Q1.

Which molecule does **not** have a permanent dipole?

A CH_3Br ⬭

B CH_2Br_2 ⬭

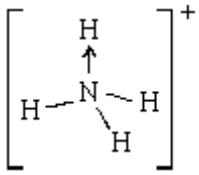
C $CHBr_3$ ⬭

D CBr_4 ⬭

(Total 1 mark)

Q2.

(a) An ammonium ion, made by the reaction between an ammonia molecule and a hydrogen ion, can be represented as shown in the diagram below.



(i) Name the type of bond represented in the diagram by N—H

_____

(ii) Name the type of bond represented in the diagram by N→H

_____

(iii) In terms of electrons, explain why an arrow is used to represent this N→H bond.

_____

_____

(5)

(b) Define the term *electronegativity*.

_____

_____

(2)

(c) A bond between nitrogen and hydrogen can be represented as $\overset{\delta-}{N}—\overset{\delta+}{H}$

(i) In this representation, what is the meaning of the symbol $\delta+$?

_____

(ii) From this bond representation, what can be deduced about the electronegativity of hydrogen relative to that of nitrogen?

_____

_____

(2)

Q3.

(a) Both HF and HCl are molecules having a polar covalent bond. Their boiling points are 293 K and 188 K respectively.

(i) State which property of the atoms involved causes a bond to be polar.

_____

_____

(ii) (HINT IM FORCES) Explain, in terms of the intermolecular forces present in each compound, why HF has a higher boiling point than HCl.

_____

_____

_____

_____

_____

(4)

(b) When aluminium chloride reacts with chloride ions, as shown by the equation below, a co-ordinate bond is formed.

$$AlCl_3 + Cl^- \rightarrow AlCl_4^-$$

Explain how this co-ordinate bond is formed.

_____

_____

_____

(2)

Q5.

This question is about periodicity, the Period 4 elements and their compounds.

(a) State the meaning of the term periodicity.

_____

_____

_____

(1)

(b) Identify the element in Period 4 with the highest electronegativity value.

_____

(1)

(c) Identify the element in Period 4 with the largest atomic radius.

Explain your answer.

Element _____

Explanation _____

_____

_____

_____

(3)

Q6.

Which bond has the most unsymmetrical electron distribution?

A H–O ⬭

B H–S ⬭

C H–N ⬭

D H–P ⬭

(Total 1 mark)

Q7.

Which molecule has a permanent dipole?

A CF_4 ⬭

B PCl_5 ⬭

C CO_2 ⬭

D Cl_2O ⬭

(Total 1 mark)

Q8.

Which species contains bonds that have different polarities?

A NH_4^+ ⬭

B CCl_4 ⬭

C CH_3Cl ⬭

D H_3O^+ ⬭

(Total 1 mark)

Q9.

The table below shows the electronegativity values of atoms of some elements.

Atom	H	C	N	O	Br
Electronegativity	2.1	2.5	3.0	3.5	2.8

(b) Define the term electronegativity.

_____

_____

_____

(1)

(c) Deduce the **two** atoms from the table above that will form the most polar bond.

_____

(1)

(d) The C–Br bond is polar.

Explain why CBr_4 is **not** a polar molecule.

_____

_____

_____

_____

(2)

(e) (HINT: IM FORCES) Suggest, in terms of the intermolecular forces for each compound, why CBr_4 has a higher boiling point than $CHBr_3$

_____

_____

_____

_____

_____

_____ **(3)**

10

This question is about intermolecular forces in some organic compounds.

The table below gives some information about three organic compounds.

Compound	dichloromethane	tetrachloromethane	propan-1-ol
Boiling point / °C	40	77	97
Polarity of molecules	polar	non-polar	polar

(a) State why the C–Cl bonds in dichloromethane and tetrachloromethane are polar.

_____

_____

(1)

(b) Suggest why tetrachloromethane molecules are non-polar.

_____

_____

_____

(1)

11

The table below shows some data about three compounds that all contain the same number of electrons.

Compound	CH_3CH_2OH	$CH_3CH_2NH_2$	CH_3OCH_3
Boiling point / K	352	290	248

(b) All three compounds in the table above are polar.
Ethanol is the most polar and ethylamine is the least polar.

Explain why all three molecules are polar and why ethylamine is the least polar.
In your answer refer to the shapes around, and relative electronegativities of, the most electronegative atoms.

_____

_____

_____

_____

_____

(4)

(c) (Q is about IM forces) Explain the trend in the boiling points of the three compounds. Refer to the intermolecular forces in all three compounds in your answer.

(3)

Mark schemes

Q1.

D

[1]

Q2.

(a) (i) Covalent **(1)**

(ii) Co-ordinate **(1)** (or dative)

(iii) Both / two / pair electrons come from nitrogen **(1)**

(b) Power (or ability) of an element / atom to attract electron pair**/**electrons/ an electron/electron density **(1)**

in a covalent bond **(1)**

Allow attract from, withdraw in, do not allow remove from, withdraw from.

2

(c) (i) Electron deficient **(1)**

Or small, slight, partial positive charge

(ii) H < N **(1)**

2

[11]

Q3.

(a) (i) Electronegativity (difference) or suitable description **(1)**

Accept F and Cl are highly electronegative
Not both atoms are highly electronegative

(ii) HF = hydrogen bonding **(1)**
HCl = (permanent) dipole-dipole bonding **or** even van de Waals' **(1)**
Hydrogen bonding stronger / is the strongest IMF **(1)**

Accept a statement that HF must have the stronger IMF, even if no IMFs identified

*The explanation **must** be based on **intermolecular** forces/attractions*

Note: if the explanation is clearly intramolecular = CE

4

(b) Electron pair **or** lone pair donated **(1)**

Do not accept 'donation of electrons'

From chloride ion to Al **or** $AlCl_3$ **(1)**

M1 can be earned by a general explanation of coordinate bonding, even if the electron pair is said to come from Al. The second mark, M2, is for this specific bond

Ignore missing charge

2

]

Q5.

(a) Repeating pattern/trends (of physical or chemical properties/reactions)

Allow named property

Penalise groups

1

(b) Bromine/Br

Not Br_2

Accept Kr or Krypton

1

(c) Potassium /K

*If Na or Rb lose **M1** but allow access to **M2** and **M3***

If other incorrect elements 0/3

1

Smallest number of protons/smallest nuclear charge

1

Similar shielding / same number of shells (as other elements in period 4)

Allow same shielding

1

Q6.

A

H–O

[1]

Q7.

D

Cl_2O

[1]

Q8.

C

CH_3Cl

[1]

Q9.

(b) The (relative) tendency of an atom to attract a pair of electrons/ the

electrons/ electron density in a covalent bond

Allow

Nucleus instead of atom

Power of an atom to attract a bonding/shared pair of electrons

Power of an atom to withdraw electron density from a covalent bond

Not lone pair / element

1

(c) H and O

O−H

1

(d) M1 the molecule is completely symmetrical / the molecule is tetrahedral / there is an even distribution of electron density

1

M2 the dipoles cancel out

1

Do not allow

The polar bonds cancel out / no dipole moment / partial charges cancel

(e) M1 CBr_4 has van der Waals' forces between molecules

1

M2 $CHBr_3$ has van der Waals' forces and dipole-dipole intermolecular forces

1

M3 The van der Waals' between CBr_4 molecules are stronger than the dipole-dipole and van der Waals' forces between $CHBr_3$ (because it has a larger mass/more electrons/larger electron cloud)
OR
The intermolecular forces between CBr_4 molecules are stronger than the intermolecular forces between $CHBr_3$

M3 cannot be awarded if mention of breaking bonds

1

[10]

10

(a) Cl is more electronegative (than C) **or**

C and Cl have different electronegativities

Allow idea that electrons (in bond) are not shared equally

1

(b) idea that dipole moments (or dipoles) cancel out (due to symmetry)

Allow polar bonds / polarities cancelling out

1

11

(b) **M1** O **AND** N more electronegative than C and/or H (so all have polar bonds)

M2 CH_3CH_2OH and CH_3OCH_3 both v-shaped/non-linear/bent **AND** $CH_3CH_2NH_2$ (trigonal) pyramidal

M3 shapes are not symmetrical (so molecules are polar)

M4 O more electronegative than N (so ethylamine is least polar)

ALLOW *'different electronegativities' PLUS diagrams labelled δ+ and δ-*

ALLOW *angular for v-shaped in* ***M2***

Diagrams from ***M2*** *do not require lone pairs*

ALLOW M3 *if diagrams in* ***M2*** *show asymmetry*

Correct diagrams of the three shapes gives ***M2*** *and* ***M3***

4

(c) **M1** hydrogen bonding in CH_3CH_2OH and $CH_3CH_2NH_2$ **AND** (permanent) dipole-dipole forces in CH_3OCH_3

M2 hydrogen bonding stronger (than other (intermolecular) forces)

M3 hydrogen bonding stronger in CH_3CH_2OH than in $CH_3CH_2NH_2$

IGNORE *van der Waals' / temporary/induced dipole-dipole forces*

M1 NOT *any reference to breaking covalent bonds*

M3 ALLOW *reference to O being more/most electronegative (than N) OR ethanol has greater dipole moment / more polar than ethylamine*

If none of M1, M2 or M3 have been awarded:

ALLOW *one mark for an indication that higher boiling point = stronger intermolecular forces but*

NOT *if reference to breaking covalent bonds*

3