AQA Chemistry A-level

3.3.1: Introduction to Organic Chemistry

Detailed Notes

3.3.1.1 - Nomenclature

There are different way of writing and representing organic compounds:

1. **Empirical Formula**
   - The simplest whole number ratio of atoms of each element in a compound.

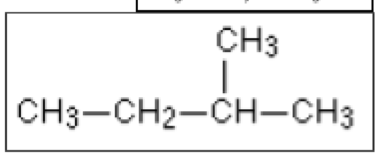
2. **Molecular Formula**
   - The true number of atoms of each element in a compound.

3. **General Formula**
   - All members of a homologous organic series follow the general formula.
   Example:

$$\text{Alkanes} = C_nH_{2n+2}$$

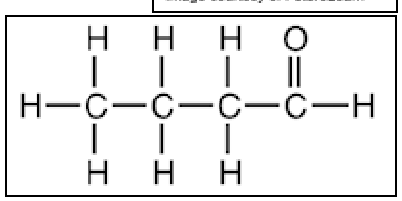
4. **Structural Formula**
   - Shows the structural arrangement of atoms within a molecule.
   Example:

Image courtesy of Chemguide

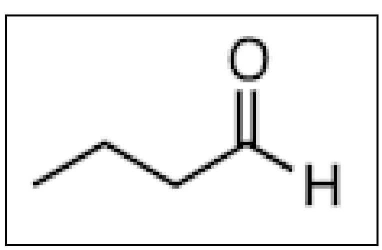


5. **Displayed Formula**
   - Shows every atom and every bond in an organic compound.
   Example:

Image courtesy of FutureLearn



6. **Skeletal Formula**
   - Shows only the bonds in a compound and any non-carbon atoms.
   - Vertices are carbon atoms.
   - Hydrogen is assumed to be bonded to them unless stated otherwise.
   Example:



Homologous Series

Organic compounds are often part of a **homologous series**, in which all members follow a **general formula** and react in a very similar way. Each consecutive member **differs by CH_2** and there is an **increase in boiling points** as chain length increases.

Example:

Image courtesy of DP Chemistry

TABLE 25.1 First Several Members of the Straight-Chain Alkane Series

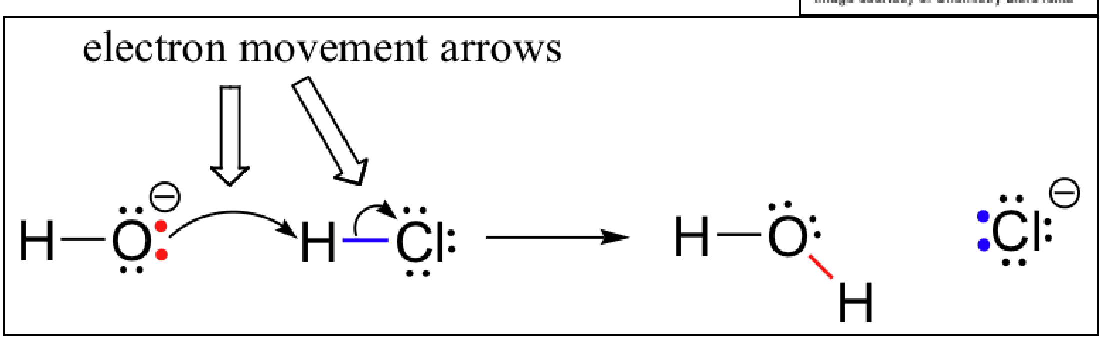
Molecular Formula	Condensed Structural Formula	Name	Boiling Point (°C)
CH_4	CH_4	Methane	-161
C_2H_6	CH_3CH_3	Ethane	-89
C_3H_8	$CH_3CH_2CH_3$	Propane	-44
C_4H_{10}	$CH_3CH_2CH_2CH_3$	Butane	-0.5
C_5H_{12}	$CH_3CH_2CH_2CH_2CH_3$	Pentane	36
C_6H_{14}	$CH_3CH_2CH_2CH_2CH_2CH_3$	Hexane	68
C_7H_{16}	$CH_3CH_2CH_2CH_2CH_2CH_2CH_3$	Heptane	98
C_8H_{18}	$CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_3$	Octane	125
C_9H_{20}	$CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_3$	Nonane	151
$C_{10}H_{22}$	$CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_3$	Decane	174

3.3.1.2 - Reaction Mechanisms

These show the **movement of electrons** within a reaction, shown with **curly arrows**.

Example:

Image courtesy of Chemistry LibreTexts



Mechanisms are used to show the reactions of organic compounds.

3.3.1.3 - Isomerism

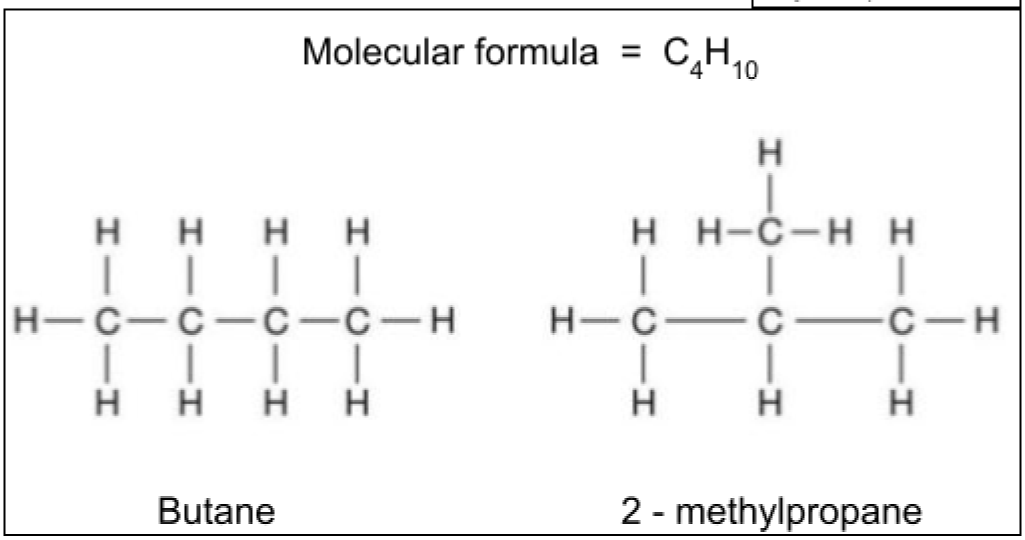
Isomers are molecules with the **same molecular formula** but a **different arrangement** of atoms within the molecule.

Structural Isomers

These have a **different structural arrangement** of atoms. They can be **straight** chains or **branched** chains but will have the same molecular formula.

Example:

Image courtesy of SlideShare

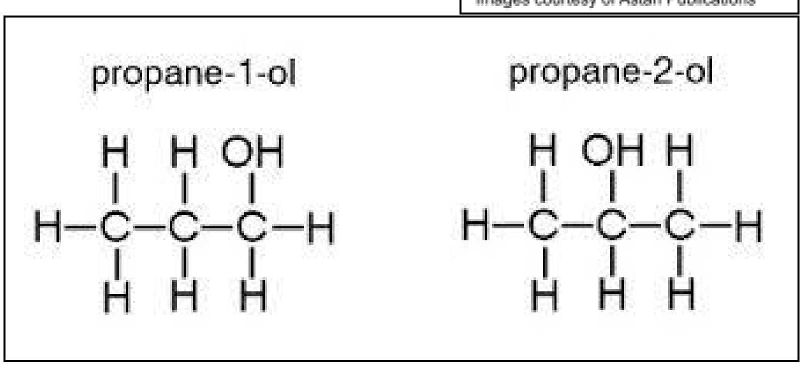


Position Isomers

These have the **functional group** of the molecule in a **different position** of the carbon chain.

Example:

Images courtesy of Astan Publications

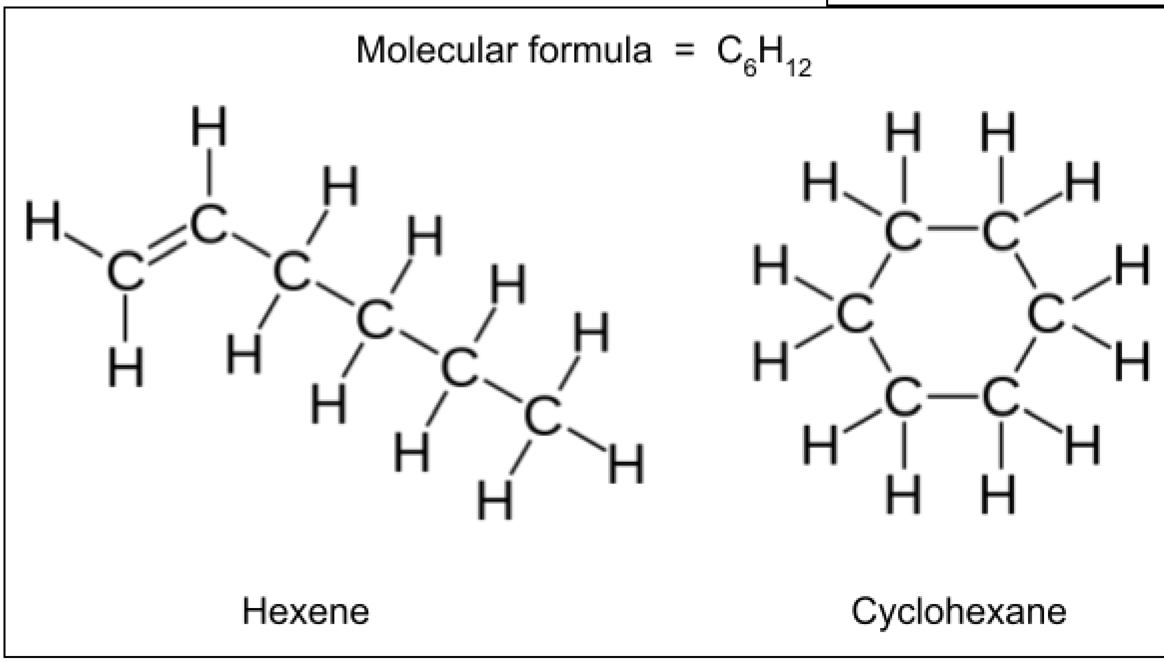


Functional Group Isomers

These have a different arrangement of the same molecular formula so that the molecule has a **different functional group**.

Example:

Image courtesy of Wikimedia Commons

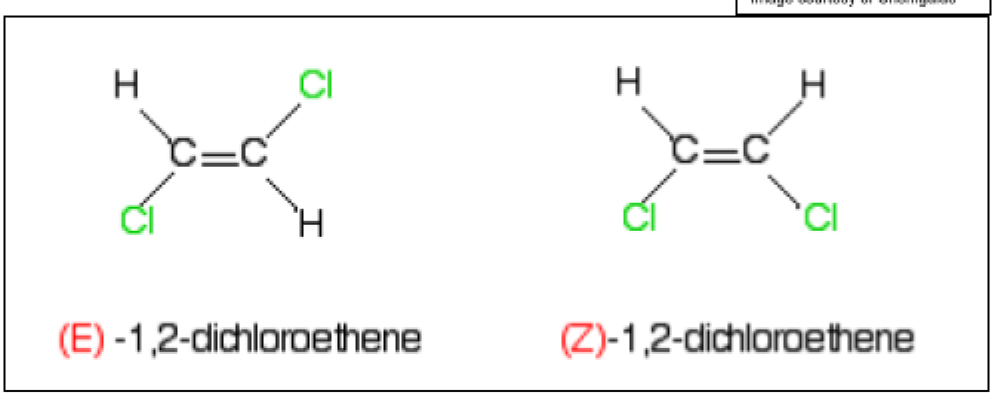


Stereoisomers

These have a **different spatial arrangement**. A type of stereoisomerism is **E-Z isomerism**, where **limited rotation** around a double carbon bond means that functional groups can either be 'together' or 'apart'. The ***E*** isomer (german for entgegen meaning apart) has functional groups **on opposite sides.** The ***Z*** isomer (german for zusammen meaning together) has functional groups **together** on the same side of the double bond.

Example:

Image courtesy of Chemguide

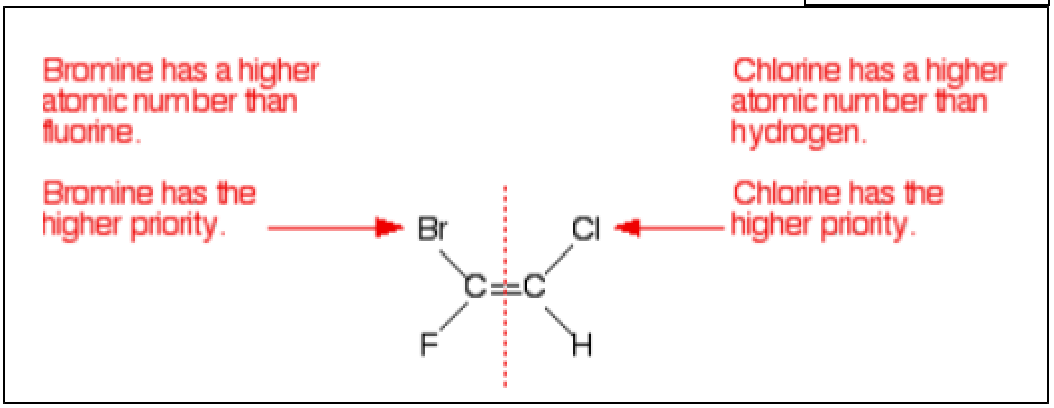


Cahn-Ingold-Prelog (CIP) Priority Rules

There is a **priority of different groups** in molecules that can display E-Z isomerism. The first atom which is directly bonded to the carbon with the double bond with the **higher atomic number** is given the **higher priority**. These groups are used to determine if it is the E or Z isomer.

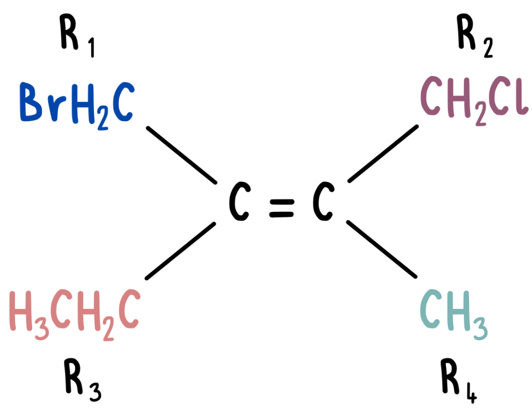
Example:

Image courtesy of Chemguide



Therefore this molecule is the Z isomer as the highest priority atoms are on the same side.

<u>How to determine a more complicated E/Z isomers</u>



Compound A

- **Step 1: Apply the CIP priority rules**
  - Look at R1 and R3:
    - Carbon is the **first atom** attached to the C=C bond, on the left hand side
  - Look at R2 and R4:
    - Carbon is the first atom attached to the C=C bond, on the right hand side
  - This means that we cannot deduce if compound A is an *E* or *Z* isomer by applying the CIP priority rules to the first atom attached to the C=C bond
    - Therefore, we now have to look at the **second atoms** attached

- **Step 2: Apply the CIP priority rules (using the second atoms)**
  - Look again at R1 and R3:
    - The second atoms attached to R1 are **hydrogens** and **bromine**
    - The second atoms attached to R3 are **hydrogens** and another **carbon**
    - We can ignore the hydrogens as both R groups have hydrogens
    - Bromine has a **higher atomic number** than carbon, so bromine is the **higher priority**
      - Therefore, the CH_2Br group has priority over the CH_3CH_2 group
  - Look again at R2 and R4:
    - The second atoms attached to R2 are **hydrogens** and **chlorine**
    - The second atoms attached to R4 are **hydrogens**
    - Chlorine has a **higher atomic number** than hydrogen, so chlorine is the **higher priority**
      - Therefore, the CH_2Cl group has priority over the CH_3 group

- **Step 3: Deduce *E* or *Z***
  - In compound A, the two highest priority groups are on the **same side** (both above) the C=C bond
    - Therefore, compound A is the ***Z* isomer**