3.5: Looking Back and Ahead

The concepts of bond energy and thermal energy are very useful in models that help us make sense of the particulate nature of matter. However, the quantities that are actually measured, although closely related to these ideas, are not quite the same. That is, the ΔH's we encountered in Chapter 1 and the bond energy we used there based on these ΔH's are not precisely the same as the bond energy defined in terms of the pair-wise interactions. However, it is rather tricky to understand precisely how they are related. Until then, we will accept that when making comparisons of the concepts in our models to empirical data, we are making some approximations, which will always be pointed out.

These approximations typically allow us to still make numerical comparisons to within 10-20 percent of the best we can do with extremely complicated models. From a modeling perspective, this is initially a price well worth paying in order to have a model sufficiently simple and broadly applicable to enable us to develop a meaningful understanding of a great deal of the "how and why" matter behaves the way it does from a particulate perspective. The models we develop in this chapter apply, in the sense that they allow us to make sense of phenomena and get pretty close when making numerical predictions, to a *very wide range of phenomena* without getting bogged down in so many details that we never get anywhere in our understanding. Thermodynamics is the "science" of understanding the subtleties and the details of precisely determined empirical data. In Chapter 4 we will get a brief introduction and a taste of the power it provides, but at a cost of the loss of the simplicity of the models in Chapter 3.

At this point we have developed the energy-interaction approach rather completely. There are still some "kinds" of energy we have not encountered, but when we do, we know what to do: treat it as another type of energy. We know how to approach physical systems that involve changes in macroscopic mechanical energies as well as changes in internal energies. We have a systematic way of "dealing with" friction as the transfer of energy to thermal systems. We have also refined our model of matter to a point where we can understand most of the thermal properties it exhibits. For certain thermal properties, we can make very definite numerical predictions with our model.

With our model of matter and understanding of energy and energy conservation, we now can actually understand many of the fundamental concepts that underlie much of thermal physics, thermochemistry and the properties of gases, liquids, and solids. We have also developed a much more sophisticated understanding of temperature. We have made a solid connection of the macroscopic concept of temperature that we measure with a thermometer to our extended microscopic model of matter.

Up to this point we have tried to avoid getting into the messy details of the interactions of matter. What is remarkable, is how much we have accomplished with this approach. There are, however, many questions that we cannot answer without getting involved in the details. An example is how do we determine the strength of bonds (or spring force constant). It turns out that the spring constants are directly related to the frequency of vibration of the particles themselves. Infrared spectroscopy is one way to determine these frequencies and thus the spring constants. This is an important question that we definitely want to explore. But before we can proceed, we need to go back and spend some time developing the general connection between unbalanced force and change in motion. In Physics 7B, we will do this, and can then come back to the question of oscillation frequency of our oscillators.

In the meantime, we will use our model of matter and energy interaction approach, along with some new constructs and relationships to explore other interesting physical phenomena using a very powerful approach to understanding interactions of a chemical and biological nature: the thermodynamic model.