# Symmetry, Stereochemistry and Applications
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## Lecture - 38
## Some Problems and Their Answers in Stereochemistry

Welcome back to the course entitled Symmetry, Stereochemistry and Applications. In the last few lectures, we have discussed about the reactions with C-C double bond, C-C triple bond, some oxidation and reduction reactions. So as we indicated in the last class that we will discuss about some of the problems related to the last couple of lectures. So in this lecture, we will talk about some of the problems that you may encounter in this course. So let us start with a little descriptive type question, question number 1.

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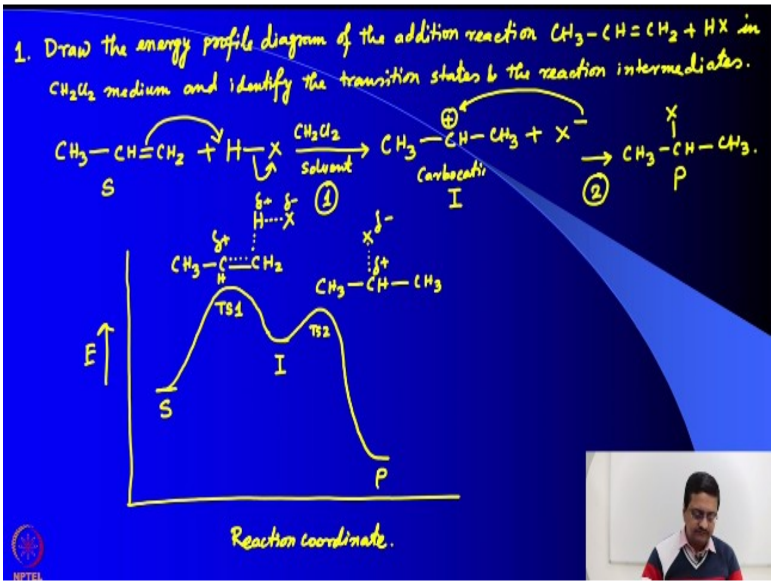

1. Draw the energy profile diagram of the addition reaction $CH_3-CH=CH_2 + HX$ in $CH_2Cl_2$ medium and identify the transition states & the reaction intermediates.

Draw the energy profile diagram of the addition reaction CH3-CH=CH2 + HX in dichloromethane medium and identify the transition states and the reaction intermediates. So what should be the answer of this question? First thing is we need to write down the products of this reaction in a stepwise manner. So this is our substrate. We are adding H-X to it in dichloromethane medium as solvent.

So what will happen is this double bond will first open up to capture this proton and its single bond will break to form the X- ion. This is the carbocation that is formed in this reaction. So the next step of this reaction is the attack of X- to this carbocation site to give you the final product of addition reaction. So as we can see, it is a two-step process, step 1 and step 2.

So the energy profile diagram will have two steps as we have seen in case of substitution reactions. So in this energy profile diagram, the energy of the compounds or the intermediates or the transition states are plotted in y axis and the progress of the reaction is plotted in x axis. So now let us assume that this is the position where we have our starting material or the substrate S.

It goes through an activation process and forms the reaction intermediate which is the carbocation, I write it as I. What I should do is probably we should identify the compounds, identify the steps as 1 and 2 instead of Roman I and II. So this is the reaction intermediate I, which is the carbocation and then again carbocation reacts with the X- to give you the product which is this one, the product P.

So there are two transition states TS1 and TS2. What is happening when the substrate starts to react with your H-X, the C-C double bond that is the pi bond of that C-C group starts to break and it starts to form a bond with the hydrogen of H-X and H-X bond is slowly breaking down to give you X-. So this should be the situation of the transition state.

So the dotted bonds are the bonds which are either breaking or forming. On the other hand, the second transition state is in situation where the X- forms the bond with the central carbon atom. Remember we have the hydrogen here. So these are the two transition states in this reaction and substrate, intermediate and products are identified with S, I and P. So this should be a complete answer to this type of question.

We have identified the reaction, we have written down the mechanism and then also identified the transition states and the reaction intermediates. Now let us try to address some of the other problems, question number 2.

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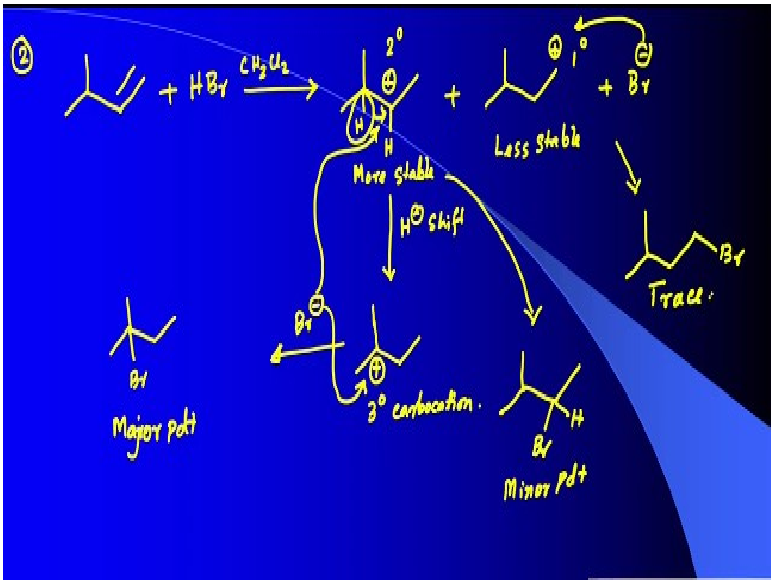

So if we do this reaction in presence of HBr in a solvent dichloromethane $CH_2Cl_2$, what would be the product? You can understand that of course, it will go through the formation of carbocation and the more stable carbocation that is formed in this reaction is this one compared to the other carbocation which is less stable.

So what will happen is this more stable carbocation can further get rearranged by a hydride transfer from the adjacent carbon. So we write it as hydride shift and form a 3 degree carbocation like this. So this was a 2 degree carbocation. This was 1 degree carbocation and by hydride shift we have come to a 3 degree carbocation. So when Br- reacts, it has three possibilities to react.

The possibility of reacting with the 3 degree carbocation to form this compound, to react with the 2 degree carbocation to form this compound. And if Br- reacts with the 1 degree carbocation which is very unlikely would give you a third possible product, which is this one. So obviously, the third 3 degree carbocation is most stable. So this product will be the major product.

This product will be a minor product. And this will be trace. So in this reaction there are possibility of having three different compounds as products.

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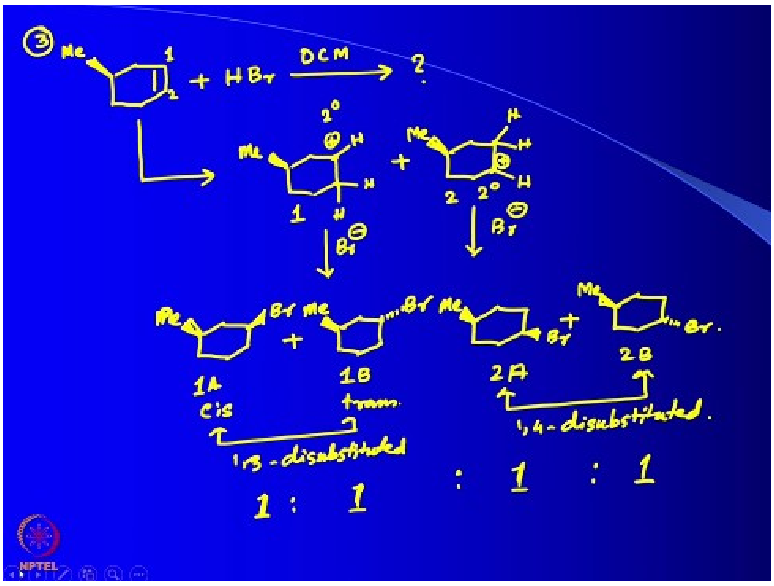

Now let me ask you the question. If I have a cyclohexane or rather we have a cyclohexene derivative with a methyl group like this and we treat this with HBr in dichloromethane solvent, what would be the product? So here we have two carbon atoms C1 and C2. In terms of the stability of carbocation the compounds which I am drawing are having the same amount of stability.

Both of them are 2 degree carbocation and they do not have any other chance to get converted to a 3 degree carbocation. So as a stability of carbocation, these two have very similar and equivalent stability. Therefore, both of them will give their corresponding products with Br-. Now you see that the carbocation which is here or there, that carbocation has two equivalent faces, the top and the bottom.

So if bromine comes from the top, we will get a product which would have bromine about the plane with methyl group about the plane. And if bromine comes from bottom, then we will have this product. So this carbocation if we number as 1 and this one as 2 and this product as 1A and 1B, these two compounds we can clearly see that are cis and trans isomers.

Similarly, from the second carbocation you would get products which are both cis and trans. So here this cis and trans isomers are 1,3-disubstituted while this 2A and 2B are 1,4-disubstituted. And all the four compounds have the probability of the formation equal because they are originating from these carbocation which have similar or same stability. Therefore, these four compounds will form nearly in the ratio of 1:1 : 1:1. Right?

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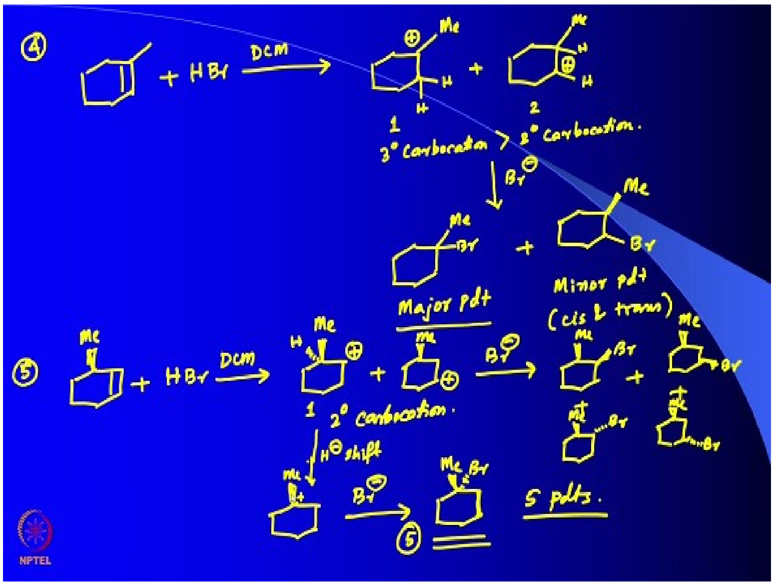

Now let us see in question number 4, what happens when the methyl group is at a different position? Now the methyl group is associated with the C-C double bond and we are treating this with HBr in DCM solvent. So what are the possible carbocations? These possible carbocations are these two. The first carbocation number 1 is a 3 degree carbocation while the carbocation 2 is a 2 degree carbocation.

Therefore, 3 degree carbocation having higher stability than 2 degree carbocation when Br- attacks you will get a compound which is this one. No matter whether it is coming from up or down, it is not a chiral center, so we will get this as a major product.

And this will be the minor product which will be actually a mixture of cis and trans isomer because now the position of methyl whether it is above and below with respect to the bromine becomes important and you will get both cis and trans isomers. So you will have very small amount of cis and trans isomers of 1,2-disubstituted cyclohexane derivative with 1,1-disubstituted cyclohexane derivative as the major product.

Now if we change this to a very similar but different compound like this and do the reaction with HBr once again as usual. So what we can see, we can clearly understand that again there are two possibilities of carbocations. One is this and other one is this one. Both of them are 2 degree carbocation. So technically these two carbocations will have similar stability.

Therefore, both of them will give the corresponding product with the reaction of bromine and once again, what you can see is that the possibility of products become large. Because there can be top attack and bottom attack of Br- on each carbocation. This is coming from the carbocation 1 and these two compounds will originate from the carbocation 2.

Now what you can see is that this carbocation 1 has a possibility of hydride shift. So if that hydride shift happens what we get is a new 3 degree carbocation from a 2 degree carbocation which is more stable. And then Br- can attack on this carbocation to form this compound, which is again it can be up or down.

So technically what we would get is we will get five products and we may get this product as a major product as it comes from the most stable carbocation after hydride shift. So we will have five compounds with more amount of this compound number 5, which is generated from the most stable carbocation. So now we hope you understand that how important it is to establish which carbocation is more stable in this kind of addition reactions.

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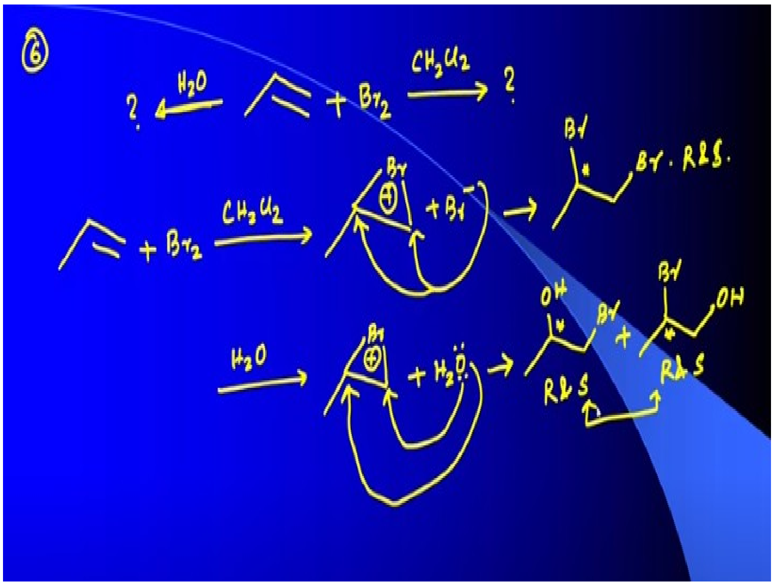

Now let me ask you a different question. Of course, the examples that I am taking are similar. But now we are doing the addition reaction with bromine in two different medium. What would be the products of these two reactions? When you do the addition of bromine with an alkyl in CH2Cl2 medium or dichloromethane methane medium, the first step as you know is the formation of bromonium ion and Br- is released.

And then that Br- can attack on either carbon to open this bromonium ion and form a product which is a dibromo compound. But the same reaction when done in water, of course the first step is same, the formation of bromonium ion and you have water molecule in the medium. So this water molecule can either attack on the carbon 1 or it can attack on carbon 2 and result into two different compounds.

Of course, this happens after elimination of one proton from water molecule to make this as a neutral compound. So what you see that here this is a chiral center and in this compound, you have this as a chiral center and of course, this will have both R and S. This will also have both R and S. This will have both R and S. And these two are two different compounds altogether.

So they are once again isomers. This reaction as you have already studied in the class is a halohydrin formation reaction.

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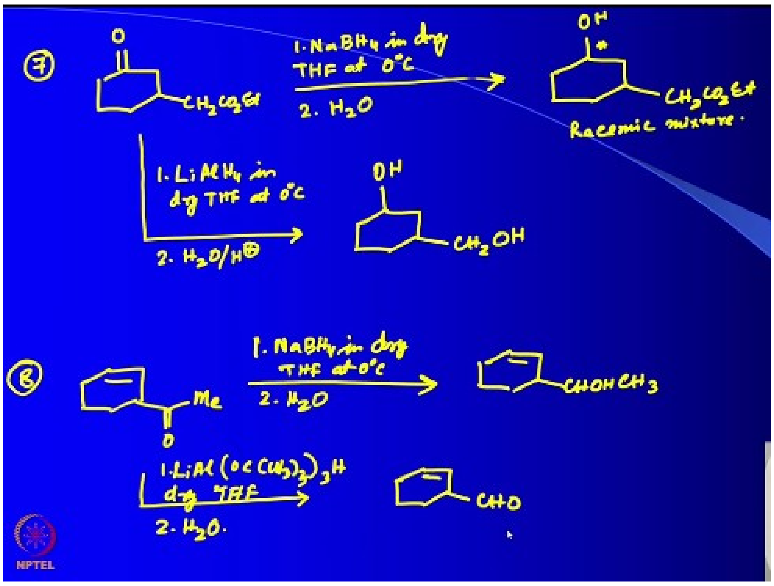

Now let us move to some reduction reaction. If we have carbonyl group and ester group together in a compound, what happens if we do a reduction reaction with sodium borohydride in dry THF medium at 0 degree centigrade followed by hydrolysis in the second step? What will be the reaction product? As you know sodium borohydride is a mild reducing agent.

So it will reduce your ketone to alcohol and make it a chiral enter keeping the ester unaltered. So this will be a racemic mixture. But on the other hand if you treat this compound with lithium aluminum hydride in dry THF at 0 degree centigrade and then later treat this with water in the presence of H+ you will get OH here. Thus the ketone will be reduced to alcohol and also the ester will be reduced to alcohol as well.

So lithium aluminum hydride reduces both the ketocarbonyl groups, that is one ketone and one ester to corresponding alcohol. Let us take the last example, which contains a double bond and a carbonyl group as well. What will happen if we treat this with sodium borohydride in dry THF at 0 degree C followed by hydrolysis?

As we all know that this carbonyl or the ketone will get converted to the corresponding alcohol keeping the double bond intact. If you do this reaction in the presence of a mild reducing agent LiAl(OCCH2)3)3H which is a single hydride transfer reagent and then in presence of dry THF as usual and do the hydrolysis. What you would get is an aldehyde instead of the alcohol.

So this reduction will result in to the reduction of carbonyl to ketone to an aldehyde. So with this we conclude this session with some examples. I would like you to practice this type of problems from some textbook that are prescribed throughout this course. Thank you.