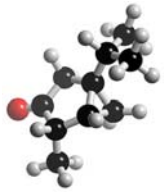
AS.CHEM1.3.007

FORCES BETWEEN MOLECULES



Name …… Form ……

1) Van der Waals' forces (induced dipole-dipole forces)

- Even in molecules with no polar bonds, there are temporary dipoles due to uneven electron distribution due to the constant movement of electrons.
- This induces a temporary dipole in a neighbouring molecule, producing a temporary induced dipole-dipole attraction.
- The bigger the molecule (i.e. the more electrons), the greater the van der Waals' forces (e.g. C_2H_6 boiling point -89°C, C_3H_8 boiling point -42°C).

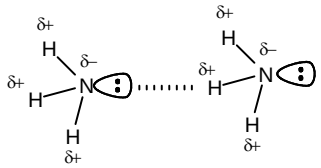
2) Permanent dipole-dipole attraction

- Some molecules with polar bonds have an overall dipole (e.g. $\delta+$ H–Cl $\delta-$) [although not all do (e.g. CCl_4 - the individual dipoles cancel each other out)].
- There are attractions between these permanent dipoles in neighbouring molecules (e.g. between H-Cl molecules).

3) Hydrogen bonding

- This is a special case of permanent dipole-dipole attractions – where an H atom is bonded to a very electronegative atom (i.e. F, O, N)
- The polar bond leaves the H nucleus exposed as H only has one electron.
- Therefore there is a strong attraction from the lone pair on the N, O or F of one molecule to the exposed H nucleus of another molecule.
- This is simply a strong intermolecular force – it is **NOT** a bond!

e.g. NH_3



e.g. H_2O

e.g. HF

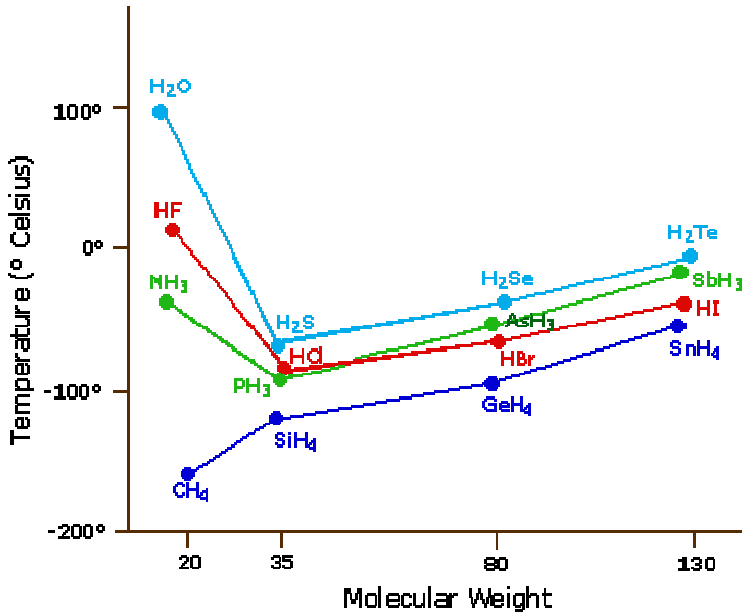
The strength of intermolecular forces

- H-bonding > permanent dipole-dipole > van der Waals'
- Covalent bonds are very strong (values in hundreds of kJ mol^{-1}). The forces between molecules are much weaker, with van der Waals' forces being in units of kJ mol^{-1} and hydrogen bonds in tens of kJ mol^{-1} (dipole-dipole attractions are inbetween).

Some comparisons

Molecule	CH_4	HCl	H_2O
Boiling points (ºC)	-162	-85	100
Intermolecular forces			

Boiling points of hydrides of Groups 4, 5, 6 and 7



In each pair of molecules, which molecule has the highest boiling point and why?

1) Br_2 & I_2

2) Br_2 & HBr

3) H_2O & H_2S

4) CH_4 & C_4H_{10}

5) CH_3OCH_3 & CH_3CH_2OH

6) $(CH_3)_3N$ & $(CH_3)_2NH$

7) CCl_4 & $CHCl_3$