- 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

H-bonding is dominant and strong in $CH_3CH_2CH_2OH$ due to the electronegativity of oxygen. The lower electronegativity of sulfur ensures that H-bonding is quite weak in $CH_3CH_2CH_2SH$ and weaker dipole-dipole interactions are probably more important.

The alkyl chain in both will interact via dispersion forces, but these are likely to be similar in both systems.

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- 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.

- 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.