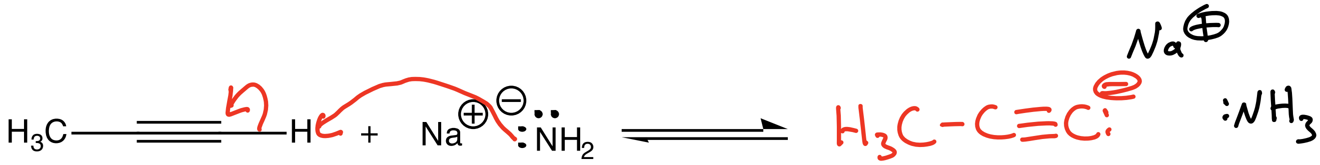
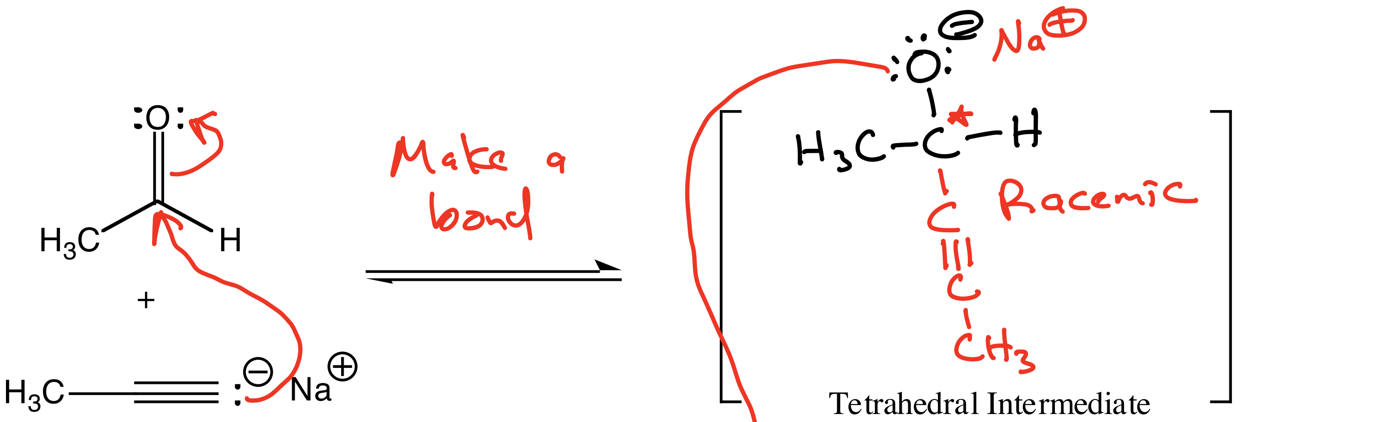
I am here to help <u>all</u> of you succeed.

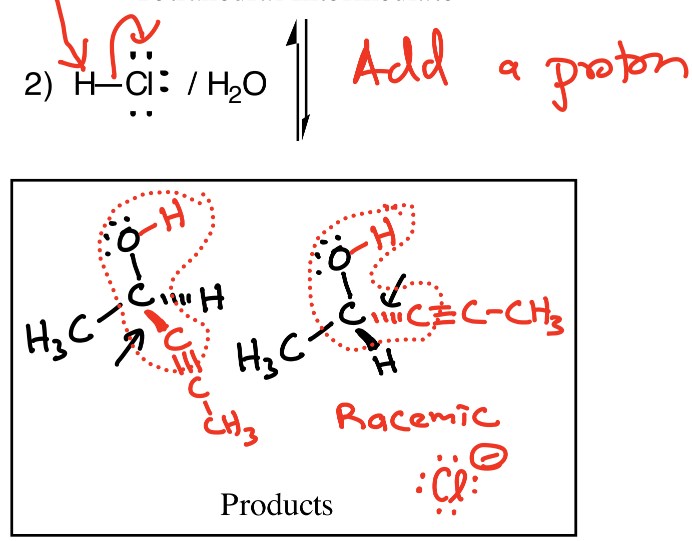
I can provide you with multiple paths to success in this class. You need to choose and commit to the one that is best for you.

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

Alkyne Anion Reacting with an Aldehyde or Ketone





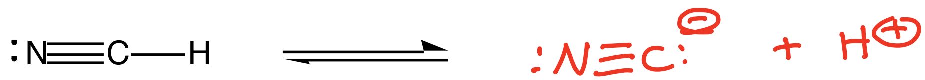


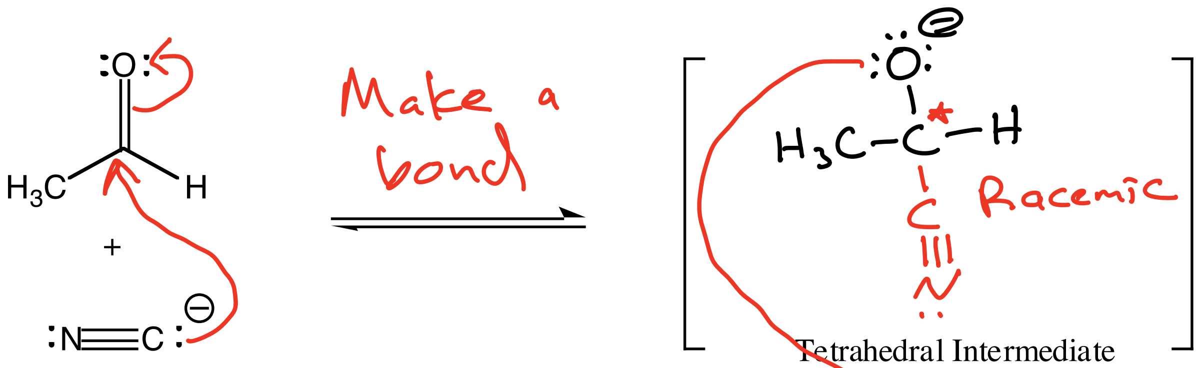
Mechanism A

Key Recognition Element (KRE):

OH on the carbon that makes a new C–C bond to sp C atom (alkyne)

HCN Reacting with an Aldehyde or Ketone

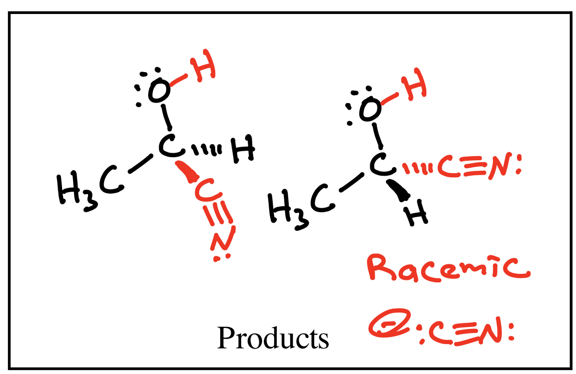




Mechanism A

Key Recognition Element (KRE):

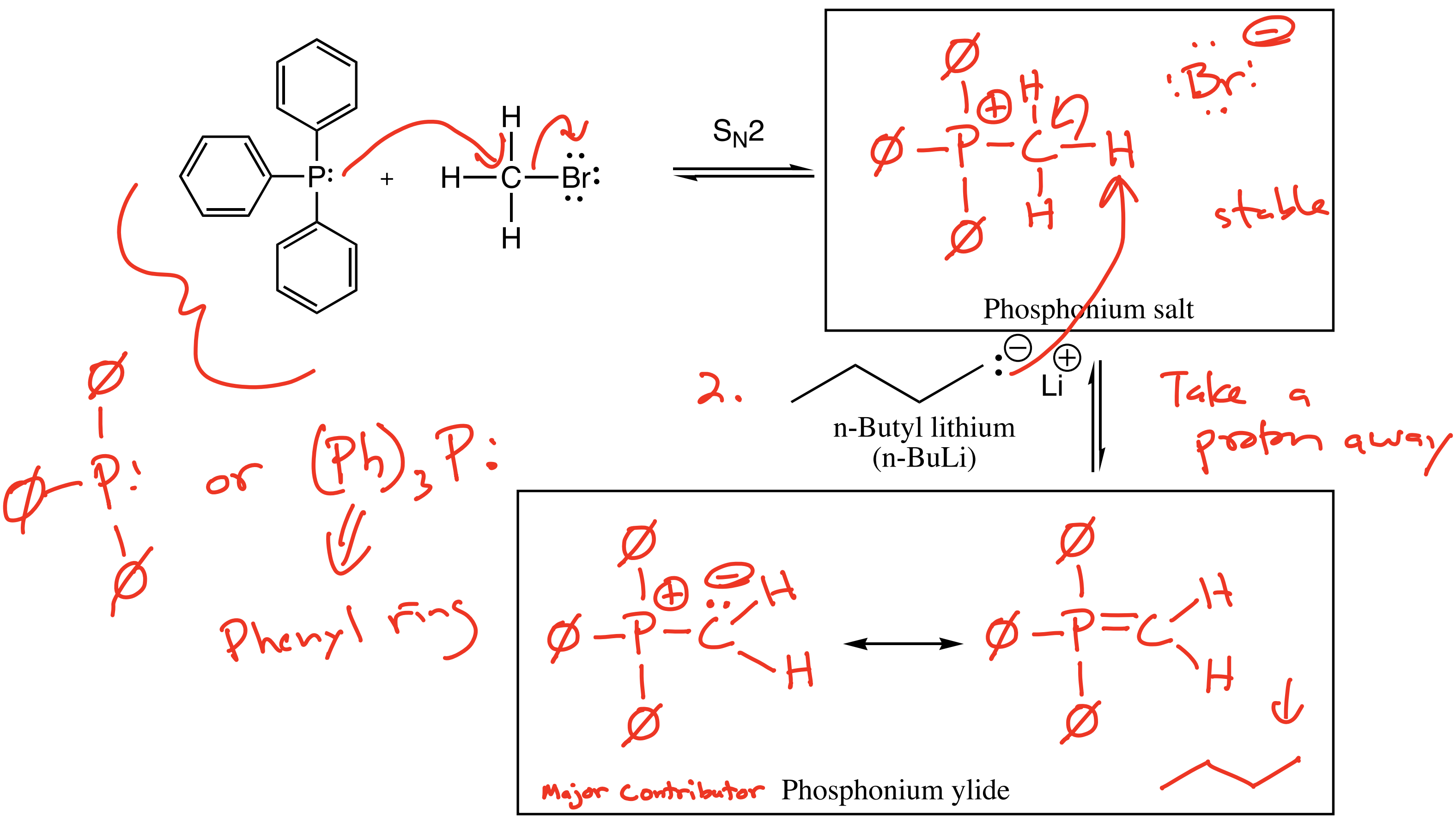
Cyanohydrin → OH on a C atom that made a new bond to –C≡N:

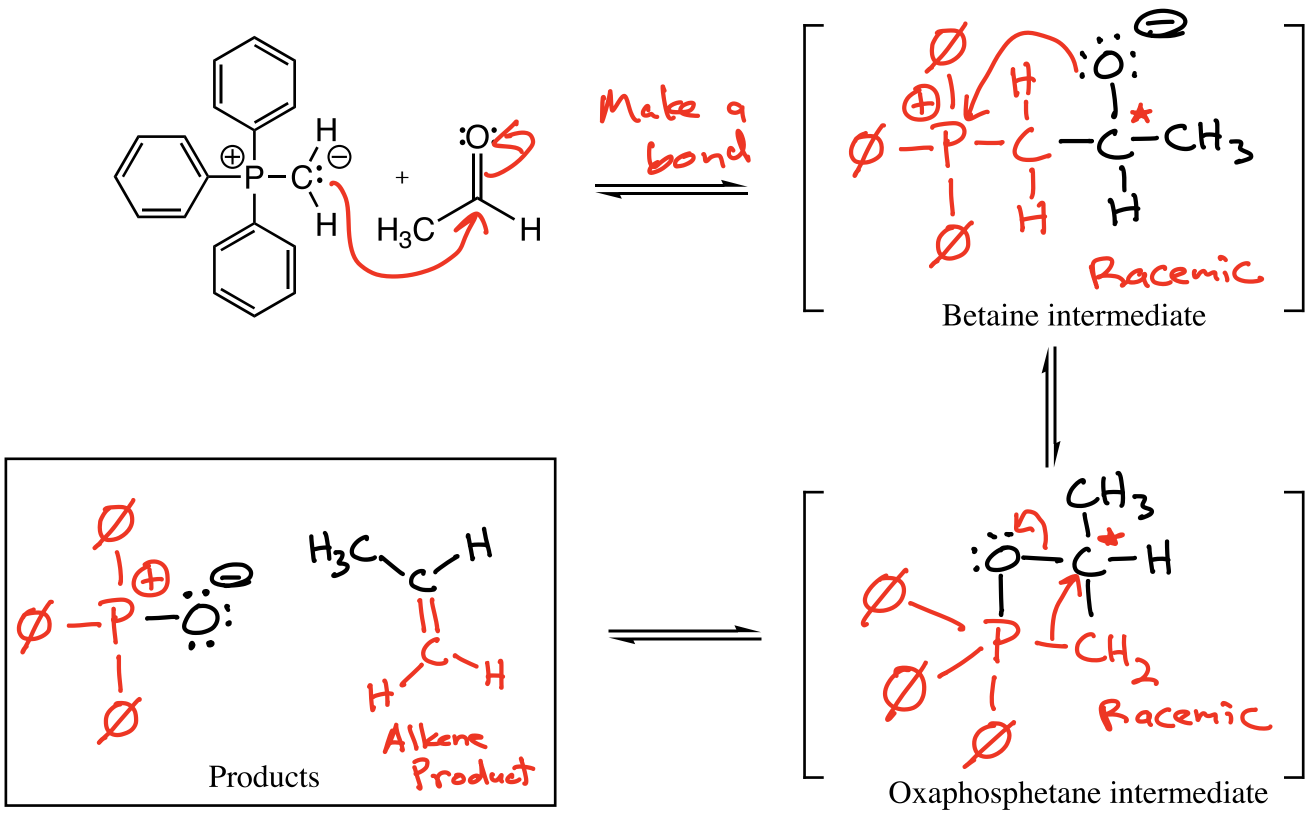


Time capsule → cyanohydrins can be hydrolyzed in H_2SO_4/H_2O to give α-hydroxyacids

↑ "alpha"

Wittig Reaction

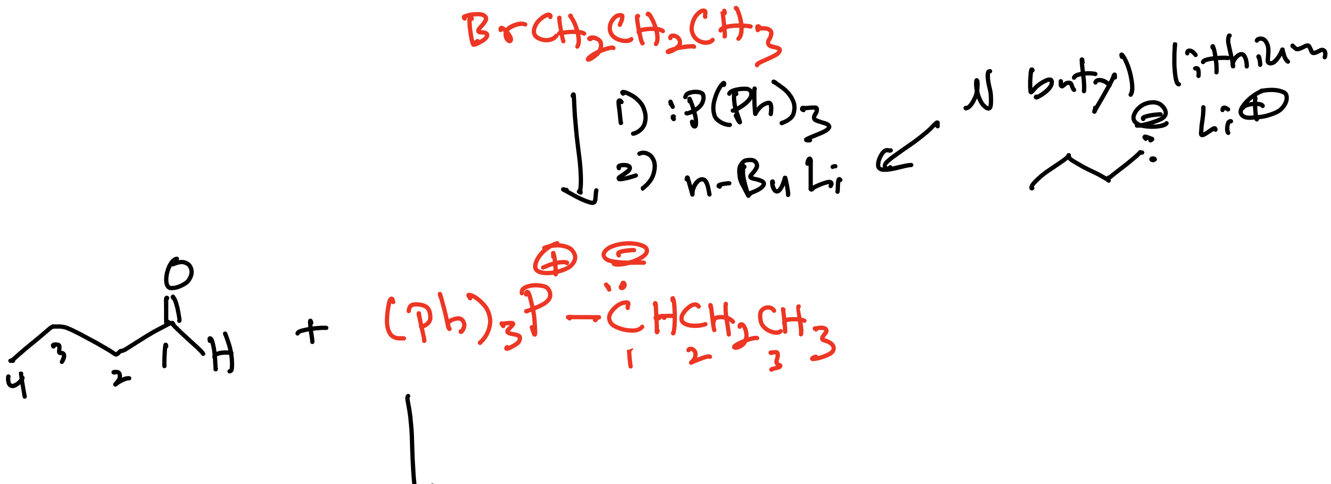


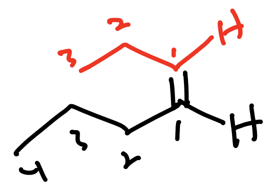


"Four membered ring intermediate"

Key Recognition Element (KRE):

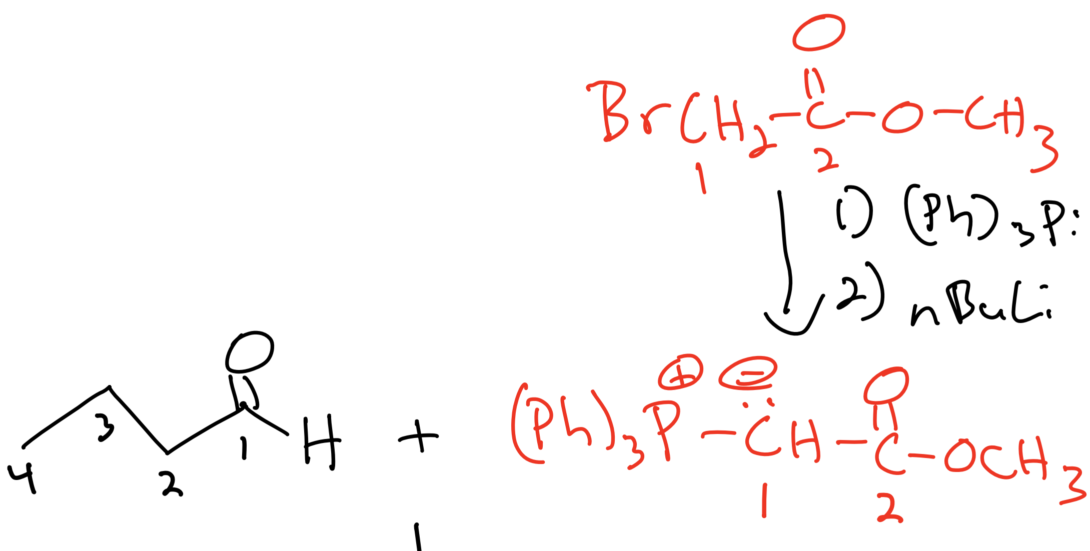
Alkene ⇒ New C=C where the C=O was!

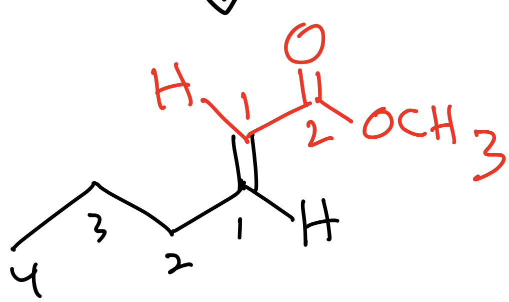




Z

Z product because the Wittig Reagent is an alkyl chain

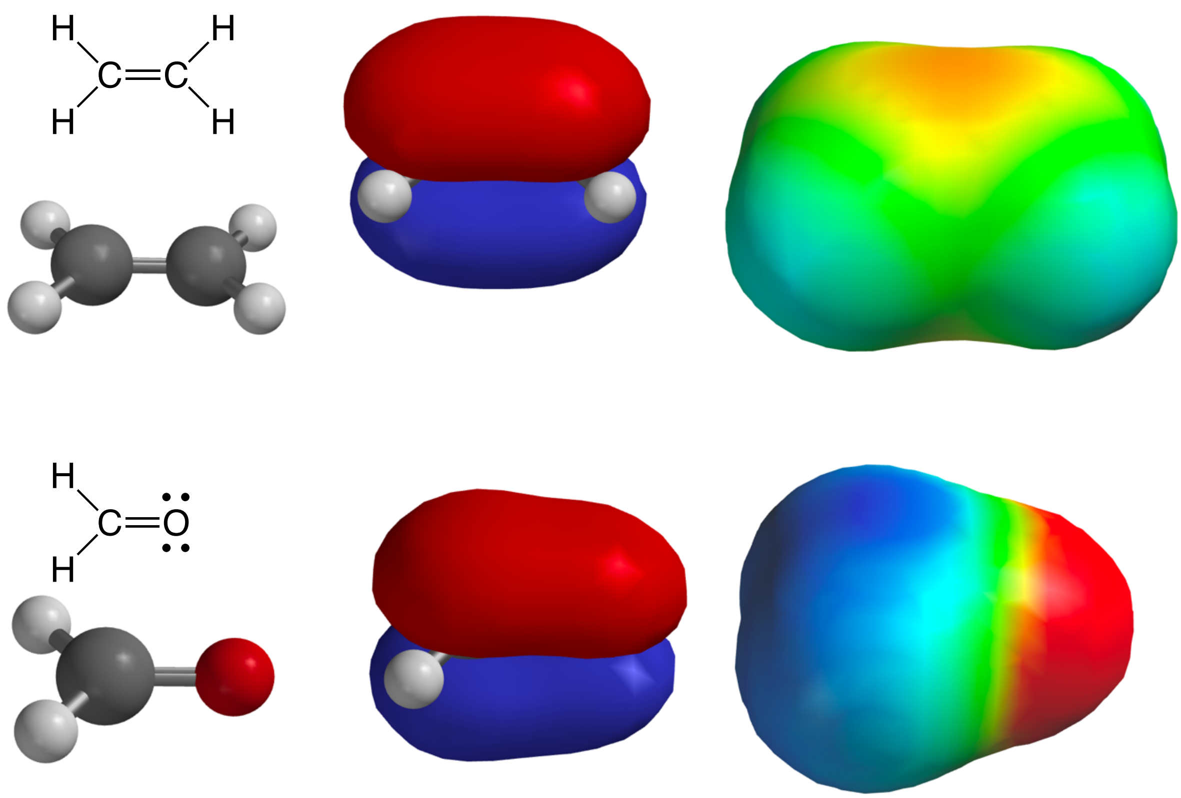




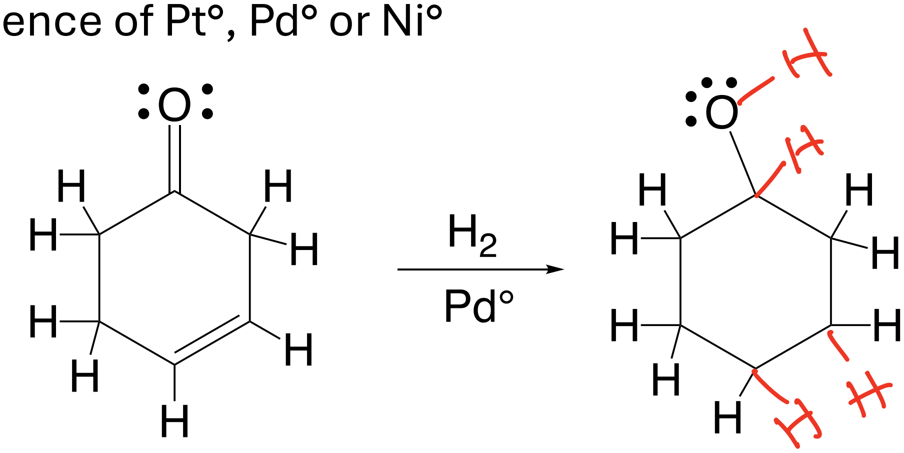
E product

because the Wittig reagent has a C=O adjacent to the C with the ⊖ charge.

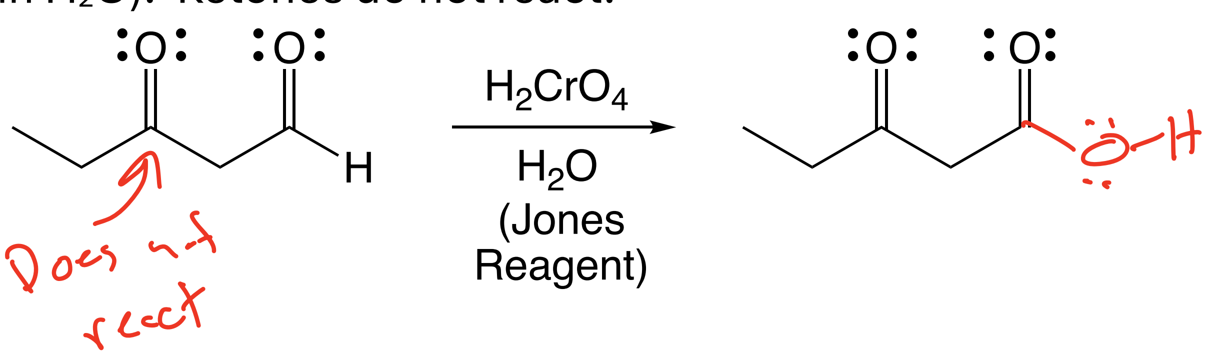
Detour: Hydrogenation and Oxidation of Aldehydes and Ketones

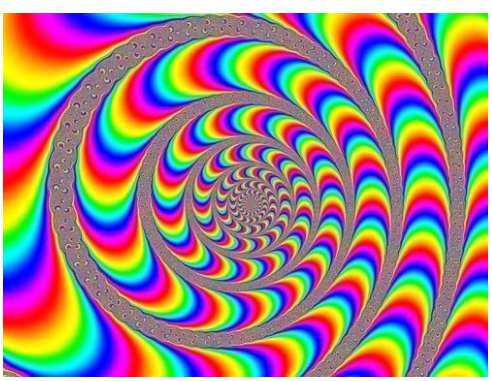


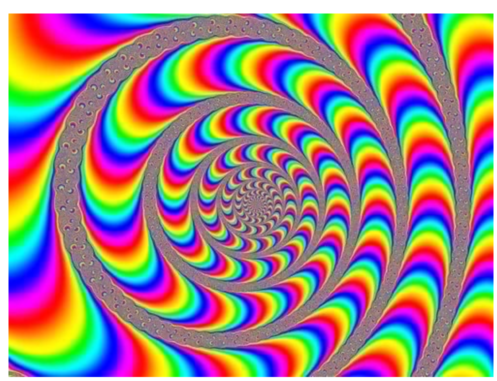
The pi bonds of carbonyls react the same as pi bonds of alkenes with H_2 in the presence of Pt°, Pd° or Ni°



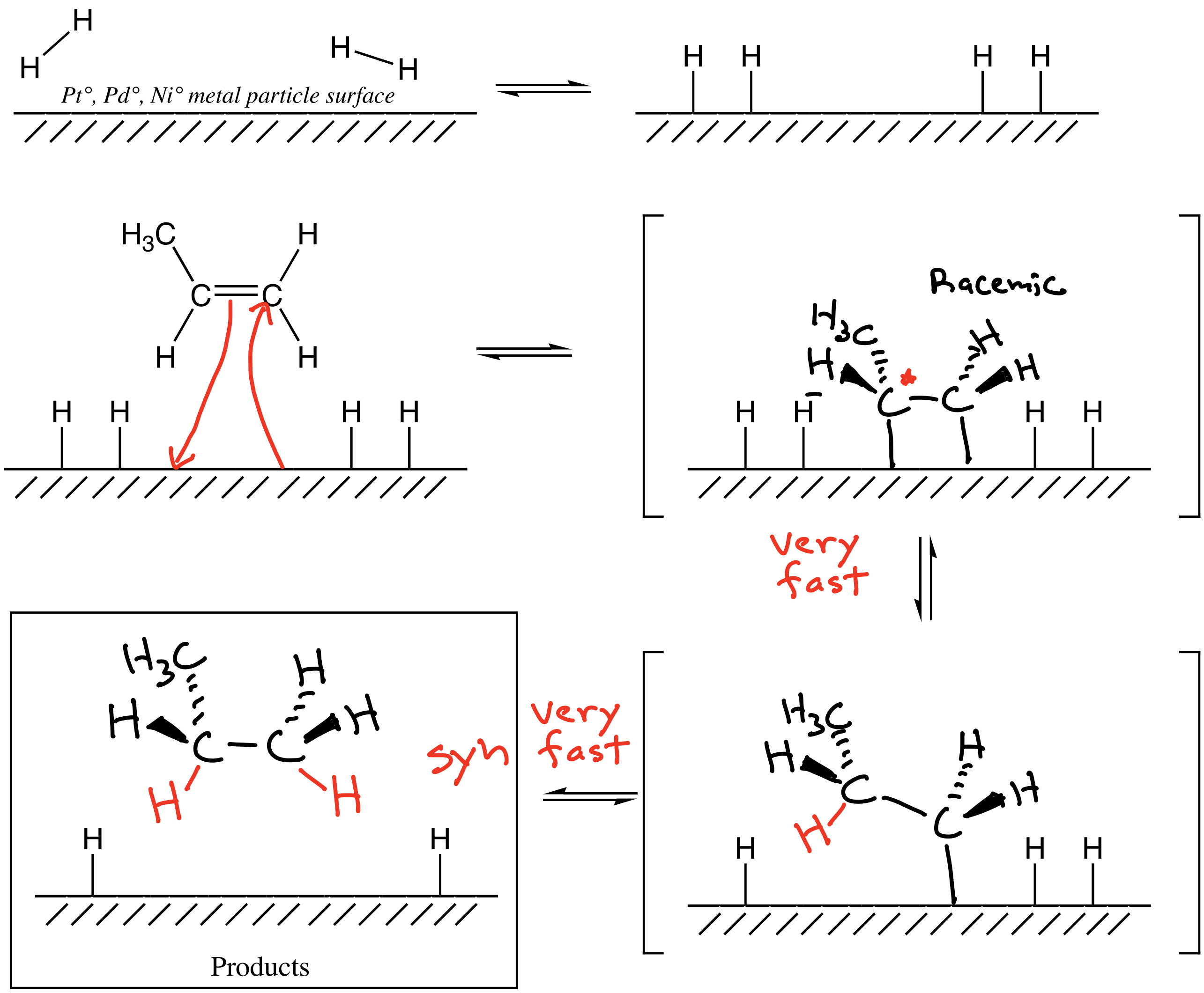
Aldehydes are oxidized to carboxylic acids using the Jones Reagent (H_2CrO_4 in H_2O). Ketones do not react.







Hydrogenation: H_2 with Pt°, Pd°, Ni°

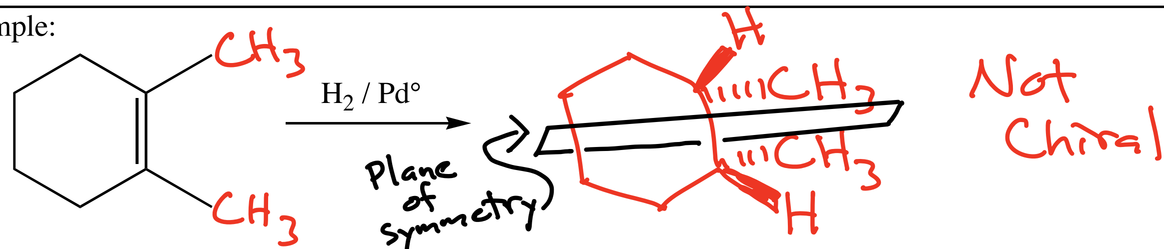


Summary: H_2 adsorbs onto the metal surface. The alkene adsorbs onto the metal surface. H atoms transfer to both C atoms → on the same face → before the C-C bond rotates

Regiochemistry: N/A

Stereochemistry: Syn

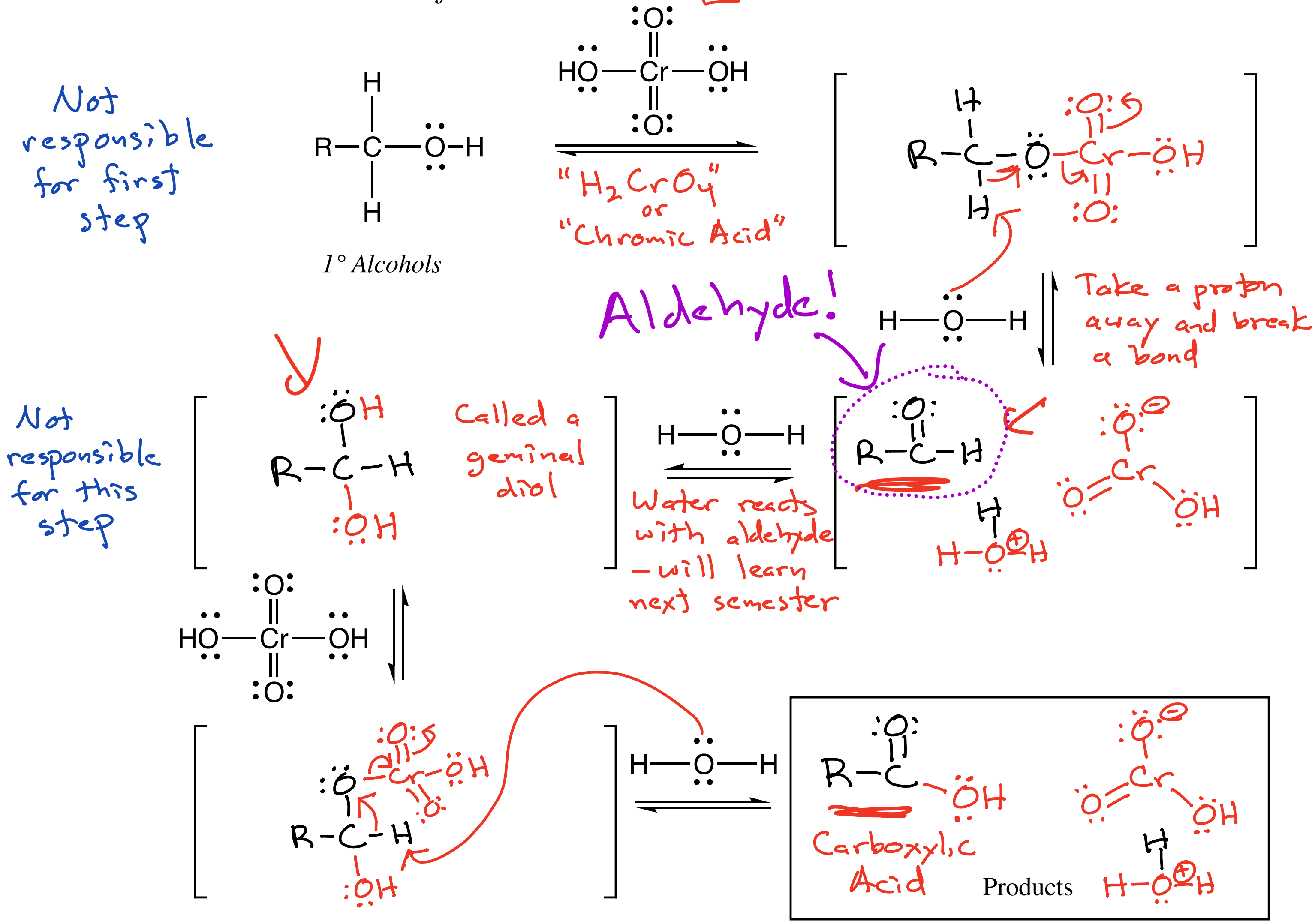
Example:



Alkene Alkane

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

Chromic Acid Oxidation of Alcohols



Summary:
1° alcohols ⇒ Carboxylic Acid (R–C(=O)–OH)
2° alcohols ⇒ Ketone (R–C(=O)–R)
3° alcohols ⇒ NO REACTION

Regiochemistry: N/A

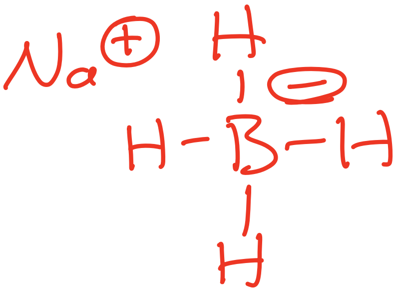
Stereochemistry: N/A

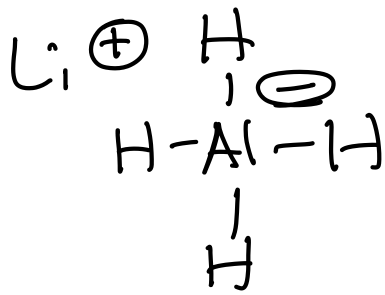
Example:

We now return to our regularly scheduled discussion of Mechanism A

Metal Hydride Reduction

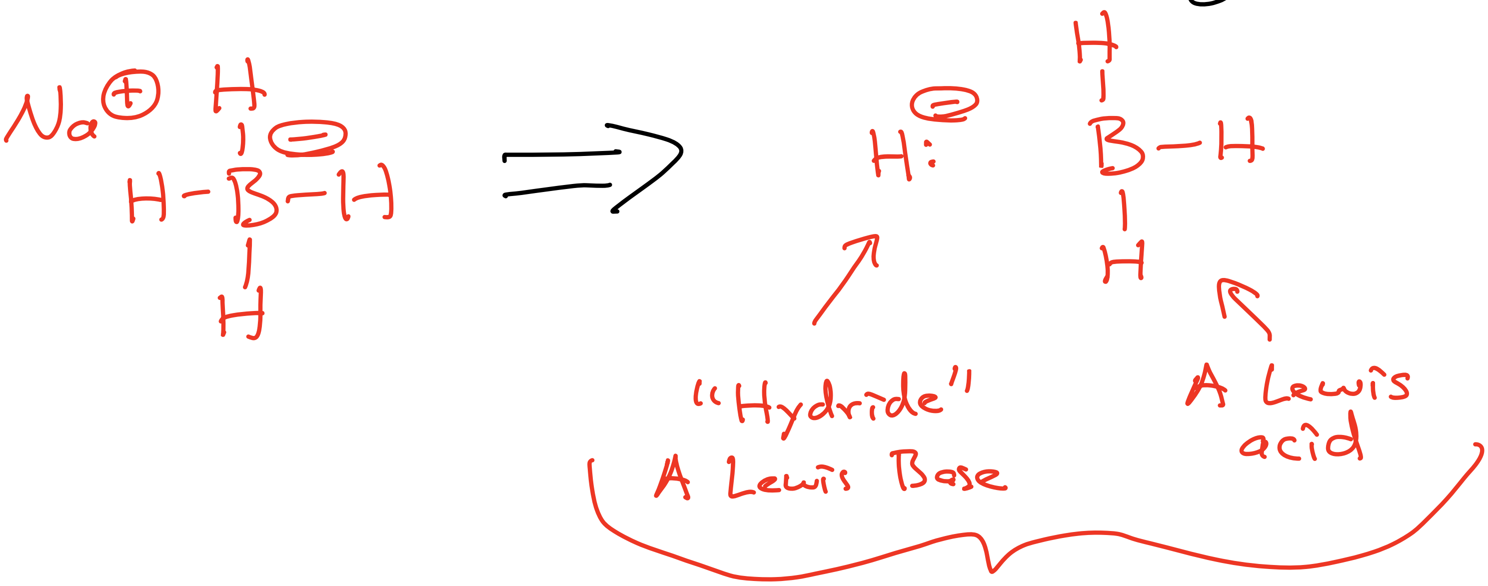
⇒ Reduce C=O but not C=C





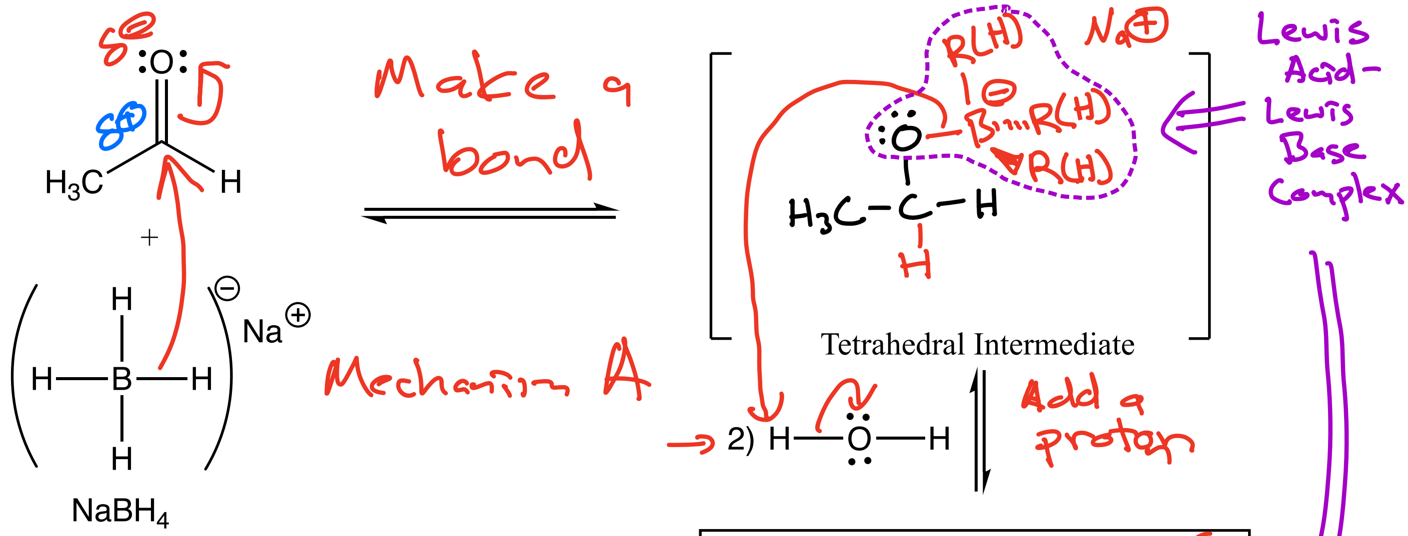
$NaBH_4$ ✓ $LiAlH_4$ ✓

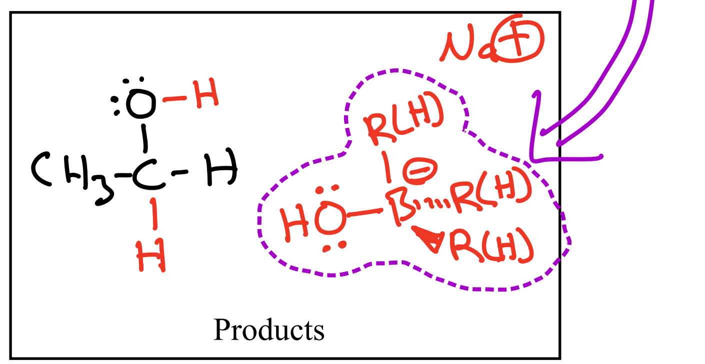
How to think about the reagent:



You can think of $NaBH_4$ as a Lewis base–Lewis acid complex between hydride ($H:^-$) and BH_3

Sodium Borohydride Reacting with an Aldehyde or Ketone





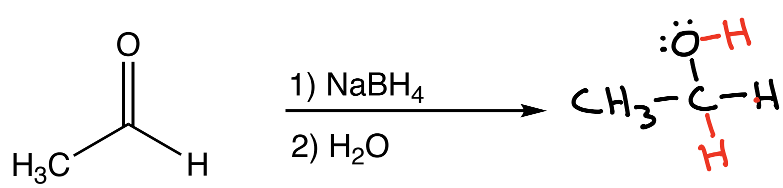
Key Recognition Element (KRE):

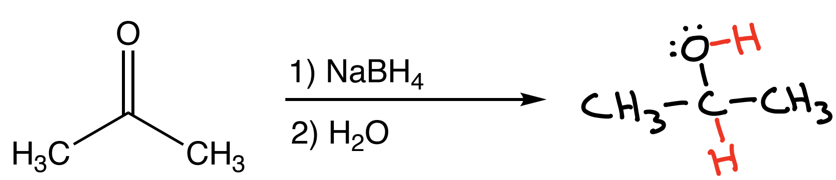
An -OH group where there was a C=O of an aldehyde or ketone

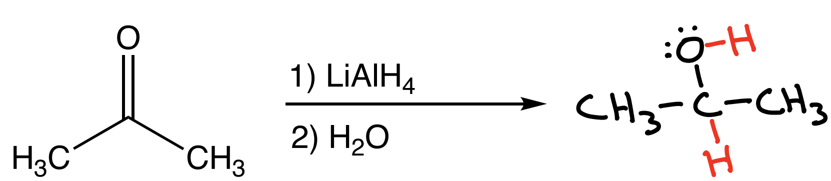
All four H of $BH_4^{\ominus}$ react!

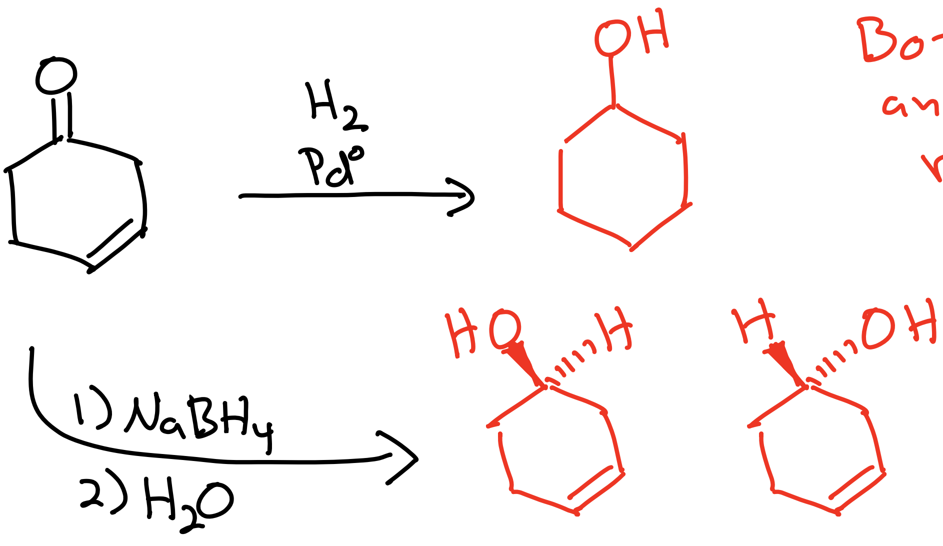
$$4\ CH_3\text{-}\overset{O}{\overset{\|}{C}}\text{-}H + BH_4^{\ominus} \rightleftharpoons\rightleftharpoons\rightleftharpoons\rightleftharpoons (CH_3CH_2\text{-}O)_4B^{\ominus} \xrightarrow{2)\ H_2O} 4\ CH_3CH_2OH$$

+ Borate salts









Both the C=O and C=C are reduced

Only the C=O reacts!

Racemic

This makes sense because $H:^{\ominus}$ ("hydride") 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–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 <u>much</u> better electrophile → protonate the O atom

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

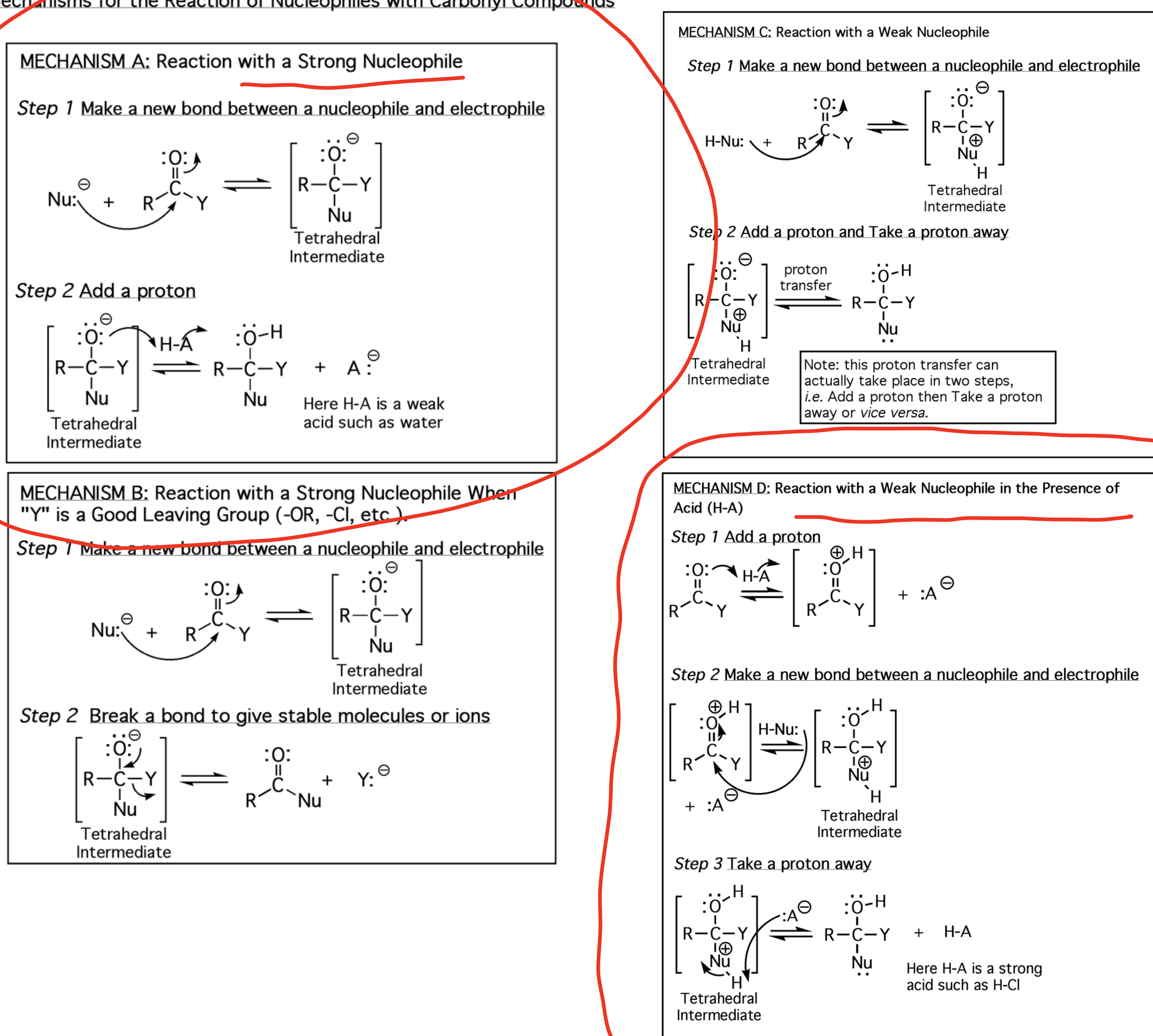
1) There are basically four different mechanisms elements that make up the steps of carbonyl reactions.

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



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

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

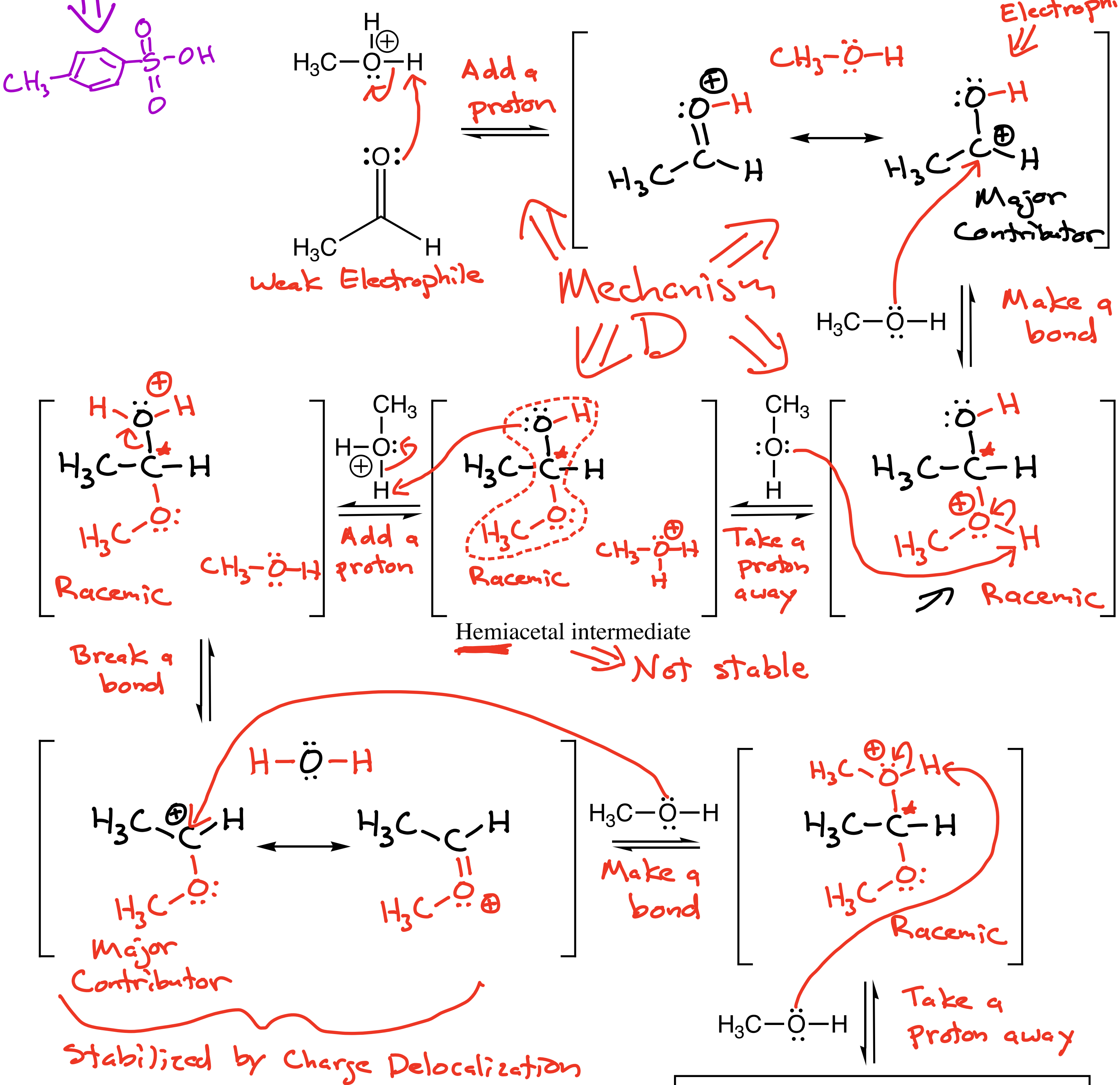
https://www.youtube.com/watch?v=Lk9TyzgundA

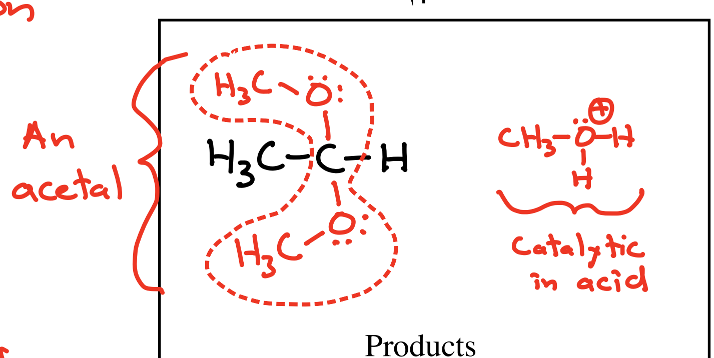
TsOH or H_2SO_4

Tosylic Acid

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

Acid Catalyzed Hemiacetal and Acetal Formation From an Aldehyde or Ketone





Key Recognition Element (KRE):

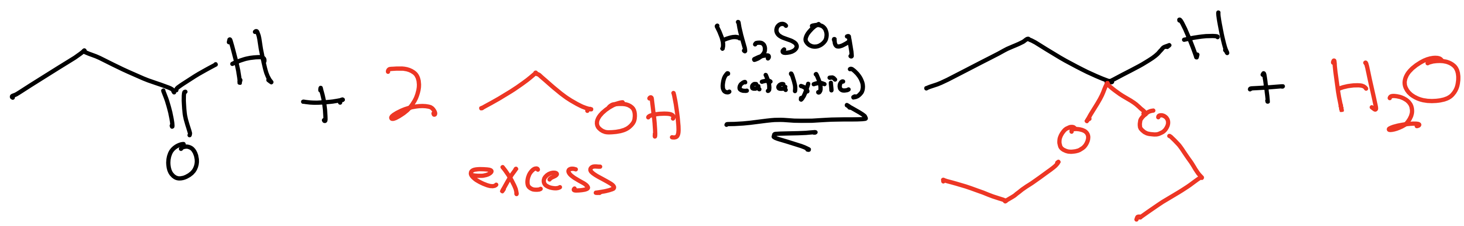
Two bonds to O atoms from an sp^3 C atom

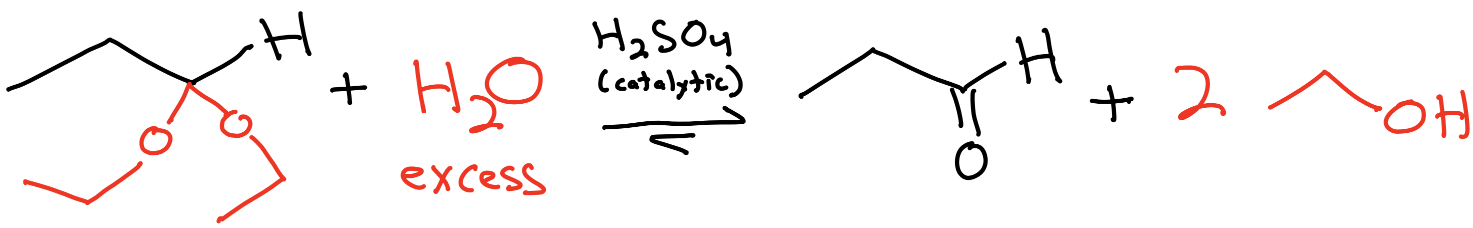
Definition of an acetal

alcohol dehydration

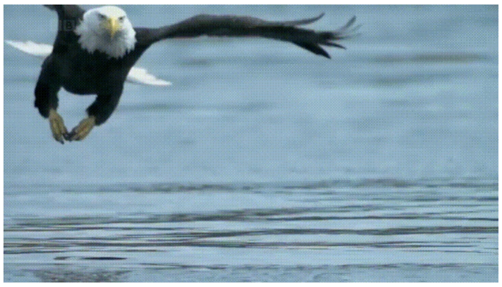
⇅

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





Le Chatlier's Principle



"The Claw"

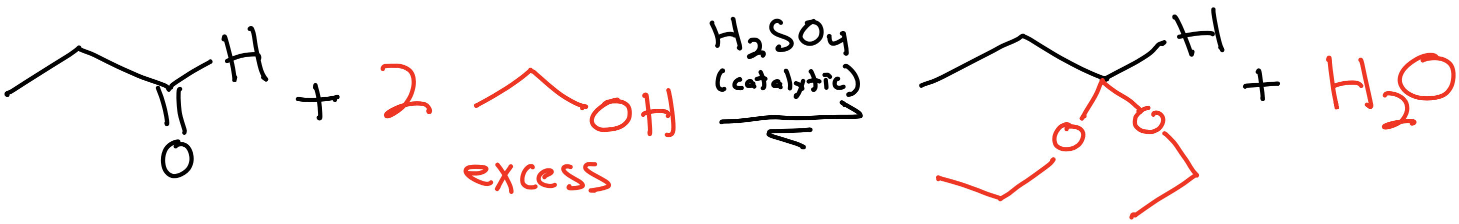
Cyclic acetals are more stable than "normal" acetals because of the chelate effect.

⇓

"claw" in Latin

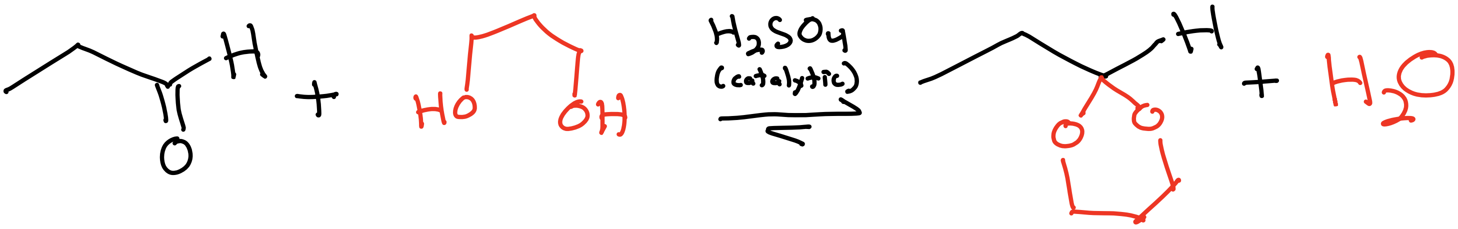
"Two OH groups already attached to each other 'go on' easier and 'come off' harder"

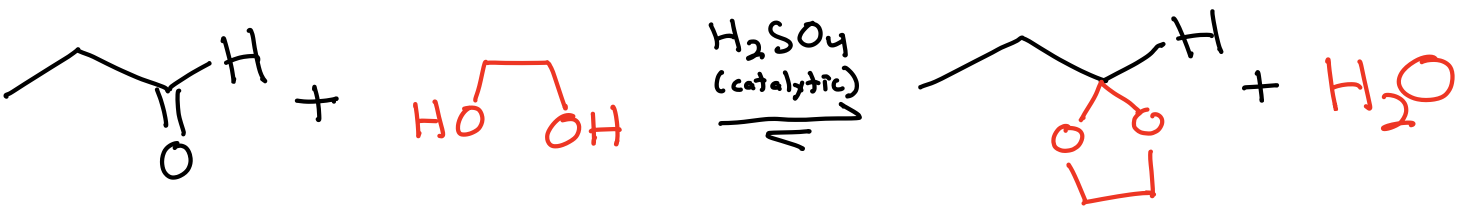
"Normal" acetal



Cyclic acetals → 5 and 6-membered rings!

Stable → Strain free



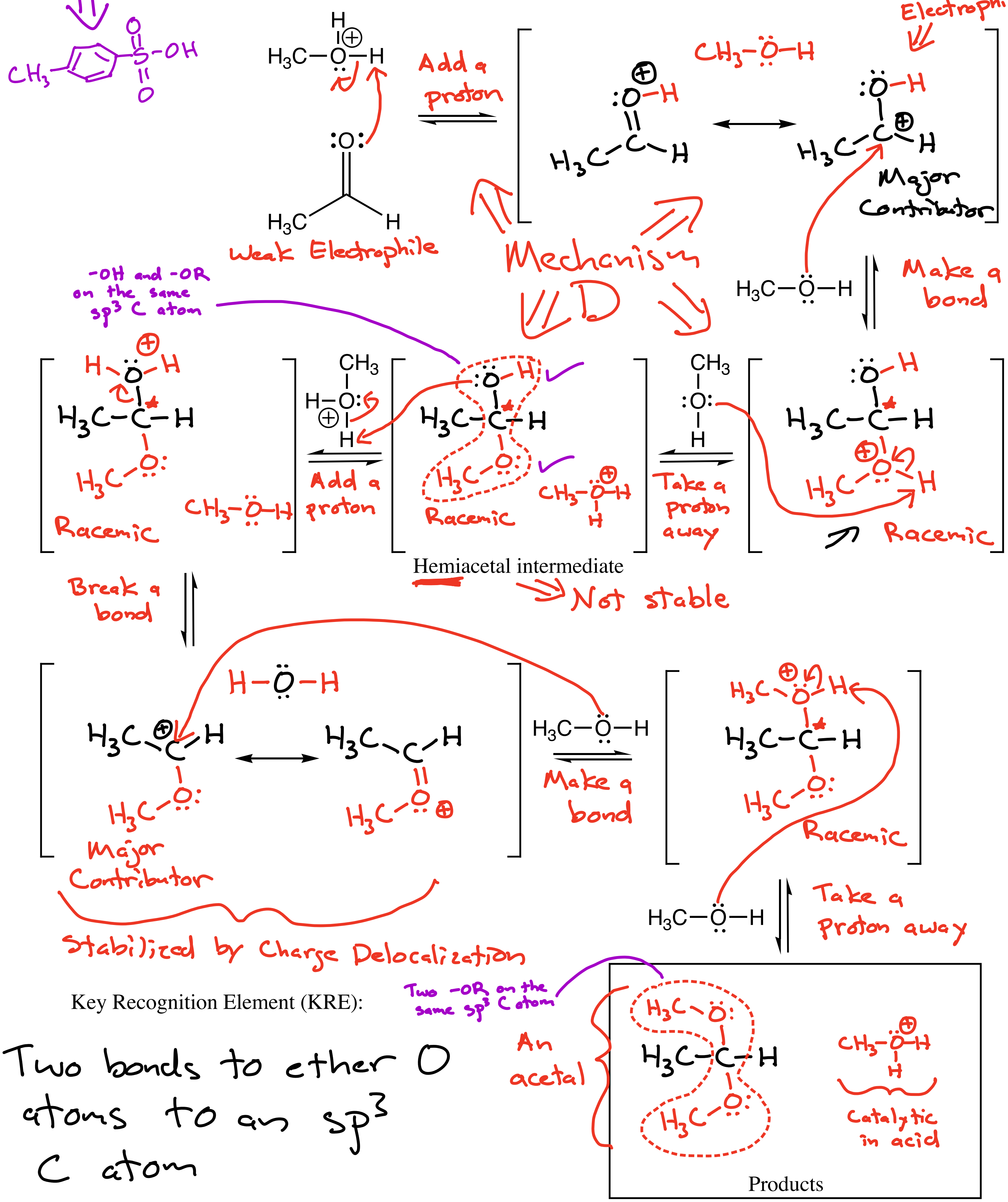


TsOH or H_2SO_4

Tosylic Acid

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

Acid Catalyzed Hemiacetal and Acetal Formation From an Aldehyde or Ketone

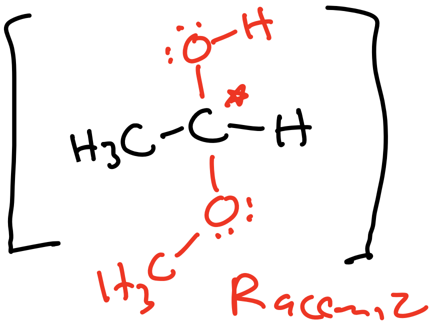


Key Recognition Element (KRE):

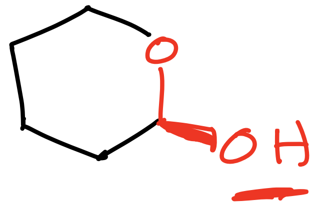
Two bonds to ether O atoms to an sp³ C atom

Recap

Hemiacetal → One alcohol and one ether on the same C atom.



Not Stable



Stable
(Chelate effect)