Intermolecular Forces Map

Cambridge International AS & A Level Chemistry · Topic 3 Chemical bonding · Intermolecular forces

1 Bonds or forces?

3.6.3(a), 3.6.4

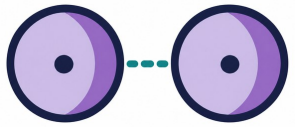
- **Covalent bonds**: inside molecules, strong
- **Intermolecular forces**: between molecules, weak
- Boiling separates molecules
- No covalent bonds break



2 id–id forces

3.6.3(b)

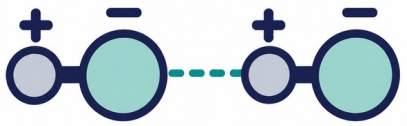
- Electrons move: **instantaneous dipole**
- Neighbour: **induced dipole**, δ+ facing δ−
- Act between **all** particles
- More electrons, more contact: stronger

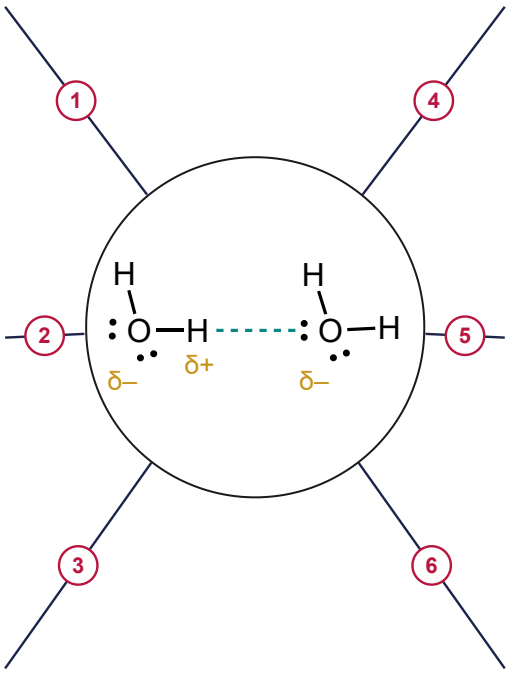


3 pd–pd forces

3.6.2, 3.6.3(b)

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

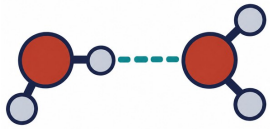




4 Hydrogen bonds

3.6.3(c)

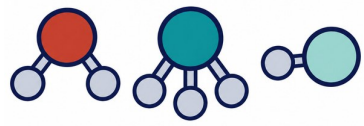
- H on **N, O or F**: strongly δ+
- To a **lone pair** on N, O or F
- X–H···Y straight: **180°**
- Alcohols, amines, acids: yes



5 H_2O, NH_3 and HF

3.6.1(a)

- 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

3.6.1(b)

- Boils at 373 K, not about 200 K
- Ice: **4 hydrogen bonds**, tetrahedral
- **Open lattice**: ice 0.917 g cm^{-3}
- High **surface tension**



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	id–id only	85 K
HCl	18	id–id + pd–pd	188 K
Ar	18	id–id only (single atoms)	87 K
H_2S	18	id–id + pd–pd	213 K
CH_4	10	id–id only	112 K
H_2O	10	id–id + hydrogen bonds	373 K

Worked examples

Polar or not?

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

id–id 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 boiling points (Boiling point trends, 4.2.2(b)); all of them are van der Waals' forces.

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