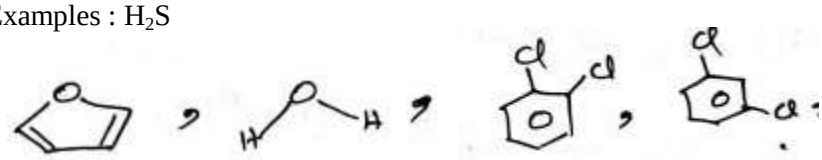
Point Group syllabus : C_{2v}, C_{3v},C_{2h}, D_{2h}, D_{3h}, D_{4h}, D_{6h}, T_d and O_h

Definition : ***A set of symmetry operations form a point group if all the elements in the set obey all the four rules of a mathematical Group.***

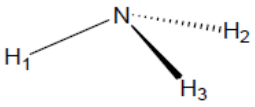
Water molecule: C_{2V}

- Water molecule has Angular shape
- The principal axis of the molecule is C_2
- It is a non-linear molecule
- It has two perpendicular planes i.e) σ_v planes
- It has no horizontal planes
- It has no n no of C_2.
- Therefore it does not belong to D class of point group
- Hence, the point group of water molecule is C_{2V}
- The elements of symmetry of C_{2V} point group is {E, C_2, σ_v', σ_v''}

Examples : H_2S

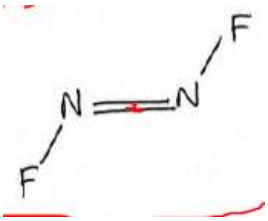


C_{3V} point group:



- Ammonia has pyramidal shape
- The principal axis of the molecule is C_3.
- It has one more rotational operation namely, C_3^2
- It is a non-linear molecule
- It has three perpendicular planes i.e)3 σ_v planes
- It has no horizontal planes
- It has no n no of C_2.
- It has no centre of symmetry
- Therefore it does not belong to D class of point group.
- Point group of ammonia is C_{3V}.
- Its symmetry elements are {E, C_3, C_3^2, σ_v', σ_v'', σ_v'''}
- Other examples are XeO_3, Pcl_3, $CHCl_3$

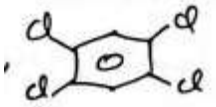
C_{2h} Point group:



- Trans N_2F_2 belongs to this point group.
- It has one principal axis C_2.
- It is a non-linear molecule.
- It has one inversion centre i
- It has one horizontal plane σ_h.
- It has no vertical planes.
- It has no n no of C_2.
- Therefore it does not belong to D class of point group.
- Its symmetry elements are {E, C_2, i, σ_h}
- Other examples are H_2O_2, Trans dichloro ethylene

D_{2h} point group:

$CH_2=CH_2$

- It is a planar molecule.
- It has one principal axis C_2
- It has two C_2 axes orthogonal to the principal axis.
- Hence, it belongs to D class of point group
- It has one inversion centre
- It also has a horizontal mirror plane intersecting the principal axis i.e) $\sigma_{h.}$
- It also has two vertical mirror planes parallel with the principal axis i.e) $2\sigma_v$ planes
- Its symmetry elements are {E, $C_{2,}$ 2 C_2, i, $2\sigma_{v,}$ $\sigma_{h.}$}
- Another example is
- 

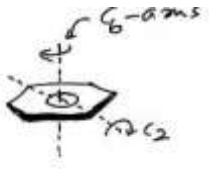
D3h Point group:

- It has Triangular planar shape
- It is a non-linear molecule.
- It has one principal axis C_3
- It also has C_3^2 axis of rotation
- It has three C_2 axes orthogonal to the principal axis.
- Hence, it belongs to D class of point group
- It has three vertical planes i.e) $3\sigma_v$ planes
- It also has a horizontal mirror plane intersecting the principal axis i.e) σ_h
- Its symmetry elements are {E, $C_{3,}$ C_3^{2}, 3 $C_{2,}$ $3\sigma_{v,}$ $\sigma_{h,,}$ $2S_3$ }
- Other examples are, Pcl5, eclipsed ethane

D_{4h} point group:

- $Ptcl_4^{2-}$ has square planar geomentry.
- It is a non-linear molecule
- It has one principal axis C_4 and C_4^2
- It also has one perpendicular C2 axis
- It has four C_2 axes orthogonal to the principal axis.
- Hence, it belongs to D class of point group
- Similiarly, it has2 vertical planes and two dihedral planes i.e) $2\sigma_v$ planes and $2\sigma_d$ planes.
- It has one inversion centre
- It also has two S_4 axis.
- It also has a horizontal mirror plane intersecting the principal axis i.e) σ_h
- Its symmetry elements are {E, $C_{4,}$ C_4^{2}, $C_{2,}$ 4 $C_{2,}$ $2\sigma_{v,}$ $2\sigma_{d,}$ i ,$\sigma_{h,,}$ $2S_4$ }
- Other examples are XeF_4,

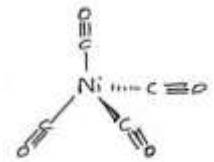
D_{6h} point group:



- Benzene
- It is a non-linear molecule.
- It has one principal axis C_6
- It has six C_2 axes orthogonal to the principal axis.
- Hence, it belongs to D class of point group
- Similiarly, it has three vertical planes and three dihedral planes i.e) $3\sigma_v$ planes and $3\sigma_d$ planes.
- It has one inversion centre
- It also has a horizontal mirror plane intersecting the principal axis i.e) σ_h
- In addition, it also has $2S_3$ and $2S_6$ improper axis of rotation.
- Its symmetry elements are $\{E, 2C_6, C_2, 6C_2, 3\sigma_v, 3\sigma_d, i, \sigma_h, 2S_3, 2S_6\}$
- Other examples are coronene, kekulene,[18]- Annulene, superphane

Cubical point group;

T_d point group :



- It is a non-linear molecule.
- The principal axis of Td point group is C_3.
- It has three C2 axes.
- It also has six dihedral planes.
- It has no inversion centre
- It has no horizontal mirror plane intersecting the principal axis i.e) σ_h
- It has no C5 axis of symmetry
- Its symmetry elements are $\{E, 8C_3, 3C_2, 6\sigma_d, 6S_4\}$
- Other examples are CH4, Urotropine, fullerene-28, adamantine