Alkenes and Alkynes – Unsaturated Hydrocarbons

Alkenes

- contain at least one double bond between two carbon atoms
- non-polar molecules
- intermolecular forces are slightly lower than alkanes
- more reactive than alkanes (because of π bond; shorter bond length and greater electron density)
- low water solubility and low boiling points

Alkynes

- contain at least one triple bond between two carbon atoms
- even more reactive than alkenes (because of 2π bonds; shorter bond length and even greater electron density)

Rules for naming Alkenes and Alkynes

Follow the rules for alkanes, noting the following changes:

1. the parent chain *must* contain the multiple bond
2. number the parent chain so that the *multiple bond has the lowest possible position number*
3. include the position number before the suffix, e.g. but-1-ene
4. suffix is *–ene* for alkenes, and *–yne* for alkynes

Naming cycloalkenes and cycloalkynes

1. identify the branches
2. number carbons in ring in either direction so that multiple bond is between the two lowest numbers, and the branches get the lowest possible position numbers
3. write prefix and root as for cycloalkanes *(note if there are no branches, and only one double bond, NO position number is needed for the molecule)*
4. write the suffix *–ene* for cycloalkenes, and *–yne* for cycloalkynes

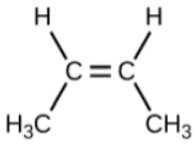
Structural isomers – are compounds that have the same molecular formula, but different structures and properties.

Stereoisomers – molecules that have the same chemical formula and carbon backbone, but different arrangement of atoms in space, e.g. *cis-trans* isomers

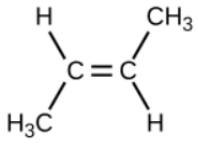
cis-trans isomers - molecules that are identical except for the position of the groups on either side of a double bond.

- Each carbon in the double bond must be attached to two *different* groups
- In a *cis-* isomer, the like groups are attached on the same side
- In a *trans-* isomer, the like groups are attached to each carbon in the double bond on opposite sides

cis-2-butene



trans-2-butene



- As in structural isomers, stereoisomers have different physical and chemical properties.

Reactions of Alkenes and Alkynes

Presence of reactive double/triple bonds allows for *addition reactions*

- Common atoms / groups added include:
  - H and OH (From H_2O) – *Hydration Reaction*
  - H and X (from HX), where X = Cl, Br, or I – *Hydrohalogenation Reaction*
  - X and X (from X_2), where X = Cl, Br, or I – *Halogenation Reaction*
  - H and H (from H_2) – *Hydrogenation Reaction*
- Product could be an alcohol, alkyl halide, alkane, or alkene

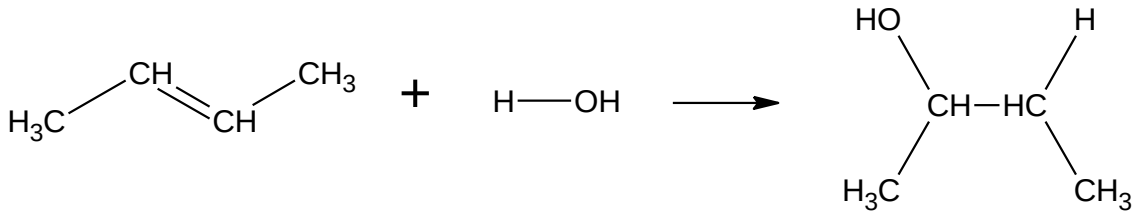
Addition Reactions - Alkenes

- Products depend on *symmetry* of reactants

> ***Symmetrical alkenes*** have identical groups on either side of the double bond
> ***Asymmetrical alkenes*** have different groups on either side of the double bond

- if at least one reactant is symmetrical, only one product is possible:

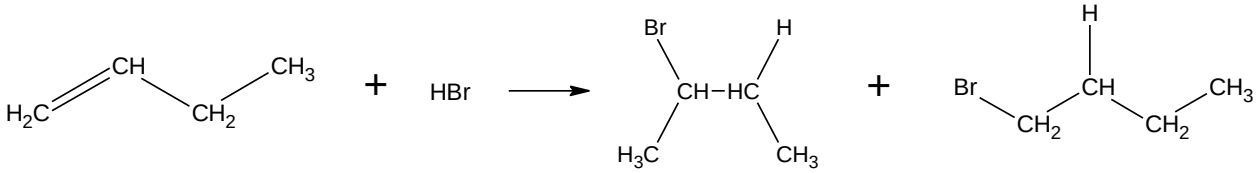
Example: addition of water to but-2-ene



but-2-ene (symmetrical) | water | butan-2-ol (asymmetrical)

- If both reactants are asymmetrical, more than one product *(isomer)* is possible:

Example: addition of bromine to but-1-ene



but-1-ene (asymmetrical) | hydrobromic acid (asymmetrical) | 2 – bromobutane | 1-bromobutane

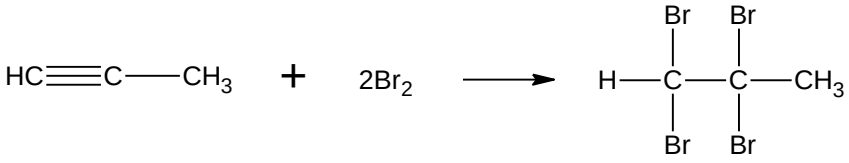
- In this example both products are formed, but *2 –bromobutane* is the *major product* as more of it is produced

> ***Markovnikov's Rule*** states that the halogen atom or OH group in an addition reaction is usually added to the more substituted carbon atom – *the carbon atom that is bonded to the largest number of other carbon atoms*

Addition Reactions - Alkynes

- Two addition reactions are possible because of the triple bond contained in alkynes

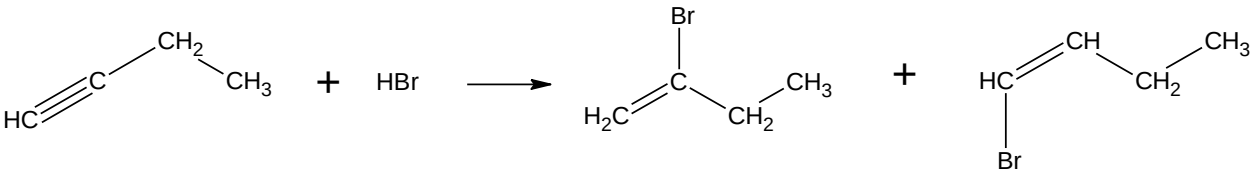
Example:



Propyne bromine 1,1,2,2-tetrabromopropane

- Alkynes adhere to Markovnikov's rule when an asymmetrical molecule is added to a triple bond

Example:



but-1-yne hydrobromic Acid 2-bromobut-1-ene (major product) 1-bromobut-1-ene (minor product)