (lower than Mg)

CE if not Al or S

1

(Outer) electron in (3)p orbital / sub-shell (level)

If 2p or 4p orbital lose M2 and M3

1

(3p) higher in energy

Allow more shielded or weaker nuclear attraction

M3 is dependent on M2

1

or
Sulfur / S (lower than P)
(Outer) electrons in (3)p orbital begin to pair
Repel

If 2p or 4p orbital lose M2 and M3

Allow 2 electrons in (3)p

M3 is dependent on M2

(c) Sulfur / S

CE if not S

1

Large jump after 6^{th} or between 6^{th} and 7^{th}

Do not allow M2 if atom/ion is removed

1

(d) Silicon

CE if not Si

1

Giant covalent structure / macromolecule

1

Covalent (bonds)

Giant covalent scores M2 and M3

1

Many / strong (covalent bonds) or
(covalent bonds) need lots of energy to break

CE for M2-M4 if molecules / metallic / ionic / IMFs mentioned

1

[13]

8 (a) OH AND alcohol

***IGNORE** hydroxy(l)*

1

(b) **A** = butan-2-ol / $CH_3CH(OH)CH_2CH_3$

If formulae given then must be unambiguous

If both formula and name given then formula must match name for mark to be awarded

1

B = butan-1-ol / $CH_3CH_2CH_2CH_2OH$

1

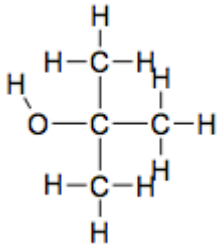
Product from **A / P** is a <u>ketone</u>
AND
Product from **B / Q** is an <u>aldehyde</u>

Penalise reference to incorrect class of alcohol

1

(c) Type of Bond: C=C

1



*Must show all bonds in Isomer **C** including O–H bond*

1

Reagent: conc. H_2SO_4 / conc. H_3PO_4

If incorrect attempt at correct reagent, mark on

Apply list principle for reagents and conditions marks

Conc required - may appear on conditions line

NOT (aq) For M3 even if seen on conditions line

ALLOW

Reagent = Al_2O_3

Condition = 'passing vapour over hot solid' owtte

1

Conditions: 180 °C / High temp / Hot / Reflux /

ALLOW stated temp in range 100-300 °C/373-573 K

IGNORE 'heat'

M4 dependent on correct reagent in M3

1

(d) (i) S = aldehyde/CHO **AND** T = carboxylic/COOH/CO_2H

1

T forms hydrogen bonds

1

(Which are) stronger than / need more energy to break than forces <u>between molecules/IMFs</u> in S ora (or reverse argument)

If implication of breaking covalent bonds max M1 only

1

(ii) (No oxidation has occurred as..)

(Still) contains peak at 3230−3550 cm-1 due to O−H/alcohol

Does not contain peak at 2500−3000 cm-1 due to O−H/carboxylic acid

Does not contain peak at 1680−1750 cm-1 due to C=O

Must have wavenumber range (or value within range) and bond or functional group to score each mark.

Any 2

[13]

9 (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 × 412 + 4(F–F)] – [4 × 484 + 4 × 562]

4(F–F) = –1904 – 4 × 412 + [4 × 484 + 4 × 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]

10	B	**[1]**
11	A	**[1]**
12	C	**[1]**
13	C	**[1]**
14	D	**[1]**