An introduction to A Level organic chemistry

A-Level Chemistry

New functional groups and naming

At A Level you meet more **functional group** 官能团 families, including the **amide** 酰胺 group and **aromatic** 芳香 compounds (those built on a benzene ring). As before, the functional group decides the properties, and you read it from the general, structural, displayed or skeletal formula.

Naming aromatic compounds

A **benzene** 苯 molecule is a ring of six carbons. When you name an aromatic compound, use the **benzene ring** 苯环 as the parent and number the positions of the substituents. For example, 3-nitrobenzoic acid has a $-NO_2$ group on carbon 3, and 2,4,6-tribromophenol has three bromine atoms on a phenol ring. You can also name cyclic compounds with a single ring of up to six carbons.

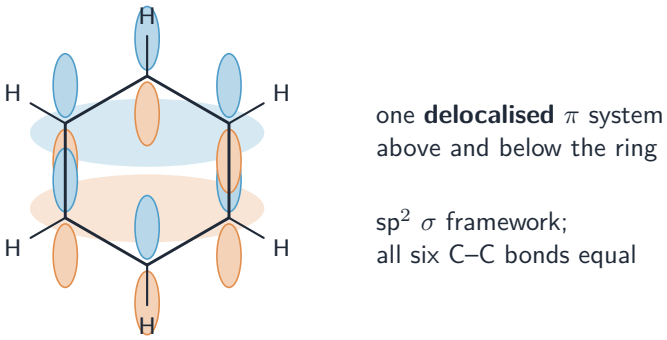
Two new types of mechanism

- **electrophilic substitution** 亲电取代: an electrophile replaces a hydrogen atom on a benzene ring (this is how benzene reacts).
- **addition–elimination** 加成消去: a molecule first adds on, then a small molecule is removed (seen with 2,4-DNPH and with acyl chlorides).

The shape of benzene

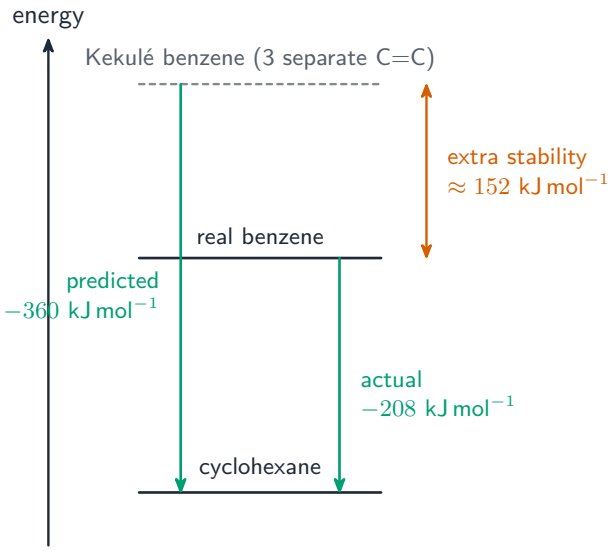
Benzene is a flat, regular hexagon. Each carbon is **sp²** hybridised, using its three **hybridisation** 杂化 orbitals to make **sigma bonds** 键 to two neighbouring carbons and one hydrogen. This gives the ring of bonds.

Each carbon also has one electron left in a p orbital, standing up at right angles to the ring. These p orbitals overlap sideways all the way round, making a single **delocalised** 离域 **pi bond** 键 system —a ring of electrons above and below the plane. Because the electrons are shared evenly, all six C–C bonds are the same length, and benzene is very stable.



Benzene's bonding: an sp^2 σ framework makes the flat hexagon, while the p orbitals overlap into one delocalised π system above and below the ring

How do we know benzene really is delocalised? One strong piece of evidence is its **enthalpy change of hydrogenation** 氢化焓变. Adding hydrogen to one C=C double bond (as in cyclohexene) releases about 120 kJ mol^{-1}, so a Kekulé ring of three separate double bonds should release about $3 \times 120 = 360$ kJ mol^{-1}. Real benzene releases only 208 kJ mol^{-1} —it is about 152 kJ mol^{-1} **more stable** than the model predicts.



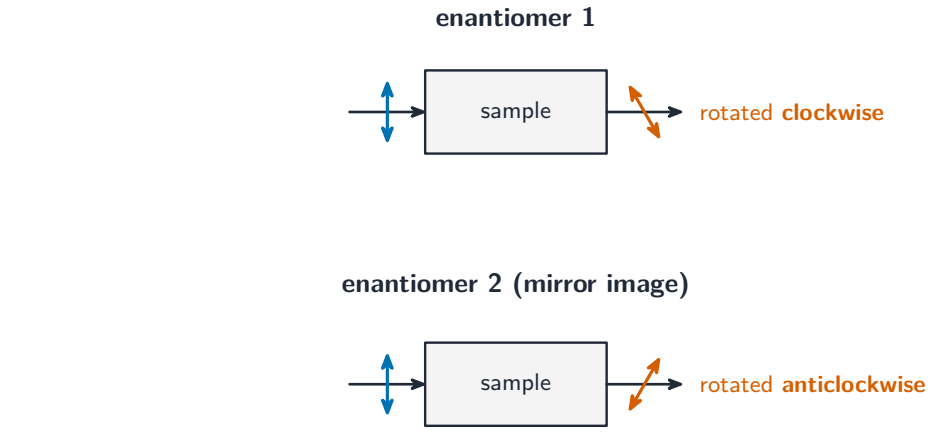
Evidence for delocalisation: real benzene releases far less on hydrogenation (-208 kJ mol^{-1}) than the Kekulé model predicts ($-360 = 3\times$ cyclohexene), so it is about 152 kJ mol^{-1} more stable than expected

Optical isomerism

Two **enantiomers** 对映体 (mirror-image isomers) have **identical** physical and chemical properties, with two exceptions:

- they rotate **plane polarised light** 平面偏振光 in opposite directions. A substance that does this is **optically active** 旋光活性.
- they may have different effects in living things (biological activity).

A **racemic mixture** 外消旋混合物 is a 50:50 mix of the two enantiomers. It does **not** rotate plane polarised light, because the two opposite rotations cancel out.



The two enantiomers rotate plane-polarised light in opposite directions; a 50:50 racemic mixture gives no net rotation

Why chirality matters for drugs

Chirality 手性 is important when making medicines. A molecule with a **chiral centre** 手性中心 has two enantiomers, and they can behave very differently in the body —one may cure while the other does harm. So drug makers either:

- separate a racemic mixture into the two pure enantiomers, or
- use a **chiral catalyst** 手性催化剂 to make just the single enantiomer they want.