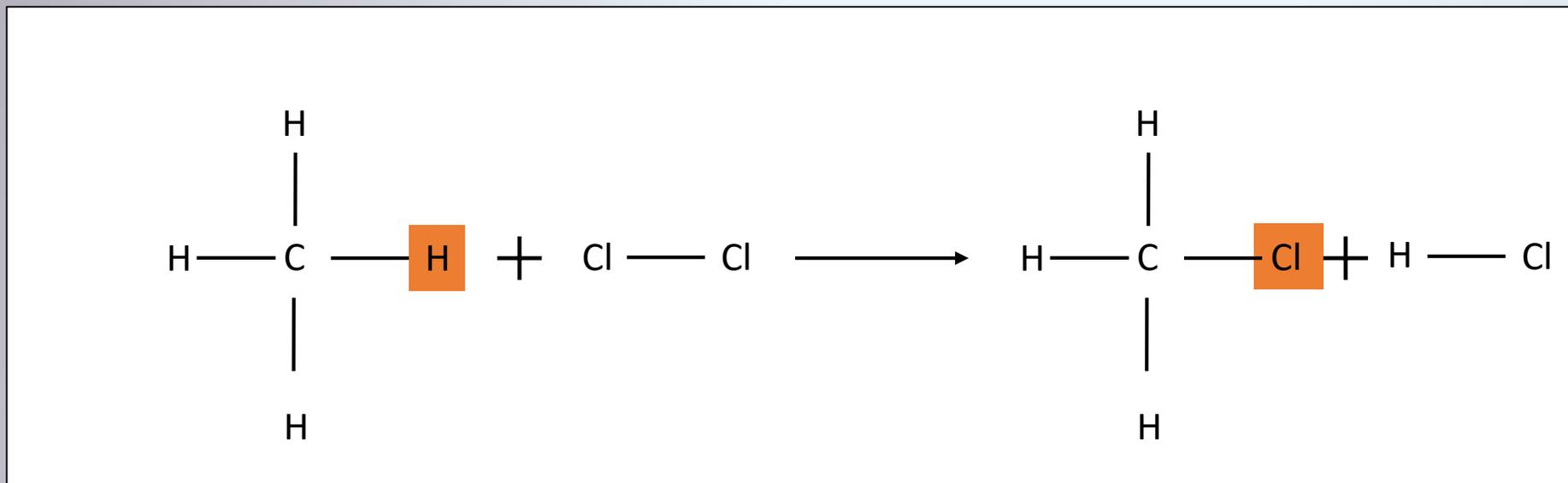


# Types of Reaction in Organic Chemistry



# Substitution Reactions

A substitution reaction is a reaction where an atom or group of atoms is replaced with another atom or group of atoms.



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# Mechanisms of Reactions

Mechanism of a reaction is a detailed step by step description of how the overall reaction occurs.

Chain reaction is a reaction that continues on and on because a product of one step of the reaction is a reactant for another step of the reaction.

Photochemical reaction is a reaction brought about by light.

A free radical is any atom or group of atoms that has an unpaired electron (highly reactive).



# Mechanism of Monochlorination of Methane

## Step 1: Initiation

Chlorine molecule is broken into two chlorine free radicals by UV light.

(This is a photochemical reaction. One electron from the bond goes to each chlorine atom, this is homolytic fission.)

Evidence for this stage is that the reaction does not occur in the dark. The energy from the UV light is required to break the bond.



## Step 2: Propagation

A chlorine free radical attacks a methane molecule, stripping it of a hydrogen.

This produces hydrogen chloride and a methyl free radical



### Step 3: Propagation

A methyl free radical attacks a chlorine molecule producing chloromethane and a chloride free radical.

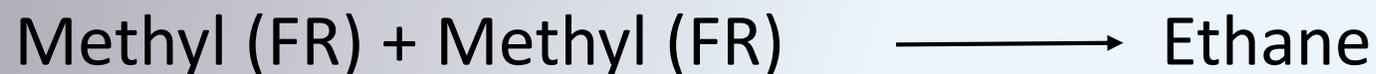
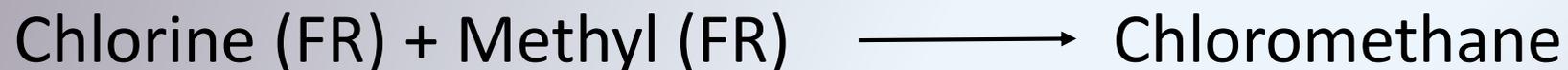
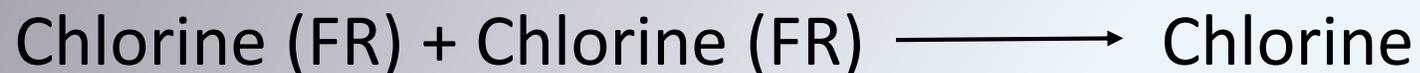
Step 3 creates a reactant for Step 2 so a chain reaction is set up.

Evidence: For every photon of light absorbed thousands of chloromethane molecules are produced. Suggesting a chain reaction is taking place



## Step 4: Termination

Termination involves reactions where free radicals (FR) combine with one another.



# Evidence for this mechanism

Ethane is produced so methyl free radicals must be present.

Adding a source of free radicals such as tetramethyl lead speeds up the reaction. Therefore the mechanism must involve free radicals.

Adding an inhibitor such as oxygen slows the reaction. Oxygen is combining with free radicals slowing the chain reaction.



# Chlorination of ethane

The chlorination of ethane undergoes the same mechanism and can be asked.

In this case the free radical formed is ethyl rather than methyl.

In the termination stage butane is produced when two ethyl (FR) collide.



# Demonstration of halogenation of alkanes

Procedure	Observations	Explanation
Fill two test tubes with cyclohexane and add bromine water to give a pale red solution.		
1. Place one near a source of UV light	1. Turns colourless	1. Substitution reaction between bromine and cyclohexane has occurred to produce bromocyclohexane (a colourless compound)
2. Wrap the other in tin foil to prevent UV light reaching it.	2. No change	2. No reaction.



# Uses of Halogenated Alkanes

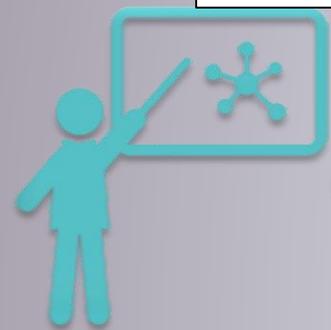
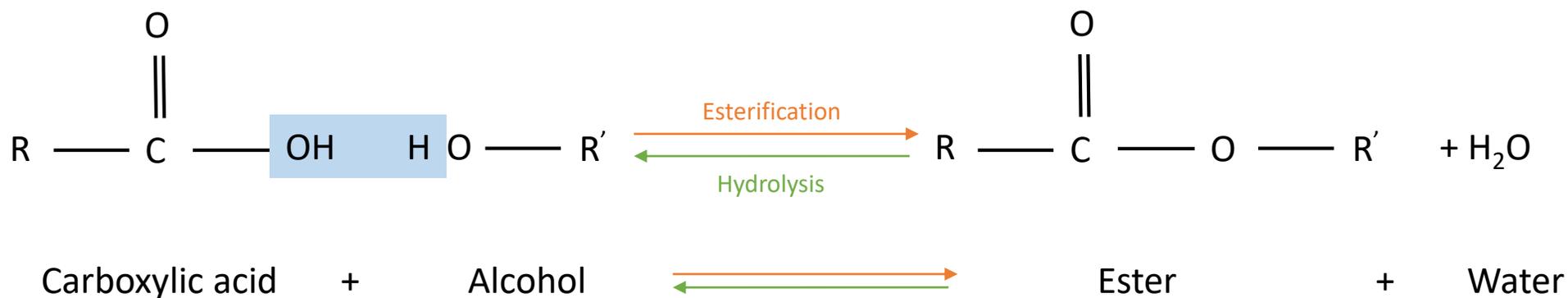
Fully halogenated alkanes are flame retardants and had been used in fire extinguishers.

However their use has been stopped due to damage to the ozone layer.



# Esterification

Esters are formed when an alcohol and a carboxylic acid react together. This is known as a **condensation reaction** as water is produced.



# Esterification and Hydrolysis

Esterification is the formation of esters, this is an equilibrium reaction where hydrolysis is the reverse reaction.

Hydrolysis of an ester is brought on by the presence of a base such as sodium hydroxide or potassium hydroxide.

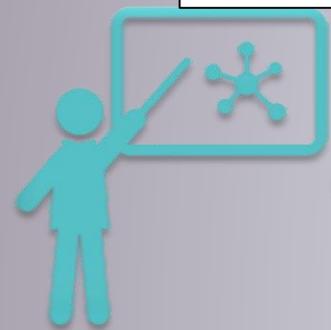
This can be referred to as **base hydrolysis, saponification, or base-catalyzed hydrolysis of esters.**



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# Base Hydrolysis

Esters are formed when an alcohol and a carboxylic acid react together. This is known as a **condensation reaction** as water is produced.

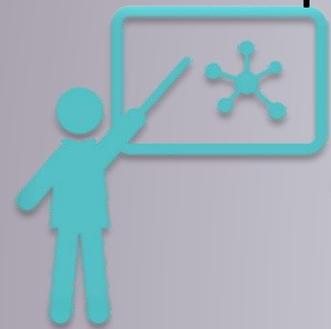


# Production Soap

Fats and oils from nature are esters. They are formed from an alcohol and several carboxylic acids (also called fatty acids).

Glyceryl tristearate is a common fat. It is formed from one glycerol (propane-1,2,3-triol) and three stearic acid (octadecanoic acid) molecules.

Glyceryl tristearate is then reacted with NaOH in a saponification reaction to form sodium stearate (sodium octadecanoate) which is soap.



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# Exp: Production Soap

## Overview of reaction

Stearic acid + glycerol  $\longrightarrow$  glycerol tristearate

Glycerol tristearate + sodium hydroxide  $\longrightarrow$  Sodium Stearate + Glycerol  
(soap)

Note: Glycerol is a useful by-product used to make nitroglycerine (TNT)

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Procedure	Observations	Explanation
Sunflower oil is placed in reflux reaction setup	<p>Drops of condensed liquid fall back into the flask.</p> <p>A coating forms on the inside of the flask. This is the sodium salts and oil that has not been hydrolysed</p>	<p>This keeps the reactants together for long enough to <b>bring the reaction to completion</b>. (maximises the yield)</p> <p>There is also <b>no loss of the solvent ethanol</b> as the vapour is continuously condensed.</p>
Sodium hydroxide is added to the flask		Sodium hydroxide is the base <b>that brings about the saponification reaction</b> .
Ethanol is added to the flask		Ethanol is a <b>solvent for the oil</b> .
Anti-bumping chips are added to the flask		Ensure that the <b>boiling takes place smoothly</b> .
Water bath is used to heat mixture		Ensures that the <b>mixture boils gently</b> .
The flask is swirled periodically		This <b>brings the coating on the flask back into the reaction mixture</b> .



Procedure	Observation	Explanation
Apparatus is rearranged for distillation and ethanol is distilled off		Removal of ethanol makes the isolation of soap easier (maximise yield). Some soap would remain dissolved otherwise.
Remaining mixture is added to 100cm <sup>3</sup> of brine	A solid substance is precipitated in the brine.	Excess sodium hydroxide dissolves into the brine. Soap does not dissolve, it is precipitated.
A minimum of water is used to wash residue from flask into the brine		To avoid diluting the brine solution, this maximises the yield
Soap is washed with a fresh salt solution followed by ice-cold water.		Fresh salt solution ensures any remaining sodium hydroxide is removed. Ice-cold water minimizes the amount of soap that might be dissolved (maximises yield).
A dry sample of the soap is added to deionised water in a test tube and shaken	A lather is formed in the test tube	Formation of a lather proves that soap had been produced.

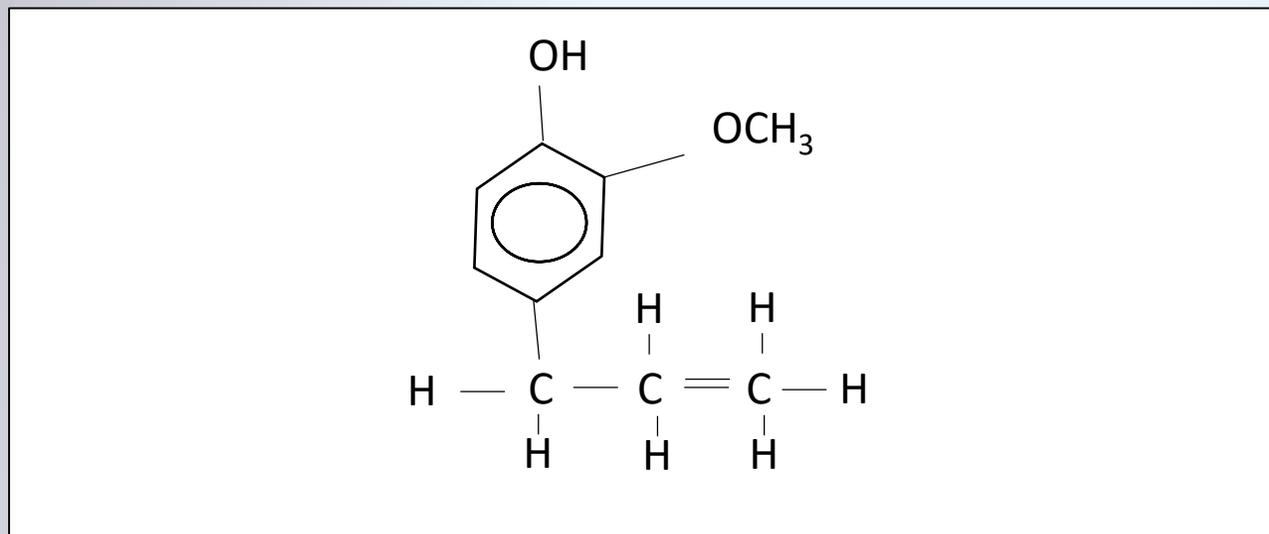


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# Exp: Extraction of Clove Oil from Cloves by Steam Distillation

Steam distillation is used to prevent the oil from decomposing.

The main constituent of clove oil is **eugenol** (you must be able to draw its structure).



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# Clove Oil Extraction

## Safety precautions:

1. Steam is being used, great care needs to be taken to avoid scalding.
2. Eugenol can burn the skin, gloves need to be worn when handling the emulsion.



Procedure	Observations	Explanation
Whole cloves are used in the experiment		Whole cloves contain more oil than dry, powdered cloves.
A safety tube and rubber stop are placed in the steam generator		Safety tube prevents the build up of pressure from the steam in the steam generator.
The end of the safety tube is placed below the water level		Otherwise the steam would escape through the safety tube and not enter the flask containing the cloves
A steam trap is placed before the flask of cloves		This prevents the flask containing cloves from filling with water caused by condensed steam.
	A colourless liquid collects in the steam trap	Colourless liquid is water caused by the steam condensing.
	A milky coloured liquid collects in the graduated cylinder	This is the emulsion of oil from the cloves and water.



Exp: Isolation of eugenol from an emulsion of clove oil and water by liquid-liquid extraction using cyclohexane

**Liquid-liquid extraction** – is a technique in which two immiscible liquids are separated using a solvent in which one compound of the mixture has a higher solubility than the other.

i.e. organic component is removed by dissolving it in an organic solvent.



Procedure	Observations	Explanation
Cyclohexane is added to the emulsion		Cyclohexane is the solvent that removes eugenol from the emulsion.
Mixture placed into a separating funnel	Two liquid layers are observed. Cyclohexane floats on the emulsion.	Cyclohexane (non-polar) will not mix with water (polar). Cyclohexane floats on top as it is less dense.
Funnel is shaken 10 times and whilst inverted the tap is opened.		Tap is opened to release any pressure build up in the separating funnel.
Funnel is clamped vertically and the bottom layer (aqueous) is collected in a beaker. Upper layer is collected in a conical flask. This washing and separating is repeated twice more.	After each washing the emulsion becomes less milky	Three washings completed to maximise the amount of clove oil removed from emulsion.  Milky colour is caused by the oil in the emulsion. In the washing the cyclohexane removes the oil, thus the solution is less milky.
Anhydrous magnesium sulfate ( $\text{MgSO}_4$ ) is added to the cyclohexane solution	Magnesium sulfate forms clumps on the side and bottom of the conical flask.	Magnesium sulfate acts as a drying agent by absorbing water.



Procedure	Observations	Explanation
The mass of a second dry conical flask is measured.		This will be used to calculate the mass of oil extracted.
The solution is passed through filter paper. Fresh cyclohexane solution is used to wash the residue from the conical flask.		The magnesium sulfate is separated from the solution and left on the filter paper.
The mixture of cyclohexane and clove oil is placed in a water bath in a fume hood.	Small amount of an oily substance is left in the conical flask.	Cyclohexane is volatile and evaporates off. The clove oil (mostly eugenol) is left in the flask.
<b>Be able to calculate the percentage of oil in cloves.</b>		



# Addition Reaction

Addition reaction is a reaction where two or more molecules react together to form a single molecule.

Example: hydrogen + ethene  $\longrightarrow$  ethane

Addition reactions involving hydrogen can also be called **hydrogenation reactions**



# Ethene

Ethene is vital to industry as it undergoes addition reactions to form a number of useful compounds.

Ethene + Bromine  $\longrightarrow$  1,2 -dibromoethane (termite fumigation)

Ethene + Chlorine  $\longrightarrow$  1,2 -dichloroethane (makes PVC)

Ethene + Hydrochloric acid  $\longrightarrow$  Chloroethane (dentistry)

Ethene + Water  $\longrightarrow$  Ethanol (solvent and fuel)



# Hydrogenation of Vegetable Oils

Edible oils are polyunsaturated meaning they have more than one C=C double bond.

In general animal fats are saturated and vegetable oils are unsaturated.

Unsaturated oils are thought to be less damaging to our health than saturated fats. However as oils they cannot be used as spreads on bread.

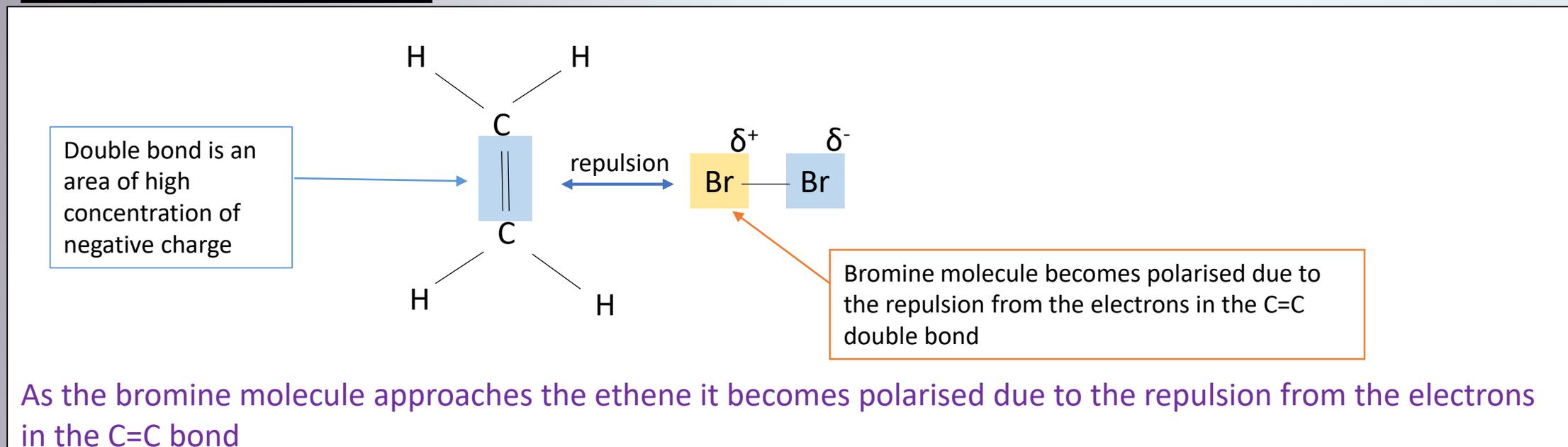
So chemists added hydrogen to some of the C=C in vegetable oils to make margarine a compound with less saturated fats and lower melting point than butter.



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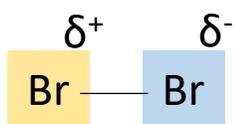
# Mechanism for Reaction between Ethene and Bromine

## Step 1: Polarisation



# Mechanism for Reaction between Ethene and Bromine

## Step 2: Heterolytic Fission



Polarisation of Br<sub>2</sub> molecule gets greater and greater.



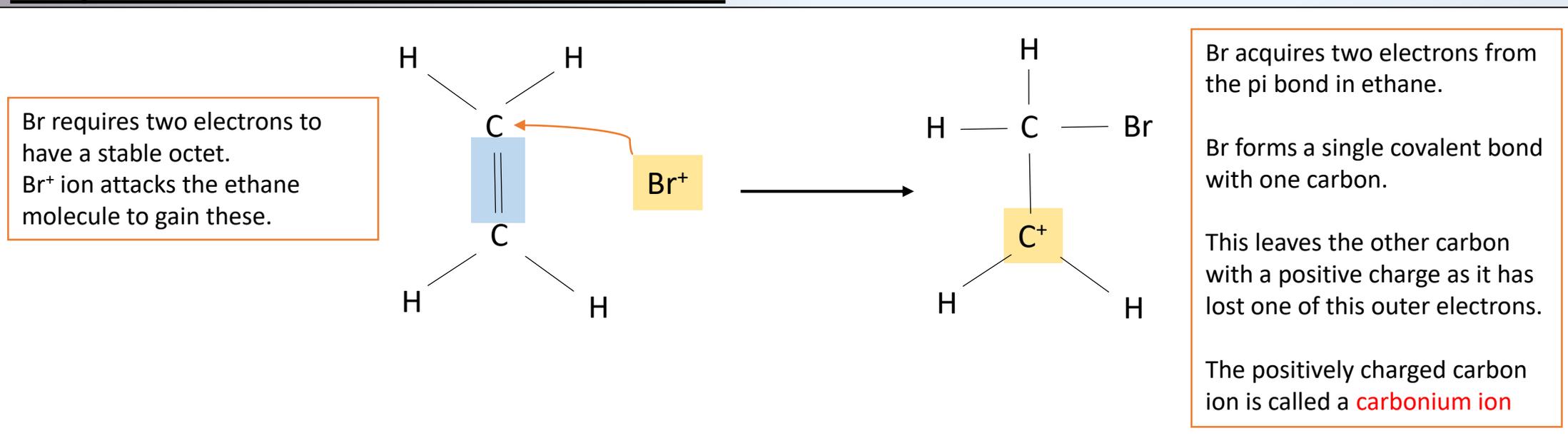
**Heterolytic fission** occurs where two electrons from the single bond both go to one of the bromine atoms.

The induced polarisation becomes so great that heterolytic fission takes place and the bromine molecule splits into Br<sup>+</sup> and Br<sup>-</sup> ions.



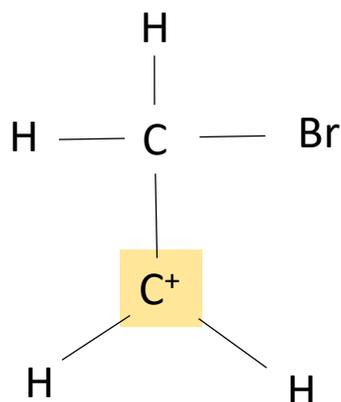
# Mechanism for Reaction between Ethene and Bromine

## Step 3: Carbonium Ion Formation

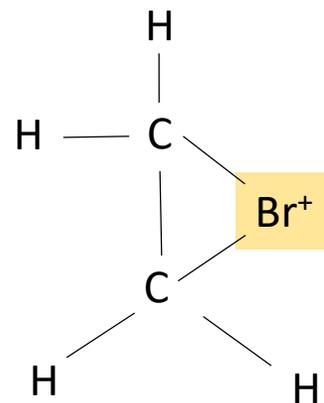


# Mechanism for Reaction between Ethene and Bromine

## Step 3: Carbonium Ion Formation



or



Cyclic bromonium ion

There is evidence to suggest that the structure formed is actually the cyclic version on the right.

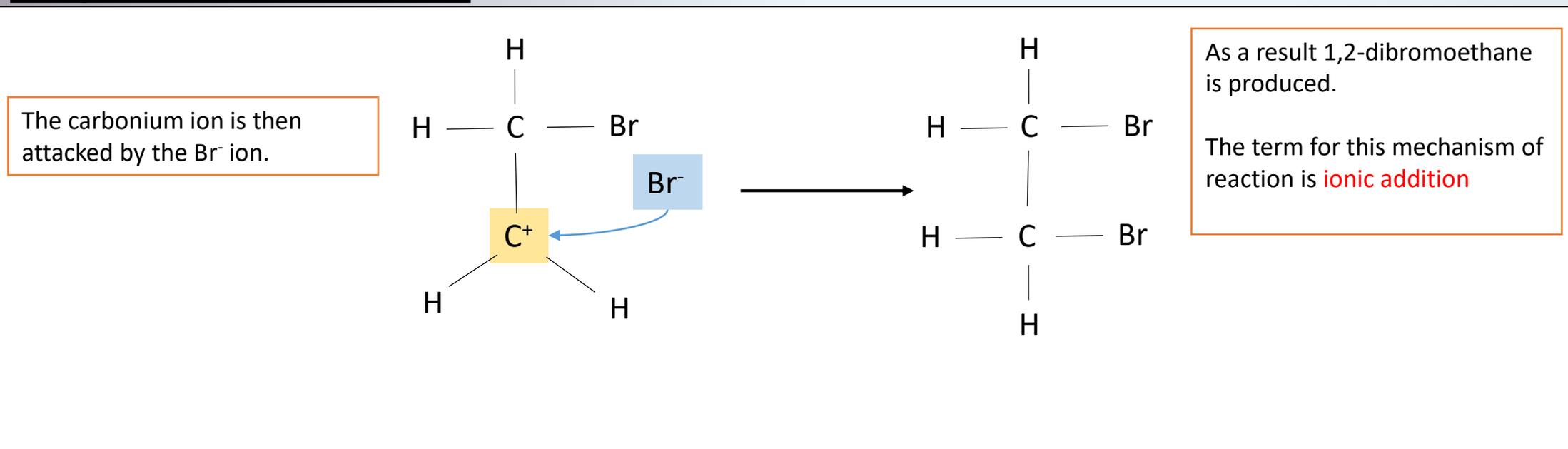
The bromine atom's relatively large size allows for this structure.



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# Mechanism for Reaction between Ethene and Bromine

## Step 4: Ionic Addition



# Evidence

When ethene reacts with bromine in water containing sodium chloride **two other compounds are formed**.

**1-bromo-2-chloroethane** occurs when  $\text{Cl}^-$  ion present in the solution attacks the carbonium ion.

**2-bromoethanol** occurs when  $\text{OH}^-$  ion present in the solution attacks the carbonium ion.



# Other reactions that follow this mechanism

Ionic addition mechanism also applies to:

Chlorine ( $\text{Cl}_2$ ) when it reacts with ethene. ( $\text{Cl}^-$  and  $\text{Cl}^+$  ions)

Hydrochloric acid ( $\text{HCl}$ ) when it reacts with ethene. ( $\text{H}^+$  and  $\text{Cl}^-$  ions)

This reaction type is an example of addition reactions.



# Polymerisation Reactions

Polymers are long chain molecules made by joining together many small molecule.

The small molecules from which the polymer is made are called **monomers**.



# Common Polymers

Polyethene.

Polychlorethene (PVC).

Polypropene (used in toys, chairs, plastic jugs).



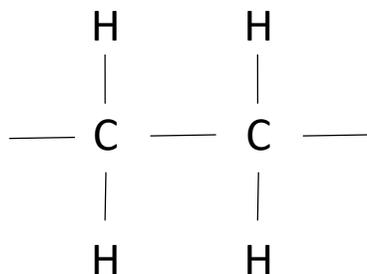
# Repeating Unit

Repeating unit of a polymer is that part of the polymer whose repetition produces the complete polymer chain except for the end groups.

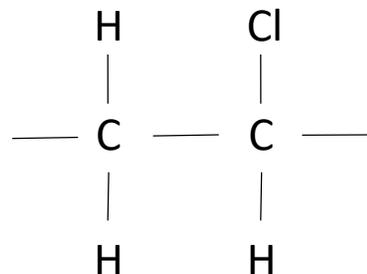
You must be able to draw these.



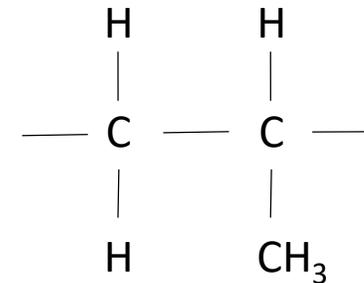
# Repeating units



Polyethene



Polychloroethene

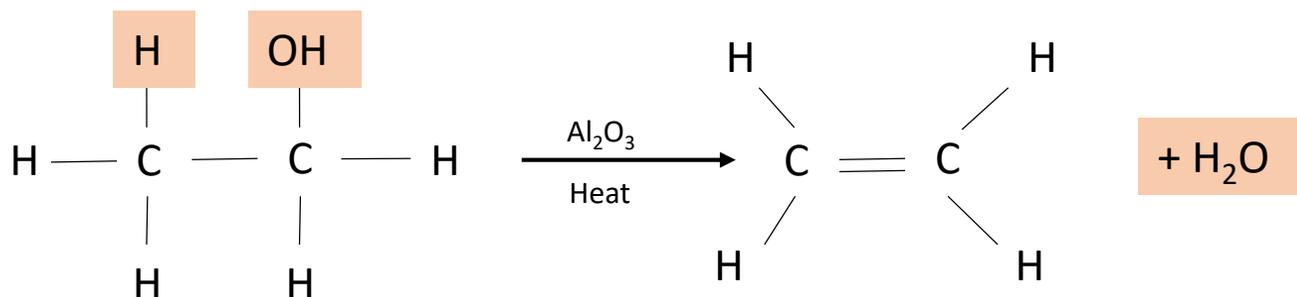


Polypropene



# Elimination reactions

Elimination reaction is one in which a small molecule is removed from a larger molecule to leave a double bond in the larger molecule.



Elimination reactions where water is lost can also be also **dehydration reaction**



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# Redox Reactions: Oxidation

Suitable oxidising agents: Sodium dichromate(VI) ( $\text{Na}_2\text{Cr}_2\text{O}_7$ )

Acidified Potassium Manganate(VII) ( $\text{KMnO}_4$ )

Primary alcohol + Oxidising agent  $\longrightarrow$  Aldehyde

Primary alcohol  $\xrightarrow{\text{Na}_2\text{Cr}_2\text{O}_7}$  Aldehyde  $\xrightarrow[\text{Only if oxidising agent is in excess}]{\text{Na}_2\text{Cr}_2\text{O}_7}$  Carboxylic acid

Secondary alcohol + Oxidising agent  $\longrightarrow$  Ketones



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# Redox Reactions: Reduction

Suitable reducing agents: **Nickel catalyst and Hydrogen**



# Reaction of ethanal with acidified potassium permanganate ( $\text{KMnO}_4$ )

Procedure	Observations	Explanation
Acidified potassium permanganate (purple) is added to a test tube.	Purple colour of potassium permanganate in test tube.	
Some ethanal is added to the test tube. Test tube placed in warm water.	Colour change from purple to colourless.	Ethanal has been oxidised to ethanoic acid.  Purple colour disappears because $\text{Mn}^{7+}$ ions have been reduced to $\text{Mn}^{2+}$ ions.
Experiment repeated with propanone.	Solution remains purple.	Ketones are not oxidised by potassium permanganate, as it is a weak oxidising agent.



# Reaction of ethanal with Fehling's reagent

Procedure	Observations	Explanation
Fehling's reagent is made up by adding Fehling's A and Fehling's B	Royal blue formed	
Some ethanal is added to the test tube. Test tube placed in hot water.	Colour change from royal blue to brick red.	Ethanal has been oxidised to ethanoic acid.  $\text{Cu}^{2+}$ ions (blue) have been reduced to $\text{Cu}^+$ ions (red).
Experiment repeated with propanone.	Solution remains blue.	Ketones are not oxidised by Fehling's solution, as it is a weak oxidising agent.

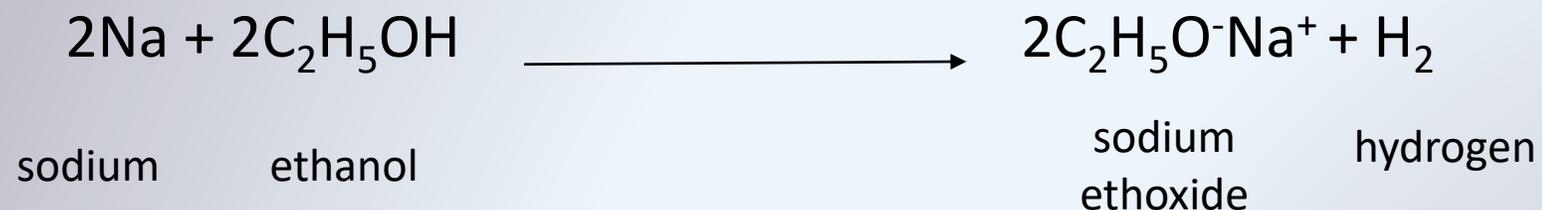


# Reaction of ethanal with ammoniacal silver nitrate

Procedure	Observations	Explanation
Fresh Tollens' reagent is made up by mixing nitrate solution, dilute sodium hydroxide, and dilute ammonia solution.		Tollens' reagent must be fresh as if it is stored it will form an explosive product.
Some ethanal is added to the test tube. Test tube placed in warm water.	A silver mirror is formed inside the test tube	Ethanal has been oxidised to ethanoic acid.
Experiment repeated with propanone.	No change	Ketones are not oxidised by Tollens' reagent, as it is a weak oxidising agent.

# Acidic Behaviour of Certain Organic Compounds

## Alcohol and Sodium reaction



Alcohol loses a  $\text{H}^+$  ion during the reaction as Na substitutes the H in the O-H bond. Therefore alcohol is acting as an acid.

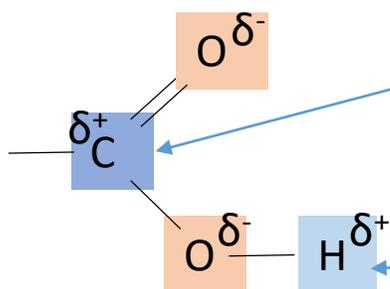
In general, alcohols are much weaker acids than water.



# Acidic Behaviour of Carboxylic acids

There are two reasons for carboxylic acids to be able to act as acids.

## a) Inductive Effect



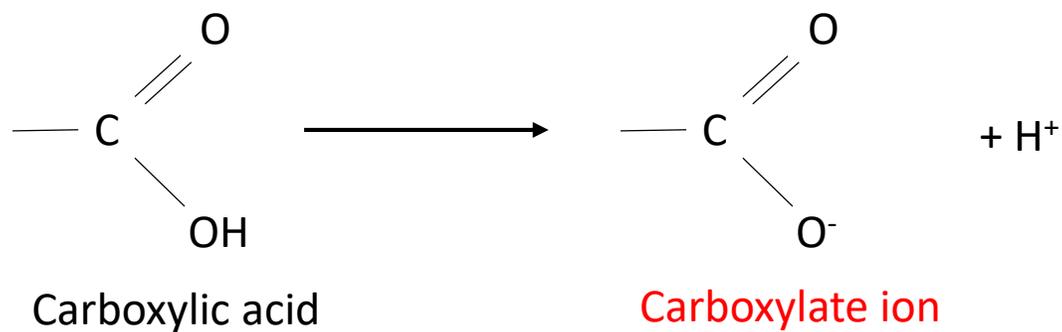
Carbon is slightly positive and so draws the electrons towards it from the oxygen in the O-H bond. This is called the **inductive effect**.

The **inductive effect** of the carbon facilitates the further polarisation of hydrogen in the O-H bond. The hydrogen is now easily removed giving  $H^+$  ions.

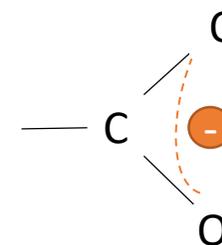
# Acidic Behaviour of Carboxylic acids

There are two reasons for carboxylic acids to be able to act as acids.

## b) Stability of carboxylate ion



## Resonance hybrid



Chemists have found that the bond lengths are actually intermediate in length. The negative charge is shared across the three atoms. The structure is called a resonance hybrid.

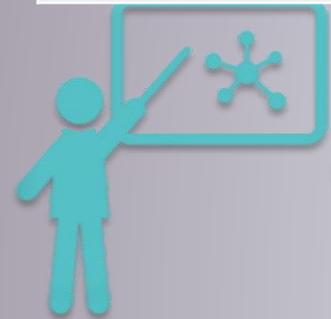
**The resonance hybrid gives extra stability.**



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# Reaction of ethanoic acid with sodium carbonate

Procedure	Observations	Explanation
Sodium carbonate powder and ethanoic acid are placed in a boiling tube.	Fizzing occurs	A gas is being produced
Test 1: Lighted taper is placed in mouth of tube.	Taper is extinguished.	The gas produced is carbon dioxide.
Test 2: Some of the gas produced is passed through limewater	Limewater turns milky.	



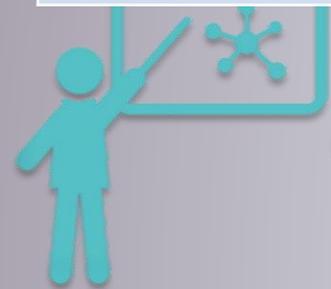
# Reaction of ethanoic acid with magnesium metal

Procedure	Observations	Explanation
Magnesium ribbon and ethanoic acid are placed in a boiling tube.	Fizzing occurs	A gas is being produced
Test: Lighted taper is placed in mouth of tube.	A 'pop' is heard	The gas produced is hydrogen.



# Reaction of ethanoic acid with ethanol

Procedure	Observations	Explanation
Ethanol and ethanoic acid are placed in a boiling tube.		
Three drops of sulphuric acid are added		Sulphuric acid acts as a catalyst
	No colour change.  Fruity smell from test tube	Ethanol and ethanoic acid undergo a condensation reaction to form ethyl ethanoate.  This is the cause of the fruity smell. There is no colour change as reactants and products are all colourless.



# Organic Synthesis

Organic synthesis is the process of making organic compounds from simpler starting materials.

**Target molecule** refers to the new molecule being made.

**Intermediate compounds** are new compounds formed before the final compound.



# Organic Chemistry Reaction Catalysts

Nickel (Ni) – hydrogenation / reduction

Aluminium oxide ( $\text{Al}_2\text{O}_3$ ) – elimination / dehydrogenation

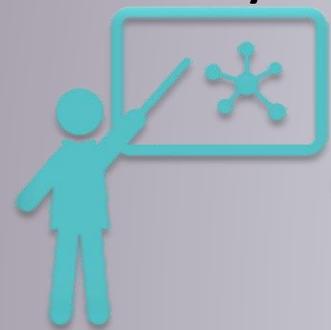
Acidified potassium permanganate ( $\text{KMnO}_4$ ) – oxidation

Sodium dichromate ( $\text{Na}_2\text{Cr}_2\text{O}_7$ ) – oxidation

Sodium hydroxide (NaOH) - base hydrolysis

Hydrogen ion ( $\text{H}^+$ ) – oxidation

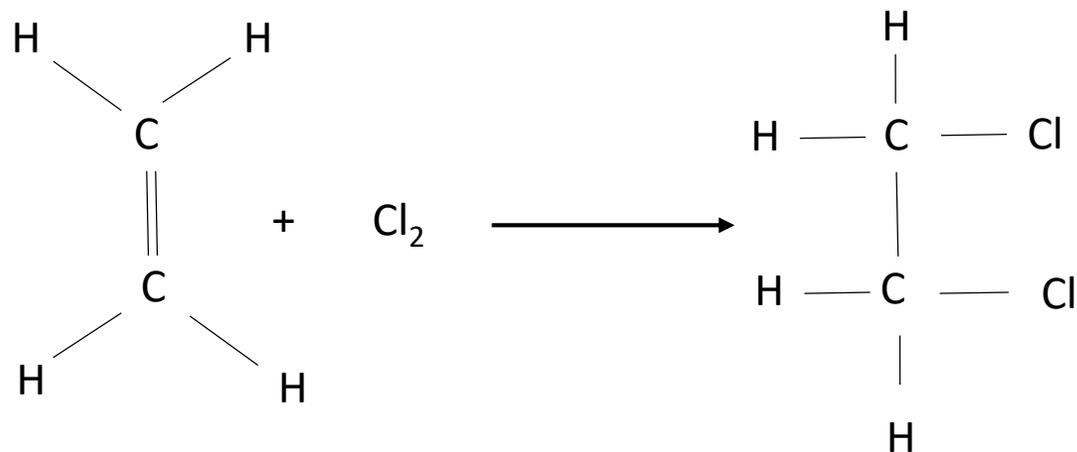
Hydrogen ( $\text{H}_2$ ) – reduction



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# Synthesis of PVC from Ethene

## Step 1: First intermediate formed



Ethene reacts with chlorine to form 1,2-dichloroethane, this is the first intermediate

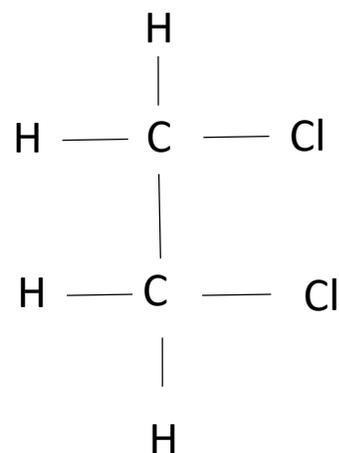


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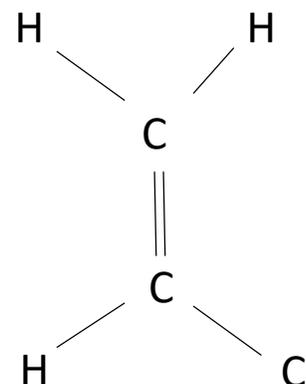
# Synthesis of PVC from Ethene

## Step 2: Cracking (formation of second intermediate)

1,2-dichloroethane



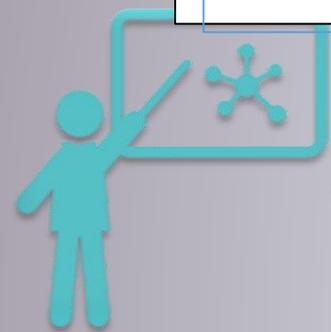
Chloroethene (vinyl chloride)



Hydrogen chloride

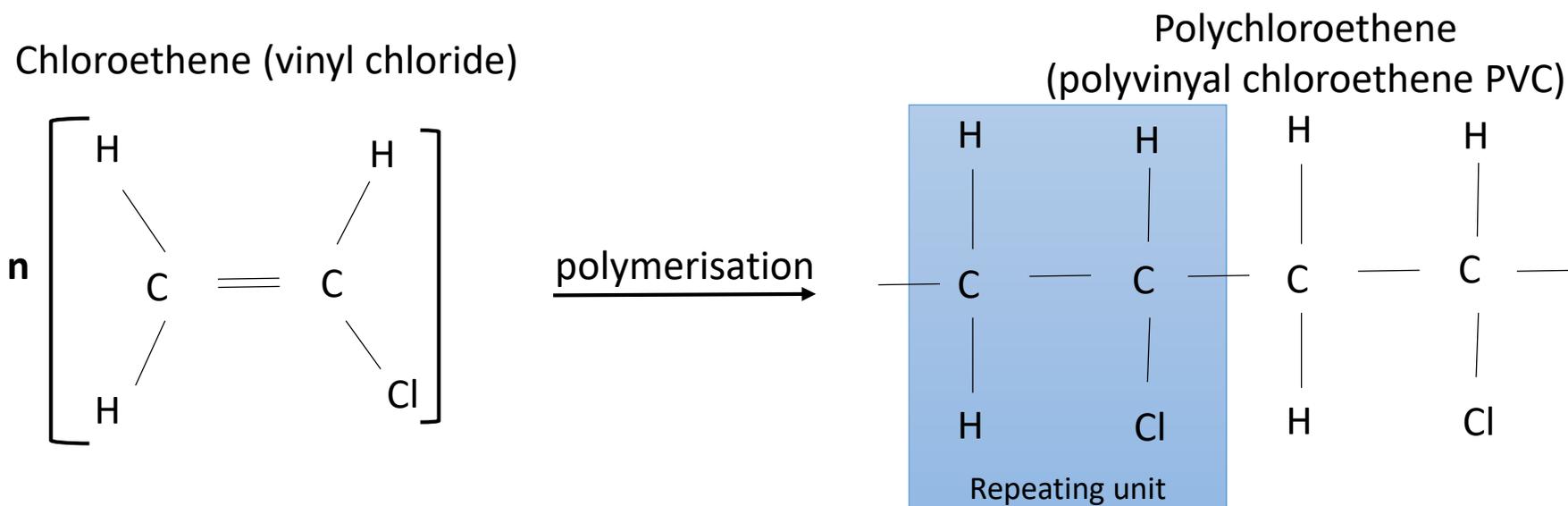


1,2-dichloroethane undergoes thermal cracking, eliminating HCl and producing chloroethene. Chloroethene is the second intermediate.



# Synthesis of PVC from Ethene

## Step 3: Polymerisation



Many chloroethene molecules join together in a polymerisation reaction to form poly(chloroethene).

Exp: Oxidise phenylmethanol (benzyl alcohol) to benzoic acid with potassium permanganate under alkaline conditions.



Procedure	Observations	Explanation
Phenylmethanol (benzyl alcohol), saturated solution of potassium permanganate are placed in a beaker.		Potassium permanganate is saturated to insure that it is in excess to that all the phenylmethanol is oxidized to benzoic acid.
Sodium carbonate is added and the mixture is heated in a water bath.	Purple colour changes to brown  Brown precipitate is formed	Mn <sup>+7</sup> ions (purple) have been reduced to Mn <sup>+2</sup> ions (brown)  MnO <sub>2</sub> (brown) is insoluble in water.



Procedure	Observations	Explanation
<p>Concentrated hydrochloric acid is added to the conical flask.</p>		<ol style="list-style-type: none"> <li>1. Sodium benzoate (intermediate compound) is formed during the reaction, hydrochloric acid converts it to benzoic acid.</li> <li>2. Hydrochloric acid neutralises any excess sodium carbonate.</li> <li>3. Hydrochloric acid provides an acidic medium for reduction of Mn ions (<math>\text{Mn}^{4+}</math> to <math>\text{Mn}^{2+}</math>)</li> </ol>
<p>Sodium sulfite is added to the flask</p>	<p>Brown precipitate disappears, white crystals become visible.</p>	<p>Sodium sulfite reduces Mn ions. Half reactions:</p> $\begin{array}{ccc} \text{Mn}^{4+} + 2\text{e}^- & \longrightarrow & \text{Mn}^{2+} \\ \text{Insoluble} & & \text{soluble} \end{array}$ $\text{SO}_3^{2-} + \text{H}_2\text{O} \longrightarrow \text{SO}_4^{2-} + 2\text{H}^+ + 2\text{e}^-$ <p>White crystals of benzoic acid become visible as brown precipitate is removed.</p>

Procedure	Observations	Explanation
Conical flask is placed in ice.		Benzoic acid has poor solubility in cold water. Maximises the yield.
White crystals are separated by filtration using Buchner funnel and flask.		Suction filtration is used to speed up the process and help dry the crystals.
Conical flask is washed out with the filtrate from the filtration.		Remove any benzoic acid crystals left in the conical flask.
Crystals are washed with ice-cold water		Removes any soluble impurities.
Mass of crystals formed is measured.		<b>Be able to perform a percentage yield calculation</b>

Exp: To recrystallise a sample of benzoic acid.

Recrystallise: is a process of repeated crystallisation in order to purify a solid or to obtain more satisfactory crystals of a solid that is already pure.



Procedure	Observations	Explanation
<b>Stage 1:</b> Benzoic acid crystals are dissolved in a minimum amount of boiling water		<p>This creates a saturated solution of benzoic acid, if too much water is used then the yield is reduced.</p> <p>Benzoic acid is highly soluble in boiling water and only slightly soluble in cold water.</p>
<b>Stage 2:</b> Hot filtration is used to separate any insoluble impurities.	The filtration equipment is hot (heated).	Hot filtration is used to insure the benzoic acid remains dissolved in the solution.
<b>Stage 3:</b> Filtered solution is allowed to cool to room temperature and the cooled with ice.		<p>Larger crystals will form when solutions cools slowly to room temperature.</p> <p>Using ice to cool after maximizes the yield.</p> <p>Soluble impurities will not crystallise as their concentration is too low.</p>



Procedure	Observations	Explanation
<b>Stage 4:</b> Benzoic acid crystals are separated by vacuum filtration		Suction filtration is used to speed up the process and help dry the crystals.
<b>Stage 5:</b> Filter paper containing the crystals is placed in a clock glass and allowed to air dry.  Mass of crystals is measured.		<b>Be able to complete percentage yield calculation.</b>



# Exp: To measure the melting point of benzoic acid

Pure Benzoic Acid	Impure Benzoic Acid
Melting point: 121-122°C	Melting point: 116-119°C (lower)
Melting point range is sharp only 1°C	Melts over a wider range (3°C)

Impure benzoic acid melts at a lower temperature and over a wider range of temperatures.



Procedure	Observations	Explanation
The end of a capillary tube is sealed by rotating it briefly in the blue flame of a Bunsen burner.		
The open end of the capillary tube is placed into the benzoic acid crystals to collect a sample.		
The capillary tube is placed in the aluminium melting-point block on a hot plate. The temperature is recorded with a digital thermometer.		Digital thermometer is used to give reading of at least one decimal place.



Procedure	Observations	Explanation
<p>When the crystals begin to melt the temperature is noted.</p> <p>When the crystals finish melting the temperature is noted.</p> <p>These two temperatures are the melting point range of the benzoic acid.</p>		



# Analytic Chemistry

Chromatography – is a separation technique where a mobile phase carrying a mixture moves in contact with a selectively absorbent stationary phase.

**Principle of Chromatography** – separation of a mixture into its components occurs as a result of selective absorbance of the components of the mixture on a stationary phase while being carried by a mobile phase.



# Exp: Separation of the components of ink using paper chromatography.

Procedure	Observations	Explanation
Cut a suitable length of chromatography paper. Mark a line 2cm from bottom in pencil.		Pencil will not be carried by the mobile phase (water)
Avoid holding paper with bare hands		Oils from hands can affect the results.
Place dots of the inks to be tested on the line.		



Procedure	Observations	Explanation
<p>Water is added to the jar (about 1cm)</p> <p>Paper is dipped in the water ensuring that the line is above the water.</p>	<p>As the solvent rises up the paper, the separation of colours is observed.</p>	<p>As the mobile phase rises each component of the ink is adsorbed to a different extent on the paper.</p>



# Gas Chromatography

The mobile phase is a gas in this process.

1. Sample is injected into the column
2. Sample is vapourised and carried by an unreactive gas (nitrogen) this is called the carrier gas
3. Components of the mixture are adsorbed to different extents in the stationary phase.
4. As each component leaves the column it is detected and recorded.



# Principle of gas chromatography

The principle of gas chromatography is that a gaseous mobile phase is in contact with a stationary phase (non-volatile liquid) and separation of the mixture occurs as a result of selective adsorption of the components of the mixture on the stationary phase.

Uses: Testing alcohol levels in blood or drug testing in athletes.



# High-Performance Liquid Chromatography

Mobile Phase: Liquid

Stationary Phase: Fine Silica Particles

1. Injection of sample
2. Pumping the sample along the column
3. Separation in the column
4. Detection of components
5. Display results



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# Principle of High-Performance Liquid Chromatography

The principle of HPLC is that a liquid mobile phase is in contact with a stationary phase (fine particles of a solid) and separation of the mixture occurs as a result of selective adsorbance of the mixture on the stationary phase.

Uses: Analysis of food



# Infra-Red Spectrometry

Wavelength: 0.001m - 0.000001m

It was found that organic compounds absorb light differently e.g. C=O absorbs differently to C-O.

1. Infra-red radiation is passed through sample
2. IR radiation of certain frequencies is absorbed
3. Absorption spectrum is obtained and can be used to identify the compound



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# Principle of IR Spectrometry

The principle of IR spectrometry is that organic compounds absorb infra-red radiation of certain frequencies. The combinations of frequencies that are absorbed depend on the bonding within the molecule and are unique to the particular molecule.

Uses: Identifying compounds



# Ultraviolet Spectrometry

Wavelength: 0.00000001m

1. A solution of the sample is placed between a source of UV light and a detector.
2. The detector measures the amount of light reaching it.
3. A UV spectrum is obtained.



# Principle of UV Spectrometry

The principle of UV Spectrometry is that absorbance is directly proportional to the concentration of a substance.

Uses: To detect functional groups and concentrations of substances.

