CLASSIFICATION OF AXIS OF SYMMETRY

Axis

- **Principal Axis (P-axis)**
  - Axis of highest order
  - n = order of axis
  - e.g. BF_3 : C_3 is P-axis
- **Subsidiary Axis (S-axis)**
  - Axis other than P-axis
  - 3 C_3 are S-axis

CLASSIFICATION OF PLANE OF SYMMETRY :

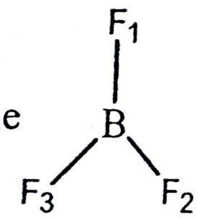
Plane

- **Vertical Plane** σ_v
  - Plane || to P-axis
- **Horizontal Plane** σ_h
  - Plane ⊥ to P-axis
- σ_d **Dihedral Plane**
  - Plane || to P-axis and bisecting angle between two C_2 axis in the moleculs.

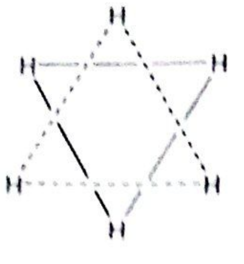
Plane in BF_3

σ BF^1
σ BF^2 } $3\sigma_v$
σ BF^3

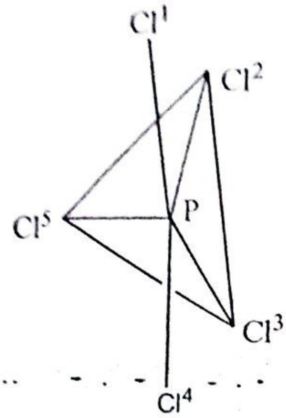
1 σ_h i.e. molecular Plane



Eg : Staggered Ethane : $3\sigma_d$



PCl_5 : $1C_3$, $3C_2$, $3\sigma v$, $1\sigma h$

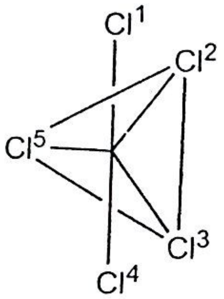


$1\ C_3$ axis : Passing through. Cl^1–P–Cl^4

$3\ C_3$ axis :

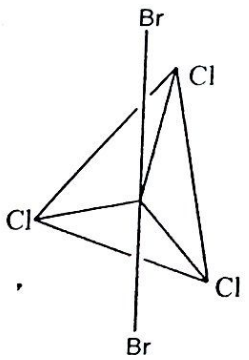
C_2 Passing through.	P—Cl^2	interchanging Cl^1/Cl^4
C_2 Passing through.	P—Cl^3	interchanging Cl^1/Cl^4
C_2 Passing through.	P—Cl^5	interchanging Cl^1/Cl^4

Planes :

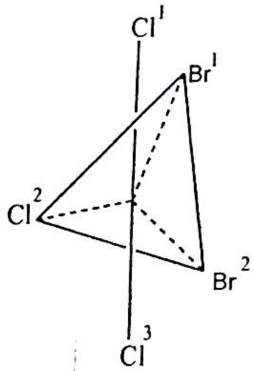


σ_v bisecting	$Cl^1\ Cl^2\ Cl^4$ P	reflecting	Cl^3/Cl^5
σ_v bisecting	$Cl^1\ Cl^3\ Cl^4$ P	reflecting	Cl^2/Cl^5
σ_v bisecting	$Cl^1\ Cl^5\ Cl^4$ P	reflecting	Cl^2/Cl^3
σ_v bisecting	$Cl^2\ Cl^3\ Cl^5$ P	reflecting	Cl^1/Cl^4

In PCl_5 replace 2Cl with 2 Br and Keep all elements as such.



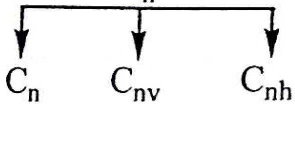
C_3, $3C_2$, $3\sigma v$, $1\sigma h$



C_2, $2\sigma_V$

1. C_{nV} Point Group :

$$C_{nV} = C_n + n\ \sigma v$$



eg : $C_{2v} = C_2 + 2\sigma_v$ no. of operation = 2n = 4

$C_3V = C_3 + 3\sigma_v$ no. of operation = 2n = 6

$C_{4v} = C_4 + 4\sigma_v$ no. of operation = 2n = 8

Total no. of operation of elements = order of group = 2 n

(2) C_{nh} Point Group : $C_{nh} = C_n + \sigma_h$

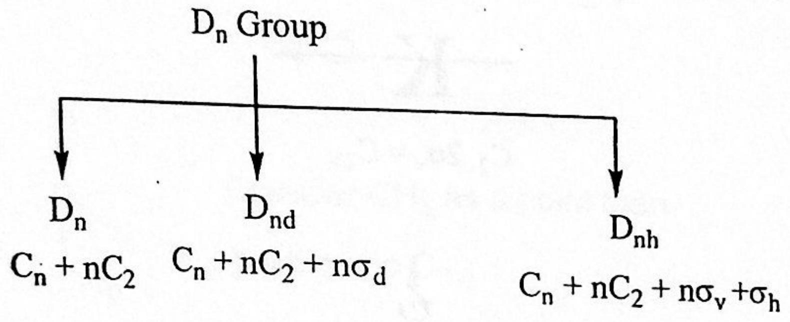
eg : $C_{2h} = C_2 + \sigma_h$ no. of operation = 2n = 4

$C_{3h} = C_3 + \sigma_h$ = 6

$C_{4h} = C_4 + \sigma_h$ = 8

Total no. of operation is known as order of group.

(3) D_n Point Group : no. of operation = 4n



$$D_n = C_n + nC_2$$

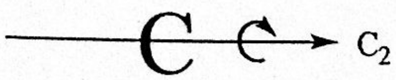
$$D_n d = C_n + nC_2 + \sigma_d$$

$$D_n h = C_n + nC_2 + n\sigma_v + \sigma_h$$

Any molecule having either 1 C_2 or 3C_2 not having 2 C_2 always.

C_2,, $2\sigma_v = C_{2v}$

C_2 , $2\sigma_v = C_{2v}$



C_2 , $2\sigma_v = C_{2v}$

D **E**

$C_2 \times 2\sigma_v = C_{2v}$ $C_2 \times 2\sigma_v = C_{2v}$

F **G**

C_s only plane of symmetry C_s

The molecule having only one plane not any axis then called they fall in C_s point group.

H **I**

$3C_2 + 2\sigma_v + \sigma_h$

$C_2 + 2C_2 + 2\sigma_v + \sigma_h = D_{2h}$

$C_2 + 2\,C_2 + 2\sigma_v + \sigma_h = D_{2h}$

J **K**

C_s $C_2, 2\sigma_v = C_{2V}$

L **M**

C_s $C_2, 2\sigma_v = C_{2V}$

N **O**

$C_2 + \sigma_h = C_{2h}$ $C_\infty + \infty C_2 + \infty\sigma_v + \sigma_h = D_{\infty h}$

$$C_n = \frac{360}{\theta} = n$$

C_∞ n = ∞ n = because θ^o is so much small then $n = \infty$

P **Q** **R**

C_s C_s C_s

S **T** **U**

$C_2 + \sigma_h = C_{2h}$ $C_2 + 2\sigma_v = C_{2v}$ $C_2 + 2\sigma_v = C_{2v}$

V

$C_2 + 2\sigma_v = C_{2v}$

W

$C_2 + 2\sigma_v = C_{2v}$

X

$C_4 + 4C_2 + 4\sigma_v + \sigma_h = D_{4h}$

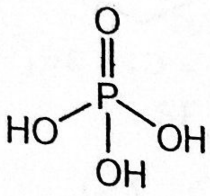
Y

$C_3 + 2C_2 + 2\sigma_v = C_{3v}$

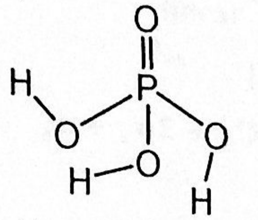
Z

$C_2 + \sigma_h = C_{2h}$

Example: H_3PO_4



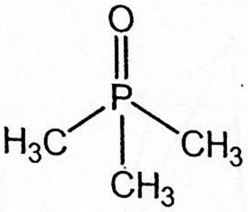
C_3



(Actual Structure)

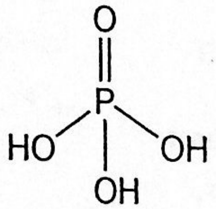
We will state the point group of any molecule in its highest stable arrangement.

Example:



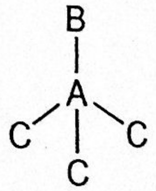
Consider CH_3 as a point then point group C_{3V}.

Example:



Consider OH as a, point then. point group C_{3V}.

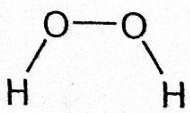
means



Type molecule

EXAMPLE: H_2O_2 :

Having 3 structures - Cis, Trans, Open book

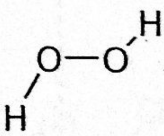


Cis

$C_2 + 2\sigma_v = C_{2v}$

dihedral angle = 0

C is having no dihedral angle

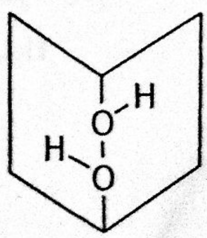


Trans

$C_2 + \sigma_h = C_{2h}$

dihedral angle = 180°

Trans having many dihedral angle.



C_2 point group