Exercise 2.1

Give all the symmetry elements of H_2O, NH_3 and CH_4. For each molecule list the symmetry operations which commute.

Solution 2.1

https://symotter.org/gallery

(a) H_2O belongs to the point group $\mathscr{C}_{2v}$, which has 4 symmetry elements, viz. E, C_2, $\sigma_v(xz)$, $\sigma_v(yz)$.

(b) NH_3 belongs to the point group $\mathscr{C}_{3v}$, which has 6 symmetry elements, viz. E, C_3, C_3^2, σ_{v1}, σ_{v2}, σ_{v3}.

(c) CH_4 belongs to the point group $\mathscr{T}_d$, which has 24 symmetry elements, viz. E,

Exercise 2.2

On the basis of symmetry, which of the following molecules cannot have a dipole moment: CH_4, CH_3Cl, CH_2D_2, H_2S, SF_6?

Solution 2.2

(a) CH_4 has no dipole moment.

(b) CH_3Cl has a dipole moment.

(c) CH_2D_2 has a dipole moment.

(d) H_2S has a dipole moment.

(e) SF_6 has no dipole moment.

Exercise 2.3

Which of the following molecules cannot be optically active: CHFClBr, H_2O_2, $[Co(en)_3]^{3+}$, *cis*-$[Co(en)_2(NH_3)_2]^{3+}$, *trans*-$[Co(en)_2(NH_3)_2]^{3+}$?

Solution 2.3

(a) CHFClBr belongs to the point group $\mathscr{C}_1$, which is optically active.

(b) H_2O_2 belongs to the point group $\mathscr{C}_2$, which is optically active.

(c) $[Co(en)_3]^{3+}$ belongs to the point group $\mathscr{D}_3$, which is optically active.

(d) *cis*-$[Co(en)_2(NH_3)_2]^{3+}$ belongs to the point group $\mathscr{C}_2$, which is optically active.

(e) *trans*-$[Co(en)_2(NH_3)_2]^{3+}$ belongs to the point group $\mathscr{C}_{2h}$, which is optically inactive.