

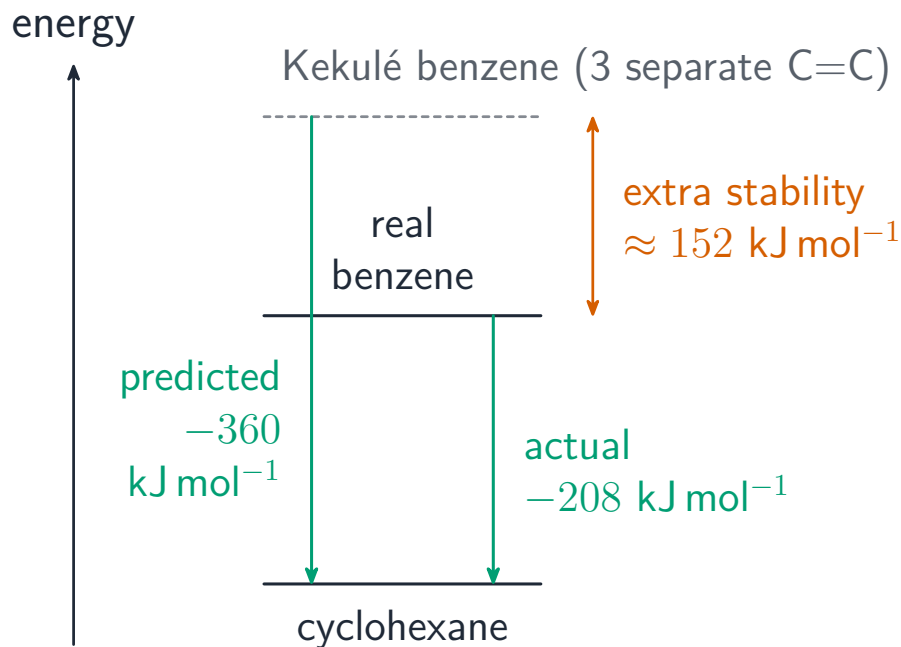
Exercise walk-through

29.2

Characteristic organic reactions

A-Level Chemistry

Evidence for delocalisation

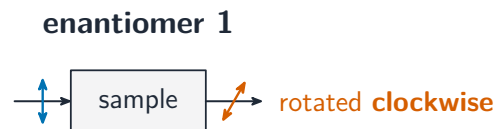


The **enthalpy change of hydrogenation** is the proof:

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

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

Optical isomerism



enantiomer 2 (mirror image)



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

Two **enantiomers** are identical except:

- they rotate **plane polarised light** in opposite directions (**optically active**)
- a **racemic mixture** (50:50) gives no net rotation

Chirality matters in drugs.

Worked example – spotting a chiral centre

Explain why lactic acid $\text{CH}_3\text{CH}(\text{OH})\text{COOH}$ 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**.
- Its mirror image cannot be superimposed $\Rightarrow$ two **enantiomers**, rotating polarised light oppositely.
- $\text{CH}_3\text{CH}_2\text{COOH}$ 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.

Exercises 2.1·2.2

2.1 State what is meant by an **electrophile**.

[1]

2.2 Classify the reaction of bromine with ethene (an alkene).

[1]

Exercises 2.1·2.2

2.1 State what is meant by an **electrophile**. [1]

2.1

- an electron-pair acceptor / a species that is attracted to a region of high electron density
-

2.2 Classify the reaction of bromine with ethene (an alkene). [1]

2.2

- electrophilic addition

Exercises 3.1·3.2

3.1 The reaction of OH^- with bromoethane is best classified as:

[1]

☐

A electrophilic addition

B nucleophilic substitution

C electrophilic substitution

D free-radical substitution

3.2 Which species is a nucleophile?

[1]

☐

A NO_2^+

B H^+

C :NH_3

D $\text{Cl}^\bullet$

Exercises 3.1·3.2

3.1 The reaction of OH^- with bromoethane is best classified as:

[1]

- ☐ **A** electrophilic addition
B nucleophilic substitution
C electrophilic substitution
D free-radical substitution

3.1 B

- OH^- is a nucleophile and it replaces the bromine – nucleophilic substitution

3.2 Which species is a nucleophile?

[1]

- ☐ **A** NO_2^+
B H^+
C $:\text{NH}_3$
D $\text{Cl}^\bullet$

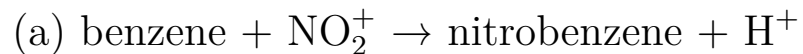
3.2 C

- $:\text{NH}_3$ has a lone pair to donate – a nucleophile

Exercise 3.3 (a)

3.3 For each reaction, name the **type** and the **reagent class**:

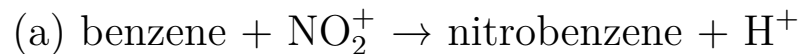
[3]



Exercise 3.3 (a)

3.3 For each reaction, name the **type** and the **reagent class**:

[3]



(a)

- electrophilic substitution; electrophile

Exercise 3.3 (b)

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[3]

(b) ethene + Br₂ → 1,2-dibromoethane

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(b)

- (electrophilic) addition; electrophile

Exercise 3.3 (c)

3.3 For each reaction, name the **type** and the **reagent class**:

[3]

(c) an ester + water $\rightarrow$ a carboxylic acid + an alcohol

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- hydrolysis (substitution); water/nucleophile

Exercise 3.4

3.4 Explain why benzene undergoes **substitution** rather than **addition**, unlike an alkene. [2]

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3.4

- benzene's delocalised π system is very stable; substitution keeps the stable ring intact, whereas addition would destroy the delocalisation, so substitution is favoured

Exercise 3.5 (a)

3.5 Four reactions of propene and its derivatives are shown.

- **I** $\text{CH}_3\text{CH}=\text{CH}_2 + \text{Br}_2 \rightarrow \text{CH}_3\text{CHBrCH}_2\text{Br}$
- **II** $\text{CH}_3\text{CHBrCH}_3 + \text{KOH}(\text{aq}) \rightarrow \text{CH}_3\text{CH}(\text{OH})\text{CH}_3 + \text{KBr}$
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- **IV** $\text{CH}_3\text{CH}(\text{OH})\text{CH}_3 + [\text{O}] \rightarrow \text{CH}_3\text{COCH}_3 + \text{H}_2\text{O}$

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(a) Classify each reaction by type.

[4]

(a)

- **I** electrophilic addition; **II** nucleophilic substitution; **III** elimination; **IV** oxidation

Exercise 3.5 (b)

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(b)

- The **electrophile** is bromine, Br_2 , acting as $\text{Br}^{\delta+}-\text{Br}^{\delta-}$. The high electron density of the π bond repels the electrons in the approaching Br_2 , inducing a dipole; the now $\delta+$ bromine atom is attacked by the π electrons

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- The **solvent and conditions**: aqueous KOH favours substitution, giving the alcohol; hot KOH in ethanol favours elimination, giving the alkene

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(d)

- Acidified potassium dichromate(VI), $\text{K}_2\text{Cr}_2\text{O}_7/\text{H}_2\text{SO}_4$; the solution turns from orange to green as $\text{Cr}_2\text{O}_7^{2-}$ is reduced to Cr^{3+} . Propanone is a **ketone** – its carbonyl carbon carries no hydrogen, so further oxidation would need a C–C bond to break, which this reagent cannot do