TRU
Open Press

20 - Energy changes during reactions

From Reactants to Products: The Energetic Journey

Video 20 - Transcript

Hi everyone. Welcome to video number 20, the last video in this series. Today we're going to be looking at energy changes that occur during our chemical reactions. Now, chemical reactions, as we mentioned in previous videos, and of course by extension, biochemical reactions can be simplified as reactants going to products. Okay, now in this video we're going to focus on what we call the thermodynamics or heat changes; Thermodynamics, or heat changes that occur during chemical reactions. But before we get into the thermodynamics, let's mention that there are two aspects to any chemical reaction. We have the thermodynamic aspect, which is related to the amount of heat. This is normally represented using delta H - delta, which means change, and H which means heat, or enthalpy, as we like to say. Enthalpy is another word for heat. When we look at thermodynamics, we're investigating the changes in the heat energy, or the enthalpy that is occurring between the reactants and the products. That's one aspect of chemical reactions. The other aspect of chemical reactions is the kinetics of that reaction. Now, the kinetics essentially means that we're looking at how fast a reaction is going to occur. Basically, kinetics focuses on the pathway from the reactants to the products. Now the reactions that we observe are a product of these two processes occurring side by side. The heat change and how fast it occurs. But we want to focus today on the heat changes or the energy changes. If we recall the principle of conservation of energy, we say that energy can neither be created nor destroyed, but it can be converted from one form into another. This is essentially the first law of thermodynamics. Okay, we can't make energy, we can't destroy energy - Energy is simply converted from one form, let's say kinetic energy, into another form, for example, heat energy. Chemical reactions take place through energy changes, usually in the form of heat. This is associated with the breaking and the making of bonds. Let's think about this. When we have reactants, we want to convert them into products. What we need to do is we need to break the bonds in our reactants, and we need to make bonds in our products. Breaking a bond requires energy. If we recall when we looked at bonding, a bond is essentially, for example, a covalent bond. We have the sharing of electrons. Breaking a covalent bond means we need to put energy into that system so that we remove the mutual attraction between the two positive nuclei to those shared electrons. Bond breaking, which occurs when we're breaking up our reactants versus bond formation. These are the two processes that we want to look at today. If we think about bond breaking, we normally say that this requires energy. Bond formation releases energy. In order to break a chemical bond, we must overcome that mutual attraction. In order to make a bond, we are going to release energy to bring those two species together and form a bond. We want to introduce the concept of delta H or enthalpy. We want to think about two terms. Okay? These terms are endothermic and exothermic. So bond breaking is an endothermic process; bond formation is an exothermic process. If I have an endothermic reaction, that means that I am requiring energy. An endothermic reaction has a positive delta H, or a positive change in enthalpy. Exothermic reaction has a negative delta H. This means that we are releasing heat to the environment. Now, the more energy that a system contains, the less stable that system is. If you think about the fact that in nature we would imagine that systems tend to want to be stable, then it makes sense that bond formation type reactions, or exothermic type reactions, are the ones that are favorable, or in other words, thermodynamically favorable. We want to be able to release heat. We want to bring our energy level down so that we can increase stability. We can graphically represent these two processes, endothermic and exothermic reactions using what we call energy profile diagrams. Here we see two different energy profile diagrams. On this side, we have an energy profile diagram for an exothermic reaction, and here we see for an endothermic reaction. Let's make sure that we understand what we're seeing in these two graphs. For an exothermic reaction, we start off with our energy at relatively zero. Our reactants are at relative energy of zero. What is going to happen is that in order to convert reactions to products, we need to break bonds. Remember we said that breaking bonds means that we need to put energy into the system. This energy hump, as we call it, is called activation energy. Activation energy. Activation energy, otherwise abbreviated Ea. This refers to the energy that we're putting into the system in order to break the bonds in our reactants. Now, once we have broken all of the bonds and we have achieved a high energy level, what is going to happen then is the bonds are now going to be formed. New bonds are now going to be formed in order to make our products. Now, when bonds are formed, as we said before, energy is released. This is why we see a sharp drop in our energy levels. What is happening here is that the products in an exothermic reaction end up at a much lower energy level than the reactants were. So, that the change in heat, or the change in enthalpy, or the delta H, is a negative value. The products have less energy than the reactants, and therefore, they are more stable. We will find therefore, exothermic reactions tend to be thermodynamically feasible, they tend to be spontaneous, and these are the reactions that we do not necessarily need to push energy into in order for the reaction to proceed. Now, on the other hand, endothermic reactions: again, our reactants start off at a relative value of zero. We again, have to break bonds to achieve our high energy states. This requires, again, the use of activation energy. The difference here is that when bonds are formed, of course we're going to have a drop in energy, but the products end up at a higher energy level than the reactants were, so that the change in enthalpy, or the heat change in an endothermic reaction is positive. Essentially what we see is that the products in an endothermic reaction are less stable than the reactants were. Endothermic reactions are generally not thermodynamically feasible, They are not spontaneous, and therefore, we need to put energy into our system to facilitate an endothermic reaction. Now essentially what we need to remember is that the process of bond breaking and bond making, they will always require either to put energy into, in order to break bonds; Bond making will always release energy. But it is the sum of these two processes - bond breaking and bond making - It's the sum of these - whether we get a negative value or a positive value, that will then determine if our overall reaction is exothermic or endothermic. As you explore different metabolic reactions in biology, you will see a lot of the times that there is a delta H value associated with that reaction. That is going to give you an idea of the energy change that is occurring. We can think about every day processes that we see that are endothermic. For example, if we think about ice melting, if we think about even photosynthesis. Photosynthesis is an endothermic reaction. Photosynthesis needs the energy of the sun being irradiated onto the chloroplast of the plant cells, in order for that reaction to proceed, - photosynthesis is endothermic. Melting of ice is endothermic. Evaporation of water is also endothermic. The boiling of water going from a liquid gas is endothermic. On the other hand, will also come across exothermic reactions. Respiration is an exothermic reaction. When we think about respiration, we know that this is the burning of glucose; the oxidation of glucose to produce energy in our cells. It is an energy producing reaction. The delta H is negative. Other exothermic reactions are, if we think about combustion burning anything in oxygen, an acid dissolving in water, and of course, just generally, bond making is exothermic. That's all that we're going to discuss today regarding energy changes in chemical reactions. I hope that you have now a good understanding of what to look out for when you see this term delta H being quoted for a chemical reaction. And remember always to appreciate the sum of bond making and bond breaking in a biochemical reaction will determine if it is spontaneous or not. That's all guys, thank you so much for viewing these videos. I hope that they have been very useful to you and feel free to come back to them as you continue to study your biological concepts. I hope that it helps you. Thanks everyone.