Modern Inorganic Chemistry
Second Edition, W.L. Jolly

FIGURE 2.7
Side view of an S_4 ring.

twofold axes perpendicular to the fourfold axis. It has no horizontal plane, but it has four vertical planes. Thus, the point group is D_{4d}.

5. **NH_3.** The pyramidal ammonia molecule possesses a threefold rotational axis. It does not have a horizontal mirror plane, but it does have a set of three vertical planes. Hence the point group is C_{3v}.
6. **CH_4.** This regular tetrahedral molecule has four threefold axes, no center of symmetry, and six mirror planes, corresponding to the T_d point group.

Further examples are given in Table 2.1. The student should become adept at recognizing symmetry elements and at determining the point groups of molecules. A list of compounds and objects is given in the problems at the end of the chapter for practice.

Even if we pursued the subject of symmetry no further, you would find that familiarity with point groups is an asset. For example, consider how much structural information is condensed in the simple statement that the $Ni(CN)_4^{2-}$ ion has D_{4h} symmetry. This statement implies that (1) the ion is completely planar, (2) the Ni—C—N bond angles are all 180°, (3) the C—Ni—C bond angles are all 90°, (4) the four Ni—C bond lengths are all equal, and (5) the four C—N

TABLE 2.1
Examples of some common point groups

Point group	Examples
C_1	SiFClBrI, SOFCl
C_s	ONCl, HOCl, $SOCl_2$
C_2	Nonplanar H_2O_2
C_{2h}	Trans-planar H_2O_2, *trans*-$C_2H_2Cl_2$
C_{2v}	H_2O, SO_2F_2, SCl_2, ClO_2^-
C_{3v}	NH_3, SiH_3Cl, PF_3
C_{4v}	$XeOF_4$, SF_5Cl
D_{2h}	N_2O_4, $C_2O_4^{2-}$
D_{3h}	BCl_3, PCl_5, SO_3
D_{4h}	$PtCl_4^{2-}$, $Ni(CN)_4^{2-}$, *trans*-SF_4Cl_2
D_{5h}	Eclipsed $Fe(C_5H_5)_2$
D_{6h}	$Cr(C_6H_6)_2$
D_{2d}	Staggered B_2Cl_4, $H_2C{=}C{=}CH_2$
D_{3d}	Staggered Si_2H_6
D_{4d}	$Mn_2(CO)_{10}$
D_{5d}	Staggered $Fe(C_5H_5)_2$
T_d	$GeCl_4$, ClO_4^-
O_h	UF_6, SF_6, PF_6^-
$D_{\infty h}$	H_2, N_3^-, CO_2
$C_{\infty v}$	HCl, CO, OCS