ISOMERISM

Can be of two types :

1. Structural isomers
   a. Chain isomers
   b. Positional isomers
   c. Functional group isomers
2. Stereoisomers
   a. Geometrical isomers (cis - trans)
   b. Optical isomers

Q. What are structural isomers?
Compounds with the same molecular formula but a different structural formula.

CHAIN ISOMERS (STRUCTURAL)

↳ Isomers with the same molecular formula but the difference arises in the length of the carbon skeleton
↳ longest continuous chain

- This occurs when there are 4 or more carbons in the molecule

Example :

$\overset{1}{CH_3}-\overset{2}{CH_2}-\overset{3}{CH_2}-\overset{4}{CH_3}$ ⇒ butane

$\overset{1}{CH_3}-\overset{2}{CH}(\overset{4}{CH_3})-\overset{3}{CH_3}$ ⇒ 2-methyl propane

Hence, 2-methylpropane is a straight chain isomer of butane

POSITIONAL ISOMERS (STRUCTURAL)

↳ is exhibited by compounds in the same homologous series having the same molecular formula, but they differ in the position of the functional group.

- Note : The carbon skeleton / longest chain remains the same

Examples :

$\overset{1}{CH_3}\overset{2}{CH_2}\overset{3}{CH_2}OH$ ⇒ Propan-1-ol

$CH_3\overset{2}{C}H(\overset{1}{O}H)CH_3$ ⇒ propan-2-ol

Hence, propan-2-ol is a positional isomer of propanol

$CH_3CH_2CH_2CH_2OH \Longrightarrow CH_3CH_2CH_2CH_3$ (OH on C2)

⇒ butan-1-ol

⇒ butan-2-ol

$CH_3CH_2CH=CH_2 \Longrightarrow CH_3CH=CHCH_3$

⇒ but-1-ene ⇒ but-2-ene

$CH_3CH_2CH_2CH_2CH=CH_2 \Longrightarrow CH_3CH_2CH_2CH=CHCH_3$

⇒ hex-2-ene ⇒ hex-2-ene

$CH_3CH_2CH=CHCH_2CH_3$

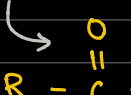
⇒ hex-3-ene

FUNCTIONAL GROUP ISOMERS (STRUCTURAL)

→ Occurs when two compounds have the same molecular formula but possess different functional groups.
↳ Hence, they belong to different homologous series.

- Generally occur between:
  i) Aldehydes & Ketones
  ii) Alcohols & Ethers
  iii) Carboxylic Acids & Esters
  iv) Alkenes & Cycloalkanes

ALDEHYDES



R - C(=O) - H

alkyl, must contain at least one carbon

↳ terminal Hydrogen - Has to be H, cannot be C

KETONES

R - C(=O) - R

R and R' must be alkyls with carbons, cannot be hydrogens

Example:

1. C_3H_6O

Aldehyde

$CH_3 - CH_2 - C(=O) - H$ → propanal

Ketone

$CH_3 - C(=O) - CH_3$ → propanone

Thus, two different molecules were made from the same molecular formula.

2. C_4H_8O

Aldehyde

$CH_3-CH_2-CH_2-C(=O)-H$ → butanal

↳ H on one side

Ketone

$CH_3-C(=O)-CH_2CH_3$ → butanone

alkyls on both sides

3. $C_5H_{10}O$

These two are functional group isomers of each other

Aldehyde

$CH_3-CH_2-CH_2-CH_2-C(=O)-H$

↳ pentanal

Chain isomers of each other

$CH_3-CH(CH_3)-CH_2-C(=O)-H$

↳ 3-methylbutanal

Ketone

$CH_3-C(=O)-CH_2-CH_2-CH_3$ → pent-2-one

These two are positional isomers of each other

$CH_3-CH_2-C(=O)-CH_2-CH_3$

↳ pent-3-one

ALCOHOLS & ETHERS

Alcohol

$R-OH$

Ether

$R-O-R'$

ie. C_2H_6O

Alcohol:

CH_3-CH_2-O-H

ethanol

Ether:

CH_3-O-CH_3

dimethyl ether

ie. $C_4H_{10}O$

Alcohol:

$CH_3-CH_2-CH_2-CH_2-OH$

butan-1-ol

Ether:

$CH_3-CH_2-O-CH_2-CH_3$

diethyl ether

$CH_3-O-CH_2-CH_2-CH_3$

ethyl methyl ether

CARBOXYLIC ACIDS & ESTERS

Carboxylic Acid:

Ester:

ie. $C_4H_8O_2$

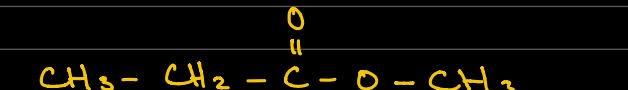
Carboxylic Acid

→ butanoic acid

↳ H on one end

This one carboxylic acid (with the exception of it's positional isomers), has all these functional group isomers / corresponding esters.

Ester: ↷ made up of carboxylic acids + alcohols



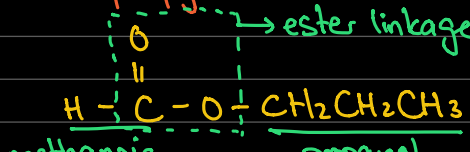
→ methyl propanoate

↳ alkyl group on one end

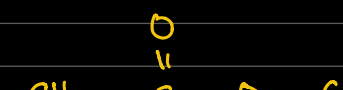
Since esters are a combination of carboxylic acids and alcohols, we could mix n' match carboxylic acids and alcohols such that the total number of C atoms; to produce different isomers:

	Carboxylic Acid		Alcohol
A.	(methanoic acid) ($HCOOH$) 1C	+	3C ($CH_3CH_2CH_2OH$) (propanol)
B.	(ethanoic acid) (CH_3COOH) 2C	+	2C (CH_3CH_2OH) (ethanol)
C.	(propanoic acid) (CH_2CH_2COOH) 3C	+	1C (CH_3OH) (methanol)

A. → propylmethanoate



B. → ethyl ethanoate



C. → methyl propanoate

D. This additional isomer is a result of using propan-2-ol instead of propan-1-ol for example A: propylmethanoate

* Don't worry about naming branched functional group isomers ↳ not in syllabus

C_nH_{2n} ALKENES & C_nH_{2n} CYCLOALKANES

↳ need at least 3 carbons in the compound for this type of functional group isomerism to occur.

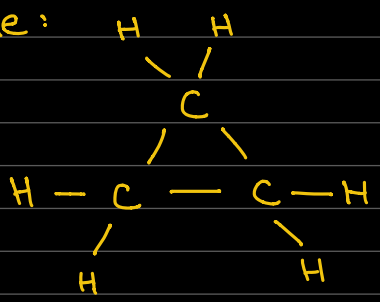
ie. C_3H_6

Alkene:

$CH_3 - CH = CH_2$

→ propene

Cycloalkane:



→ cyclopropane

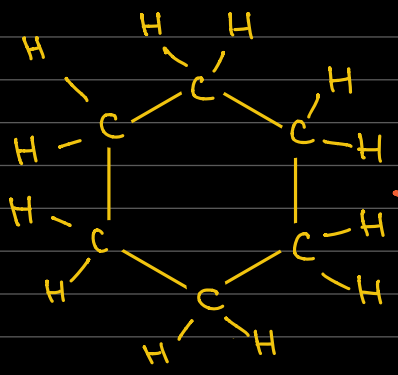
ie. C_6H_{12}

Alkene:

$CH_3CH_2CH_2CH_2CH = CH_2$

→ hexene

Cycloalkane:

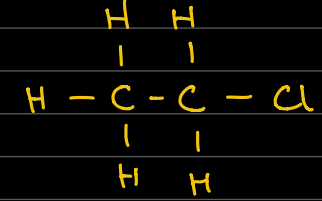


→ cyclohexane

Q. For $C_2H_{6-n}Cl_n$, where 'n' can be any integer from 1 to 6. what is the total number of different chloroethanes that can be made? Draw and name them.

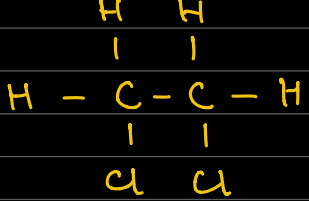
Have to do the full, tedious process

$n = 1 \rightarrow C_2H_5Cl$

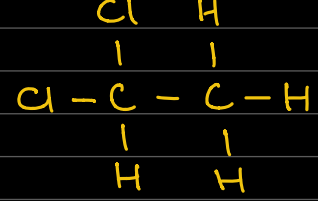


→ chloroethane

$n = 2 \rightarrow C_2H_4Cl_2$

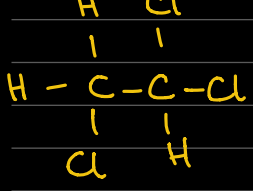


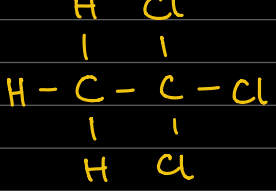
1,2-dichloroethane



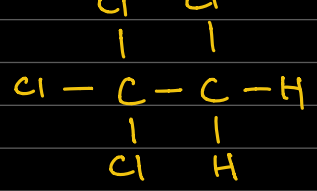
→ 1,1-dichloroethane

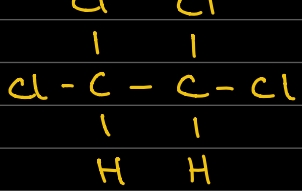
$n = 3 \rightarrow C_2H_3Cl_3$





$n = 4 \rightarrow C_2H_2Cl_4$





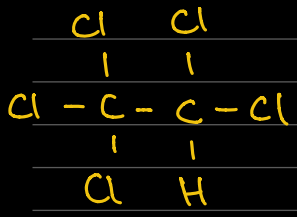
→ 1,1,2-trichloroethane

→ 1,1,1-trichloroethane

→ 1,1,1,2-tetrachloroethane

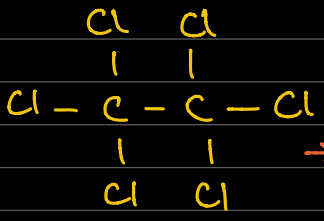
→ 1,1,2,2-tetrachloroethane

n = 5 → $C_2H_1Cl_5$



→ 1,1,1,2,2-pentachloroethane

n = 6 → C_2Cl_6



→ hexachloroethane

Hence, 9 total isomers, the names and displayed formulae are given above.