ELEMENTS OF SYMMETRY

M.Sc. Sem. I
Paper : CC III
Unit : II (Stereochemistry)

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Elements of Symmetry

→ Whether the molecule — chiral / achiral
→ " " " — superimposable / non-superimposable on its mirror image.

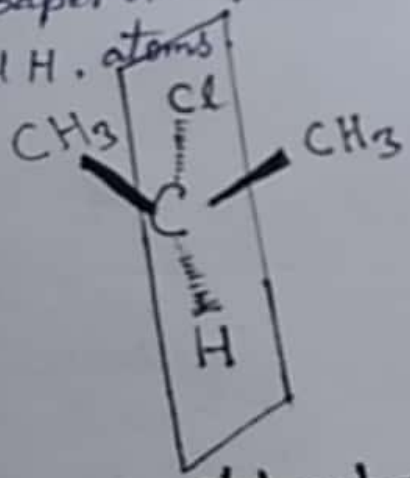
The superimposability of an object and its mirror image can be tested with the help of three elements of symmetry such as a plane of symmetry or a centre of symmetry or an alternating axis of symmetry.

Chiral molecules donot have any elements of symmetry.

Achiral molecules have at least one or more elements of symmetry.

(i) Plane of symmetry : A plane of symmetry is defined as an imginary plane which divides the molecule into two equal halves such that one half of the molecule into two equal halves such that one half of the molecule is a mirror image of the other.

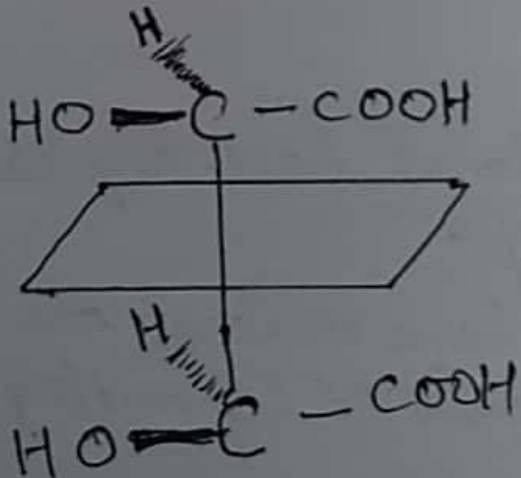
For Example : 2-chloropropane has plane of symmetry which is perpendicular to the plane of the paper and passes through Cl, C and H. atoms



2-chloropropane

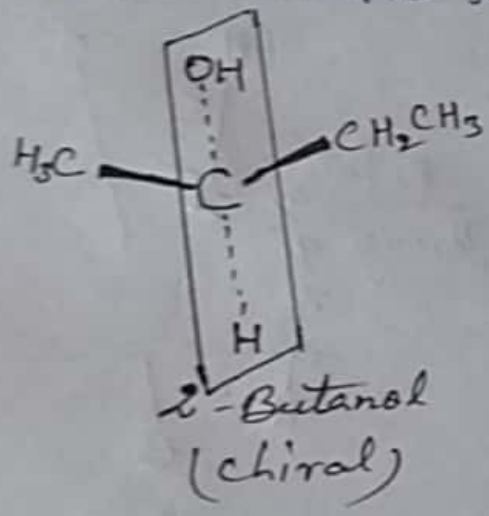
Another Example :

meso-tartaric acid has a plane of symmetry which is perpendicular to the plane of the paper and passes through midpoint of C-C bond. both molecules are Achiral.

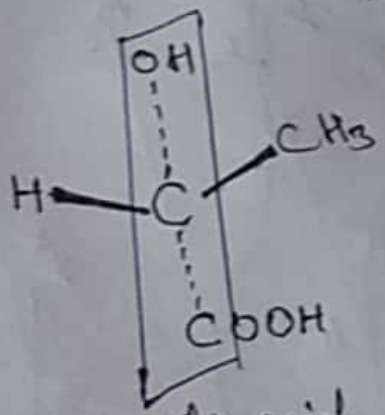


(mesotartaric acid)

Another Example for Chiral (No plane of symmetry)



2-Butanol
(chiral)

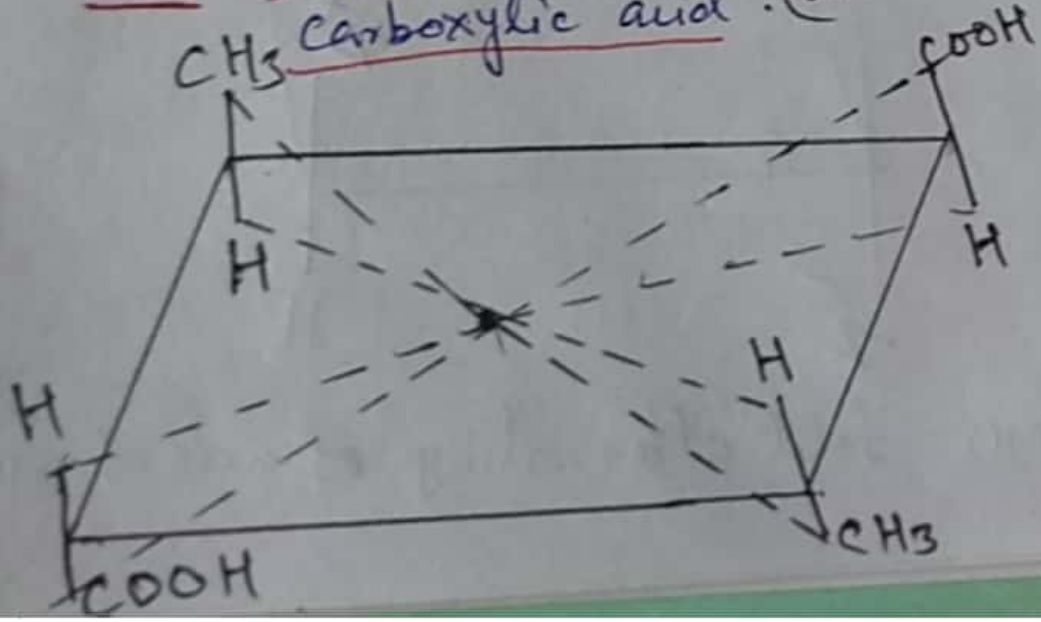


Lactic acid
(Chiral)

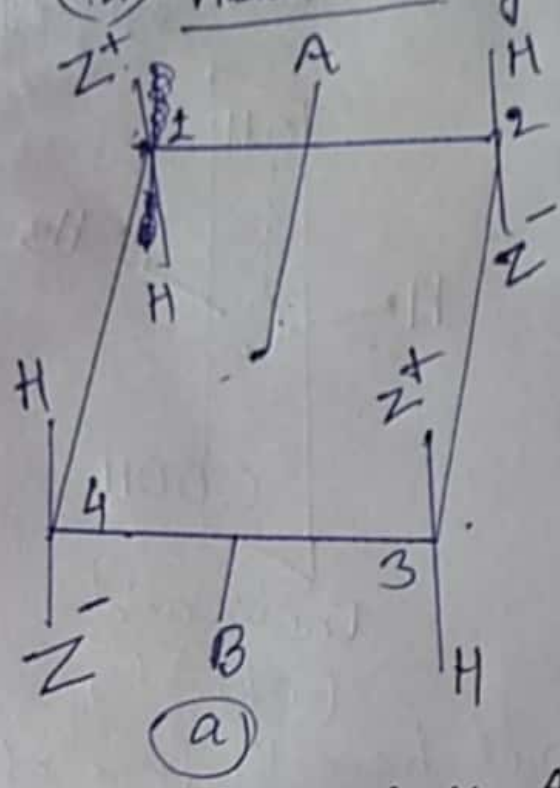
Both molecules donot have the plane of symmetry and hence are Chiral.

(ii) Centre of symmetry: It is defined as a point from which lines, when drawn on one side and produced an equal distance on the other side, will meet identical points.

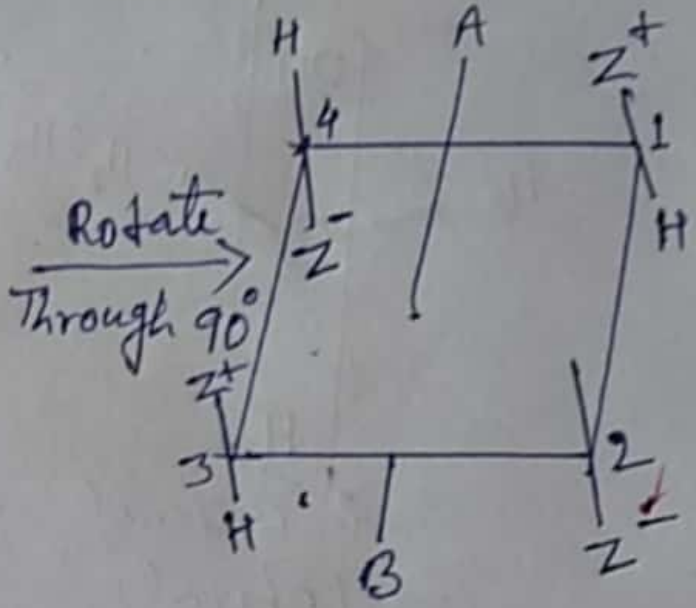
e.g. 2, 4 dimethylcyclobutane-1,3 di carboxylic acid. (an achiral molecule)



(iii) Alternating axis of symmetry :—

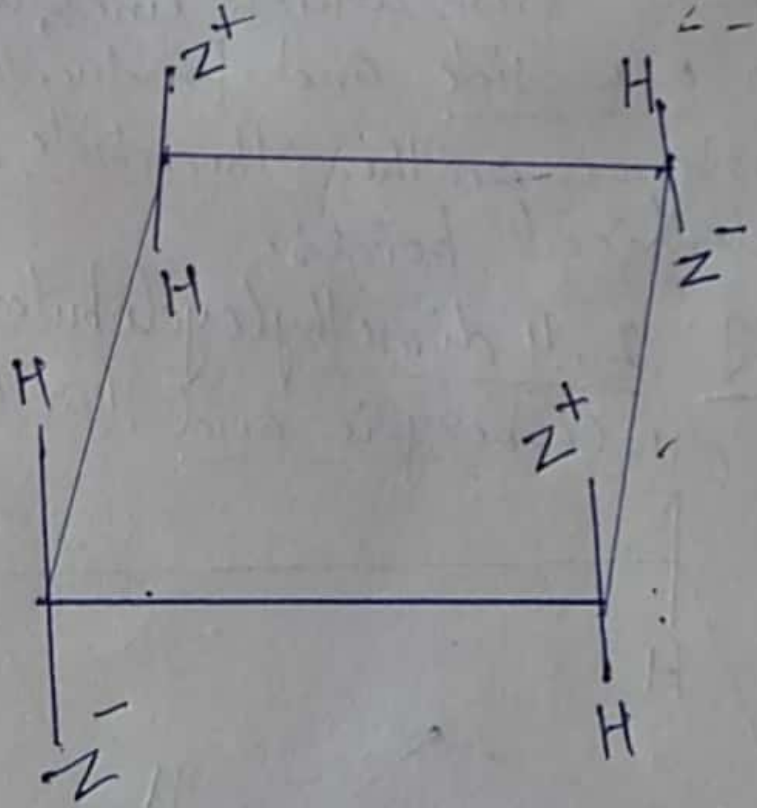


(a)



(b)

Reflection through
A plane perpendicular
to axis AB. →



Four. fold alternating ~~of~~ axis of Symmetry.

(iii) Alternating axis of symmetry :- A molecule is said to be possess an n-fold alternating axis of symmetry if rotation through an angle of 360/n about this axis and then followed by reflection in a plane perpendicular to the axis gives a molecule which is indistinguishable from the original molecule. For Example, the molecule (a) as shown above in figure. Here Z^+ and Z^- represent chiral group such as (+) $-CH(CH_3)C_2H_5$ and (−) $-CH(CH_3)C_2H_5$ respectively. Rotation of molecule (a) through 90° about axis AB which passes through centre of the ring and perpendicular to its plane, gives molecule (b). The reflection of (b) gives the original molecule (a). Thus this molecule has a four-fold ($360°/90° = 4$) alternating axis of symmetry and hence is Achiral.