Intermolecular Forces Map

AQA A-level Chemistry · 3.1.3 Bonding · Intermolecular forces

1 Bonds or forces?

3.1.3.7 i

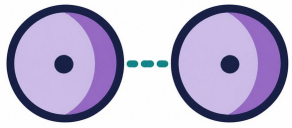
- **Covalent bonds**: inside molecules, strong
- **Intermolecular forces**: between molecules, weak
- Boiling separates molecules
- No covalent bonds break



2 van der Waals forces

3.1.3.7 i

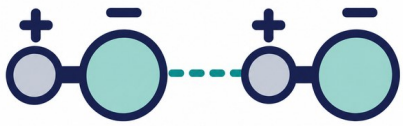
- Electrons move: **instantaneous dipole**
- Neighbour: **induced dipole**, δ+ facing δ−
- Act between **all** particles
- More electrons, more contact: stronger

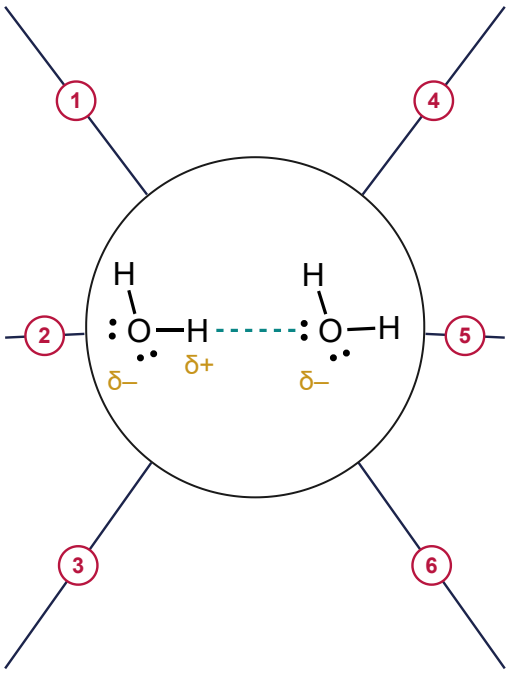


3 Permanent dipoles

3.1.3.7 i

- Electronegativity difference: **δ+ and δ−**
- Symmetrical shapes cancel (CO_2, CCl_4)
- δ+ of one attracts δ− of the next
- As well as van der Waals forces

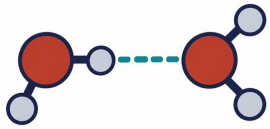




4 Hydrogen bonds

3.1.3.7 i–ii

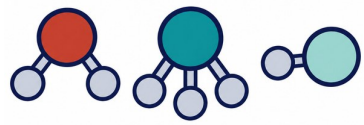
- H on **N, O or F**: strongly δ+
- To a **lone pair** on N, O or F
- X–H···Y straight: **180°**
- Alcohols, amines, acids: yes



5 H_2O, NH_3 and HF

3.1.3.7 ii

- Draw δ charges and **every lone pair**
- H_2O: 2 H, 2 lone pairs: up to **4**
- NH_3: 1 lone pair; HF: 1 H: chains
- Strength: HF > H_2O > NH_3



6 Water is odd

3.1.3.7 iv

- Boils at 373 K, not about 200 K
- Ice: **4 hydrogen bonds**, tetrahedral
- **Open lattice**: ice 0.917 g cm^{-3}
- Melting: molecules pack closer



Which forces? Same electrons, different forces

boiling points from the data book; compare like with like

Substance	Electrons	Forces between molecules	Boiling point
F_2	18	van der Waals only	85 K
HCl	18	van der Waals + permanent dipole–dipole	188 K
Ar	18	van der Waals only (single atoms)	87 K
H_2S	18	van der Waals + permanent dipole–dipole	213 K
CH_4	10	van der Waals only	112 K
H_2O	10	van der Waals + hydrogen bonds	373 K

Worked examples

Polar or not?

- $CHCl_3$: one C–H
- dipoles do not cancel
- **polar**: dipole–dipole forces

van der Waals wins

- CCl_4 74 e^-, non-polar: 350 K
- $CHCl_3$ 58 e^-, polar: 334 K
- **more electrons** outweigh

Why ice floats

- 4 hydrogen bonds each
- open hexagonal lattice
- **less dense** than water

Intermolecular forces explain melting and boiling points (3.1.3.7 iii) and return in organic chemistry (3.3).

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