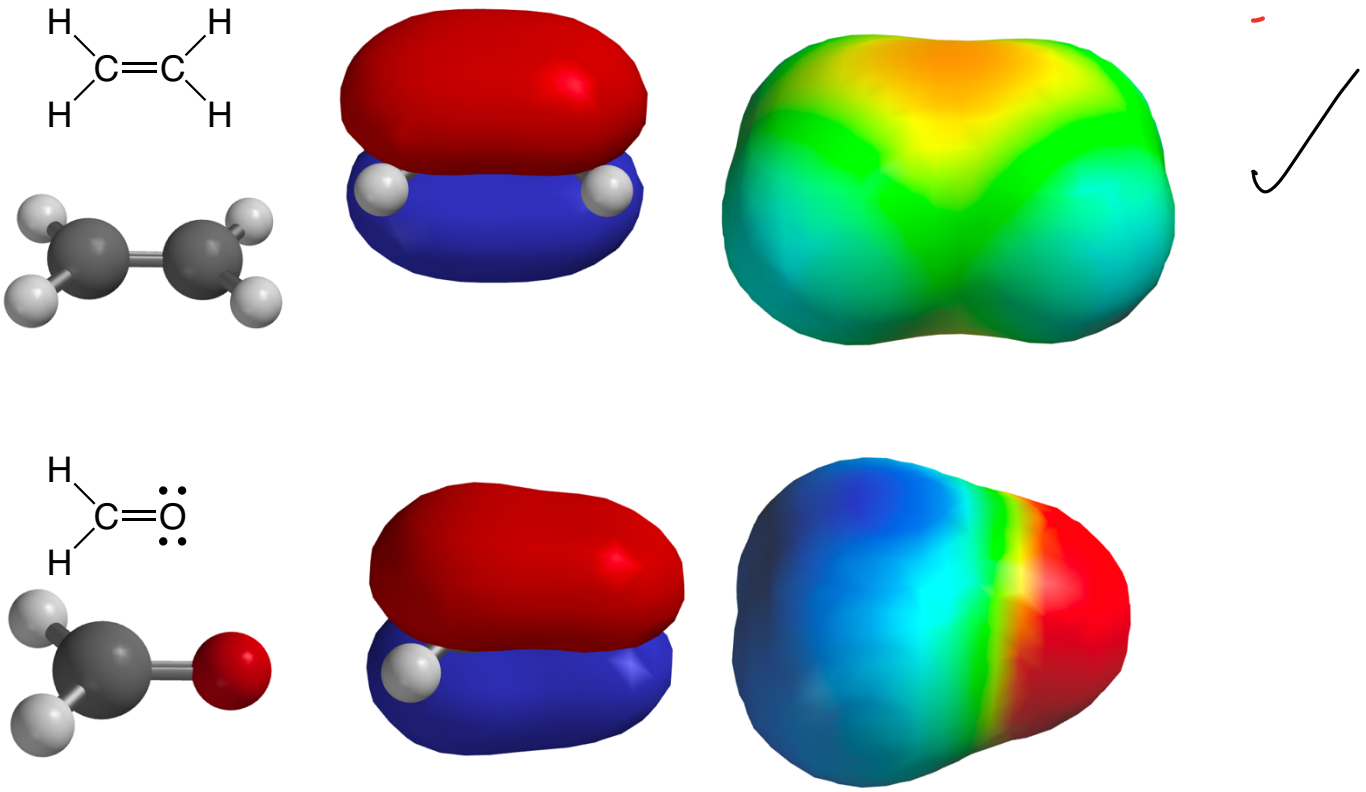
I am here to help all of you succeed.

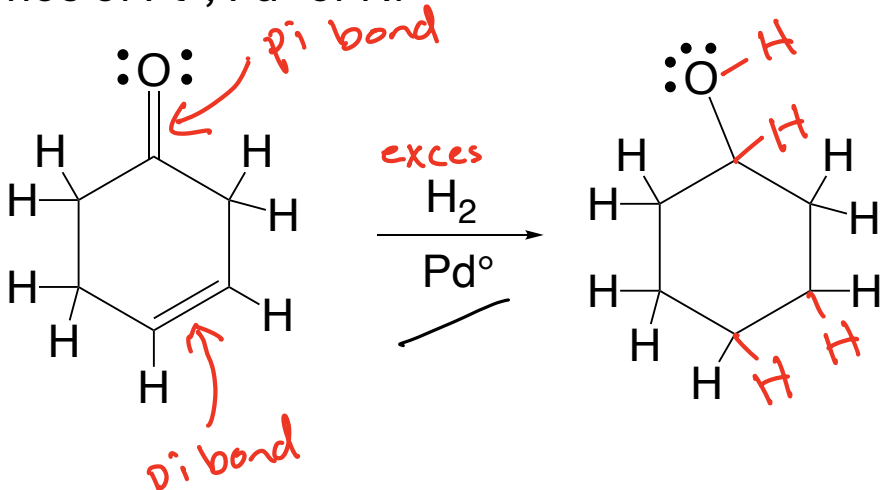
I can provide you with multiple paths to success in this class. You need to choose and commit to the one that is best for you.

I will listen when you tell me what you need from me.

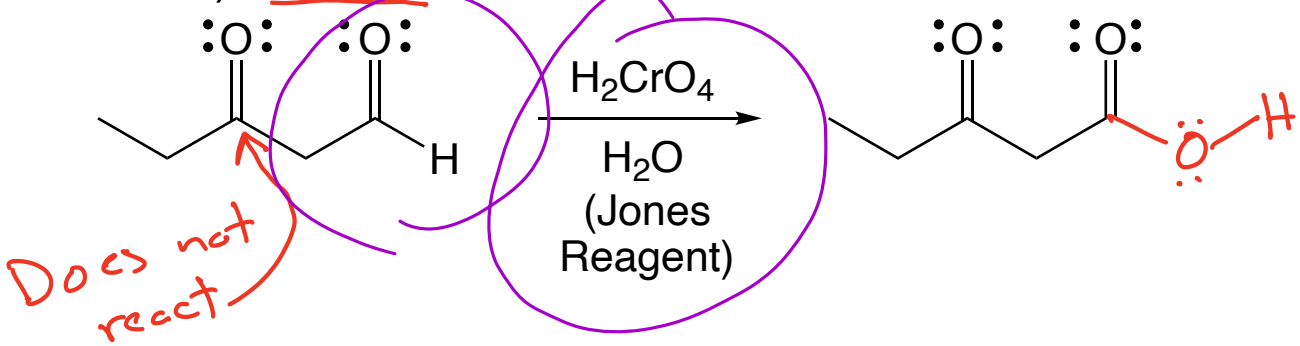
Detour: Hydrogenation and Oxidation of Aldehydes and Ketones

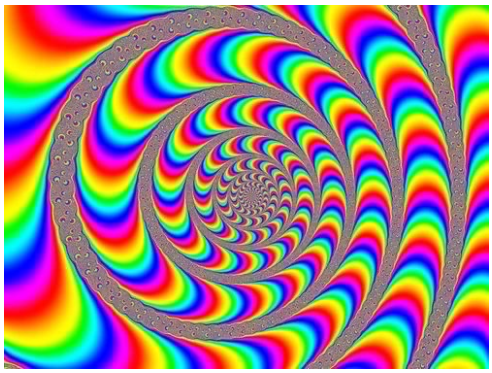


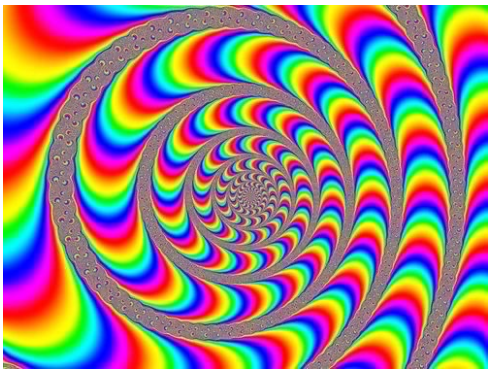
The pi bonds of carbonyls react the same as pi bonds of alkenes with H_2 in the presence of Pt°, Pd° or Ni°

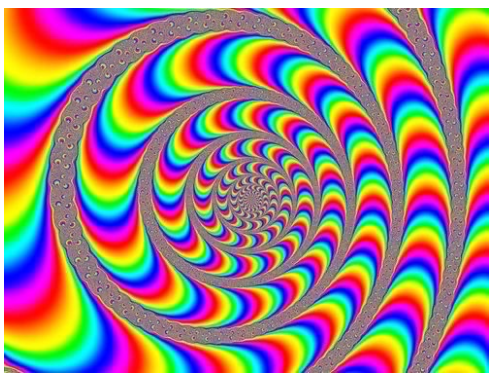


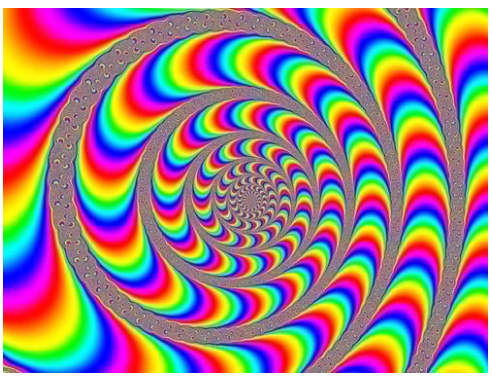
Aldehydes are oxidized to carboxylic acids using the Jones Reagent (H_2CrO_4 in H_2O). Ketones do not react.



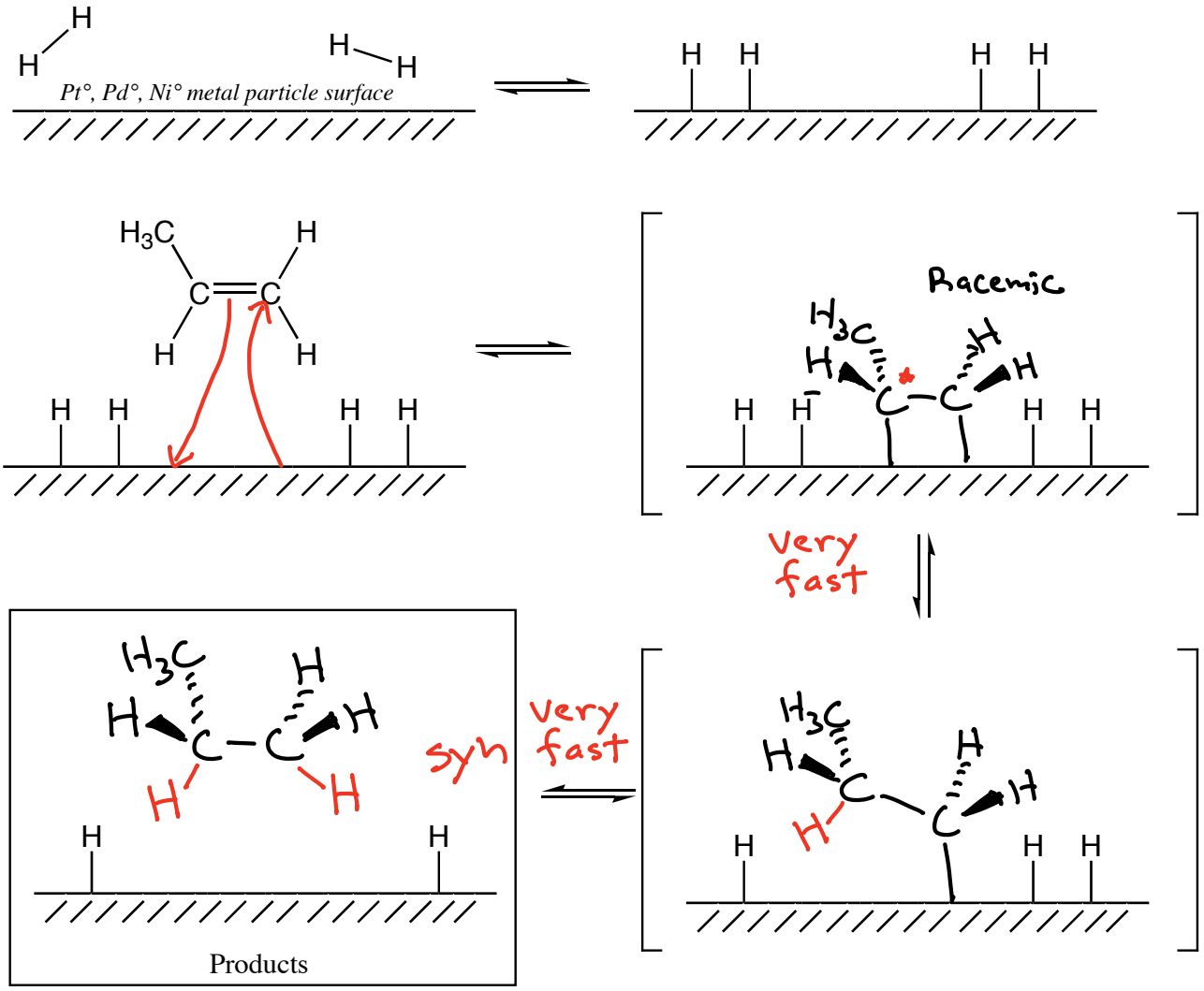








Hydrogenation: H_2 with Pt°, Pd°, Ni°

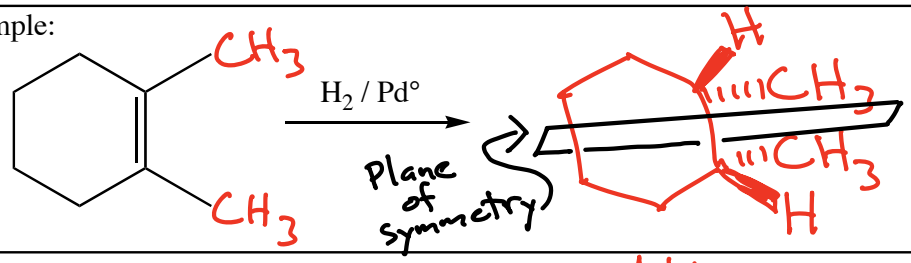


Summary: H_2 adsorbs onto the metal surface. The alkene adsorbs onto the metal surface. H atoms transfer to both C atoms → on the same face → before the C-C bond rotates

Regiochemistry: N/A

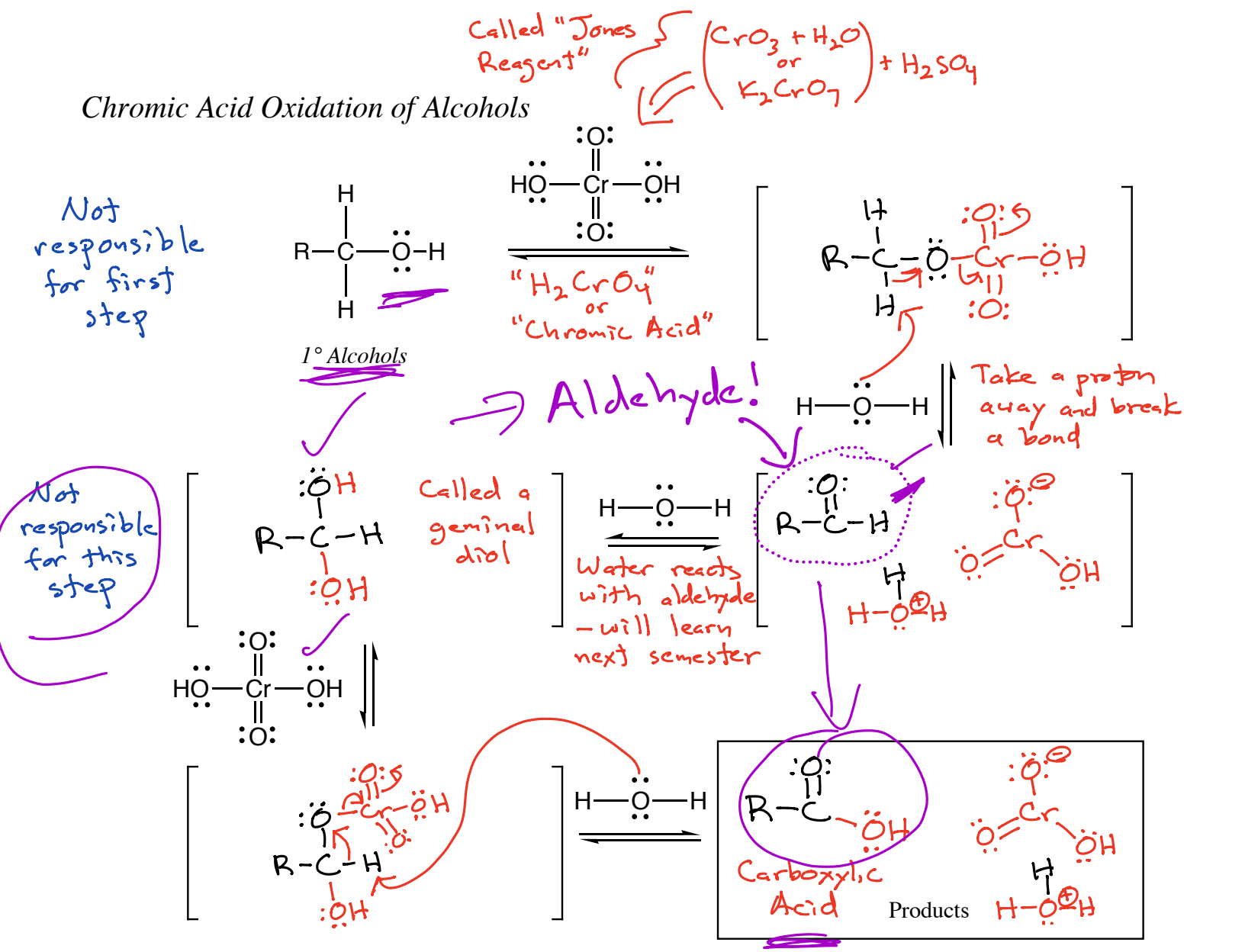
Stereochemistry: Syn

Example:



Alkene Alkane

Chromic Acid Oxidation of Alcohols



Summary:

1° alcohols ⇒ Carboxylic Acid

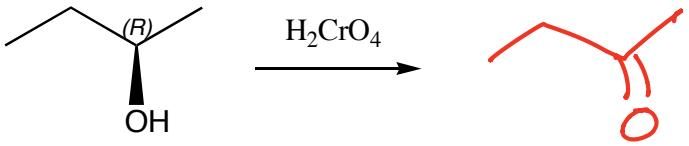
2° alcohols ⇒ Ketone

3° alcohols ⇒ NO REACTION

Regiochemistry: N/A

Stereochemistry: N/A

Example:

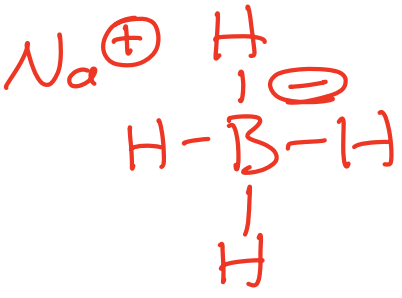


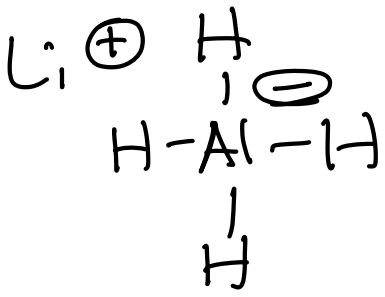
Ketone

We now return to our regularly scheduled discussion of Mechanism A

Metal Hydride Reduction

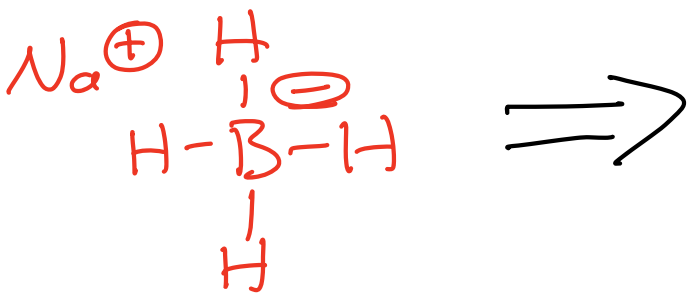
⇒ Reduce C=O but not C=C

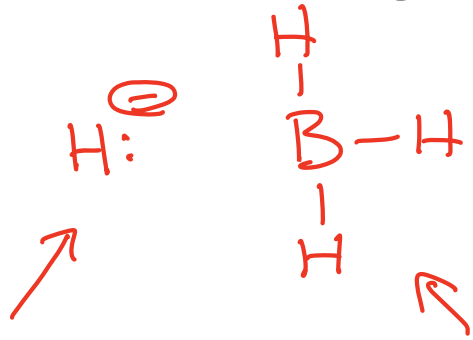




$NaBH_4$ ✓ $LiAlH_4$ ✓

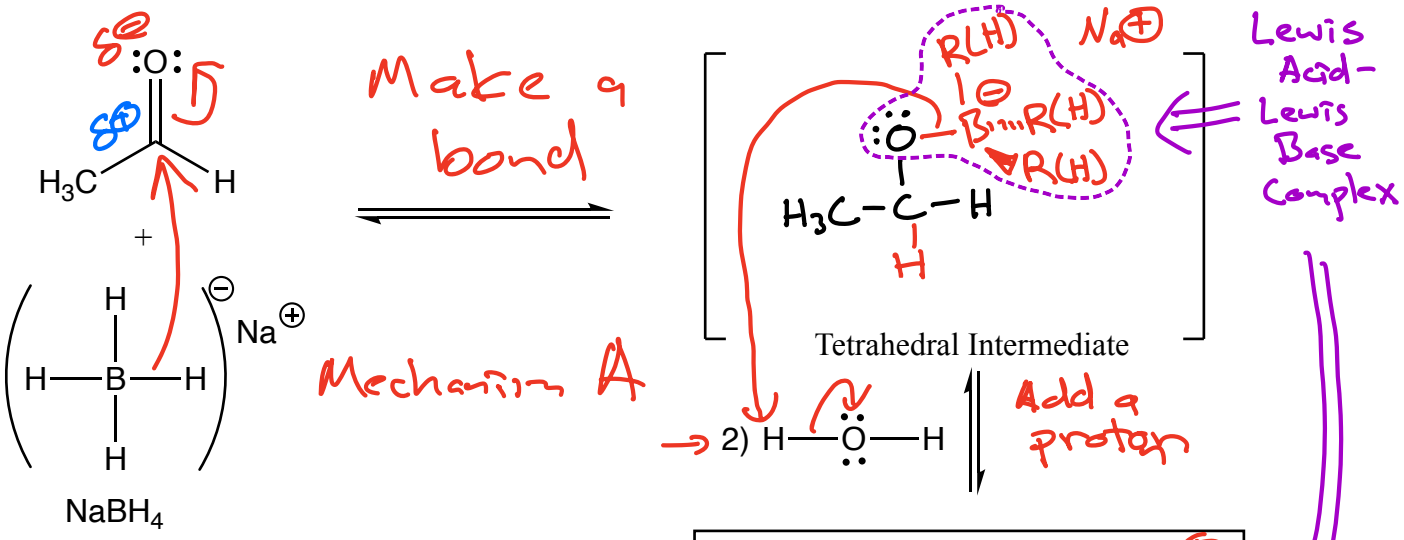
How to think about the reagent:





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

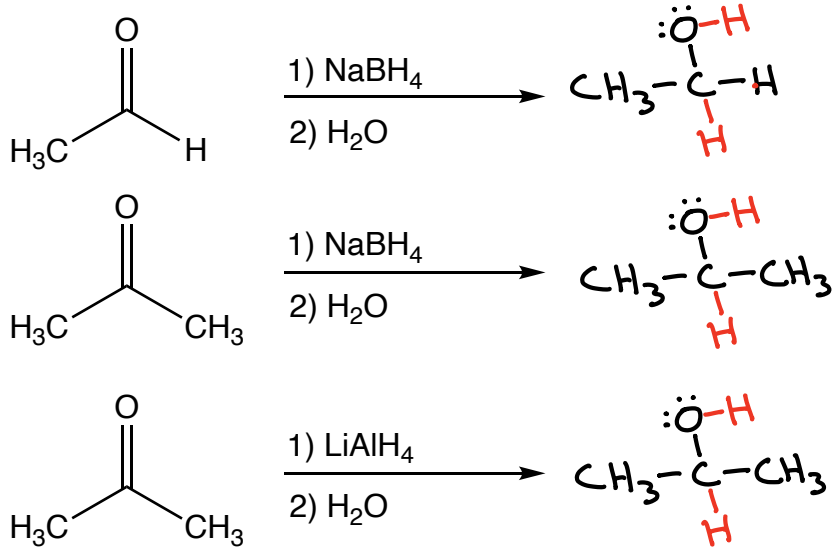


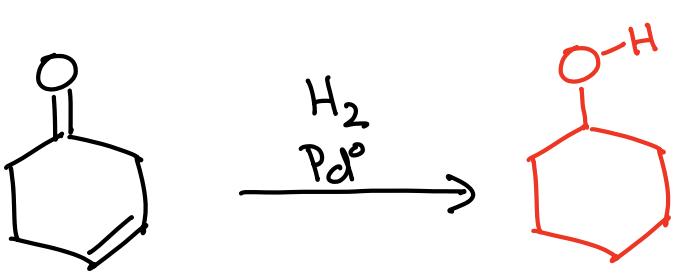
Key Recognition Element (KRE):

An -OH group where there was a C=O of an aldehyde or ketone

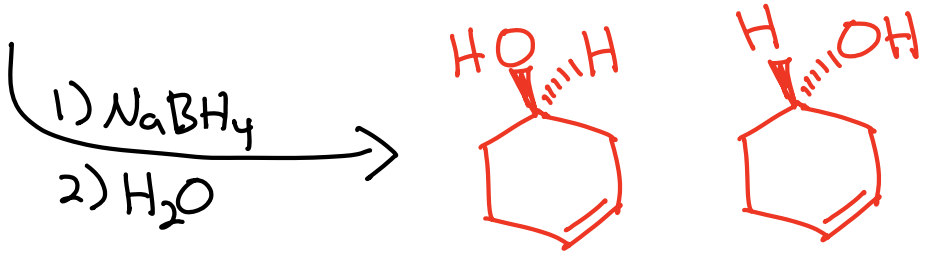
All four H of BH_4^- react!

$$4\ CH_3CHO + BH_4^- \rightleftharpoons\rightleftharpoons\rightleftharpoons\rightleftharpoons (CH_3CH_2O)_4B^- \xrightarrow{2)\ H_2O} 4\ CH_3CH_2OH + \text{Borate salts}$$





Both the C=O and C=C react



Only the C=O reacts

Racemic

"hydride" $H:^{\ominus}$

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

Weak nucleophiles such as R-Ö-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 mechanisms 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

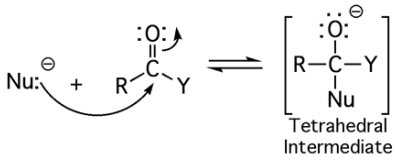
2) These same four mechanism elements describe most of the other mechanisms you have/will learn!!! (Yes, organic chemistry really is this simple if you look at it this way!!)

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.

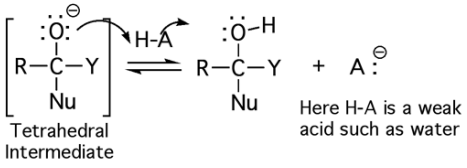
Four Mechanisms for the Reaction of Nucleophiles with Carbonyl Compounds

MECHANISM A: Reaction with a Strong Nucleophile

Step 1 Make a new bond between a nucleophile and electrophile

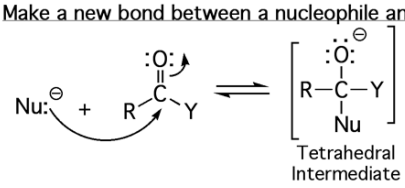


Step 2 Add a proton

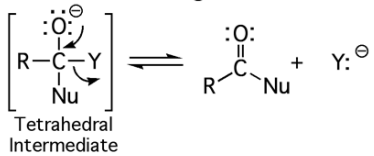


MECHANISM B: Reaction with a Strong Nucleophile When "Y" is a Good Leaving Group (-OR, -Cl, etc.).

Step 1 Make a new bond between a nucleophile and electrophile

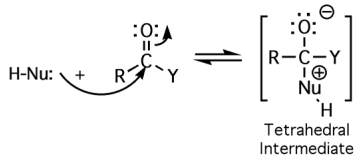


Step 2 Break a bond to give stable molecules or ions

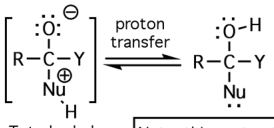


MECHANISM C: Reaction with a Weak Nucleophile

Step 1 Make a new bond between a nucleophile and electrophile



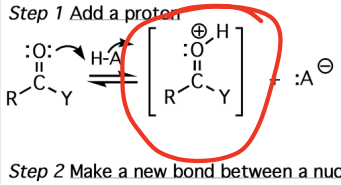
Step 2 Add a proton and Take a proton away



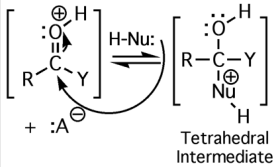
Note: this proton transfer can actually take place in two steps, *i.e.* Add a proton then Take a proton away or *vice versa*.

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

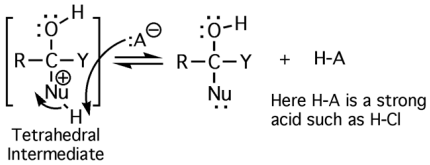
Step 1 Add a proton



Step 2 Make a new bond between a nucleophile and electrophile



Step 3 Take a proton away



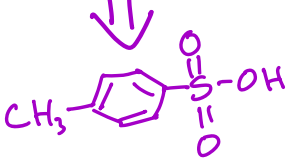
Watch these car commercials before the proceeding to the next mechanisms!

https://www.youtube.com/watch?v=J4EXfrySjI4

https://www.youtube.com/watch?v=Lk9TyzgundA

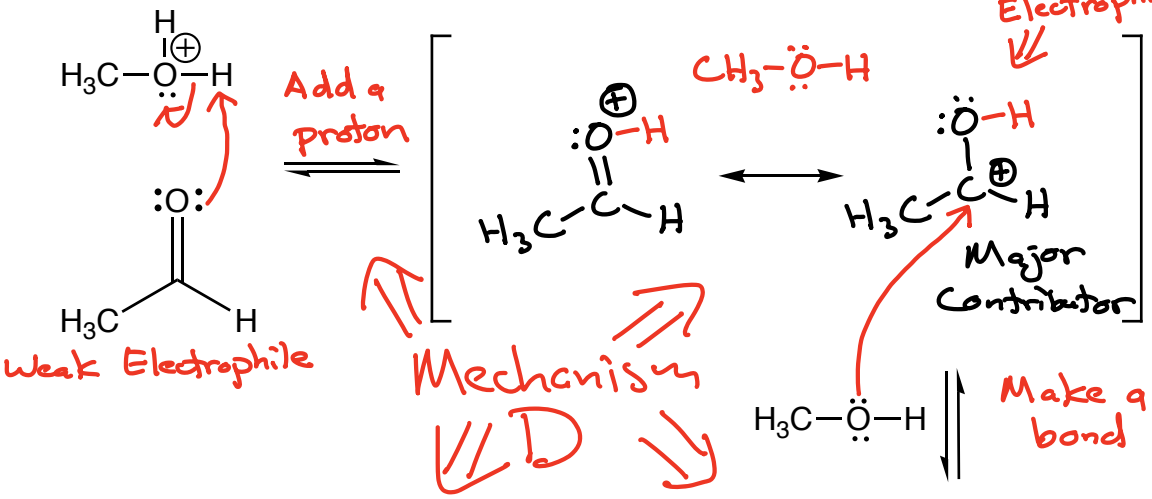
TsOH or H_2SO_4

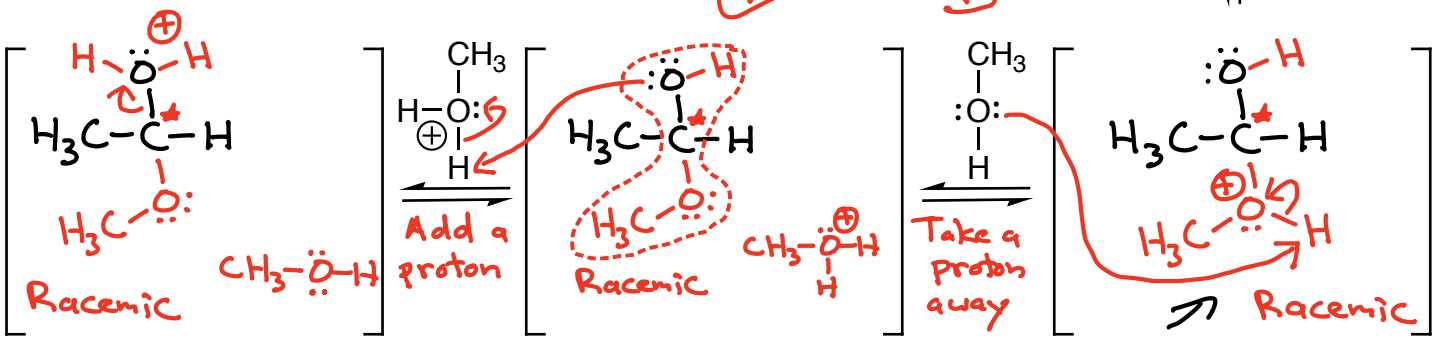
Tosylic Acid



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

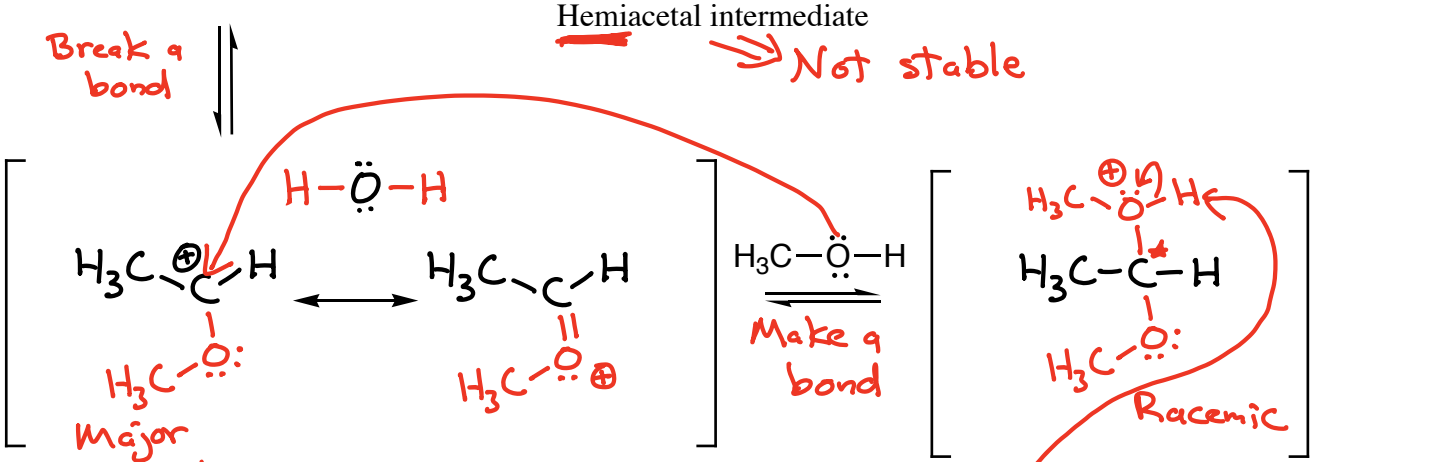
Acid Catalyzed Hemiacetal and Acetal Formation From an Aldehyde or Ketone





Hemiacetal intermediate

Not stable

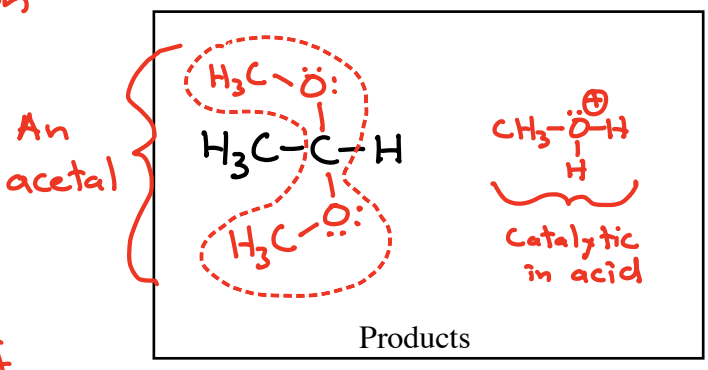


Stabilized by Charge Delocalization

Key Recognition Element (KRE):

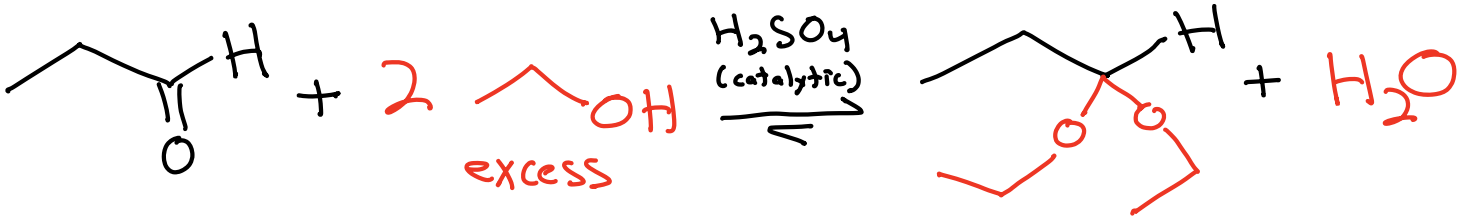
Two bonds to O atoms from an sp^3 C atom

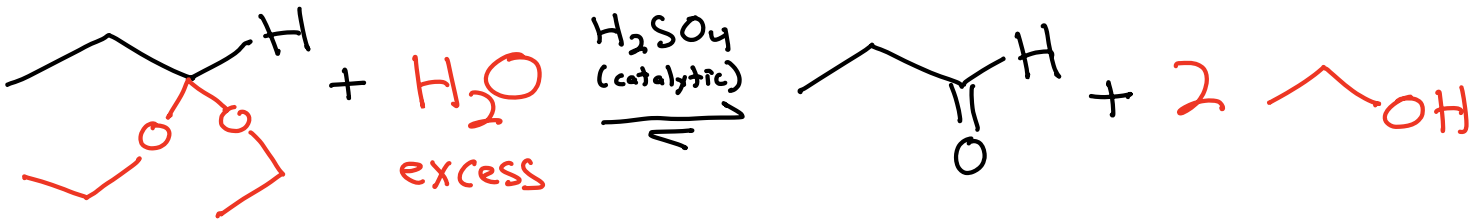
Definition of an acetal



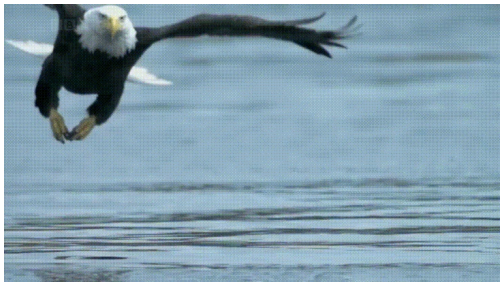
alcohol dehydration II

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





Le Chatliers Principle



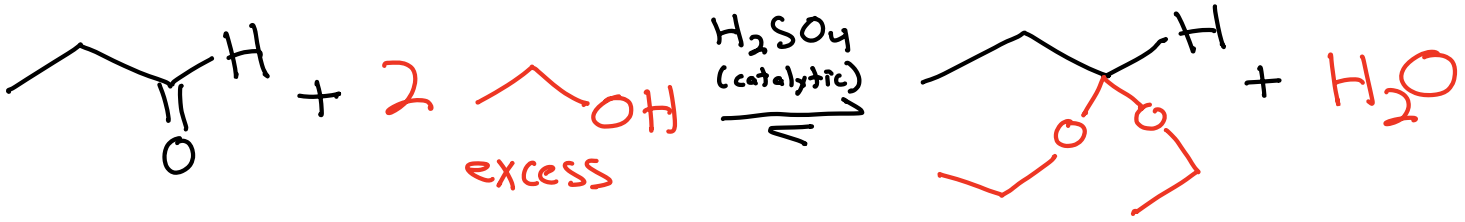
"The Claw"

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

"Claw" in Latin

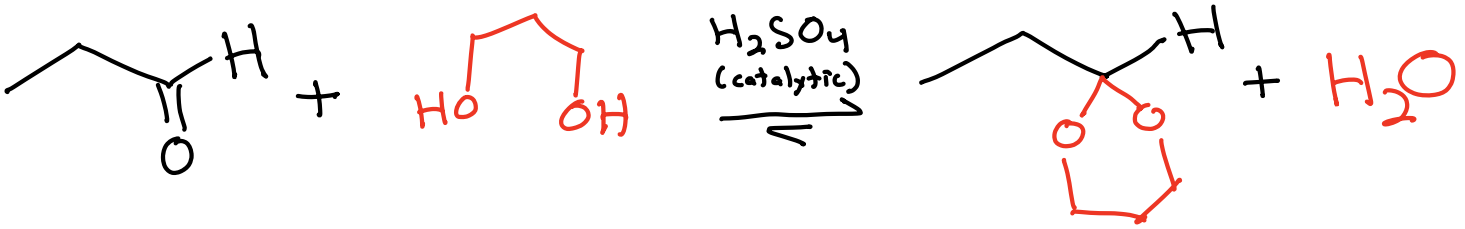
"Two OH groups already attached to each other 'go on' easier and 'come off' harder"

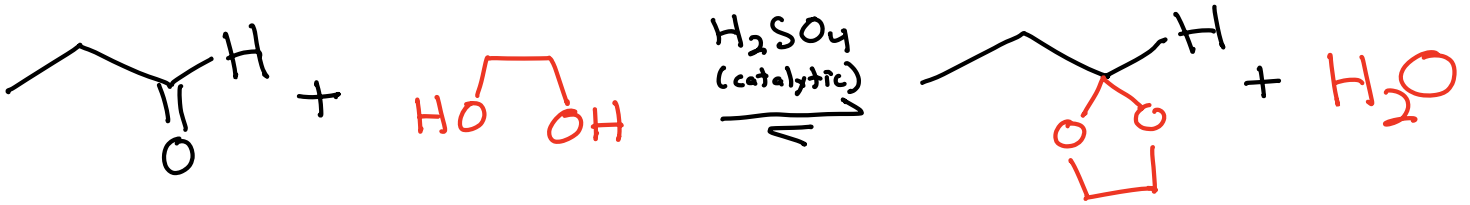
"Normal" acetal



Cyclic acetals → 5 and 6-membered rings!

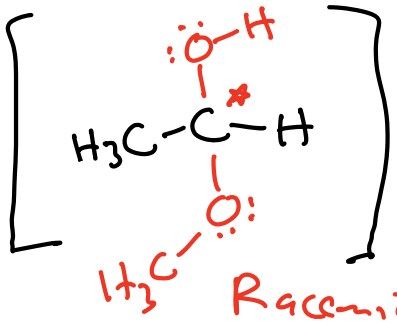
Stable → Strain free



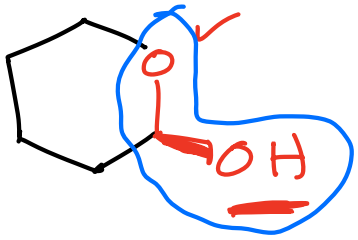


Recap

Hemiacetal → One alcohol and one ether on same Carbon

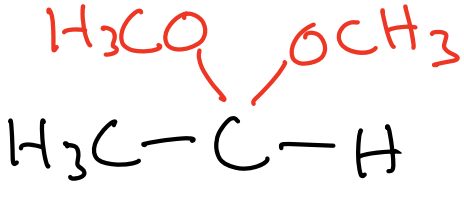


Not stable

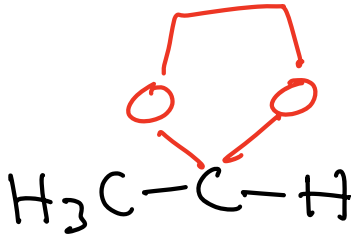


Stable
(Chelate effect)

Acetal → two ethers on same carbon



Stable



More stable
(Chelate effect)