

3.7 Organic naming and Isomerism continued

See chapter 3.1 for basic naming of organic molecules. This chapter extends the naming for functional groups met in next few chapters

homologous series	functional group	prefix / suffix (* = usual use)	example
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	 methylethanoate
Acyl chloride		-oyl chloride	 ethanoylchloride
Amide		-amide	 ethanamide
Acid Anhydrides		-oic anhydride	 Ethanoic anhydride

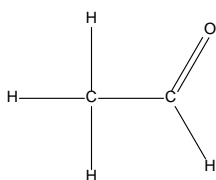
When compounds contain more than one functional group, the order of precedence determines which groups are named with prefix or suffix forms. The highest precedence group takes the suffix (and the lowest number on the carbon chain), with all others taking the prefix form. However, double and triple C-C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

Order of priority highest first:

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

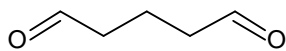
Aldehydes

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



Ethanal

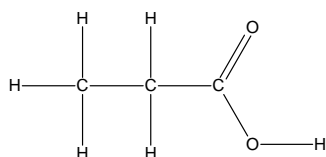
If two aldehyde groups then **di** is put before **-al** and an **e** is added to the stem.



pentanedial

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

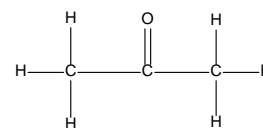


Propanoic acid

Ketones

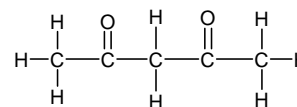
Ketones end in **-one**

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



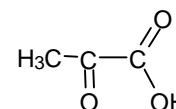
Propanone

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



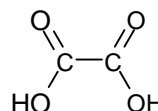
Pentane-2,4-dione

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



2-oxopropanoic acid

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

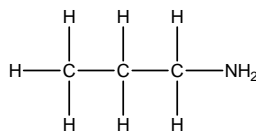
Amines

These end in **-amine**.

There is, however, rather confusingly two ways of using this suffix.

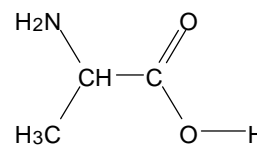
The exam board tend to use the common version where the name stem ends in **-yl** propylamine.

The IUPAC version of the same chemical is propan-1-amine. (This is used in the same way as naming alcohols)



propylamine
Or propan-1-amine

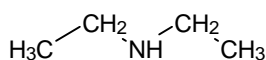
If there is another priority functional group as well as the amine group then the prefix **amino** is used.



2-aminopropanoic acid.

If the amine is secondary and has two alkyl groups attached to the nitrogen, then each chain is named and the smaller alkyl group is preceded by an **-N** which plays the same role as a number in positioning a side alkyl chain

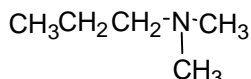
$\text{CH}_3\text{CH}_2\text{CH}_2\text{NHCH}_3$
N-methylpropylamine (common name)
N-methylpropan-1-amine (IUPAC name)



Diethylamine (common name- does not use N if chains are same length)
N-ethylethanamine (IUPAC name does still use N)

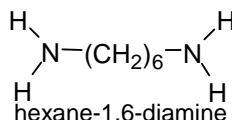
In the common naming version if the chain lengths are the same an **-N** is not used

If a tertiary amine similar rules apply, and each alkyl side group is given an N



N,N-dimethylpropylamine (common name)
N,N-dimethylpropan-1-amine (IUPAC name)

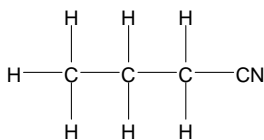
If there are two amine groups then name as following



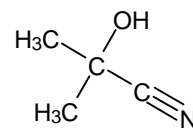
It could also be named
1,6-diaminohexane

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.



butanenitrile



2-hydroxy-2-methylpropanenitrile

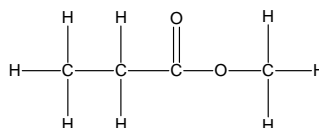
Carboxylic acid derivatives

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.

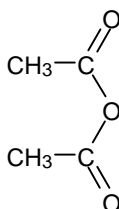
The bit ending in **-anoate** comes from the carboxylic acid. (This is the chain including the C=O bond)



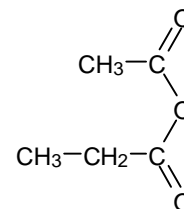
methylpropanoate

Acid Anhydrides

This is called **ethanoic anhydride**. It is ethanoic because it is two ethanoate groups joined together.

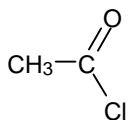


If the alkyl groups are of different lengths then each one is named e.g. ethanoic propanoic anhydride

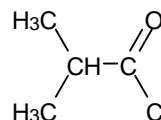


Acyl Chlorides

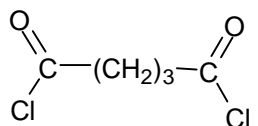
add **-oyl chloride** to the stem name



ethanoyl chloride



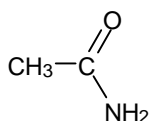
2-methylpropanoyl chloride



Pentanedioyl dichloride

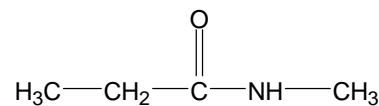
Amides

Add **-amide** to the stem name

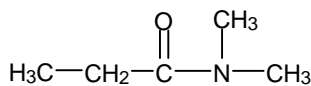


ethanamide

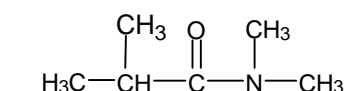
Secondary and tertiary amides are named differently to show the two (or three) carbon chains. The smaller alkyl group is preceded by an -N which plays the same role as a number in positioning a side alkyl chain



N-methylpropanamide



N,N-dimethylpropanamide



N,N,2-trimethylpropanamide

Isomers

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

See 3.1 for more on structural isomerism

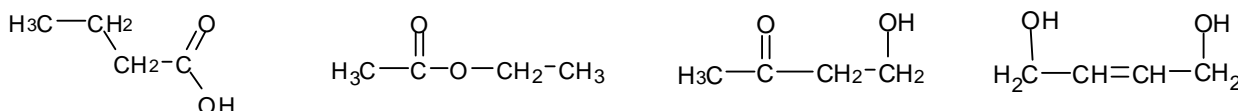
Structural isomerism can arise from

- Chain isomerism
- Position isomerism
- Functional group isomerism

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

Aldehydes and ketones of the same chain length would be classed as functional group isomers- e.g. Propanal and propanone (both C_3H_6O)

Questions often involve functional group isomers of carboxylic acids: including esters etc



Stereoisomerism

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

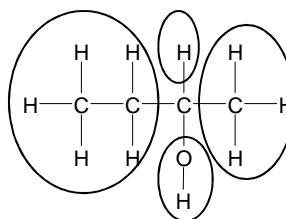
See 3.1 for EZ isomerism

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

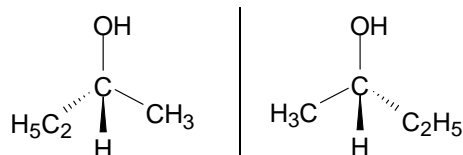
Optical Isomerism

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.



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



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

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

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

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

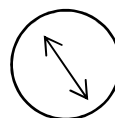
Optical isomers have similar physical and chemical properties, but they rotate plane polarised light in different directions.

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

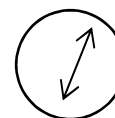
One optical isomer will rotate light clockwise (+)(called dextrorotatory). The other will rotate it anticlockwise(-)(called laevorotatory).

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

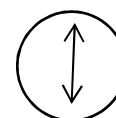
Different systems of nomenclature are in existence for optical isomers. D/L or +/- are commonly used, but both have been superseded by the more useful and informative R/S system (this is not on the syllabus – for information only).



-ve enantiomer
Anticlockwise
rotation



+ve enantiomer
clockwise
rotation

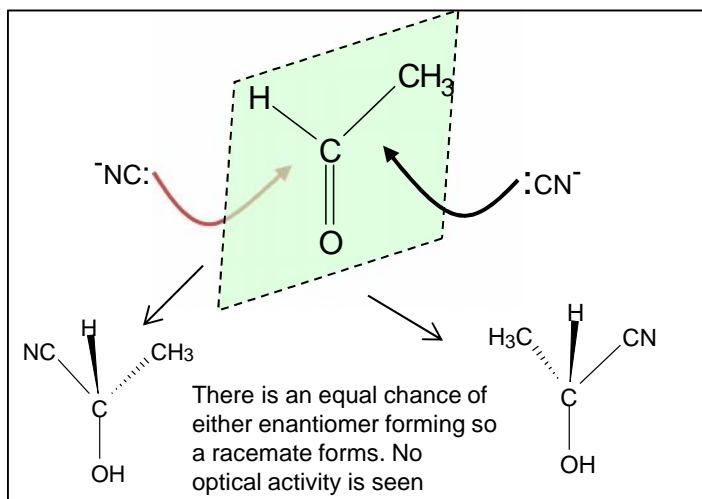


Racemate
no rotation

Chemical Reactions and Optical Isomers

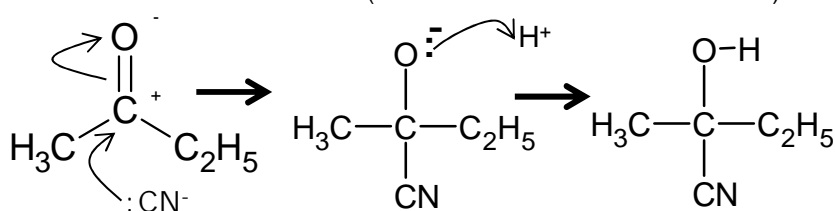
Formation of a racemate

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

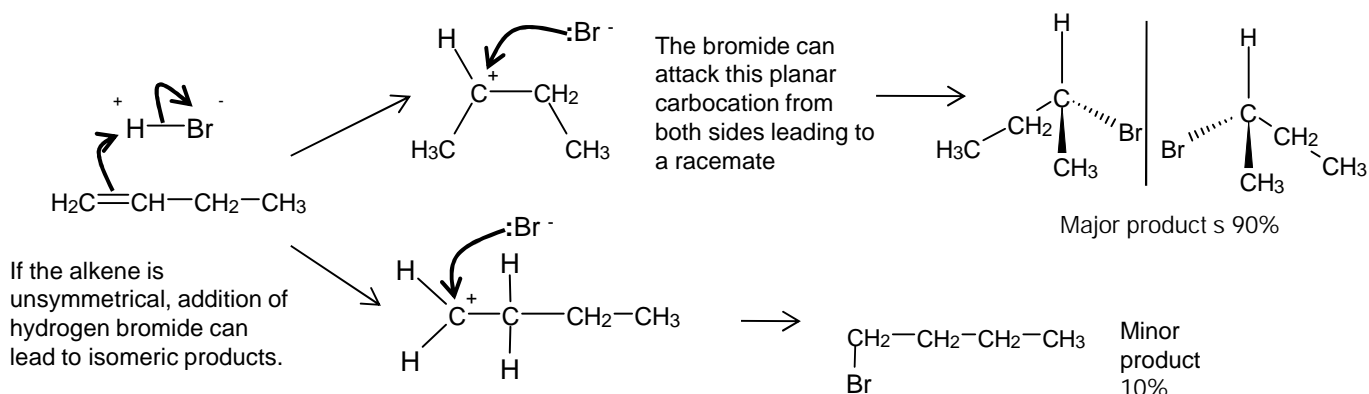


Nucleophilic addition of HCN to aldehydes and ketones (unsymmetrical) when the **trigonal planar carbonyl group** is approached from both sides by the HCN attacking species: results in the formation of a racemate

Mechanism for the reaction (drawn the same for both enantiomers)



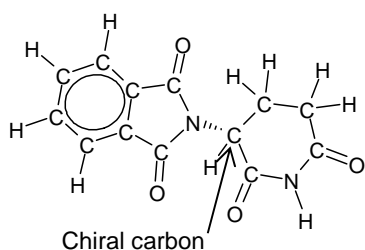
A racemate can also be formed in the AS reaction of the electrophilic addition of HBr to an unsymmetrical alkene



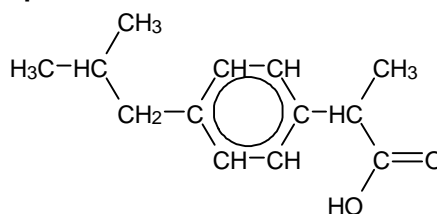
Drug action and optical isomers

Drug action may be determined by the stereochemistry of the molecule. Different optical isomers may have very different effects

Thalidomide



Ibuprofen



One enantiomer of thalidomide causes birth defects in unborn children whilst the other had useful sedative problems. Unfortunately it was given in a racemic mixture when first used.