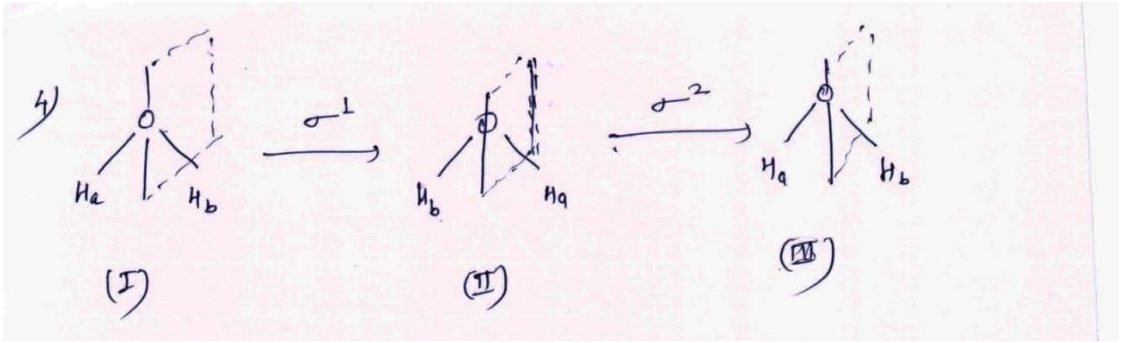
Plane of Symmetry

It is an imaginary plane within the molecule which bisects it into two equal half which are mirror image s of each other. A plane of symmetry exists when a reflection through the plane gives an equivalent configuration. Plane of symmetry is represented by σ.

Let us consider the example of water molecule. There exists a plane of symmetry for this molecule which contains oxygen atom and bisect the angle HOH as shown in figure.



We can see that the configuration II is equivalent to I as the reflection through the plane results in the exchange of the two hydrogen atoms. The atom of oxygen which lies in the plane is not shifted. We get an identical configuration III after carrying out one more operation of reflection.

From the above example we also find that carrying out the operation of reflection twice results in an identical configuration. When the operation carried out one more time, we get the configuration II.

In general we write

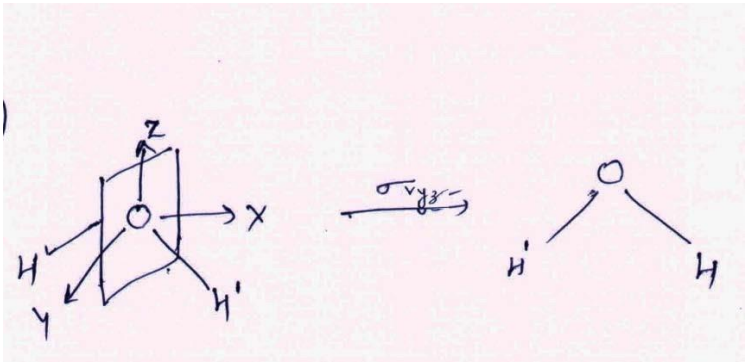
$\sigma^n = E$ {When n is even}

$\sigma^n = \sigma$ {When n is odd}

Types of plane of symmetry: the plane of symmetry can be divided into three types-

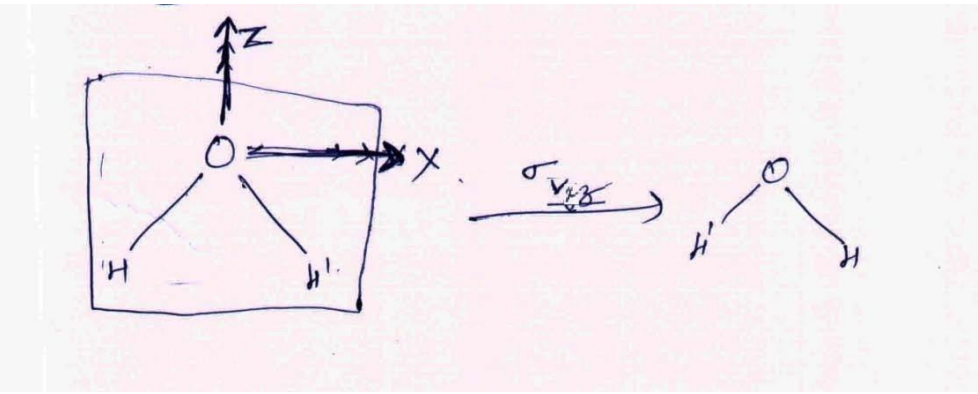
1) Vertical plane of symmetry (σ_v) - The plane passing through the principal axis and one of the subsidiary axis (If present) is called vertical plane of symmetry.
2) Horizontal plane of symmetry (σ_h) - The plane perpendicular to the axis is called horizontal plane of symmetry.
3) Dihedral plane of symmetry (σ_d) – The plane passing through principal axis but passing in between two subsidiary axes is called dihedral plane.

Water molecule has 2 planes of symmetry one in passing through O and in between 2 H atoms that is in yz plane



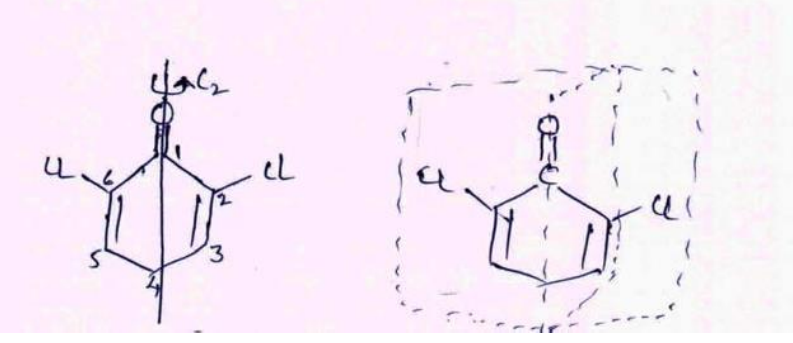
As this plane passes through C_2 axis which is principal axis in case of H_2O molecule so this plane is a vertical plane and it is represented as σ_{yz}. The other isthe molecular plane passing through O and 2 H atoms in XZ plane. This plane also

passes through C_2 axis so it is called as σv_{xz}.



The ammonia molecule has three σ_v, each passing through N atom and one of the H atoms and bisects the H-N-H angle. The BF_3 molecule, with trigonal planar geometry has a C_3 axis and has four planes of symmetry. Out of these four planes three planes passing through C_3 axis and one of the C_2 axis, can be represented as σ_v. The molecule has also a plane of symmetry which is perpendicular to C_3 axis represented as σ_h.

Consider the example of 2,6- dichloro benzophenone.



As shown in figure the molecule possesses C_2 axis and it is the only axis of symmetry so it is principal axis. The two planes of symmetry the molecular plane and the plane containing the oxygen atom and bisects the angle between the carbon

atom 2, 1 and 6 containing the principal axis and hence are vertical planes of symmetry σ_v. So in this molecule horizontal plane of symmetry is absent.

There is one more kind of plane of symmetry σ_d, The dihedral plane of symmetry. These are the planes which bisects the angle between two adjacent subsidiary axes. The molecule of allene as shown in figure has two dihedral planes of symmetry.