CLASS XII ACADEMIC PROGRAM 2020

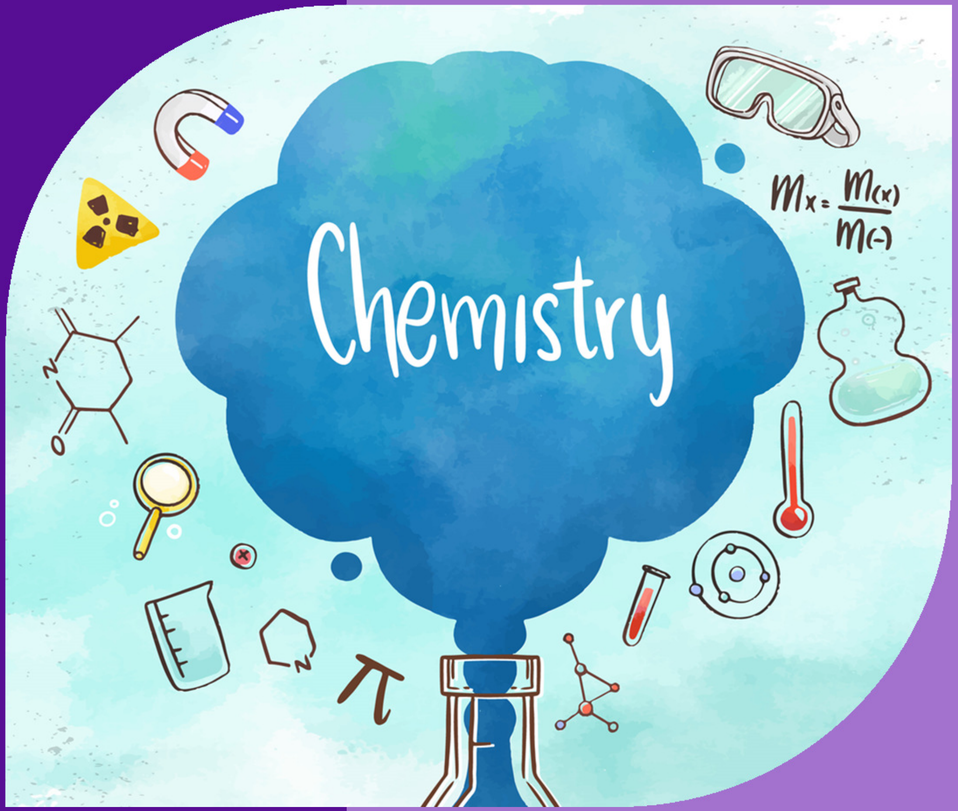
CHEMISTRY 2ND PAPER

LECTURE : C-07

CHAPTER 2 : ORGANIC CHEMISTRY

C-7 Isomerism

Sadat Ahmed Dipto



Isomerism of Organic Compounds

The compounds with same molecular formula but different structural formula or different 3d arrangement of atoms because of which their properties differ are called Isomers of one another and this property is called Isomerism.

$CH_3 - CH_2 - CH_2 - CH_3$
n–butane
(C_4H_{10})

$CH_3 - CH - CH_3$ (with CH_3 on the central CH)
iso–butane
(C_4H_{10})

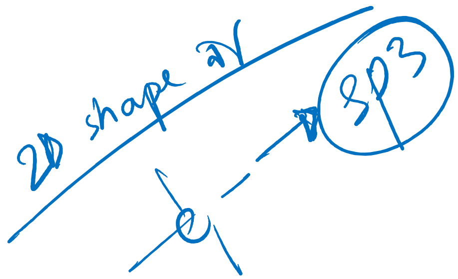
$CH_3 - CH_2 - CH_2 - CH_2 - CH_3$
n–pentane
(C_5H_{12})

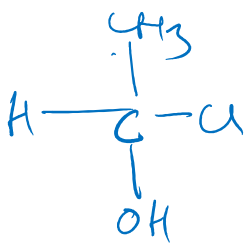
$CH_3 - CH - CH_2 - CH_3$ (with CH_3 on the CH)
iso–pentane
(C_5H_{12})

$CH_3 - C - CH_3$ (with CH_3 above and below the central C)
neo–pentane
(C_5H_{12})

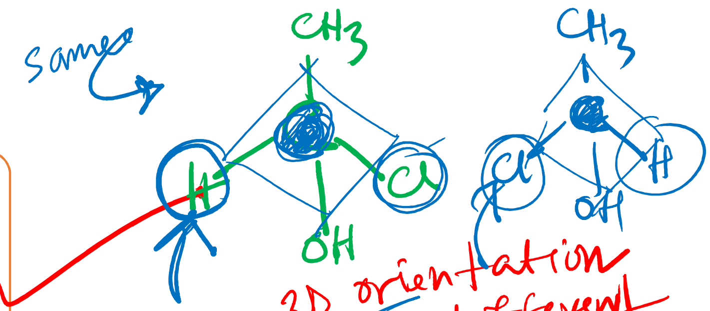
Isomerism

- **Structural isomerism**
  - Chain Isomerism
  - Position Isomerism
  - Functional Group
  - Metamerism
  - Tautomerism
  - Ring Chain Isomerism
- Stereo Isomerism
  - **Geometrical Isomerism**
  - **Optical Isomerism**





Same mo. formula
Diff. structural formal



3D orientation different

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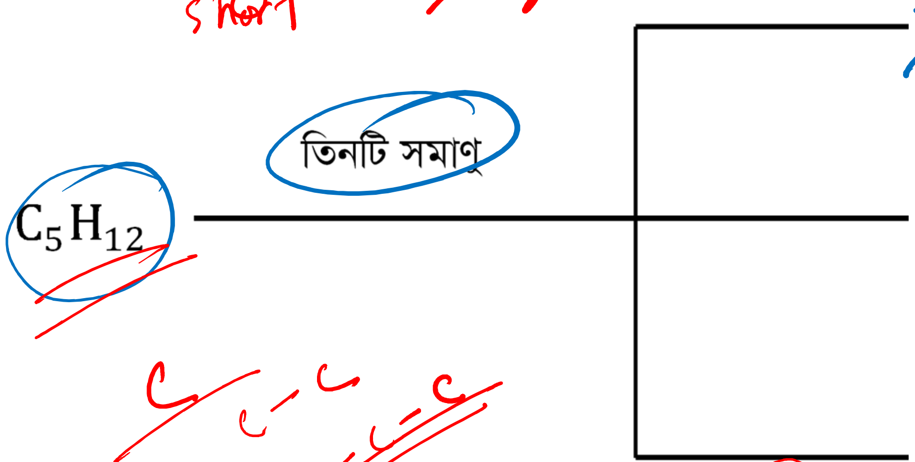
Chain Isomerism

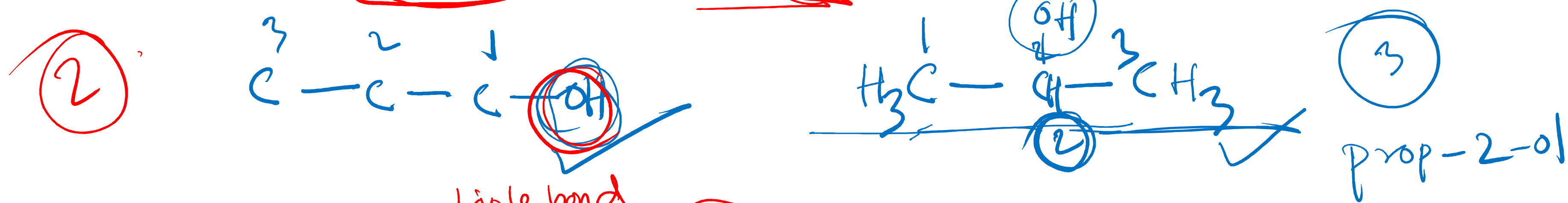
The isomerism that is formed due to the different structure of carbon chains is called chain isomerism. The isomers are homologous and the carbon chain can be branched or not.



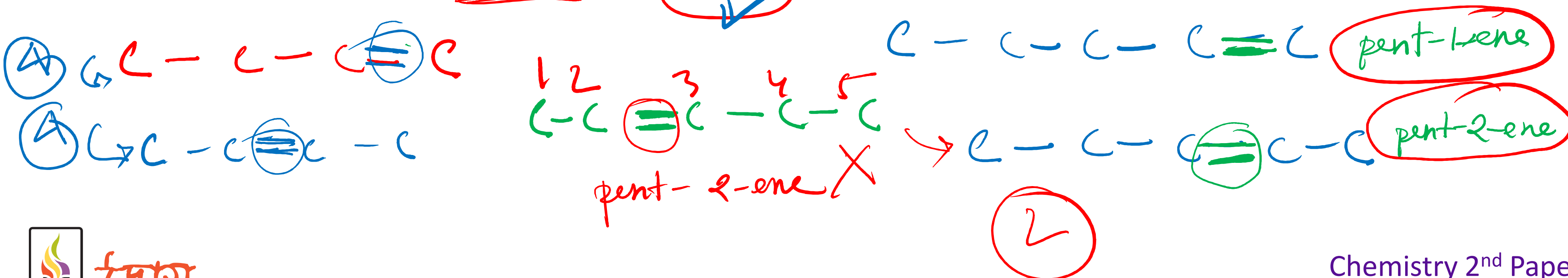
Position isomerism

The isomerism created in the homologues due to the presence of double bonds or triple bonds in different carbons of the compound or due to the shift in position of functional group is called poition isomerism. The position of the carbon atoms remain unchanged here.

Change in position of functional group : C_3H_7OH



Difference in position of double bond : C_5H_{10}



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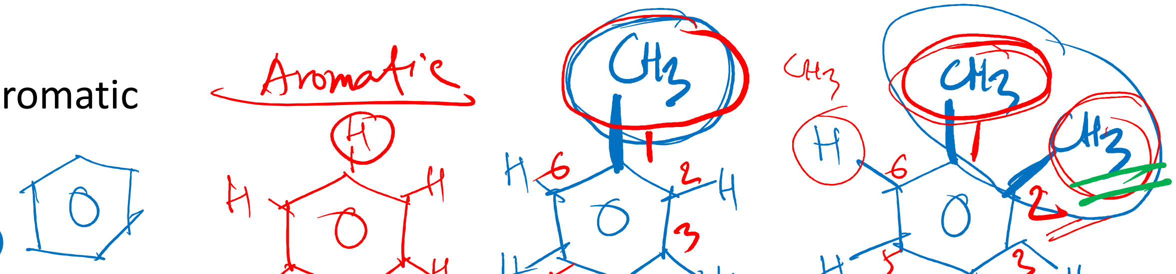
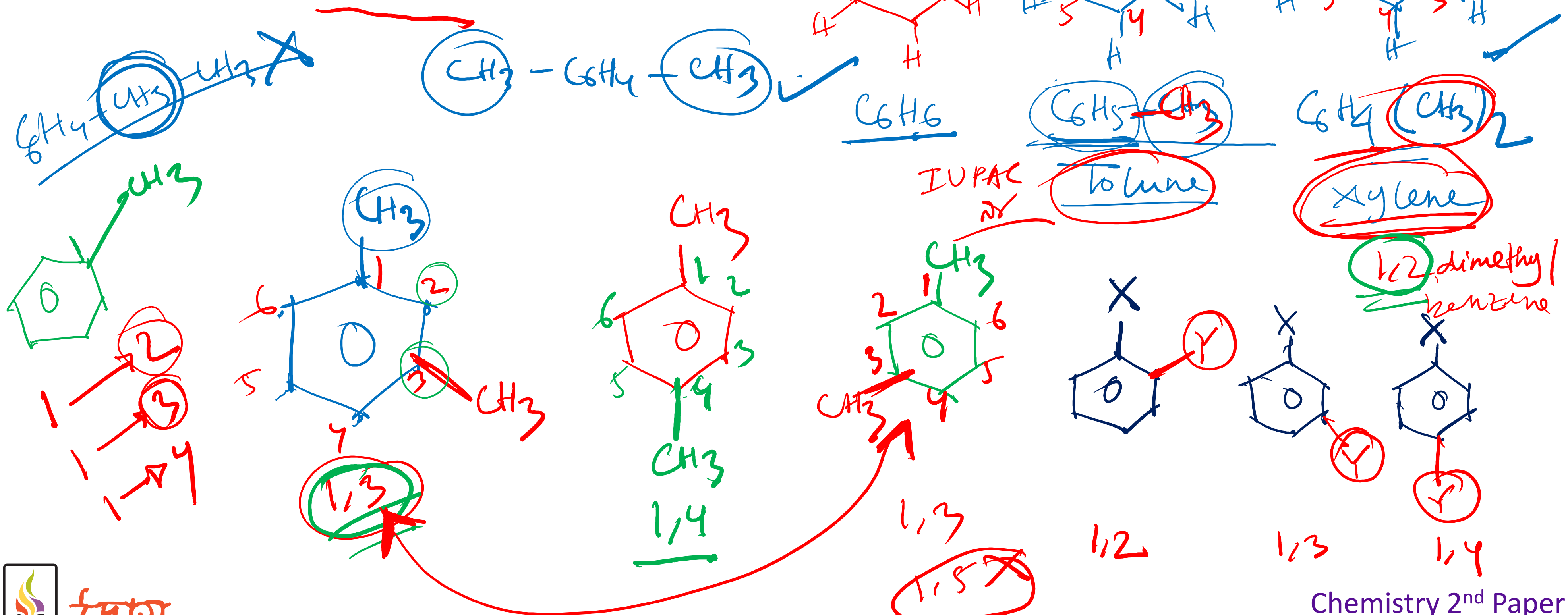
Position isomerism

Position isomers due to the substituents in Aromatic compounds:

Molecular formula: $C_6H_4(CH_3)_2$, (**xylene**)

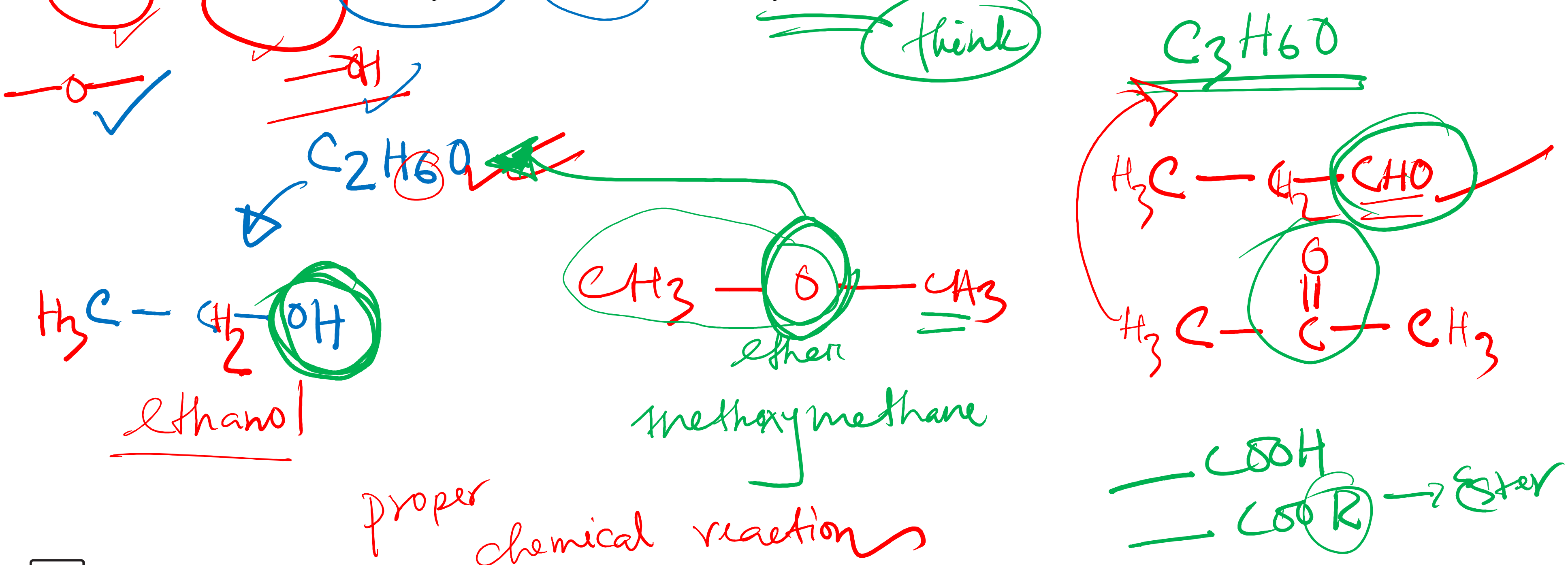




Functional group isomerism

Due to the presence of different functional groups in the molecules having same formula, functional group isomerism is created. The characteristics differ a lot because of being in different homologous series

Like- ether and alcohol , aldehyde and ketone , carboxylic acid and aster



Metamerism

The molecules of compounds in the same homologous series might have different number of carbon atoms and the isomers created in such a way is called metamerism **and the isomers are called** metamers. It occurs in ether, ketone and secondary amines

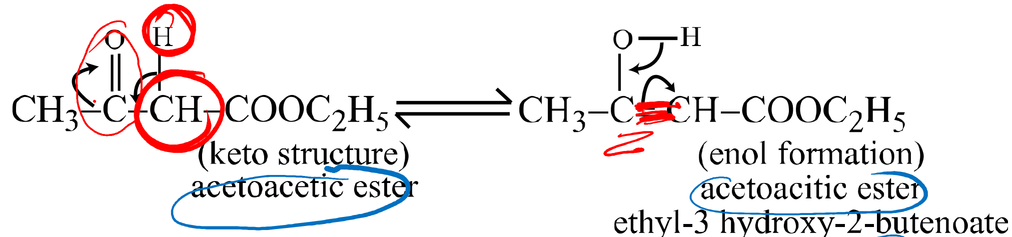
$C_4H_{10}O$

$C_5H_{10}O$

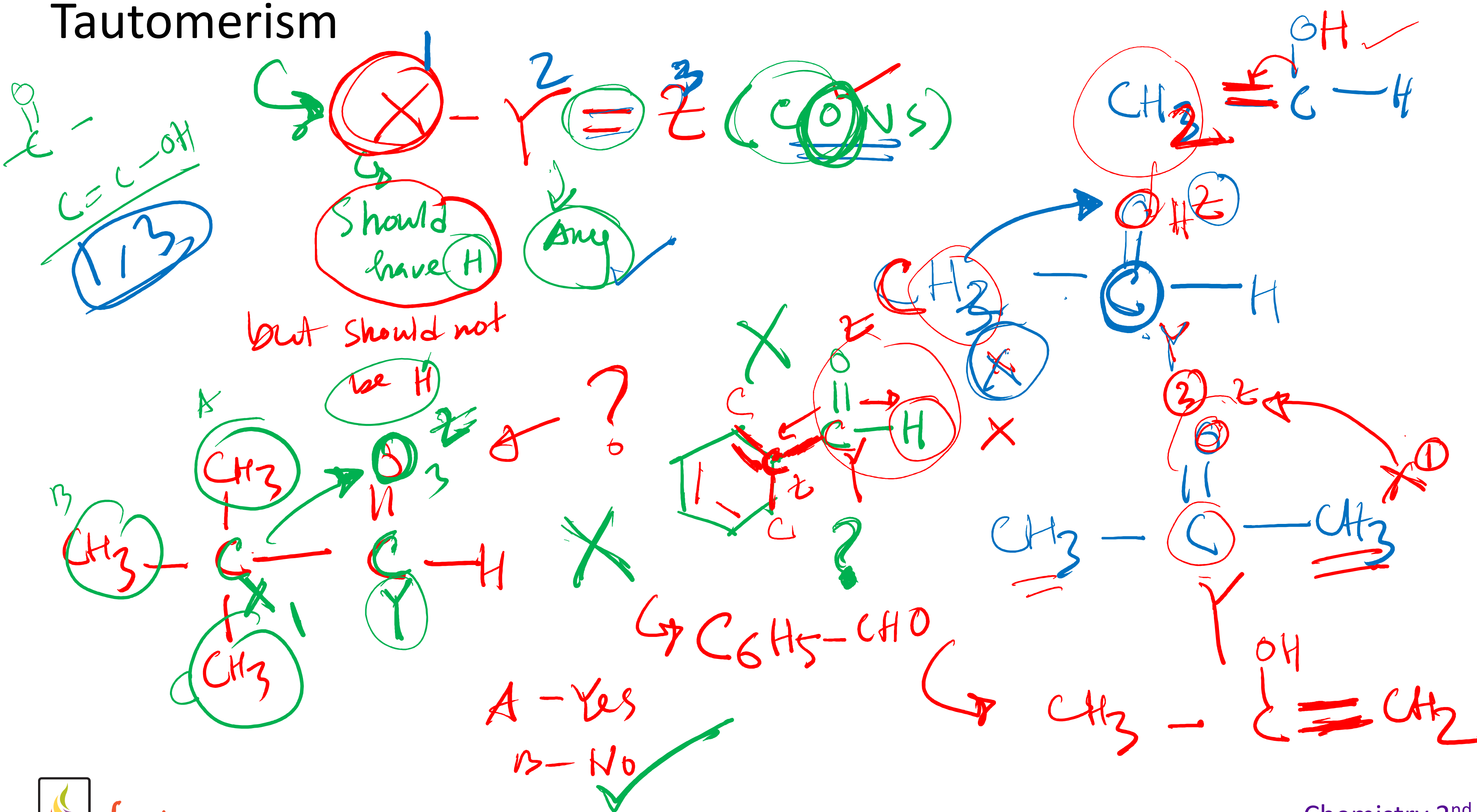
Tautomerism

It is a special type of functional group isomerism which is dynamic and easily changeable. The isomers are called tautomers.

like: (i) tautomerism of acetoacetic ester. It is also called keto enol tautomerism.

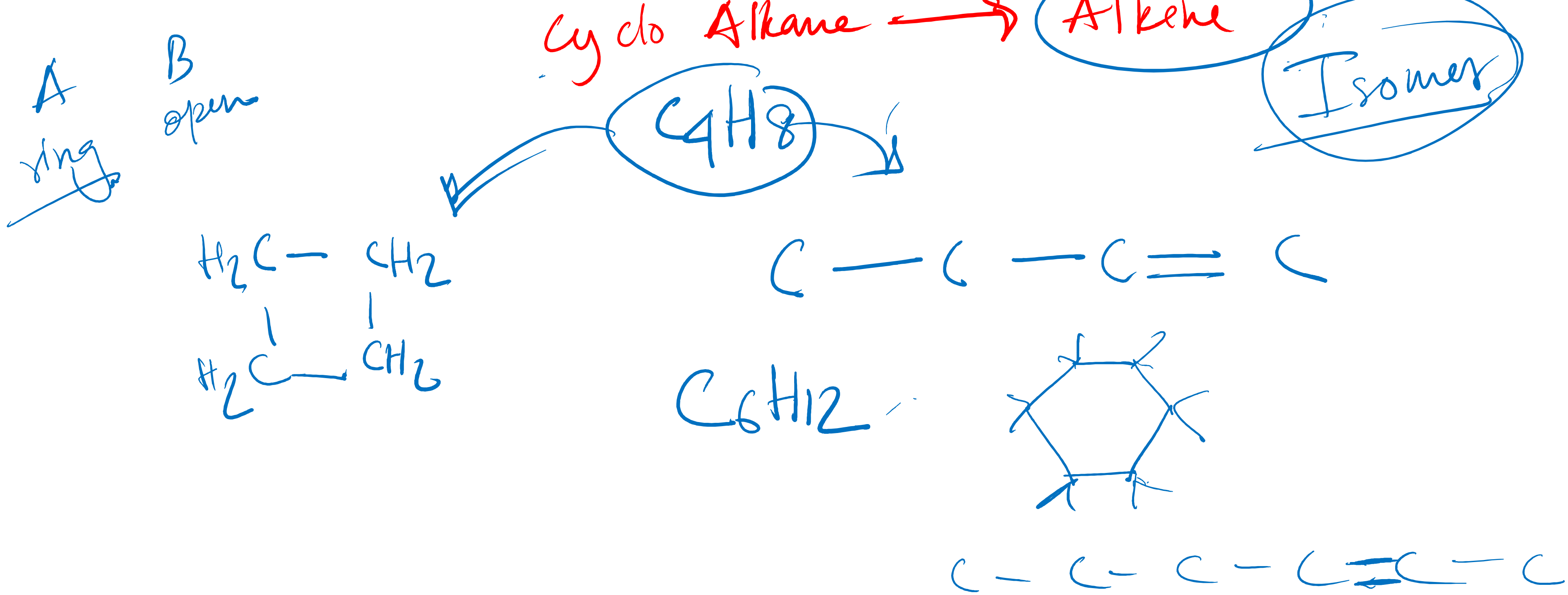


Tautomerism



Ring Chain Isomerism

Organic compounds having same molecular formula forming isomers of both open chain and closed chain compounds because of the formation of their chain structure are known as ring chain isomers and the isomers created in such a way is called ring chain isomerism.



Determining structural isomerism

1.Determining homologues

2. after determining homologous series, establish as many carbon chains as possible by the number of carbons given in the formula

3. in the established carbon chains, place functional group in different places

4. place hydrogen to fulfill the valency of the carbon atoms

5. finally check if a stereo isomer can be formed.

Determining structural isomerism

C_nH_{2n+2} → C_5H_{12}, C_4H_{10} → chain isomer.

C_nH_{2n} → Position, Ring/chain

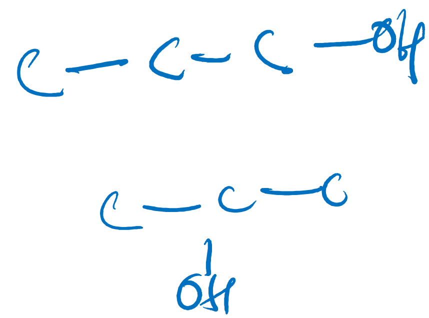
$C_nH_{2n} +_2 O$

Let's think

$C_nH_{2n}O$

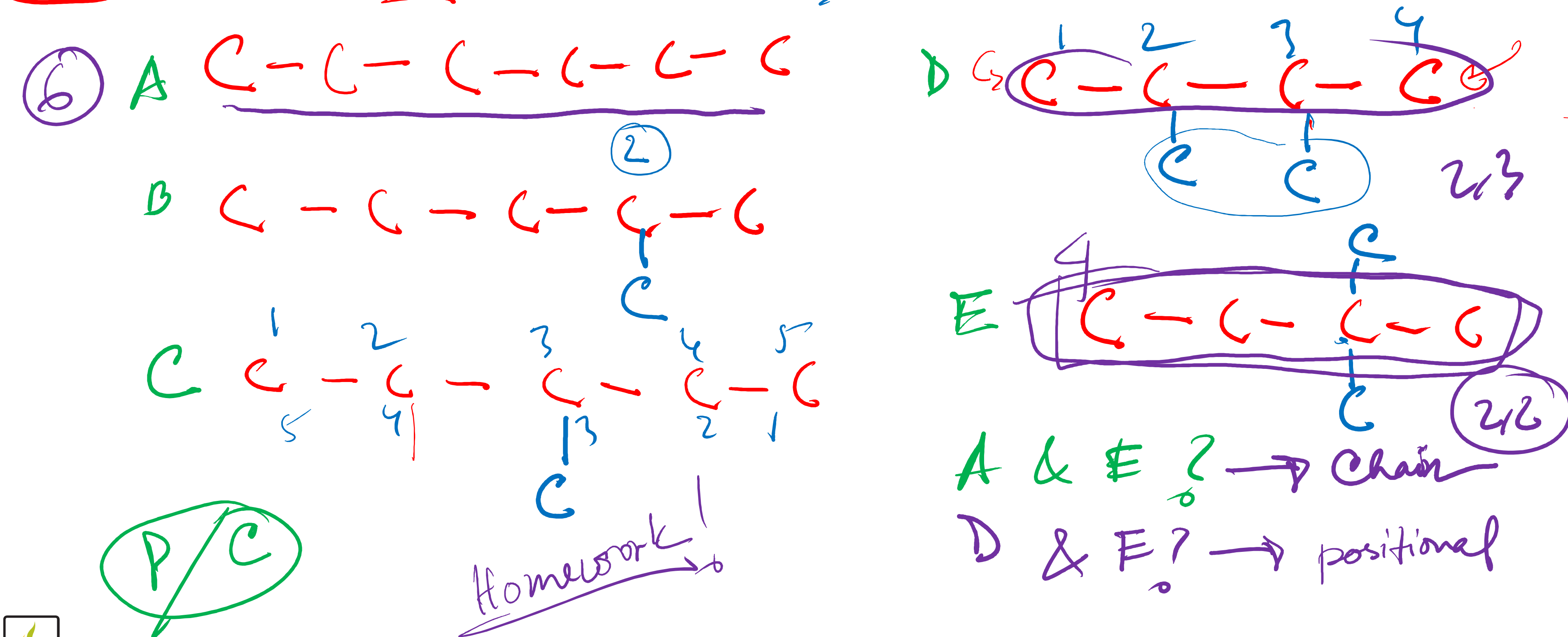
C_4H_8O

$C_nH_{2n+1}OH$ Alcohol → Positional



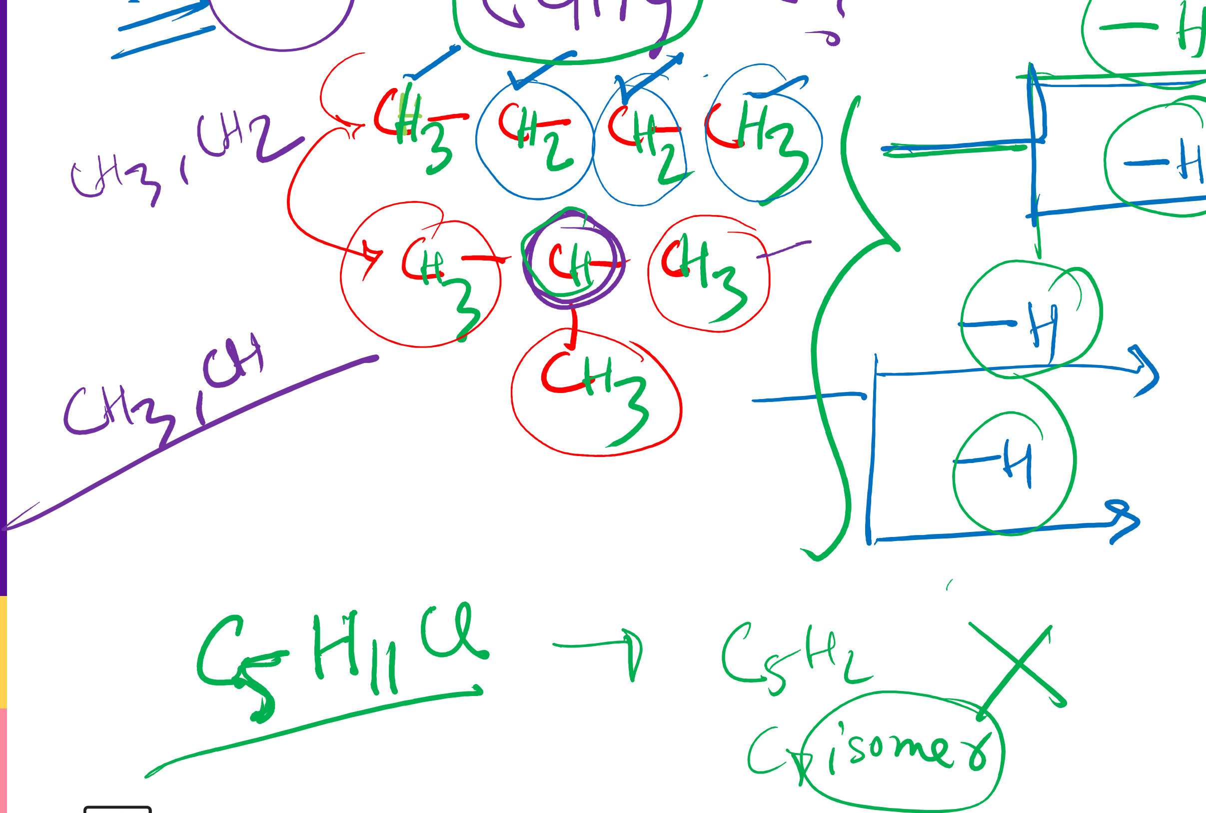
Determining structural isomerism

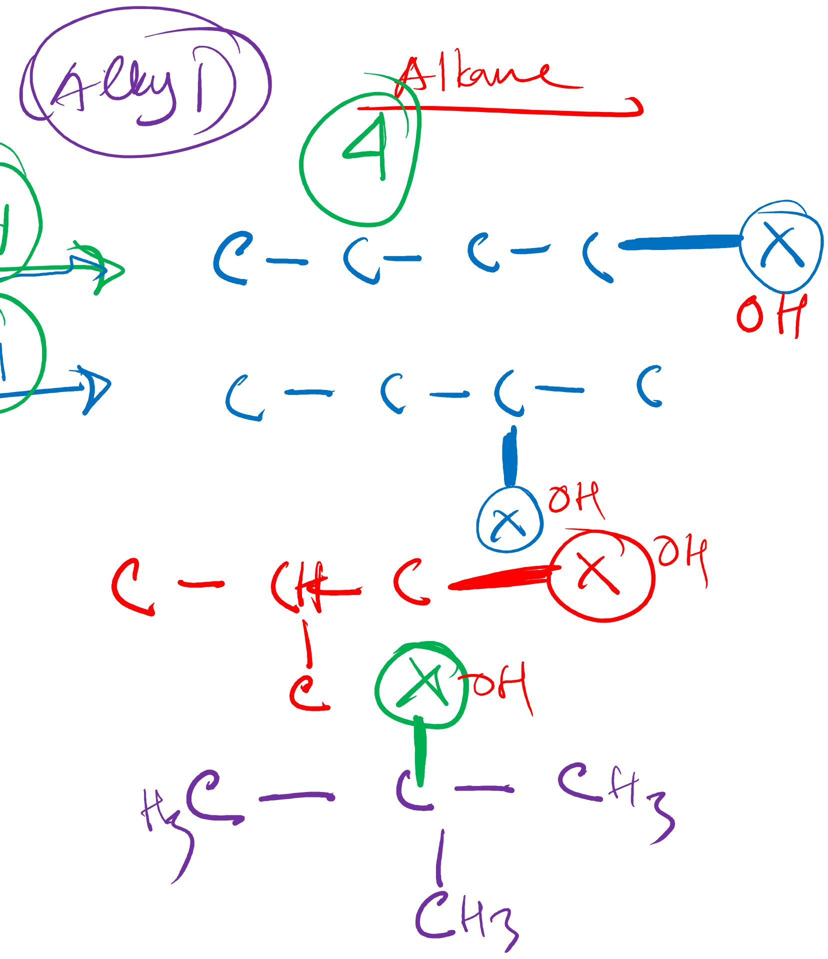
C_6H_{14}



Determining structural isomerism

C_4H_9Br





Determining structural isomerism

C_4H_9OH → How many Alcohols?

→ Let's try

C_4H_9Br → 4

C_4H_9OH → 4

(A) $CH_3-CH_2-CH_2-CH_2-OH$

(B) $CH_3-CH_2-CH(OH)-CH_3$

(C) $CH_3-C(OH)(CH_3)-CH_3$

(D) $CH_3-CH(CH_3)-CH_2-OH$

Determining structural isomerism

4 Alcohol + 3 Ether → 7 isomer

$C_4H_{10}O$ → Homework! Solve

sadat.dipro@gmail.com

Alcohols are shown in the previous page

4 → Alcohols

Ethers

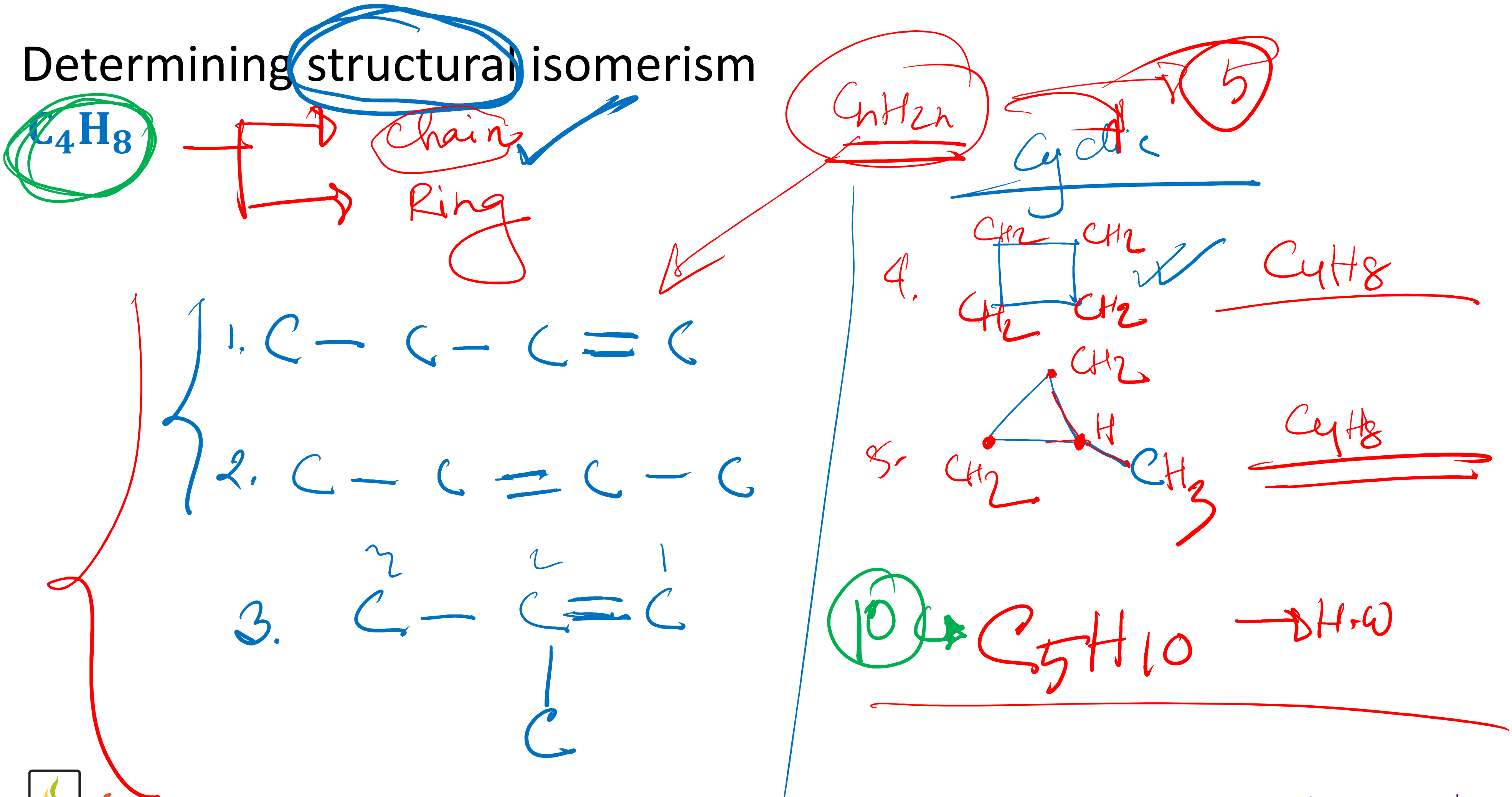
$CH_3-CH_2-O-CH_2-CH_3$

$CH_3-O-CH_2-CH_2-CH_3$

$CH_3-O-CH(CH_3)-CH_3$

Determining structural isomerism

C_4H_8



Determining structural isomerism

C_3H_6O → Homework

Aldehyde, Ketone → enol

Solve:

Draw Only straight chain / no Rings !

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

$CH_3-C(=O)-CH_3$: Ketone

$CH_3-CH=CH-OH$: enol

$CH_2=CH-CH_2-OH$: enol

$H_3C-C(OH)H=CH_2$: enol

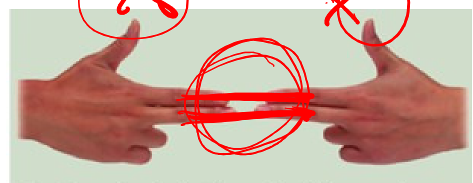
unsaturated ether

$H_2C=HC-O-CH_3$

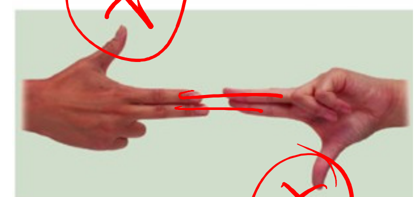
May be you forgot this one

Geometrical Isomerism or Cis-truns Isomerism

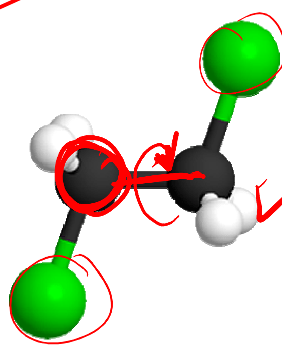
Geometrical isomerism is one type of carbon carbon double bond stereo isomerism. substituted alkenes or the compounds with same structural formula which have different 3d arrangement of the groups attached with the carbons in the double bond and which have different physical and chemical properties are called geometrical isomers and this feature is called geometrical isomerism.

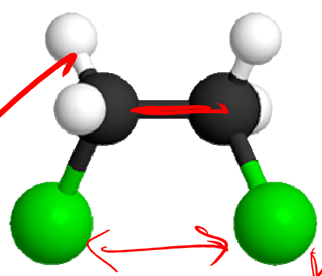


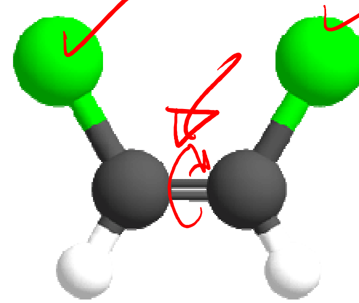
Cis-hands (*cis*-thumbs/fingers)

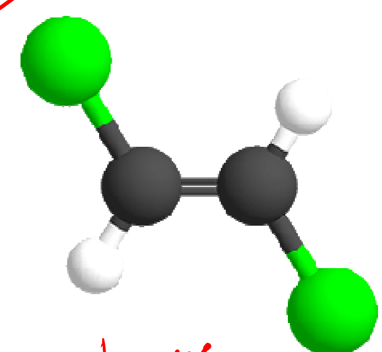


Trans-hands (*trans*-thumbs/fingers)

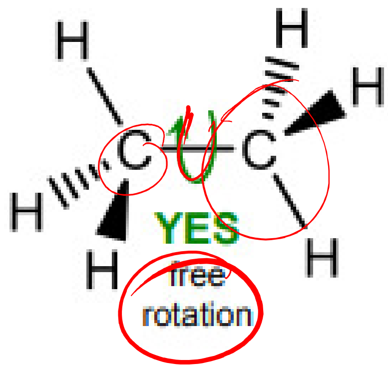


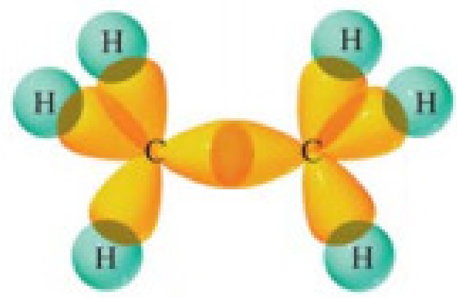


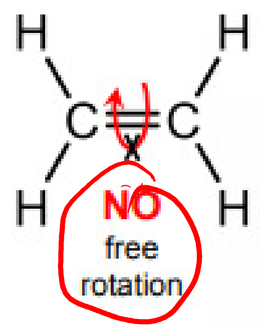


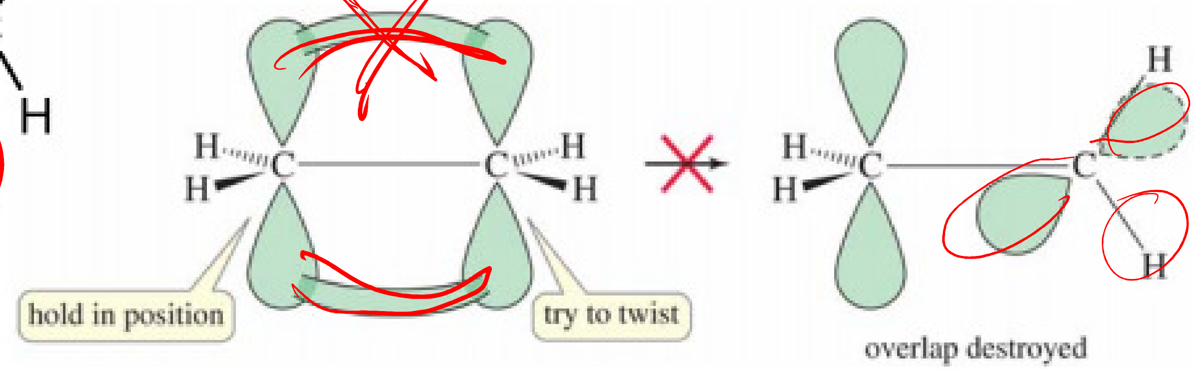


❑ sp2 and sp3 hybridization of carbon

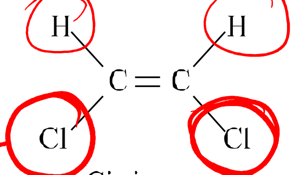






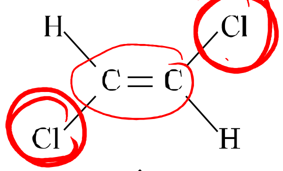


Geometrical Isomerism or Cis-trans Isomerism



Cis isomer

cis-1,2-dichloro ethene

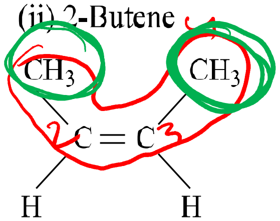


trans isomer

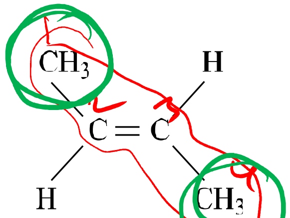
trans-1,2-dichloro ethene

Here, a = H
b = Cl

(ii) 2-Butene

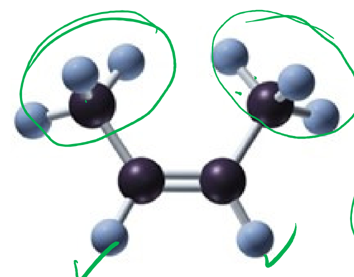


cis-2-butene

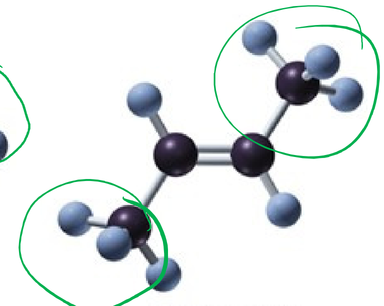


trans-2-butene

Here, a = CH_3
b = H

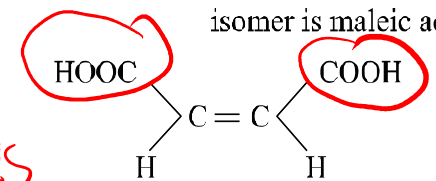


cis-2-butene

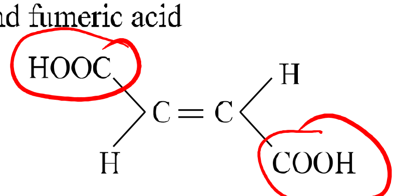


trans-2-butene

Other mentionable example of sis-trans isomer is maleic acid and fumeric acid

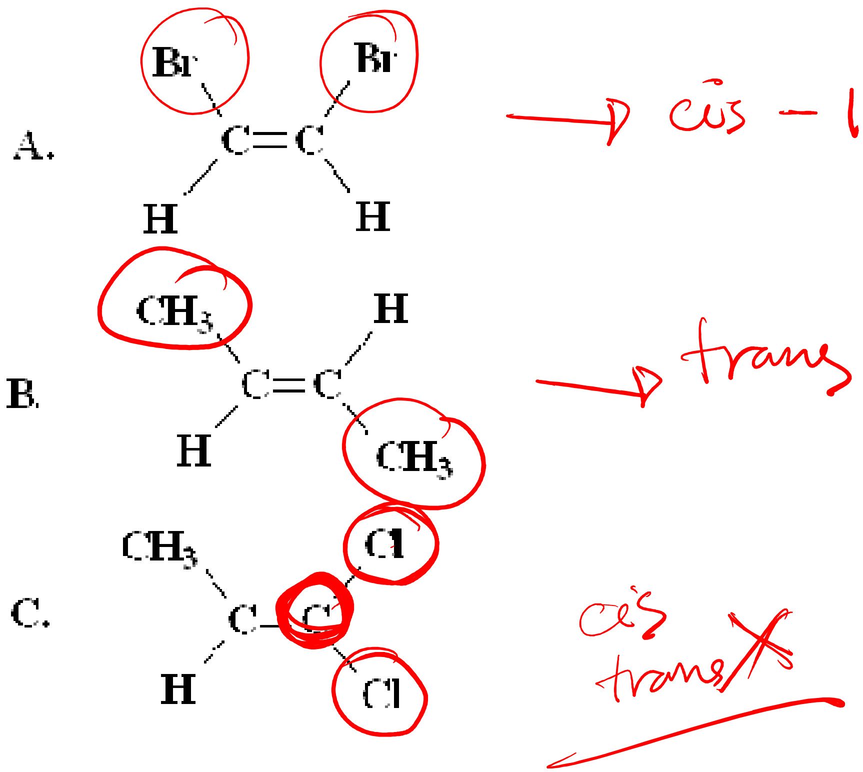


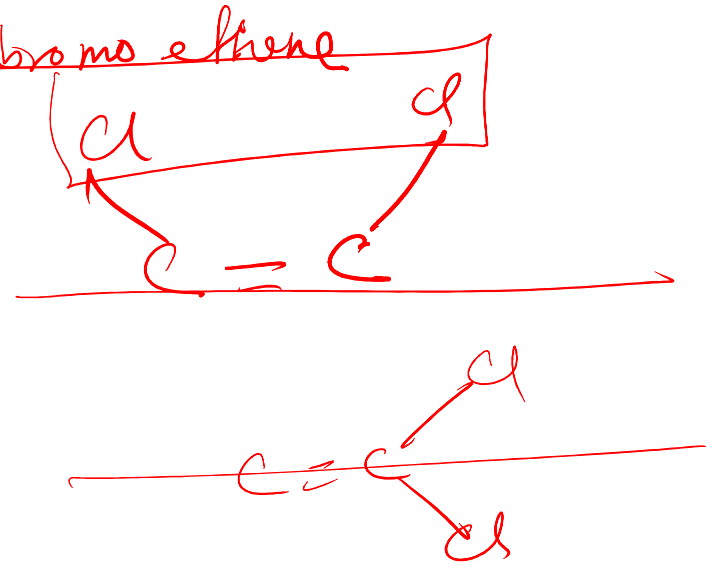
Melting point of sis-butene dioic acid: 135°C (maleic acid)



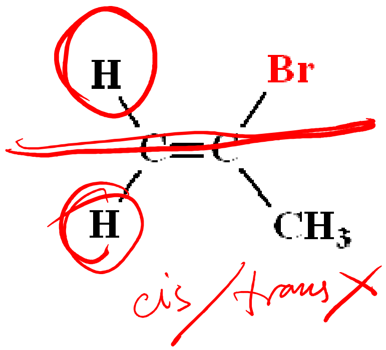
melting point of sis-butene dioic acid: 287°C (fumeric acid)

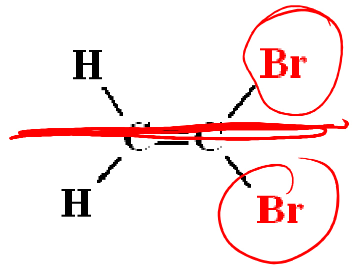
Geometrical Isomerism or Cis-trans Isomerism

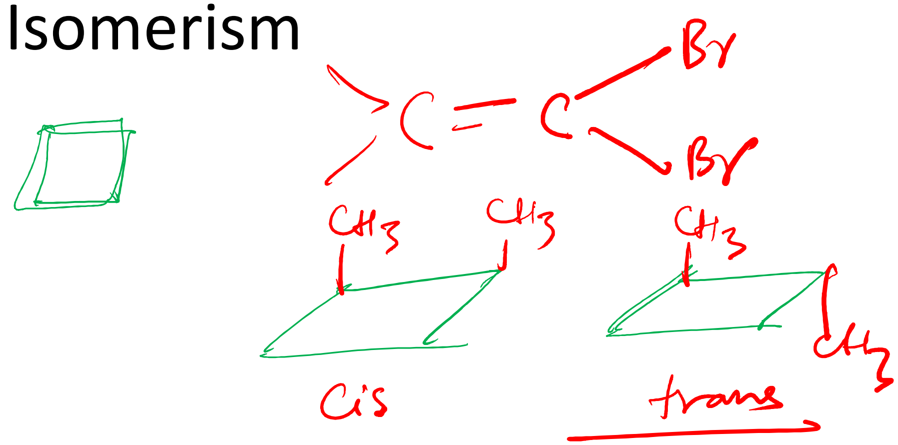


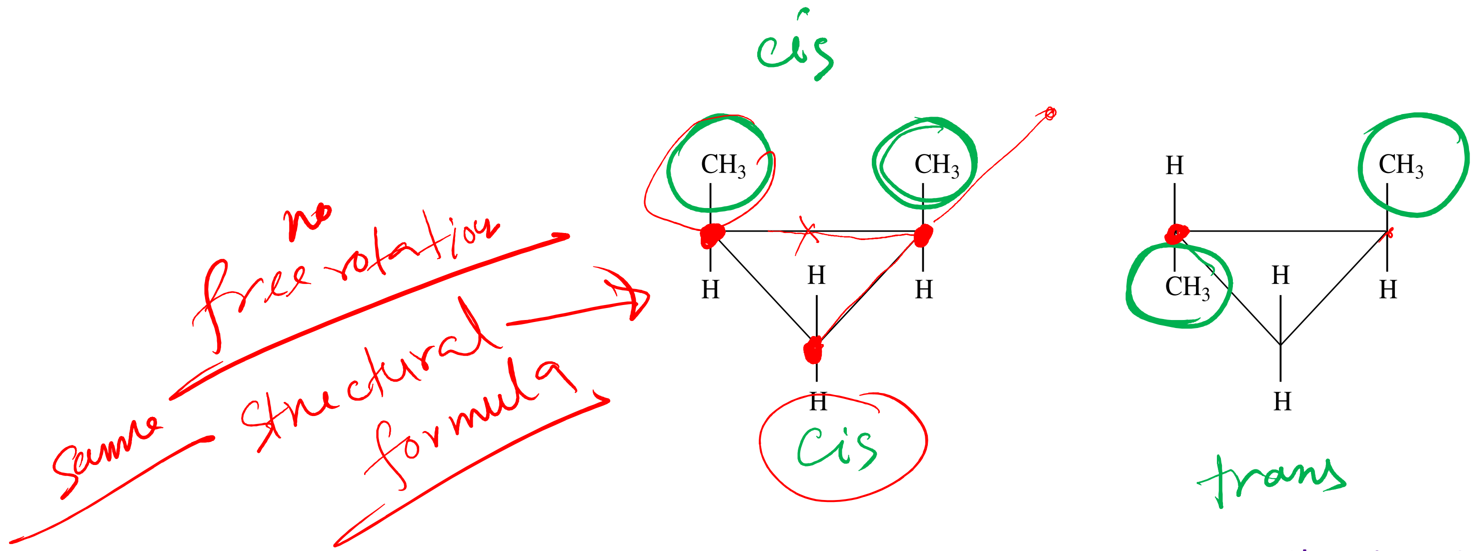


Geometrical Isomerism or Cis-trans Isomerism



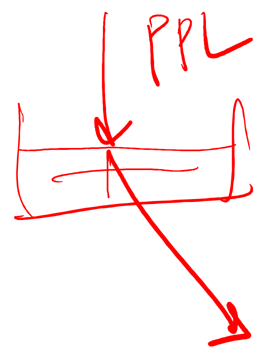






Optical Isomerism

Compounds having same molecular and structural formula and similar physical and chemical properties but behaves differently with plane polarized light are called Optical Isomers and this phenomena is called Optical Isomerism.



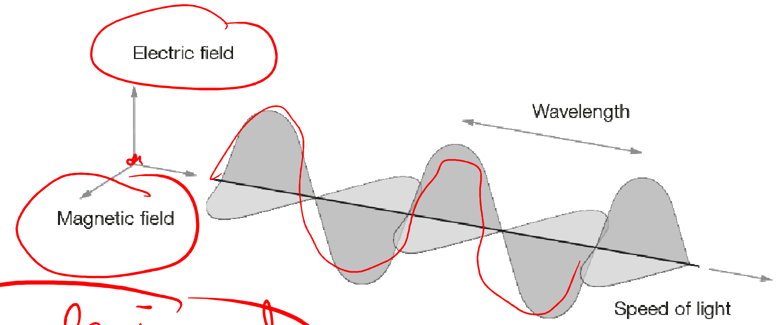
- Plane Polarized Light
- Optical Activity
- Chiral Centre
- Chirality
- Enantiomers

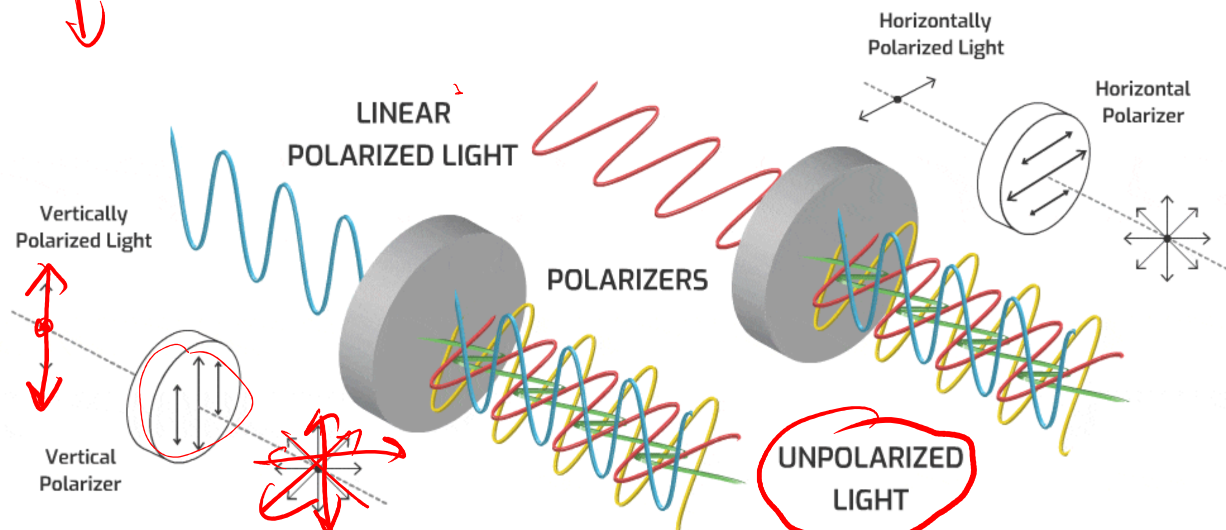
Plane Polarised Light

PPL

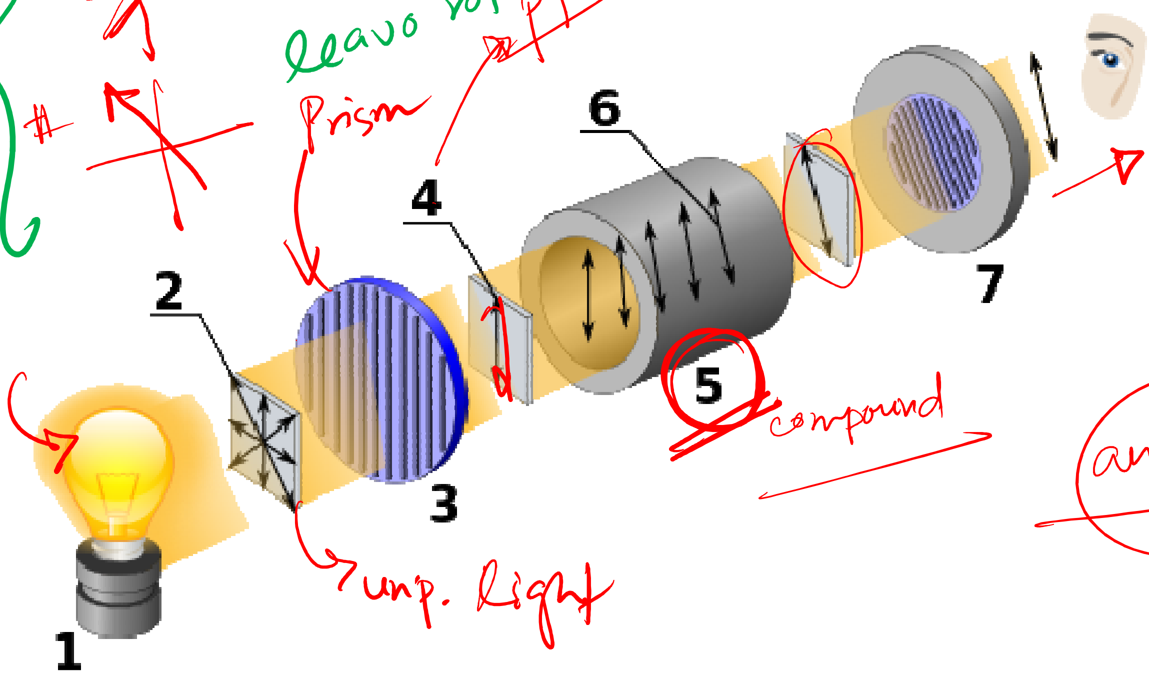
electromagnetic wave

Nicol Prism
Polarizer





Optical Activity

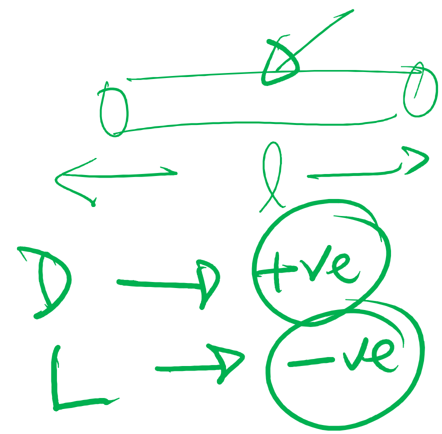


Polarimeter

Optical Activity

To compare the optical activity of different compounds specific rotation is used. specific rotation $[\alpha]$ is expressed through the equation-

$$[\alpha]_D^t = \frac{1000a}{lc}$$



Here, a = observed rotated angle;

l= length of light's travelled distance inside solution, dm

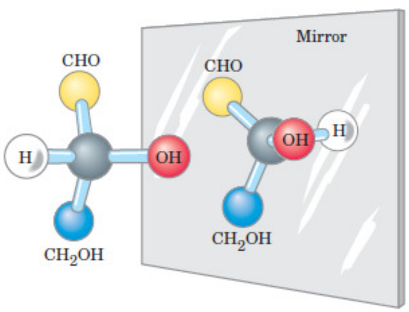
c = conc. of solution, gmL^{-1}; t = temperature °C

So the solution with conc. 1 gmL^{-1} kept in a tube of length 1 dm in polarometer if plane polarized kight is passed the amount of rotation visible is called Specific Rotation of that compound

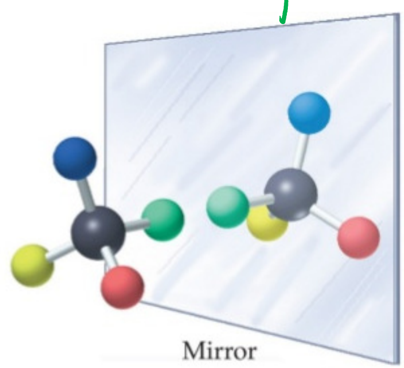
like, at 25°C if in monochromatic sodium light the relative value of rotated angle in an assymetric compound is $[\alpha]_D^{25} = +37°$ Then the compound will be called Dextro-Rotatory

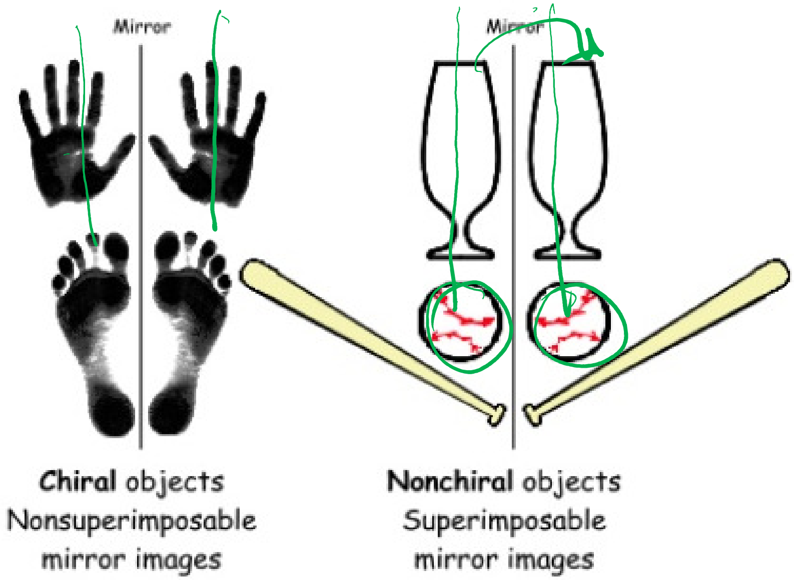
Conditions of showing optical isomerism

- The molecule must have a chiral carbon.
- The molecule must be assymetrical with respect to chiral carbor
- The molecule and its Mirror Image will not be superimposed.



Ball-and-stick models

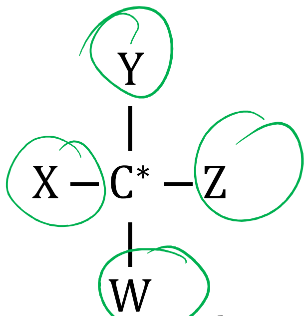




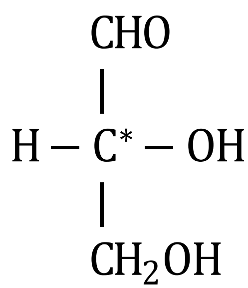
Explanation of Optical Activity

Asymmetric Carbon Atom

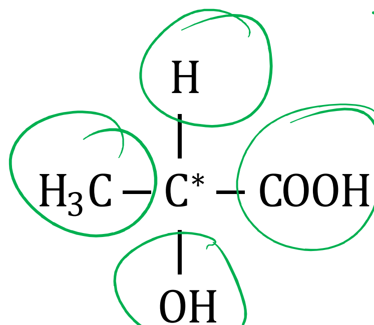
The presence of assymetric carbon atom in molecule is the reason for showing optical isomerism. In a compound if a carbon atom has four different atoms/groups attached with it, it is called an **Asymmetric Carbon and assymetric carbon is called Chiral Carbon or Chiral Centre.**



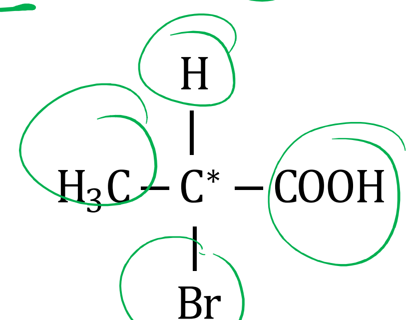
Asymmetric Carbon



glyceraldehyde



lactic acid



2 bromopropanoic acid

1 chiral carbon ✓ optical isomerism

Chiral Carbon

$$\begin{array}{c} H \\ | \\ CH_3 - CH_2 - {}^*C - CH_2 - CH_2 - CH_3 \\ | \\ CH_3 \end{array}$$

3-methylhexane

$$\begin{array}{c} H \\ | \\ CH_3 - CH_2 - {}^*C - CH_3 \\ | \\ OH \end{array}$$

secondary butyl alcohol

$$\begin{array}{c} CH_3 \\ | \\ CH_3 - CH_2 - {}^*C - NH_2 \\ | \\ H \end{array}$$

secondary butyl amine

$$\begin{array}{c} H \\ | \\ CH_3 - {}^*C - COOH \\ | \\ Br \end{array}$$

2-bromopropanoic acid

Enantiomers and Racemic Mixture

Two optically active isomers with chiral carbons which are mirror image of one another but are not superimposable and can rotate plane polarized light in the same amount to the opposite directions are called enantiomers and the phenomena is called Enantiomerism.

The equal portion mixture of two enantiomers is called racemic mixture.

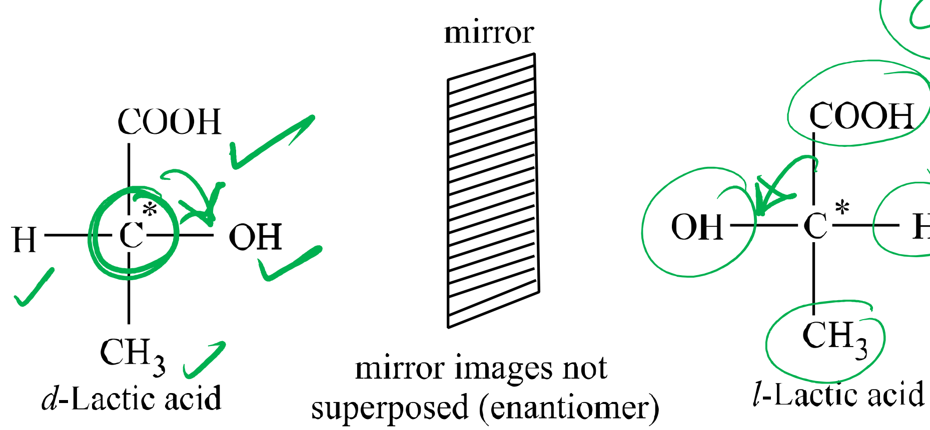
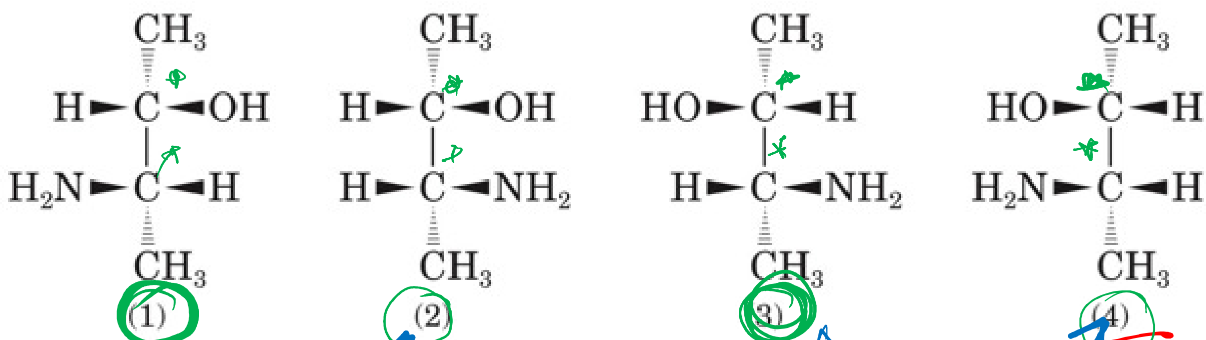


Fig: isomer of lactic acid

Diasteromer

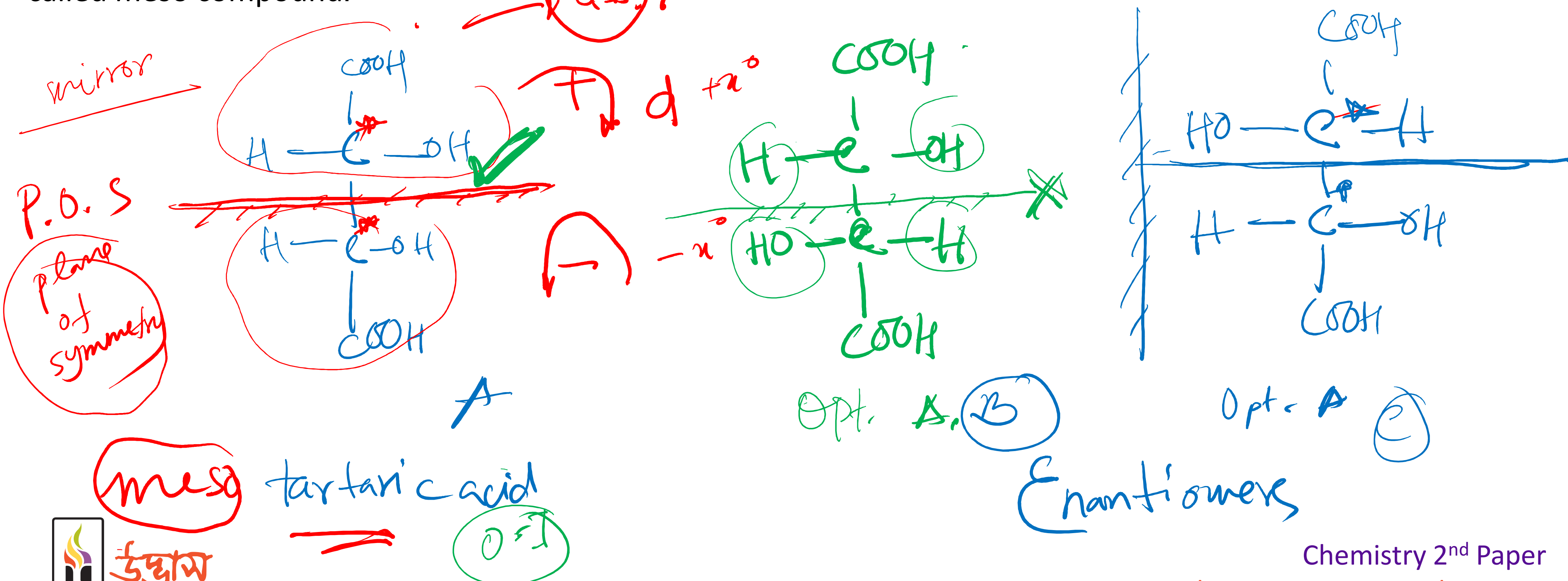
If two different optically active compounds with assymetric carbons are not mirror image of one another are called diasteromer of one another.

Two diasteromers rotate plane polarized light in the same direction but in different angles. They cannot form racemic mixture.



Meso Compounds

In a compound even though there is presence of chiral carbon, if one portion of the compound neutralizes the other portion's optical activity/rotation of plane polarized light and the compound is optically inactive, it is called meso compound.



লেগে থাকো সৎ ভাবে,
স্বপ্ন জয় তোমারই হবে।