UNDERSTANDING KINETICALLY AND THERMODYNAMICALLY CONTROLLED PRODUCTS BY SOME SOCIAL EVENTS

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ABSTRACT

This article aims to aid students' understanding of kinetically and thermodynamically controlled reactions. They were resembled to some social events. Learning approach to these reactions in this way may contribute to students. Therefore, they may easily learn and remember it, and it will be more permanent in their memory.

Keywords: Equilibrium, Kinetics, Organic Chemistry, Thermodynamic

KİNETİK VE TERMODİNAMİK KONTROLLÜ ÜRÜNLERİ BAZI SOSYAL OLAYLARLA ANLAMA

ÖZET

Bu makale, kinetik ve termodinamik kontrollü tepkimelerin öğreniciler tarafından anlaşılmasına katkı sağlamayı amaçlar. Bu tepkimeler bazı sosyal olaylara benzetildi. Bu tepkimelere bu şekilde öğrenme yaklaşımı öğrencilere kolaylık sağlayabilir. Bundan dolayı, onlar onu kolaylıkla öğrenebilir ve hatırlayabilirler ve o (konu) onların hafızalarında daha kalıcı olacaktır.

Anahtar Kelimeler: Denge, Kinetik, Organik Kimya, Termodinamik

1. INTRODUCTION

The concept of kinetic and thermodynamic control of reactions has been generally discussed in most organic textbook [1,2,3]. Its effect on product formation such as sulfonation, isomerization, and addition reactions is frequently observed. Kinetically and thermodynamically controlled products are described in these reactions. These products compete with each other the reactions. Depending on the experimental conditions, one of them is alone or major product in the reactions.

Understanding kinetic and thermodynamic control is difficult for majority of students at introductory level. Some authors have been studied for understanding of this topic [4,5,6,7,8,9]. Kinetic and thermodynamic control in the dehydration of 2-

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methyl-1-phenylcyclopentanol [4]. and lights extracted from the reactions [6] were worked.

It is important that any phenomenon such as aromaticity, order of atomic orbitals and oxidation-reduction be easily written, learned and remembered [10,11,12]. To better understand the topics, interesting examples oflife may be given to them. We have aimed that kinetic and thermodynamic control of reactions compare with some social events in which we live society. Thus, this study may contribute to learning and remembering of kinetic and thermodynamic control of reactions.

2. DISCUSSION

$$\mathbf{B} \rightleftharpoons \mathbf{A} \rightleftharpoons \mathbf{C}$$ **Scheme 1**

In organic chemistry, a kinetically and thermodynamically controlled reaction involves a comparative reaction when reactant **A** decomposes simultaneously into products **B** and **C** until a final equilibrium state is reached. Product **B** is favored at low temperature and the high rate because it has the lower free energy of activation ($\Delta G^{\ddagger}_{AB} < \Delta G^{\ddagger}_{AC}$) (figure 1). Unlike **B**, product **C** is favored at high temperature and the high rate because it has the high free energy of activation. As also shown in scheme 1 and figure 1, products **B** and **C** are kinetic and thermodynamic products, respectively.

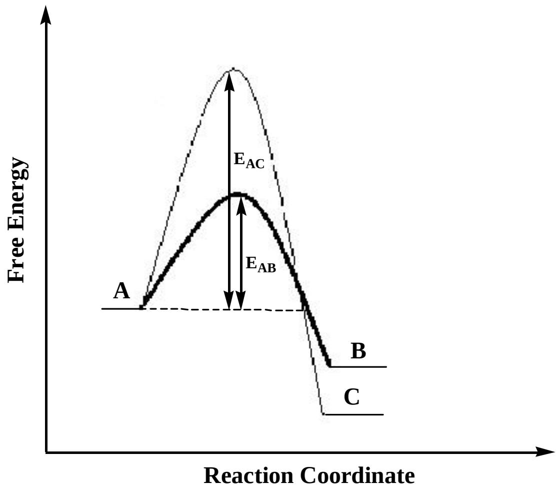
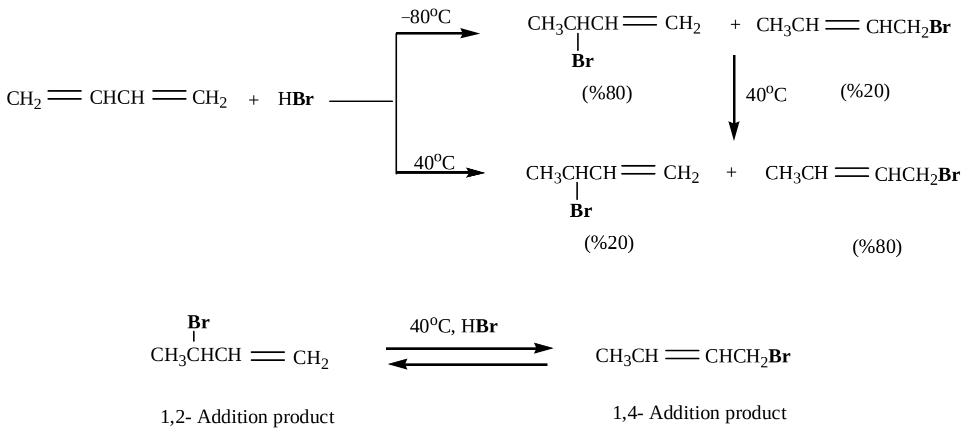


Figure 1. Reaction schematic for kinetic and thermodynamic control

For kinetically and thermodynamically controlled reactions, we can give the addition of hydrogen bromide to 1,3-butadine as an example. The relative amounts of 1,2- and 1,4-addition are dependent on the reaction temperature. As shown in scheme 2, 1,2-addition product is major product while 1,4-addition product is minor product at -80^{o}C in the reaction of hydrogen bromide and 1,3-butadiene. The ratio of 1,2- and 1,4- addition products is opposite when the reaction was treated at 40^{o}C. In competitive reactions such as kinetic and thermodynamic control reactions, thermodynamically controlled products are more stable and major products at higher temperature. The 1,2-addition product rearranges to the 1,4-addition product and that an equilibrium exists between them at the higher temperature and in the presence of hydrogen bromide. Therefore, 1,4-addition product is thermodynamically controlled product while 1,2-addition product is kinetically controlled product [1].



Scheme 2

Systems with high energy attend to go to systems with lower energy, more stable state. Chemical reactions occurring spontaneously are also a part of these systems [13]. At the same way, these reactions are called exothermic reactions which produce heat. Difference of energy of between reactants and products are produced as heat in the exothermic reactions. In these reactions which is one step or more steps, activation energies is absolutely necessary for each step. For example, we can give the combustion reaction, known and felt, of coal. Heat is produced in the combustion reaction. This heat is equal to difference of energy between reactants (coal and oxygen) and products (carbon dioxide and water). But, this reaction does not spontaneously occur. Energy which is more than activation energy of the reaction is necessary for the combustion reaction.

Kinetically and thermodynamically controlled reactions were compared with some social events in which we live. As shown in figure 2, we have taken into consideration money and comfort or stability instead of energy and reaction coordinate, respectively. Whether people have economic power or not, they almost want to a position in whom they can comfortably live. Something is needed to have more comfortable position is called necessity. For people, necessities never finish.

Necessities are generally solved by money. According to money that people have, they try to solve their necessities.

People who have almost the same money were represented as a reagent (**A**). They can easily buy a motorcycle (**B**) by their money while they could not easily afford to buy a car (**C**) because they have to almost give all their money for the car (figure 2), but they need something else to spend their money. Therefore, many of them have a motorcycle while some of them have a car. They can convert their motorcycle or car into money if they want. We can easily make a connection those social events with our chemical topic which is called kinetic and thermodynamic reactions. In this sense, values of car, motorcycle and value difference between car and motorcycle, were symbolized as ΔH_1, ΔH_2 and ΔH_3,respectively. E_{a1}, E_{a2} and E_{a3} were also symbolized as activation energies of car, motorcycle and conversion from motorcycle to car, respectively. Activation energies indicate the money such as tax in trade. If they want to sell and buy them or change one with another, E_{a1}', E_{a2}' and E_{a3}' also are inverse activation energies of car, motorcycle and conversion from car to motorcycle, respectively. Inverse activation energies include the moneys which is equivalent of wearing out and getting old of them addition to the money such as tax in trade. Therefore, inverse activation energies are more than activation energies ($E_{a1} < E_{a1}'$, $E_{a2} < E_{a2}'$ and $E_{a3} < E_{a3}'$).

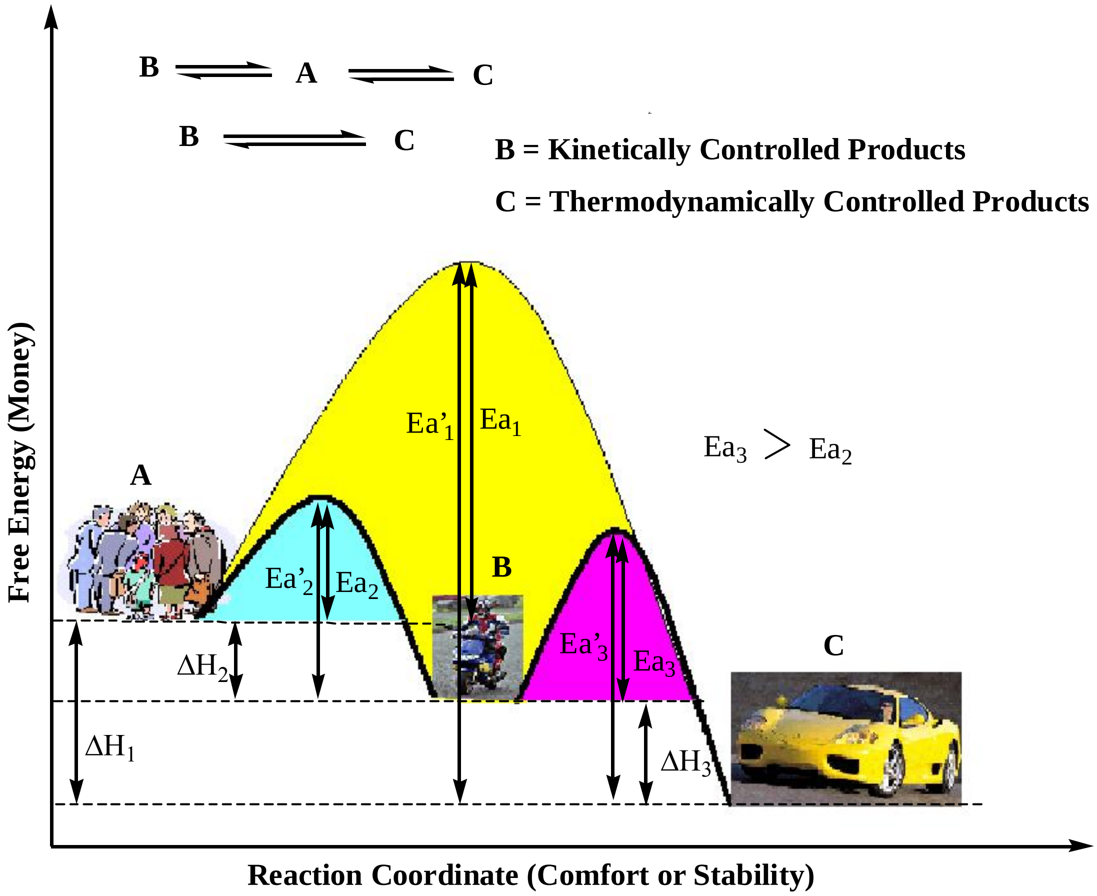


Figure 2. Reaction schematic for kinetic and thermodynamic control compared with social events.

As mentioned above, many of people will have a motorcycle while some of them have a car for the position in which they easily live. Therefore, number of motorcycles is many more than that of cars. This type change can be mentioned as "kinetically controlled change" such as kinetically controlled reactions.

In future, people may have more money by their gain or by inheritance, and then, can sell their motorcycles and then buy cars. At the sometime most people will have cars in future. The change in future can be mentioned as "thermodynamically controlled change" such as thermodynamically controlled reactions in chemistry.

The number of people with motorcycles is many more that of others because having motorcycle is both easy and short time which is needed for buying the motorcycle than that of other. Increasing the number of people who have cars needs to take a long times. Velocity determines the formation of kinetically controlled products while equilibrium and stability determine that of thermodynamically controlled products. On the other hand, the formation velocity of kinetically controlled products is faster than that of other. Therefore, kinetically and thermodynamically controlled reactions may be resembled to the social events mentioned above.

As a result, kinetically and thermodynamically controlled reactions were resembled to social events in this study. Explaining an approach to these reactions in this way will contribute to learning of students. Therefore, they can easily learn and remember it, and it may be more permanent in their memory. However, this subject will also be discussed out of chemistry lessons.

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