Marks
3

- Consider the boiling points of the following hydrides:

compound	boiling point (K)
H_2O	373
HF	293
NH_3	240
CH_4	111

Explain the origin of the difference in boiling points between:

i) CH_4 and NH_3

The electronegativity of C and H are very similar so that the C-H bond has a very low polarity. The tetrahedral shape of CH_4 also means that there is no overall dipole moment. The only significant force existing between CH_4 molecules is dispersion. The small size of CH_4 means that dispersion interactions are very weak.

The N-H bond is quite polar due to the higher electronegativity of nitrogen. The pyramidal shape of NH_3 leads to a significant dipole moment with the nitrogen lone pair at one end and the hydrogen atoms, which bear a partial positive charge, at the other. There is significant H-bonding possible between NH_3 molecules as well as weak dispersion forces. The intermolecular forces are much stronger than in CH_4 and so NH_3 has a much higher boiling point.

ii) HF and NH_3

Fluorine is significantly more electronegative than nitrogen so the H-F bond is more polar than the N-H bonds. Very strong H-bonding occurs between HF molecules leading to its higher boiling point.

iii) H_2O and HF

Fluorine is more electronegative than oxygen so the H-F bond is also more polar than the O-H bonds leading to again stronger H-bonding between HF molecules. These interactions are so strong, however, that HF exists as H-bonded dimers (and even larger clusters) in the vapour whereas H_2O is only H-bonded in the liquid. As not all of the H-bonds need to be broken to boil HF, it actually has a lower boiling point than H_2O,

ANSWER CONTINUES ON THE NEXT PAGE

- Which molecule in each of the following pairs has the greater dipole moment? Give reasons for your choice.

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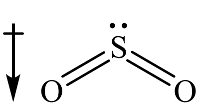
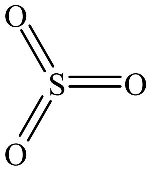
a) SO_2 or SO_3

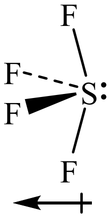
SO_2 has a larger dipole moment than SO_3.
Both have δ^+ S and δ^- O atoms.
SO_2 is bent leading to the dipole shown.
SO_3 is trigonal planar so that the individual dipoles on the S-O bonds cancel and the molecule has no dipole moment.

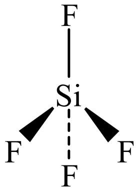




b) SiF_4 or SF_4

SF_4 has a larger dipole moment than SiF_4.
Both have δ^- F with δ^+ Si and S respectively.
The unsymmetrical 'see-saw' structure of SF_4 leads to an overall dipole, as shown.
SiF_4 is tetrahedral so that the individual dipoles on the Si-F bonds cancel and the molecule has no dipole moment.





c) H_2S or H_2Te

H_2S has a larger dipole moment than H_2Te.
Both have δ^+ H with δ^- S and Te respectively and are bent leading to overall dipoles, as shown.
S is more electronegative than Te so the partial negative charge on S is considerably bigger leading to a larger dipole moment.