Shriver Symmetry Made Simple

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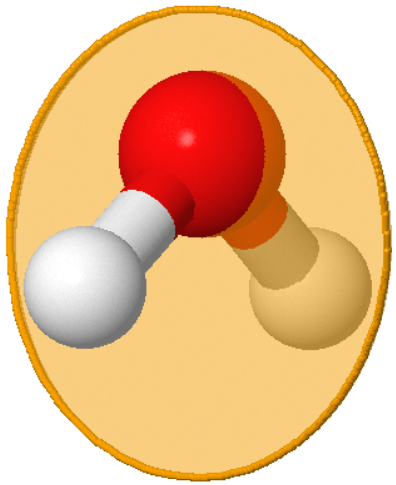
Introduction

We begin by introducing a few motivations we have to acquire a basic understanding of molecular symmetry. An understanding of the symmetry of an atom can provide us with a simpler way to predict physical properties, like it's visible color and how other energies affect it; or its chemical properties, like how electrons are distributed about a molecule and how they behave in a magnetic field.

The Idea

We shall clarify what we define a symmetry as: Symmetry is a way of expressing that you can rotate, flip, reflect, invert, and many more to achieve a molecule that has the same image. Imagine chopping a water molecule in half, right through the oxygen atom. Then take the flat face oxygen atom and glue it to a mirror; if you chop it the right way, the thing you see will be identical to the original atom, so it has a planar symmetry where the mirror is the plane.



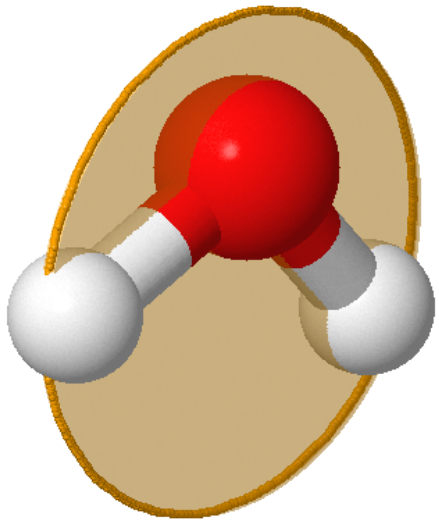
Developing the Idea

Remember the "planar symmetry" we talked about on the previous slide? Professional chemists have devised a method of collecting all the possible symmetries of a molecule into a set called a "group." This is the set of all modifications (the symmetries I talked about prior) that do not change an atom. A few things are to be known about groups before we dive further:

1. Applying two symmetries consecutively must also be a symmetry.
2. For all symmetries there is an inverse.
3. The relative position of each point in the symmetry must be the same.

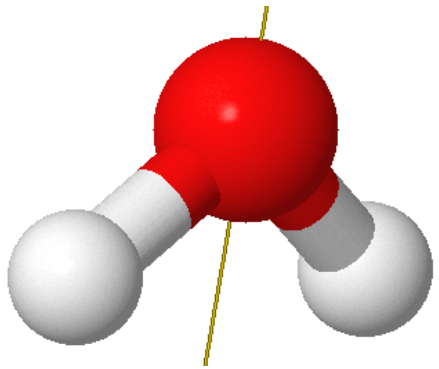
The Definition - Mirror

The "professional" chemists also designed a complex-looking way of talking about a molecules symmetries, compressing an idea into a letter: Mirroring a molecule about a plane can be described by σ (lowercase sigma) with some subscript $xy, xz,$ or yz, with each describing a different plane. Deciding the x, y and z axes is either random or beyond the scope of this lesson. The water molecule has two planes of symmetry, one as seen on the previous slide and one as seen below:



The Definition - Rotation

In a similar manner, the letter C was assigned to describe the ability to rotate about an axis, but more interesting is the labelling method; Below C is some positive integer x, and this represents the ability to rotate a molecule by $\frac{360}{x}$ degrees and have it be unchanged. The water molecule we have been looking at exhibits only one case of this, at the intersection of the planes we were talking about prior, a C_2 through the oxygen:



Rotating about this axis by $\frac{360^\circ}{2} = 180^\circ$ is a symmetry, :wow:

Lovely.