1. Atomic or molecular translations transform in the same way as the \( (x), (y), (z) \) (or \( (T_x), (T_y), (T_z) \)) functions listed in the character tables.

2. Molecular rotations transform in the same way as the \( (R_x), (R_y), (R_z) \) functions listed in the character tables.

3. The irreducible representations spanned by the motions of a polyatomic molecule may be determined using the \((3N)\) Cartesian basis, made up of \( (x), (y), (z) \) axes on each atom. The characters of the matrix representatives are best determined using a table as follows:

\[
\begin{array}{ll}
\text{Operation:} & \text{List the symmetry operations in the point group} \\
\Gamma_{\text{Cart}} & \text{List the characters for } x + y + z \text{ (from the character table) for each operation} \\
N_{\text{unshifted}} & \text{List the number of atoms in the molecule that are unshifted by each symmetry operation} \\
\Gamma_{3N} & \text{Take the product of the previous two rows to give the characters for} \\
\end{array}
\]

4. The irreducible representations spanned by the molecular vibrations are determined by first subtracting the characters for rotations and translations from the characters for \( \Gamma_{3N} \) to give the characters for \( \Gamma_{\text{vib}} \) and then using the reduction formula or inspection of the character table to identify the irreducible representations contributing to \( \Gamma_{\text{vib}} \).

5. The molecular displacements for the vibrations of each symmetry may be determined by using projection operators on the \((3N)\) Cartesian basis vectors to generate SALCs.

6. Alternatively, a basis of internal coordinates (bond lengths and angles) may be used to investigate stretching and bending vibrations. Determine the characters, identify the irreducible representations, and construct SALCs.

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**Contributors**

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