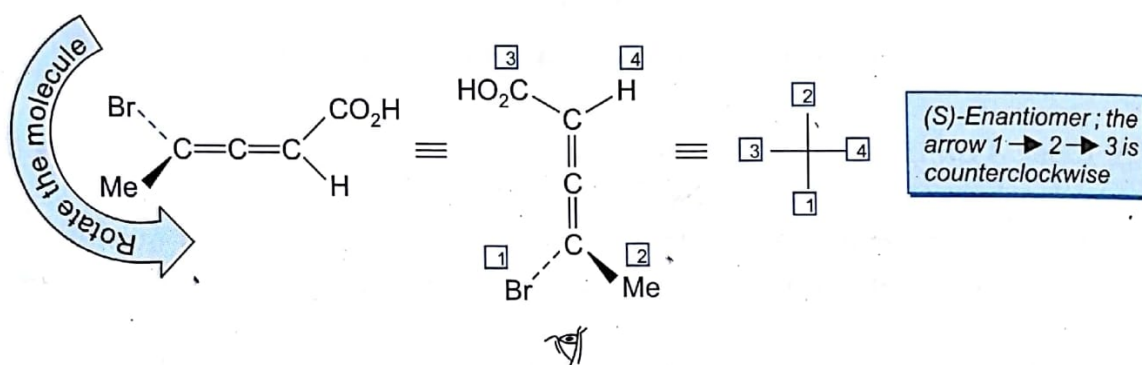


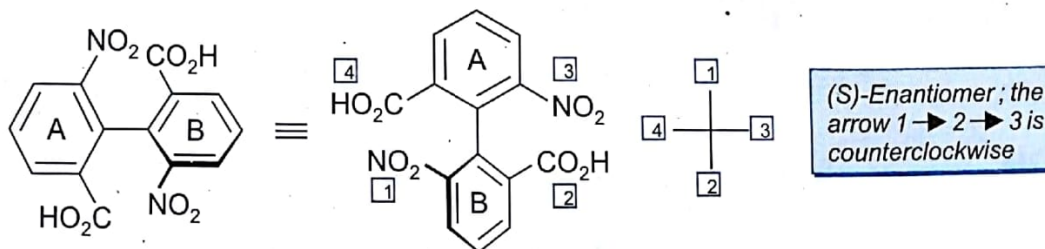
- Put the groups of the bottom pair (perpendicular to the plane of paper) on the vertical line of the cross with the group on the thick line (*i.e.*, the group at the front) at the top while the group at back (*i.e.*, the group on dotted line) at the bottom of the vertical line.
- The sequence $1 \rightarrow 2 \rightarrow 3$ clockwise show *R* configuration while $1 \rightarrow 2 \rightarrow 3$ anticlockwise shows *S* configuration.

Example 1. Consider (scheme 1.133b) the enantiomer considered here is the same as (I, scheme 1.133a). Thus if the orientation (scheme 1.133b) is rotated anticlockwise around the axis defined by the three allenic carbons the COOH group on left and H on right occupy the plane of paper while Br and Me become perpendicular to give the same enantiomer (scheme 1.133b).



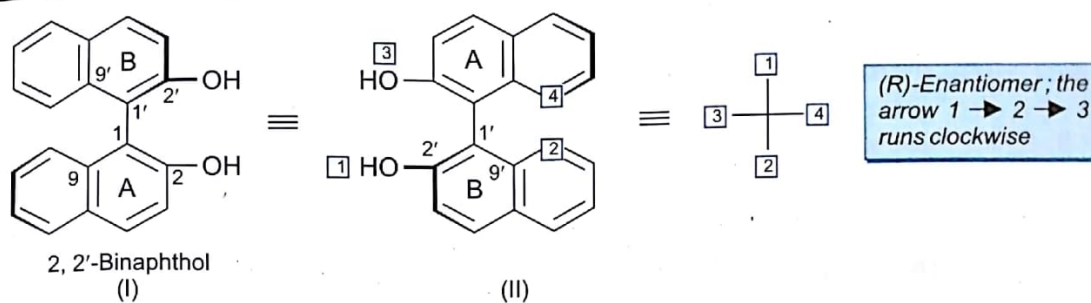
SCHEME 1.133b

Example 2. Consider one of the enantiomers of a chiral biphenyl by considering the relevant *ortho* groups (scheme 1.133c). One turns the molecule so as to put the ring A (in the plane of paper) at top while ring B which is perpendicular to ring A at the bottom. Looking from bottom and assignment of priorities to the *ortho* groups shows that it is *S* enantiomer. The NO₂ group in ring B is on a thick portion of the molecule so it is at the top of vertical line of the cross.



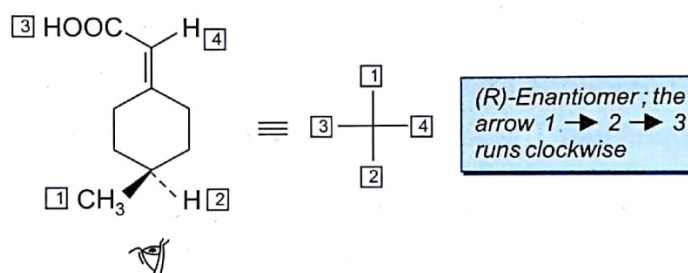
SCHEME 1.133c

Example 3. The configuration of one of the enantiomers of 2, 2'-binaphthol (I, scheme 1.133d) is to be determined. This will be with reference to the carbons C2, C9 and C2' and C9'. One looks along C1 and C1' bond, by first turning the orientation so that as drawn, the ring system A (in the plane of the paper) is at top while the ring system B perpendicular to it is at bottom (I \rightarrow II, scheme 1.133d). As in other cases the molecule is viewed from bottom and priorities are assigned. The configuration comes out to be *R*.



SCHEME 1.133d

Example 4. A similar procedure is applied to cyclic molecules with an exocyclic alkylidene moiety *e.g.*, (scheme 1.133e). This system has two different groups at C4 of the cyclohexyl ring while two different groups are present at the π bond. The cyclohexyl "arms" (ring residues) are in the plane of the π bond and COOH and H group along with the cyclohexyl arms are in the plane of paper and are already at the top. The CH_3 and H at C4 of the cyclohexane ring are in a different plane and these constitute the bottom. The molecule when viewed from bottom with assigned priorities come out to have R configuration.



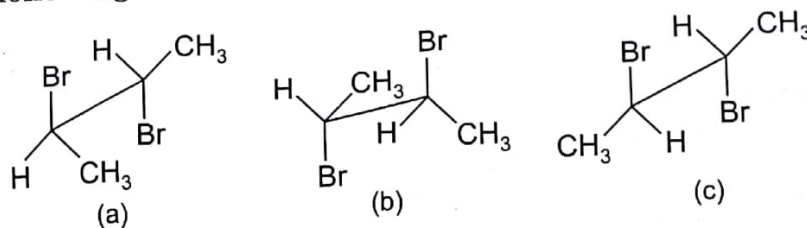
SCHEME 1.133e

(D) Helical Descriptors *M* and *P* for Molecules with Chiral Axes

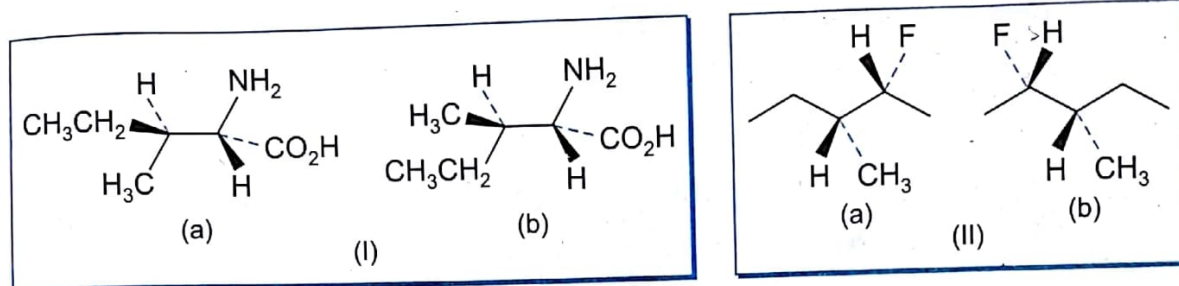
The perpendicular segment of the substituents about the chiral axis (stereoaxis) means that such compounds like, allenes, biphenyls, alkylidenecycloalkanes, etc. have very short helical segments and their configuration may be denoted as *P* or *M* (as for compounds which are chiral due to helical structure). For the assignment of helix descriptors only the groups of highest priority nearer to the view direction and the far are considered. The considered, ligands are 1 and 3. In case the turn from priority front group 1 to priority rear group 3 is clockwise. The stereodescriptor is *P*, if anticlockwise it is *M*. Thus (*S*)-2, 3-pentadiene (II, scheme 1.128) is *aS* (chiral axis nomenclature) or *P* (helix nomenclature). The correspondence of *aR* with *M* and *aS* with *P* is general.

One has seen that the smallest carbocyclic ring that can incorporate a double bond with trans-geometry is eight membered (see schemes 1.54 and 1.137). Similarly the smallest sized ring which can contain an allene has nine carbons. One enantiomer of this compound of cyclonona-1, 2-diene (scheme 1.133f) has the *S* configuration as arrived by adopting third method or *P* configuration (helix nomenclature).

1.9. How are the following conformations of 2, 3-dibromobutane related with one another?

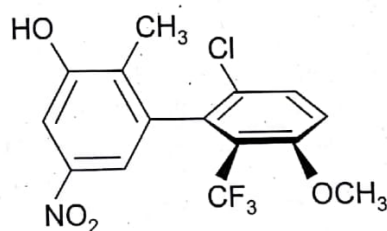


1.10. What is the stereochemical relationship, (enantiomers or diastereomers) between each of the pairs (I and II)?

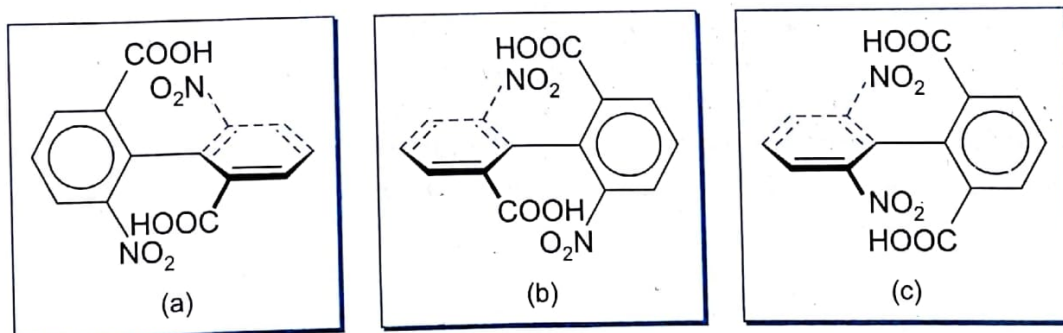


1.11. Butane on monochlorination gives a mixture of 1-chloro and 2-chlorobutane. Comment on their chirality by writing their stereostructures.

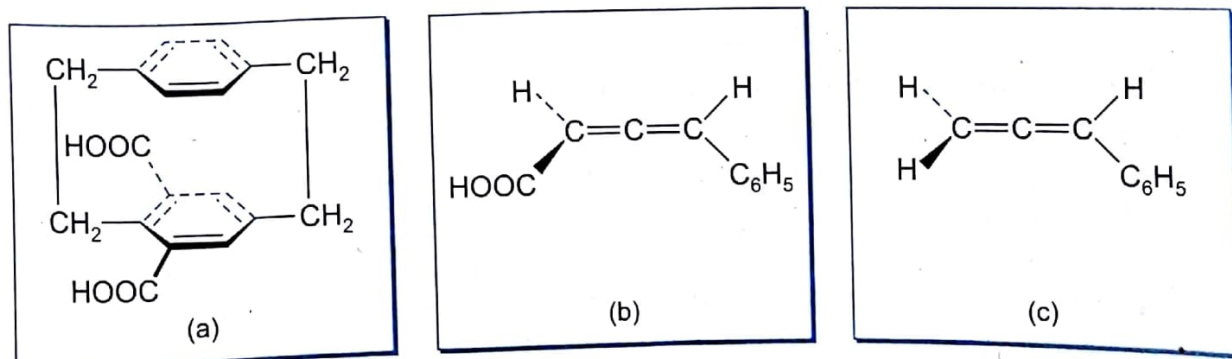
1.12. The following biphenyl is chiral. Designate its configuration.



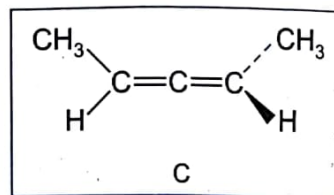
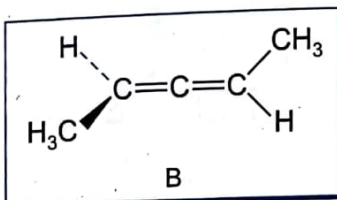
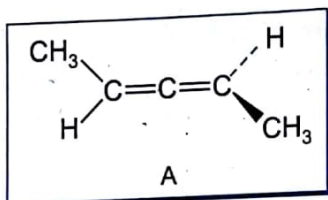
1.13. Comment on the chirality (optical isomerism) of the following biphenyls.



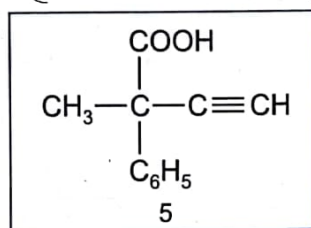
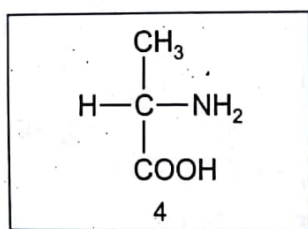
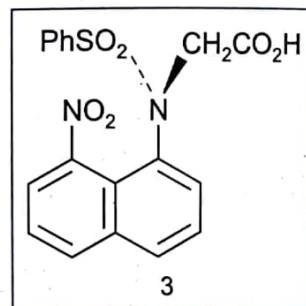
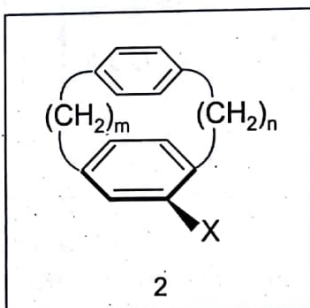
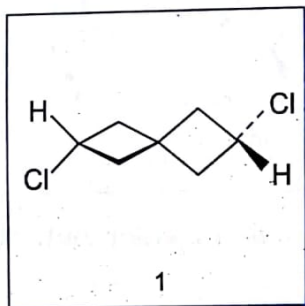
1.14. Which of the following molecules are chiral.



1.15. Comment on the identity and chirality of the following structure of penta-2, 3-diene.

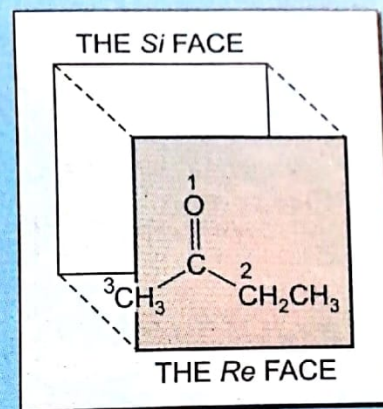


1.16. Label each compound as either having center, axes or planes of symmetry. How the chirality of compounds 2 depends on m , n , and x . Assign the order of priorities to individual ligands in compounds 4 and 5.



CHAPTER 2

Prochirality—Prostereo- isomerism and Asymmetric Synthesis



2.1 INTRODUCTION—NOMENCLATURE

(A) Prochiral Center—Prochiral Molecules

A tetrahedrally bonded atom (of an achiral compound) of the general formula C_{abc_2} (as in propionic acid) which becomes a stereocenter C_{abcd} and the compound becomes chiral on replacement of one of the identical groups with a different group d is called a prochiral center and the molecule as prochiral. This situation is available in the molecule of propionic acid.

A chiral molecule C_{abcd} with four different groups attached to the carbon is said to have a stereogenic center or simply a stereocenter, the term is preferred to a "chiral center". However, a prochiral molecule (like propionic acid) is said to have a prochiral center, the term "prostereogenic center" or simply "prostereocenter" is not yet widely used.

Prostereoisomerism/prochirality is the property of certain molecules due to which these can be converted into stereoisomers (enantiomers or diastereomers).

In a molecule like propionic acid (scheme 2.1) the carbon atom marked C_α is not a stereocenter (or one may put it as C_α is a nonstereogenic carbon since a carbon atom that is a stereocenter is also called a stereogenic carbon). The carbon C_α can be made a stereocenter by replacing one or other of the two apparently identical ligands (in this case the ligands are two H atoms of the methylene group) in turn by a different ligand e.g., OH to give enantiomeric products (*S*)-lactic acid and (*R*)-lactic acid.

Prochirality and Prostereoisomerism

The molecules which have stereoheterotopic ligands e.g., propionic acid are prochiral molecules. These display prochirality so that appropriate replacement of such ligands, in turn in an achiral precursor leads to chiral products. Recall that a stereocenter may also be trigonal planar (see scheme 1.3) thus a prostereocenter may not necessarily be a prochiral center (see scheme 2.9). The cis-trans isomers of alkenes and certain cyclanes display stereochemical differences (diastereoisomerism) without being chiral. In cyclobutanol C3 center bearing H^e and H^f hydrogens is prostereogenic (a prostereocenter) and not prochiral, thus C3 in cyclobutanol exhibits prostereoisomerism and not prochirality. "Prostereoisomerism" is a more general term.

A summary of topic relationship

Topicity	Substitution-addition criterion	Symmetry criterion	Difference
Homotopic	Identical product	Ligands related through C_n and faces by C_2 axis	No difference by any method
Enantiotopic	Enantiomeric products	Ligands (faces) related through σ , i , or S_n	Distinguishable, in principle, in chiral media (NMR), by chiral reagents, and enzymes
Diastereotopic	Diastereomeric products	Ligands and faces not related by any symmetry element	Distinguishable, in principle, by all methods

Homomorphous ligands will be homotopic if the operation of the symmetry axis make the nuclei in question interchange places. Thus in 1,3-dioxolane (I, scheme 2.13d), the hydrogen atoms at C(2) are homotopic since they are interchanged by operation of the C_2 axis. On the other hand, the geminal hydrogen atoms at C(4), or C(5), are not interconverted by the C_2 symmetry operation and are thus heterotopic (H_A with respect to H_B and H_C with respect to H_D). However, H_A and H_D are homotopic (as are H_B and H_C), since these are also interchanged by the C_2 axis.

In monochloroallene (II) and paracyclophane (III) only one pair of enantiotopic H's is shown) H_a and H_b are enantiotopic, since replacement of either in turn with D gives

