

17. Organic Chemistry II

A2 Organic naming

Basic definitions to know

Hydrocarbon is a compound consisting of hydrogen and carbon **only**

Saturated: Contain single carbon-carbon bonds only

Unsaturated : Contains a C=C double bond

Molecular formula: The formula which shows the actual **number of each type of atom**

Empirical formula: shows the simplest whole number ratio of atoms of each element in the compound

General formula: algebraic formula for a homologous series e.g. C_nH_{2n}

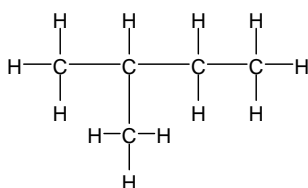
Displayed formula: shows all the covalent bonds present in a molecule

Homologous series are families of organic compounds with the **same functional group** and **same general formula**.

- They show a gradual change in physical properties (e.g. boiling point).
- Each member differs by CH_2 from the last.
- same chemical properties.

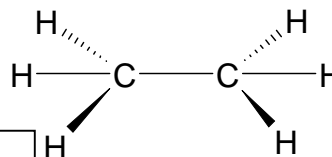
Functional group is an atom or group of atoms which when present in different molecules causes them to have similar chemical properties.

Drawing Displayed formulae



When drawing organic compounds add the hydrogen atoms so that each carbon has 4 bonds

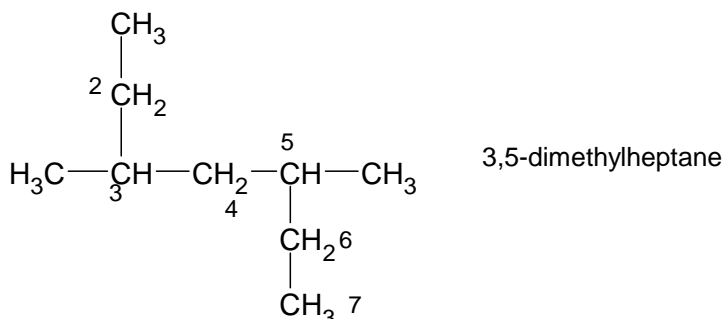
Remember that the shape around the carbon atom is tetrahedral and the bond angle is 109.5°



General rules for naming carbon chains

- Count the longest carbon chain and name appropriately
- Find any branched chains and count how many carbons they contain
- Add the appropriate prefix for each branch chain

Eg $-CH_3$ methyl or $-C_2H_5$ ethyl $-C_3H_7$ propyl



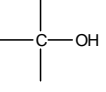
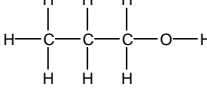
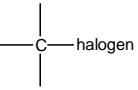
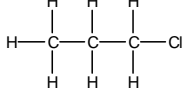

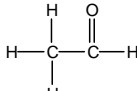

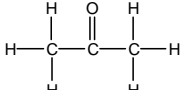
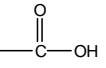
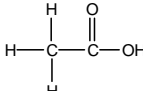
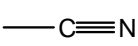
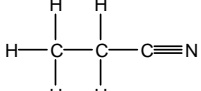
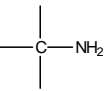
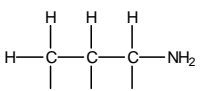
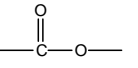
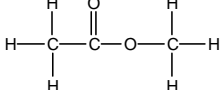
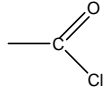
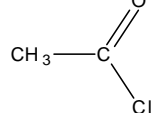
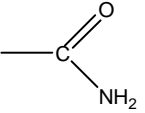
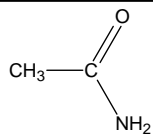


code	no of carbons
meth	1
eth	2
prop	3
but	4
pent	5
hex	6
hept	7
oct	8
non	9
dec	10

When compounds contain more than one functional group, the order of precedence determines which groups are named with prefix or suffix forms. The highest precedence group takes the suffix, with all others taking the prefix form. However, double and triple C-C bonds only take suffix form.

Order of priority highest first:

Carboxylic acids > carboxylic acid derivative > nitriles > aldehydes > ketones > alcohols > amines

homologous series	functional group	prefix / suffix (* = usual use)	example
alkenes		suffix -ene	 ethene
alcohols		suffix* -ol prefix hydroxy-	 Propan-1-ol
halogenoalkane		prefix chloro- bromo- iodo-	 1-chloropropane
aldehydes		suffix -al prefix formyl-	 ethanal
ketones		suffix* -one prefix oxo-	 Propanone
carboxylic acids		suffix -oic acid	 Ethanoic acid
nitriles		suffix -nitrile prefix cyano-	 Propanenitrile
amines		suffix* -amine prefix amino-	 Propylamine Or propan-1-amine
esters		-yl -oate	 Methyl ethanoate
Acyl chloride		-oyl chloride	 ethanoylchloride
Amide		-amide	 ethanamide

General rules for naming functional groups

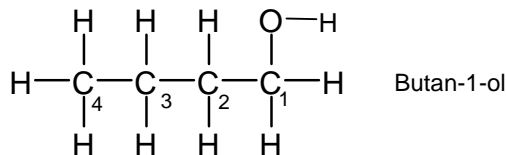
•The functional group is indicated by a prefix or suffix. e.g. *chloroethane*

•When using a suffix, add in the following way :

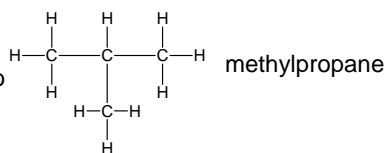
If the suffix starts with a vowel- remove the **-e** from the stem alkane name
e.g. Propan-1-ol, butan-1-amine, ethanoic acid, ethanoylchloride, butanamide

If the suffix starts with a consonant or there are two or more of a functional group meaning di, or tri needs to be used then **do not remove the -e** from the stem alkane name
e.g. Propanenitrile, ethane-1,2-diol, propanedioic acid, propane-1,2,3-triol, Pentane-2,4-dione.

•The position of the functional group on the carbon chain is given by a number – counting from the end of the molecule that gives the functional group the lowest number. For aldehydes, carboxylic acids & nitriles, the functional group is always on carbon 1.



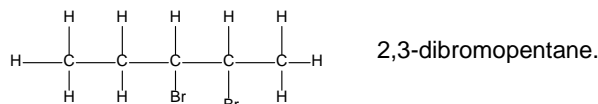
•We only include numbers, however, if they are needed to avoid ambiguity.



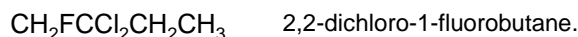
•The functional groups take precedence over branched chains in giving the lowest number

3-methylbut-1-ene is correct and not 2-methylbut-3-ene

•Where there are two or more of the same groups, *di-*, *tri-* or *tetra* are used. Note the point made above about the addition of 'e' to the stem



•Words are separated by numbers with dashes



• numbers are separated by commas



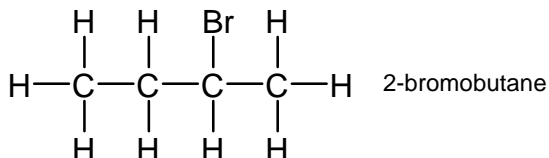
•If there is more than one functional group or side chain, the groups are listed in alphabetical order (ignoring any *di*, *tri*).



The suffix for alkenes can go in front of other suffixes.

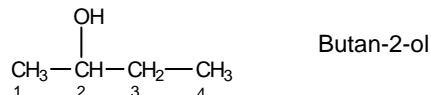
Halogenoalkanes

Class the halogen as a substituent on the C chain and use the suffix **-fluoro**, **-chloro**, **-bromo**, or **-iodo**. (Give the position number if necessary)

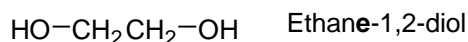
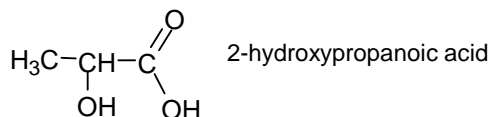


Alcohols

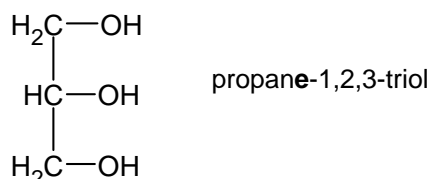
These have the ending **-ol** and if necessary the position number for the OH group is added between the name stem and the **-ol**



If the compound has an **-OH** group in addition to other functional groups that need a suffix ending then the OH can be named with the prefix **hydroxy-**:

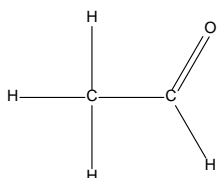


If there are two or more **-OH** groups then di, tri are used. Add the **'e'** on to the stem name though



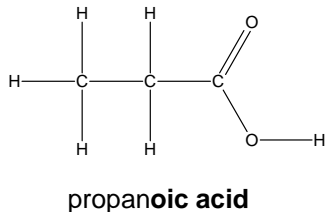
Aldehydes

An aldehyde's name ends in **-al**
It always has the C=O bond on the first carbon of the chain so it does not need an extra number. It is by default number one on the chain

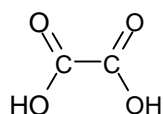


Carboxylic acids

These have the ending **-oic acid** but no number is necessary for the acid group as it must always be at the end of the chain. The numbering always starts from the carboxylic acid end



If there are carboxylic acid groups on both ends of the chain then it is called a -dioic acid



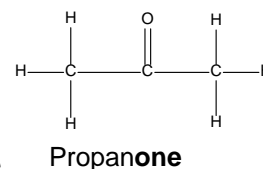
Ethanedioic acid

Note the **e** in this name

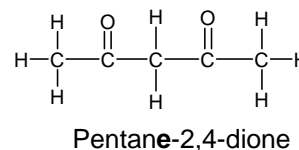
Ketones

Ketones end in **-one**

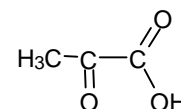
When ketones have 5C's or more in a chain then it needs a number to show the position of the double bond. E.g. pentan-2-one



If two ketone groups then **di** is put before **-one** and an **e** is added to the stem



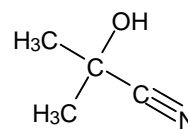
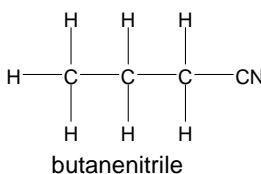
The prefix **oxo-** should be used for compounds that contain a ketone group in addition to a carboxylic acid or aldehyde



2-oxopropanoic acid

Nitriles

These end in **-nitrile**, but the C of the CN group counts as the first carbon of the chain. Note the stem of the name is different: butanenitrile and not butannitrile.



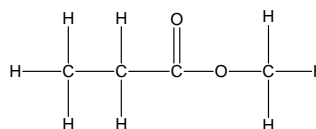
2-hydroxy-2-methylpropanenitrile

Carboxylic acid derivatives

Esters

Esters have two parts to their names

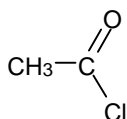
The bit ending in **-yl** comes from the alcohol that has formed it and is next to the single bonded oxygen.
The bit ending in **-anoate** comes from the carboxylic acid.
(This is the chain including the C=O bond)



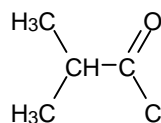
Methyl propanoate

Acyl Chlorides

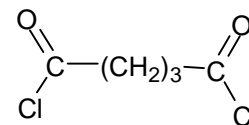
add **-oyl chloride** to the stem name



ethanoyl chloride



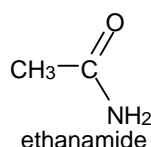
2-methylpropanoyl chloride



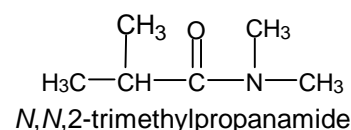
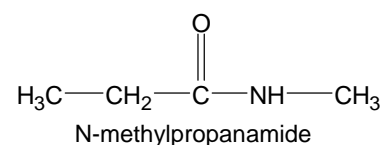
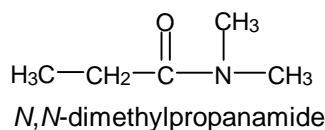
Pentanedioyl dichloride

Amides

Add **-amide** to the stem name



Secondary and tertiary amides are named differently to show the two (or three) carbon chains. The smaller alkyl group is preceded by an **-N** which plays the same role as a number in positioning a side alkyl chain



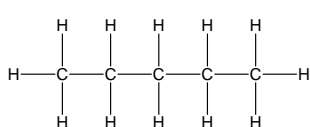
Isomers

Structural isomers: same molecular formula different structures (or structural formulae)

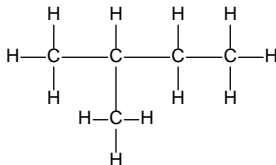
Structural isomerism can arise from

- Chain isomerism
- Position isomerism
- Functional group isomerism

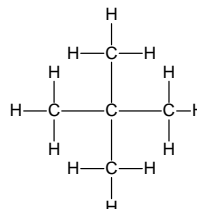
Chain isomers: Compounds with the same molecular formula but different structures of the carbon skeleton



pentane

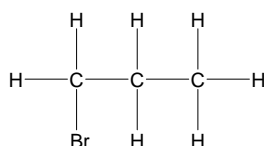


2-methylbutane

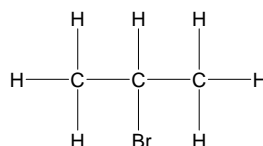


2,2-dimethylpropane

position isomers: Compounds with the same molecular formula but different structures due to different positions of the same functional group on the same carbon skeleton

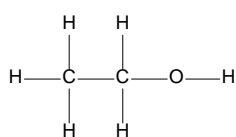


1-bromopropane

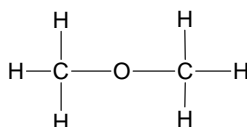


2-bromopropane

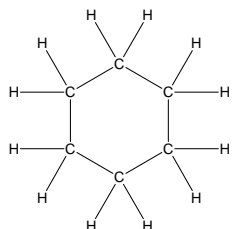
Functional group isomers: Compounds with the same molecular formula but with atoms arranged to give different functional groups



ethanol: an alcohol



Methoxymethane: an ether



Cyclohexane- cyclo alkane

$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}=\text{CH}_2$ hexene- alkene

Aldehydes and ketones of the same chain length would be classified as functional group isomers- e.g. Propanal and propanone (both $\text{C}_3\text{H}_6\text{O}$)

Stereoisomerism

Definition: Stereoisomers have the same structural formulae but have a different spatial arrangement of atoms

There are two types of **stereoisomerism**: geometrical (E- Z isomerism) and optical isomerism

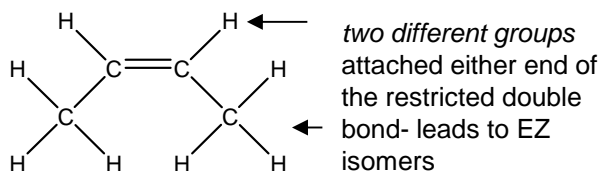
Alkenes can exhibit a type of isomerism called **E-Z stereoisomerism**

E-Z isomers exist due to restricted rotation about the $\text{C}=\text{C}$ bond

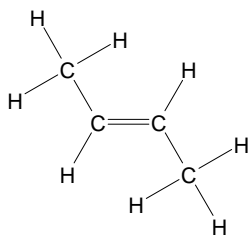
Single carbon-carbon covalent bonds can easily rotate

E-Z stereoisomers arise when:

- There is **restricted rotation** around the $\text{C}=\text{C}$ double bond.
- There are **two different groups/atoms** attached both ends of the restricted double bond

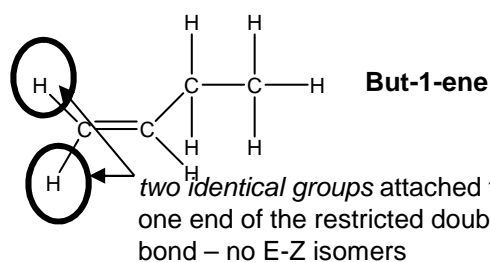


Z-but-2-ene



E-but-2-ene

These are two isomers as the lack of rotation around the double bonds means one cannot be switched to the other

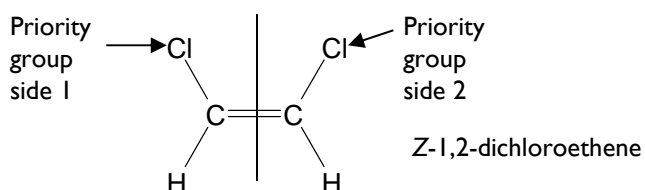


But-1-ene is a structural isomer of But-2-ene but does not show E-Z isomerism

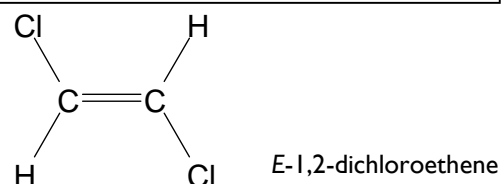
Naming E-Z stereoisomers

On both sides of the double bond determine the priority group

PRIORITY Group: The atom with the bigger A_r is classed as the priority atom



If the priority atom is on the same side of the double bond it is labelled Z from the german *zusammen* (The Zame Zide!)

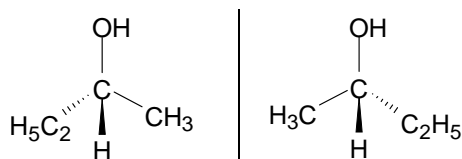


If the priority atom is on the opposite side of the double bond it is labelled E from the german *entgegen* (The Epposite side!)

17A Optical Isomerism

Optical isomerism occurs in carbon compounds with 4 different groups of atoms attached to a carbon (called an **asymmetric carbon**).

These four groups are arranged tetrahedrally around the carbon.



This causes two different isomers that are not superimposable to be formed. They are mirror images

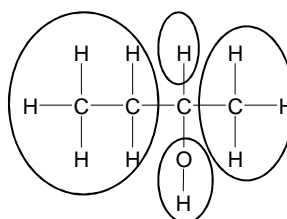
Two compounds that are optical isomers of each other are called **enantiomers**.

Optical isomers have similar physical and chemical properties, but they rotate plane polarised light in different directions.

One enantiomer rotates it in one direction and the other enantiomer rotates it by **the same amount in the opposite direction**.

One optical isomer will rotate light clockwise (+)(called dextrorotatory). The other will rotate it anticlockwise(-)(called laevorotatory).

A racemic mixture (a mixture of equal amounts of the two optical isomers) **will not rotate** plane-polarised light.

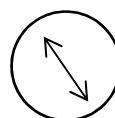


A carbon atom that has four different groups attached is called a **chiral** (asymmetric) carbon atom

A mixture containing a 50/50 mixture of the two isomers (enantiomers) is described as being a **racemate** or **racemic mixture**.

Many naturally occurring molecules contain chiral C atoms, but are usually found in nature as a pure enantiomer

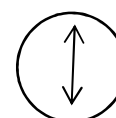
Different systems of nomenclature are in existence for optical isomers. D/L or +/- are commonly used, but both have been superseded by the more useful and informative R/S system (this is not on the syllabus – for information only).



-ve enantiomer
Anticlockwise
rotation



+ve enantiomer
clockwise
rotation



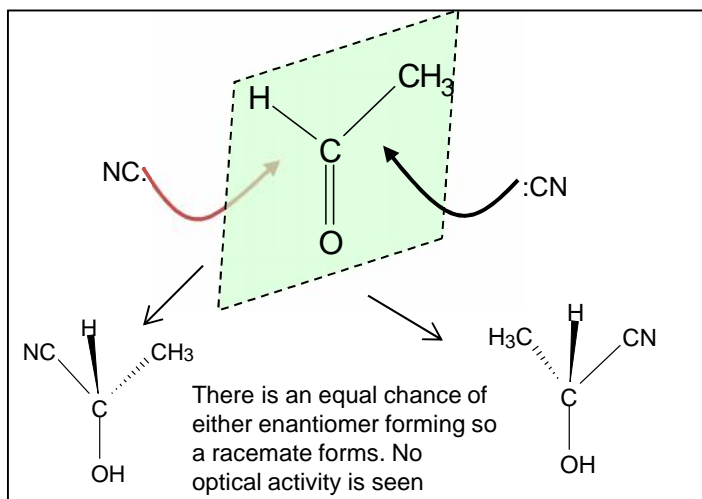
Racemate
no rotation

Chemical Reactions and Optical Isomers

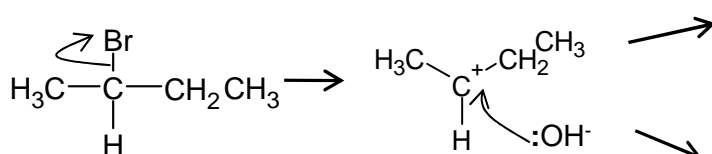
Formation of a racemate

A racemate will be formed in a reaction mechanism when a trigonal planar reactant or intermediate is approached from both sides by an attacking species

Nucleophilic addition of HCN to aldehydes and ketones (unsymmetrical) when the trigonal planar carbonyl is approached from both sides by the HCN attacking species: results in the formation of a racemate

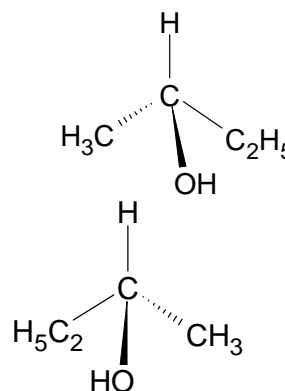


Formation of a racemate with S_N1 mechanism



The Br first breaks away from the haloalkane to form a planar carbocation intermediate

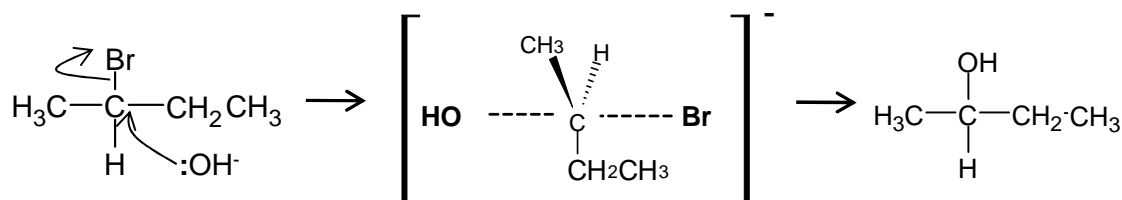
The OH^- ion can then attack from either side resulting in different enantiomers and a **racemate forms**



Because a racemate forms there will be no optical activity in the products

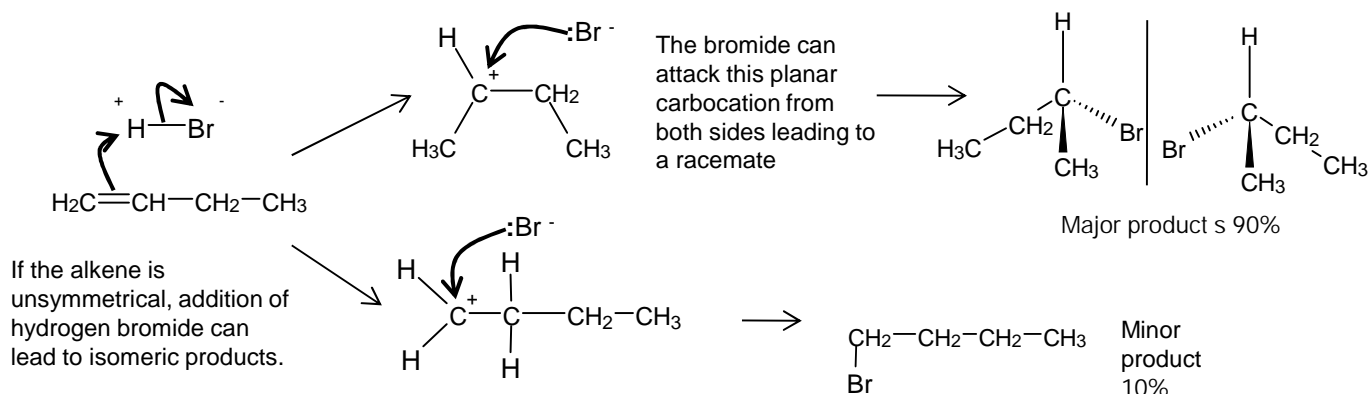
Comparison with S_N2 mechanism

In the S_N2 mechanism no intermediates are formed and the reaction occurs via a transition state.



If the reactant was chiral then during the reaction the **opposite enantiomer would form**. The product will rotate light in the opposite direction to the reactant

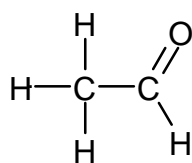
A racemate can also be formed in the A_S reaction of the electrophilic addition of HBr to an unsymmetrical alkene



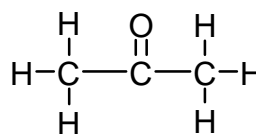
Compounds with C=O group

17B Carbonyls: Aldehydes and Ketones

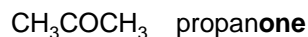
Carbonyls are compounds with a C=O bond. They can be either aldehydes or ketones



If the C=O is on the end of the chain with an H attached it is an aldehyde.
The name will end in **-al**

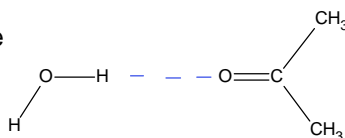


If the C=O is in the middle of the chain it is a ketone.
The name will end in **-one**



Solubility in water

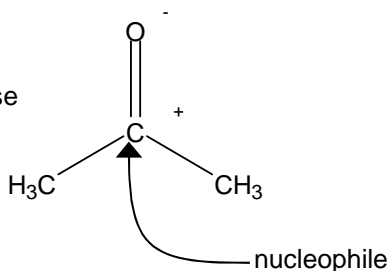
The smaller carbonyls are soluble in water because they can form hydrogen bonds with water.



Pure carbonyls cannot hydrogen bond, but bond instead by permanent dipole bonding.

Reactions of carbonyls

The C=O bond is polarised because O is more electronegative than carbon. The positive carbon atom attracts nucleophiles.



In comparison to the C=C bond in alkenes, the C=O is stronger and does not undergo addition reactions easily.

This is in contrast to the electrophiles that are attracted to the C=C.

Oxidation Reactions

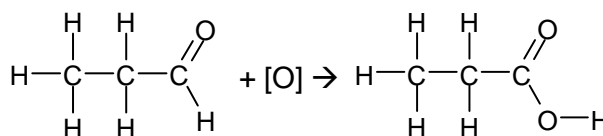
Potassium dichromate K₂Cr₂O₇ is an oxidising agent that causes alcohols and aldehydes to oxidise.

Primary alcohol → aldehydes → carboxylic acid
Secondary alcohol → ketones
Tertiary alcohols do not oxidise

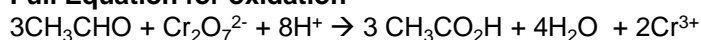
Key point: Aldehydes can be oxidised to carboxylic acids, but ketones cannot be oxidised.

Oxidation of Aldehydes

Reaction: aldehyde → carboxylic acid
Reagent: potassium dichromate (VI) solution and dilute sulphuric acid.
Conditions: heat under reflux



Full Equation for oxidation



Observation: the orange dichromate ion (Cr₂O₇²⁻) reduces to the green Cr³⁺ ion

Aldehydes can also be oxidised using Fehling's solution or Tollen's Reagent. These are used as tests for the presence of aldehyde groups

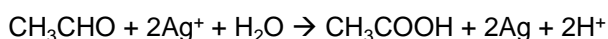
Tollen's Reagent

Reagent: Tollen's Reagent formed by mixing aqueous ammonia and silver nitrate. The active substance is the complex ion of [Ag(NH₃)₂]⁺.

Conditions: heat gently

Reaction: aldehydes only are oxidised by Tollen's reagent into a carboxylic acid and the silver(I) ions are reduced to silver atoms

Observation: with aldehydes, a silver mirror forms coating the inside of the test tube. Ketones result in no change.



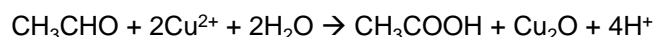
Fehling's solution

Reagent: Fehling's Solution containing blue Cu²⁺ ions.

Conditions: heat gently

Reaction: aldehydes only are oxidised by Fehling's Solution into a carboxylic acid and the copper ions are reduced to copper(I) oxide.

Observation: Aldehydes: Blue Cu²⁺ ions in solution change to a red precipitate of Cu₂O. Ketones do not react.



Reduction of carbonyls

Reagents: LiAlH₄ in dry ether

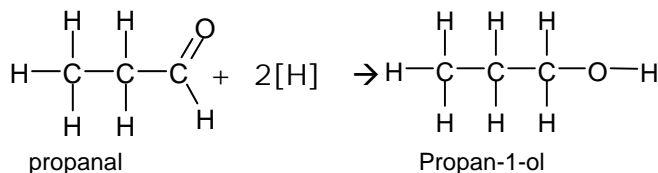
Conditions: Room temperature and pressure

Type of reaction: Reduction

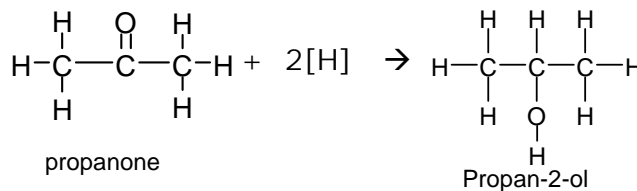
Role of reagent: Reducing agent

Reducing agents such as NaBH₄ (sodium tetrahydridoborate) or LiAlH₄ (lithium tetrahydridoaluminate) will reduce carbonyls to alcohols.

Aldehydes will be reduced to primary alcohols



Ketones will be reduced to secondary alcohols.



Addition of hydrogen cyanide to carbonyls to form hydroxynitriles

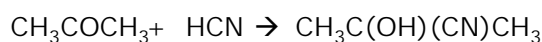
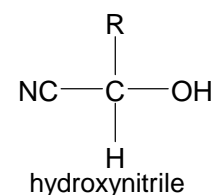
Reaction: carbonyl → hydroxynitrile

Reagent: HCN in presence of KCN

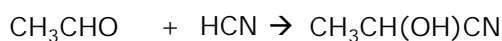
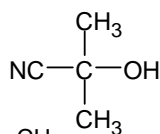
Conditions: Room temperature and pressure

Mechanism: nucleophilic addition

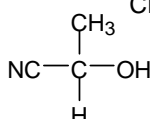
When naming hydroxynitriles the CN becomes part of the main chain



2-hydroxy-2-methylpropanenitrile

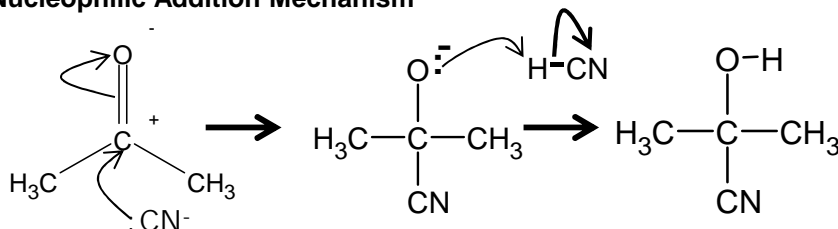


2-hydroxypropanenitrile



The extra KCN increases the concentration of the CN⁻ ion nucleophile needed for the first step of the mechanism

Nucleophilic Addition Mechanism



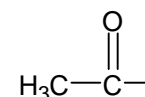
Reaction of carbonyls with iodine in presence of alkali

Reagents: Iodine and sodium hydroxide

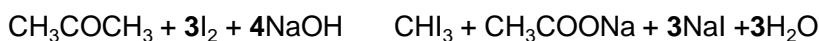
Conditions: warm very gently

The product CHI₃ is a yellow crystalline precipitate with an antiseptic smell

Only carbonyls with a methyl group next to the C=O bond will do this reaction. Ethanal is the only aldehyde that reacts. More commonly is methyl ketones.



This reaction is called the Iodoform test

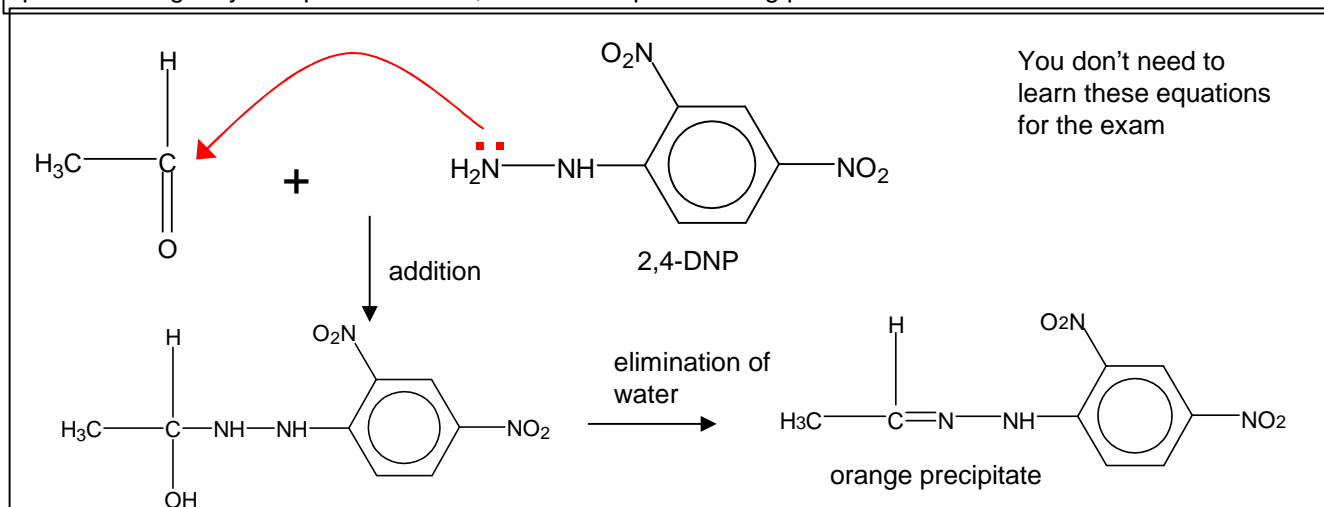


Reaction with 2,4-dinitro phenylhydrazine

2,4-DNP reacts with both aldehydes and ketones. The product is an orange precipitate, It can be used as a test for a carbonyl group in a compound.

Use 2,4-DNP to identify if the compound is a carbonyl. Then to differentiate an aldehyde from a ketone use Tollen's reagent.

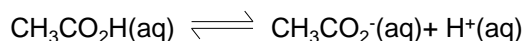
The melting point of the crystal formed can be used to help identify which carbonyl was used. Take the melting point of orange crystals product from 2,4-DNP. Compare melting point with known values in database



17C Carboxylic Acids

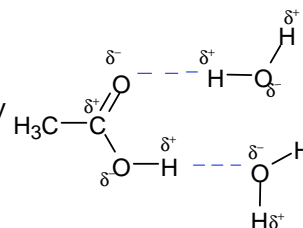
Acidity

The carboxylic acid are only weak acids in water and only slightly dissociate, but they are strong enough to displace carbon dioxide from carbonates.

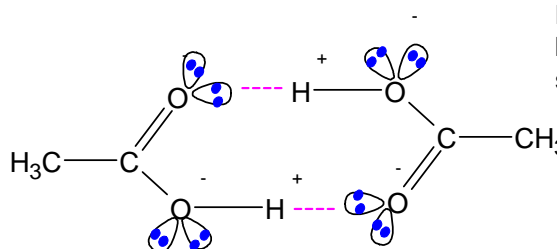


Solubility in Water

The smaller carboxylic (up to C4) acids dissolve in water in all proportions but after this the solubility rapidly reduces. They dissolve because they can hydrogen bond to the water molecules.



Hydrogen bonding in solid ethanoic acid



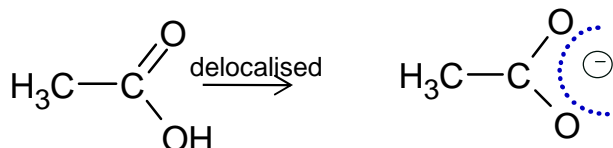
Hydrogen bonding between dimer in solid ethanoic acid

Solid Ethanoic appears to have Mr of 120

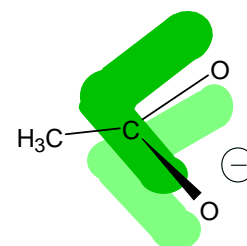
Delocalisation

The carboxylic acid salts are stabilised by delocalisation, which makes the dissociation more likely.

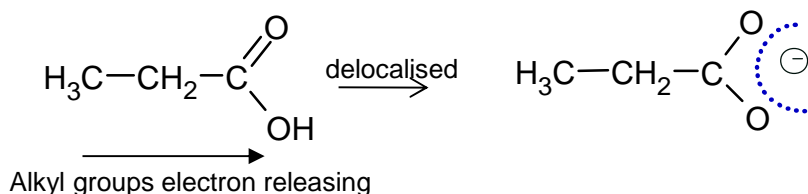
The delocalised ion has equal C-O bond lengths. If delocalisation did not occur, the C=O bond would be shorter than the C-O bond.



The pi charge cloud has delocalised and spread out. The delocalisation makes the ion more stable and therefore more likely to form.

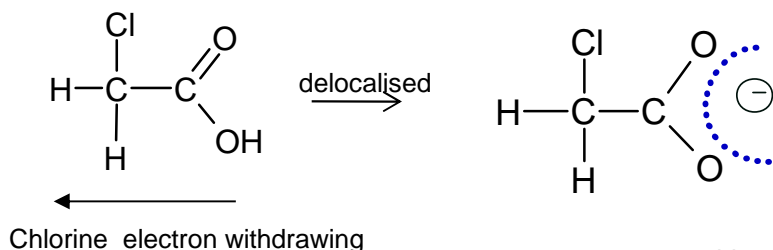


Strength of carboxylic acids



Increasing chain length pushes electron density on to the COO^- ion, making it more negative and less stable. This makes the acid less strong.

Propanoic acid less acidic than ethanoic acid



Electronegative chlorine atoms withdraw electron density from the COO^- ion, making it less negative and more stable. This makes the acid more strong.

chloroethanoic acid more acidic than ethanoic acid

Methods of preparing carboxylic acids

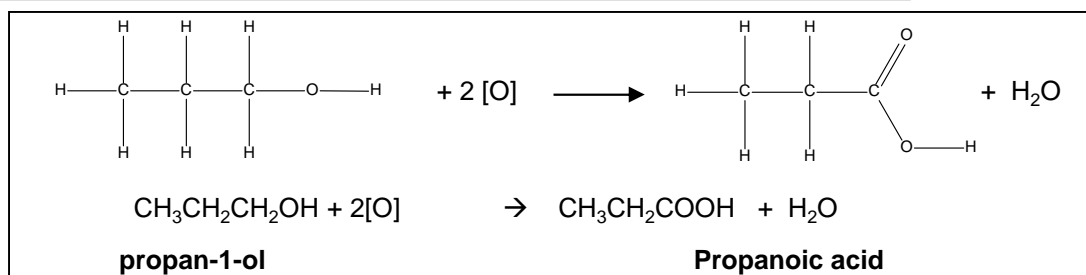
Full Oxidation of Primary Alcohols

Reaction: primary alcohol \rightarrow carboxylic acid

Reagent: potassium dichromate(VI) solution and dilute sulphuric acid

Conditions: use an excess of dichromate, and **heat under reflux**: (distill off product after the reaction has finished)

Observation: the orange dichromate ion ($\text{Cr}_2\text{O}_7^{2-}$) reduces to the green Cr^{3+} ion

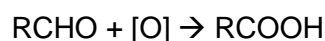
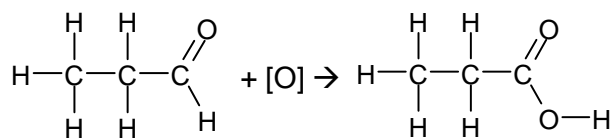


Oxidation of Aldehydes

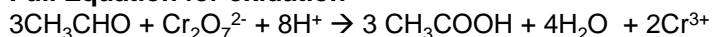
Reaction: aldehyde \rightarrow carboxylic acid

Reagent: potassium dichromate (VI) solution and dilute sulphuric acid.

Conditions: heat under reflux



Full Equation for oxidation

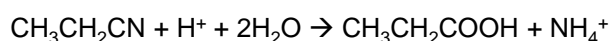


Hydrolysis of Nitriles

Reaction: Nitrile \rightarrow carboxylic acid

Reagent: dilute hydrochloric/ sulphuric acid.

Conditions: heat under reflux



The Reactions of Carboxylic Acids

Reduction of carboxylic acids to alcohols

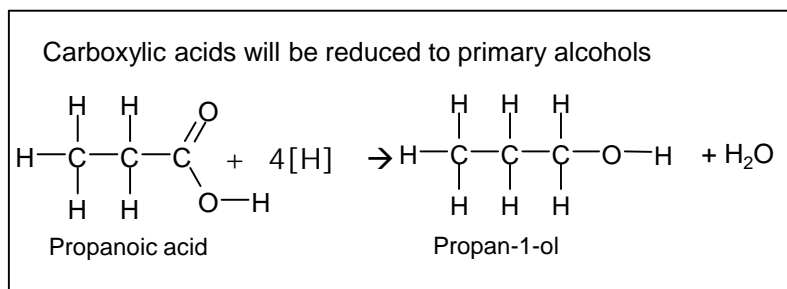
Lithium tetrahydridoaluminate (LiAlH_4) is a strong reducing agent

Reagents: LiAlH_4 In dry ether

Conditions: Room temperature and pressure

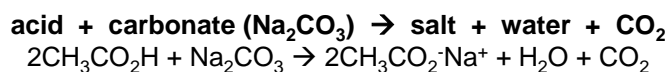
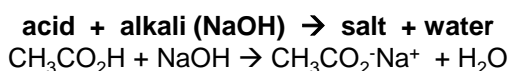
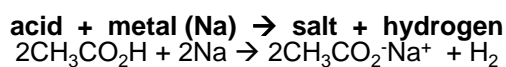
Type of reaction: Reduction

Role of reagent: Reducing agent



Salt formation reactions of carboxylic acids

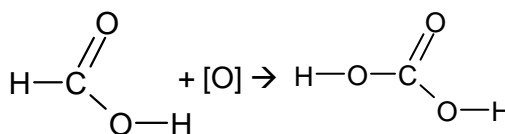
Carboxylic acids can form salts with metals, alkalis and carbonates.



The effervescence caused by production of CO_2 with carboxylic acids with solid Na_2CO_3 or aqueous NaHCO_3 can be used as a functional group test for carboxylic acids

Oxidation of methanoic acid

Carboxylic acids cannot be oxidised by using oxidising agents but methanoic acid is an exception as its structure has effectively an aldehyde group



It forms carbonic acid (H_2CO_3) which can decompose to give CO_2

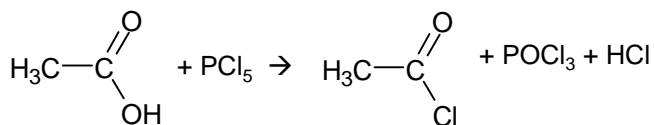
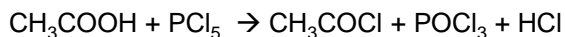
Reaction of carboxylic acid with phosphorous (V) chloride

Reaction: carboxylic acid → acyl chloride

Reagent: PCl_5 phosphorous(v)chloride

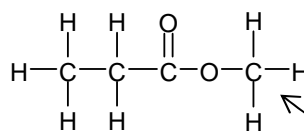
Conditions: room temp

This reaction with PCl_5 (phosphorous(v)chloride) can be used as a test for carboxylic acids. You would observe misty fumes of HCl produced.



Esterification

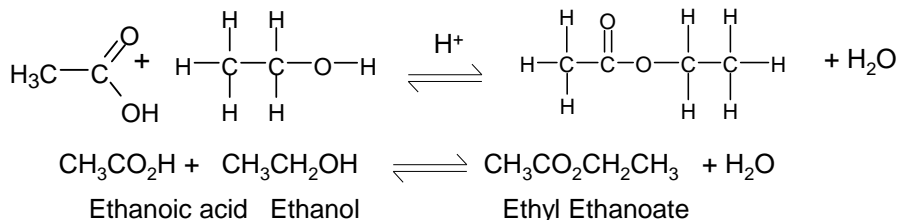
Carboxylic acids react with alcohols, in the presence of a strong acid catalyst, to form esters and water.



Esters have two parts to their names, eg **methyl** propanoate.

The bit ending in **-anoate** comes from the carboxylic acid and includes the C in the C=O bond.

The bit ending in **-yl** comes from the alcohol that has formed it and is next to the single bonded oxygen.



The reaction is reversible. The reaction is quite slow and needs heating under reflux, (often for several hours or days). Low yields (50% ish) are achieved. An acid catalyst (H_2SO_4) is needed.

Uses of Esters

Esters are sweet smelling compounds that can be used in **perfumes** and **flavourings**.

Esters can be used as **solvents** for polar organic substances

Ethyl ethanoate is used as a solvent in glues and printing inks

Esters can have pleasant smells

For use in perfumes they need to be non toxic, soluble in solvent such as ethanol, volatile (turns into gas easily), and not react with water.

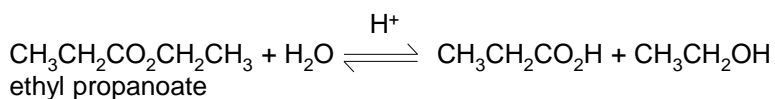
Although polar, they do not form hydrogen bonds (reason: there is no hydrogen bonded to a highly electronegative atom) thus, they have much lower b.p. than the hydrogen-bonded carboxylic acids they came from. They are also almost insoluble in water

Hydrolysis of esters

Esters can be hydrolysed and split up by either heating with acid or with sodium hydroxide.

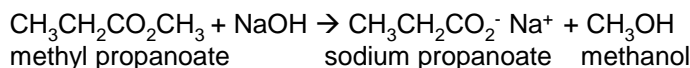
i) with acid
reagents: dilute acid (HCl)
conditions: heat under reflux

This reaction is the reverse reaction of ester formation. When an ester is hydrolysed a carboxylic acid and an alcohol are formed.



This reaction is reversible and does not give a good yield of the products.

ii) with sodium hydroxide
reagents: dilute sodium hydroxide
conditions: heat under reflux

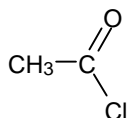


This reaction goes to completion.

The carboxylic acid salt product is the anion of the carboxylic acid. The anion is resistant to attack by weak nucleophiles such as alcohols, so the reaction is not reversible.

Carboxylic acid derivatives: Acyl Chlorides

Acyl Chlorides



ethanoyl chloride

Acyl chlorides are much more reactive than carboxylic acids

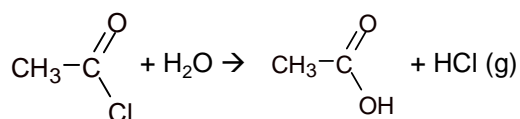
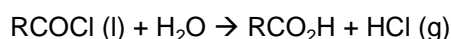
The Cl group is classed as a good leaving groups (to do with less effective delocalisation.) This makes acyl chlorides and acid anhydrides much more reactive than carboxylic acids and esters

Reaction with water

Change in functional group: **acyl chloride** → **carboxylic acid**

Reagent: **water**

Conditions: **room temp.**



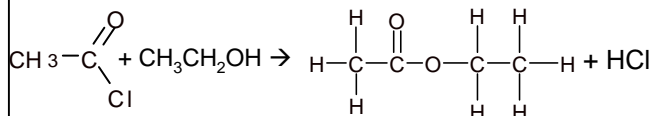
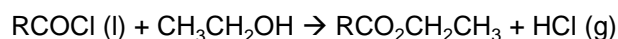
Observation: Steamy white fumes of HCl are given off

Reaction with alcohol

Change in functional group: **acyl chloride** → **ester**

Reagent: **alcohol**

Conditions: **room temp.**



Observation: Steamy white fumes of HCl are given off

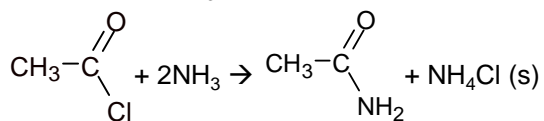
This reaction for making esters is much better than using carboxylic acids as the reaction is much quicker and it is not a reversible reaction

Reaction with ammonia

Change in functional group: **acyl chloride** → **primary amide**

Reagent: **ammonia**

Conditions: **room temp.**



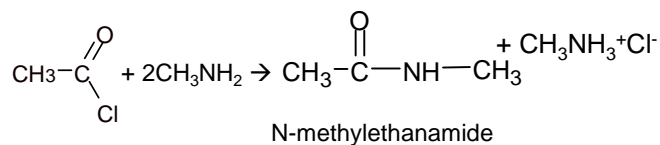
Observation: white smoke of NH_4Cl is given off

Reaction with primary amines

Change in functional group: **acyl chloride** → **secondary amide**

Reagent: **primary amine**

Conditions: **room temp.**



Polyesters

There are two **types** of polymerisation: **addition** and **condensation**

Condensation Polymerisation

The two most common **types** of condensation polymers are **polyesters** and **polyamides** which involve the formation of an **ester** linkage or an **amide** linkage.

In condensation polymerisation there are two different monomers that add together and a small molecule is usually given off as a side-product e.g. H₂O or HCl.

The monomers usually have the same functional group on both ends of the molecule e.g. di-amine, di carboxylic acid, diol, diacyl chloride.

Forming polyesters uses these reactions we met earlier in the course

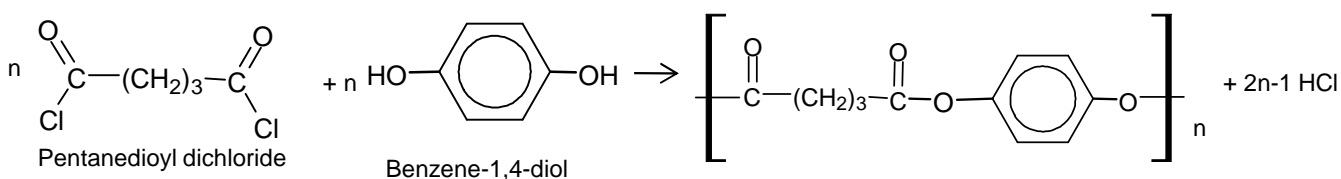
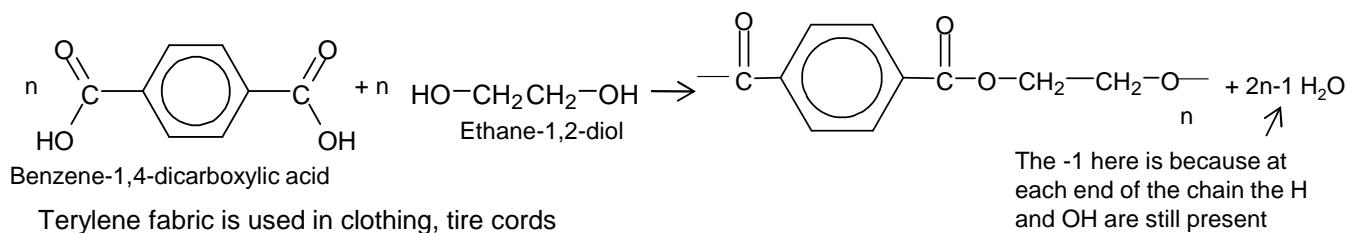


If we have the same functional group on each end of molecule we can make polymers so we have the analogous equations:

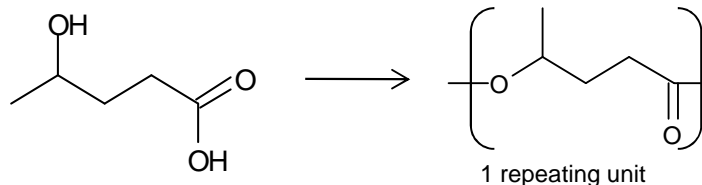
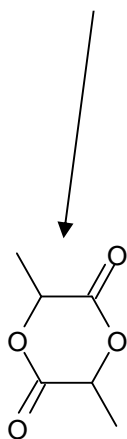
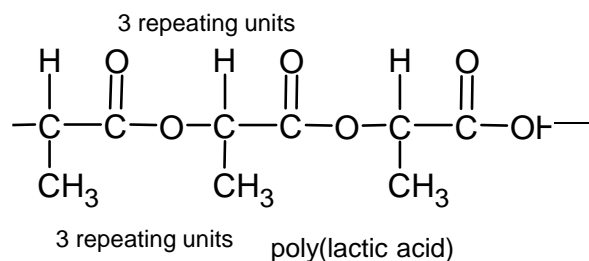
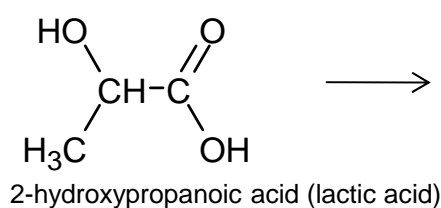


Using the carboxylic acid to make the ester or amide would need an acid catalyst and would only give an equilibrium mixture. The more reactive acyl chloride goes to completion and does not need a catalyst but does produce hazardous HCl fumes.

Terylene- a common polyester



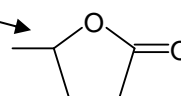
It is also possible for polyamides and polyesters to form from **one** monomer, if that monomer contains both the functional groups needed to react



4-hydroxypentanoic acid

It is possible for some of these compounds to form various cyclic esters under different conditions from forming the polymer.

You do not need to learn these but may be asked to deduce structures from information given



Chemical reactivity of condensation polymers

polyesters can be broken down by **hydrolysis** and are, therefore, biodegradable

The reactivity can be explained by the presence of **polar bonds** which can attract attacking species such as nucleophiles and acids

Polyesters can be hydrolysed by acid and alkali

With HCl a polyester will be hydrolysed and split up into the original dicarboxylic acid and diol

With NaOH an polyester will be hydrolysed and split up into the diol and dicarboxylic acid salt.