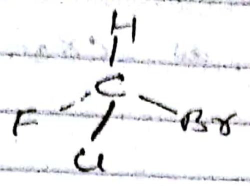
(1) (i) **Identity** → It is a symmetry operation without effect. It leaves the molecule unaffected. It is neutral element. as 360° से rotate करने पर same molecule प्राप्त हो,

as $CHBrClF$ → no other symmetry element



has (E)

(ii) Rotation C_n (Proper axis of Rotation) → n fold rotation indicate → a rotation through an angle of 360°/n → ie rotation पर same structure देता है

$$C_n^n \equiv E$$

as $H_2O \rightarrow C_2$, $NH_3 \rightarrow C_3$

(iii) mirror planes

- σ_h (horizontal) → Plane perpendicular to principal axis
- σ_d (dihedral), σ_v (vertical) → Plane linear with principal axis
- σ_d → σ parallel to C_n & bisecting C_2'' axis
- σ_v → vertical, parallel to principal axis

(Short $\vec{n}$)

Elements	Operation	Symbol
Identity	identity	→ E
plane of symmetry	Reflection in a plane	→ σ
~~Inver~~ Centre of symmetry	Inversion of all the atoms through centre of symmetry	$i = S_2$
Proper axis	Rotation by 360°/n	→ C_n
Improper axis	① Rotation by 360°/n ② Reflection in plane perpendicular to Rotation axis	S_n (n=3

Point gr	Symmetry elements (4)
(1) C_1 ⟷	E as CnFBrCl
(2) C_2 ⟷	E, C_2 as H_2O_2, F_2O_2
(3) C_3 ⟷	E, C_3 as CX_3-CY_3
(4) C_s ⟷	E, σ_v
(5) C_{2v} ⟷	$E, C_2, 2\sigma_v$
(6) C_{3v} ⟷	$E, C_3, 3\sigma_v$
(7) $C_{\infty v}$ ⟷	E, C_∞, σ_v all linear molecu
(8) C_{2h} ⟷	E, C_2, σ_h, i
(9) D_{2h} ⟷	$E, 3C_2, 3\sigma, i$
C_{nh} →	E, C_n axis (principal), σ_h

(V) ⇒ C_n (Rotational point gr) →

(1) C_1 gr → $C_1 \equiv E$

C_{2V} &

C_{3V} → E, $C_{(n)}$, σ_V

Point gr

① C_{nh} point gr →

formula $\boxed{C_{nh} = C_n + 1\sigma_h}$

Total No of elements / operation $= 2n$

② C_{nv} point gr →

$$C_{nv} = C_n + n\sigma_V$$

Total No of operations $= 2n$

As if $n = 2$, then $C_{2V} = 4 = \underset{1}{C_2} + \underset{2}{2\sigma_V} + \underset{1}{E}$

③ D_{nh} point gr →

formula → $C_n + nC_2 + n\sigma_V + 1\sigma_h$

No. of operation $= 4n$

As if $n = 2$ then →

$$8 = D_{2h} = \underset{1}{C_2} + \underset{2}{2C_2} + \underset{2}{2\sigma_V} + \underset{1}{1\sigma_h} + \underset{1}{E} + \underset{1}{S_n}$$

as $\boxed{BF_3 \text{ का } D_{3h}}$

↳ $C_3 + 3\sigma_V + 1\sigma_h + 3C_2$

④ D_{nd} point gr → $C_n + nC_2 + n\sigma_d$

No of operations $= 4n$

As → $8 = D_{2d} = \underset{1}{C_2} + \underset{2}{2C_2} + \underset{2}{2\sigma_d} + \underset{1}{E} + \underset{2}{S_4}$

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C_{2v} — E, C_n …
C_{3v} — E, C_2, σ_h, i
$C_{\infty v}$ — $E, \ldots C_n, 3\sigma, i$

6

5. C_n point gr $\rightarrow$ $\boxed{C_n + E}$

No of operation $= n$

eg. $C_2 = C_2 + E$ (2)

$C_3 = C_3 + E$

6. S_{2n} point gr

$\rightarrow$ $S_{2n} + C_n + E$

$\rightarrow$ No of operation $= 2n$

$\rightarrow$ eg. $S_4 = \underset{2}{S_4} + \underset{1}{C_2} + \underset{1}{E} = 4$

7. D_n point gr $\rightarrow$

$C_n + nC_2$

$\rightarrow$ No of operation $= 2n$

eg. $6 = D_3 = \underset{2}{C_3} + \underset{3}{3C_2} + \underset{1}{E}$

8. Tetrahedral point gr $\rightarrow$ CH_4

$\rightarrow$ 4 corners

$\rightarrow$ 6 edges

$\rightarrow$ 4 triangular faces

$\rightarrow$ Total No of operators $= 24$

$\boxed{8 + 3 + 6 + 6 + 1 = 24}$

(7)

It consists of → (8)

- $4C_3$ axis → Passing through each C-H bond through each corner = 8 operation
- $3C_2$ axis → Passing through opposite edge of faces of cube = 3 operations
- $3-S_4$ → along each C_2 - axis = 6 operations
- $6-\sigma_d$ (dihedral plane) ⇒ 6 operations
- E (1 operation)

(8) Octahedral point gr) → as SF_6

- No of operations = 48
- 9 + 8 + 6 + 6 + 8 + 3 + 6 + 1 + 1 = 48
- 6 corners, 12 edges, 8 triangular faces
- $3C_4$ axis → passing through opposite corners (9)
- $4-C_3$ axis → Passing through opposite triangular faces → (8)
- $6-C_2$ axis → " " edges (6)
- $3-S_4$ axis → along each C_4 axis (6)
- $4-S_6$ " (8)
- $3-\sigma_h$ (3)
- $6-\sigma_d$ (6)
- $6-\sigma_d$ (6)
- Inversion centre (i)
- Identity (E) → (1)

② Axis of Symmetry C(n) → rotation होता है

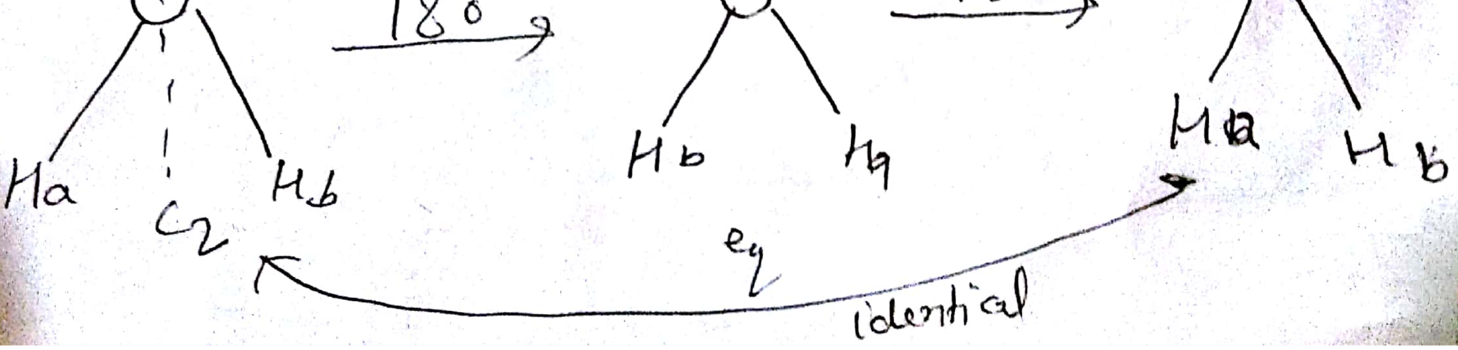
↳ rotation के बाद equivalent or identical str प्राप्त होती है

$$n = \frac{360^\circ}{\theta}$$

↳ If $\theta = 180^\circ$

↳ $n = \frac{360^\circ}{\cancel{1}80^\circ} = 2$ or C_2

ie 180° के rotation के बाद same configuration प्राप्त होता है (As) H_2O



① (Point 92)

Identity = E

Axis of symmetry → Rotation (C_n)
Plane of symmetry → Reflection (σ)
Centre of symmetry → Inversion (i)
Improper axis ⇒ Roto-reflection (S_n)
rotation

(5.)

✗ Symmetry Elements & Symmetry operations

↳ Symmetry Elements → The symmetry of a molecule is determined by the existence of symmetry operations performed with respect to symmetry elements. ie it is a geometrical entity

✗ Symmetry operations → operations which leave a object looking the same.

To characterize symmetry in a concise way, two sets of symmetry symbols are introduced →

① Schoenflies symbols — also है & mainly molecular symmetry & spectroscopy used होता है

② Hermann–Maugin symbol or International symbol.

✗ ⟶ Symmetry elements → ⑤ है

① Identity
② Plane of symmetry (σ ie sigma plane)
③ Simple or proper axis of symmetry (C_n)
④ Center of symmetry or inversion center (i)
⑤ rotation – reflection axis ie ~~alte~~ alternating axis of symmetry (S_n). ($\sigma_h \cdot C_n$)

✗ Plane of symmetry → जो एक molecule को two half में divide कर देता है। जो mirror plane है।

σ → σ_h, σ_v

$\boxed{\sigma^2 \equiv E}$

↳ सुविधा के लिए, the principal plane is placed vertically along the z axis ie z-axis is principal axis.

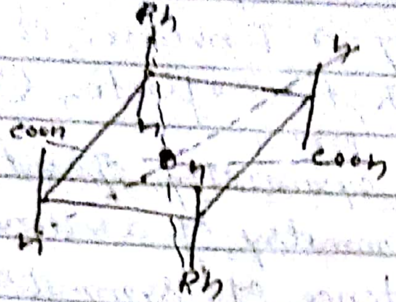
$\boxed{\sigma_h}$ → perpendicular to the principal axis ~~horizontal~~.

$\boxed{\sigma_v}$ → vertical mirror plane to the main axis

σ_d → If such a plane bisects the angle b/w a pair of rotational axis C_2, we have a diagonal mirror plane.

(7) center of symmetry (Ci inversion center)

of all straight lines that can be drawn through the center of the molecule meet identical atoms (or points) at the same distance from the centre.

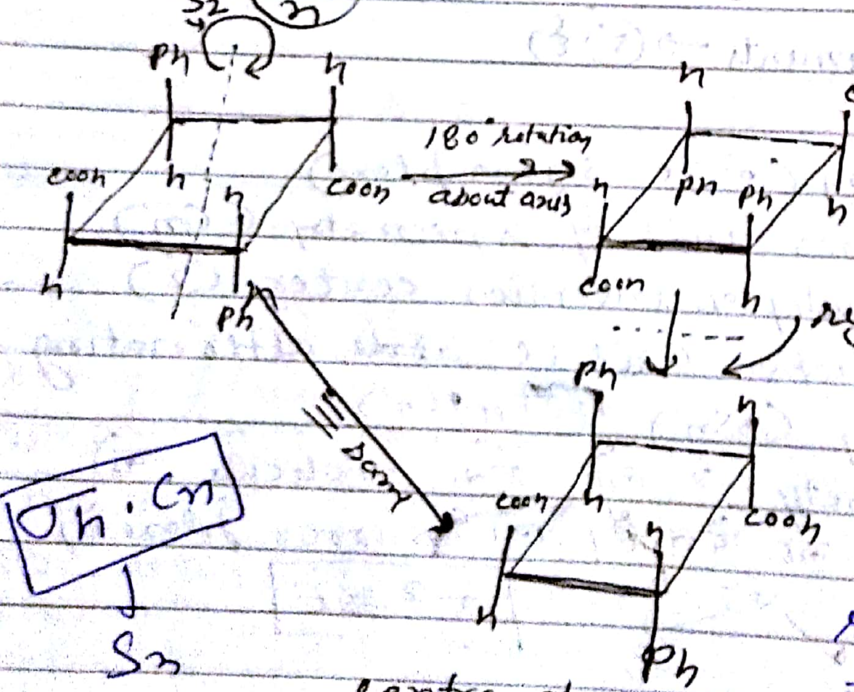


Cn → 360°/n where n is the n fold axis

(8) alternating or rotation – reflection axis

a molecule is said to have an alternating or a rotation reflection axis of symmetry if an arrangement identical to the original is restored when → (i) the molecule is rotated through n degrees about an axis passing through the molecule, & (ii) the rotated molecule is reflected in a mirror that is perpendicular to the axis of rotation in Ist step

→ 360/n → when n = angle जितने through rotated करें



$\frac{360°}{\theta} = n$

[Rotation]

180° से rotate करते है → so $\frac{360}{180} = 2$

i.e. S_2 होगा

reflection

centre of symmetry

two fold alternating axis of symmetry.

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