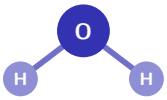
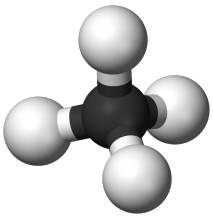
Chemical Bonding

A-Level Chemistry ▪ Topic 3

A-Level Chemistry



What we will cover



molecules in 3-D

1 Bonding types

Electronegativity

Electronegativity 电负性 is the power of an atom to attract bonding electrons towards itself.

nuclear charge

more protons pull the pair more strongly

atomic radius

closer to the nucleus ⇒ stronger pull

shielding

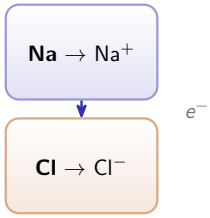
inner shells weaken the pull

It rises across a period and falls down a group. Fluorine is the most electronegative element. A large difference ⇒ ionic; a small difference ⇒ covalent.

Ionic bonding

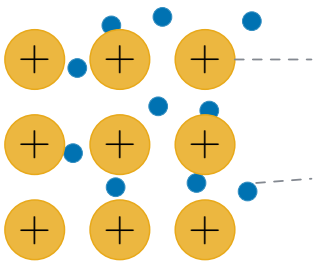
Ionic bonding 离子键 is the electrostatic attraction between oppositely charged **ions** 离子. A metal gives electrons to a non-metal. The ions pack into a giant **lattice** 晶格 held in every direction.

NaCl: sodium transfers its outer electron to chlorine → Na^+ and a full-octet Cl^-.



Metallic bonding

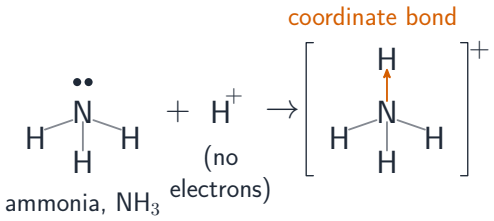
Metallic bonding 金属键 is the attraction between positive metal ions and a sea of **delocalised electrons** 离域电子. The free electrons explain why metals conduct and are strong.



positive metal ions sea of delocalised electrons (free to move)

2 Covalent bonding

Covalent and coordinate bonds

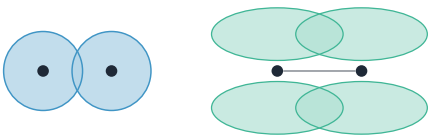


ammonia, NH_3

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



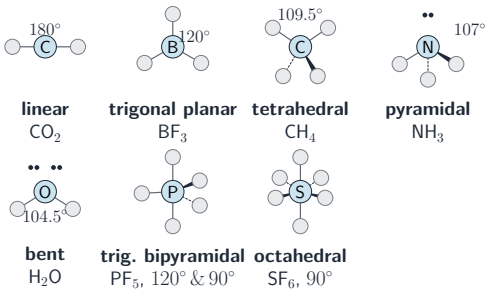
σ bond: head-on overlap

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.

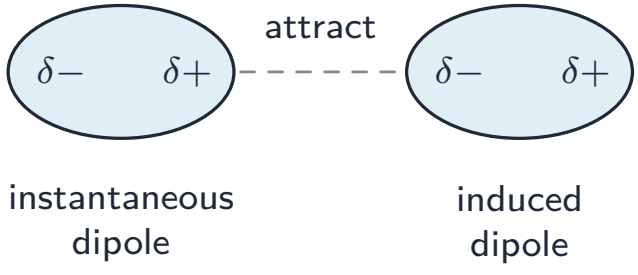
> A **lone pair** 孤对电子 repels harder than a bonding pair, squeezing the **bond angle** 键角 ($\sim 2.5°$ each) – so NH_3 is $107°$, H_2O $104.5°$.

3 Intermolecular forces

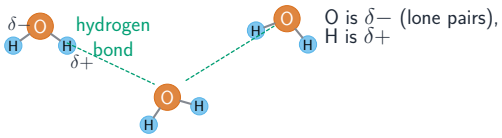
Intermolecular forces

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).

4 Recap

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

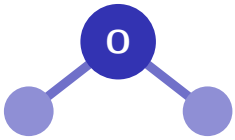
VSEPR; lone pairs squeeze the angle

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)