<u>Organic Chemistry</u> is the study of carbon-containing molecules. This class has two points.

The first point of the class is to understand the organic chemistry of living systems. We will teach you how to think about and understand the most amazing molecules on the planet!!

You will learn how MRI scans work. 1/12/23

You will learn the basic principles of pharmaceutical science and how many drugs work. 1/19/23

You will learn about the special bond that holds carbohydrates such as glucose in six-membered rings, connects carbohydrate monomers together to make complex carbohydrate structures and is critical to DNA and RNA structure.

You will learn how soap is made from animal fat and how it works to keep us clean.

You will learn the important structural reason proteins, the most important molecular machines in our bodies, can support the chemistry of life.

You will learn how important antibiotics like penicillins work, including ones that make stable covalent bonds as part of their mode of action.

You will learn why carrots are orange and tomatoes are red.

You will learn the very cool reason that the DNA and RNA bases are entirely flat so they can stack in the double helix structure.

You will learn even more about why fentanyl is such a devastating part of the opioid problem and how Naloxone is an antidote for a fentanyl overdose.

You will learn even more details about why Magic Johnson is still alive, decades after contracting HIV, and how the same strategy is being used to fight COVID.

You will learn about the surprising chemical reason the Pfizer and Moderna mRNA vaccines elicit strong immune responses.

The second point of organic chemistry is the synthesis of complex molecules from simpler ones by making and breaking specific bonds, especially carbon-carbon bonds.

You will learn how carbon-metal bonds lead to new carbon-carbon bonds. 1/17/23

You will learn how most reactions of carbonyl compounds involve only the four common mechanistic elements operating in only a few common patterns. 1/17/23

You will learn how, by simply adding a catalytic amount of base like HO^- to aldehydes or ketones, you can make new carbon-carbon bonds, giving complicated and useful products.

You will learn a reaction that can convert vinegar and vodka into a common solvent.

You will learn why molecules with six-membered rings and alternating double bonds are stable.

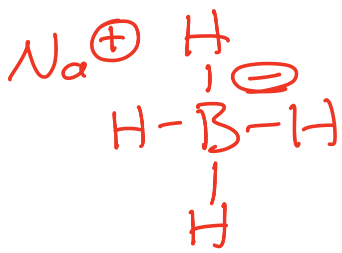
You will learn a reaction that can turn model airplane glue into a powerful explosive.

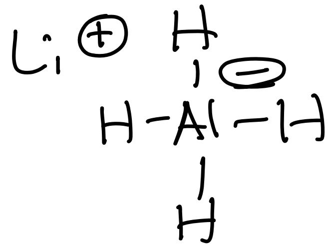
Most important, you will develop powerful critical thinking skills:

1. You will learn how to look at a molecule and accurately predict which atoms will react to make new bonds, and which bonds will break during reactions.
2. You will learn how to analyze a complex molecule's structure so that you can predict ways to make it via multiple reactions starting with less complex starting molecules.

Metal Hydride Reduction

⇒ Reduce C=O but not C=C

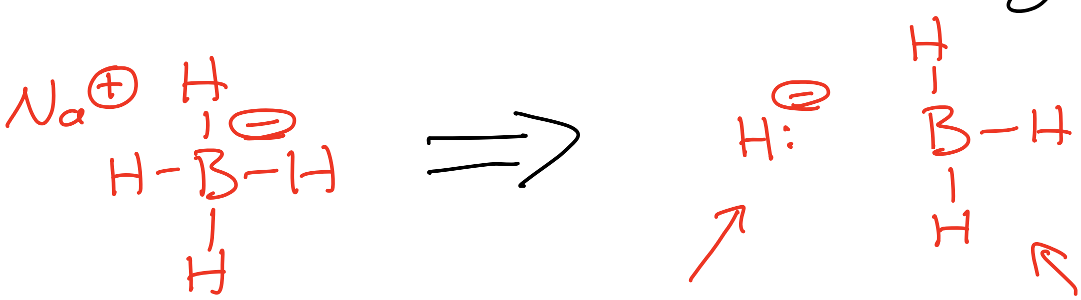




$NaBH_4$ ✓

$LiAlH_4$ ✓

How to think about the reagent:



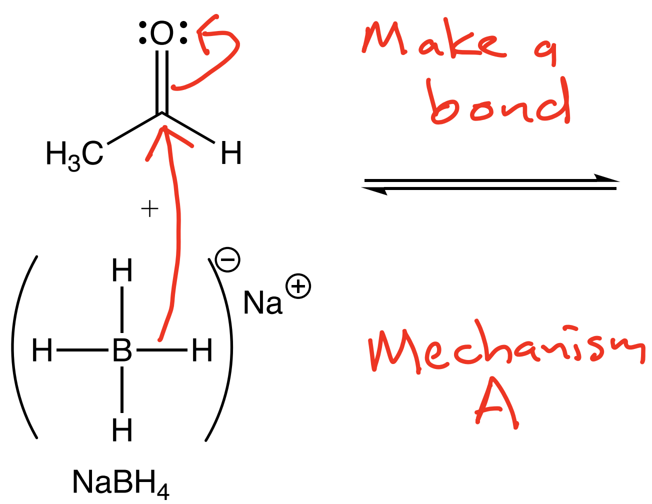
"Hydride"
A Lewis Base

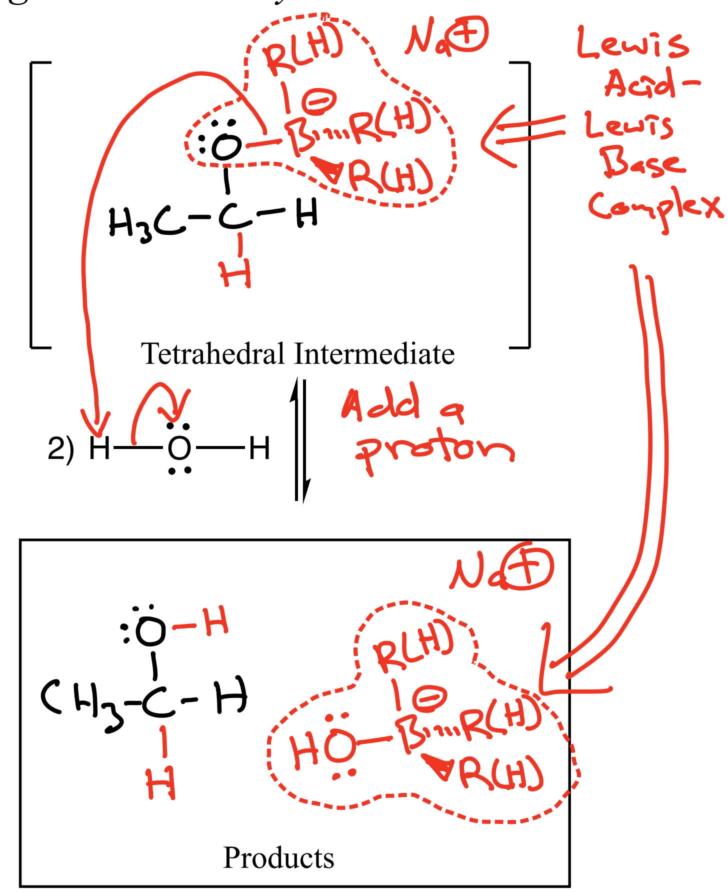
A Lewis acid

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

or LiAlH4

Sodium Borohydride Reacting with an Aldehyde or Ketone





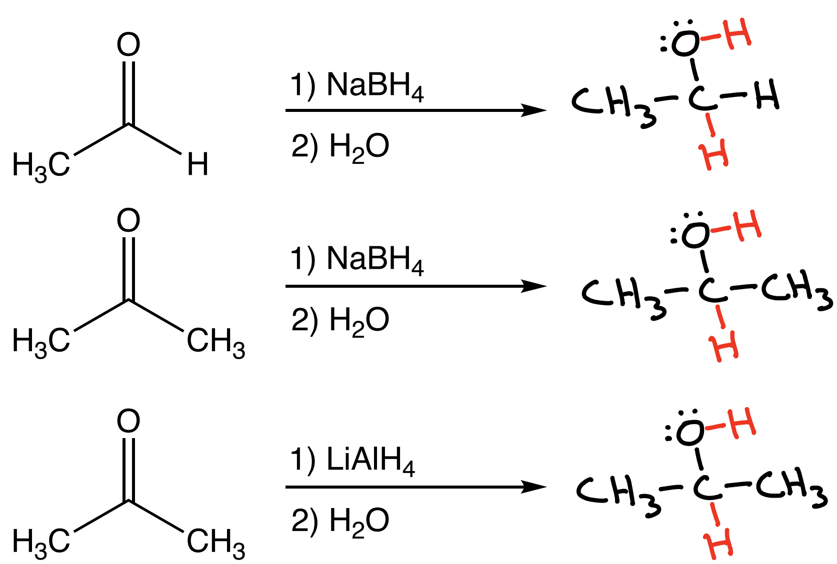
Key Recognition Element (KRE):

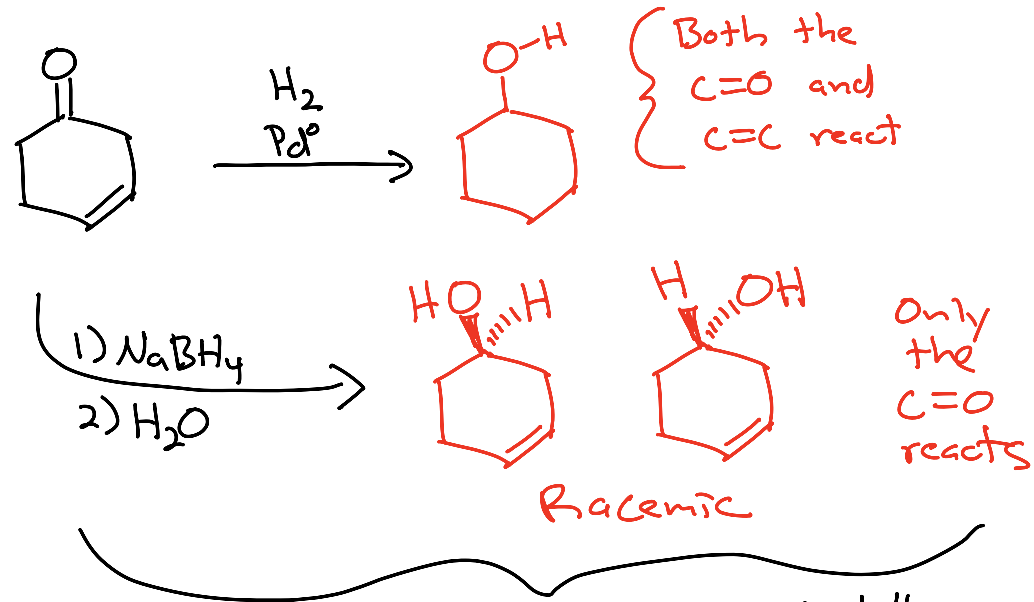
An –OH group where there was a C=O of an aldehyde or ketone

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

$$4\ CH_3\!-\!\overset{O}{\overset{\|}{C}}\!-\!H + \overset{\ominus}{B}H_4 \rightleftharpoons\rightleftharpoons\rightleftharpoons\rightleftharpoons (CH_3CH_2\!-\!O\!\rightarrow_4 \overset{\ominus}{B} \xrightarrow{2)\ H_2O} 4\ CH_3CH_2OH$$

+ Borate salts





"hydride"

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

Weak nucleophiles such as $R-\ddot{\underset{\cdot\cdot}{O}}-H$ 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 <u>much</u> better electrophile → protonate the O atom

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

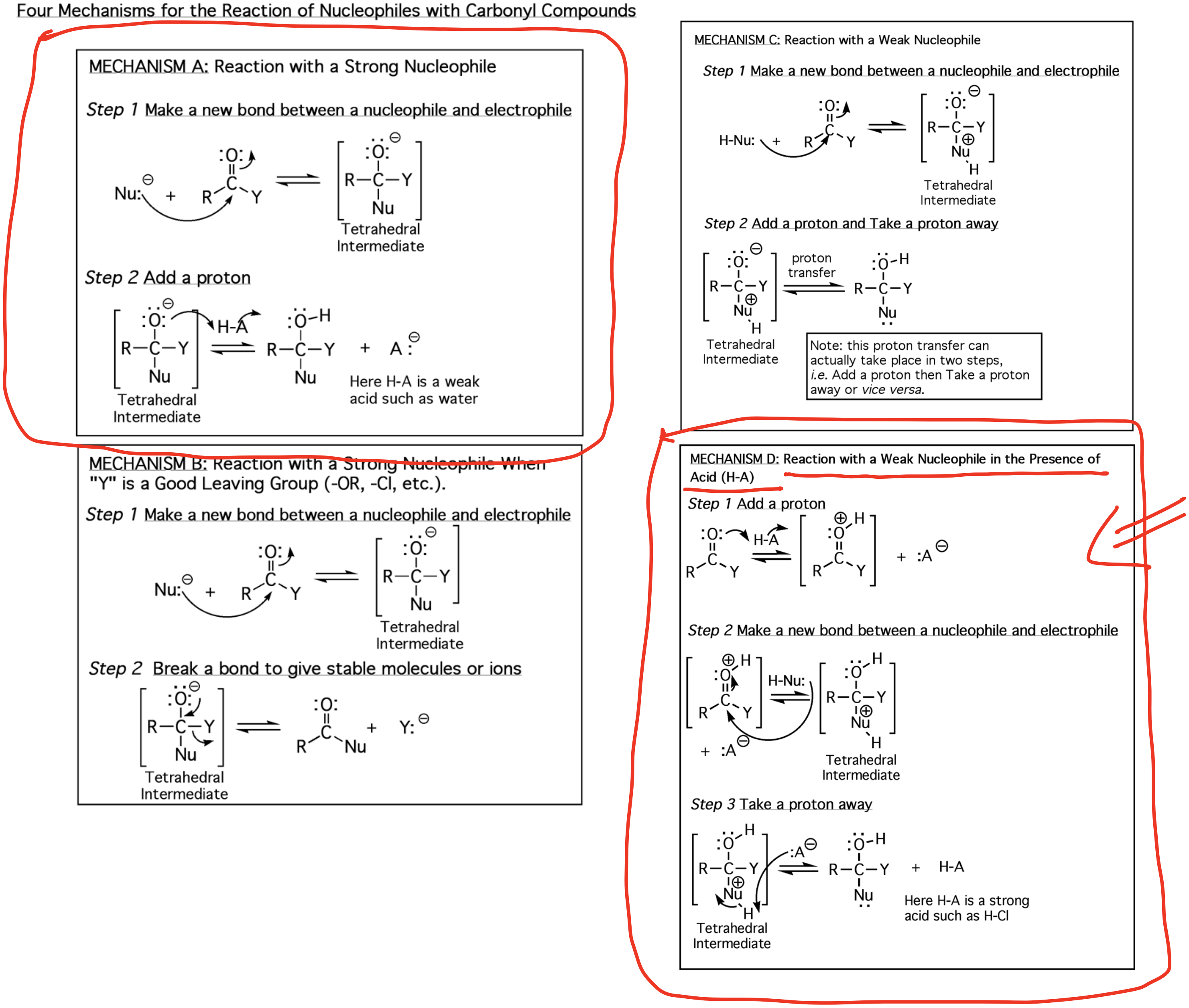
1) There are basically four different mechanisms elements that make up the steps of carbonyl reactions.

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.

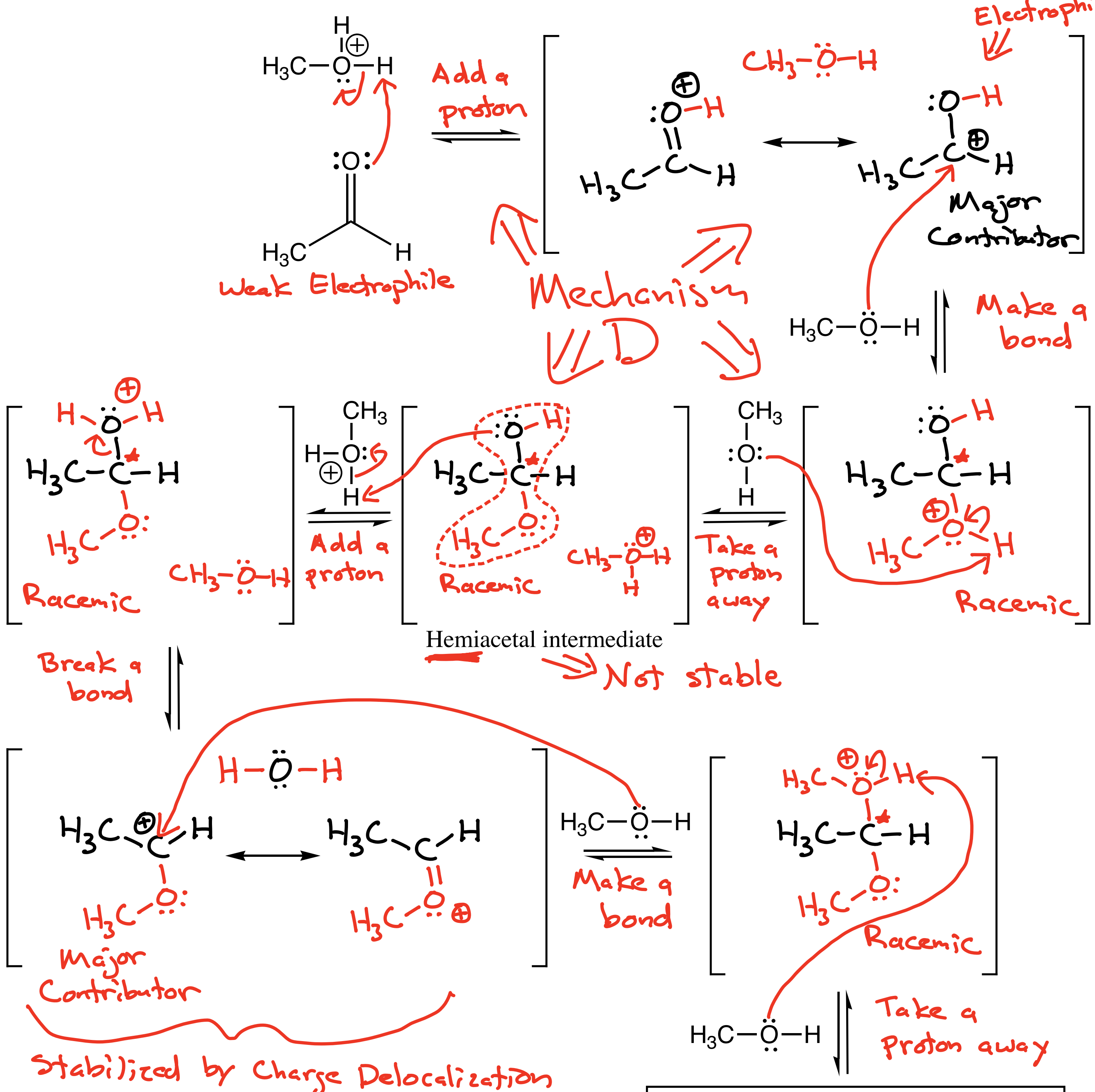
Four Mechanisms for the Reaction of Nucleophiles with Carbonyl Compounds



H_2SO_4

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

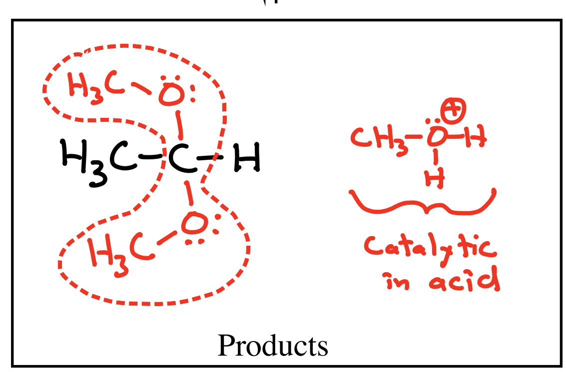
Acid Catalyzed Hemiacetal and Acetal Formation From an Aldehyde or Ketone



Key Recognition Element (KRE):

Two bonds to O atoms from an sp³ C atom

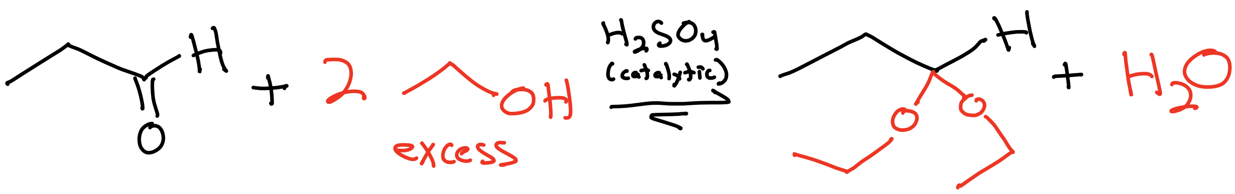
An acetal

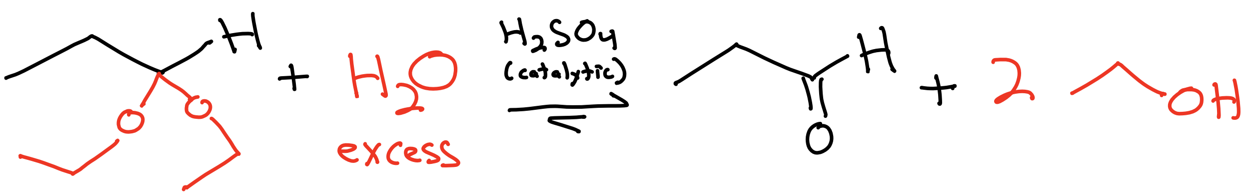


alcohol dehydration

⇅

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





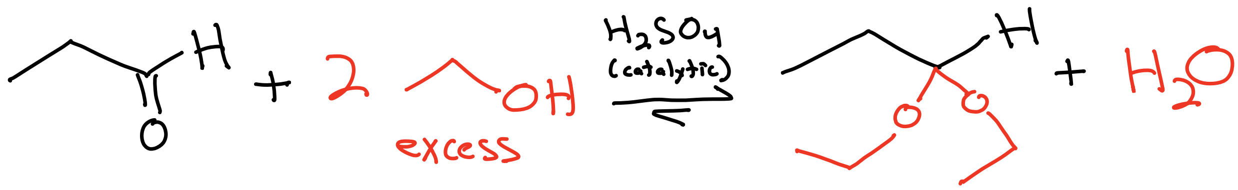
Le Chatlier's Principle

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

⇒ "claw" in Latin

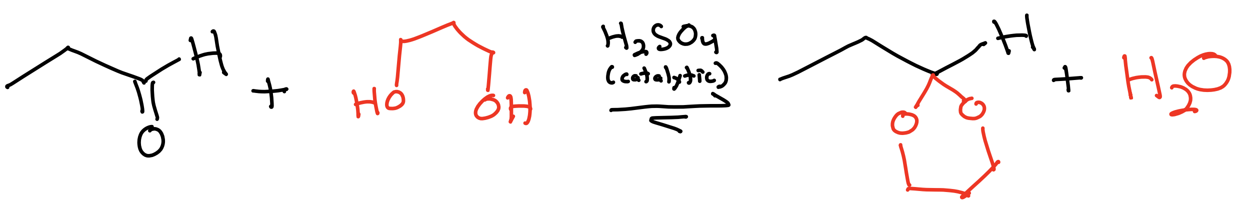
"Two OH groups already attached to each other 'go on' easier and 'come off' harder"

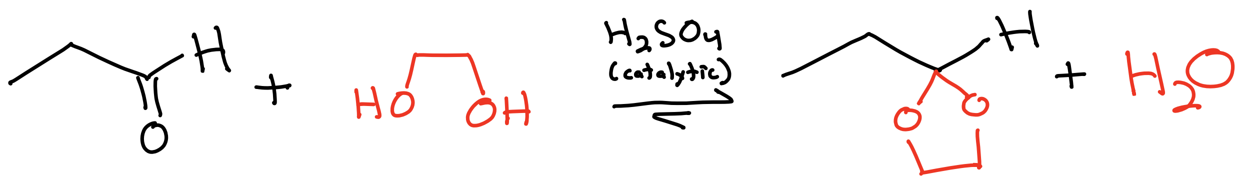
"Normal" acetal



Cyclic acetals → 5 and 6-membered rings!

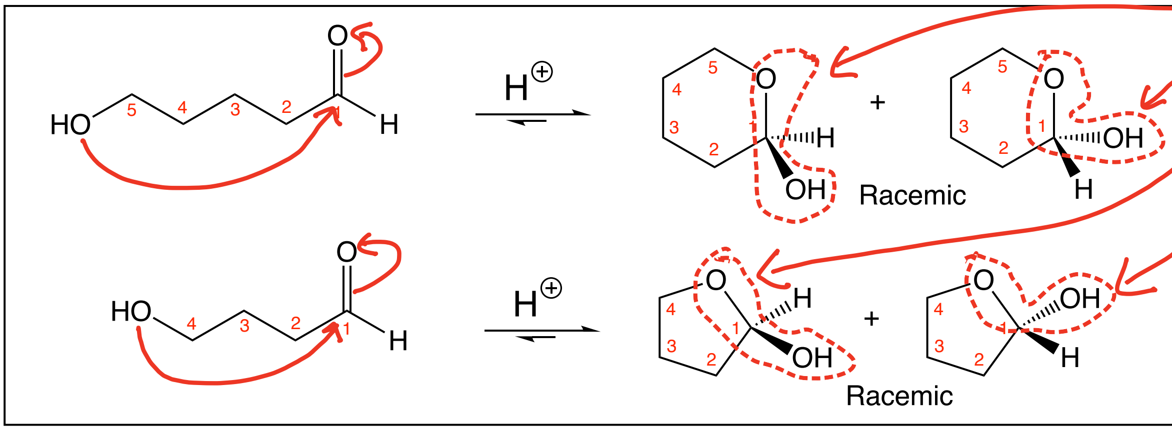
Stable → Strain free



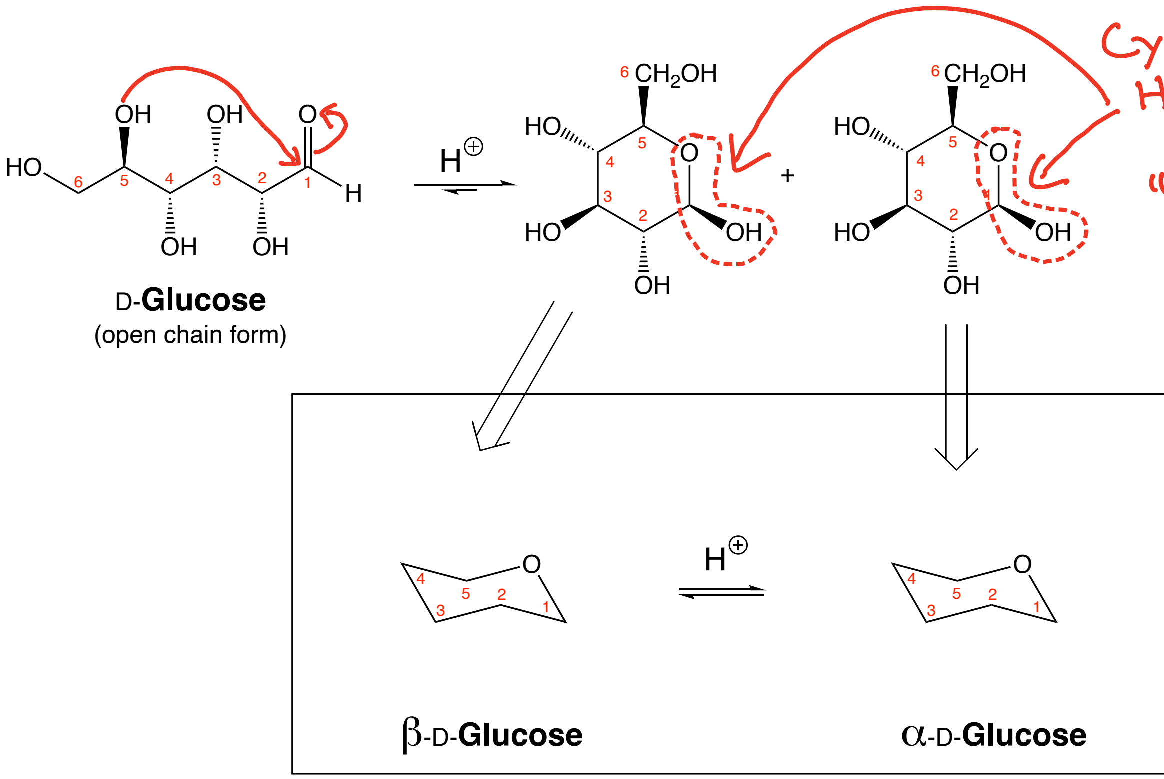


Cyclic Hemiacetals and Carbohydrates

Cyclic hemiacetals



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



Cyclic Hemiacetals

"SWEET!"