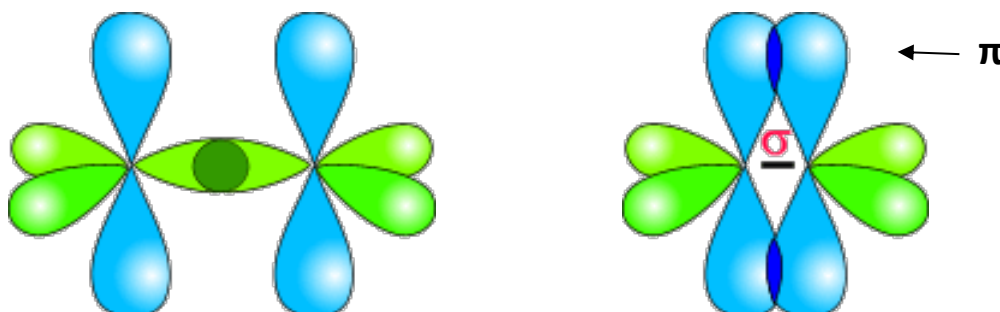


Alkenes Summary

Properties of alkenes

Alkenes and cycloalkenes are **unsaturated** hydrocarbons; they contain a C=C double bond, consisting of one σ and one π bond. This is a centre of **high electron density**.

The C=C bond comprises of a π -bond (sideways overlap of adjacent p-orbitals above and below the bonding C atoms) and a σ -bond (overlap of orbitals directly between the bonding atoms).



Ethene is a **planar** molecule with bond angles of 120 degrees as there are three negative centres around each C atom.

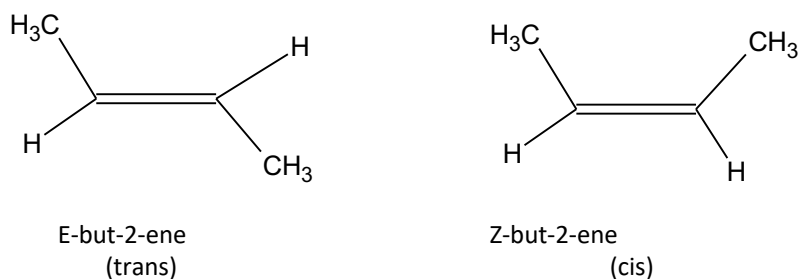
Isomerism

Stereoisomers are compounds with the same structural formula but with a different arrangement in space.

E/Z isomerism exists because of restricted rotation about a C=C double bond if each carbon atom is bonded to two different groups ie 1-bromo-2-chloropropene.



Cis/trans isomerism is a special case of E/Z isomerism in which two of the substituent groups are the same.

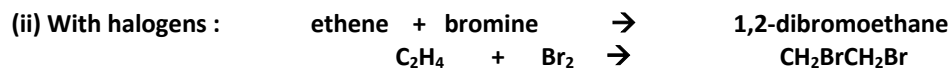
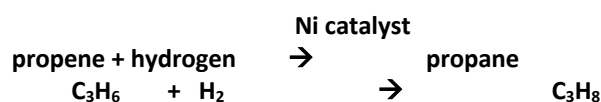
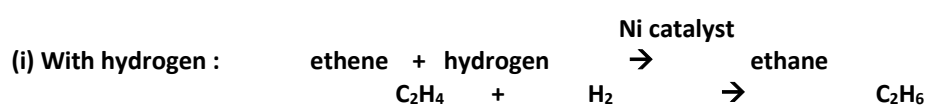


Using Cahn–Ingold–Prelog (CIP) Rules to identify E/Z stereoisomers

1. Compare the atomic number (Z) of the atoms directly attached to the double bond; the group having the atom of higher atomic number receives higher priority.
2. If there is a tie, we must consider the atoms at distance 2 from the stereocenter—as a list is made for each group of the atoms bonded to the one directly attached to the stereocenter. Each list is arranged in order of decreasing atomic number. Then the lists are compared atom by atom; at the earliest difference, the group containing the atom of higher atomic number receives higher priority.

Addition reactions of the alkenes

The C=C pi bond is electron rich, so attracts electrophiles, and is relatively weak, so easily broken. An **electrophile** is an electron pair acceptor that is attracted to an electron rich centre where it accepts a pair of electrons, forming a covalent bond. It may be a positive ion or a molecule, e.g. Br₂.

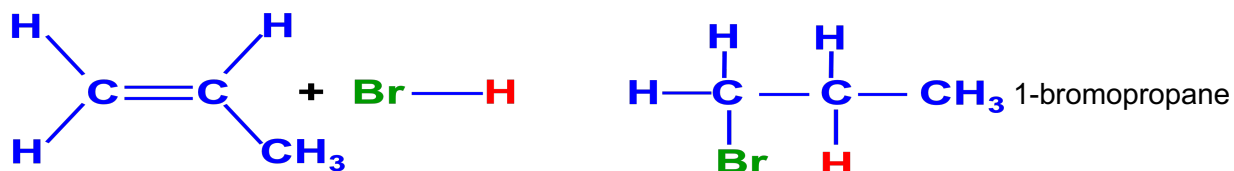
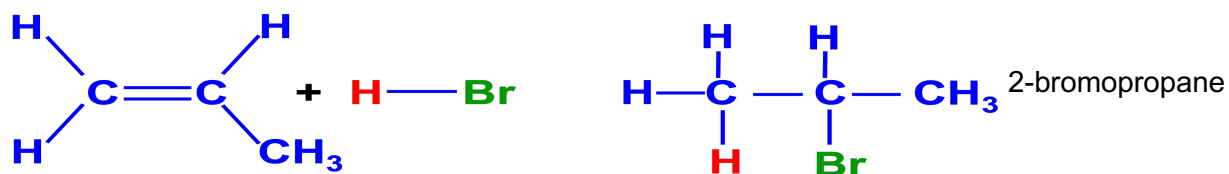


Orange aq. bromine \rightarrow colourless, a test for unsaturation, i.e. for the presence of a C=C bond.

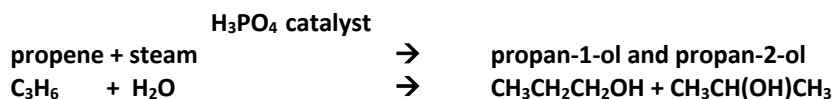
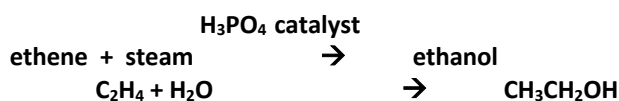
(iii) With hydrogen halides :

ethene + hydrogen bromide \rightarrow bromoethane

Addition to an unsymmetrical molecule such as propene may result in two isomeric products.



(iv) With steam :

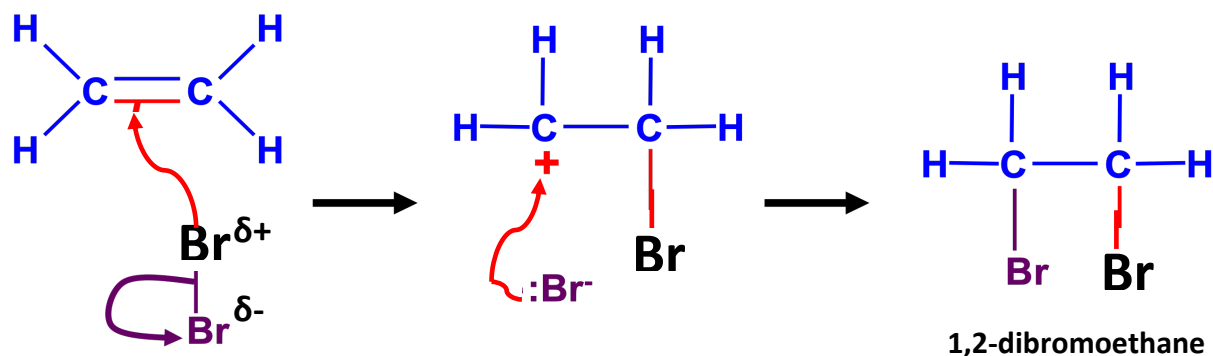


Mechanism of electrophilic addition in alkenes

e.g. $\text{C}_2\text{H}_4 + \text{Br}_2 \rightarrow \text{CH}_2\text{BrCH}_2\text{Br}$

The bromine molecule becomes polarised as it approaches the double bond. The π bond breaks and the electron pair forms a new C-Br covalent bond with the slightly positive bromine atom.

At the same time the bromine molecule undergoes **heterolytic fission**, both electrons in the bond moving to the same atom. A bromide ion and a carbocation are formed which quickly combine, forming 1,2-dibromoethane.



Predicting the formation of major and minor products in addition reactions of unsymmetrical alkenes.

Alkyl groups have a tendency to release electrons. This is known as a **positive inductive effect**. This electron releasing effect stabilises the intermediate carbocation. The more alkyl groups you have attached to the carbon with a positive charge the more stable it is.

$(\text{CH}_3)_3\text{C}^+$ is the most stable

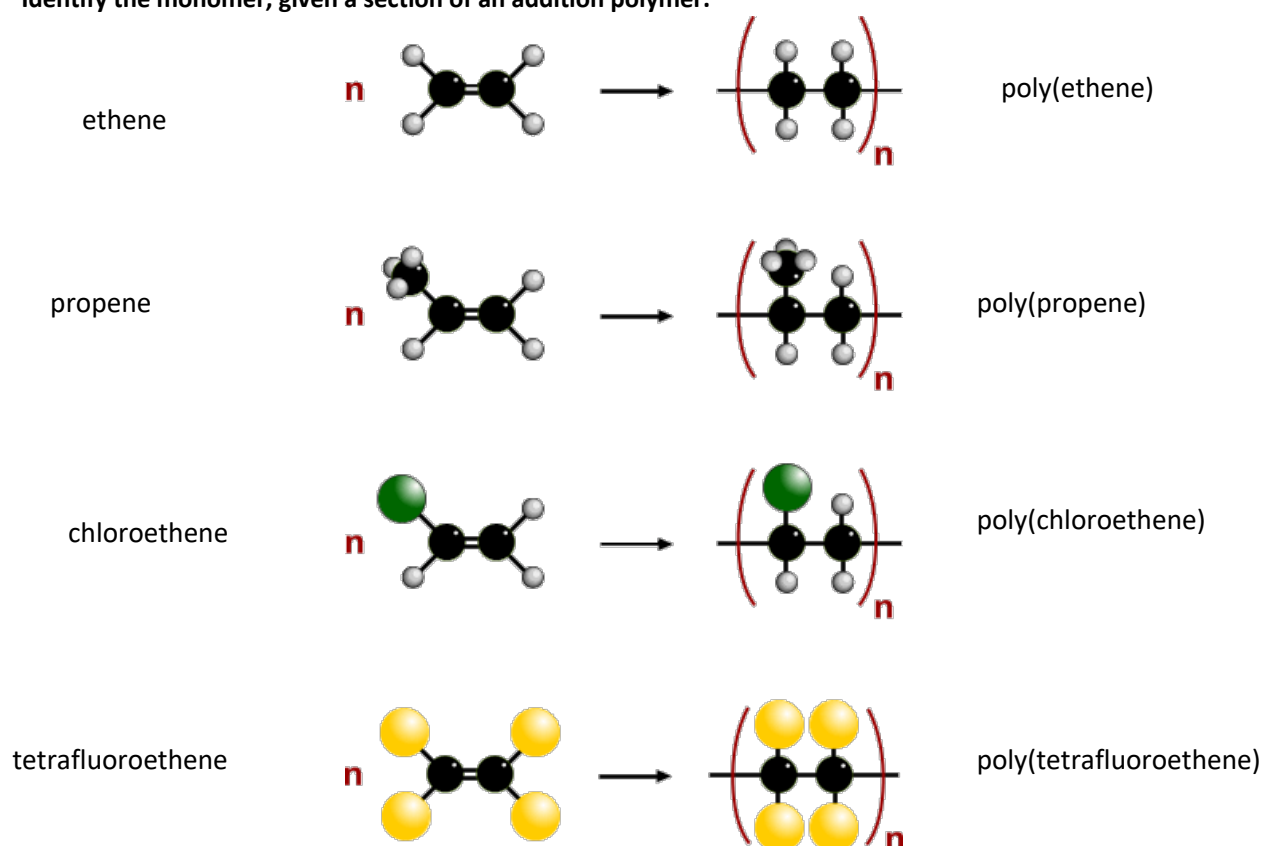
H_3C^+ is the least stable

This means that in for unsymmetrical alkenes, the H will prefer to add to the carbon with the most hydrogen atoms.

Polymers from alkenes

Addition polymerisation of alkenes Many identical monomer molecules join to form a long polymer molecule. The empirical formula of the polymer is the same as that of its monomer.

You should be able to deduce the repeat unit of an addition polymer obtained from a given monomer and identify the monomer, given a section of an addition polymer.



Addition polymers are unreactive because they have strong non-polar C-C and C-H bonds. Between the polymer molecules are Van der Waals forces.

Waste Polymers and alternatives

Benefits of cheap oil-derived plastics are counteracted by problems for environment of landfill. There is now a move to re-using waste and improving the use of resources.

Methods used to sustainably process waste polymers:

- (i)** combustion for energy production
- (ii)** use as an organic feedstock for the production of plastics and other organic chemicals
- (iii)** removal of toxic waste products, e.g. removal of HCl formed during disposal by combustion of halogenated plastics (e.g. PVC) by gas scrubbers

Benefits to the environment of the development of biodegradable and photodegradable polymers includes the reduced dependency on finite resources and alleviating problems from the disposal of persistent plastic waste.