16.3: Molecules

Atoms can bond together. Sometimes, if one atom is able to completely steal an electron from another atom (as is the case with Chlorine and Sodium atoms, where a Sodium atom will donate an electron to a Chlorine atom), the resulting ions will then stick together as a result of the electrostatic attraction between their opposite net charge.

More common, however, are molecules made from what is called covalent bonds. The electrons in the outer (unfilled) shell of an atom are known as “valence” electrons. Depending on the electronic configuration of an atom, it will have one or more effective valence electrons. In a molecule, the valence electrons are no longer associated with a single atom, but instead are shared between the electrons. In terms of the quantum mechanics involved, you wouldn’t find a solution to Schrödinger’s Equation for just the potential of one atom. Rather, you create a joint potential for the two atoms (including the effects of inner-shell electrons), and determine a solution for the system as a whole. The result is an electron wave function that indicates the electron probability cloud is shared between two or (for more complicated molecules) more of the atoms that composes the molecule. Just as nuclei have a binding energy, molecules have a binding energy, meaning that it is a lower energy state for these atoms to bind together and share an electron than it is for them to stay separate. Although this binding energy is typically a billionth of the mass energy of atoms, it is enough to create the vast majority of energy producing processes (e.g. burning gas to power a car) that we are familiar with in our everyday lives.

Finding these solutions to multi-atom potentials is an extremely difficult problem, and cannot be solved analytically (as the Hydrogen atom may be). Describing the quantum mechanical state and electron orbitals of any molecule more complicated than something like H_2 generally involves both heavy-duty numerical calculations on computers and heavy-duty quantum chemists.