- Hydrogen bond strength increases in the order N–H:::N < O–H:::O < F–H:::F. Use this information and the data given in the table to explain the differences in boiling point of ammonia, water and hydrogen fluoride.

2

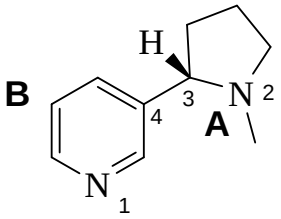
Compound	NH_3	H_2O	HF
Boiling point / °C	–33	100	20

NH_3 and HF both have two H-bond per molecule and their boiling points are in the expected order - HF has the stronger H-bonds and the higher boiling point.

H_2O has 4 H-bonds per molecule, so although the bonds are not as strong as those of HF, there are twice as many of them. As a result the boiling point of H_2O is greater than that of HF.

Marks 4

- The molecular structure of nicotine, the addictive component of tobacco, is shown below.



List the types of intermolecular interactions that each of the following sites on nicotine would be involved in when it is dissolved in water.

A – H bonding and dipole-dipole interactions
B – dispersion forces and dipole-induced dipole

Provide the requested information for each of the indicated atoms in nicotine.

Atom	Geometric arrangement of the electron pairs around the atom	Hybridisation of the atom	Geometry around the atom
N-1	**trigonal planar**	***sp*^{2}**	**bent (~120°)**
N-2	**tetrahedral**	***sp*^{3}**	**trigonal pyramidal**
C-3	**tetrahedral**	***sp*^{3}**	**tetrahedral**
C-4	**trigonal planar**	***sp*^{2}**	**trigonal planar**

3

- Consider the boiling points of the compounds 1-propanol, 1-propanethiol and 1-propaneselenol shown in the table below?

Compound	$CH_3CH_2CH_2OH$	$CH_3CH_2CH_2SH$	$CH_3CH_2CH_2SeH$
Boiling point (° C)	97.2	67.8	147.0

With reference to intermolecular forces, explain briefly why the boiling points increase in the order $CH_3CH_2CH_2SH < CH_3CH_2CH_2OH < CH_3CH_2CH_2SeH$.

Polarisability of atoms increases as the size of the atoms increase. The greater the polarisability, the stronger the dispersion forces. On this basis, the expected boiling point order would be $C_3H_7OH < C_3H_7SH < C_3H_7SeH$.

C_3H_7OH also has hydrogen bonding between the OH groups. H-bonding is a stronger intermolecular force than dispersion forces and this increases the boiling point of C_3H_7OH to be above that of C_3H_7SH. The effect is not enough to push it above the boiling point of C_3H_7SeH.

Marks

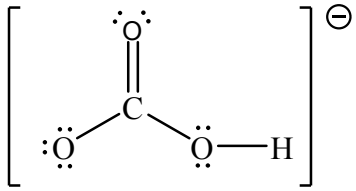
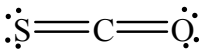
- Complete the following table. Give, as required, the formula, the systematic name, the oxidation number of the underlined atom and, where indicated, the principal ions present in a solution prepared by adding the substance to water. **4**

FORMULA	SYSTEMATIC NAME	OXIDATION NUMBER	PRINCIPAL IONS IN WATER SOLUTION
$\underline{N}O_2$	**nitrogen dioxide**	**+IV**	N/A
$\underline{Pb}(CH_3CO_2)_2$	**lead(II) acetate**	**+II**	**Pb^{2+}(aq), $CH_3CO_2^-$(aq)**
$Mg(\underline{Cl}O_4)_2$	**magnesium perchlorate**	**+VII**	Mg^{2+}(aq); $\underline{Cl}O_4^-$(aq)

Write the full electron configuration of the As^{3+} ion.

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2$

- Draw the Lewis structures, showing all valence electrons for the following species. Indicate which of the species have contributing resonance structures. **5**

HCO_3^-	COS	CN^-
		
Resonance: **YES** / NO	Resonance: YES / **NO**	Resonance: YES / **NO**

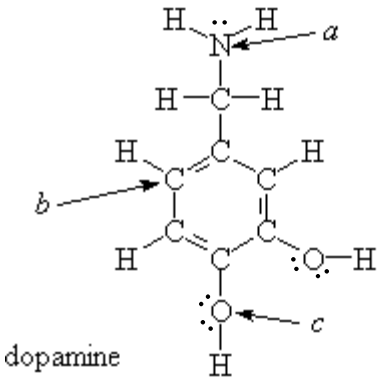
- Name the two intermolecular forces, which best explain the difference in boiling points of 1-propanol ($CH_3CH_2CH_2OH$; bp = 97.2 °C) and 1-propanethiol ($CH_3CH_2CH_2SH$; bp = 67.8 °C). **2**

Hydrogen bonding in 1-propanol (strong)

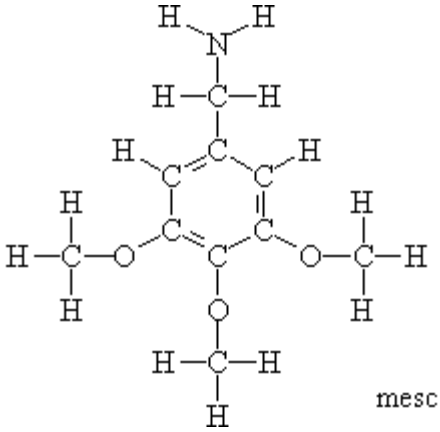
Dipole / dipole forces in 1-propanethiol (relatively weak)

Marks 6

- The structures of dopamine and mescaline are given below.



dopamine


mescaline

Dopamine is involved in the transmission of nerve impulses in the brain. Complete the Lewis structure for dopamine by including all lone pair electrons.

How many π electrons are there in dopamine?

1 lone pair on each O and the π electrons in the 3 C=C bonds are involved in π bonding: 10 e^- in total

Predict the bond angles at the points labelled *a*, *b*, and *c* in dopamine.

a	**~109.5°**
b	**~120°**
c	**~109.5**

Mescaline is an hallucinogenic compound found in the peyote cactus. Suggest a reason for the ability mescaline to disrupt nerve impulses.

Mescaline has a similar structure to dopamine, with a benzene ring and a amine group plus O groups on the ring. It can bind to the receptors designed for dopamine.

Which compound, dopamine or mescaline, has the higher solubility in water? Give reasons for your answer.

The O-H groups in dopamine are able to form H-bonds with water molecules making it quite soluble. In mescaline, these are ethers groups which will form much weaker H-bonds and so mescaline has a lower solubility.