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

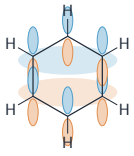
Two new mechanisms

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

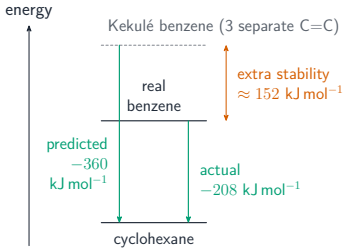


one **delocalised** π system above and below the ring
sp^2 σ framework;
all six C–C bonds equal

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



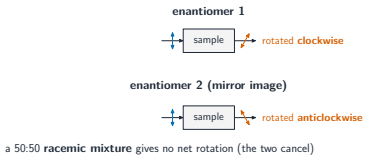
The **enthalpy change of hydrogenation** 氢化焓变 is the proof:

- 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

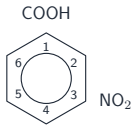
$-CONH_2$ – a carbonyl bonded straight to nitrogen; the link in proteins and nylon

aromatic 芳香

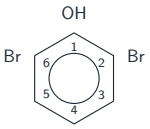
anything built on a benzene ring, with its delocalised electrons and its own chemistry

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 ⇒ a **chiral centre** 手性中心.
- Its mirror image cannot be superimposed ⇒ two enantiomers, rotating polarised light oppositely.
- CH_3CH_2COOH has no such carbon (the middle C has two H) ⇒ 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