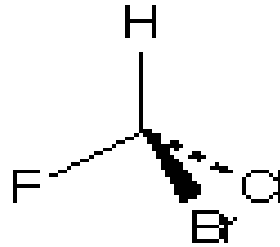


# Point Groups

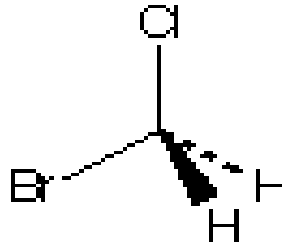
## Exercises

# Low Symmetry Groups

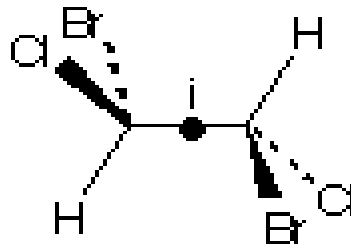
- $C_1$  : only E



- $C_s$  : only E and  $\sigma$

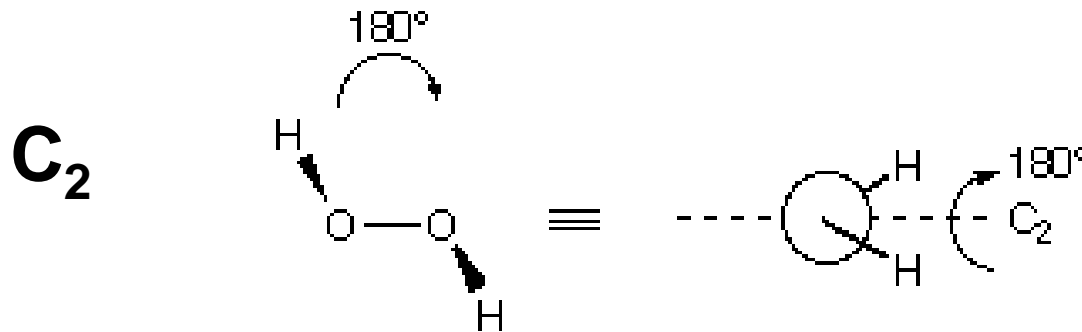


- $C_i$  : only E and i



# $C_n$ , $C_{nv}$ , $C_{nh}$ Groups

- $C_n$ : E and  $C_n$  only



$C_{nv}$ : E and  $C_n$  and  $n \sigma_v$ 's

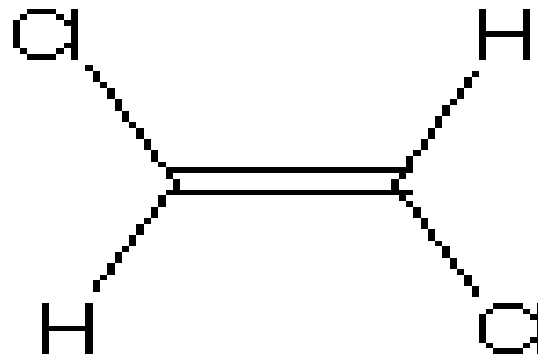
$C_{2v}$ : E,  $C_2$ , 2  $\sigma_v$        $H_2O$

$C_{3v}$ : E,  $C_3$ , 3  $\sigma_v$        $NH_3$

$C_{\infty v}$ : E,  $C_{\infty}$ ,  $\sigma_{\infty v}$        $HF, HCN$

•  $C_{nh}$ : E and  $C_n$  and  $\sigma_h$ , i

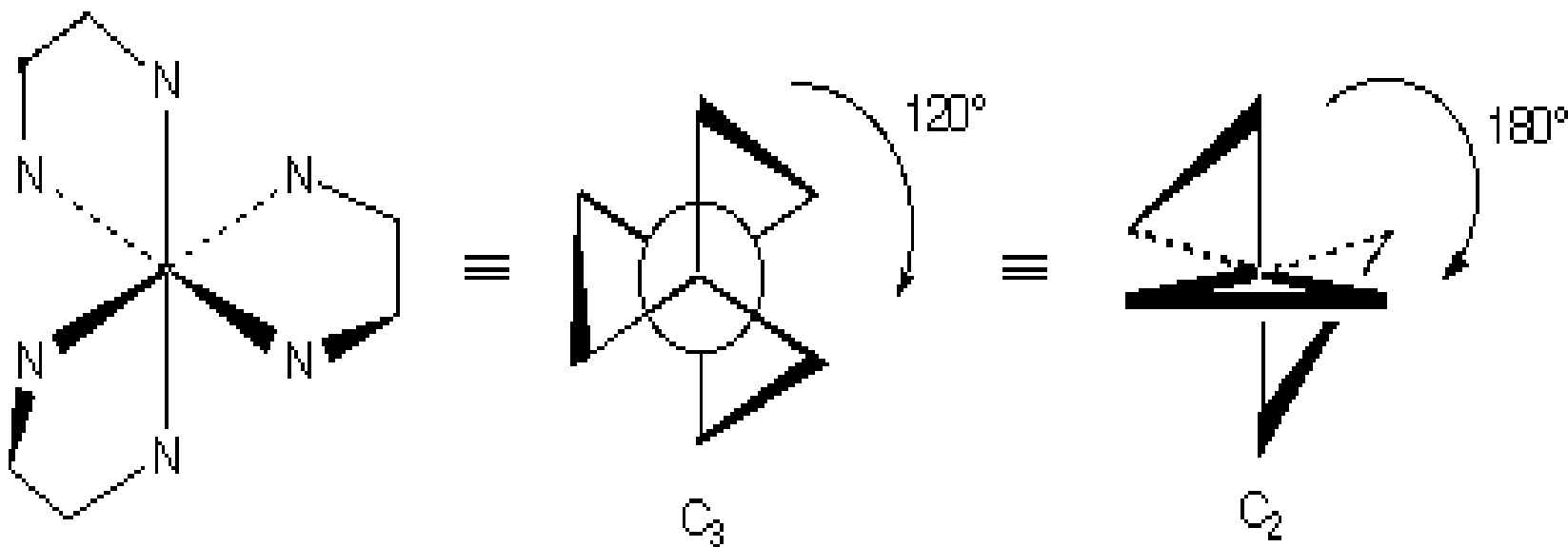
$C_{2h}$ : E,  $C_2$ ,  $\sigma_h$ , i



# $D_n$ , $D_{nv}$ , $D_{nh}$ Groups

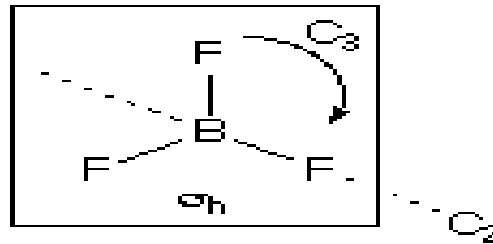
$D_n$ :  $E$ ,  $C_n$ ,  $n$   $C_2$  axes  $\perp$  to  $C_n$

- $D_3$ :  $E$ ,  $C_3$ ,  $3 \perp C_2$ ,  $[\text{Co}(\text{en})_3]^{3+}$

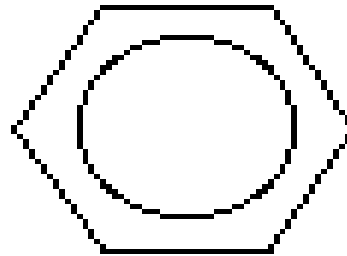


# $D_{nh}$ : $E$ , $C_n$ , $n C_2$ axes $\perp$ to $C_n$ , $\sigma_h$

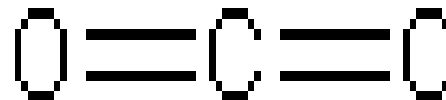
- $D_{3h}$ :  $E$ ,  $C_3$ ,  $3 \perp C_2$ ,  $\sigma_h$



- $D_{6h}$ :  $E$ ,  $C_6$ ,  $6 \perp C_2$ ,  $\sigma_h$

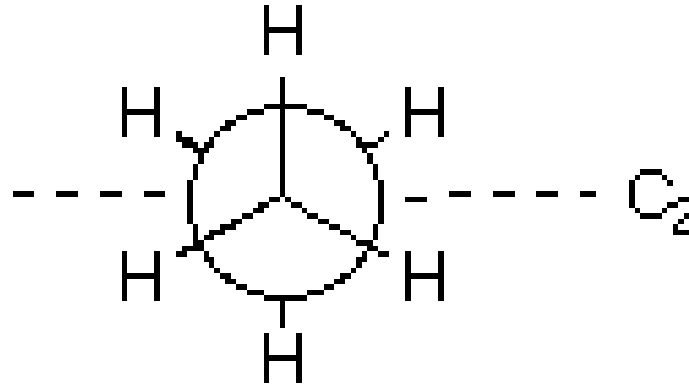


- $D_{\infty h}$ :  $E$ ,  $C_{\infty}$ ,  $\infty \perp C_2$ ,  $\sigma_h$



# $D_{nd}$ : $E$ , $C_n$ , $n C_2$ axes $\perp$ to $C_n$

- $D_{3d}$ :  $E$ ,  $C_3$ ,  $3 \perp C_2$ ,  $3 \sigma_d$



staggered

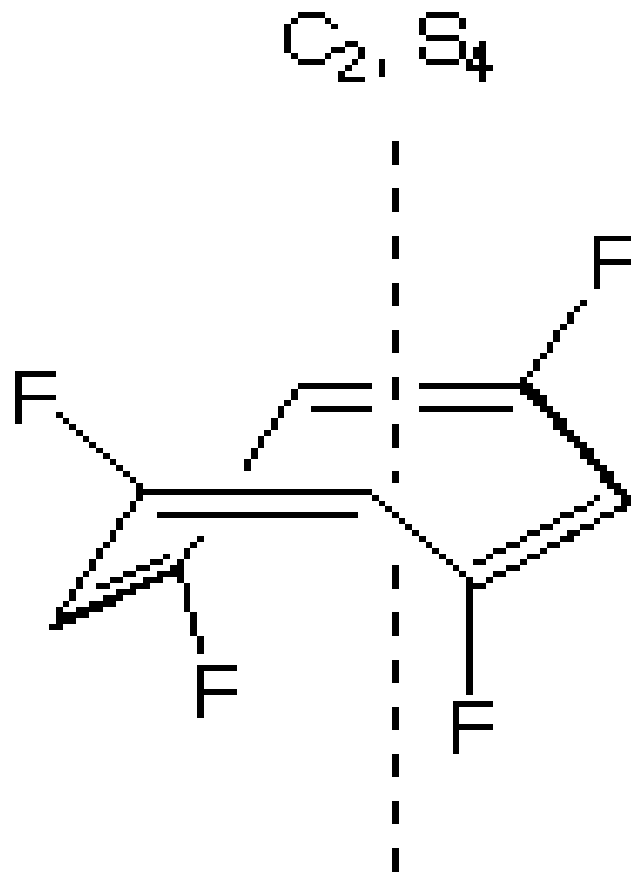


eclipsed



# $S_{2n}$ : $E$ , $C_n$ , $S_{2n}$ (no mirror planes)

$S_4$ ,  $S_6$ ,  $S_8$ , etc. (Note: never  $S_3$ ,  $S_5$ , etc.)



•  $S_4$ :  $E$ ,  $C_2$ ,  $S_4$



# High Symmetry Groups, $T_d$ , $O_h$ , $I_h$

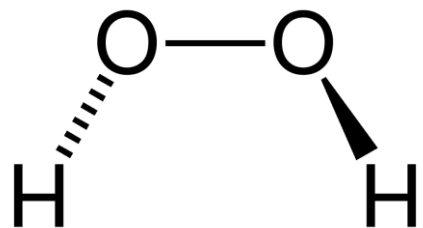
- $T_d$ : E, 8  $C_3$ , 3  $C_2$ , 6  $S_4$ , 6  $\sigma_d$

No need to identify all the symmetry elements – simply recognize  $T_d$  shape.

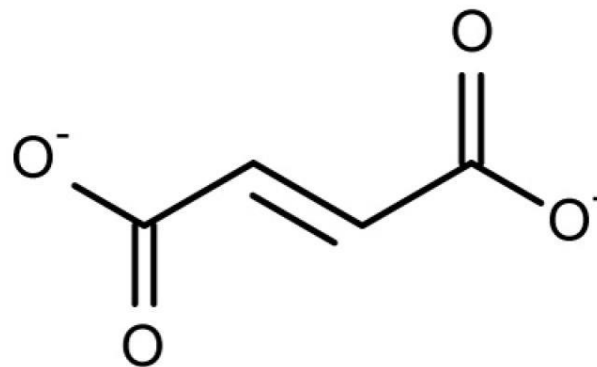
- $O_h$ : E, 8  $C_3$ , 6  $C_2$ , 6  $C_4$ , i, 6  $S_4$ , 8  $S_6$ , 3  $\sigma_h$ ,  $\sigma_d$

No need to identify all the symmetry elements - simply recognize  $O_h$  shape

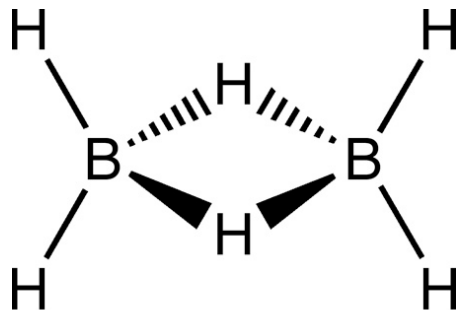
Hydrogen Peroxide  $\text{H}_2\text{O}_2$



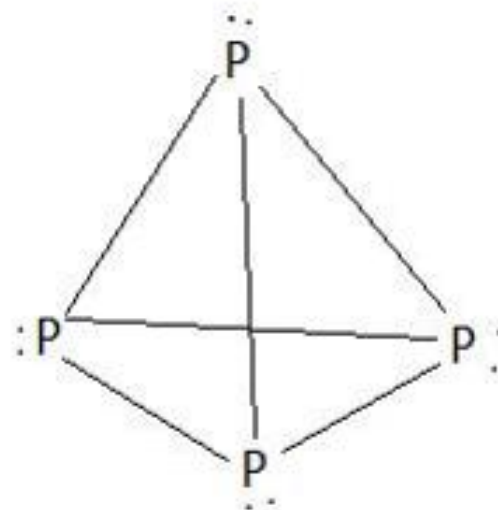
Fumarate  $\text{C}_4\text{H}_2\text{O}_4$

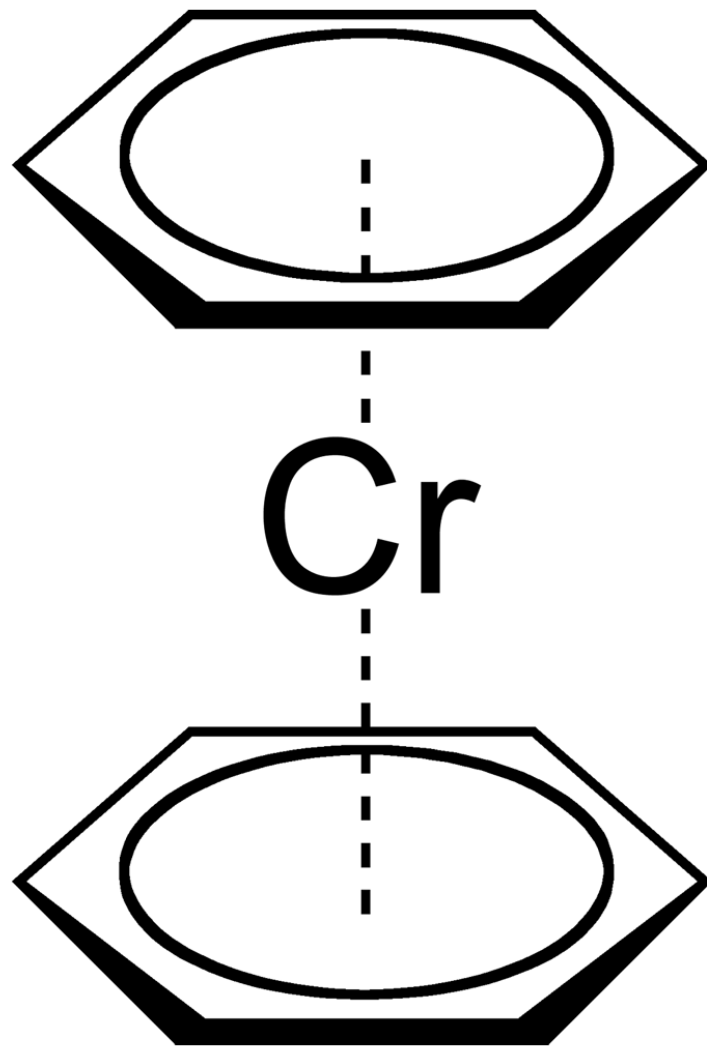


Diborane ( $\text{B}_2\text{H}_6$ )



$\text{P}_4$  white phosphorus





القطبية	النشاط الضوئي	الزمرة	عمليات التماثل	الجزيء
Yes	Yes	$C_2$	$E, C_2$	$H_2O_2$
Yes	No	$C_s$	$E, \sigma$	$NHF_2$
No	No	$D_{2h}$	$E, C_2(z), C_2(y), C_2(x), i, \sigma(xy), \sigma(xz), \sigma(yz)$	$C_2H_4$
No	No	$D_{2h}$		$B_2H_6$
Yes	No	$C_{4v}$	$E, 2C_4, C_2, 2\sigma_v, 2\sigma_d$	$BrF_5$
Yes	No	$C_{4v}$		$[CoCl_5F]^{2-}$
No	No	$D_{3d}$	$E, 2C_3, 3C_2, i, 2S_6, 3\sigma_d$	$C_2H_6$ stagg
No	No	$D_{3h}$	$E, 2C_3, 3C_2, \sigma_h, 2S_3, 3\sigma_v$	$C_2H_6$ eclips
Yes	No	$C_{2v}$	$E, C_2, \sigma_v(zx), \sigma_v(zy)$	$XeF_2O_2$
No	No	$D_{2h}$		$[PtH_2Cl_2]^{2-}$
No	No	$C_{2h}$	$E, C_2, i, \sigma_h$	fumarate

القطبية	النشاط الضوئي	الزمرة	عمليات التماثل	الجزيء
No	No	$T_d$	$E, 8C_3, 3C_2, 6S_4, 6\sigma_d$	P4
Yes	No	$C_{3v}$	$E, 2C_3, 3\sigma_v$	$B(OH)_3$ non planner
Yes	Yes	$C_s$		$C_2H_5Br$ eclips
Yes	Yes	$C_1$	$\sigma_d, E$	$C_2H_5Br$ stagg
No	No	$C_{2h}$		Trans $C_2H_2O_2$
No	No	$D_{6h}$	$E, 2C_6, 2C_3, C_2, 3C_2', 3C_2'', i, , 2S_3, , 2S_6, \sigma_h, 3\sigma_d, 3\sigma_v$	$(C_6H_6)_2Cr$ eclips
Yes	No	$C_{2v}$		$(C_6H_6)Cr$ stagg
No	No	$C_{2h}$		Trans- 2,3 $Br_2 C_4 H_6$