GROUP THEORY

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Group Theory

- **Mathematical study of symmetry is called Group theory**

- **Symmetry Element**– A symmetry element is a geometrical entity such as a point, a line or a plane about which a symmetry operation is performed.

- **Symmetry operation**– A symmetry operation is a movement such as inversion about a point, rotation about a line or a reflection about a plane in order to get an equivalent orientation

- An **equivalent orientation** is an orientation similar to the original orientation but not the identity.

Equivalent
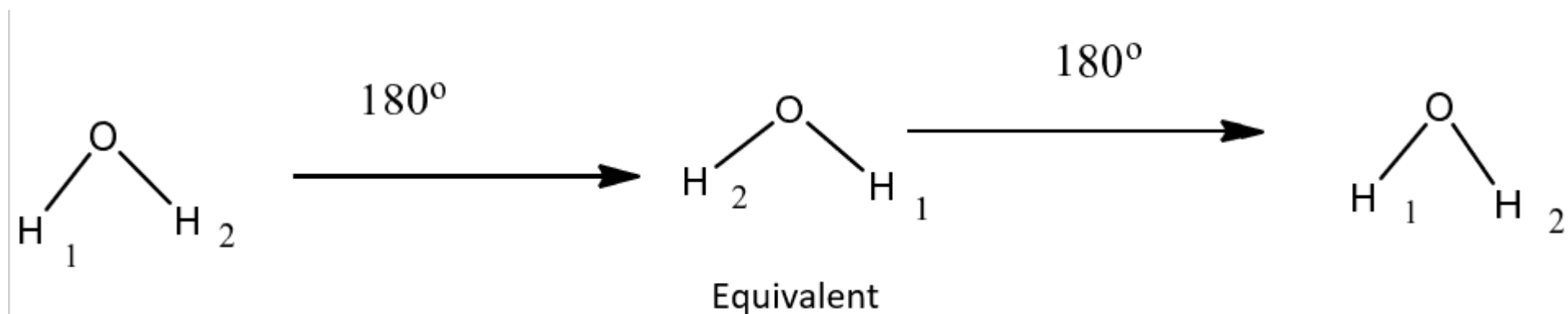
Symmetry Element

| Element	Symmetry Operation	Symbol
	Identity	E
Proper axis	Rotation by $2\pi/n$	C_n
Plane of symmetry	Reflection	σ
Center of symmetry	Inversion	i
Improper axis of symmetry	Rotation by $2\pi/n$ followed by reflection perpendicular to the axis of rotation	S_n

- Identity, E

All molecules have Identity. This operation leaves the entire molecule unchanged. A highly asymmetric molecule such as a tetrahedral carbon with 4 different groups attached has only identity, and no other symmetry elements.

- **Centre of symmetry (i)**

It is a point within the molecule from which lines drawn to opposite direction meet similar points at exactly the same distance and direction.

1,2dichloro-1,2difluoroethane
(Staggered) C_i

Cl F H

i

F H Cl
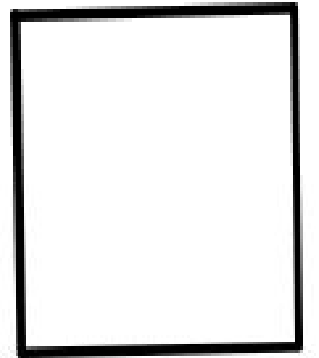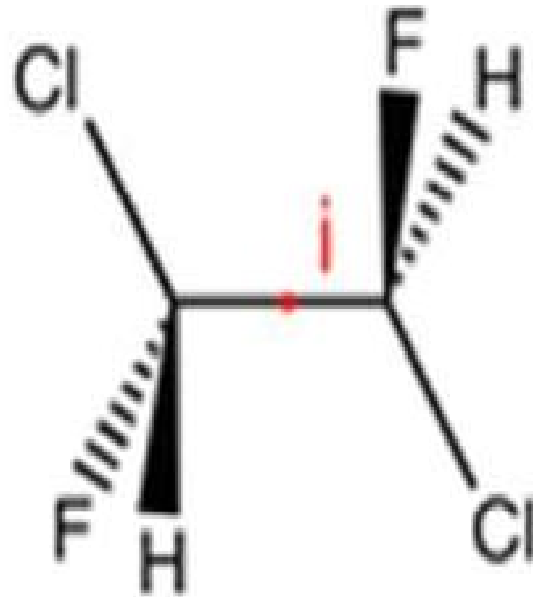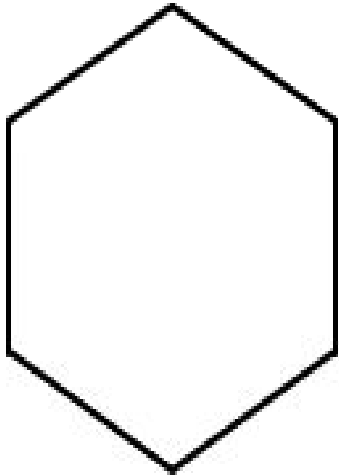
Proper axis of symmetry

It is an axis passing through the molecule about which the molecule is rotated through $360°$, if we get n times equivalent orientations the molecule has an n-fold axis of symmetry.

Equivalent
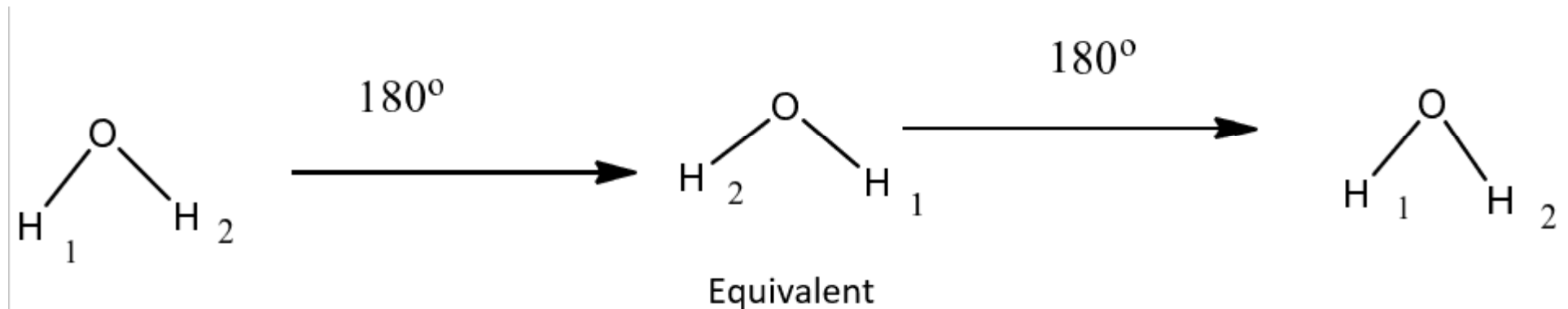
Principal axis

- If there are more than one axis of symmetry in many cases one of the axis is identified as principal axis. The selection will be on the following basis:-

1. Highest order axis
2. Unique axis
3. The axis passing through maximum no of molecule.
4. The axis perpendicular to the plane of the molecule

- The other axis are known as subsidiary axis

Plane of symmetry

- Plane of symmetry is a plane which divide the molecule into two equal halves such that one half is the mirror image of the other half.

- On the basis of the principal axis they are of two types vertical and horizontal plane.

- **HP**:-plane perpendicular to the principal axis(σ_h)

- **VP**:-plane which is along the principal axis or involving the principal axis (σ_v)