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Class 12
Chemistry

Chapter 7
Organic Chemistry
Handwritten Notes

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ORGANIC CHEMISTRY

Organic chemistry is the branch that deals with the preparation, properties, identification, and reactions of carbon compounds. All organic compounds contain carbon as the main element and usually also contain hydrogen. They may also include oxygen, nitrogen, sulfur and halogens.

Isomerism

Isomerism is the phenomenon in which compounds have the same molecular formula but different structures or arrangements of atoms. Such compounds called isomers.
It is mainly divided into two types:-
Constitutional isomerism (Structural isomerism):- different connectivity of atoms.
Stereoisomerism (Configurational isomerism):- same connectivity but different 3D arrangement in space.
This property is one of main resons why organic compounds are so numerous.

Stereoisomerism

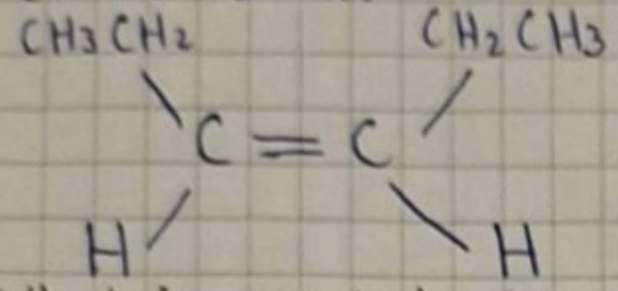
Stereoisomers have the same molecular formula and structural formula, but the atoms are arranged differently in space. This very important in living systems because enzymes only react with specific shapes of molecules. Sometimes one stereoisomer of a drug is useful, while another may cause side effects. Stereoisomerism mainly includes:- geometric isomerism and optical isomerism.

- **Geometric isomerism:** This type of isomerism is common in alkenes because the double bond restricts rotation. A double bond contains:- one sigma (σ) bond and one pi (π) bond. The π bond prevents free rotation, so groups attached to the double-bonded carbons stay fixed in position. Because of this, compounds can exist as different isomers.
  Alkenes show geometric isomerism only when each carbon of the double bond has two different groups attached.
  Alkanes do not show this because single bonds can rotate freely.
  - **Cis-Trans Isomerism:** For alkenes, geometric isomers are often named as cis and trans. Cis:- similar groups are on the same side. Trans: similar groups are on opposite sides. For example:- but-2-ene. Cis-but-2-ene: both CH_3 groups on same side. Trans-but-2-ene: CH_3 groups on opposite sides.
    The physical properties of cis-trans isomers, like melting points, boiling points, and solubility are different from one another. Cis-isomers are polar because they have dipole moment while trans-isomers are non-polar as they have zero dipole moment. Generally, cis-isomers are less stable and more reactive because bulky groups are closer together, causing steric hindrance.
- **Optical isomerism:** Optical isomerism is based on chirality. A molecule is chiral if it is non-superimposable on its mirror image, just like our right and left hands. Such molecules usually contain a chiral (assymteric) carbon atom, which is a carbon attached to four different atoms or groups.
  - **Enantiomers:** A pair of non-superimposable mirror-image isomers are called enantiomers. They have:- same physical properties, same chemical properties, different effect on plane-polarized light, different biological effects.
  - **Plane-Polarized lights:** Normal light vibrates in all directions. When passed through a polarizing filter, it vibrates in only one plane and becomes plane-polarized light. Optical isomers rotate this light: clockwise (dextrorotatory (+)), anticlockwise (laverotatory (-)). This property is called optical activity.
  - **Racemic Mixture:** A 50:50 mixture of both enantiomers is called racemic mixture. It is optically inactive because both isomers ~~tightly~~ rotate light equally in opposite directions, so the effect cancels out.
  - **Properties of Optical Isomers:** Optical isomers usually have the same melting, boiling points, and density, but they may show different effects in living organisms. For example, one form of a compound may taste sweet and the other may taste bitter. Similarly, different forms of limonene have different smells.

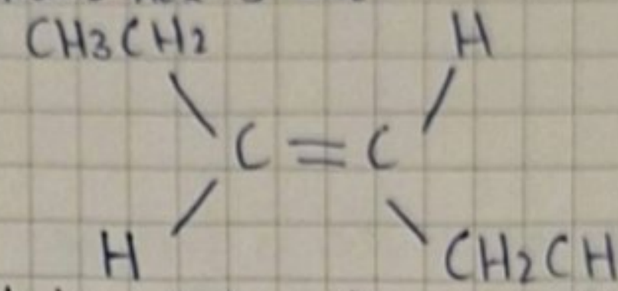
one smells like orange/lemon and the other smells like mint or pine. This shows that shape matters a lot in biological systems.

SHORT QUESTIONS

Draw the cis-trans isomers of hex-3-ene.
Hex-3-ene is $CH_3-CH_2-CH=CH-CH_2-CH_3$ The double bond is between carbon 3 and 4, so geometric isomerism is possible.
Cis-hex-3-ene:



trans-hex-3-ene



What is meant by levorotatory and dextrorotatory isomers? Give example.
Levorotatory (−) isomers are optical isomers that rotate plane-polarized light in the anticlockwise (left) direction. Dextrorotatory (+) isomers rotate plane-polarized light in the clockwise (right) direction. These are types of optical isomers that differ in the direction they rotate polarized light. For Example: (+)-limonene (found in oranges) is dextrorotatory, while (−)-limonene (found in mint) is levorotatory.
Why cant geometric isomers occur when identical groups are attached to the same carbon of a double bond?
Geometric isomerism requires that each carbon of the double bond must have two different groups. If identical atoms/groups are attached to the same carbon:
- both possible arrangements become identical molecules.
- no different spatial arrangement is possible.

So, no distinct cis or trans forms exist, and therefore geometric isomerism cannot occ
How does the π bond in alkenes restrict rotation and what is its energy implication?
In alkenes, the double bond consists of: one sigma (σ) bond and one pi (π) bond. The π bond is formed by sidewise overlap of p-orbitals, which prevents free rotation around the carbon-carbon bond. To rotate, the π bond must break, which requires a significant amount of energy. Energy implications:
- breaking the π bond in ethene requires about 264 kJ/mol.
- this high energy barrier leads to restricted rotation, making geometric isomerism possible.

Why are cis isomers generally more reactive but less stable than trans isomers?
Cis isomers are less stable because:
- bulky groups are on the same side → steric hindrance
- electron density is crowded on one side → more repulsion.

Cis isomers are more reactive because:
- their structure is more strained
- electron distribution is less stable
- electrophiles can attack more easily

Trans isomers are more stable because bulky groups are opposite, reducing repul and strain.
How can a molecule be chiral yet optically inactive? Give the term used for suc molecule?
A molecule can be chiral (non-superimposable mirror image) but still be optically inactive if it is a recemic mixture. A racemic mixture contains :- 50% dexotrotator (+) isomer and 50% levorotatory (−) isomers. Both rotate plane-polarized light equally but in opposite directions, so the effect cancels out. Therefore, the molec shows no net optical activity.

CONCEPT ASSESSMENT

Which of the following compounds can and cannot show cis-trans isomerism and why?

(i) 1-chloroprop-1-ene

Can show cis-trans isomerism.

Structure:- $CHCl=CH-CH_3$

Double bond carbons:-

- Carbon 1: H and Cl
- Carbon 2: H and CH_3

Both carbons have two different groups attached, so this compound can show cis-trans isomerism. It can exist in two different forms depending on whether the similar groups are on the same or opposite sides of the double bond.

(ii) 3-Chloroprop-1-ene

Cannot show cis-trans isomerism.

Structure:- $CH_2=CH-CH_2Cl$

Double bond carbons:-

- Carbon 1: H and H
- Carbon 2: H and CH_2Cl

Here, the first carbon has two identical hydrogen atoms. Since one carbon of the double bond does not have two different groups, cis-trans isomerism is not possible.

(iii) hex-2-ene.

CAN show cis-trans isomerism.

Structure:- $CH_3-CH=CH-CH_2-CH_2-CH_3$

Double bond carbons:-

- Carbon 2: H and CH_3
- Carbon 3: H and C_3H_7

Both carbons have different groups attached, so hex-2-ene can show cis-trans isomerism. It can exist as:-

- cis-hex-2-ene: similar groups on same side.
- trans-hex-2-ene: similar groups on opposite sides.

Separate chiral and achiral molecules in the following.

a) $CF_3CH_2CCl_3$

Achiral

Structure can be written as: $CF_3-CH_2-CCl_3$

- CH_3 carbon have two H atoms, so it cannot be chiral.
- CCl_3 carbon has three identical Cl atoms.

So, there is no carbon with four different groups.

b) $CF_2HCHFCCl_3$

Chiral

$CF_2H-CHF-CCl_3$

The middle carbon (CHF) is attached to:

- H
- F
- CF_2H
- CCl_3

These are four different groups, so this carbon is chiral

c) $CHCl_2(CH_2)_3CH(OH)CH_3$

Chiral

Focus on the carbon CH(OH). It is attached to:

- OH
- H
- CH_3
- $(CH_2)_3CHCl_2$

All four groups are different.

d) $CH(OH)ClCH_2CH_3$
Chiral
The first carbon is attached to:
- OH
- Cl
- H
- CH_2CH_3

All four groups are different.
e) $CH_2ClCH(OH)CH_3$
Chiral
The middle carbon $CH(OH)$ is attached to:
- OH
- H
- CH_3
- CH_2Cl

All are different groups.
f) $CF_3CH_2CCl_3$
Achiral
No carbon has four different groups.