Point Group Symmetry of Rigid Objects

Definitions

Symmetry operation: Rigid rotation about an axis, or rotation about an axis followed by reflection through a plane normal to the axis, such that, after the operation has been performed, the "new" object is indistinguishable from the original. In this context, indistinguishable objects can be superimposed in all their parts by rigid translation with no rotation required.

Symmetry element: A rotation axis or rotation/reflection axis which is a symmetry operation of an object.

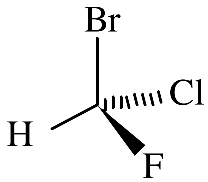
Symmetry Element	*Symbol*	*Symmetry Operations*
Identity	E	360° rotation = no operation
n-Fold axis	C_n	360°/n rotation
Mirror plane	$\sigma = S_1$	reflection through a plane = 360° rotation/reflection
Center of symmetry (inversion center)	$i = S_2$	Inversion through a point = 360°/2 rotation/reflection
Higher rotation/reflection axis	S_4	360°/4 rotation/reflection

Rotation axes are often termed **proper axes of symmetry**; rotation/reflection axes are termed **improper axes of symmetry**. Objects possessing an improper symmetry axis are said to possess reflection symmetry, and are achiral. Object lacking reflection symmetry are chiral. The point group symmetry of an abject is a group which includes all symmetry elements of the object. For example, if an object has E as its only symmetry element, it's Schoenflies point group is C_1. A selection of point groups, classified according to chirality and polarity, follows.

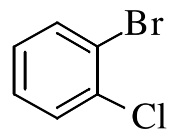
	Chiral	***Achiral***
Polar	C_1 C_n	$C_s = S_1$ C_{2v} ... $C_{\infty v}$ (a cone; E, C_∞, $\infty\sigma_v$)
Nonpolar	D_n T K (chiral isotropic)	$C_i = S_2$ C_{2h} ... C_{nh} (all C_{2h} also have i) S_4 D_{nd} D_{nh} ... $D_{\infty h}$ (a cylinder) T_d O_h I_h K_h (a sphere - achiral isotropic)

Examples

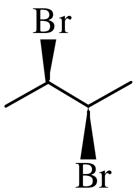
C_1



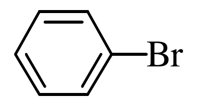
C_s

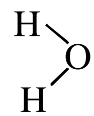


C_2

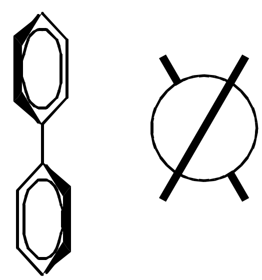


C_{2v}



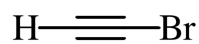


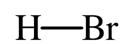
D_2



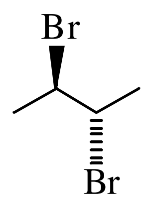
Gas phase minimum of biphenyl (dihdral angle between the rings ~ 57°)

$C_{\infty v}$

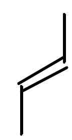




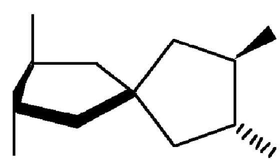
C_i



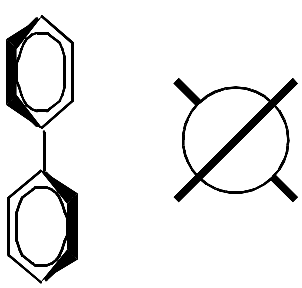
C_{2h}



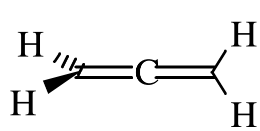
S_4



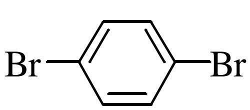
D_{2d}



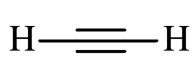
Biphenyl with a 90° dihedral between the rings (not a minimum)



D_{2h}



$D_{\infty h}$



T_d