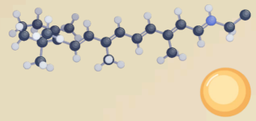
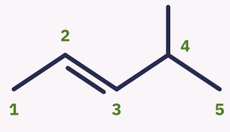
11.3 Alkenes



1 Structure, Isomerism and Naming

1.1 Structure and naming

- **Alkenes**: _____ hydrocarbons with a C=C bond, C_nH_{2n}. Each C of C=C is sp^2, trigonal planar, 120°.
- **Naming**: longest chain **containing** the C=C, number from the end giving C=C the _____ locant, e.g. $CH_3CH{=}CHCH_2CH_3$ is pent-2-ene

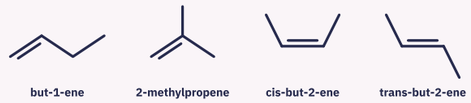




Substituents take the numbering fixed by the C=C: **4-methylpent-2-ene**, **3,3-dimethylbut-1-ene**. Name cis or trans as drawn.

1.2 Isomers of C_4H_8

- **Chain** and **position** isomers: structural isomers
- **Cis–trans** isomers: due to _____ about C=C (the π bond would have to break). Each C of C=C must have _____ groups.



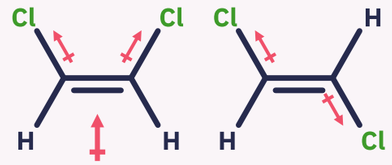
Why is trans more stable than cis?

1. In the cis isomer, the bulky groups are on the _____
2. → greater _____ (repulsion) between them

2 Physical Properties

Similar to alkanes: non-polar, held by **id–id**, insoluble in water, less dense than water, b.p. rises with chain length and falls with branching.

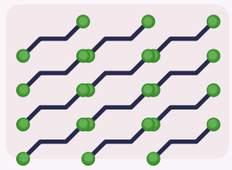
2.1 cis isomers have a higher b.p.

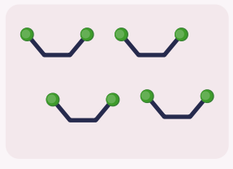


1. cis has a _____ moment (polar), in trans the dipoles cancel
2. → additional _____ between cis molecules → more energy to overcome

2.2 cis isomers have a lower m.p.

1. cis has _____ (U-shape)
2. → molecules _____ less closely in the solid
3. → weaker IMF in the lattice → less energy to overcome

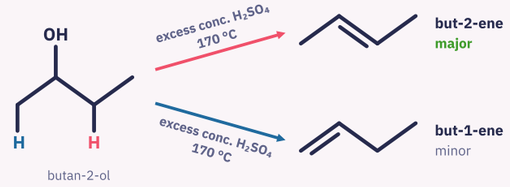




3 Preparation of Alkenes

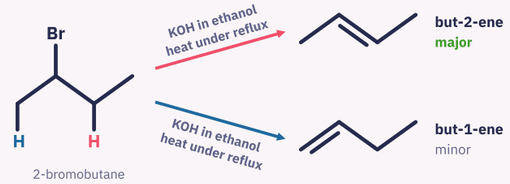
3.1 Dehydration of alcohols

- Elimination of H_2O: _____ at 170 °C, or pass the vapour over heated _____
- If the OH carbon has different neighbouring C–H groups, **more than one** alkene can form



3.2 Elimination of HX from halogenoalkanes

- Elimination of HX: _____, heat under reflux
- Major product: the _____ alkene (more alkyl groups on the C=C carbons), which is _____

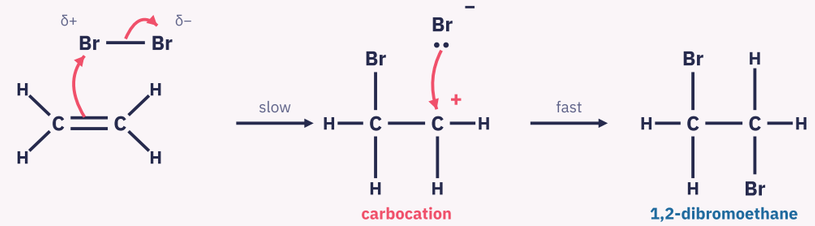


4 Electrophilic Addition

Why do alkenes react with electrophiles?

1. The C=C has a high _____, the π electrons lie above and below the plane and are _____
2. → attracts electron-deficient species: one weak π bond broken, two σ bonds formed

4.1 Mechanism: $CH_2{=}CH_2 + Br_2$ in CCl_4, room temperature



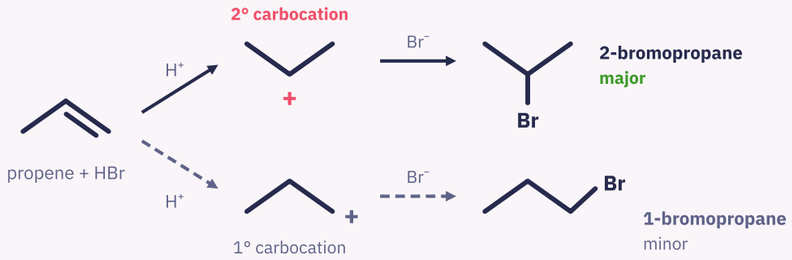
Step 1 (slow)
The π electrons _____ in Br_2 and attack $Br^{\delta+}$, Br–Br breaks **heterolytically** → carbocation + Br^-

Step 2 (fast)
The lone pair on Br^- is donated to the C^+ atom.

ANSWER STRUCTURE **Describe the mechanism** Name it (electrophilic addition), then draw it with reagents and conditions, δ+/δ−, lone pairs, charges and curly arrows. No written explanation is needed.

4 Electrophilic Addition (continued)

4.2 Markovnikov's rule: propene + HBr



The rule

H adds to the C=C carbon with _____ _____, so the more stable 2° carbocation forms → 2-bromopropane is **major**.

Why is the 2° carbocation more stable?

1. Alkyl groups are _____
2. → two alkyl groups _____ the positive charge more than one

Reactivity of HX: HI > HBr > HCl (H–X bond strength decreases).

5 Reactions of Alkenes

Reaction	Equation, with reagents and conditions on the arrow (propene)	Observation
+ HX	$CH_3CH{=}CH_2 + HBr \xrightarrow{HBr(g),\ r.t.} CH_3CHBrCH_3$	–
+ X_2	$CH_3CH{=}CH_2 + Br_2 \xrightarrow{Br_2 \text{ in } CCl_4,\ r.t.} CH_3CHBrCH_2Br$	orange-red Br_2 _____
+ X_2(aq)	$CH_3CH{=}CH_2 + Br_2 + H_2O \xrightarrow{Br_2(aq),\ r.t.} CH_3CH(OH)CH_2Br + HBr$	orange decolourises
+ H_2O	$CH_3CH{=}CH_2 + H_2O \xrightarrow{\text{steam, }_____,\ 300\ °C,\ 60\ atm} CH_3CH(OH)CH_3$	–
+ H_2	$CH_3CH{=}CH_2 + H_2 \xrightarrow{Ni,\ \text{heat (or }_____,\ r.t.)} CH_3CH_2CH_3$	–
mild [O]	$CH_3CH{=}CH_2 + [O] + H_2O \xrightarrow{_____\ KMnO_4,\ NaOH(aq)} CH_3CH(OH)CH_2OH$	purple decolourises, _____ MnO_2
strong [O]	$CH_3CH{=}CH_2 + 5[O] \xrightarrow{KMnO_4,\ H_2SO_4(aq),\ _____} CH_3CO_2H + CO_2 + H_2O$	purple decolourises

Hydration can also use cold conc. H_2SO_4, then warm water. With Br_2(aq), the bromohydrin is major as H_2O (the solvent) is present in far larger amount than Br^-.

6 Oxidative Cleavage and Tests

Hot acidified $KMnO_4$ breaks C=C. Each half becomes:

Half of C=C	Product
$=CH_2$ (terminal)	_____
=CHR	_____, RCO_2H
=CRR′	_____, RCOR′

Split C=C, add =O to each C, then replace any –H on that C by –OH.

Test for C=C: add Br_2(aq) or Br_2 in CCl_4 at r.t. → orange _____.

Test for a terminal alkene (=CH_2): heat with acidified $KMnO_4$ → purple $KMnO_4$ _____, and a colourless, odourless gas forms that gives a _____ with limewater (CO_2 from the =CH_2).

6.1 Identify the alkene

WORKED EXAMPLE Hydrocarbon X, C_7H_{12}, is heated with acidified $KMnO_4$. The only organic products are CO_2, propanone and propanedioic acid, $HO_2CCH_2CO_2H$. Deduce the structure of X.

1. Piece 1: CO_2 → from a terminal _____
2. Piece 3: propanone, $(CH_3)_2C{=}O$ → from _____
3. Piece 2: $HO_2CCH_2CO_2H$ (two $-CO_2H$) → from _____, a C=C at each end
4. Join the pieces at the C=C: X is _____, 5-methylhexa-1,4-diene (C_7H_{12} ✓)