

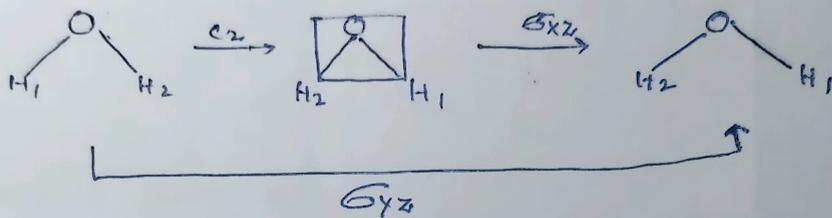
Multiplication table for  $C_{2v}$  Point group - Water ( $H_2O$ )  
belongs to  $C_{2v}$  Point group.

The set of symmetry operations of water molecule represent a group.

The total symmetry operations of water molecule are  $E, C_2, \sigma_{xz}, \sigma_{yz}$ . These four symmetry operations follow all the requirements of a mathematical group.

Rule (a) :-

$$C_2, \sigma_{xz} = \sigma_{yz}$$



$$C_2 \cdot C_2 = E$$

Rule (b) :-

$$C_2 E = C_2,$$

$$\sigma_{xz} \cdot E = \sigma_{xz}$$

Rule (c) :-

$$C_2 C_2^{-1} = E$$

$$\sigma_{xz} \sigma_{xz}^{-1} = E$$

Rule (d) :-  $C_2 (\sigma_{xz} \cdot \sigma_{yz}) = (C_2 \cdot \sigma_{xz}) \cdot \sigma_{yz} = E$

Here  $C_2 (\sigma_{xz}, \sigma_{yz}) = C_2 \cdot C_2 = E$

and  $(C_2 \cdot \sigma_{xz}) (\sigma_{yz}) = \sigma_{yz} \cdot \sigma_{yz} = E$

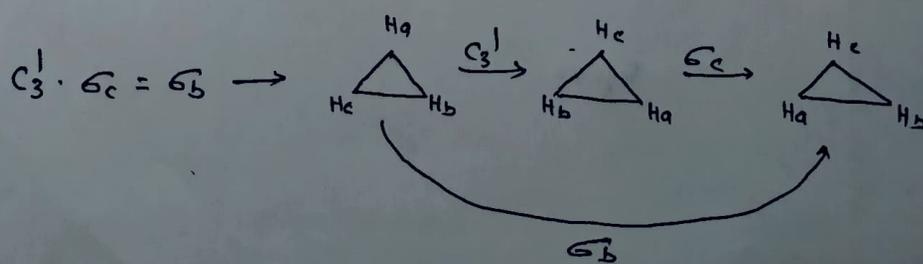
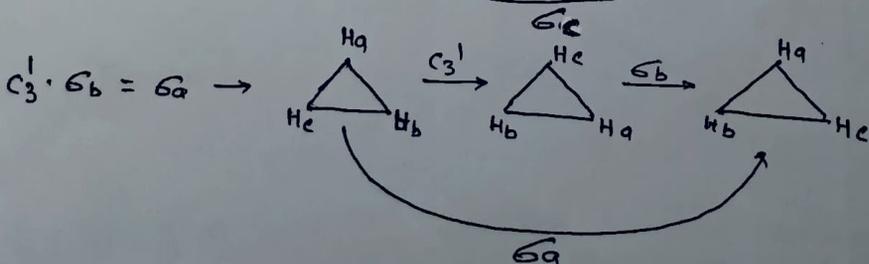
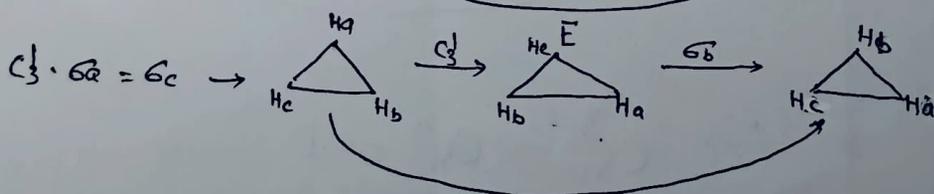
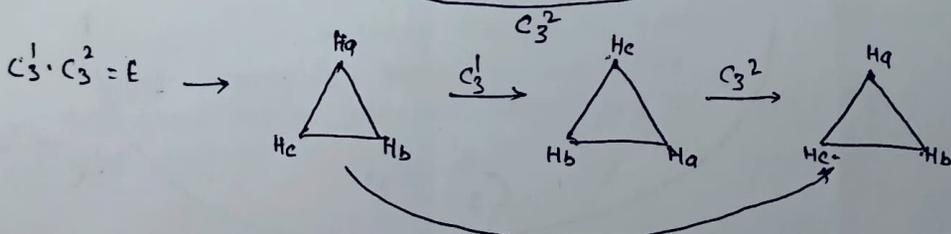
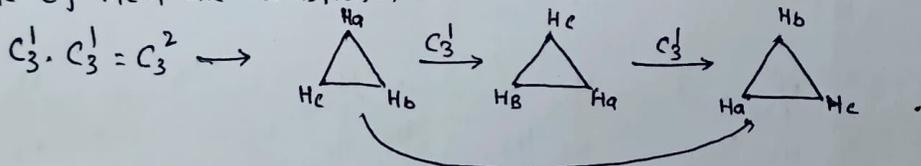
Multiplication Table for symmetry operations of water molecule  
 i.e. for  $C_{2v}$  Point group.

Symmetry Operations				
$H_2O (C_{2v})$	$E$	$C_2$	$\sigma_{xz}$	$\sigma_{yz}$
$E$	$E$	$C_2$	$\sigma_{xz}$	$\sigma_{yz}$
$C_2$	$C_2$	$E$	$\sigma_{yz}$	$\sigma_{xz}$
$\sigma_{xz}$	$\sigma_{xz}$	$\sigma_{yz}$	$E$	$C_2$
$\sigma_{yz}$	$\sigma_{yz}$	$\sigma_{xz}$	$C_2$	$E$

Multiplication Table for Symmetry Operations of  $\text{NH}_3$  Molecule is  $C_{3v}$  Point Group

Symmetry Operations						
$\text{NH}_3$ ( $C_{3v}$ )	E	$C_3^1$	$C_3^2$	$\sigma_a$	$\sigma_b$	$\sigma_c$
E	E	$C_3^1$	$C_3^2$	$\sigma_a$	$\sigma_b$	$\sigma_c$
$C_3^1$	$C_3^1$	$C_3^2$	E	$\sigma_c$	$\sigma_a$	$\sigma_b$
$C_3^2$	$C_3^2$	E	$C_3^1$	$\sigma_b$	$\sigma_c$	$\sigma_a$
$\sigma_a$	$\sigma_a$	$\sigma_c$	$\sigma_b$	$E$	$C_3^1$	$C_3^2$
$\sigma_b$	$\sigma_b$	$\sigma_a$	$\sigma_c$	$C_3^1$	E	$C_3^1$
$\sigma_c$	$\sigma_c$	$\sigma_b$	$\sigma_a$	$C_3^1$	$C_3^2$	E

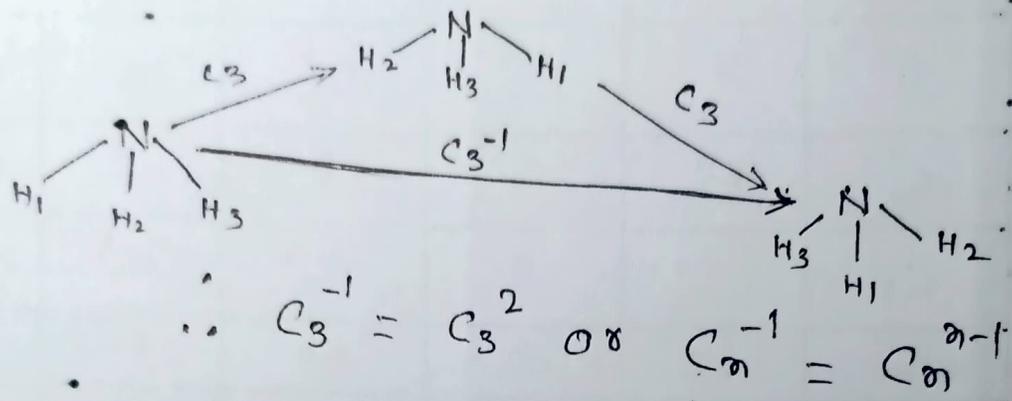
Some of them are illustrated as:-



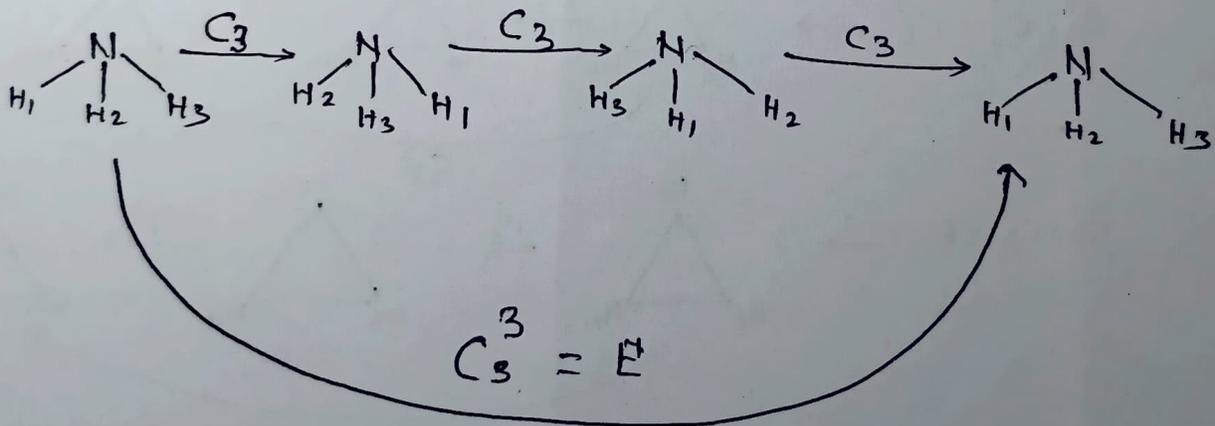
For  $\text{NH}_3$  Molecule,  
 Show that:- (i)  $C_n^{-1} = C_n^{n-1}$  or  $C_3^{-1} = C_3^2$  (ii)  $C_n^n = E$  or  $C_3^3 = E$

Ans:-  $\text{NH}_3$  molecule has a  $C_3$ , hence

(i)



(ii)



$\therefore C_3^3 = C_n^n = E$