A Level Organic Chemistry

A-Level Chemistry ▪ Topic 29

A-Level Chemistry



What we will cover

1. Naming aromatics
2. Two new mechanisms
3. The shape of benzene
4. Evidence for delocalisation
5. Optical isomerism

1

Benzene

Two new mechanisms

electrophilic substitution 亲电取代

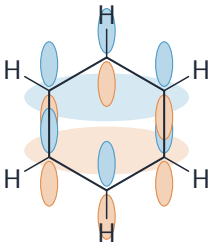
an electrophile replaces a H on benzene

addition–elimination 加成消去

a molecule adds on, then a small one leaves

New families: the **amide** 酰胺 group and **aromatic** 芳香 compounds (built on a **benzene** 苯 ring).

The shape of benzene

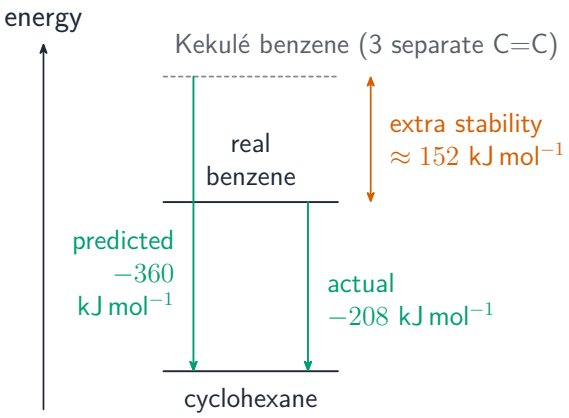


one **delocalised** π system above and below the ring
sp^2 σ framework;
all six C–C bonds equal

Each carbon is **sp^2** sp^2 杂化: σ bonds make the flat hexagon, and the leftover p orbitals overlap into one **delocalised** 离域 π system.

> All six C–C bonds are the same length, and benzene is very stable.

Evidence for delocalisation



The **enthalpy change of hydrogenation** 氢化焓变 is the proof:

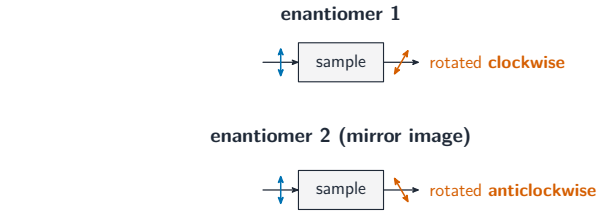
- Kekulé model predicts $-360\,\mathrm{kJ\,mol^{-1}}$
- real benzene releases only -208

So benzene is $\sim 152\,\mathrm{kJ\,mol^{-1}}$ more stable than the model.

2

Isomerism

Optical isomerism



a 50:50 **racemic mixture** gives no net rotation (the two cancel)

Two **enantiomers** 对映体 are identical except:

- they rotate **plane polarised light** 平面偏振光 in opposite directions (**optically active** 旋光活性)
- a **racemic mixture** 外消旋混合物 (50:50) gives no net rotation

Chirality 手性 matters in drugs.

Why chirality matters for a drug

A **chiral centre** 手性中心 is a carbon carrying four different groups. Its two **enantiomers** 对映体 are mirror images – and a living body is not symmetric, so they can have different biological activity: one active, the other useless or harmful.

- make both and separate them – slow and wasteful
- or use a **chiral catalyst** 手性催化剂 to make only the one you want

Which of these is chiral?

butan-1-ol – no
butan-2-ol – yes: its C2 carries H, OH, CH_3 and C_2H_5
2-methylpropan-2-ol – no, two methyls are the same

Look for one carbon with four different groups. Count carefully – two identical branches kill it.

Why chirality matters for drugs

Two enantiomers	A molecule with a **chiral centre** 手性中心 exists as two enantiomers, and they can behave very differently in the body – one may cure while the other does harm.
Separate them	One route: make the **racemic mixture** 外消旋混合物 and then separate it into the two pure enantiomers – slow, and half the product is wasted.
Or make only one	The better route: a **chiral catalyst** 手性催化剂 builds just the single enantiomer wanted, so nothing has to be thrown away.

> Same formula, same bonds, opposite handedness – and a receptor in the body only fits one of them.

New functional groups at A Level

A **functional group** 官能团 is the reactive part that names the family and fixes how the molecule behaves. Two join the list:

amide 酰胺

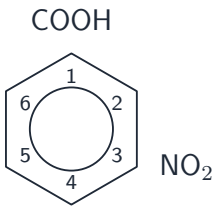
$-CONH_2$ – a carbonyl bonded straight to nitrogen; the link in proteins and nylon

aromatic 芳香

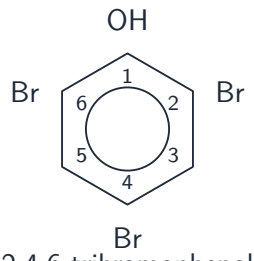
anything built on a benzene ring, with its delocalised electrons and its own chemistry

As before, name the parent chain, then the substituents – and number so the functional group gets the lowest locant.

Naming aromatic compounds



3-nitrobenzoic acid



2,4,6-tribromophenol

Number the ring from the principal group (carbon 1); the substituent positions then give the name

Two new types of mechanism

electrophilic substitution
an electrophile replaces an H on a benzene ring

addition–elimination
a molecule adds on, then a small molecule is removed

Electrophilic substitution on benzene, and **addition–elimination** 加成消去 at a carbonyl – add, then throw a small molecule out again.

Exam tips

- **Optical isomers** need a **chiral carbon** (four different groups); they are non-superimposable mirror images that rotate plane-polarised light oppositely.
- A **racemic mixture** forms when a **planar intermediate** (carbocation or C = O) is attacked equally from both sides.
- Benzene's **delocalised** ring (equal bond lengths, planar) explains its stability versus the Kekulé model.
- Learn the two new mechanisms – electrophilic substitution of arenes, and nucleophilic addition-elimination.

3 Recap

Worked example – spotting a chiral centre

Explain why lactic acid $CH_3CH(OH)COOH$ is optically active but propanoic acid is not.

- Look for one carbon carrying four different groups.
- In lactic acid the middle C has CH_3, OH, COOH and H – all different $\Rightarrow$ a **chiral centre** 手性中心.
- Its mirror image cannot be superimposed $\Rightarrow$ two enantiomers, rotating polarised light oppositely.
- CH_3CH_2COOH has no such carbon (the middle C has two H) $\Rightarrow$ not chiral.

One carbon, four different groups. Enantiomers are identical in every physical and chemical property *except* optical rotation and reactions with other chiral molecules.

Topic 29 – key takeaways

1 Mechanisms

electrophilic substitution; addition–elimination

2 Benzene

sp^2 σ frame + delocalised π ring

3 Delocalisation

more stable than the Kekulé model

4 Enantiomers

rotate polarised light oppositely

Check yourself

1. How does benzene react with an electrophile?
2. What hybridisation is each benzene carbon?
3. What proves benzene is delocalised?
4. What does a racemic mixture do to polarised light?



Answers **1.** by electrophilic substitution **2.** sp^2 **3.** its enthalpy of hydrogenation **4.** no net rotation