Intermolecular Forces, Electronegativity & Bond Properties

Mark Scheme

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	Chemical Bonding
Sub-Topic	Intermolecular forces, electronegativity & bond properties
Paper Type	Theory
Booklet	Mark Scheme

Time Allowed: **68 minutes**

Score: **/56**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	777.5%	70%	62.5%	57.5%	45%	<45%

1 **(a** fluorine: $1s^2 2s^2 2p^5$ **[1]**

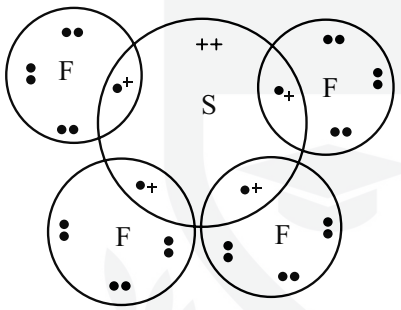
sulfur: $1s^2 2s^2 2p^6 3s^2 3p^4$

(b) **(i)** $2HCl \longrightarrow H_2 + Cl_2$ **[1]**

(ii) bond energies: HF (562) is **stronger** than HCl (431) **[1]**
or F_2 (158) is **weaker** than Cl_2 (244)

(c) *electronegativity:* **[2]**
The attraction by an atom / nucleus / element of the electrons in a bond *or* a shared pair *or* a molecule
bond polarity:
..is due to atoms / elements of **different** electronegativities at each end of a bond

(d)



(ii) Yes, it will have a dipole moment, **[3]**
either because it has an uneven distribution of electrons *or* because it contains a lone pair
or the S–F dipoles don't cancel *or* molecule is not symmetrical *or* diagram of see-saw shape.
(allow an ecf for "no dipole" if their structure in (d)(i) has **no** lone pair)

(e) Sulfur can use its d-orbitals *or* has low-lying / accessible / available d-orbitals *or* can expand its octet. **[1]**
(allow reverse argument for oxygen; do NOT allow just "sulfur has d-orbitals")

(f) **(i)** Burning of **fossil** fuels *or* coal / oil / petrol / natural gas (NOT methane *or* hydrocarbons) *or* volcanoes *or* roasting / burning sulfide ores

(ii) Acid rain **[2]**

[Total: 11]

2 **(a) (i)** 2 (1)

(ii) between 104° and 105° (1) [2]

(b) ethanal $_3CHO$ **A** (1)

ethanol $_3CH_2OH$ **C** (1)

methoxymethane $_3OCH_3$ **A** (1)

2-methylpropa $(CH_3)_2CHCH_3$ **B** (1) [4]

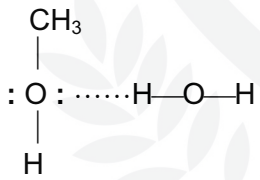
(c) hydrogen bonds (1)

(ii) correct dipole on an -O—H bond (1)

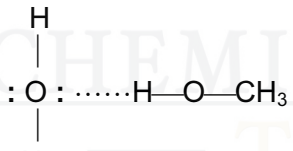
hydrogen bond shown between the lone pair of an O and a H atom in an –OH group (1)

lone pair on O atom of CH_3OH **or** H_2O clearly shown **in the hydrogen bond** (1)

e.



or



[4]

(d) hydrogen bonds exist between H_2O molecules (1)

hydrogen bonds cannot form between $C_2H_5OC_2H_5$ molecules (1) [2]

[Total: 12]

3 **(a)** volatility: $Cl_2 > Br_2 > I_2$ *or* boiling points: $Cl_2 < Br_2 < I_2$ *or* Cl_2 is (g); Br_2 is (l); I_2 is (s) [1]
more <u>electrons</u> in X_2 down the group *or* more shells/bigger cloud <u>of electrons</u> [1]
so there's greater van der Waals/dispersion/id-id/induced/temporary dipole force/attraction [1]
[3]

(b) **(i)** $H_2O > H_2S$ *(see * below for mark)*
due to H-bonding in H_2O (none in H_2S) [
diagram minimum is: $H_2O^{\delta-}\cdots^{\delta+}H\text{-}OH$ *or* $H_2O{:}\cdot H\text{-}OH$ [allow (+) for δ+] [1]

(ii) $CH_3\text{-}O\text{-}CH_3 > CH_3CH_2CH_3$ *(see * below for mark)*
due to dipole in $CH_3\text{-}O\text{-}CH_3$ (O is $\delta-$ not needed, but O is δ+ negates) *or* CH_3OCH_3 is polar [1]
* correct comparison of boiling points for **both** [1]
[4]

(c) SF_6 has 6 bonding pairs/bonds and <u>no lone pairs</u> (bonds can be read into a diagram e.g. S-F, but 'no lone pairs' can *only* be read into a diagram showing 6 <u>bonded pairs of electrons</u>. [1]
<u>clear</u> diagram *or* 'shape is octahedral' [1]
[2]

[Total: 9]

4 **(a** there are no inter-molecular forces present between ideal gas molecules
ideal gas molecules have no volume
collisions between ideal gas molecules are perfectly elastic
ideal gas molecules behave as rigid spheres (any 2) [2]

(b) high temperature (1)
low pressure (1) [2]

(c) **mo ideal** ..... neon..... nitrogen..... ammonia..... **least ideal** (1)
nitrogen has stronger van der Waals' forces than argon (1)
ammonia has hydrogen bonding as well as van der Waals' forces (1) [3]

(d) with increasing temperature,
average kinetic energy of molecules increases (1)
intermolecular forces are more easily broken (1) [2]

(e) 18 (1)

(f) **(** both have very similar/same van der Waals' forces (1)

(ii) CH_3F has permanent dipole (1) [2]

[Total: 12]

5 **(a)** covalent (*giant* or *macro*) negates, as also does any reference to ionic bonding) [1]
(*simple molecular is not enough – look for covalent*)

tetrahedral [1]

(b) **(** plotting (allow ±1°) [1]
138 – 151°C (stated in numbers, or read from the graph) [1]

(ii) (b. pt. increases due to) larger intermolecular / van der Waals / induced dipole (NOT permanent dipole) / attractions [1]

due to the larger no. **of electrons** *or* more shells **of electrons** (in MX_4) [1]

(c) **(** Si has empty low-lying orbitals *or* empty d-orbitals (C does not) [1]

(ii) $SiCl_4 + 2H_2O \longrightarrow Si_2 + 4HCl$ [1]

[*or* $SiCl_4 + 4H_2O \longrightarrow Si(OH)_4 + 4HCl$ etc.]

(iii) (yes), because Ge also has empty (low lying d-) orbitals [1]

(d) **(** $SiCl_4 + 2Zn \longrightarrow Si + l_2$ [NOT ionic equation] [1]

(ii) mass = 250 x 2 x 65.4/28.1

= **1164** (g) (actually 1163.7 – but allow 1160) [2]

*allow e.c.f from the stoichiometry of the candidate's equation e.g. allow **582**g for [2] marks if the equation shows the stoichiometry to be 1:1. But if 582g is obtai because the candidate forgot to apply the stoichiometry as given in the equation, award only [1] mark.*

correct answer = [2], with – [1] for one error. OR marks as follows:
use of 2:1 ration [1]
correct use of A_r data for Si and Zn [1]

Total = [12]