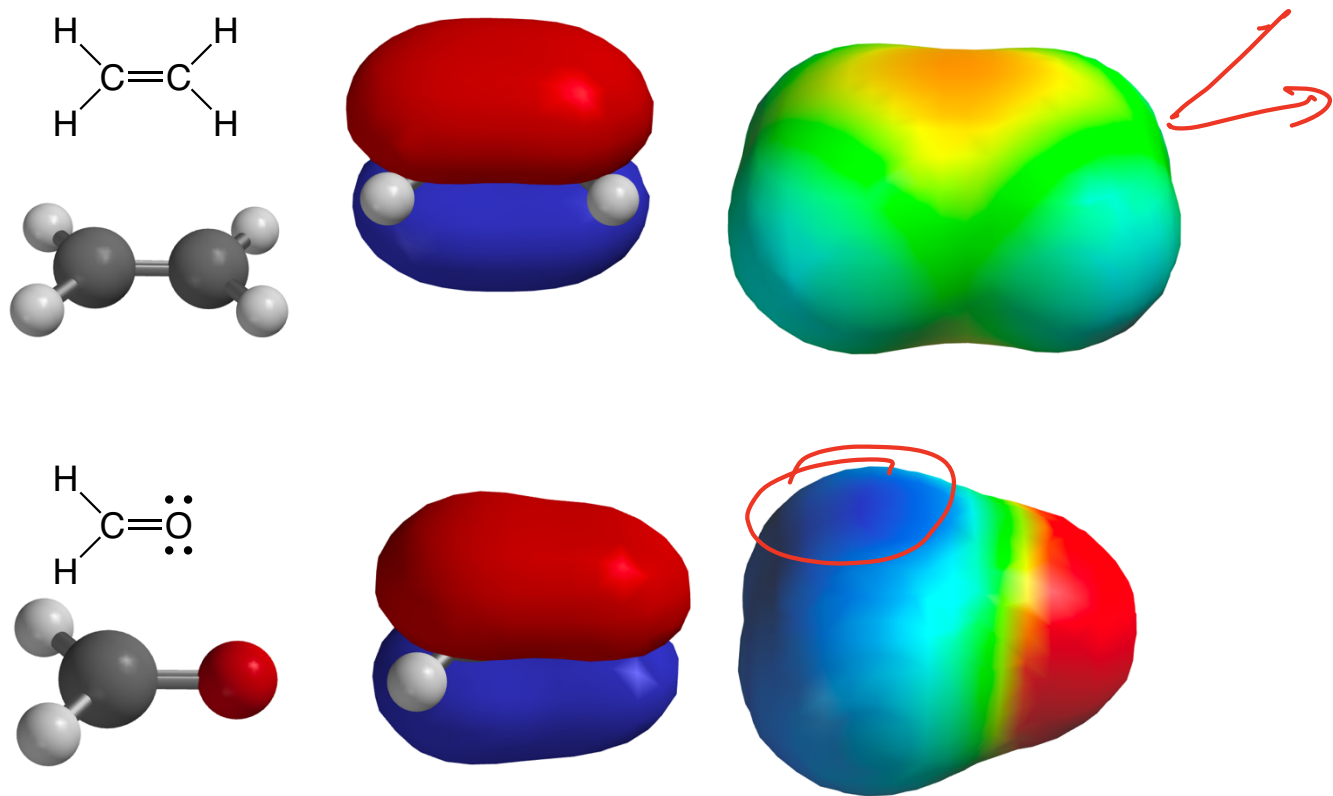
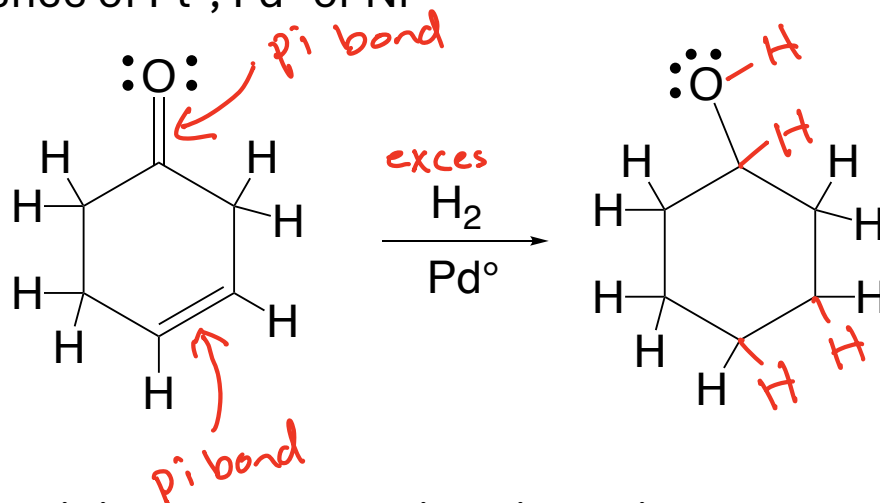




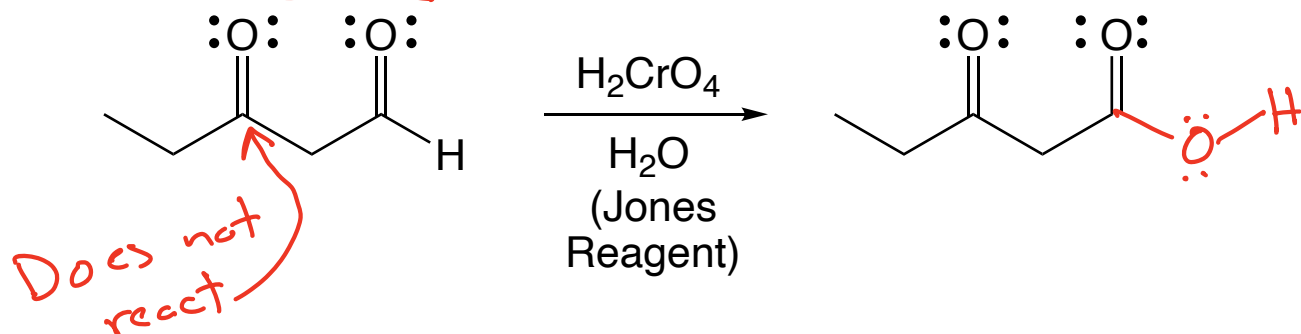
Detour: Hydrogenation and Oxidation of Aldehydes and Ketones



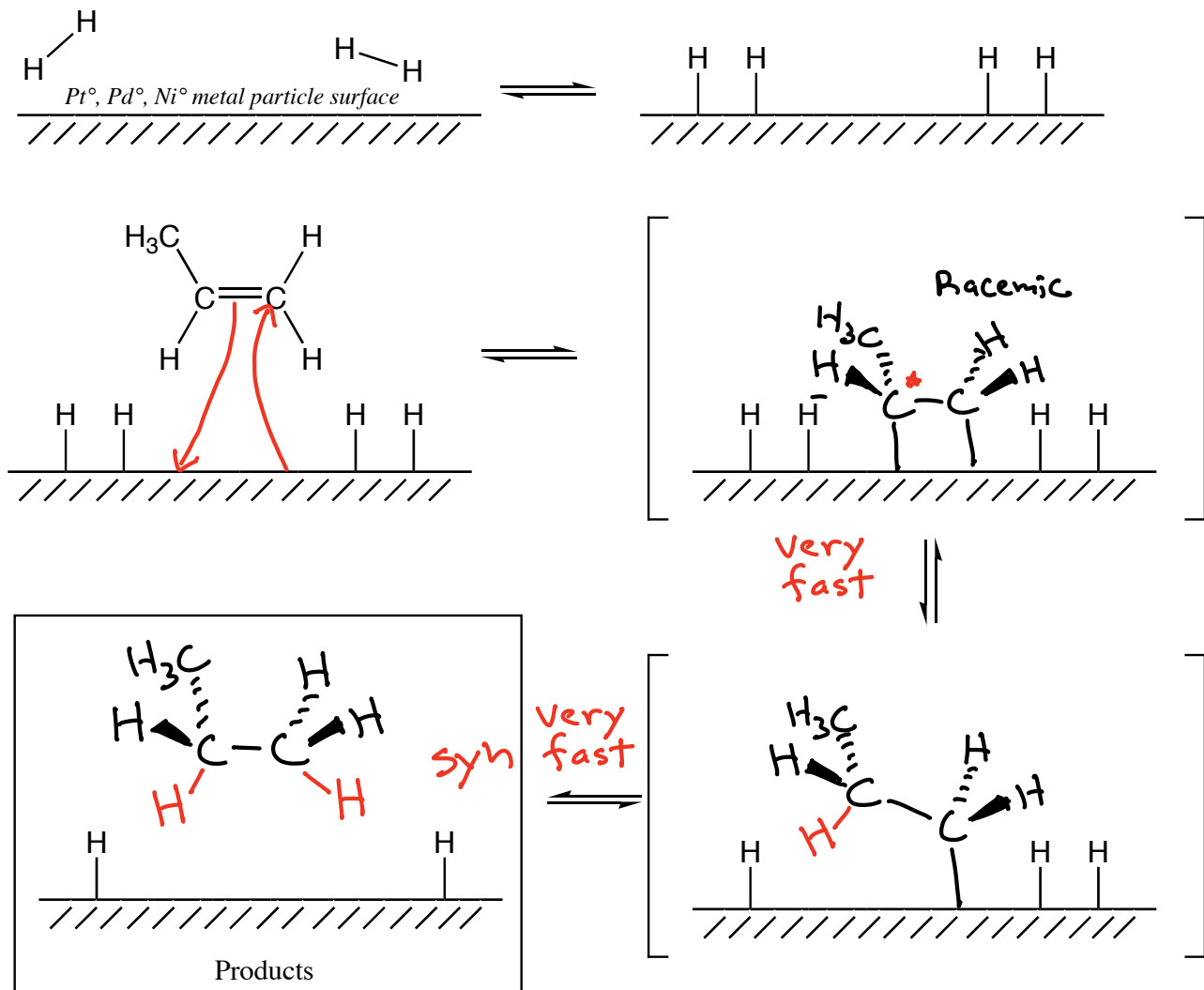
The pi bonds of carbonyls react the same as pi bonds of alkenes with H_2 in the presence of Pt° , Pd° or Ni°



Aldehydes are oxidized to carboxylic acids using the Jones Reagent (H_2CrO_4 in H_2O). Ketones do not react.



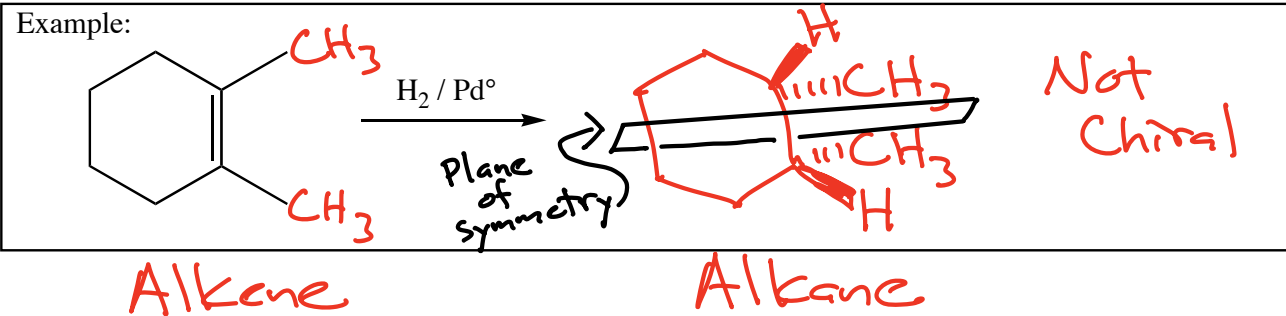
Hydrogenation: H_2 with Pt^0 , Pd^0 , Ni^0



Summary: H_2 adsorbs onto the metal surface. The alkene adsorbs onto the metal surface. H atoms transfer to both C atoms \rightarrow on the same face \rightarrow before the C-C bond rotates

Regiochemistry: N/A

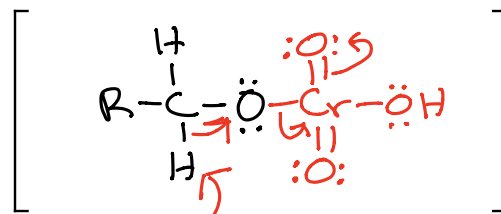
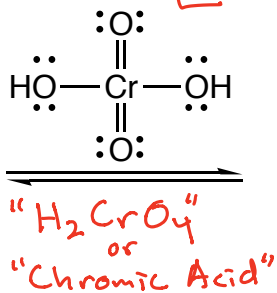
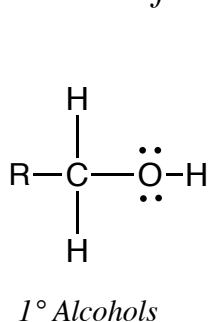
Stereochemistry: Syn



Chromic Acid Oxidation of Alcohols

Called "Jones Reagent" $(CrO_3 + H_2O)$ or $K_2CrO_7 + H_2SO_4$

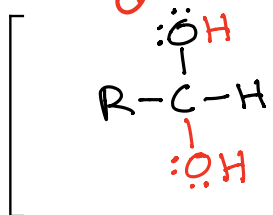
Not responsible for first step



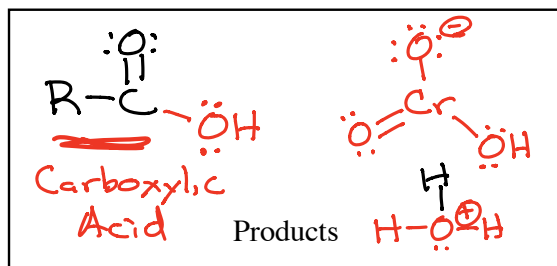
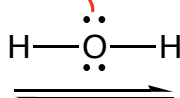
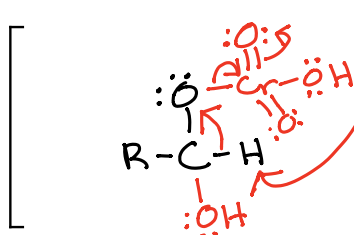
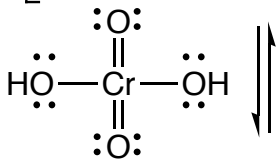
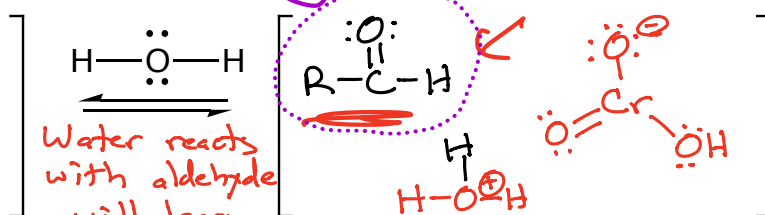
Aldehyde!

Take a proton away and break a bond

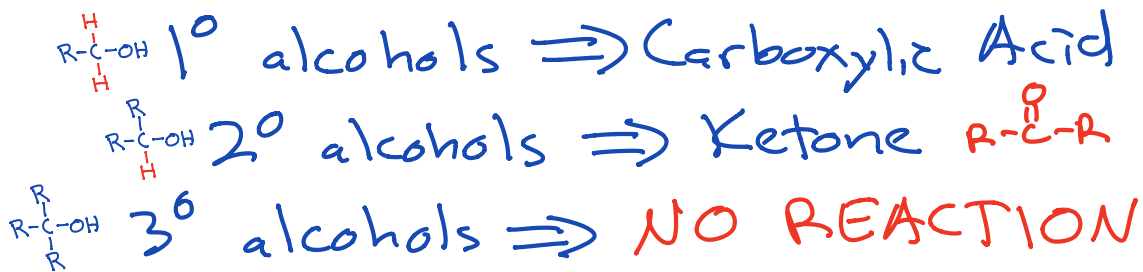
Not responsible for this step



Called a geminal diol



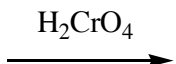
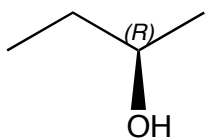
Summary:



Regiochemistry: N/A

Stereochemistry: N/A

Example:

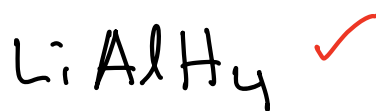
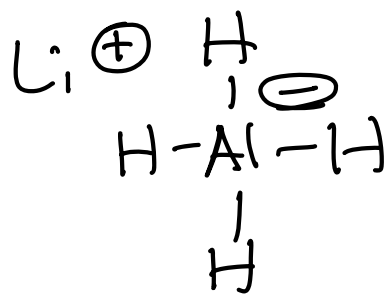
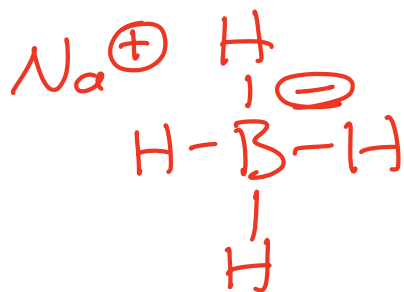


Ketone

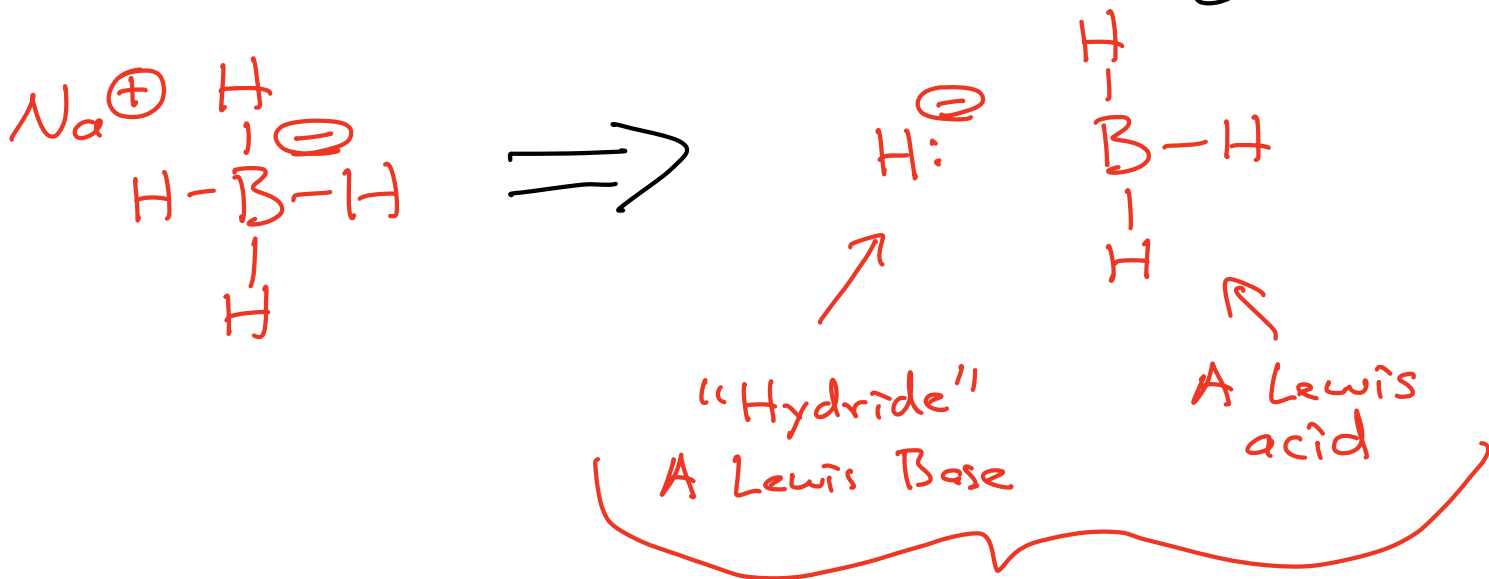
We now return to our regularly scheduled discussion of Mechanism A

Metal Hydride Reduction

⇒ Reduce C=O but not C=C

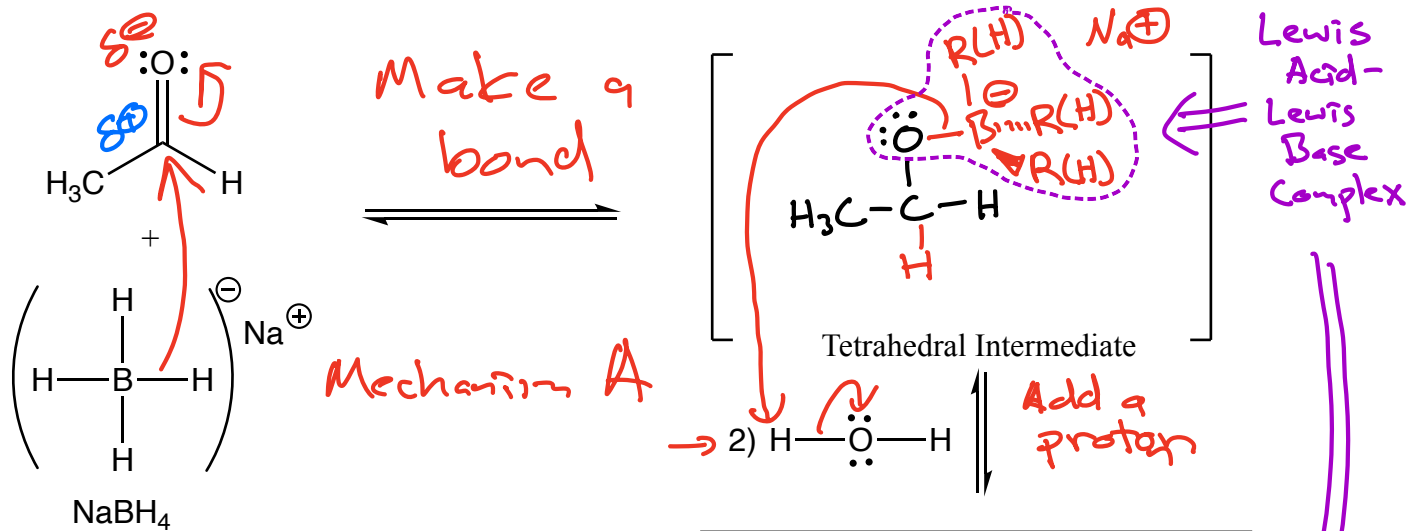


How to think about the reagent:



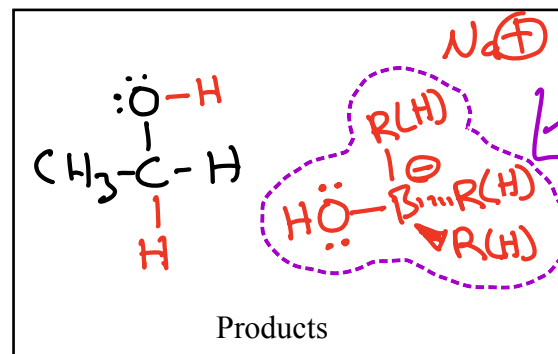
You can think of NaBH_4 as a Lewis base-Lewis acid complex between hydride (H^{\ominus}) and BH_3

Sodium Borohydride Reacting with an Aldehyde or Ketone

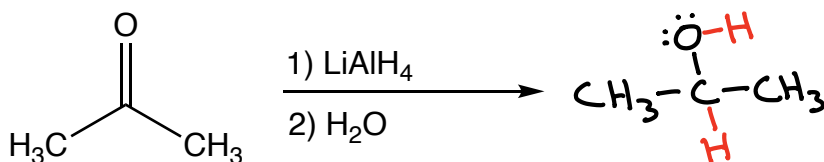
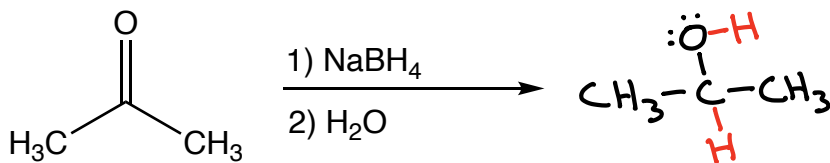
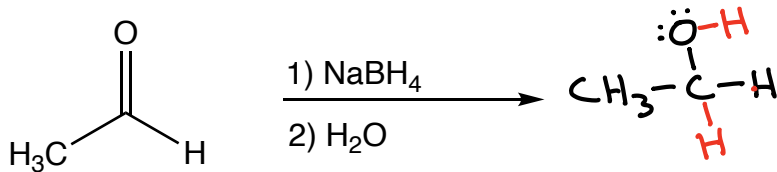
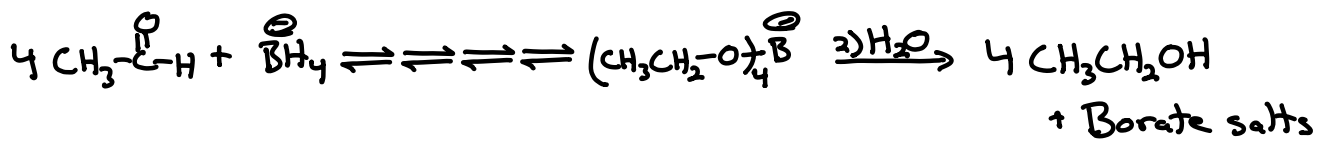


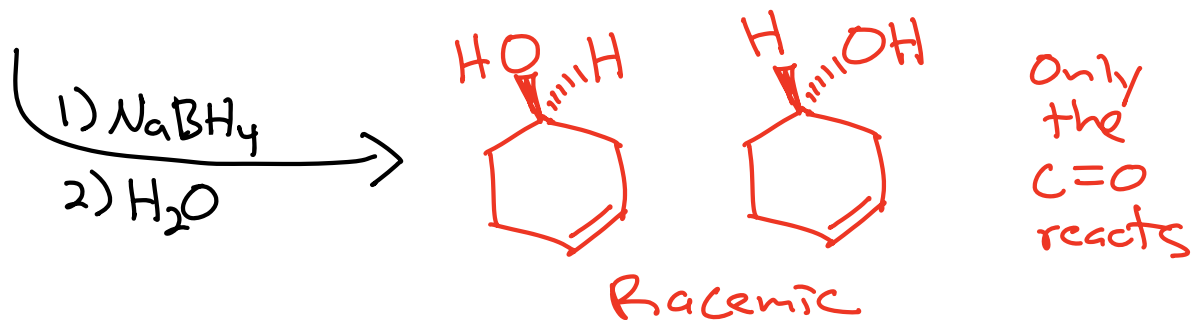
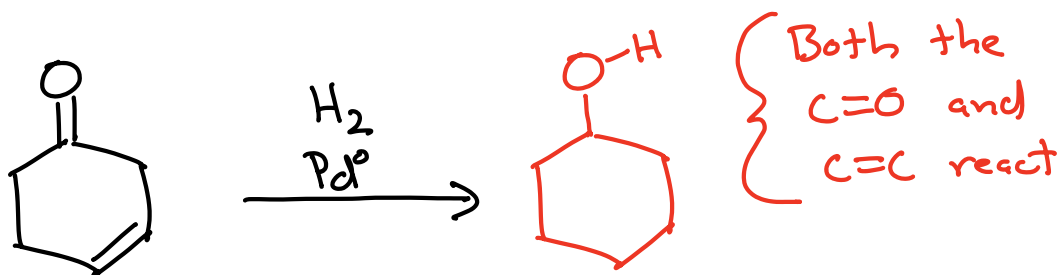
Key Recognition Element (KRE):

An $-\text{OH}$ group where there was a $\text{C}=\text{O}$ of an aldehyde or ketone



All four H of BH_4 react!





"hydride"

This makes sense because $H:\ominus$ is a nucleophile and $C=O$ is an electrophile, while $C=C$ is NOT an electrophile so it cannot react!

Weak nucleophiles such as $R-\ddot{O}-H$ are not strong enough to react with a $C=O$ of a ketone or aldehyde

→ We add acid to make the $C=O$ into a much better electrophile → protonate the O atom

Here are the keys to understanding mechanisms in 320N!!

1) There are basically four different mechanism elements that make up the steps of carbonyl reactions.

A) Make a bond between a nucleophile and an electrophile

B) Break a bond to give stable molecules or ions

C) Add a proton

D) Take a proton away

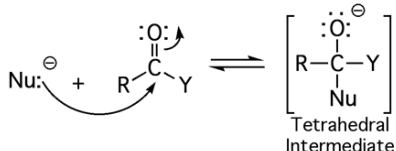
2) These same four mechanism elements describe most of the other mechanisms you have/will learn!!! (Yes, organic chemistry really is this simple if you look at it this way!!)

There are basically four different mechanisms that describe the vast majority of carbonyl reactions and these mechanisms are different combinations/ordering of the four mechanism elements listed above. In this class, I have termed them "Mechanism A", "Mechanism B", "Mechanism C", and "Mechanism D". They all involve a nucleophile attacking the partially positively charged carbon atom of the carbonyl to create a tetrahedral intermediate. Different reaction mechanisms are distinguished by the timing of protonation of the oxygen atom as well as the presence or absence of a leaving group attached to the carbonyl.

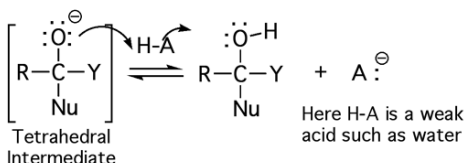
Four Mechanisms for the Reaction of Nucleophiles with Carbonyl Compounds

MECHANISM A: Reaction with a Strong Nucleophile

Step 1 Make a new bond between a nucleophile and electrophile

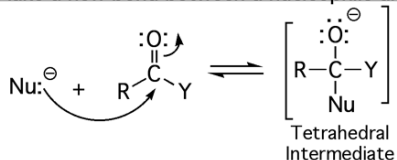


Step 2 Add a proton

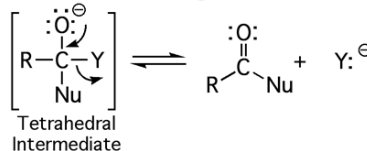


MECHANISM B: Reaction with a Strong Nucleophile When "Y" is a Good Leaving Group (-OR, -Cl, etc.).

Step 1 Make a new bond between a nucleophile and electrophile

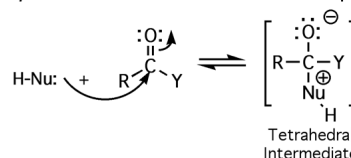


Step 2 Break a bond to give stable molecules or ions

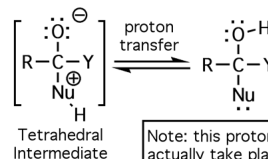


MECHANISM C: Reaction with a Weak Nucleophile

Step 1 Make a new bond between a nucleophile and electrophile



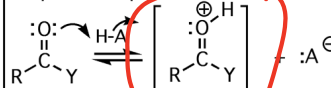
Step 2 Add a proton and Take a proton away



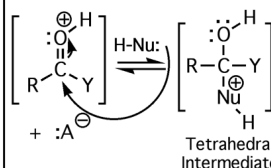
Note: this proton transfer can actually take place in two steps, i.e. Add a proton then Take a proton away or vice versa.

MECHANISM D: Reaction with a Weak Nucleophile in the Presence of Acid (H-A)

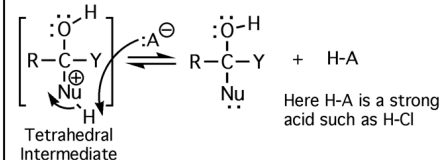
Step 1 Add a proton



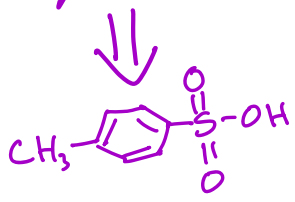
Step 2 Make a new bond between a nucleophile and electrophile



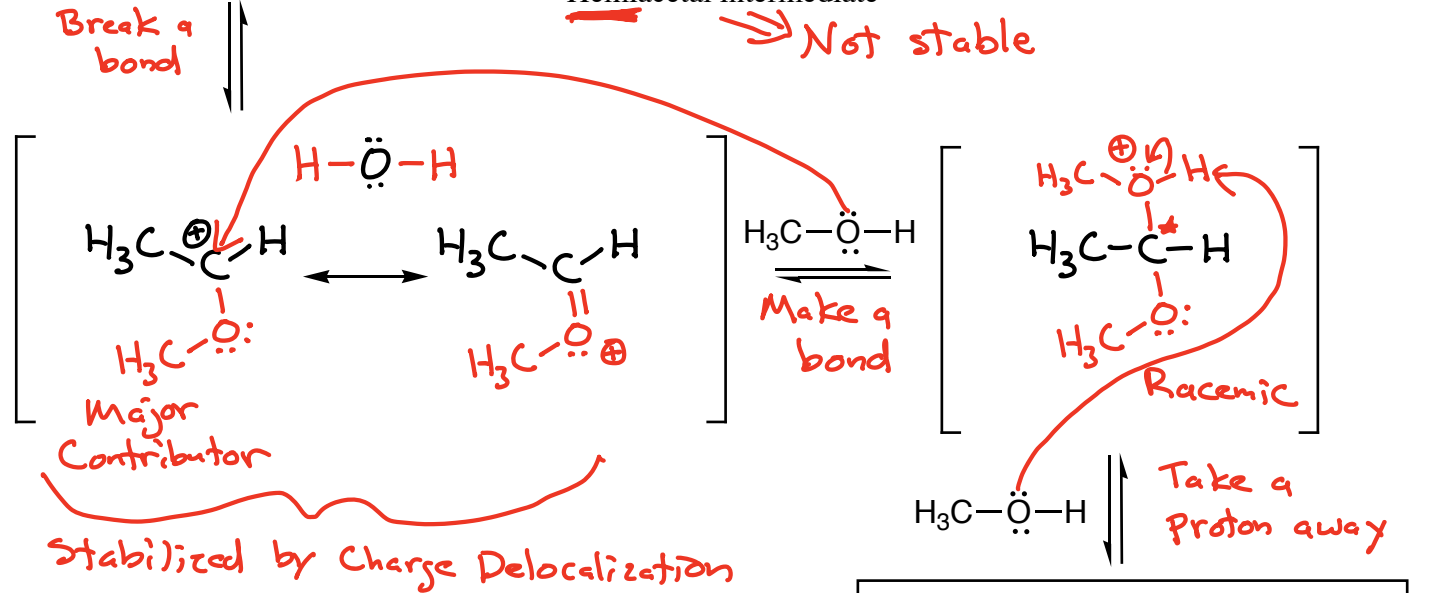
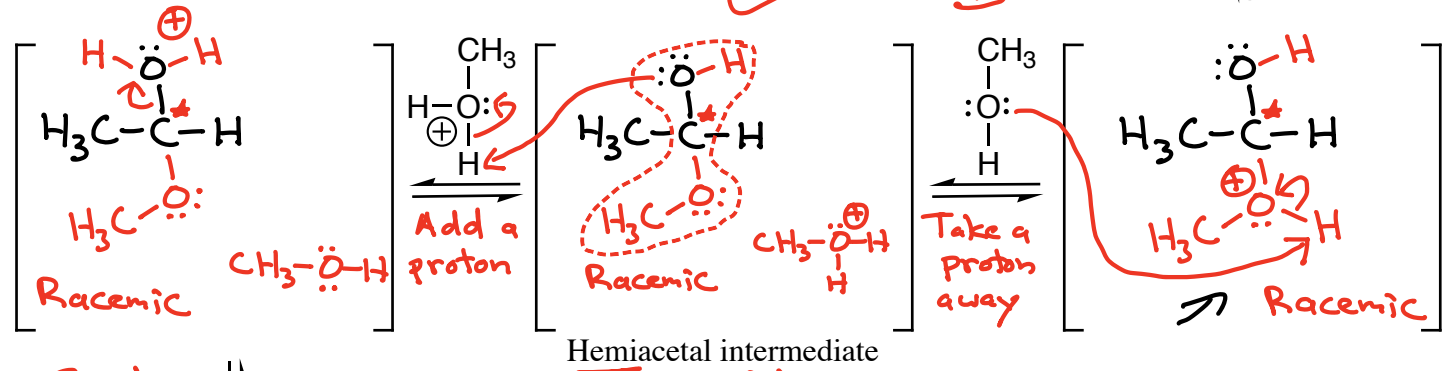
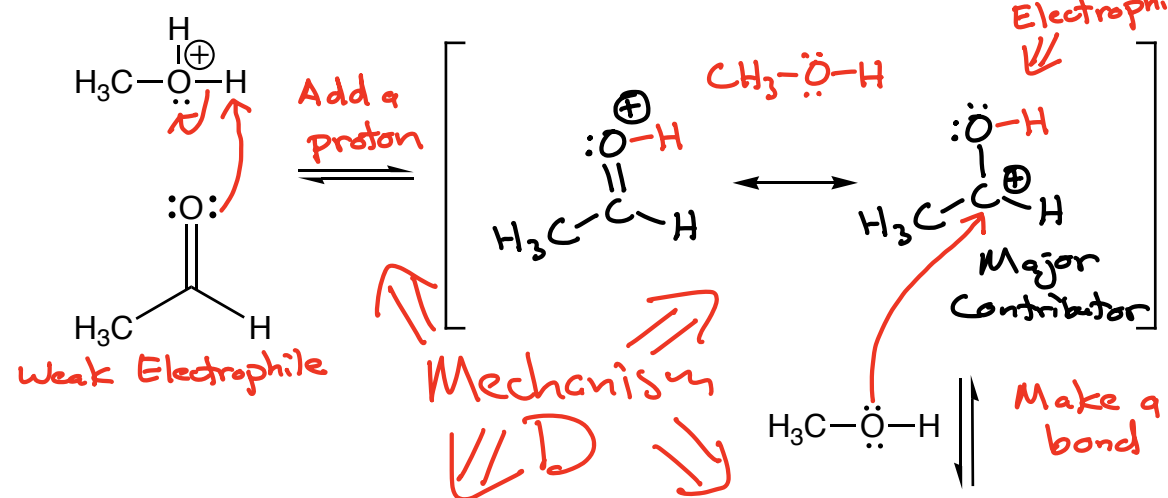
Step 3 Take a proton away



TsOH or H₂SO₄
 Tosylic Acid
 Acid Catalyzed Hemiacetal and Acetal Formation From an Aldehyde or Ketone



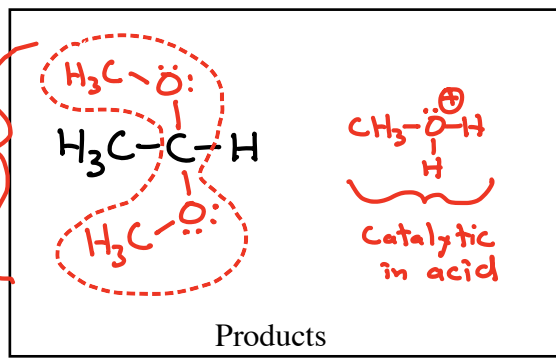
"Hey, does that thing have a hemi in it?" "SWEET!"



Key Recognition Element (KRE):

Two bonds to O atoms from an sp³ C atom

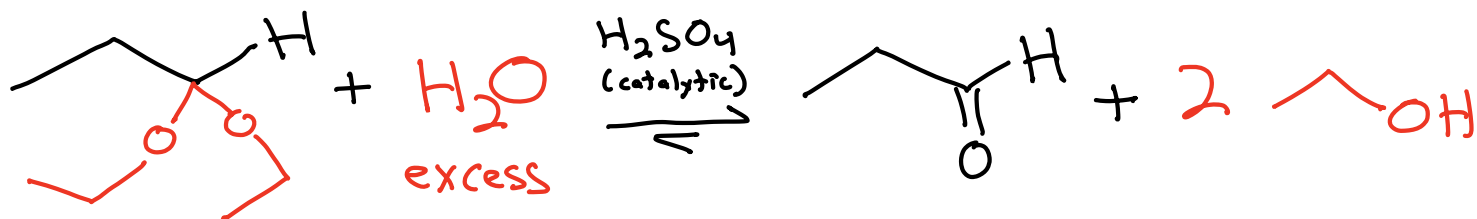
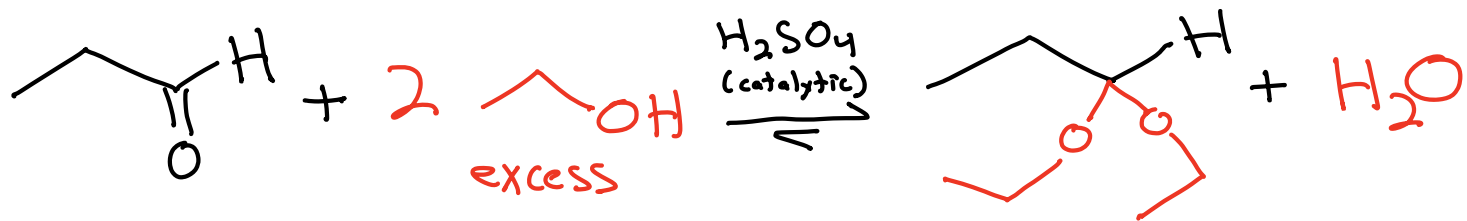
Definition of an acetal



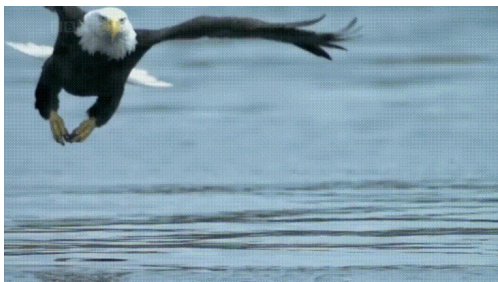
alcohol dehydration



Just like alkene hydration last semester, this acetal formation reaction is REVERSIBLE



Le Chatelier's Principle



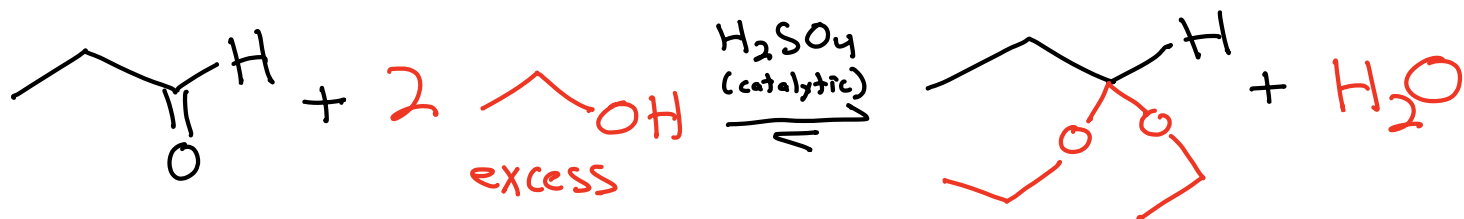
"The Claw"

Cyclic acetals are more stable than "normal" acetals because of the chelate effect.

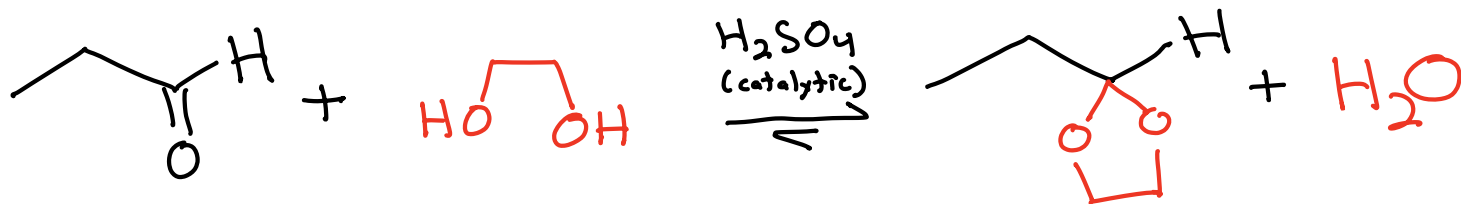
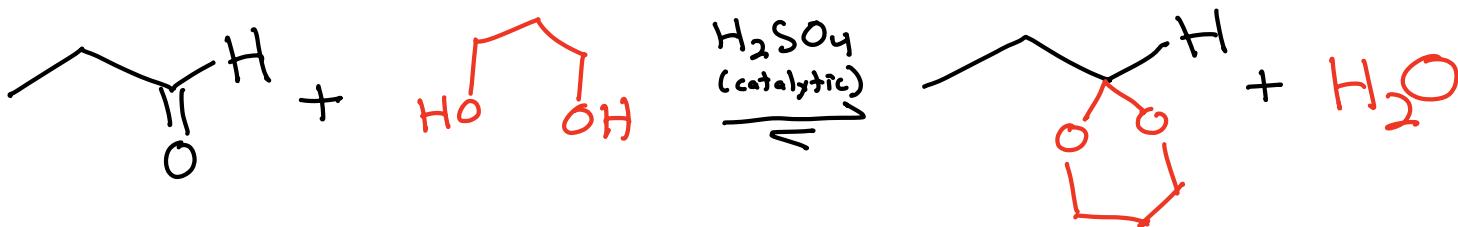
⇓
"Claw" in Latin

"Two OH groups already attached to each other 'go on' easier and 'come off' harder"

"Normal" acetal

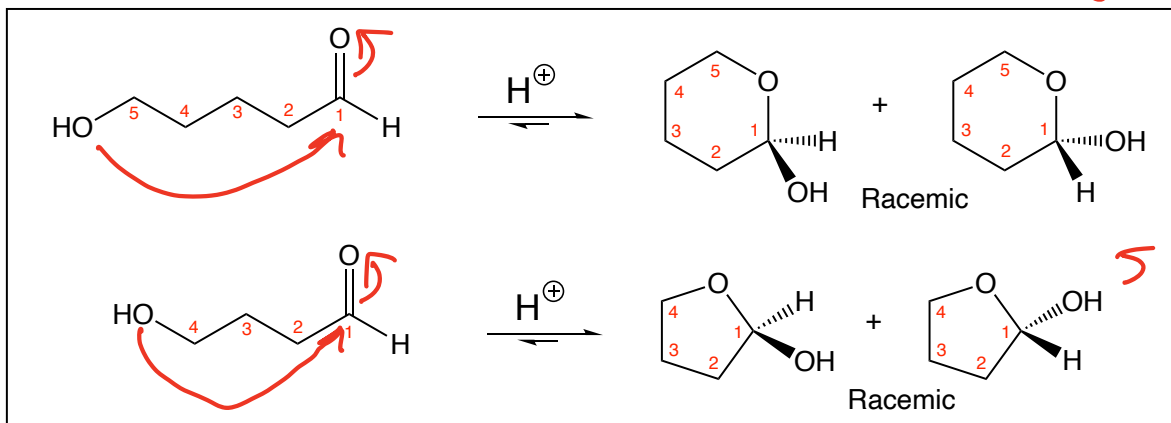


Cyclic acetals → 5 and 6-membered rings!
Stable → Strain free

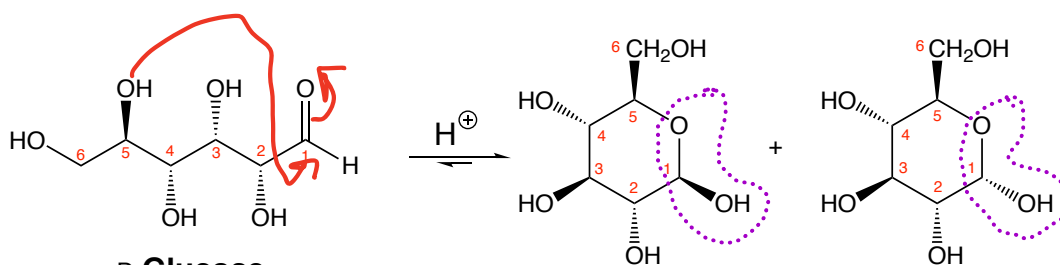


Cyclic Hemiacetals and Carbohydrates

6



Cyclic Hemiacetals are stable! Chelate effect



D-Glucose
(open chain form)

