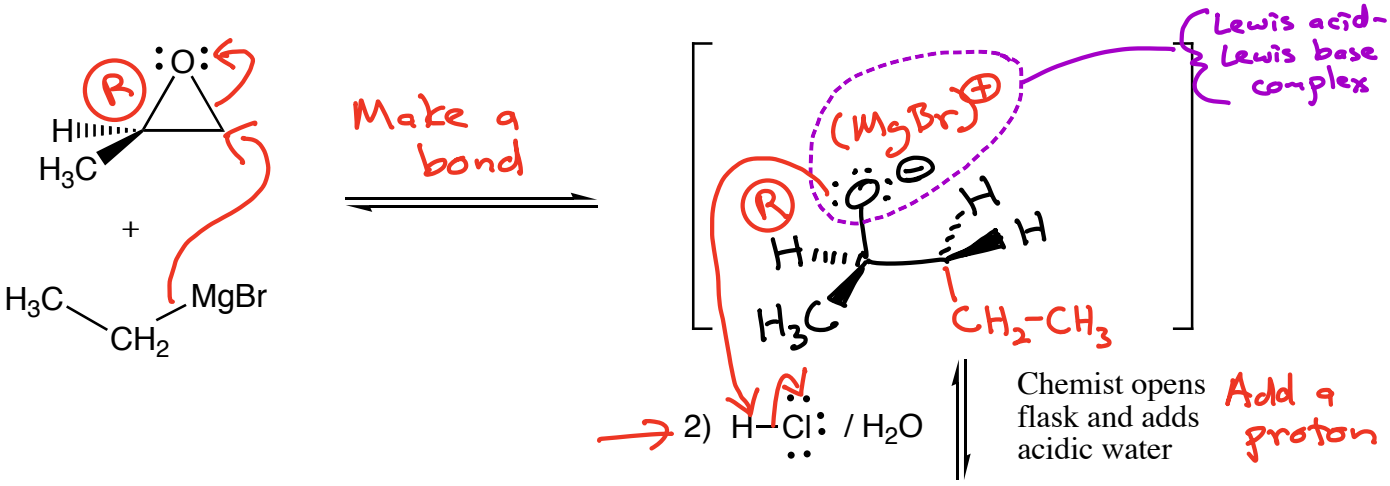
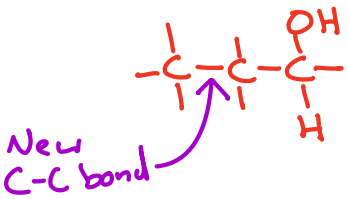
Organolithium and Gilman reagents react the same way as Grignard reagents in this reaction.

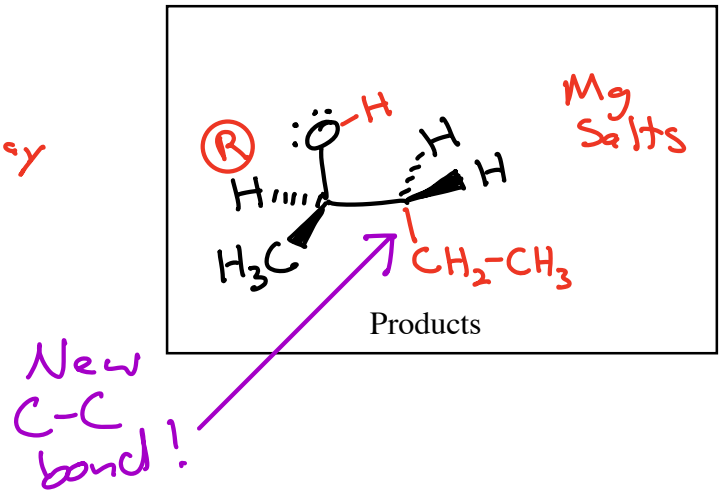
Grignard Reagent Reacting with an Epoxide

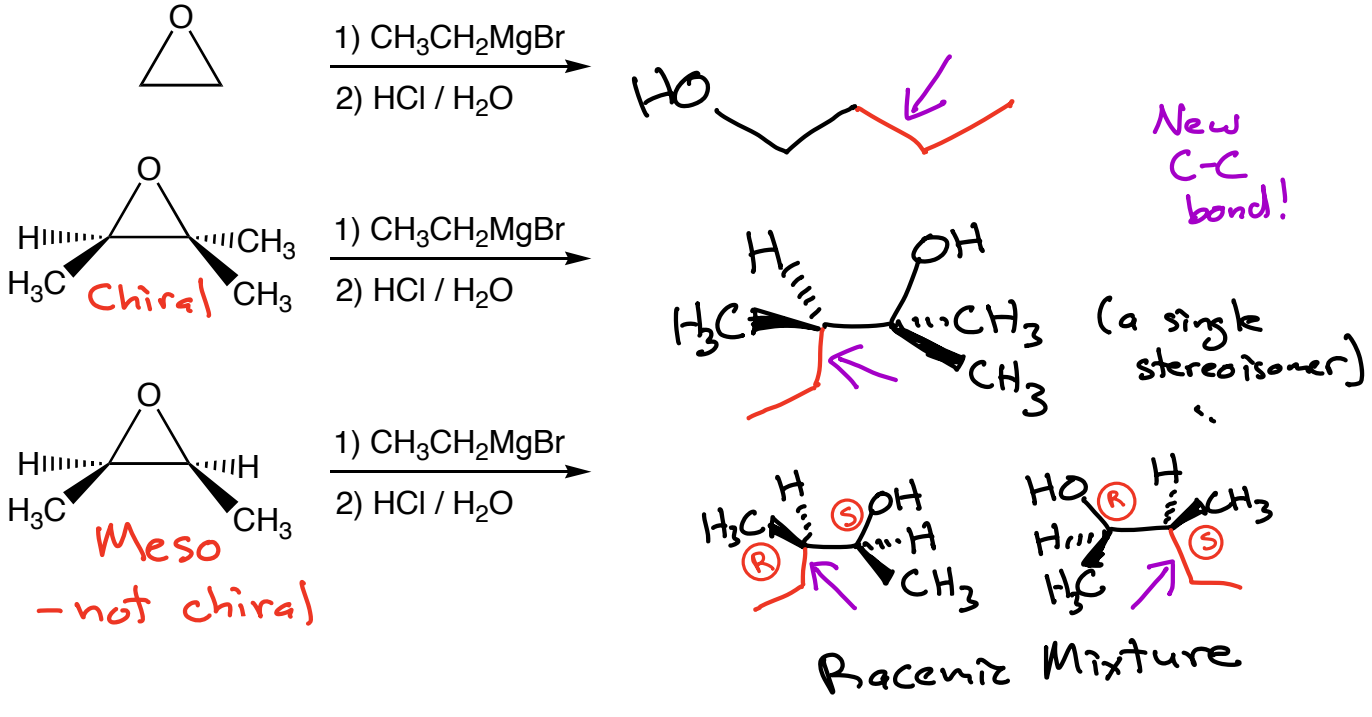


Key Recognition Element (KRE):

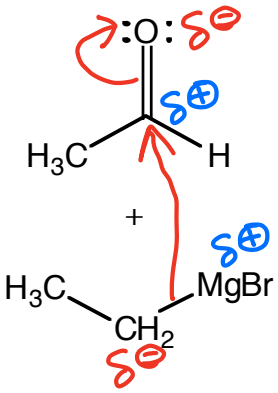
There is a new C-C bond that is two carbon atoms away from an OH group



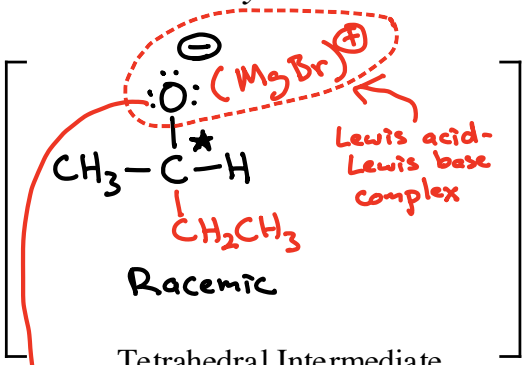




Grignard Reagent Reacting with an Aldehyde or Ketone



Make a bond



Chemist opens the flask

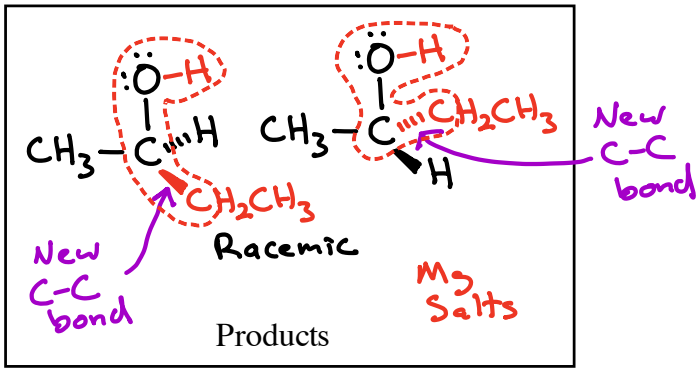
2) $H-Cl: / H_2O$

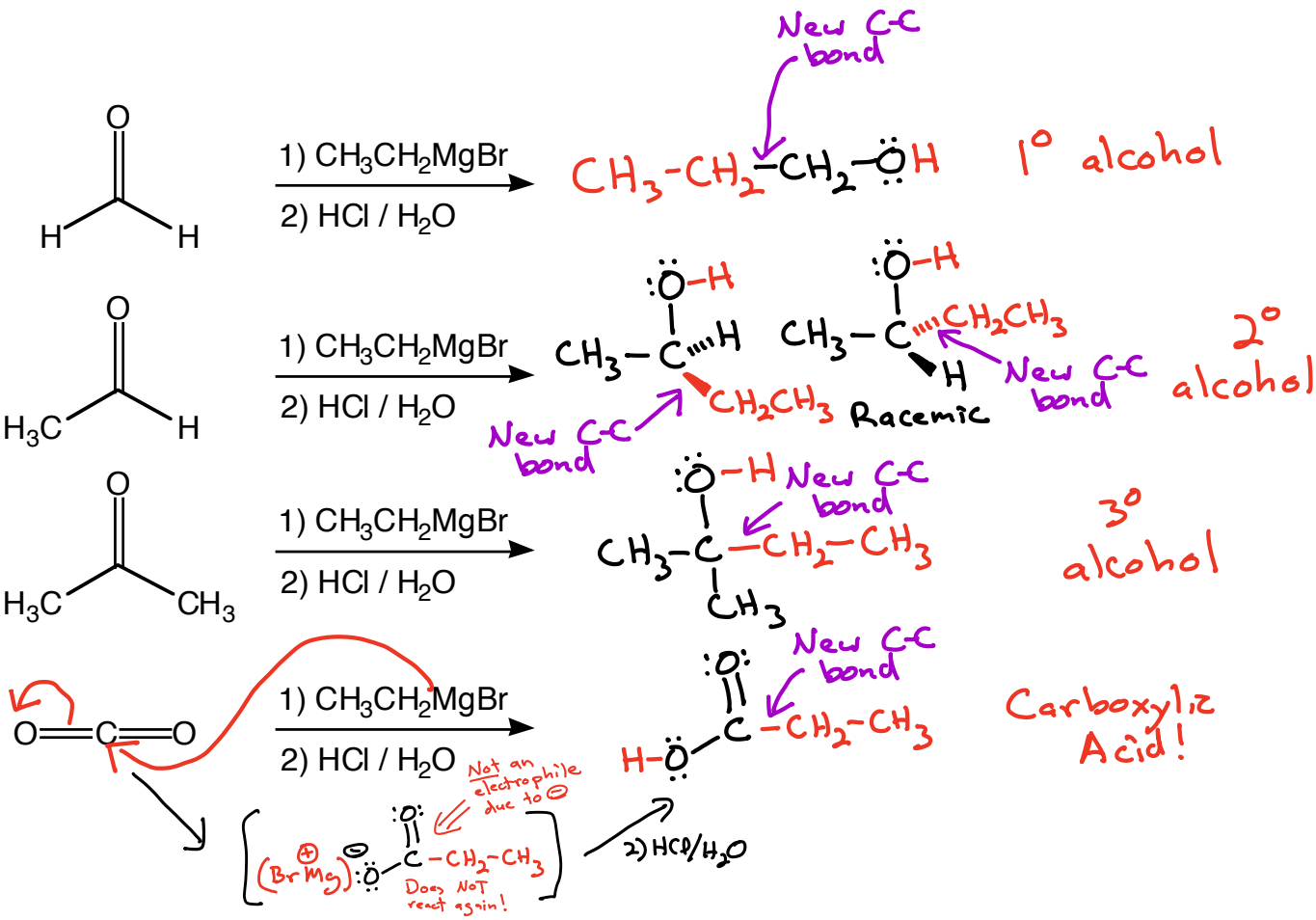
Add a proton

Mechanism A

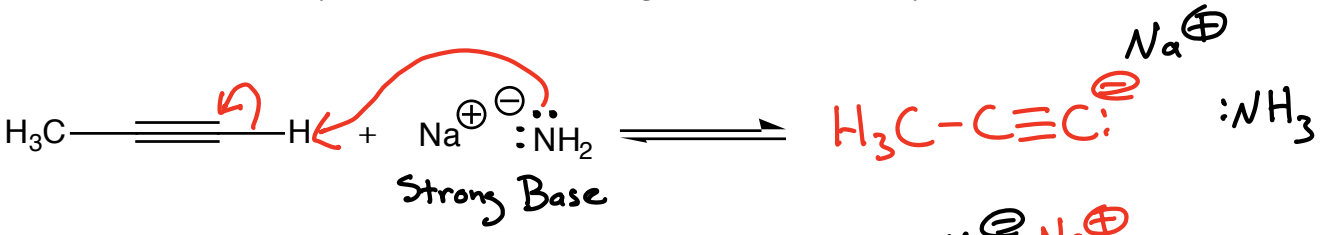
Key Recognition Element (KRE):

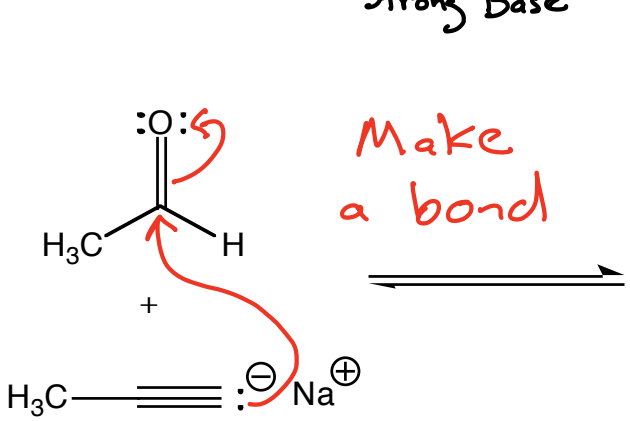
-OH group attached the same C atom as a new C-C bond

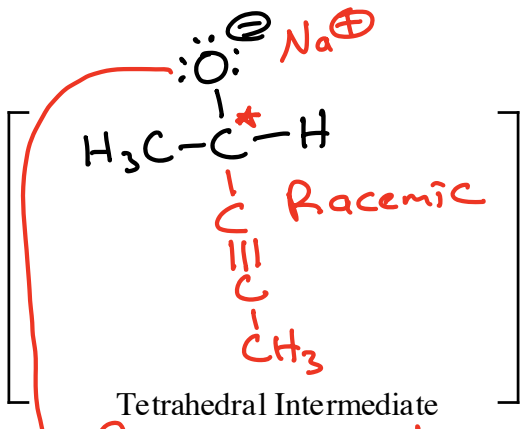


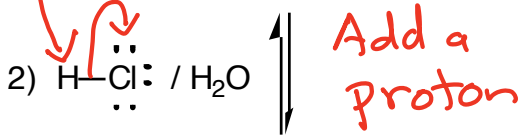


Alkyne Anion Reacting with an Aldehyde or Ketone





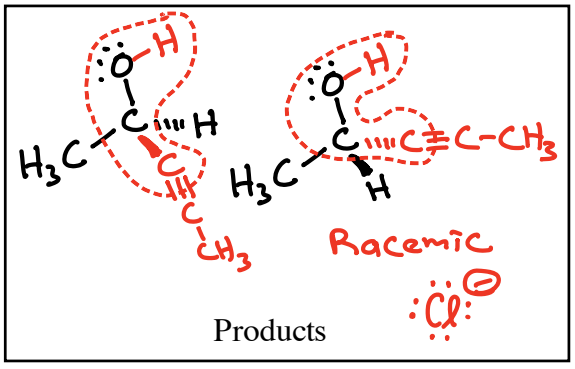




Mechanism A

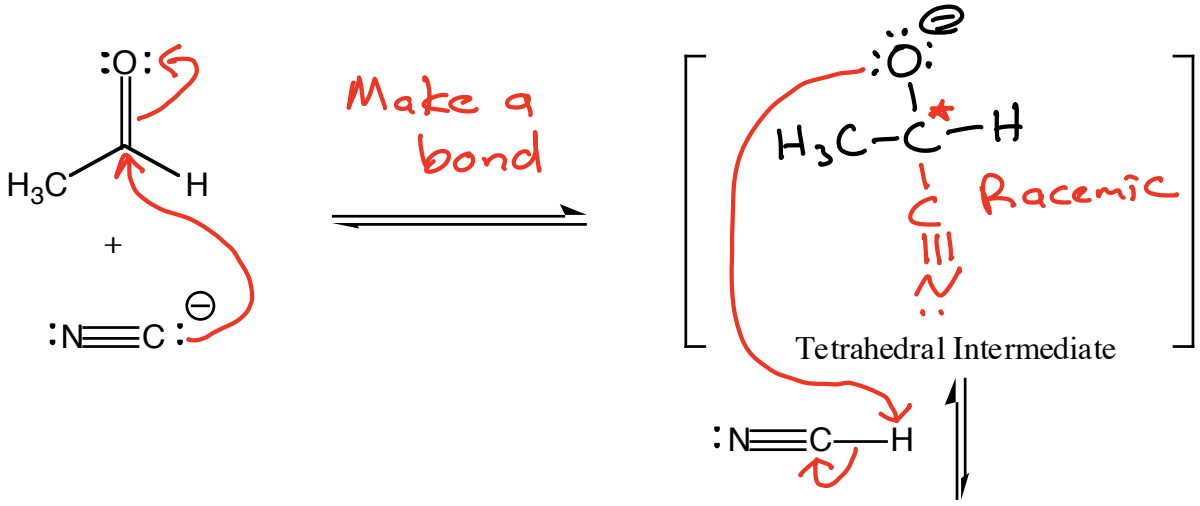
Key Recognition Element (KRE):

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



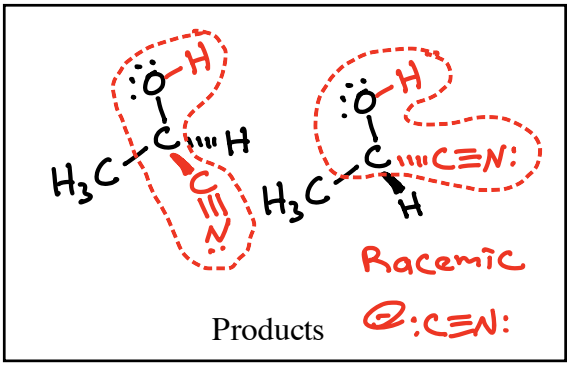
HCN Reacting with an Aldehyde or Ketone

Reacts on the C atom because that makes stronger bonds



Key Recognition Element (KRE):

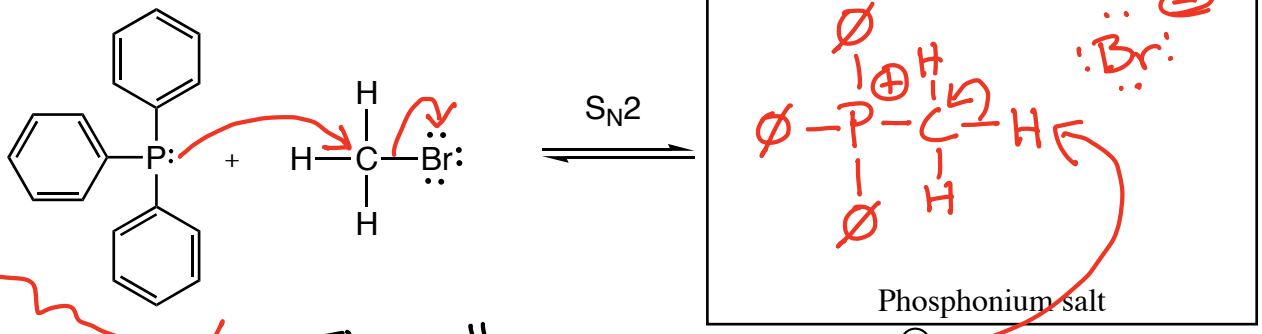
Cyanohydrin → OH on a C atom that made a new C-C bond to −C≡N:



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

"alpha"

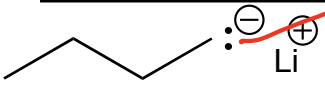
Wittig Reaction



ϕ–P: or $(Ph)_3P$:

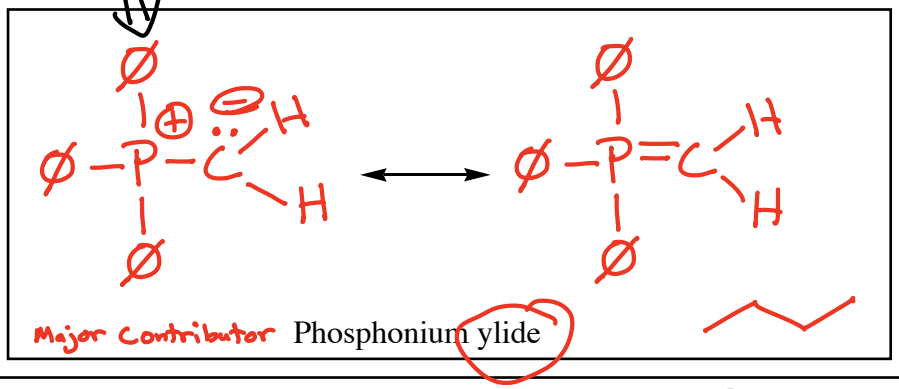
shorthand ways to indicate the same molecule

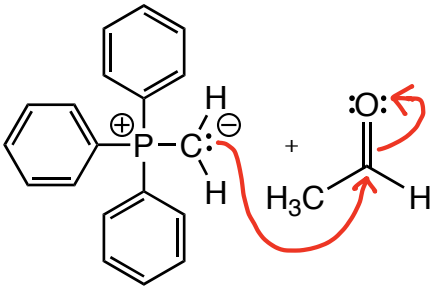
This is the way the think about a Wittig reagent



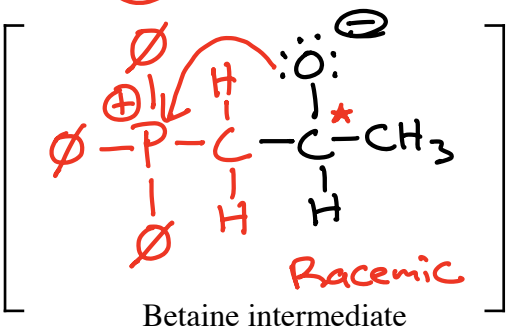
n-Butyl lithium (n-BuLi)

Take a proton away

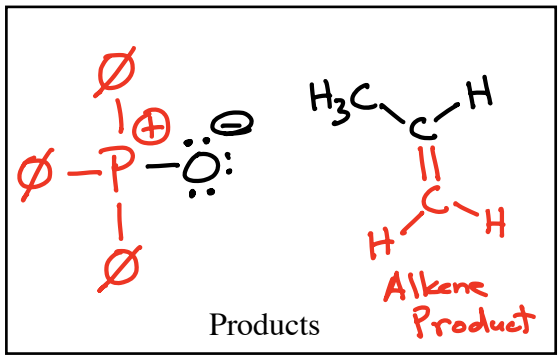




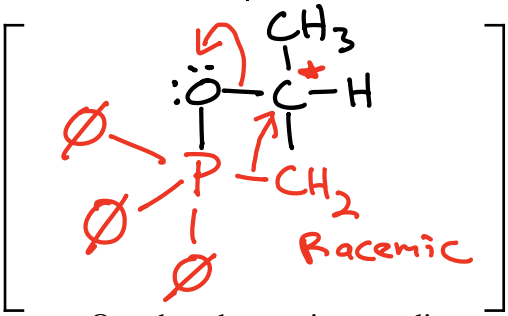
Make a bond



Make a bond



Remember this step!

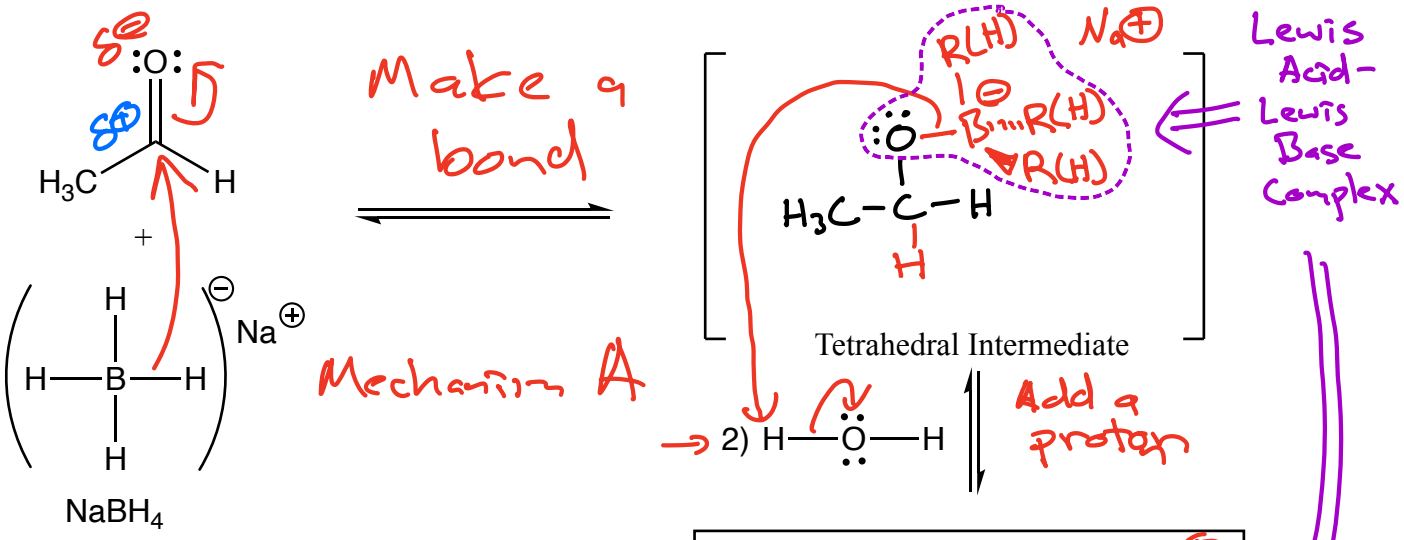


"Four-membered ring intermediate"

Key Recognition Element (KRE):

Alkene → New C=C where the C=O was!

Sodium Borohydride Reacting with an Aldehyde or Ketone

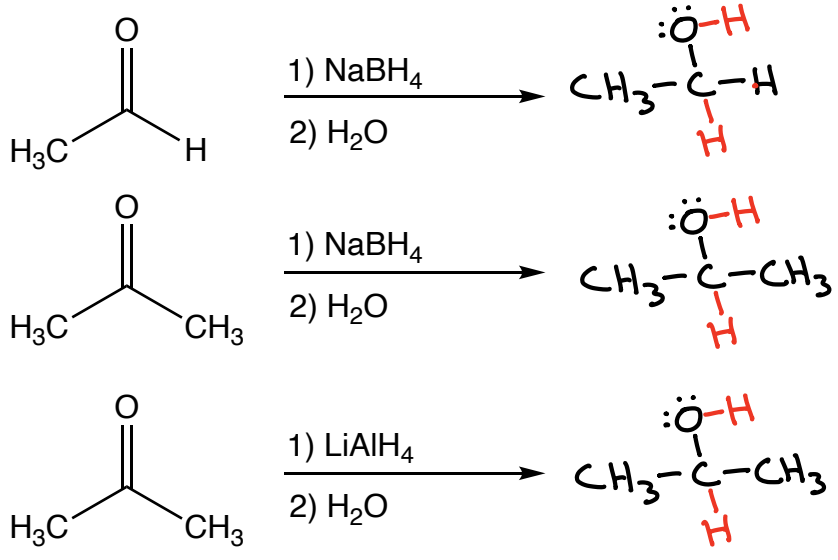


Key Recognition Element (KRE):

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

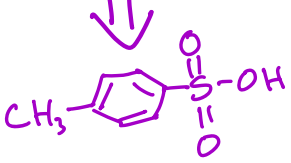
All four H of BH_4^- react!

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



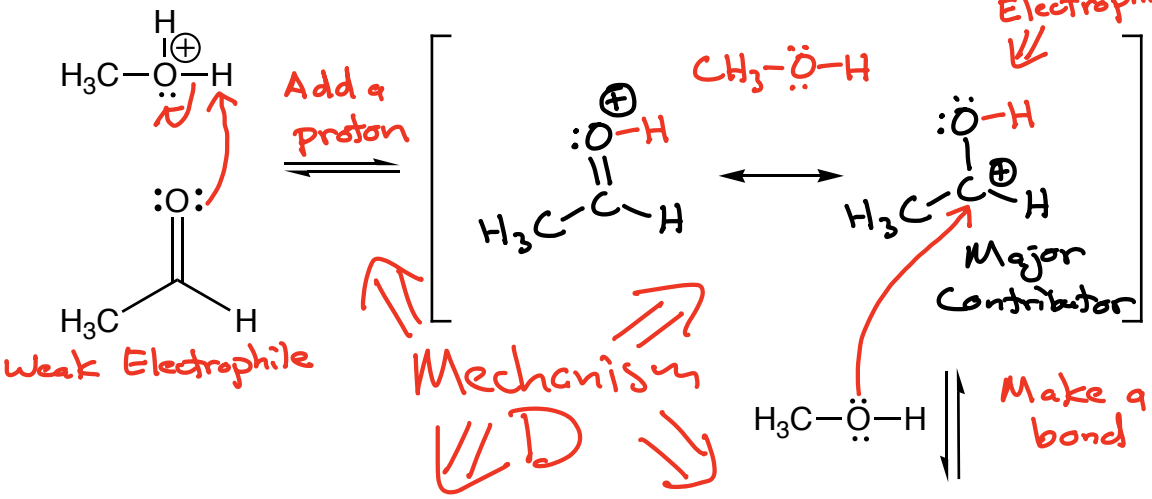
TsOH or H_2SO_4

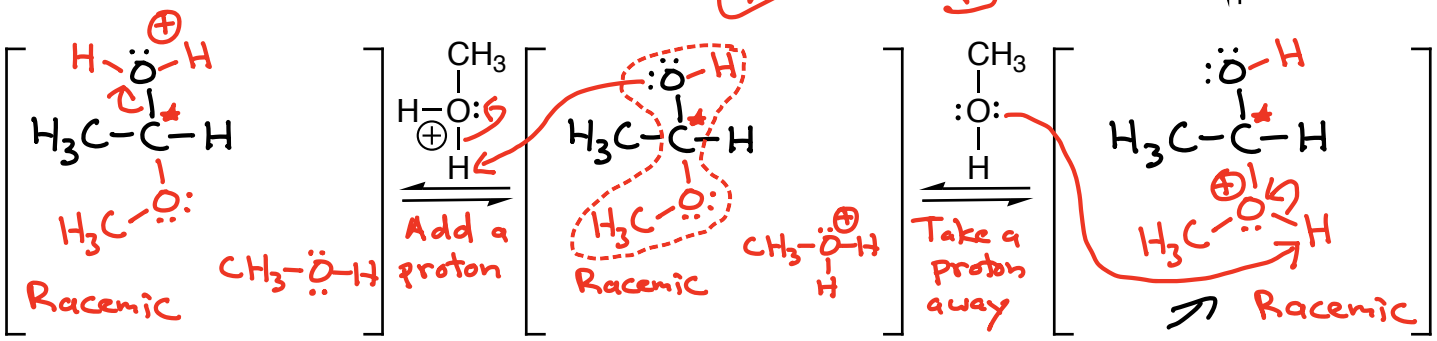
Tosylic Acid



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

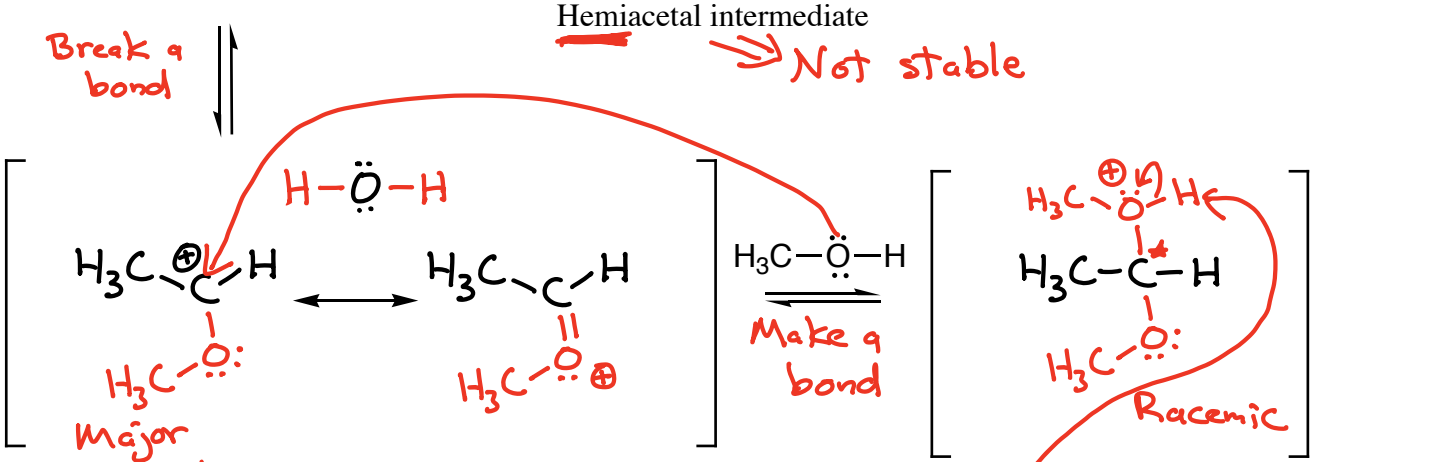
Acid Catalyzed Hemiacetal and Acetal Formation From an Aldehyde or Ketone





Hemiacetal intermediate

Not stable

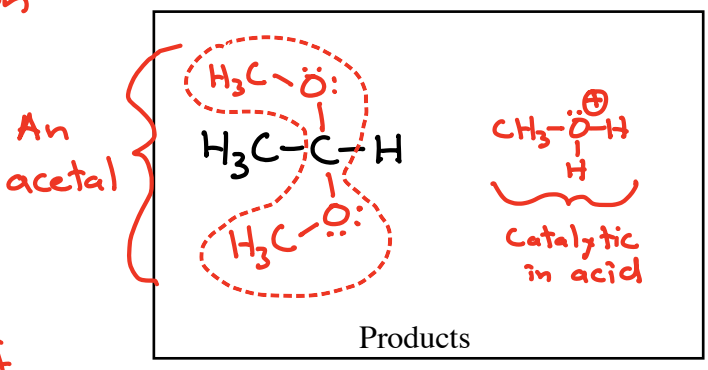


Stabilized by Charge Delocalization

Key Recognition Element (KRE):

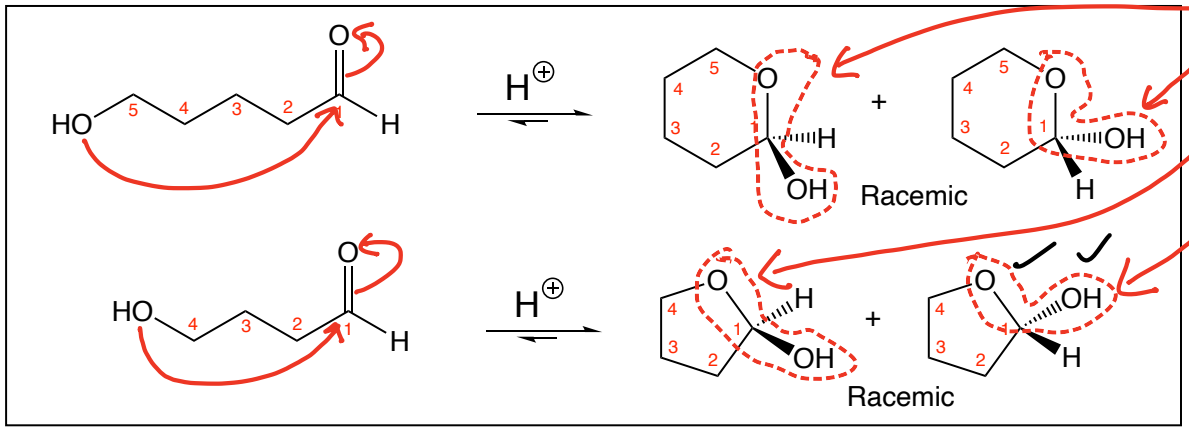
Two bonds to O atoms from an sp^3 C atom

Definition of an acetal

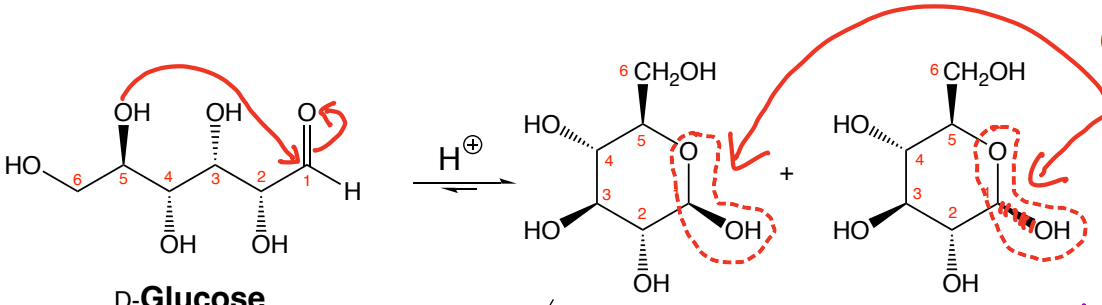


Cyclic Hemiacetals and Carbohydrates

Cyclic hemiacetals



The cyclic form of hemiacetals are stable-"SWEET!"
→ The chelate effect

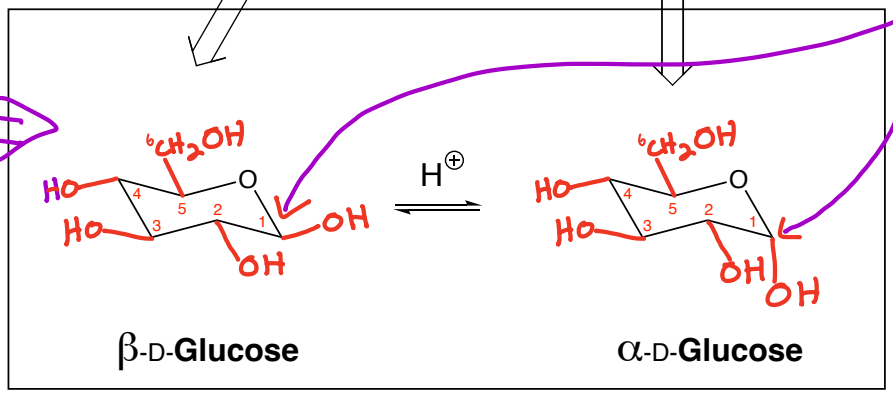


D-**Glucose**
(open chain form)

Cyclic Hemiacetals
"SWEET!"

Anomeric Carbon

This interconversion is called "mutarotation"



Biochemists call these two forms "anomers"

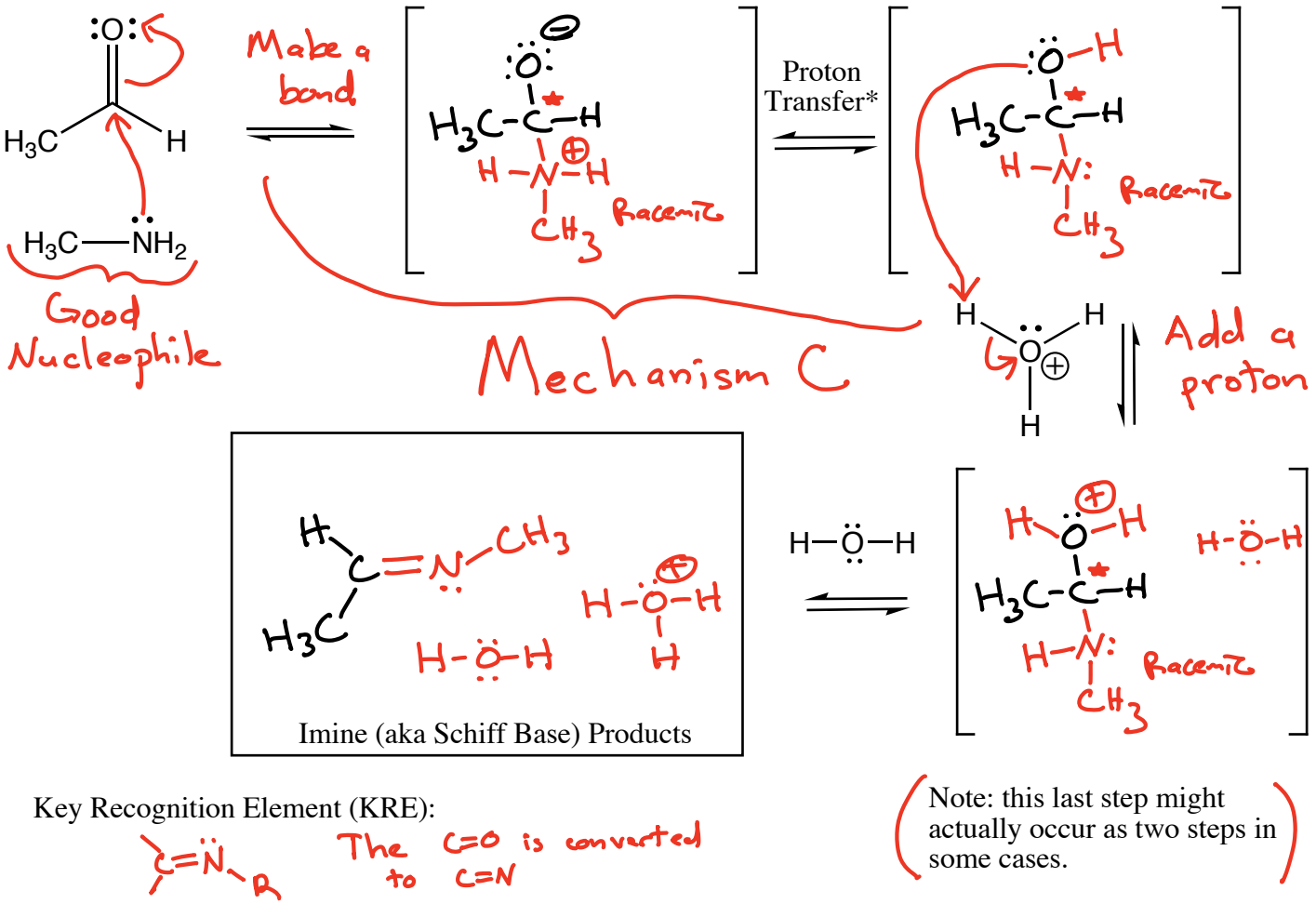
β-D-Glucopyranose
means "6-mebered ring"

More stable → every group is equatorial!

α-D-Glucopyranose

Less stable → one -OH is axial

Formation if an Imine (Schiff Base) From an Aldehyde or Ketone Reacting with an Amine



Key Recognition Element (KRE):

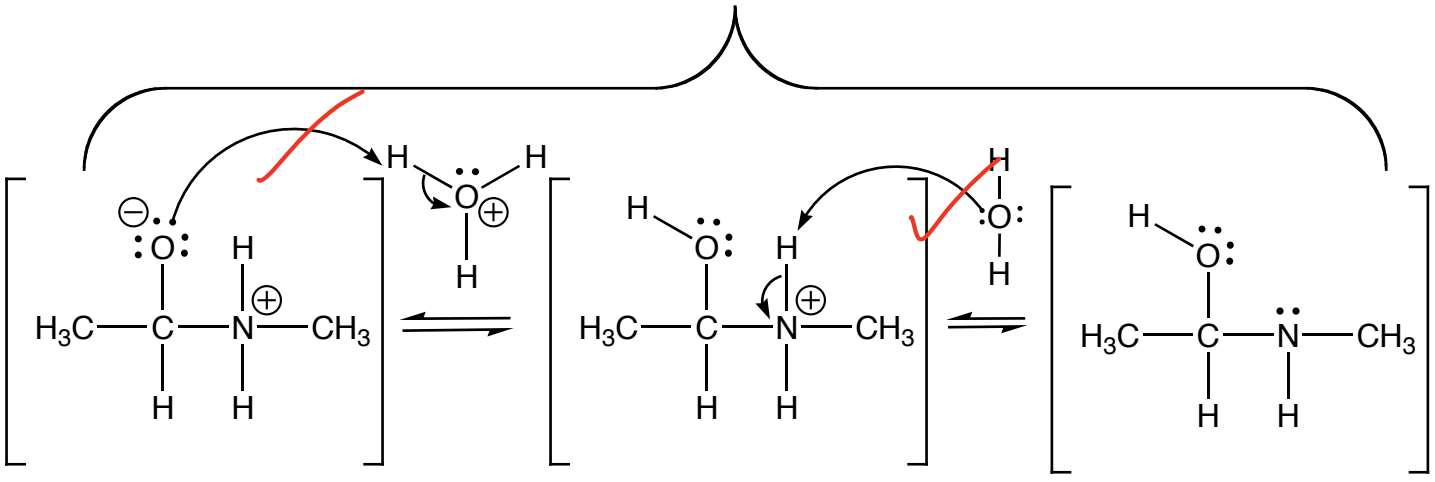
The C=O is converted to C=N

Note: this last step might actually occur as two steps in some cases.

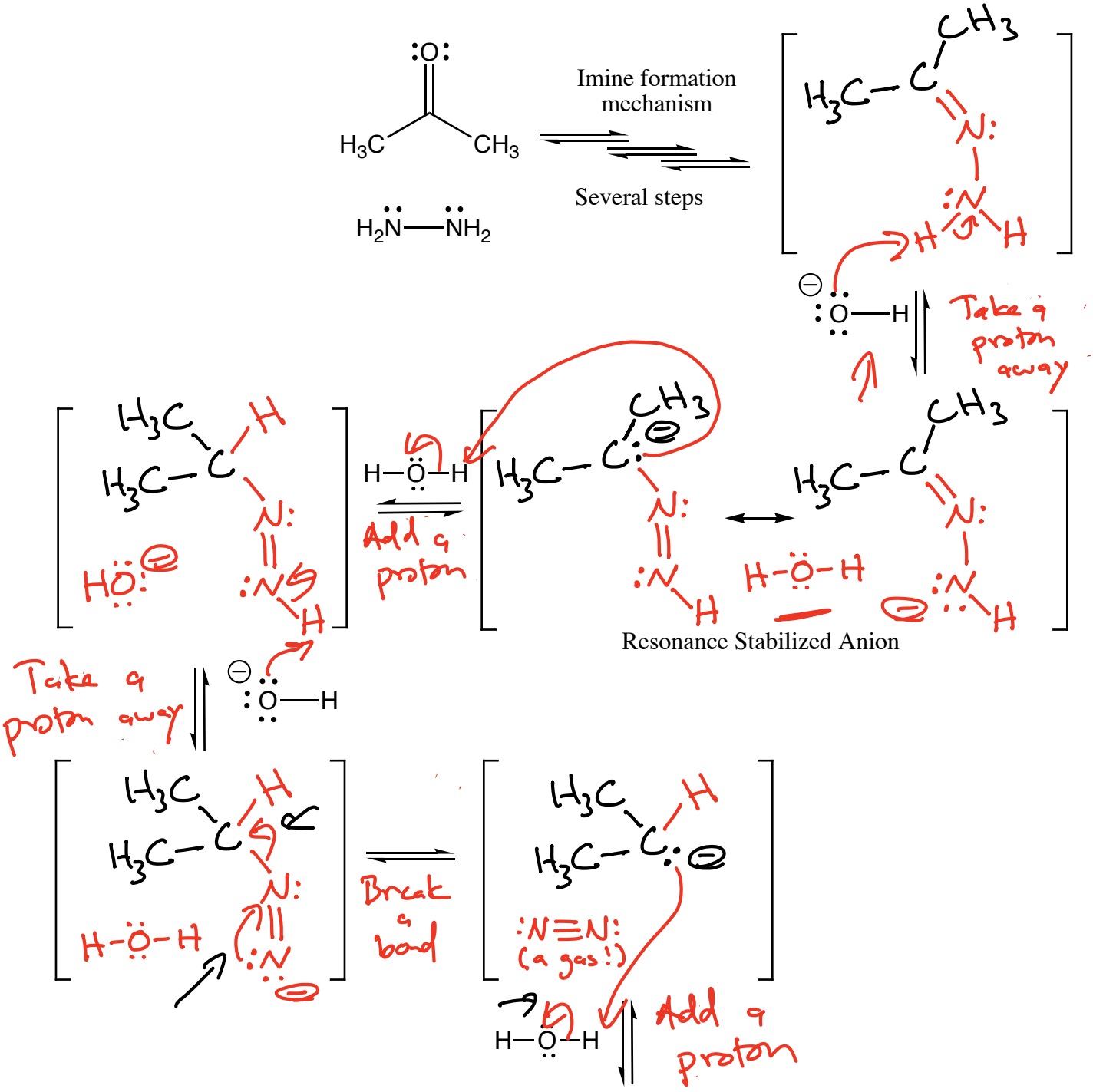
---

* "Proton Transfer" refers to a situation in which a proton moves from one part of a molecule to another on the SAME MOLECULE. We do not draw arrows for proton transfer steps because that would be deceptive. In some cases, the same proton may move from one part of the molecule to the other directly, but in other cases, solvent molecules may be involved as indicated in the following scheme. To make things even more interesting, the following two steps might even be reversed in some cases. Becuase of all the ambiguity, we just write "Proton Transfer" and do not bother with arrows.

"Proton Transfer"



Wolff-Kishner Reduction of an Aldehyde or Ketone



Key Recognition Element (KRE):

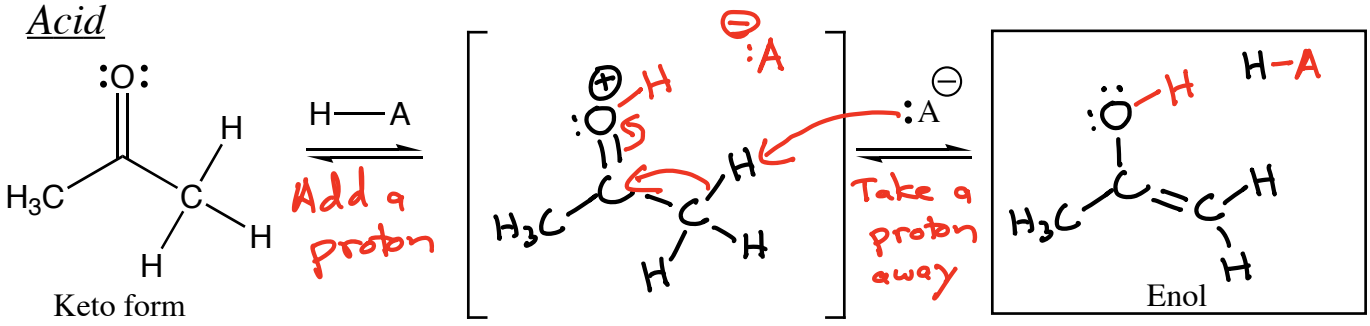
$-CH_2-$ where there was C=O

Products

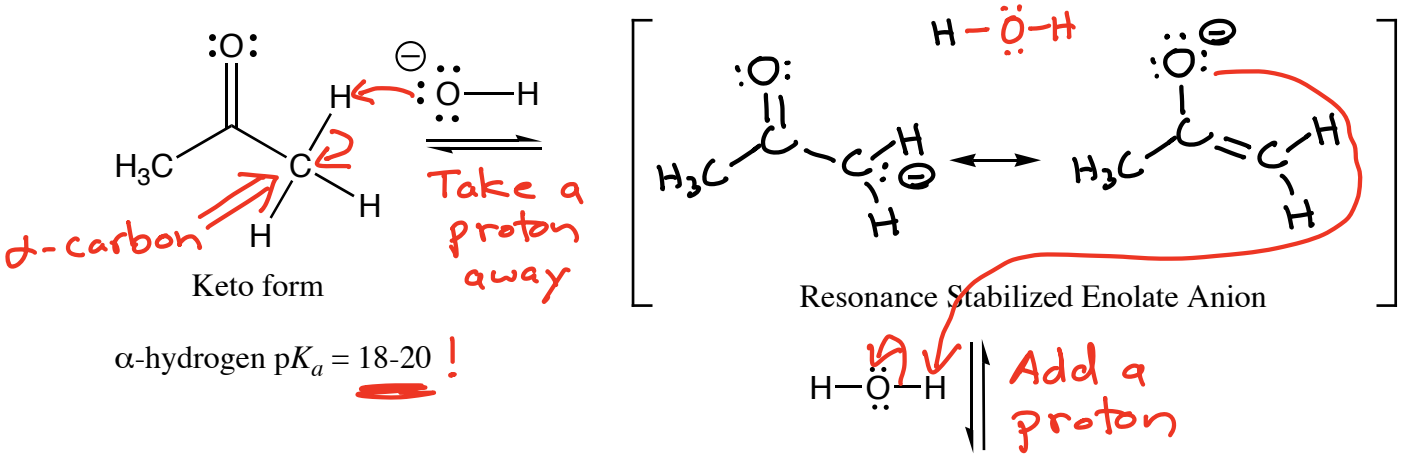
The process of interconverting the keto and enol forms is called "tautomerization"

Keto-Enol Equilibrium Catalyzed by Acid or Base

Acid



Base



α-hydrogen pK_a = 18-20 !

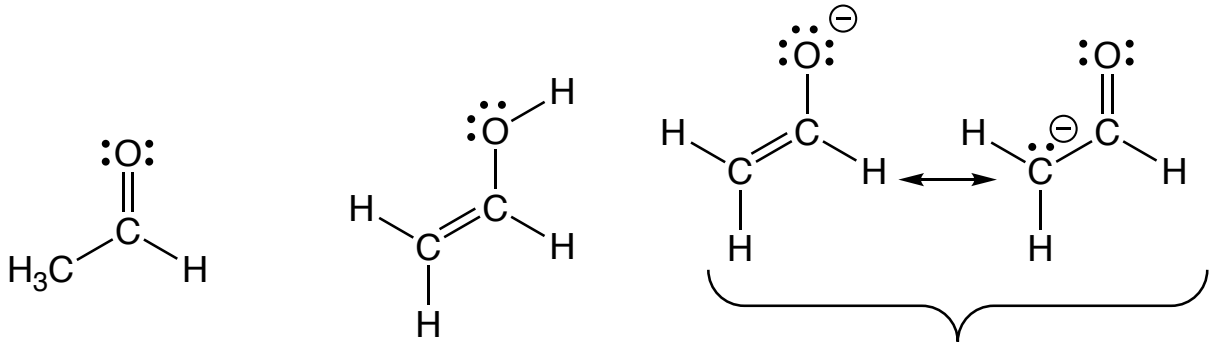
keto and enol forms are called "tautomers"

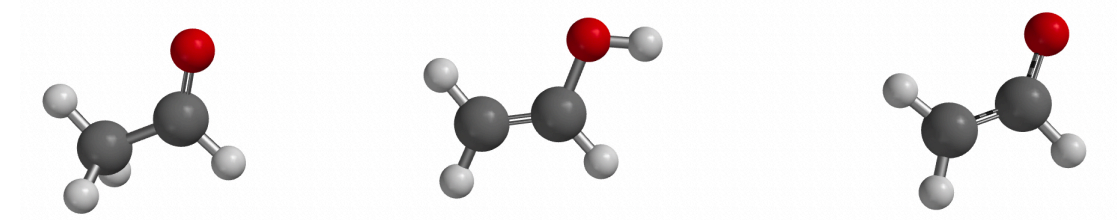
For both aldehydes and ketones, the keto form predominates at equilibrium, because C=O bonds are stronger than C=C bonds.

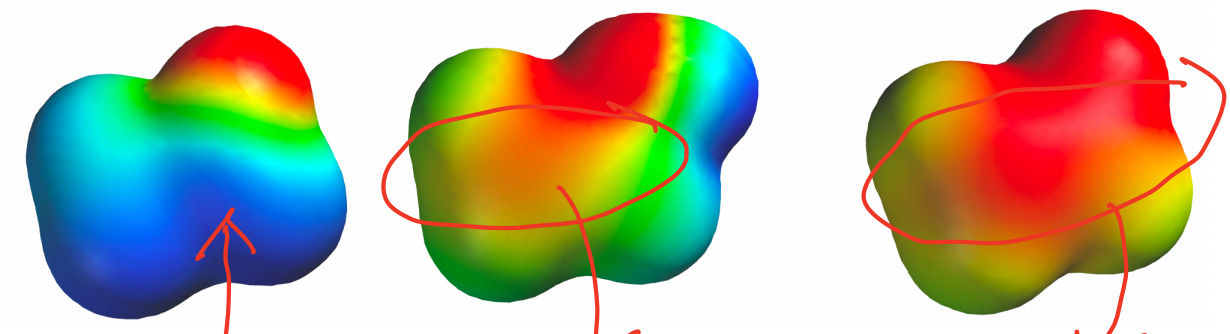
Enols are significant, however, because they react like nucleophile, not carbonyls, and this is important in certain situations.

Changing Personality:

An aldehyde or ketone is a weak electrophile.
An enol of that same aldehyde or ketone has a π bond that is a weak nucleophile!

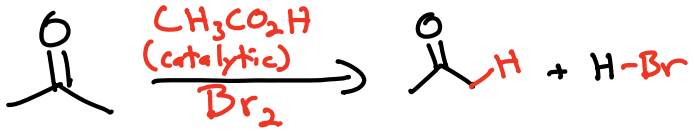


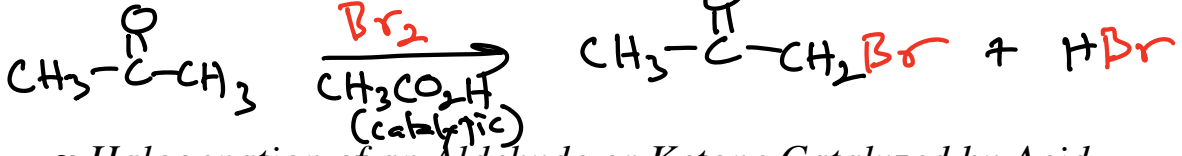




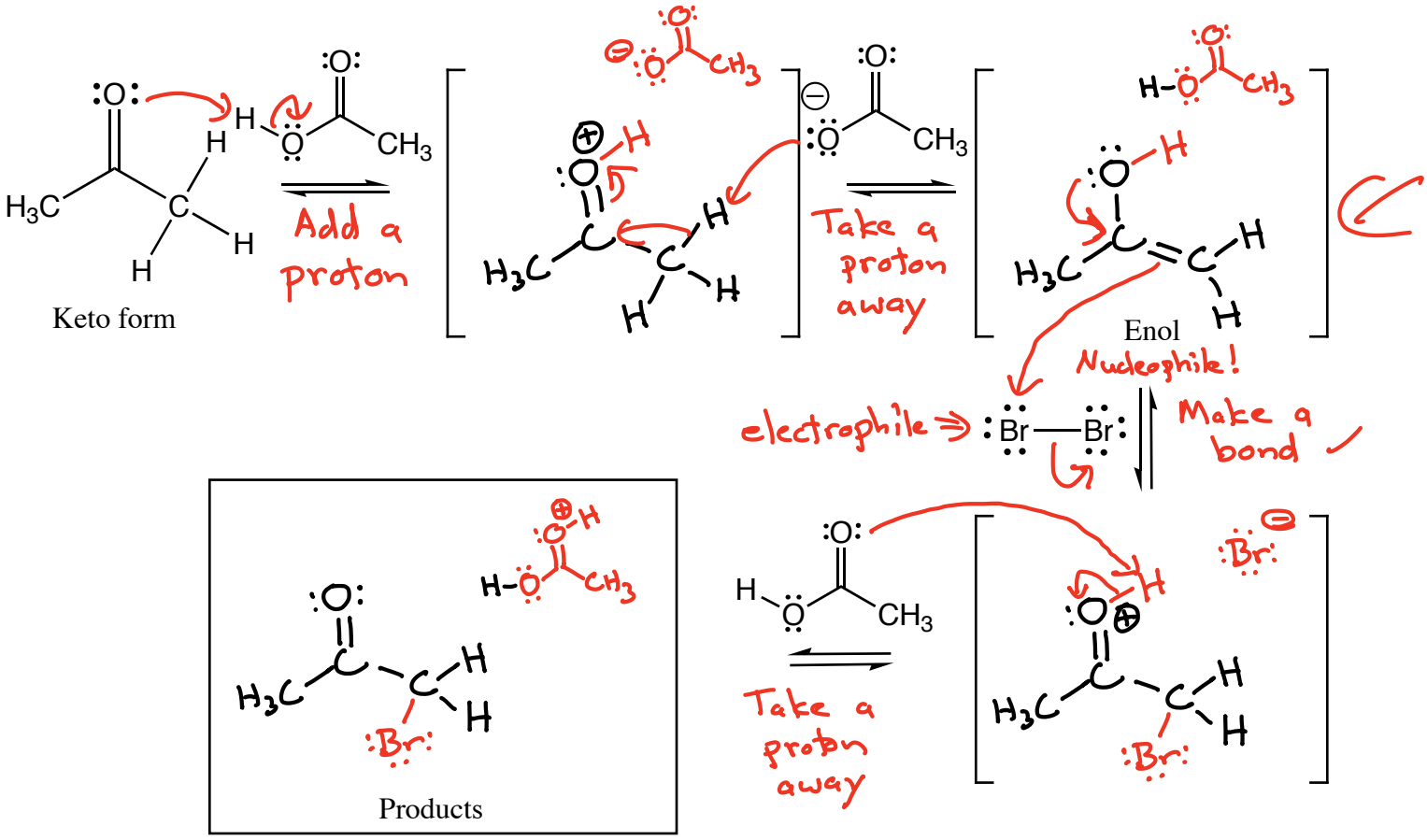
α-Halogenation of Aldehyde or Ketone in Acid

<u>Overall Reaction</u>

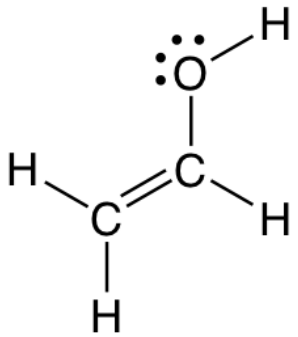


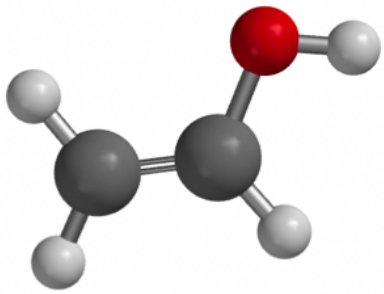


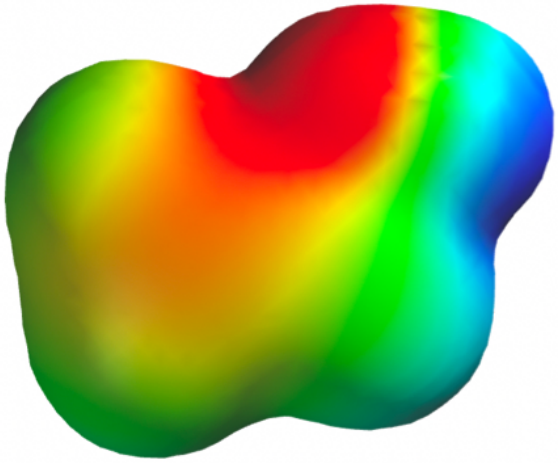
α-Halogenation of an Aldehyde or Ketone Catalyzed by Acid



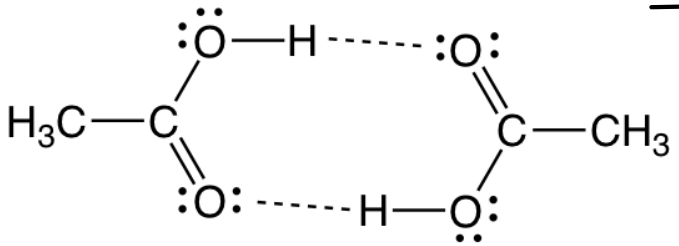
KRG: A new bond to Br at the α-carbon position
Prefers methyl groups

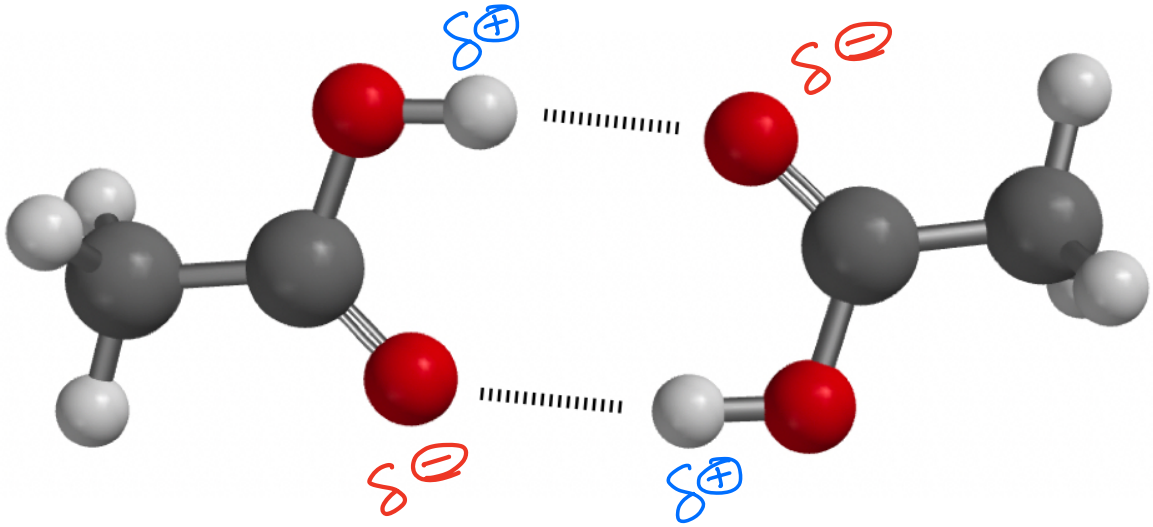


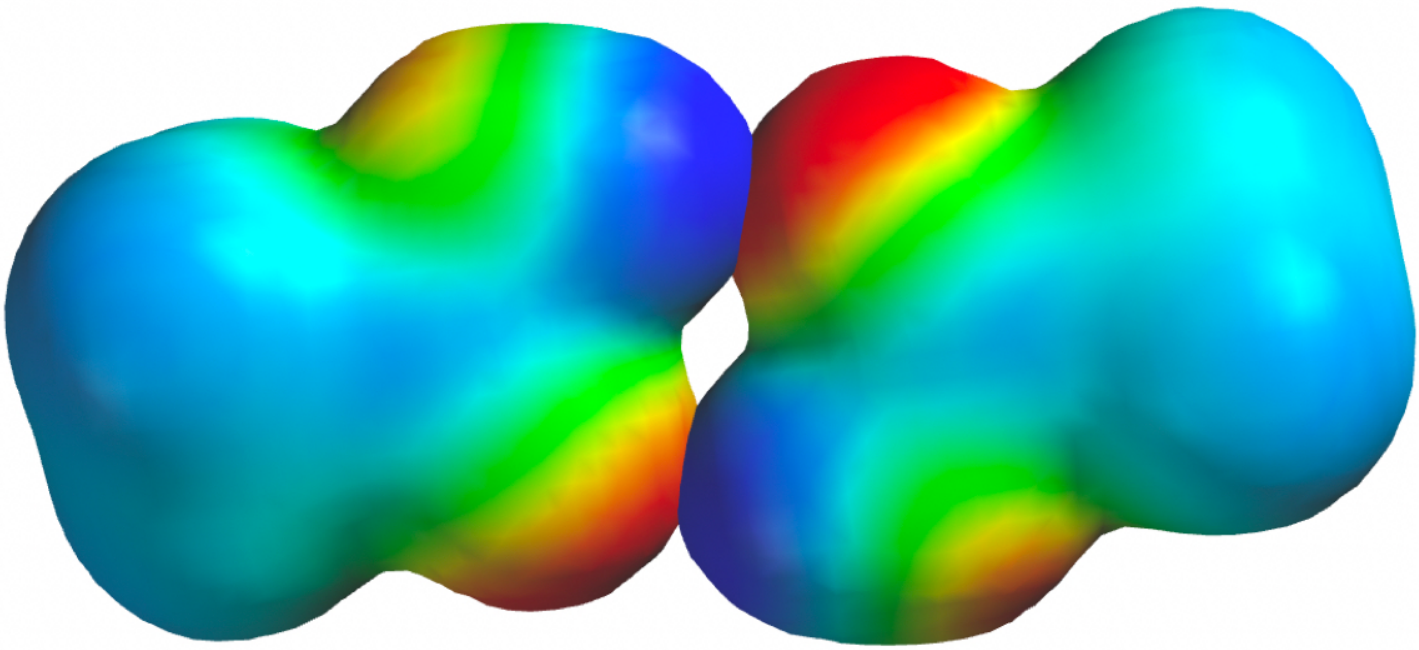


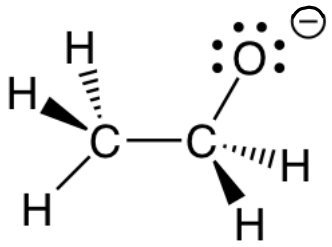


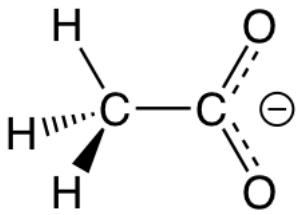
Carboxylic Acids

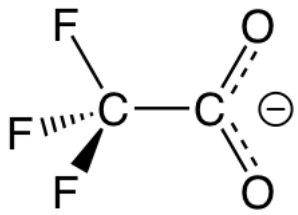


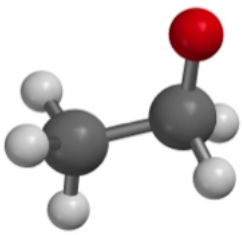


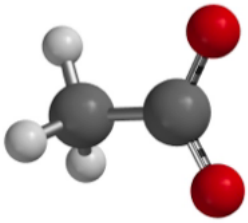


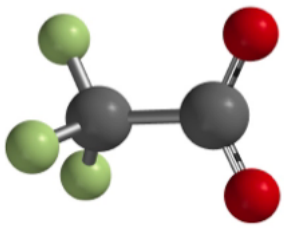


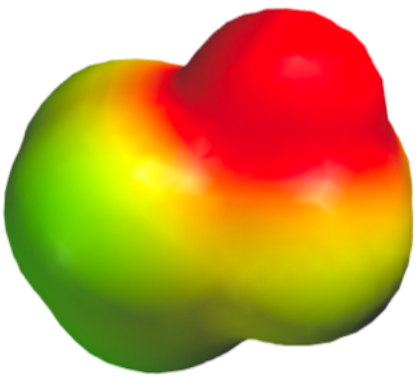


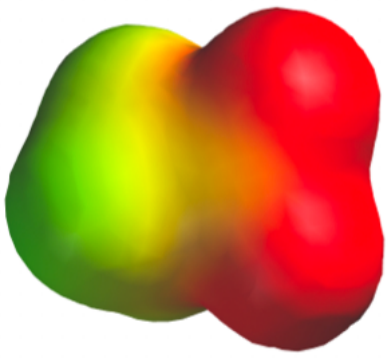


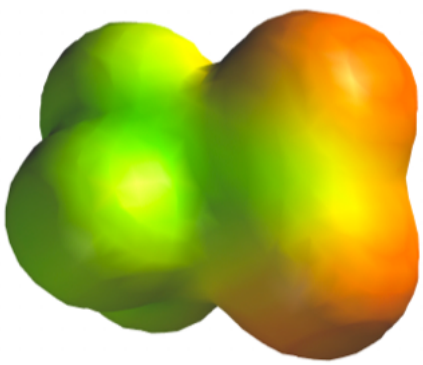




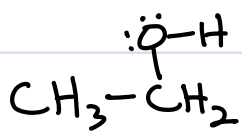


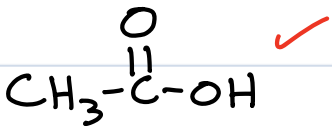


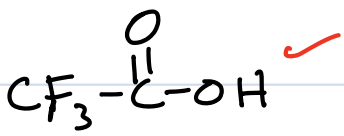




Parent Acids



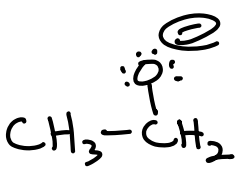


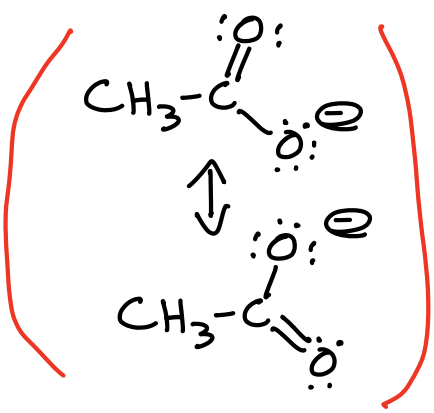


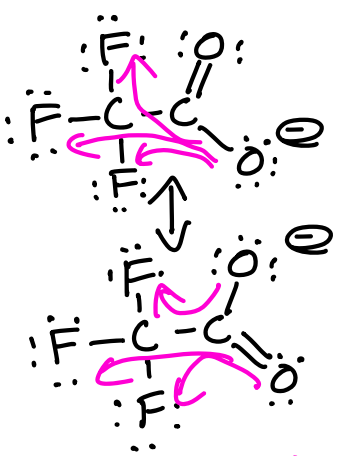
$pK_a = 16$

$pK_a = 3\text{-}5$

$pK_a = 0.3$

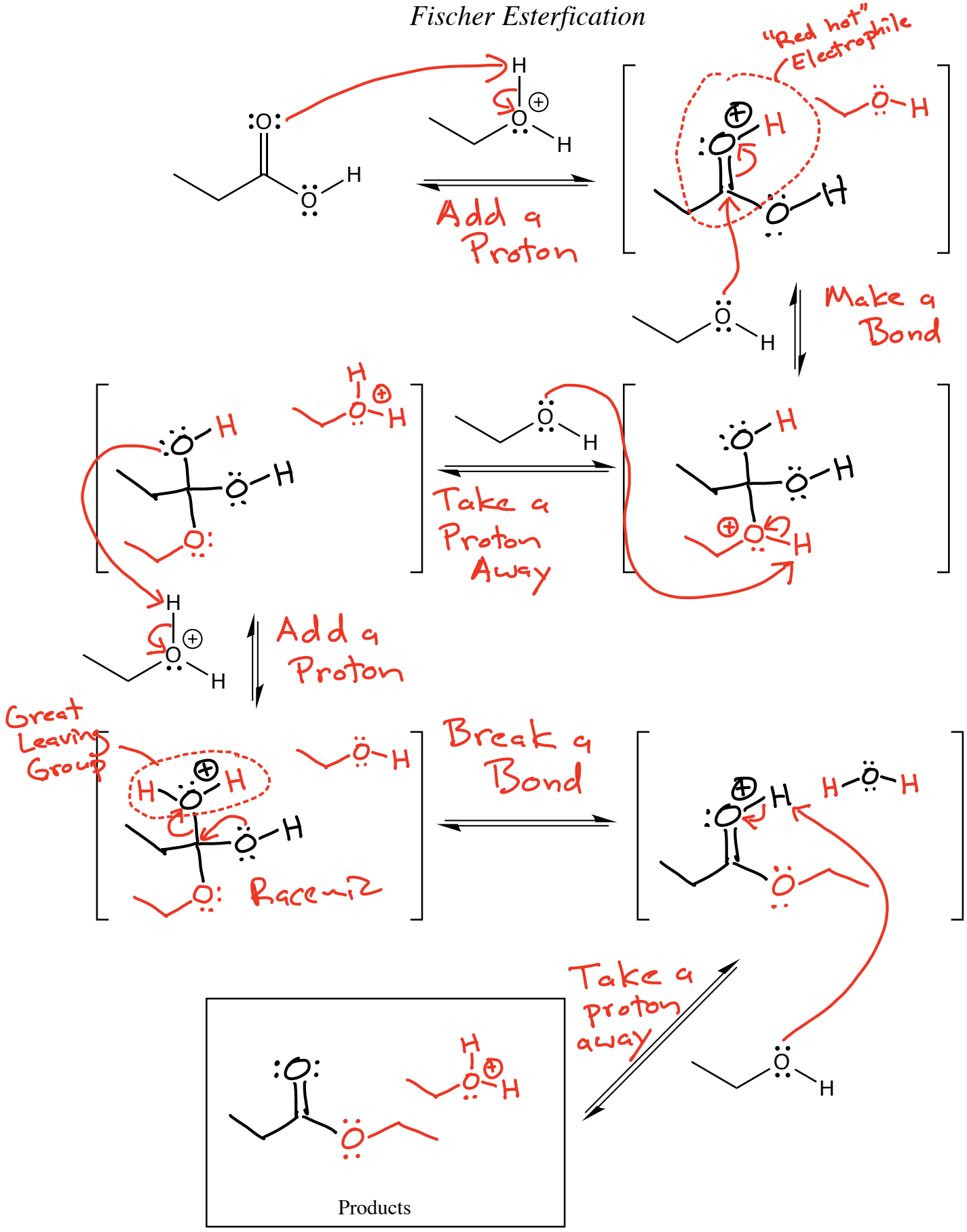




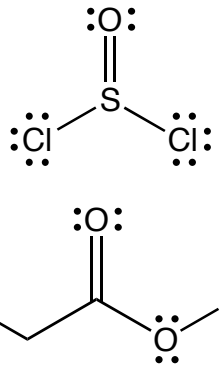


Inductive effect

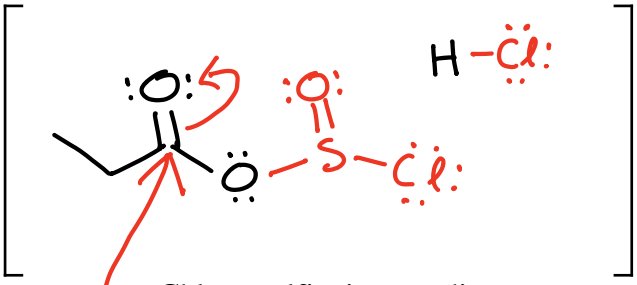
Fischer Esterfication



Reaction with Thionyl Chloride



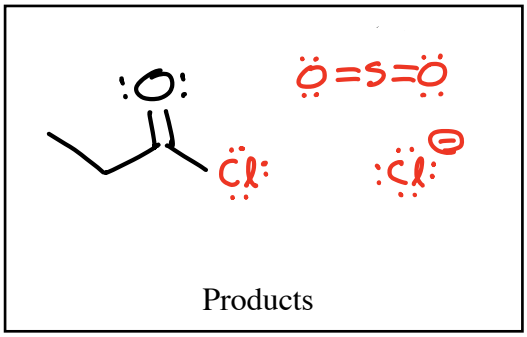
Several Steps



Chlrorosulfite intermediate

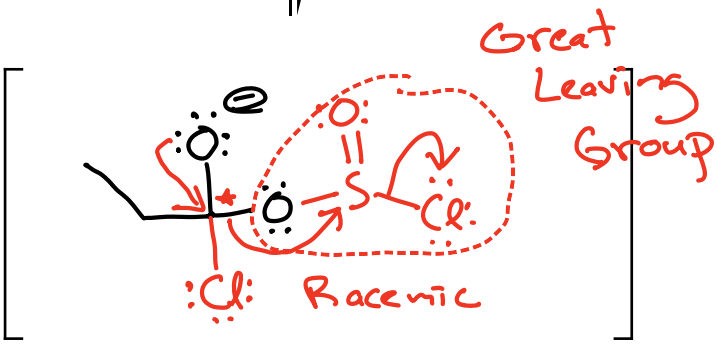
KRE → An acid chloride

Make a bond



Products

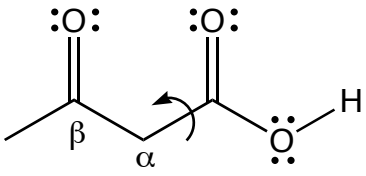
Break a Bond



Great Leaving Group

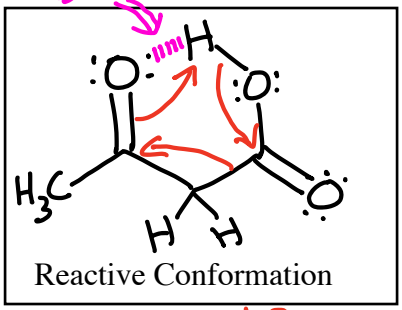
Racemic

Decarboxylation of a β-Keto Acid

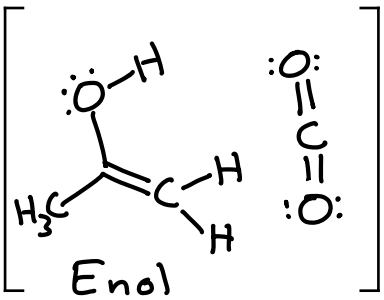


Bond rotates to give a more stable conformation

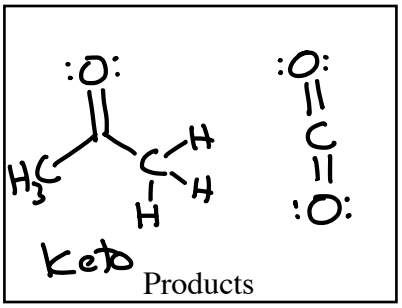
Hydrogen Bond



Reactive Conformation



Enol



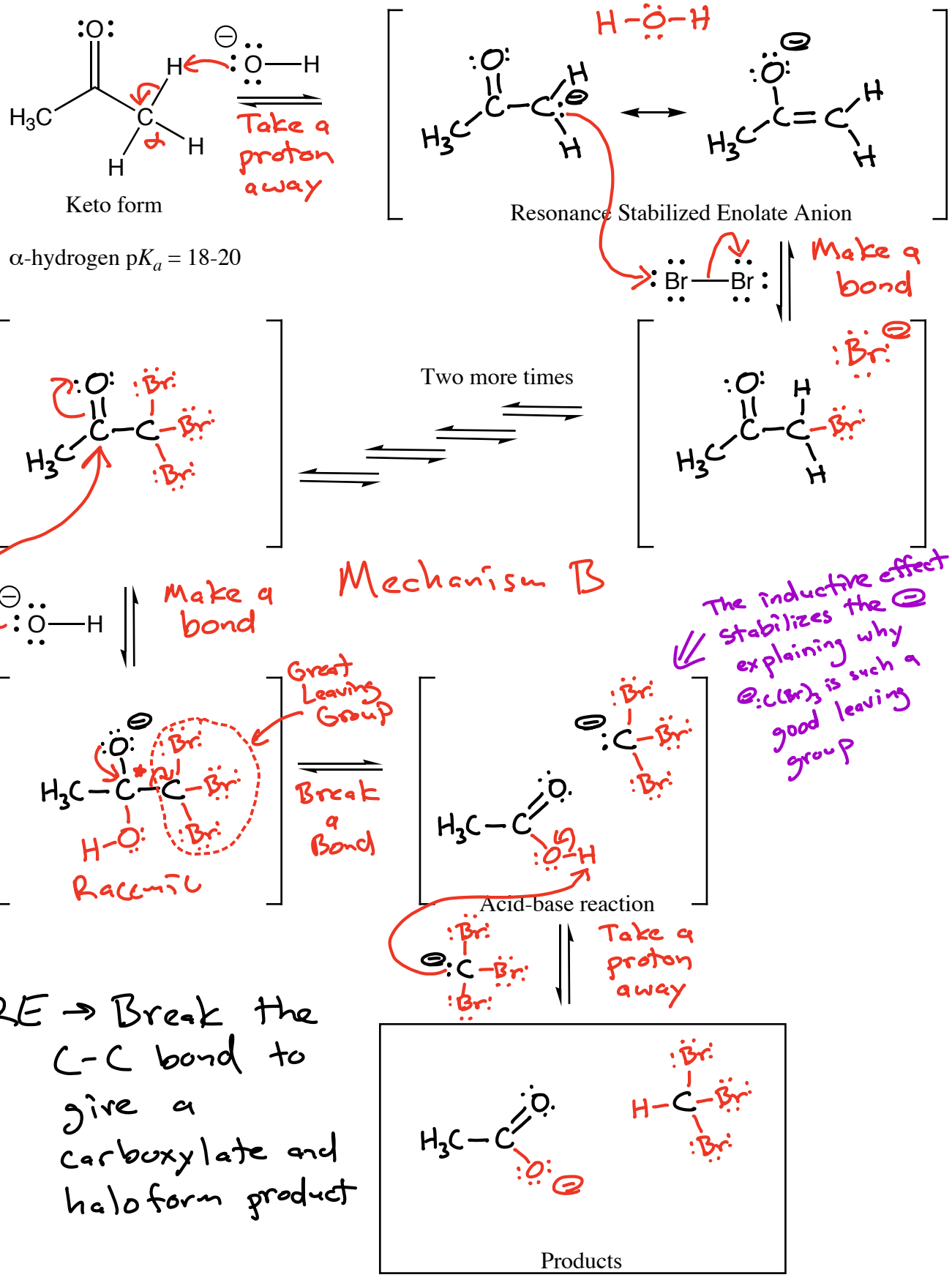
Keto

Products

6-Membered Ring
6 "Pi" Electrons
VERY STABLE
"Aromatic"

C-C Bond Breaks!

The Haloform Reaction



KRE → Break the C-C bond to give a carboxylate and haloform product