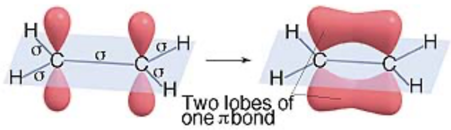
REACTIONS OF ALKENES 1

ELECTROPHILIC ADDITION



Alkenes are susceptible to attack by **electrophiles** (lone pair acceptors).

This is because the C=C double bond is very electron rich due to the electron cloud of the π bond.

In an **addition** reaction, the C=C double bond opens up and an atom or group of atoms joins onto each C of the C=C double bond.

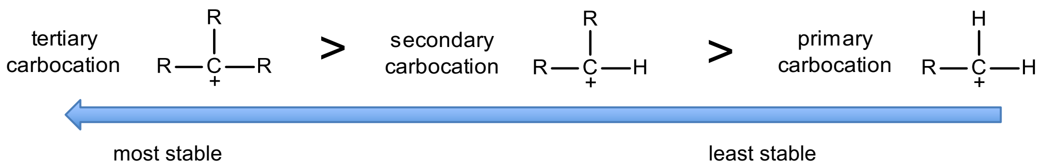
<u>**Carbocation intermediates**</u>

During the reaction, a **carbocation** is formed as an intermediate species in the mechanism.

Cations are positive ions (anions are negative ions).

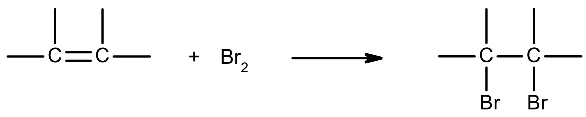
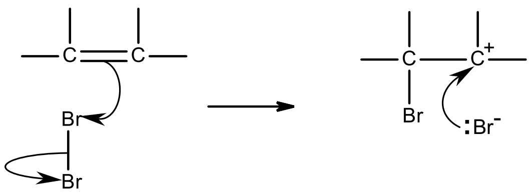
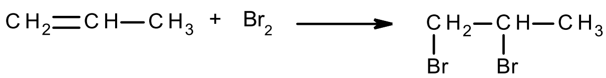
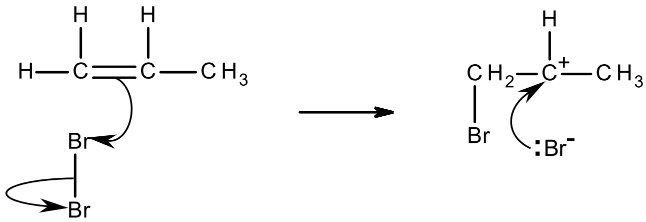
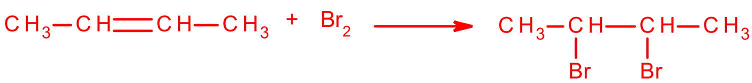
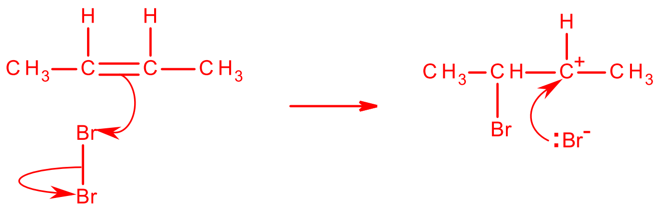
Positive ions with the positive charge on the C atom are called **carbocations**.

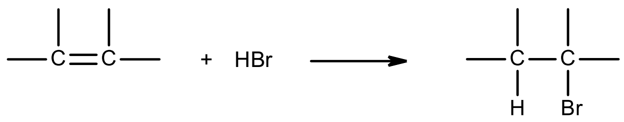
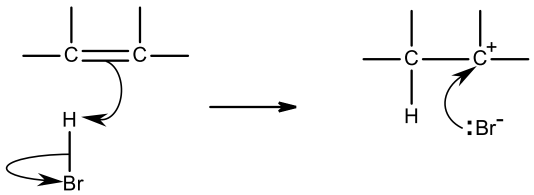
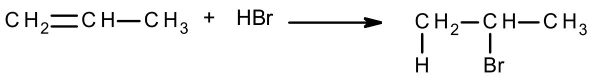
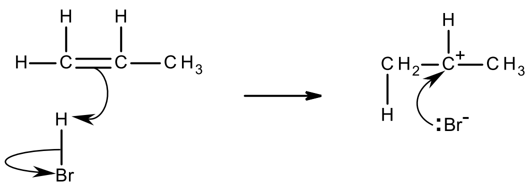
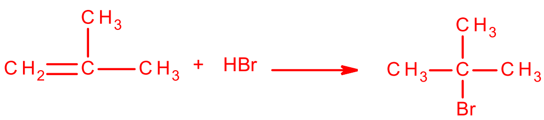
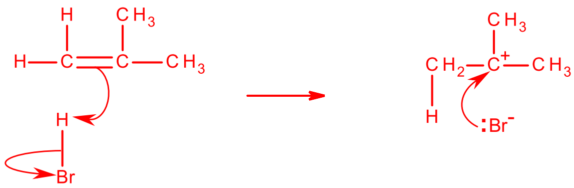
Carbocations are very unstable as the C atom only has 6 electrons around it in the outer shell. In terms of stability, tertiary carbocations (which have three alkyl groups bonded to the C+ atom) are the most stable (or least unstable).



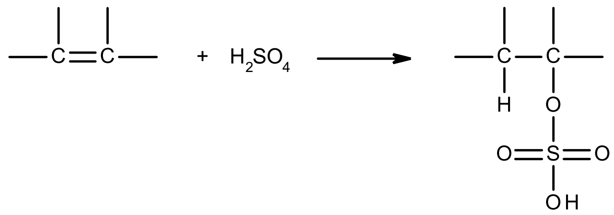
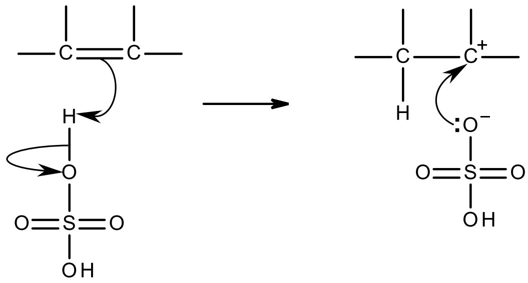
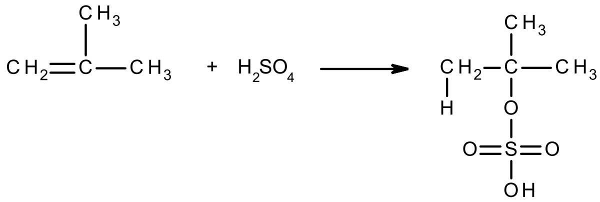
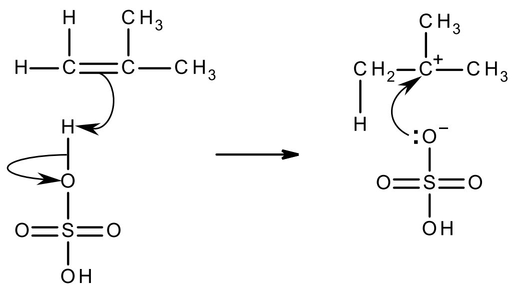
Alkyl groups (e.g. methyl, ethyl, etc) are electron-releasing compared to hydrogen atoms (this is called the **inductive effect**). Therefore the more alkyl groups (rather than H atoms) on the C+ atom, the more stable the carbocation. This explains why in terms of stability $3^y > 2^y > 1^y > CH_3^+$ carbocations.

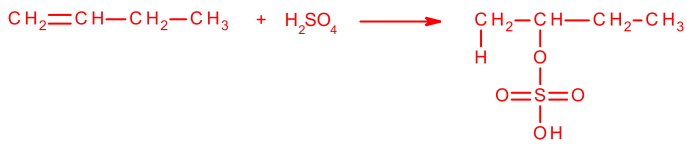
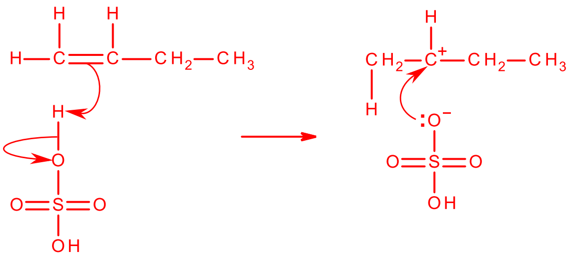
When alkenes undergo electrophilic addition reactions and different carbocations can be formed, the main product formed will be from the **more stable carbocation intermediate**. It is the structure and so stability of the carbocation intermediate that matters (<u>**not**</u> the structure / stability of the product).

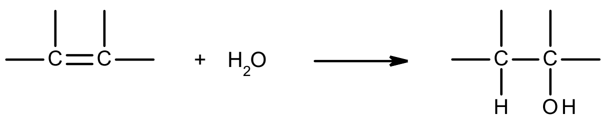
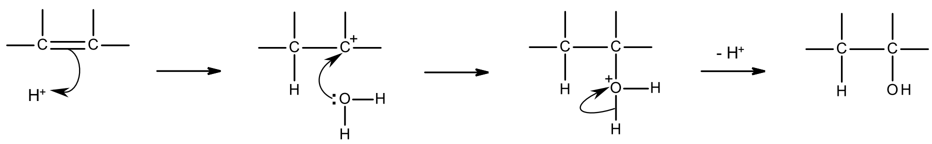
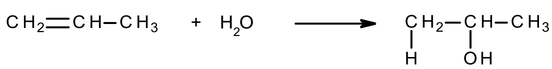
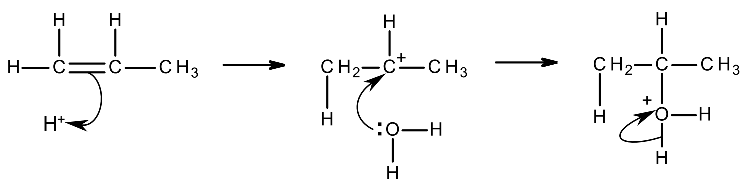
ELECTROPHILIC ADDITION 1 – reaction with Br_2	
Reagent	Br_2
Conditions	aqueous (i.e. bromine water)
What happens	C=C opens up; and added onto the two C atoms of the C=C double bond are: Br & Br
Overall equation	
Mechanism	**electrophilic addition** 
Example 1	e.g. propene + Br_2  **electrophilic addition** 
Example 2	e.g. but-2-ene + Br_2  **electrophilic addition** 

ELECTROPHILIC ADDITION 2 – reaction with HBr	
Reagent	HBr
Conditions	
What happens	C=C opens up; and added onto the two C atoms of the C=C double bond are: H & Br
Overall equation	
Mechanism	**electrophilic addition** 
Example 3	e.g. propene + HBr  **electrophilic addition**  The main product is 2-bromopropane which is formed: • from the 2ʸ carbocation intermediate $CH_3C^+HCH_3$ rather than the alternative 1ʸ carbocation intermediate $CH_3CH_2C^+H_2$ • the 2ʸ carbocation intermediate is more stable than the 1ʸ due to the inductive effect of two alkyl groups rather than one alkyl group.
Example 4	e.g. methylpropene + HBr  **electrophilic addition**  The main product is 2-bromo-2-methylpropane which is formed: • from the 3ʸ carbocation intermediate $(CH_3)_3C^+$ rather than the alternative 1ʸ carbocation intermediate $(CH_3)_2CHC^+H_2$ • the 3ʸ carbocation intermediate is more stable than the 1ʸ due to the inductive effect of three alkyl groups rather than one alkyl group.

ELECTROPHILIC ADDITION 3 – reaction with H_2SO_4

Reagent	H_2SO_4
Conditions	Concentrated H_2SO_4, cold (typically at room temperature)
What happens	C=C opens up; and added onto the two C atoms of the C=C double bond are: H & O-SO_2OH
Overall equation	
Mechanism	**electrophilic addition** 
Example 5	e.g. methylpropene + conc H_2SO_4  **electrophilic addition**  The main product is is formed: • from the 3^y carbocation intermediate $(CH_3)_3C^+$ rather than the alternative 1^y carbocation intermediate $(CH_3)_2CHC^+H_2$ • the 3^y carbocation intermediate is more stable than the 1^y due to the inductive effect of three alkyl groups rather than one alkyl group.

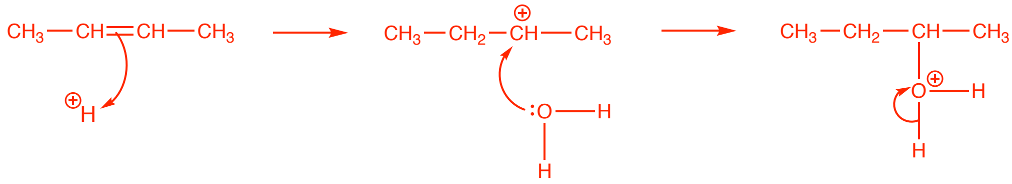
Example 5	e.g. but-1-ene + conc H_2SO_4  electrophilic addition  The main product is is formed: • from the 2^y carbocation intermediate $CH_3C^+HCH_2CH_3$ rather than the alternative 1^y carbocation intermediate $^+CH_2CH_2CH_2CH_3$ • the 2^y carbocation intermediate is more stable than the 1^y due to the inductive effect of twoalkyl groups rather than one alkyl group.

ELECTROPHILIC ADDITION 4 – reaction with H_2O	
Reagent	H_2O with strong acid (e.g. H_2SO_4, H_3PO_4)
Conditions	
What happens	C=C opens up; and added onto the two C atoms of the C=C double bond are: H & OH
Overall equation	
Mechanism	**electrophilic addition** 
Example 7	e.g. propene + water (in presence of strong acid catalyst)  electrophilic addition  The main product is formed: • from the 2^y carbocation intermediate $CH_3C^+HCH_3$ rather than the alternative 1^y carbocation intermediate $CH_3CH_2C^+H_2$ • the 2^y carbocation intermediate is more stable than the 1^y due to the inductive effect of two alkyl groups rather than one alkyl group.

Example 8

e.g. but-2-ene + water (in presence of strong acid catalyst)

electrophilic addition



There is only one product as only one carbocation intermediate can be formed in this reaction