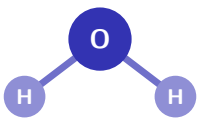
Chemical Bonding

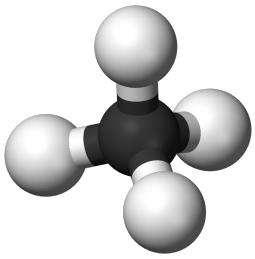
A-Level Chemistry ▪ Topic 3

A-Level Chemistry



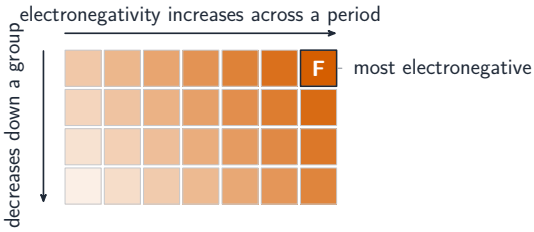
What we will cover

1. Electronegativity
2. Ionic & metallic bonding
3. Covalent & coordinate bonds
4. Sigma & pi bonds
5. Shapes of molecules
6. Intermolecular forces



molecules in 3-D

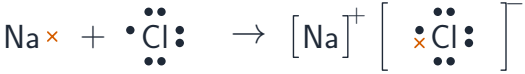
Electronegativity



nacl

crystal

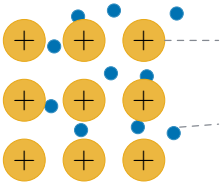
Ionic bonding



sodium gives its outer electron (×) to chlorine

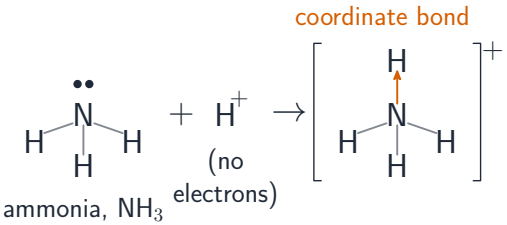
salt halite

Metallic bonding



Metallic bonding 金属键 is the attraction between positive metal ions and a sea of **delocalised electrons** 离域电子. The free electrons explain why metals conduct and are strong.

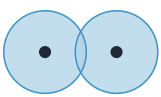
Covalent and coordinate bonds



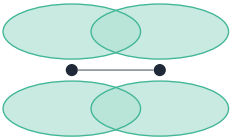
A **covalent bond** 共价键 is a shared pair of electrons.

> In a **coordinate bond** 配位键 (dative) both electrons come from one atom – e.g. N's lone pair makes NH_4^+.

Sigma and pi bonds



σ bond:
head-on overlap

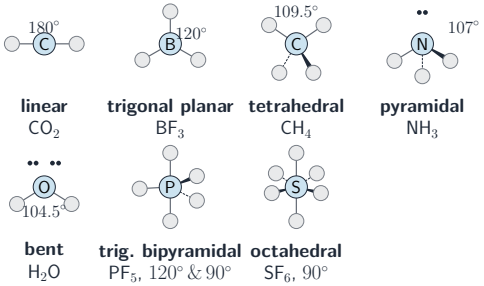


π bond: sideways overlap
of p orbitals

- a **sigma bond** σ 键 – head-on **overlap** 重叠
- a **pi bond** π 键 – sideways p-orbital overlap

Double $= 1\sigma + 1\pi$; triple $= 1\sigma + 2\pi$.
Hybridisation 杂化: sp, sp^2, sp^3.

Shapes of molecules



linear CO_2 | **trigonal planar** BF_3 | **tetrahedral** CH_4 | **pyramidal** NH_3

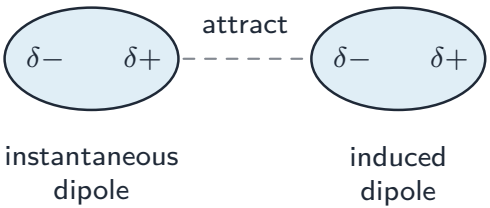
bent H_2O | **trig. bipyramidal** PF_5, $120° \& 90°$ | **octahedral** SF_6, $90°$

VSEPR

theory 价层电子对互斥理论: electron pairs push apart as far as possible.

> A **lone pair** 孤对电子 repels harder than a bonding pair, squeezing the **bond angle** 键角 ($\sim 2.5°$ each) – so NH_3 is $107°$, H_2O $104.5°$.

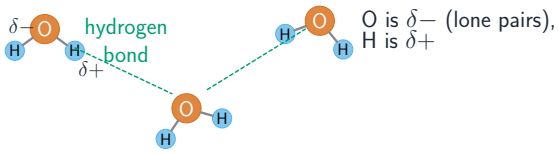
Intermolecular forces



A bond is **polar** 极性 if the atoms differ in electronegativity (a **dipole** 偶极).

- **London forces** 伦敦色散力 – between all molecules; stronger with more electrons
- permanent dipole forces – between polar molecules

Hydrogen bonding



Hydrogen bonding 氢键 forms when H is bonded to N, O or F and meets a lone pair on N, O or F.

It gives water a high **boiling point** 沸点, high **surface tension** 表面张力, and makes ice less dense (so it floats).

Worked example – shape of a molecule

Predict the shape and bond angle of NH_3.

- N has 5 outer electrons: 3 bond pairs + 1 **lone pair** 孤对电子 = 4 electron pairs.
- 4 pairs repel to a **tetrahedral** arrangement ($109.5°$).
- A lone pair repels more than a bond pair, so the angle closes.
- Name the shape from the atoms only: pyramidal, $\approx 107°$.

Count electron pairs for the arrangement, then name the shape from the atoms. Each lone pair closes the angle by about $2.5°$.

Topic 3 – key takeaways

1 Bond types

ionic, metallic, covalent (& coordinate)

2 Sigma & pi

single 1σ; double $1\sigma 1\pi$; triple $1\sigma 2\pi$

3 Shapes

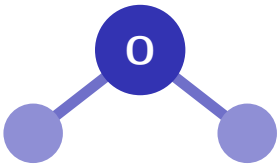
VSEPR; lone pairs squeeze the angle

4 Forces

London, dipole, hydrogen bonding

Check yourself

1. Which is the most electronegative element?
2. In a coordinate bond, where do both electrons come from?
3. How many sigma and pi bonds in a triple bond?
4. Why does ice float on water?



Answers **1.** fluorine **2.** one atom (a lone pair) **3.** one σ and two π **4.** hydrogen bonds hold an open structure (less dense)