Introduction to Organic Chemistry

A-Level Chemistry ▪ Topic 13

A-Level Chemistry

What we will cover

the feedstock of organics

1 Formulas and reactions

Types of formula

empirical

CH_2 – simplest ratio

molecular

C_2H_4 – actual numbers

structural

$CH_2{=}CH_2$ – how they join

displayed

every bond drawn

Bond fission

- **homolytic fission** 均裂 – one electron each → two **free radicals** 自由基
- **heterolytic fission** 异裂 – both electrons to one atom → two ions

homolytic fission

$Cl\bullet + \bullet Cl$

one electron each
⇒ two **radicals**

heterolytic fission

$C^+ + :Br^-$

both electrons to one
⇒ two **ions**

Nucleophiles and electrophiles

nucleophile

a lone pair attacks the electron-poor ($\delta+$) carbon

electrophile

it is drawn to the electron-rich C=C double bond

- a **nucleophile** 亲核试剂 (lone pair) attacks an electron-poor centre
- an **electrophile** 亲电试剂 is drawn to an electron-rich centre (C=C)

Reaction types: **addition** 加成, **substitution** 取代, **elimination** 消去, **hydrolysis** 水解.

Mechanisms

free-radical substitution 自由基取代 – alkanes

nucleophilic substitution 亲核取代 – halogenoalkanes

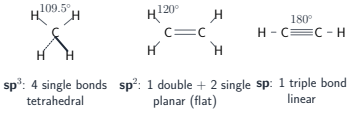
electrophilic addition 亲电加成 – alkenes

nucleophilic addition 亲核加成 – carbonyls

Free-radical steps: **initiation** 引发 → **propagation** 增长 → **termination** 终止. A **curly arrow** 弯箭头 shows a pair of electrons moving.

2 Shape and isomerism

Hybridisation and shapes



sp^3: 4 single bonds tetrahedral

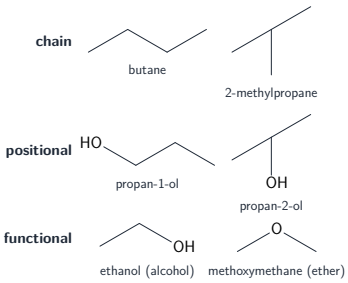
sp^2: 1 double + 2 single planar (flat)

sp: 1 triple bond linear

- sp^3 – tetrahedral, $109.5°$
- sp^2 – planar, $120°$ (ethene)
- sp – linear, $180°$

Single $= \sigma$; double $= \sigma + \pi$.

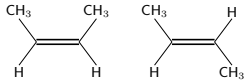
Structural isomerism



Same molecular formula, atoms joined differently:

- **chain** 链异构
- **positional** 位置异构
- **functional group** 官能团异构

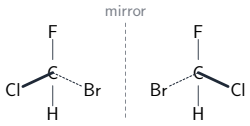
Stereoisomerism



cis
both CH_3 same side

trans
CH_3 opposite sides

cis vs trans at C=C



3 Recap

Worked example – structural isomers

Draw and name the structural isomers of C_4H_{10}, and state the type of isomerism.

- Straight chain: $CH_3CH_2CH_2CH_3$ – **butane**.
- Branched: $(CH_3)_3CH$ – **2-methylpropane**.
- There are only two: a 3-carbon chain cannot take a CH_3 anywhere else.
- Same molecular formula, different skeleton ⇒ chain isomerism.

Isomers share a molecular formula. **Chain** = different skeleton; **position** = group moved; **functional group** = a different group entirely.

Topic 13 – key takeaways

1. **Functional group** — the reactive part sets the properties
2. **Bond fission** — homolytic (radicals) vs heterolytic (ions)
3. **Shapes** — $sp^3/sp^2/sp$ give tetrahedral/planar/linear
4. **Isomerism** — structural; cis/trans; optical (chiral)

Check yourself

1. Homolytic fission makes two of what?
2. A nucleophile attacks an electron-rich or electron-poor centre?
3. What is the shape at an sp^2 carbon?
4. A chiral carbon has how many different groups?

Answers **1.** free radicals **2.** electron-poor **3.** planar ($120°$) **4.** four