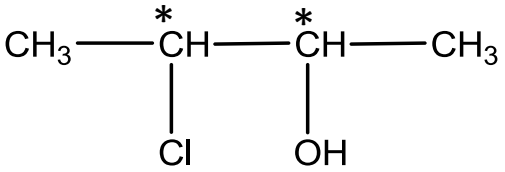
Optical Isomerism

Isomerism of Organic Molecules: Two chiral centers

Many organic compounds have more than one asymmetric carbon. The more asymmetric carbons a compound has, the more number of stereoisomers are possible for the compound.

Two asymmetric carbons



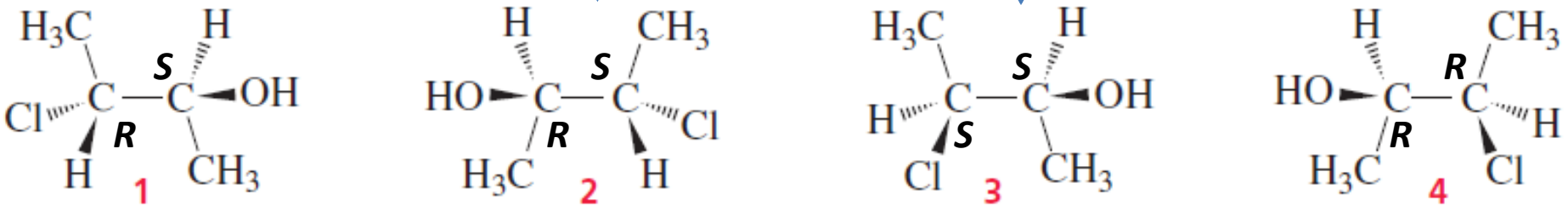
3-chloro-2-butanol

maximum number of stereoisomers one can draw for *3-chloro-2-butanol*

Only one Configuration will be opposite

No mirror image relation

Diastereoisomers



Enantiomers

nonsuperimposable mirror image

Both Configuration will be opposite

Enantiomers

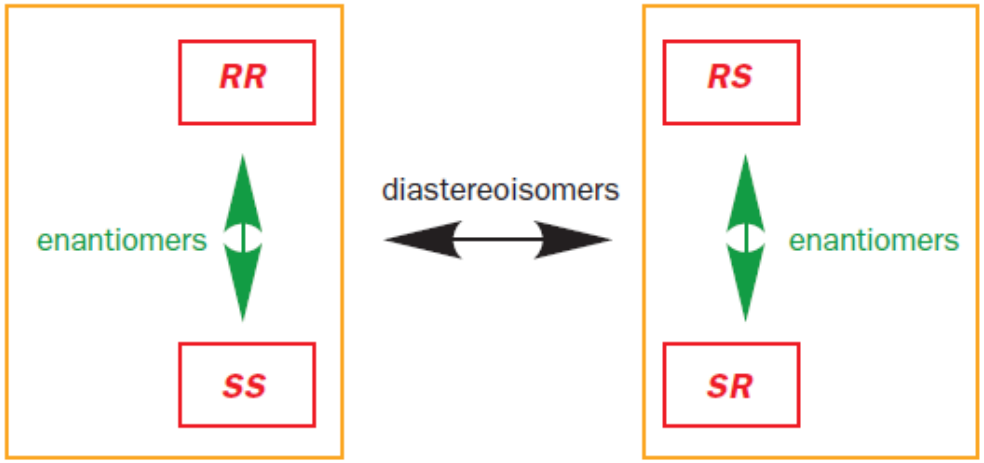
nonsuperimposable mirror image

Both Configuration will be opposite

maximum number of stereoisomers = 2^n ; n= number of asymmetric carbons

Isomerism of Organic Molecules: Two chiral centers

Compounds having 2 chiral centers/ asymmetric carbons
Maximum number of isomers will be = $2^n = 2^2 = 4$
Configurations of isomers are: ***R, R*** ***R, S*** ***S, R*** ***S, S***



Both/all Configuration will be opposite for pair of enantiomers

one Configuration will be opposite for pair of diastereoisomers

The maximum number of diastereoisomers = $2^{(n-1)}$

What are the difference between diastereoisomers and enantiomers?

Diastereoisomers:

different physical properties (different melting points, different boiling points, different solubilities, different specific rotations, and so on)

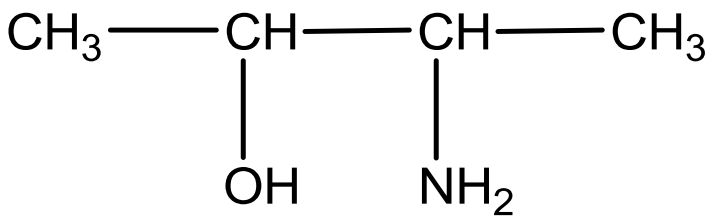
different chemical properties—they react with the same achiral reagent at different rates.

Enantiomers:

identical physical properties (except for the way they interact with polarized light)

identical chemical properties—they react at the same rate with a given achiral reagent.

Isomerism of Organic Molecules: Two chiral centers

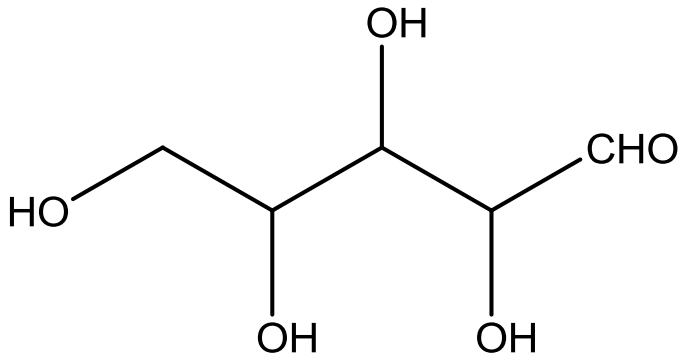


Provide the structures of all the possible isomers for the above compound

Isomerism of Organic Molecules: Three chiral centers

What is the maximum number of stereoisomer possible for the following molecule?
How many maximum number of diastereomers are possible?

Write the configuration of all the isomers.



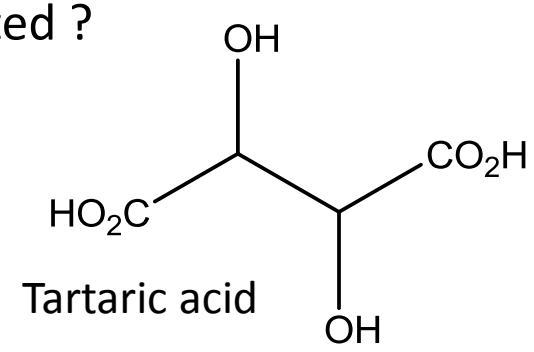
Isomerism of Organic Molecules: Two chiral centers

How many isomers are expected ?

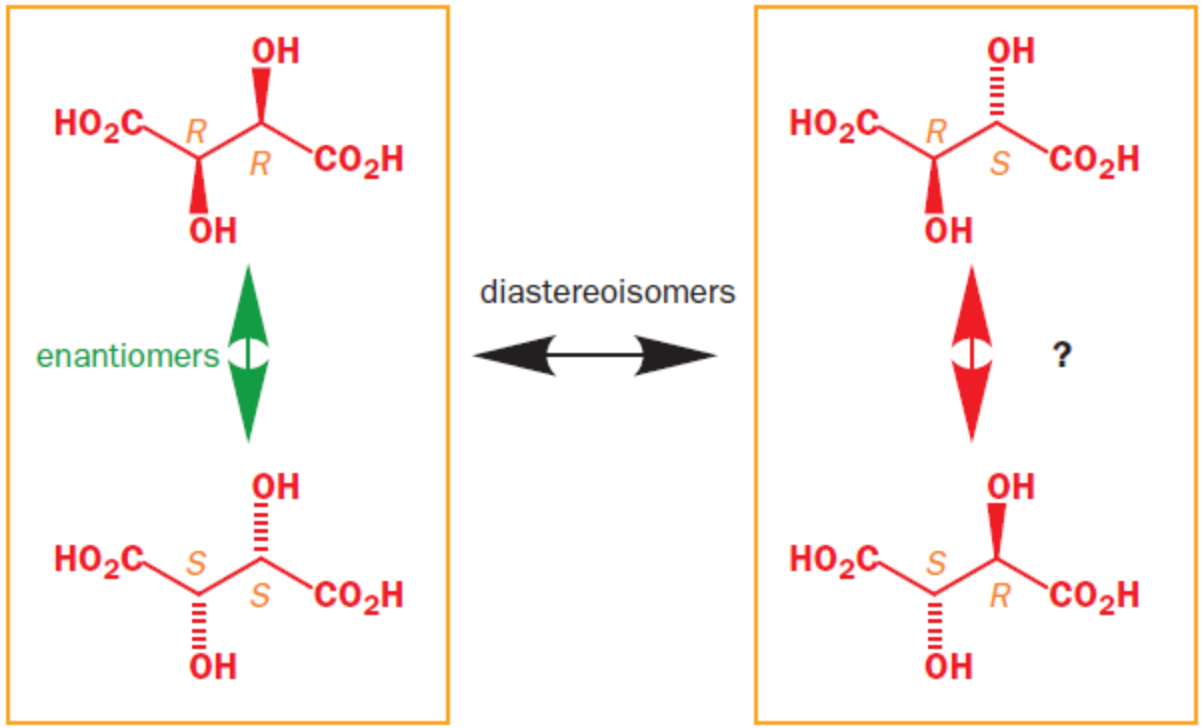
It has two stereocentres

so expected number of isomers = 2^2 = 4 stereoisomers

two diastereoisomers, each has a pair of enantiomers

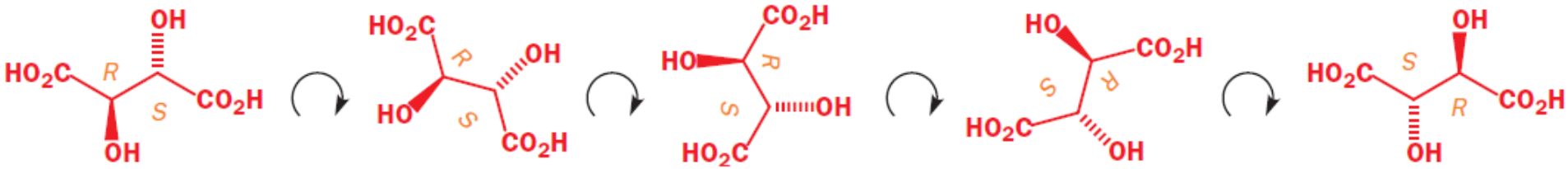


Tartaric acid

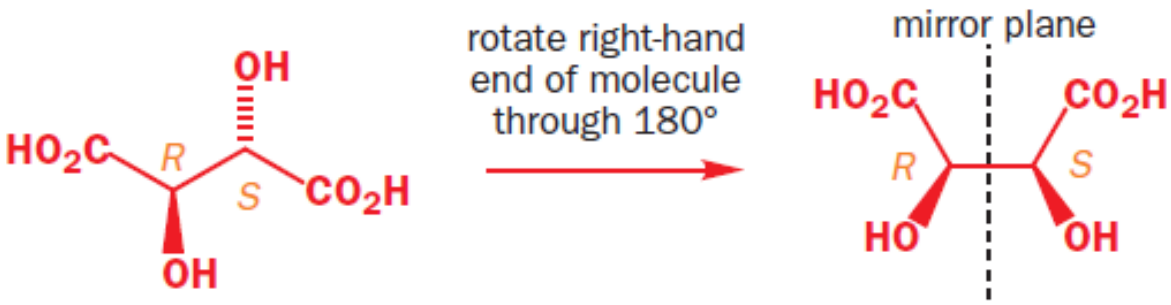


R,S-Tartaric acid and S,R-tartaric acid are not enantiomers

but they are identical



Isomerism of Organic Molecules: Two chiral centers



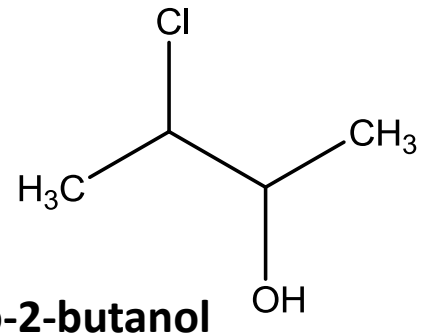
R,S-Tartaric acid and S,R-tartaric acid are achiral

Will not show optical activity

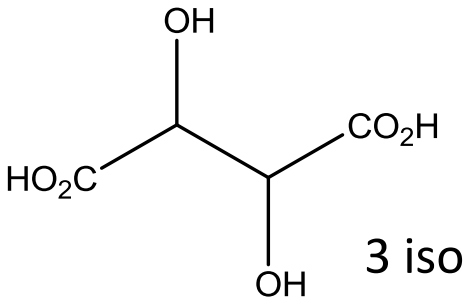
Compounds that contain stereocentres but are themselves achiral are called ***meso*** *compounds*

Total number of isomers = 3; number of diastereoisomer = 2

4 isomers

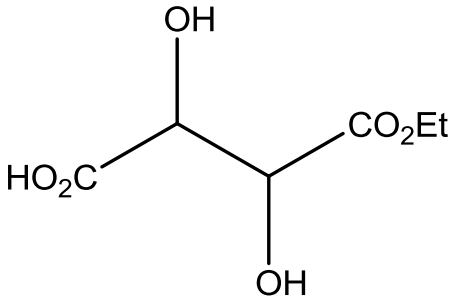


3-chloro-2-butanol



Tartaric acid

3 isomers

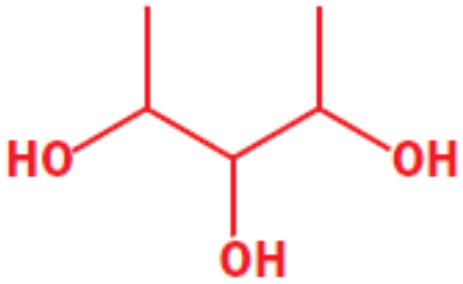


How many?

1. Both have two stereocenters
2. As compared to 3-chloro-2-butanol**,** both stereocenter of Tartaric acid have **same groups**

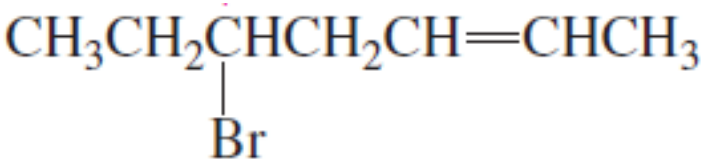
Isomerism of Organic Molecules: Three chiral centers

What is the maximum number of stereoisomer possible for the following molecule?



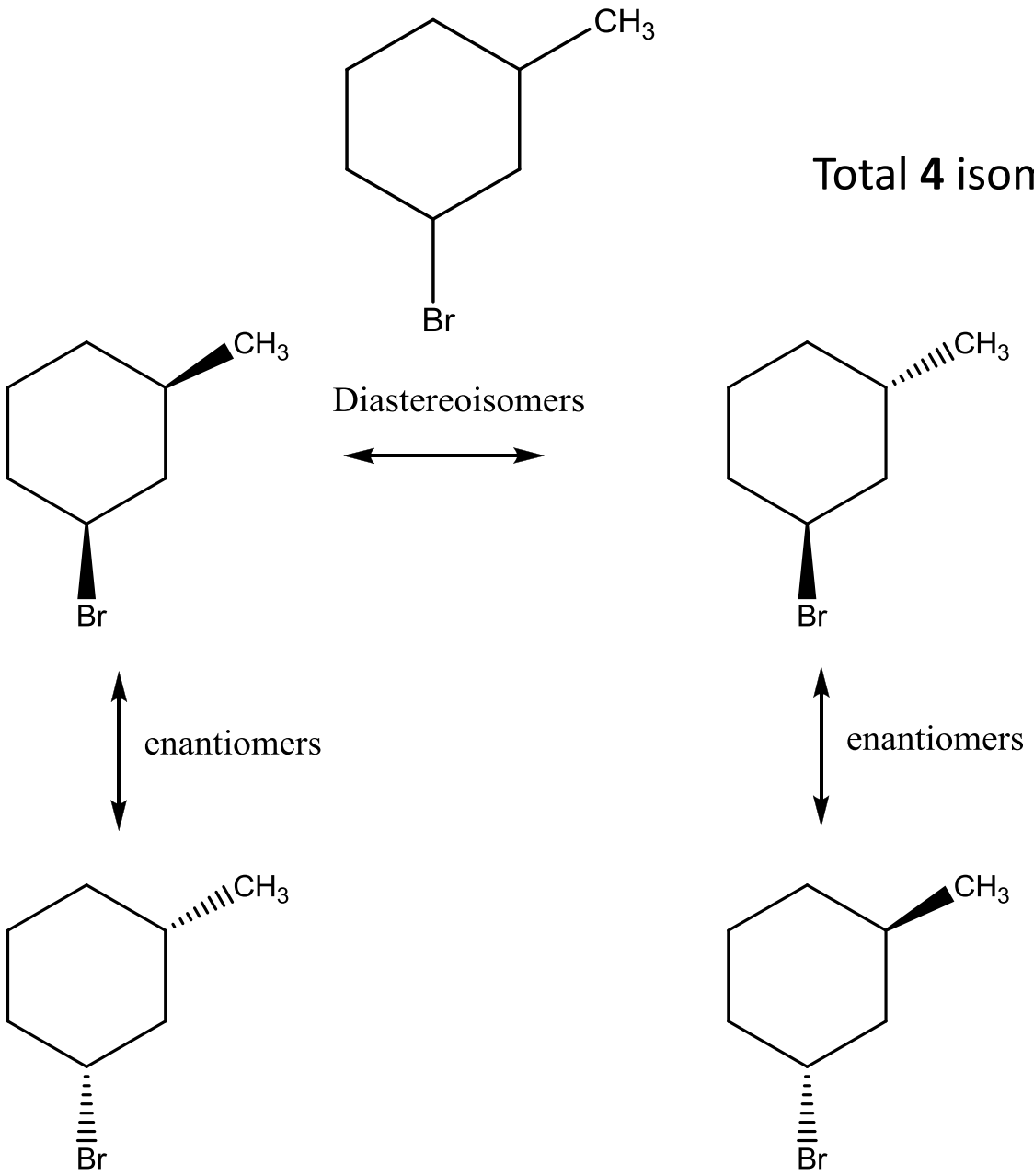
1. Draw the compound with the carbon skeleton in the usual zig-zag fashion
2. Identify the chiral centres
3. Decide how many diastereoisomers there are by putting the substituents at chiral centres up or down
4. Check for the possible planes of symmetry to see which diastereoisomers are chiral
5. Draw the enantiomers of chiral diastereoisomer by inverting *all* the stereogenic centres
6. Count the total number of isomers

Isomerism of Organic Molecules: Chiral centers and alkene

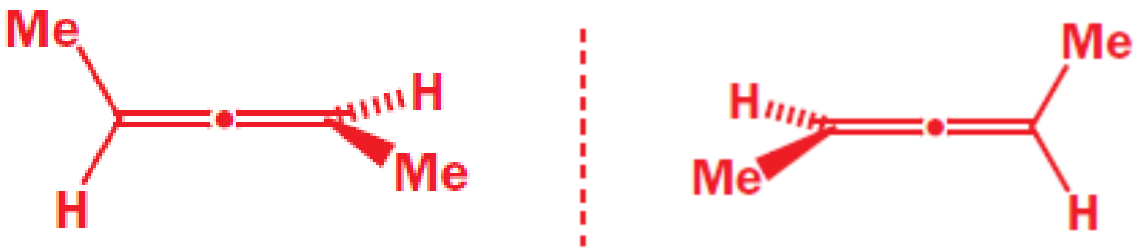


Number of isomers possible for the above compound is = 4

Isomerism of Organic Molecules: Chiral centers in cyclic structure

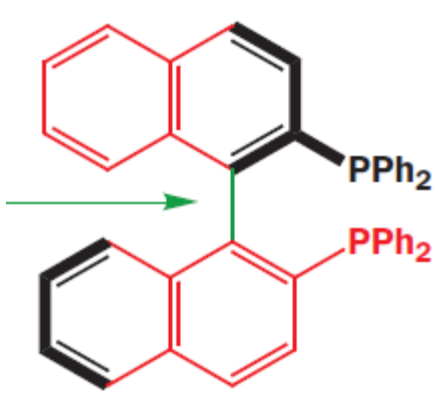


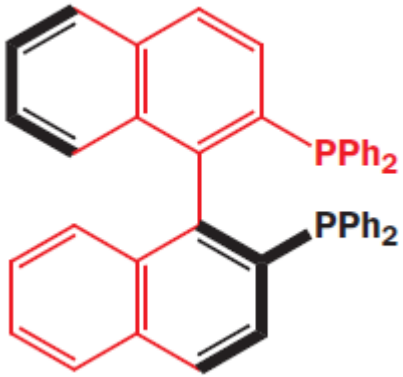
Isomerism of Organic Molecules: Without Chiral centers



The molecule does not contain chiral center but the molecule is chiral this is called axial chirality

steric hindrance means rotation about this bond is restricted

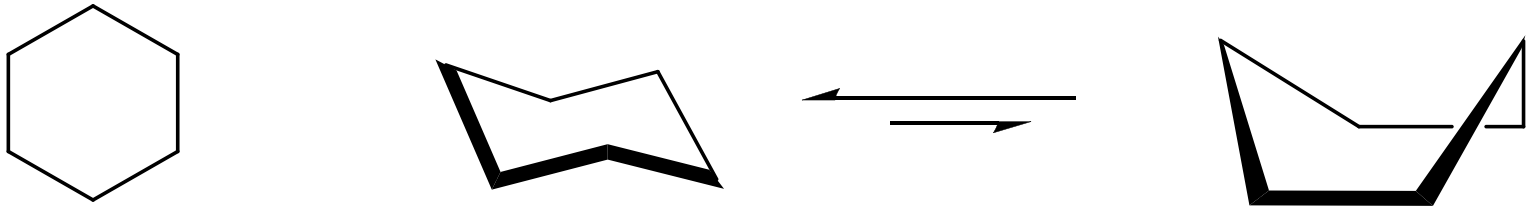




Isomerism of Organic Molecules: Configuration and conformation

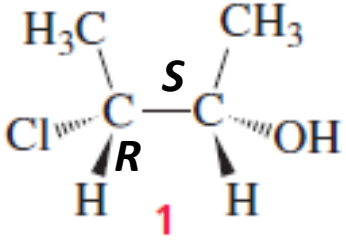
The different spatial arrangements of the atoms results from rotation about a single bond or via ring flipping are called **conformations**

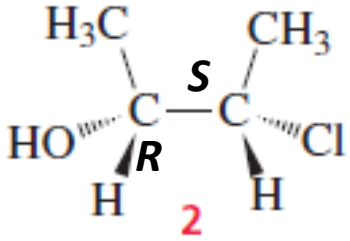
Interconversion of conformational isomers does not involve bond breaking and bond making.



Cyclohexane | Chair conformation | Boat conformation

Interconversion of isomers that involve bond breaking and bond making are called configurational isomers





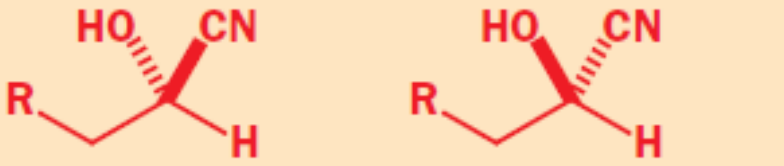
Compounds **1** and **2** can not be Interconverted by simple C-C bond rotation

compounds **1** and **2** are configurational isomers

compounds **1** and **2** are enantiomers

Isomerism of Organic Molecules: Configuration and conformation

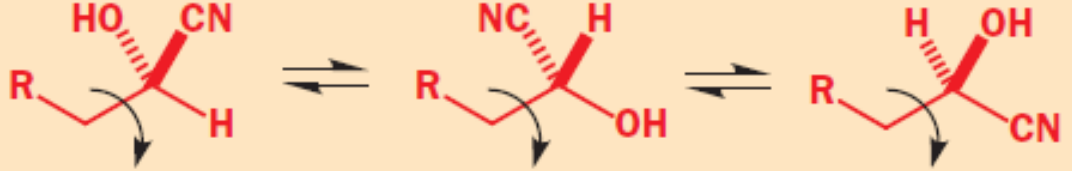
- **Changing the *configuration of a molecule always means that bonds are broken***
- **A different configuration is a different molecule**
- **Changing the *conformation of a molecule means rotating about bonds, but* not breaking them**
- **Conformations of a molecule are readily interconvertible, and are all the same molecule**



two configurations: going from one enantiomer to the other requires a bond to be broken

Configuration changes

Configuration remain unchanged

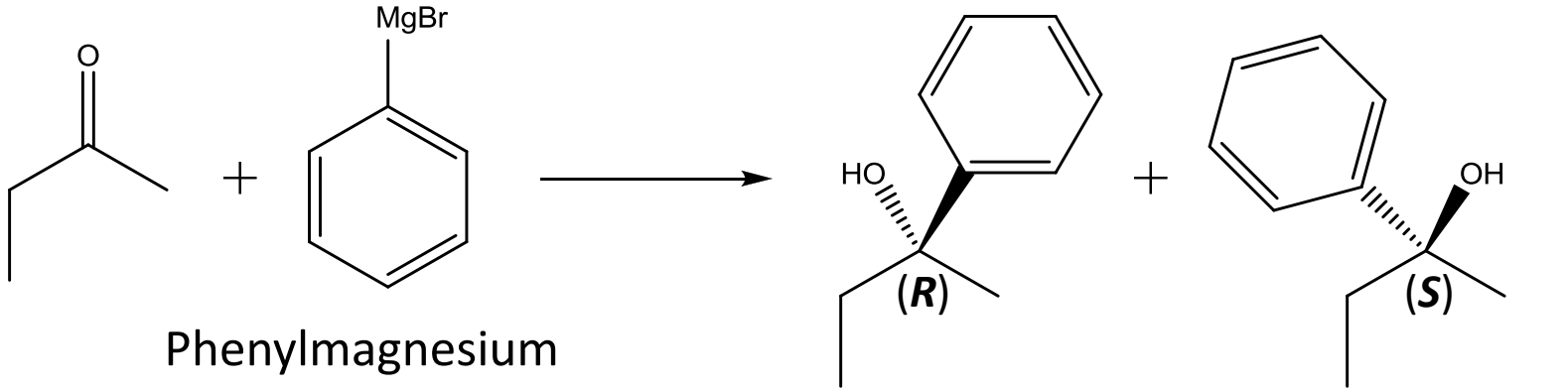


three conformations of the same enantiomer: getting from one to the other just requires rotation about a bond: all three are the same molecule

Stereoisomers and Stereoselectivity

Stereochemistry of a reaction refers to the formation of two or more stereoisomers

Grignard reactions



Phenylmagnesium bromide

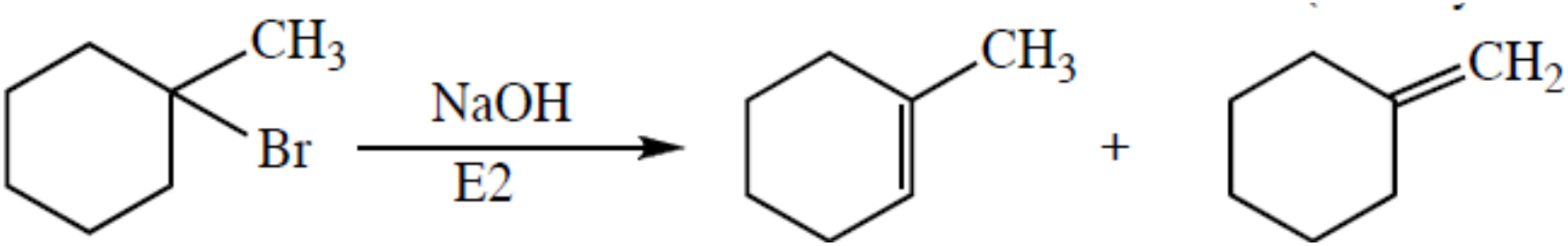
Addition from front side

Addition from back side

The selectevity in forming of one stereoisomer compared to others is called Stereoselectivity

Regioisomer and Regio-selectivity

Regiochemistry of a reaction refers to the formation of two or more isomeric products involving two or more similar regions of the reactant



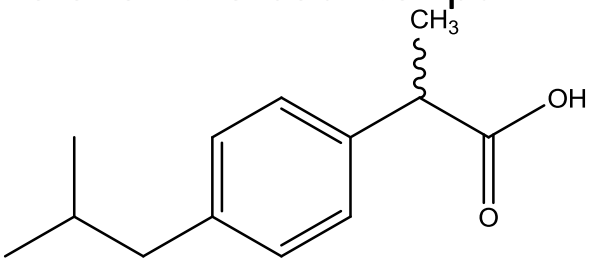
regio-isomers

The isomers formed are called regio-isomers

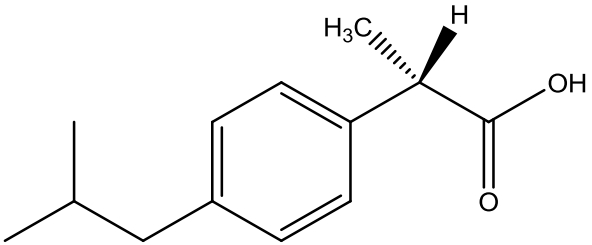
The selectivity of formation of one regio-isomer compared to others is called regio-selectivity

Significance of Chirality in Medicine

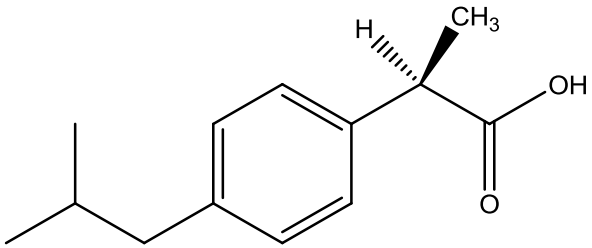
The over-the-counter painkiller **ibuprofen**



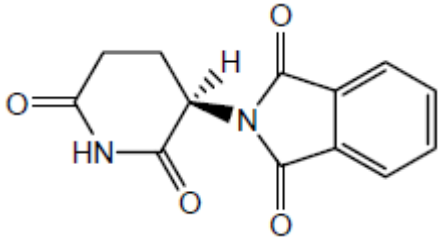
Racemic (1:1 mixture of ***R*** & ***S***)



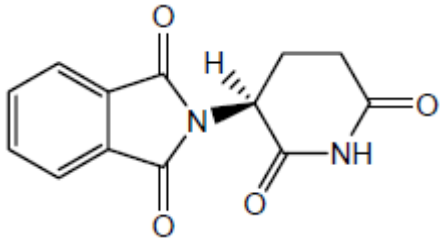
(***S***)-ibuprofen: **Active drug**



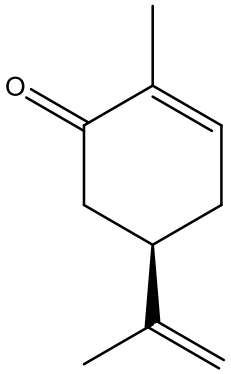
(***R***)-ibuprofen: **Inactive**



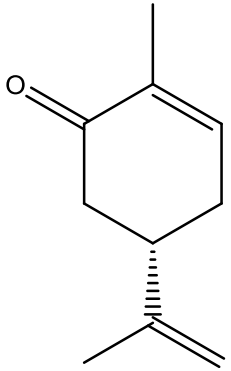
(R)-Thalidomide: Relieves anxiety



(S)-Thalidomide: TOXIC



(***R***)-Carvone: smells like **spearmint**



(***S***)-Carvone: smells like **caraway**

The two enantiomers interact differently with smell receptor proteins in your nose generating the transmission of different chemical signals to brain.

Looking forward

Pericyclic Reaction

Course material will be uploaded **after 17:00** h on **every Friday** @

http://www.iitg.ac.in/ckjana/ckjana/Teaching.html