Alkenes and addition reactions

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Show your working where needed. Check the worked answers when you finish.

Name _____ Date _____

1. Compare two observations

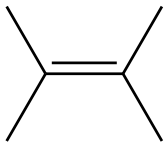
Bromine water is shaken with separate samples of hex-1-ene and hexane at room temperature, away from strong light. Describe the colour observations.

2. Explain the first interaction

A carbon-carbon double bond contains a σ bond and a π bond. Explain why an electrophile reacts with an alkene.

3. Compare two structures

For each alkene shown, decide whether it can have E/Z stereoisomers. Explain your decisions.

A 

B 

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4. Assign E or Z

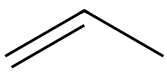
Above a C=C bond are -CH_2CH_3 on the left and H on the right. Below it are -CH_3 on the left and -CH_2OH on the right. Assign E or Z and justify the higher priority on each side.

5. Predict the products

Write the condensed structural formula of the product when ethene reacts with bromine under non-aqueous conditions, and when it reacts with hydrogen bromide. Explain why the HBr reaction gives only one structural product.

6. Draw a mechanism

Alkene A reacts with HBr. Draw and name the mechanism leading to the major product. Show relevant partial charges, full charges and curly arrows.

A 

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7. Explain the product mixture

Pent-1-ene reacts with HBr to give two structural products. Draw the intermediate leading to each product. Name both products and explain which forms in greater proportion.

8. Read an addition polymer

A repeat unit contains the backbone pattern -CH_2-$CH(CH_2CH_3)$-. Draw the monomer and explain what happens to its double bond when the polymer forms.

9. Extra challenge · Choose an alkene from reaction evidence

Adding H_2 across the double bond of an alkene C_5H_{10} gives pentane without changing the carbon skeleton. In one stereoisomer, the H atoms on the double-bond carbons are opposite.

Draw and name this isomer with its E/Z prefix. Predict both possible constitutional products with HBr. Explain whether the carbocations alone give a clear basis for choosing a major product.

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Worked answers

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1. Compare two observations

With hex-1-ene, the bromine water changes from orange-brown to colourless because bromine reacts at the double bond. With hexane, the bromine colour persists, even if some bromine moves to the organic layer.

2. Explain the first interaction

The π electrons create a region of high electron density that attracts the electrophile. The electrophile accepts a pair of π electrons to form a new bond.

3. Compare two structures

A cannot. Each double-bond carbon has two identical methyl groups.

B can. One double-bond carbon has H and methyl, and the other has H and propyl. Each carbon has two different groups, and the double bond limits rotation.

4. Assign E or Z

E. On the left, both groups attach by carbon. The next atoms are C,H,H for $-CH_2CH_3$ and H,H,H for $-CH_3$, so ethyl has higher priority.

On the right, the C of $-CH_2OH$ has a higher atomic number than H. The higher-priority groups lie on opposite sides of the double bond.

5. Predict the products

$BrCH_2CH_2Br$ forms with Br_2, and CH_3CH_2Br forms with HBr. The two carbons of ethene are equivalent, so adding H to either one gives the same product.

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Worked answers

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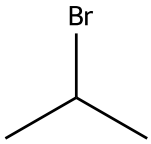
6. Draw a mechanism

Electrophilic addition. Mark H as δ^+ and Br as δ^-. Draw an arrow from the C=C π bond to H and from the H-Br bond to Br. H joins the end carbon, giving $CH_3CH^+CH_3$ and Br^-.

Draw an arrow from a lone pair on Br^- to the positively charged carbon. Product B is $CH_3CH(Br)CH_3$.

B



7. Explain the product mixture

Adding H to the end carbon gives $CH_3CH_2CH_2CH^+CH_3$, a secondary carbocation. The alternative is $CH_3CH_2CH_2CH_2CH_2^+$, a primary carbocation.

The more stable secondary carbocation forms preferentially and gives 2-bromopentane. The primary carbocation gives the minor product, 1-bromopentane.

8. Read an addition polymer

The monomer is $CH_2=CHCH_2CH_3$, but-1-ene. Its C=C becomes a single bond as each original alkene carbon forms a new C-C single bond to a neighbouring unit. The ethyl group stays on the same carbon.

9. Extra challenge · Choose an alkene from reaction evidence

The straight five-carbon chain must have the double bond between carbons 2 and 3 for both alkene carbons to carry H. The high-priority groups, CH_3 and CH_2CH_3, are opposite. The isomer is (E)-pent-2-ene.

Addition can give 2-bromopentane or 3-bromopentane. Each direct route passes through a secondary carbocation. Their substitution classes alone do not establish a clear major product.

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