

WJEC Chemistry A-level

4.1: Stereoisomerism

Detailed Notes

Welsh Specification

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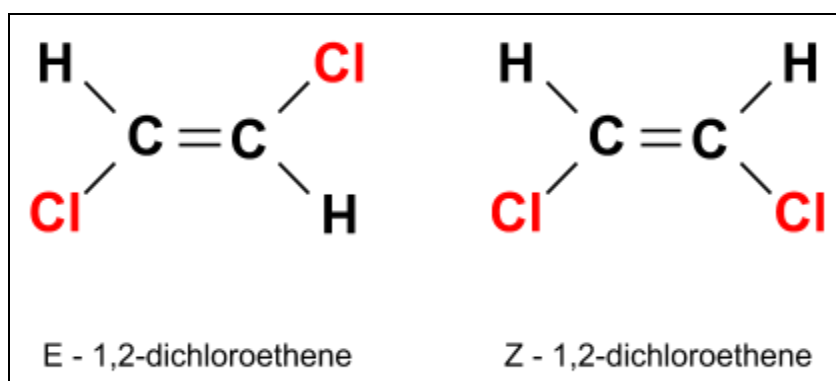
Stereoisomers

Stereoisomerism leads to molecules that have the **same molecular formula** but a **different spatial arrangement** of atoms. This **differs from structural isomerism** because the structural formula for stereoisomers is the same. There are two main types of stereoisomerism: **E-Z** isomerism and **optical** isomerism.

E-Z Isomerism

A type of stereoisomerism is E-Z isomerism, where **limited rotation** around a double carbon bond means that priority groups of the molecule can be on the **same side**, vertically across from each other, or on **opposite** sides, diagonally across from each other.

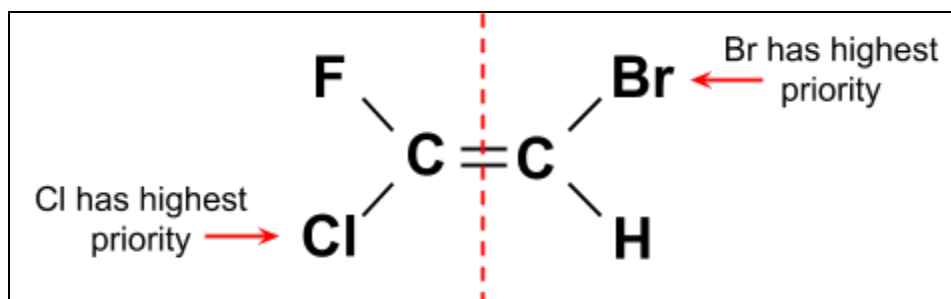
The **E isomer** (German for *entgegen* meaning apart) has these groups on opposite sides. The **Z isomer** (German for *zusammen* meaning together) has these groups together on the same side. Note, when talking about 'sides' in this context, it relates to the top and bottom - as shown below.



Cahn-Ingold-Prelog (CIP) Priority Rules

The different groups that can branch off from a carbon double bond have a series of **priorities** within E-Z isomerism. The **higher Ar or Mr** of the group, the **higher its priority**. The highest priority groups are then used to determine if it is the E or Z isomer.

Example:



Therefore, in this molecule, the highest priority groups are on opposite sides, meaning it is the E-isomer.





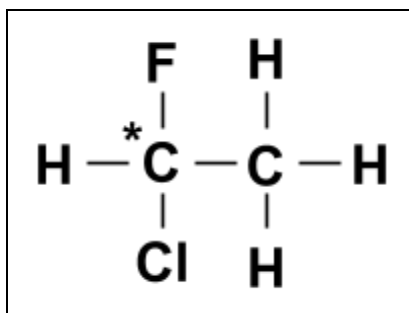
Optical Isomerism

This type of stereoisomerism, where molecules have the **same molecular formula** but a **different spatial arrangement** of atoms in space, occurs when there is an **asymmetrical carbon** within an organic molecule. This carbon atom is known as a **chiral centre** or **chiral carbon**.

Chiral Centres

A chiral centre is a carbon atom with **four different groups** bonded around it.

Example:

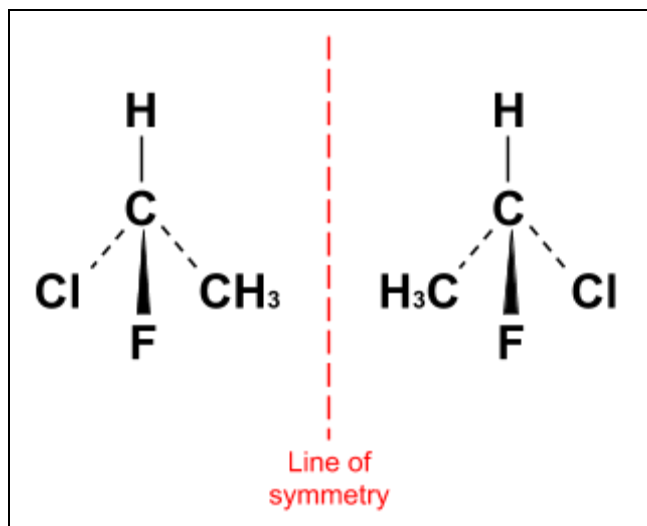


The chiral centre is commonly **indicated using *** next to the asymmetric carbon.

Optical Isomers

The presence of a chiral centre leads to the presence of **two possible isomers** that are **mirror images** of each other. These are optical isomers.

Example:



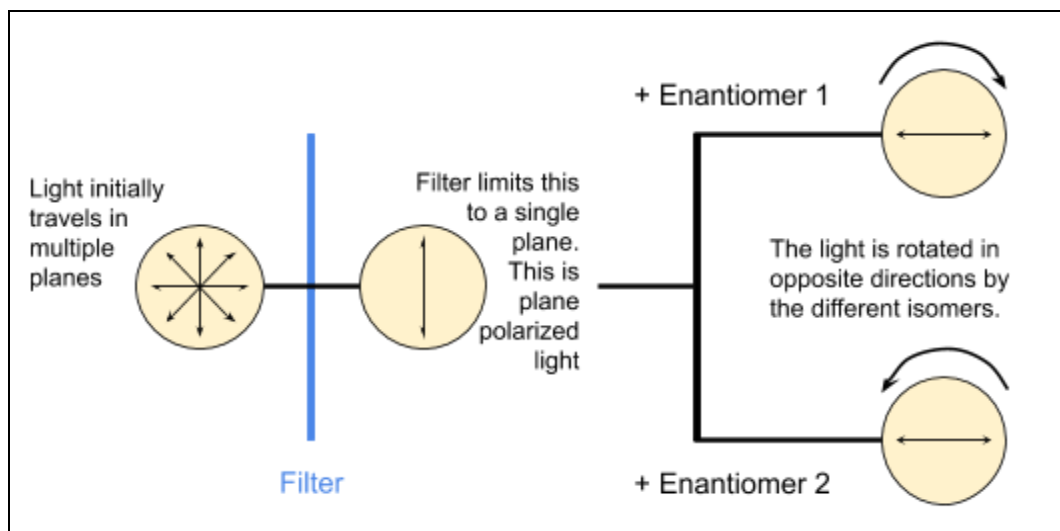
The two different isomers are called **enantiomers**.



Optical Activity

Optical isomers are **optically active** which means they can rotate **plane polarised light**.

Each enantiomer, from a pair of enantiomers, causes the rotation of plane polarised light by **90° in opposite directions**.



Racemic Mixtures

A **racemate** contains **equal quantities** of each enantiomer from an optically active compound. The optical rotational effect on polarised light caused by each enantiomer within the racemate cancels out, leading to the **overall effect being zero**. As a result, the mixture produced is **optically inactive**. The mixture is also known as a **racemic mixture**.

Racemic mixtures are often produced from **nucleophilic addition reactions**:

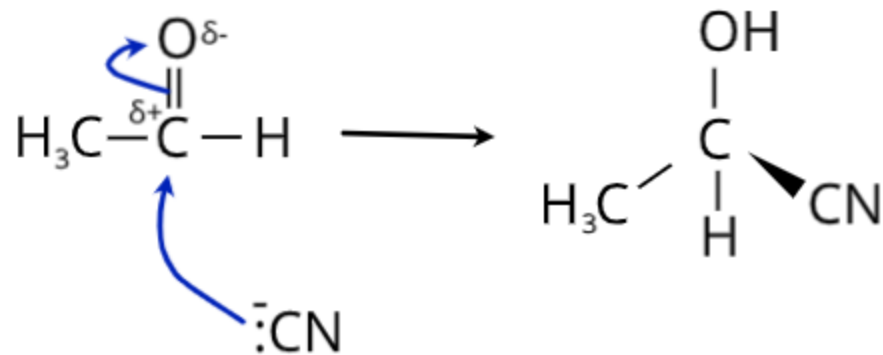
Nucleophilic Addition

Double bonds, such as C=O and C=C, are **planar**. In this reaction mechanism, the nucleophile can attack the **carbonyl group** in a molecule from **above or below** the **planar** carbon-oxygen double bond. If the carbon has different groups attached to it, then the two possible products of the reaction are **mirror images** and therefore, depending on the direction of attack from the nucleophile, one of the two different enantiomers will be produced. A **racemic mixture** will be produced as there's an **equal chance** of forming each of the enantiomers.





Mechanism - nucleophilic addition



OR

