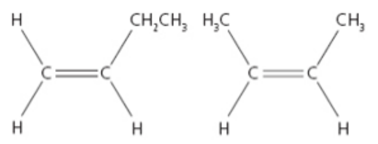
Subject: Chemistry	Topic: Alkenes 3.3.4	Year Group: 12

Bonding in alkenes

1	Alkenes have at least one carbon-carbon double bond and are said to be unsaturated hydrocarbons, with the general formula C_nH_{2n}. The double bond gives them a region of high electron density which results in alkenes being much more reactive than alkanes. Alkenes are indicated by the use of the letters 'ene' at the end of the name.

E-Z isomerism

1	Some alkenes display a type of stereoisomerism known as E-Z isomerism. The conditions necessary for this are: • A carbon-carbon double bond • Both carbons being attached to two different groups	
2	E-Z isomerism arises due to restricted rotation of groups about the double bond.	

Identifying E and Z isomers

1	E-Z isomers are named according to the Cahn-Ingold-Prelog (CIP) rules. These allow a priority to be assigned, which is based on atoms with a higher atomic number being given a higher priority. The steps to take are as follows: Look at the two atoms bonded to the first carbon of the double bond. If one has a greater atomic number than the other, then the larger has the greater priority. If both atoms are the same, then consider the atoms these are bonded to, adding together their atomic numbers. If a double bond is present in the group, this counts as two of that atom e.g. a double bond to an oxygen counts as 2 oxygens. Repeat for the second carbon of the double bond.
2	If both groups of highest priority are on the same side, this is the Z isomer, and if on opposite sides of the double bond, this is the E isomer.

Key Vocabulary

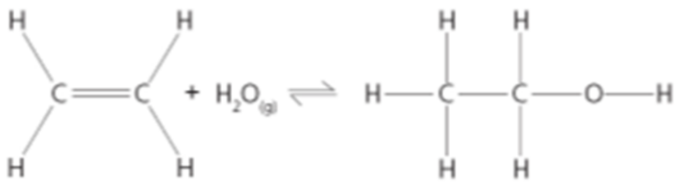
1	Unsaturated	A substance containing at least one carbon-carbon double bond.
2	Hydrocarbon	A compound containing hydrogen and carbon atoms only.
3	Stereoisomerism	Compounds with the same structural formula, but a different arrangement of atoms in space.
4	Electrophile	An electron-pair acceptor.
5	Addition	A reaction where two molecules join to form one molecule only.
6	Monomer	The molecule which forms the repeating units of a polymer.
7	Polymer	A long chain molecule formed from many monomers bonded together.
8	Addition polymerisation	The process by which alkenes react with other alkene molecules to form long chain.
9	Curly arrow	Represents the movement of a pair of electrons.
10	Carbocation	A species which contains a positive charge on a carbon atom.
11	Heterolytic Fission	Occurs when a covalent bond breaks and both electrons move to one of the atoms.

Subject: Chemistry	Topic: Alkenes 3.3.4	Year Group: 12

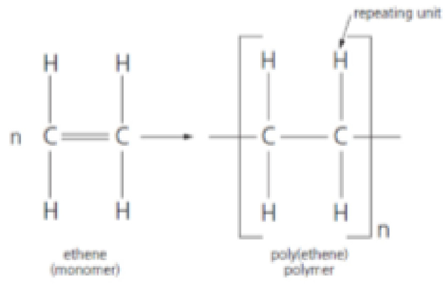
Reactions of alkenes

1	The carbon-carbon double bond in alkenes is a region of high electron density, and can be attacked by electrophiles, which are electron pair acceptors. An electrophile can be a polar molecule such as H-Br or a neutral molecule such as Br_2, which becomes an electrophile when it approached the C-C double bond and is polarised due to electron repulsion.

Production of ethanol from ethene

1	Ethanol is a member of the alcohol homologous series, and is used in methylated spirits, as a solvent and in alcoholic drinks. Industrially, it is made by the reaction of ethene with steam at a pressure of 60 atm and a temperature of 600 K in a hydration reaction. Concentrated H_3PO_4 is used as a catalyst.
2	

Addition polymers

1	Alkenes can be reacted together to form long chains known as addition polymers. They are named by placing 'poly' at the start of the name of the alkene that was used to make it e.g. propene makes the polymer poly(propene).
2	Equations showing the formation of polymers can be drawn in the manner shown below:
3	
	When asked to show the formula of a polymer, draw the image on the right side of the equation. When asked to draw a repeating unit, draw the same image, but without the square brackets or n.

Production and uses of polymers

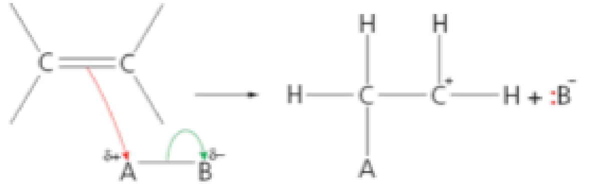
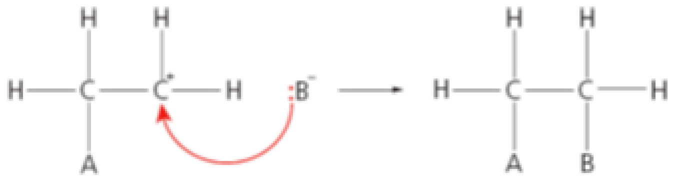
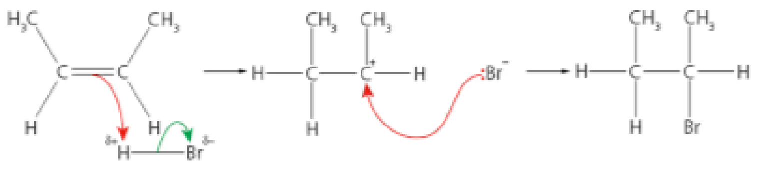
1	Addition polymers are generally very unreactive, as they are essentially long alkane molecules with no reactive carbon-carbon double bond. Ethene can be polymerised to make high density polyethene (HDPE) and low density polyethene (LDPE). HDPE is made using a catalyst, has low flexibility and is used for kitchenware, amongst other uses. LDPE is more flexible and is used for plastic bags and some plastic bottles.
2	Poly(chloroethene) (known as PVC) is a rigid plastic used for plastic window and door frames, and drainpipes. However, a plasticiser (such as a phthalate) can be added which causes the polymer to become more flexible, and can then be used for electrical wire insulation, wellington boots and raincoats. The rigid form of PVC is known as uPVC (unplasticised PVC).
3	The property of a given polymer is dependent upon the strength of the intermolecular forces between polymer chains. In simple polymers such as polyethene, simple van der Waals forces exist between chains, resulting in a high flexibility and a low melting point. If electronegative atoms such as chlorine or oxygen are present, permanent dipole-dipole interactions may be present between chains. This would decrease flexibility and increase the melting point of the polymer.

Beckfoot

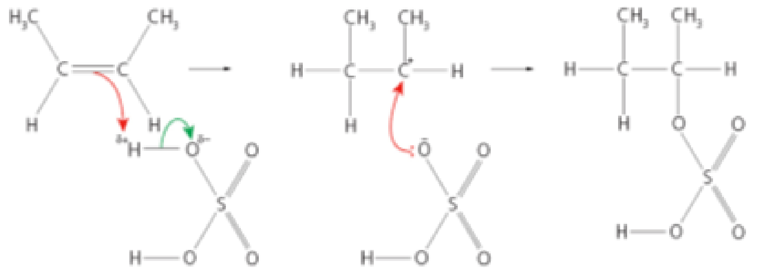
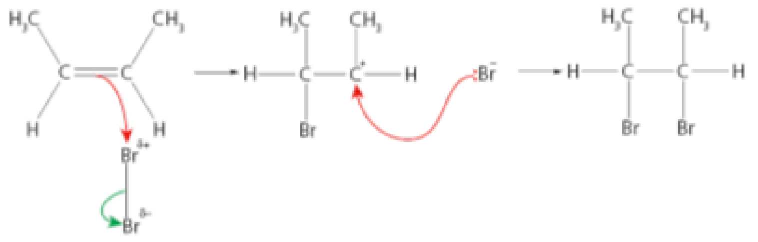
Subject: Chemistry	Topic: Alkenes 3.3.4	Year Group: 12

enjoy learn succeed

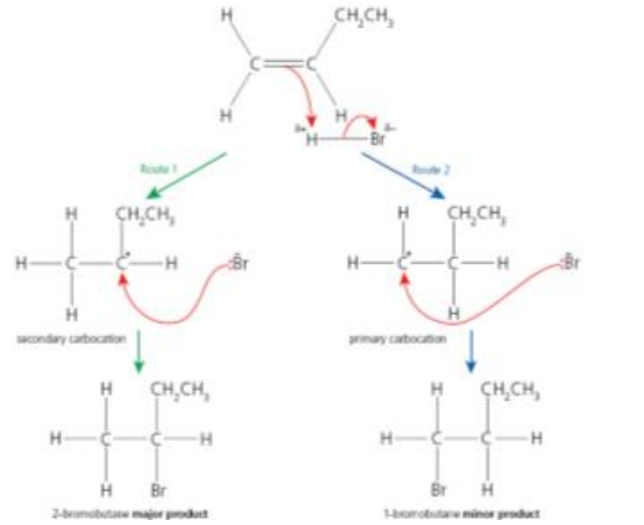
Electrophilic addition mechanism

1	When an alkene reacts with a polar electrophile, a pair of electrons from the double bond moves to the δ+ side of the molecule, and the two electrons of the A-B covalent bond move onto the B atom, forming B-.
2	
3	This causes the formation of a carbocation, which is quickly attacked by a pair of electrons on B-, forming the final product.
4	
5	This reaction can be seen in the reaction of but-2-ene and HBr.
6	

Electrophilic addition mechanism

1	An alkene will react with sulfuric acid. The key here is to think of H_2SO_4 as $H\text{-}OSO_3H$, with H being the δ+ atom, and O being δ-. The O– part of the molecule then attacks the carbocation.
2	
3	Alkenes can react with neutral molecules such as halogens, as the molecule will be polarised by the electron dense double bond. A pair of electrons from the double bond will then attack the δ+ part of the electrophile. The remainder of the mechanism is the same as those seen above.
4	

Major and Minor Products

1	When an asymmetric alkene reacts with H-X (where X is a halogen), a major and minor product will form. This is because the hydrogen atom can initially bond to either carbon of the carbon-carbon double bond.
2	
3	In the above example, the major product is 2-bromobutane. This is the major product because its mechanism involves the formation of a secondary (2o) carbocation (a carbocation that is attached to two R groups). 2o carbocations are more stable than 1o carbocations (attached to one R group), but less stable than 3o carbocations (attached to three R groups). This is because of the inductive effect, whereby the electrons in R groups are 'pushed' into the positively charged carbocation.