1.5 Alkenes

Name: _____ Class: _____ Date: _____ **Total: 19 marks**

KEY WORDS pi bond π • electrophilic addition • carbocation • Markovnikov • repeat unit

Objective

Practise Topic 5: the sigma-pi double bond, E/Z isomerism with CIP priority, electrophilic addition mechanisms, Markovnikov selectivity, and addition polymers.

1 Key knowledge and worked examples

The double bond

One σ bond (head-on overlap) plus one π bond (sideways overlap of p orbitals above and below) – the π cloud is exposed and electron-rich, which is why alkenes attract electrophiles. Rotation is locked by the π bond: hence cis/trans or E/Z isomerism. E/Z needs TWO different groups on EACH double-bond carbon; assign the higher CIP-priority group on each carbon, and if the two high-priority groups are on the same side it is Z (zusammen), opposite sides E (entgegen).

Electrophilic addition mechanism

HBr: the H^+ end is attracted to the π cloud $\rightarrow$ the π bond attacks H, forming a CARBOCATION $\rightarrow$ Br^- captures it. With an asymmetric alkene the major product goes through the MORE STABLE carbocation (secondary > primary): Markovnikov. With Br_2, the electron-rich double bond polarises Br_2 and attacks its positive end. Show electron movement from a bond or lone pair, never from a positive charge. Detailed stereochemical product prediction is not needed for this sheet.

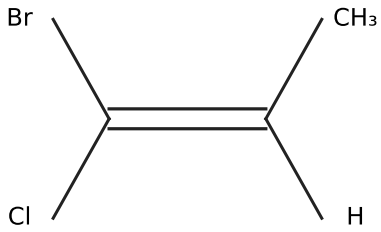
Worked check: predicting the major product

Propene + HBr: H adds to CH_2 (more hydrogens), giving the secondary carbocation CH_3-CH^+-CH_3 $\rightarrow$ 2-bromopropane major.

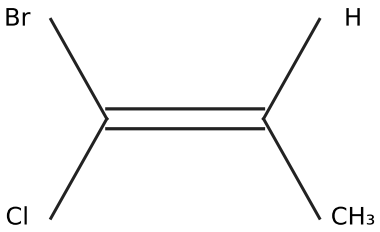
Polymers

n CH_2=CHCl $\rightarrow$ -$(CH_2$-$CHCl)_n$ – draw the repeat unit from the monomer by opening the double bond. Disposal trade-offs: incineration (energy but CO_2), recycling (sorting cost), landfill (persistence).

Assign priority separately on each double-bond carbon.



A: Z (Br and CH_3 together)



B: E (Br and CH_3 apart)

2 Practice

2.1 Explain why ethene does not show geometric isomerism but 1,2-dichloroethene does. [2]

2.2 In isomer A of 1-bromo-1-chloroprop-1-ene, Br and CH_3 are on the same side of the C=C bond. In isomer B they are on opposite sides. Assign E or Z to each. [2]

2.3 Draw the repeat unit of poly(propene). [1]

3 Exam-style questions

3.1 Describe the mechanism for the reaction between HBr and 2-methylbut-2-ene. Include curly arrows, the intermediate, and the structure of the major product. [5]

3.2 An unknown liquid decolourises bromine water. Explain what this observation supports and why it does not identify a unique compound. Write the structural equation for addition of Br_2 to ethene, and name the product. [4]

3.3 An alkene decolourises bromine water and has the molecular formula C_4H_8. Draw the three structural isomers, state which show geometric isomerism, and name each using IUPAC rules. [5]

Solutions

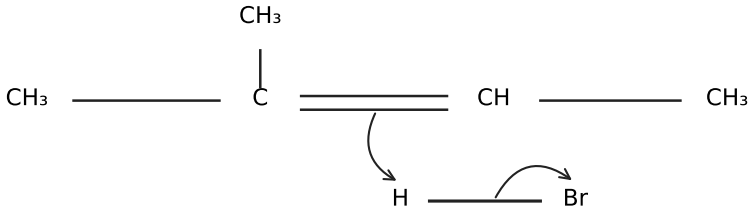
Original-task marking: M1 method, A1 accuracy, B1 reasoning.

2.1 Ethene carries two identical H atoms on each double-bond carbon; geometric isomerism requires two DIFFERENT groups on each carbon, which 1,2-dichloroethene has.

2.2 Compare groups separately on each double-bond carbon: Br > Cl on C1; C > H on C2. On C1 the high-priority group is Br; on C2 it is CH_3. A is Z; B is E.

2.3 Repeat unit -$(CH_2$-$CH(CH_3))_n$.

3.1 Curly arrow from the π bond to the H of H-Br, and from the H-Br bond to Br; the positive charge sits on the more substituted carbon – the TERTIARY carbocation; A curly arrow starts at a bromide lone pair and ends at the positively charged carbon; major product 2-bromo-2-methylbutane.



H bonds to the CH carbon; C2 becomes a tertiary carbocation.

A bromide lone pair supplies the new bond to C^+.
Product: CH_3–C(Br)(CH_3)–CH_2–CH_3 (2-bromo-2-methylbutane)

3.2 The observation supports a C=C bond in an appropriate organic test, but many alkenes give the same result, and other reducing substances can also consume bromine. CH_2=CH_2 + Br_2 → CH_2BrCH_2Br; 1,2-dibromoethane. This is addition: the two-carbon skeleton remains intact and one Br bonds to each carbon.

3.3 CH_2=$CHCH_2CH_3$, but-1-ene; CH_3CH=$CHCH_3$, but-2-ene; CH_2=$C(CH_3)_2$, 2-methylpropene. Only but-2-ene shows E/Z isomerism: each double-bond carbon has H and CH_3, whereas each other isomer has two H on one double-bond carbon.