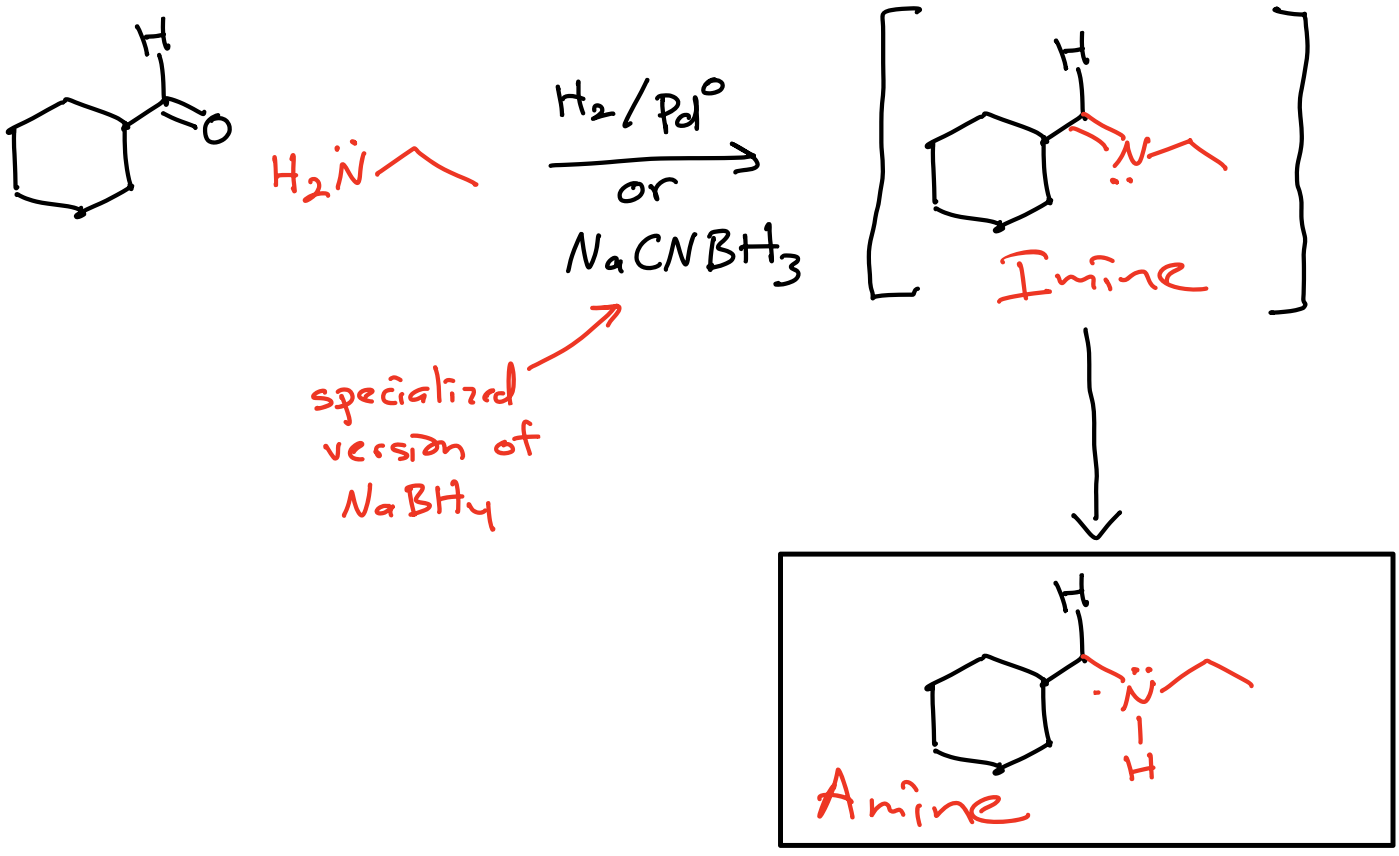
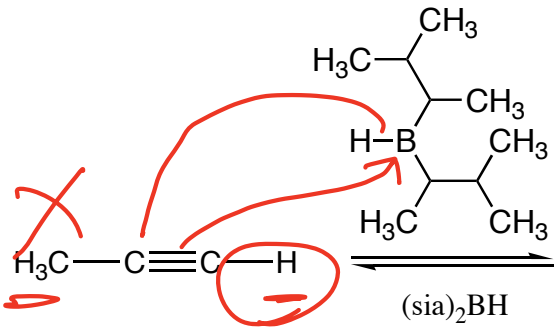
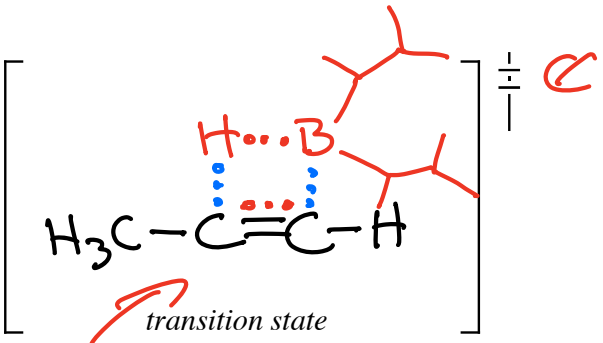
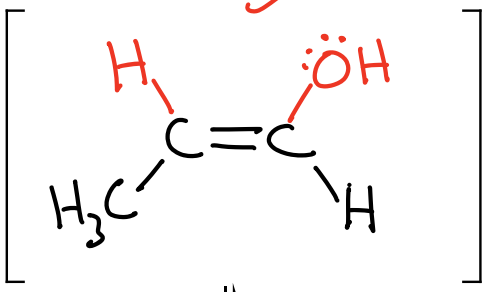


Reductive amination → reducing the C=N of an imine as it forms in the reaction.

Terminal Alkyne Hydroboration

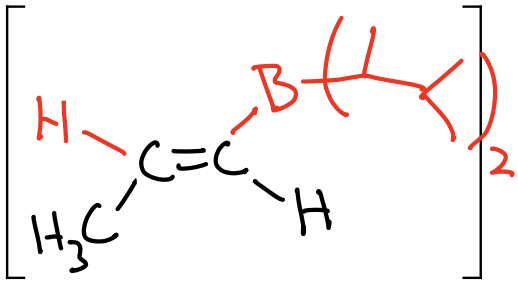




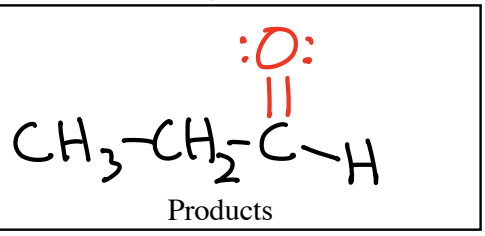


2. H_2O_2 / $HO^{\ominus}$

(Chemist opens flask and adds new reagent)



Keto-enol tautomerization



Products

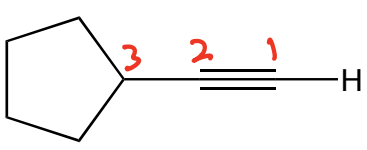
⇐ The C=O is on the C on the end → "non-Markovnikov"

Summary: The $(sia)_2BH$ reacts so the B atom attaches to the C atom on the end. The four-membered ring transition state makes both bonds simultaneously. 2. $H_2O_2/HO^{\ominus}$ → enol → keto

Regiochemistry: non-Markovnikov

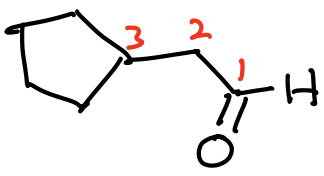
Stereochemistry: N/A

Example:



1. $(sia)_2BH$

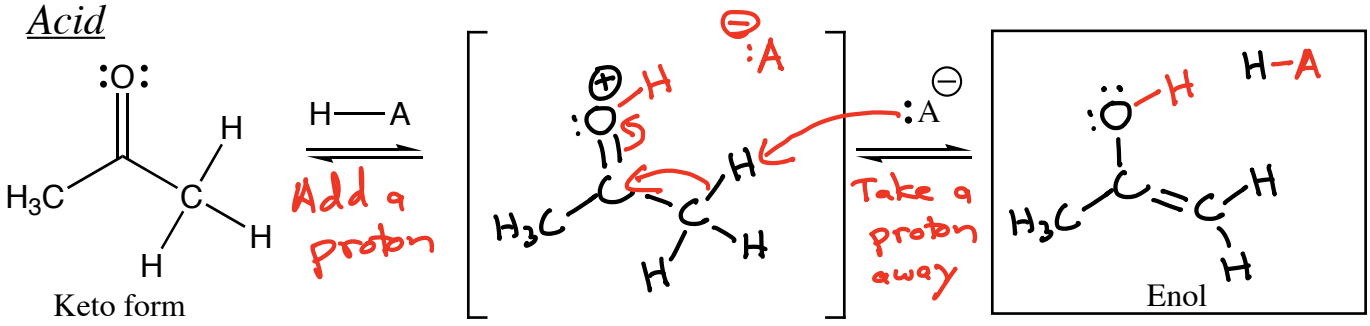
2. H_2O_2 / $HO^{\ominus}$



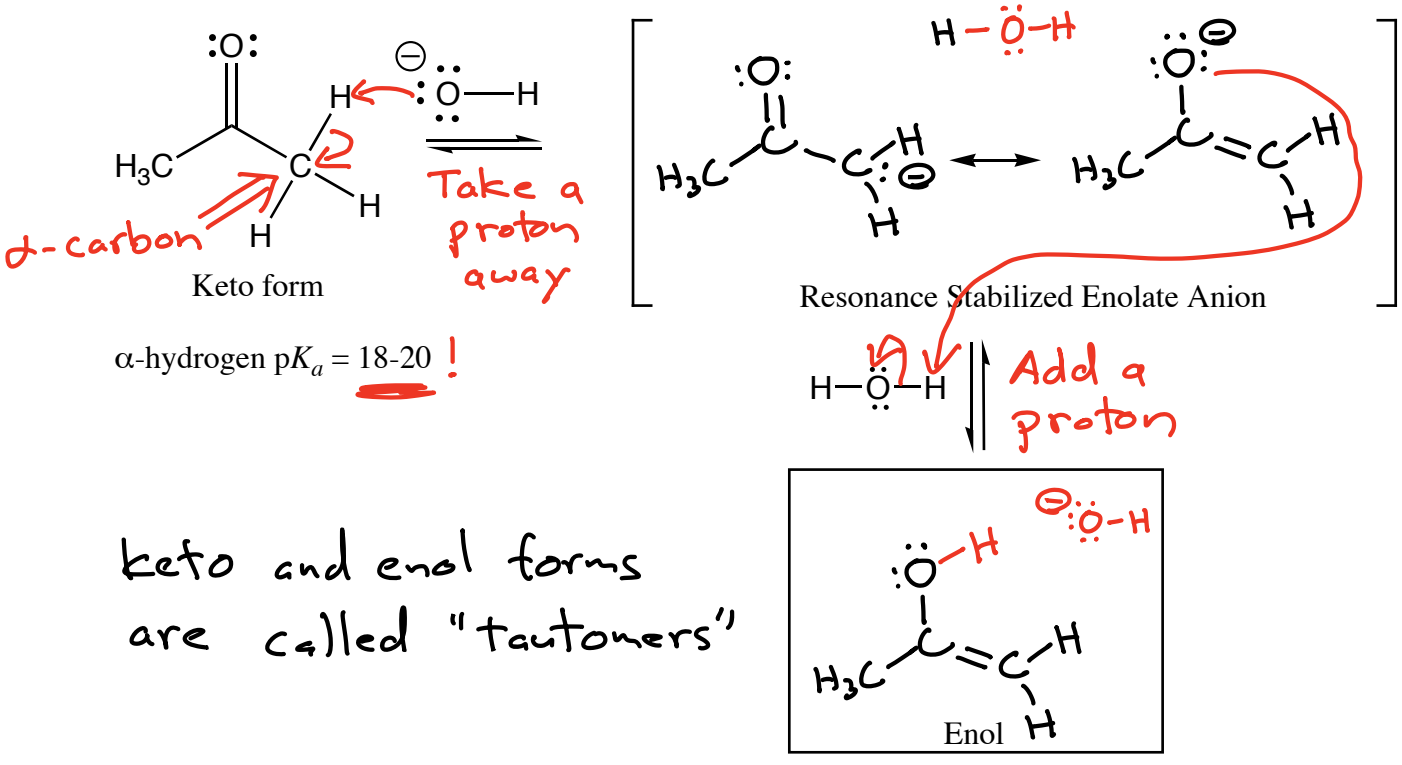
The process of interconverting the keto and enol forms is called "tautomerization"

Keto-Enol Equilibrium Catalyzed by Acid or Base

Acid



Base



α-hydrogen pK_a = 18-20 !

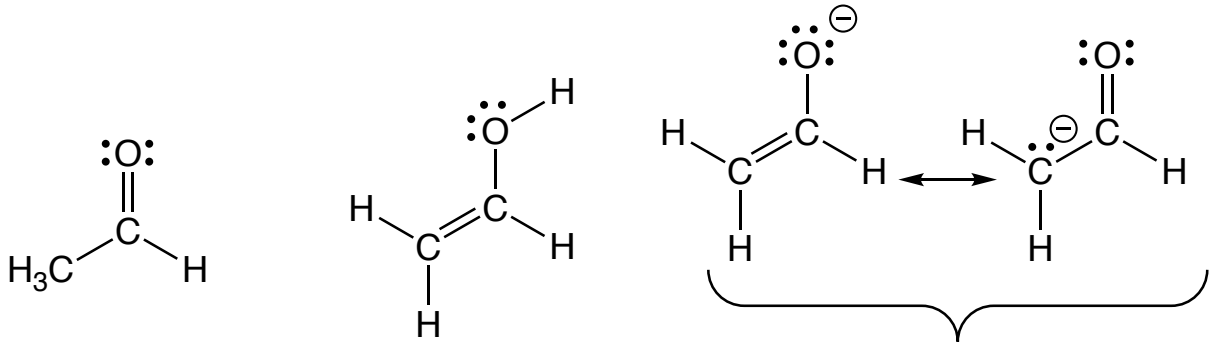
keto and enol forms are called "tautomers"

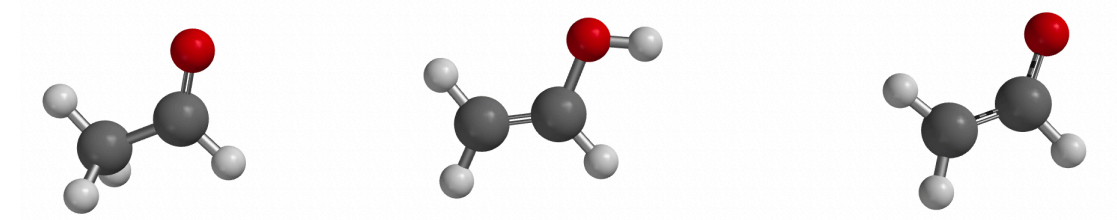
For both aldehydes and ketones, the keto form predominates at equilibrium, because C=O bonds are stronger than C=C bonds.

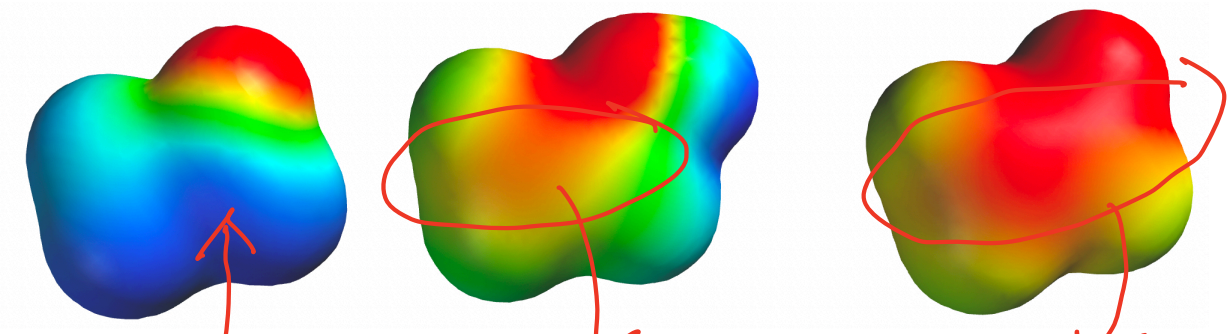
Enols are significant, however, because they react like nucleophile, not carbonyls, and this is important in certain situations.

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!

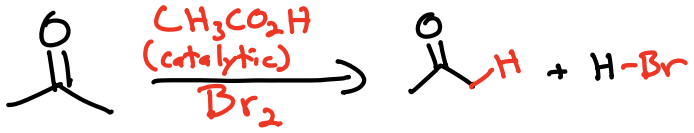




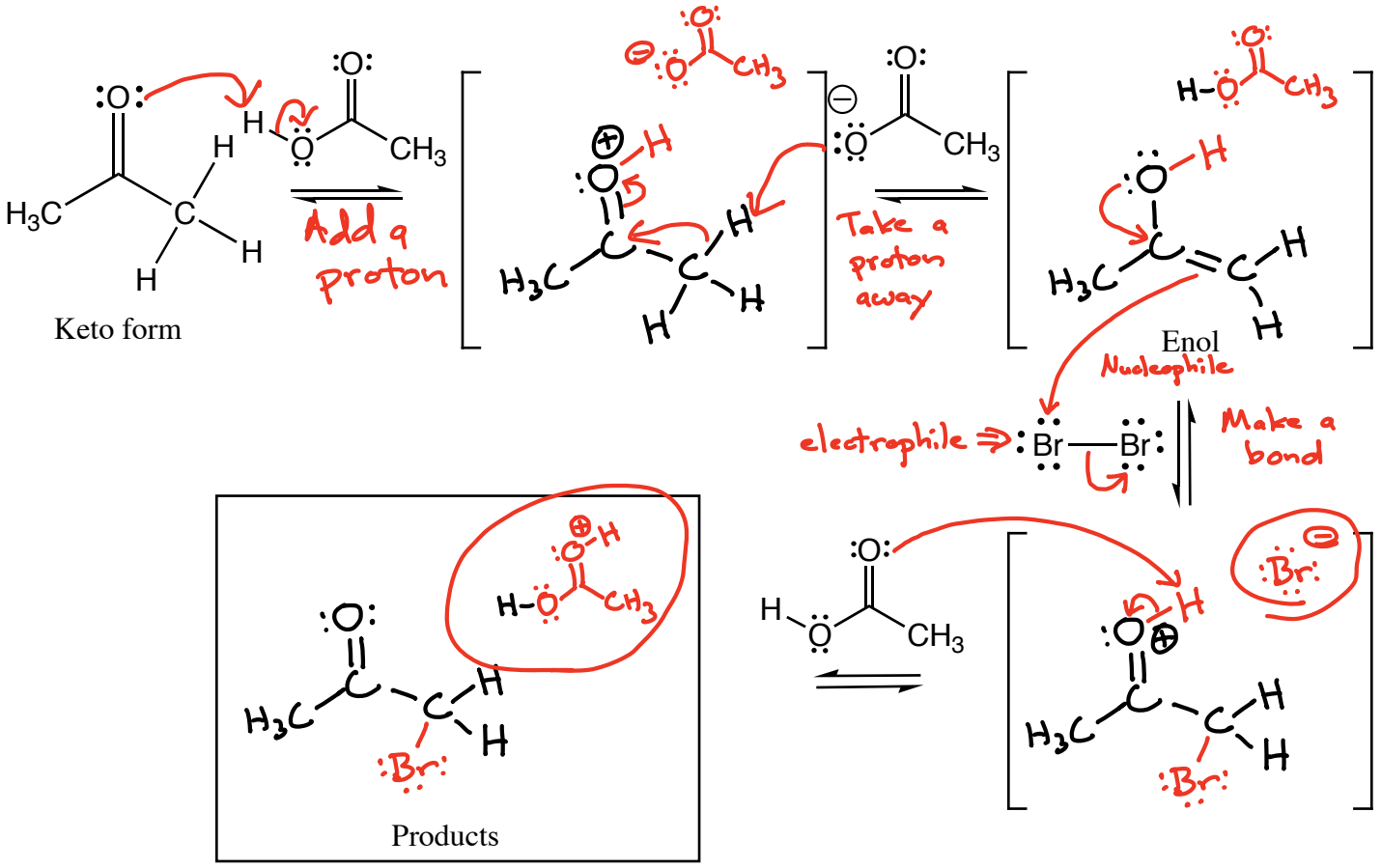


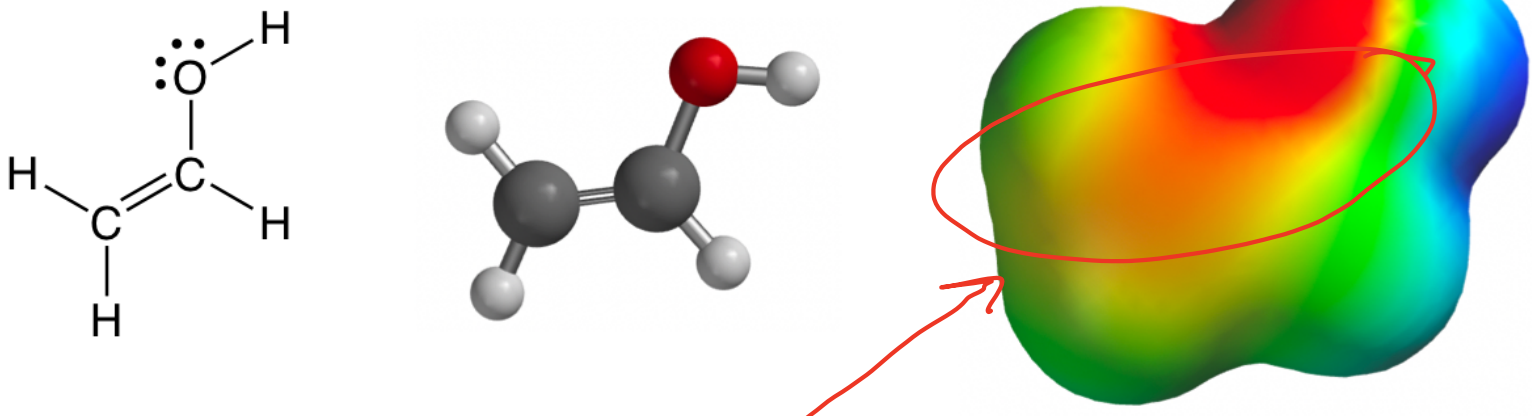
α-Halogenation of Aldehyde or Ketone in Acid

<u>Overall Reaction</u>



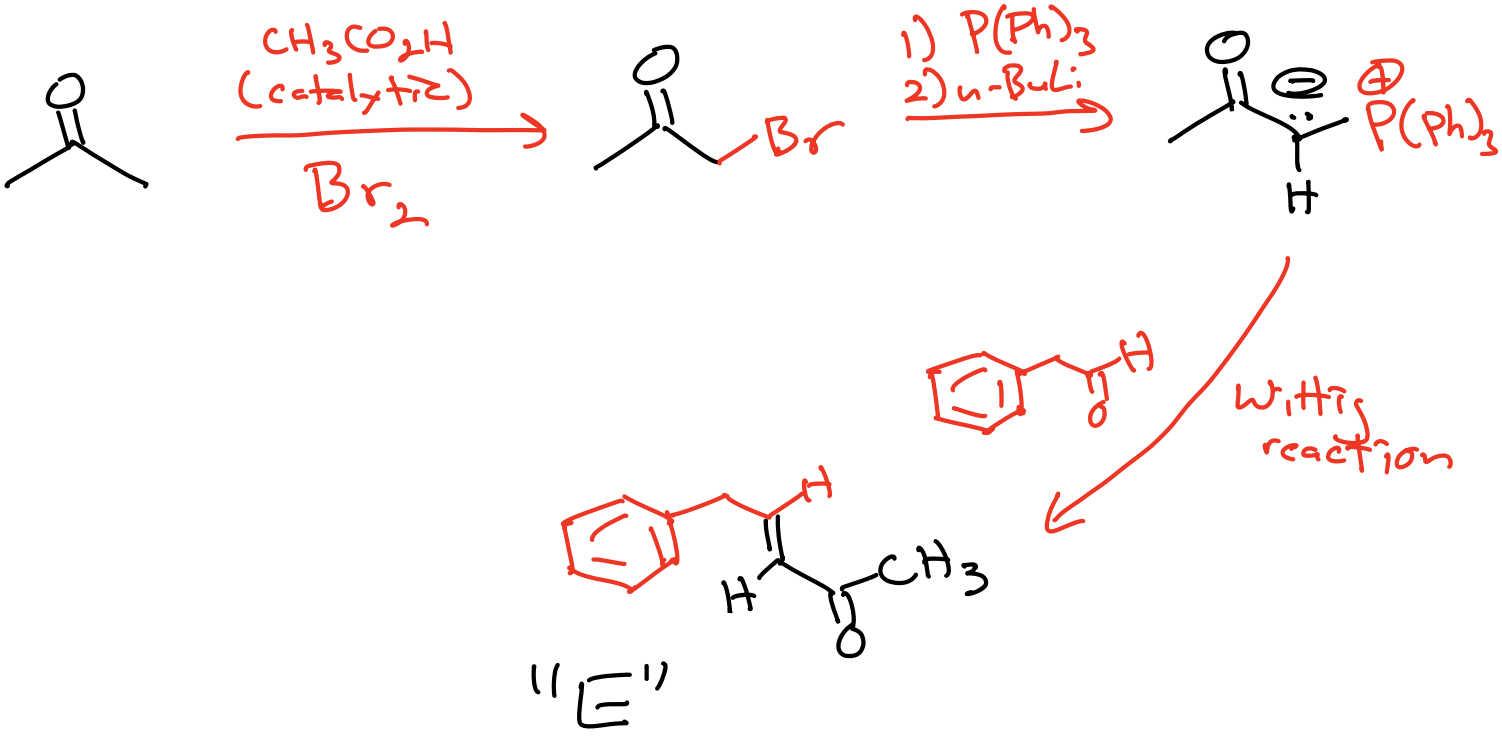
α-Halogenation of an Aldehyde or Ketone Catalyzed by Acid

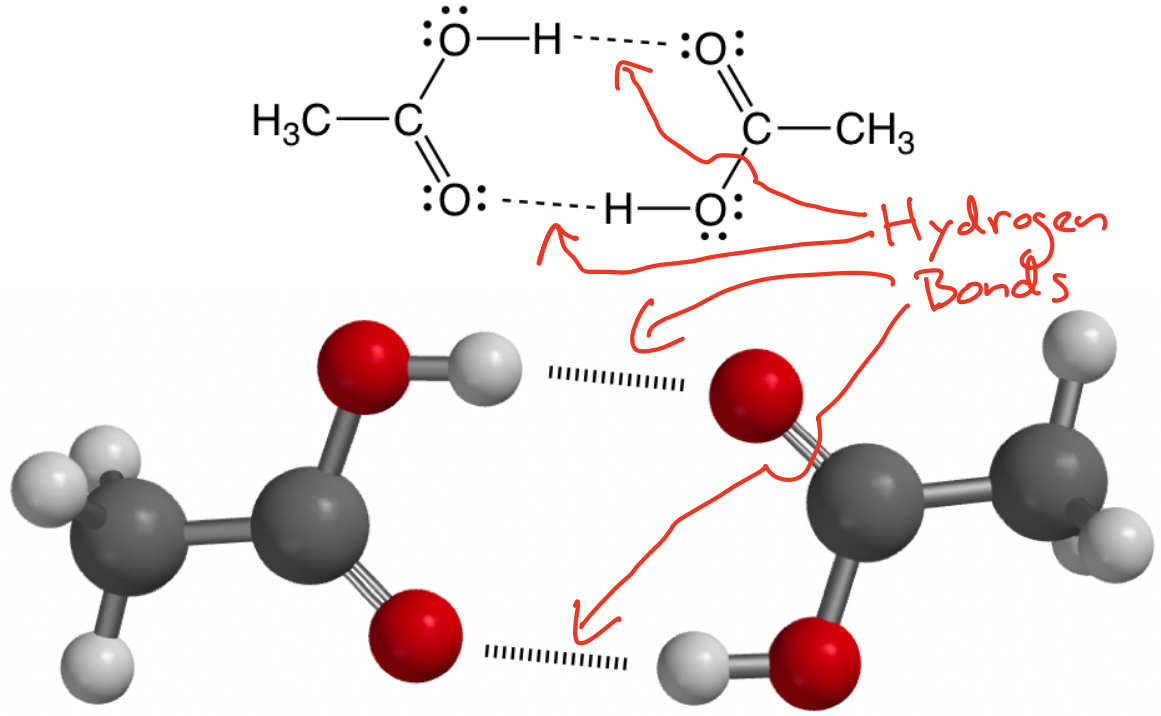


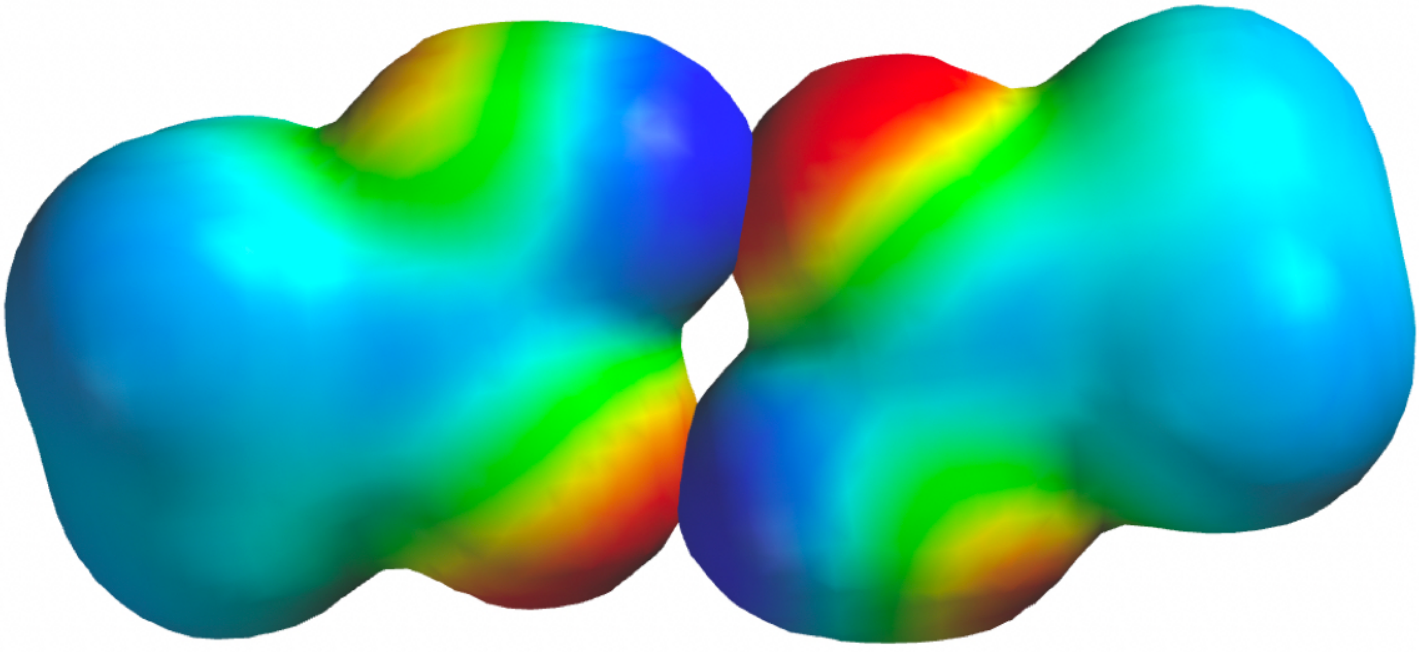


Nucleophile

Example

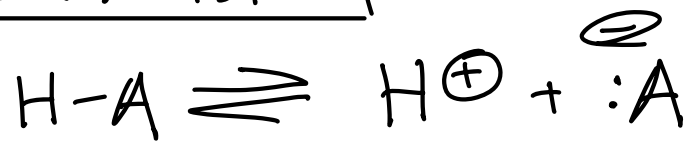

CH3CO2H
(catalytic)
Br2
Br
1) P(Ph)3
2) n-BuLi
P(Ph)3
H
Wittig
reaction
H
H
CH3
O
"E"





Carboxylic Acids → exist as "dimers" in solution → held together by hydrogen bonds

Acidity Revisited



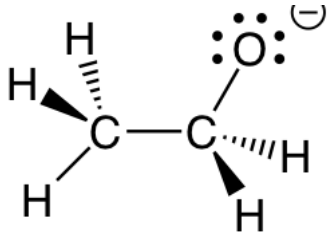
$$K_a = \frac{[A:^{\ominus}][H^{\oplus}]}{[HA]}$$

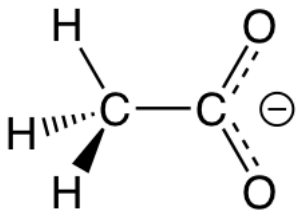
$$pK_a = -\log_{10} K_a$$

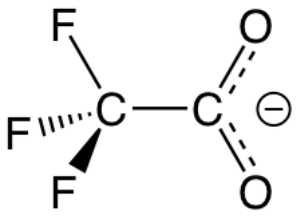
The lower the pK_a value, the stronger the acid

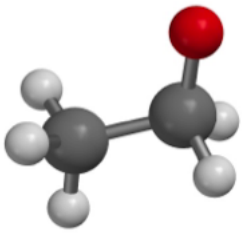
If an anion is created when an acid dissociates → the more stable the anion, the stronger the acid

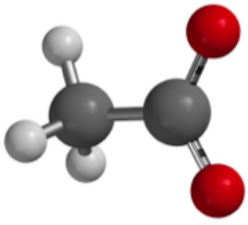
Anions are stabilized when the negative charge is distributed over more atom

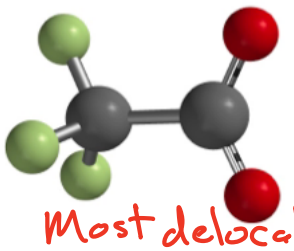








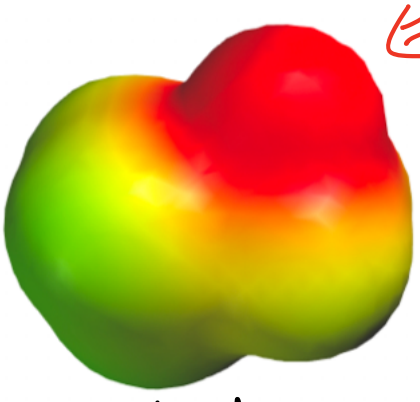


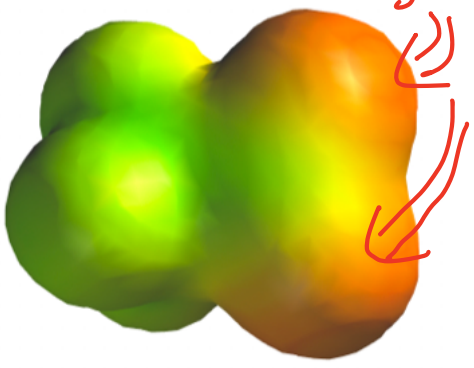


Least delocalized ⊖ charge

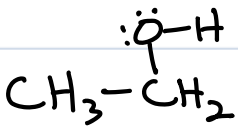
Somewhat delocalized ⊖ charge

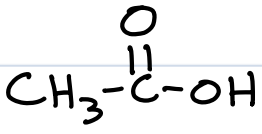
Most delocalized ⊖ charge

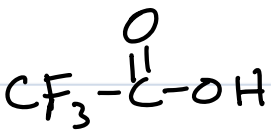




Parent Acids





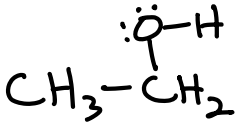


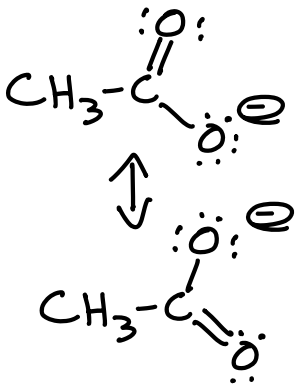
$pK_a \cong 16$

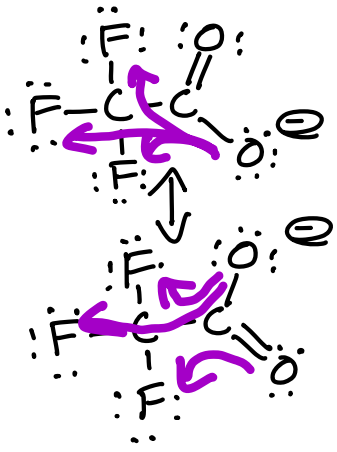
$pK_a \cong 3\text{–}5$

$pK_a = 0.3$

Rank acidity by comparing anion stabilities







Inductive effect pulls some ⊖ charge into F atoms

For an acid H-A

$$K_a = \frac{[A^{\ominus}][H^{\oplus}]}{[HA]}$$

$$pK_a = -\log_{10} K_a$$

$$pH = -\log_{10}[H^{\oplus}]$$

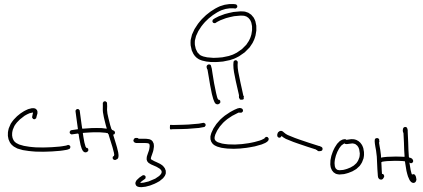
$$\frac{K_a}{[H^{\oplus}]} = \frac{[A^{\ominus}]}{[HA]} = 10^{(pH - pK_a)}$$

If $pH = 7$ and $pK_a = 3$

$$\frac{[A^{\ominus}]}{[HA]} = 10^{(pH - pK_a)} = 10^{(7-3)} = 10^4$$

1) If the pH of a solution is above (larger) than the pK_a of an acid, the acid will be largely <u>deprotonated</u>

2) If the pH of a solution is below (smaller) than the pK_a of an acid, the acid will be largely <u>protonated</u>.

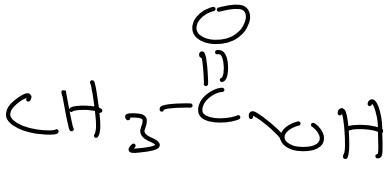


$pK_a = 4.76$

at pH 7.0

Deprotonated

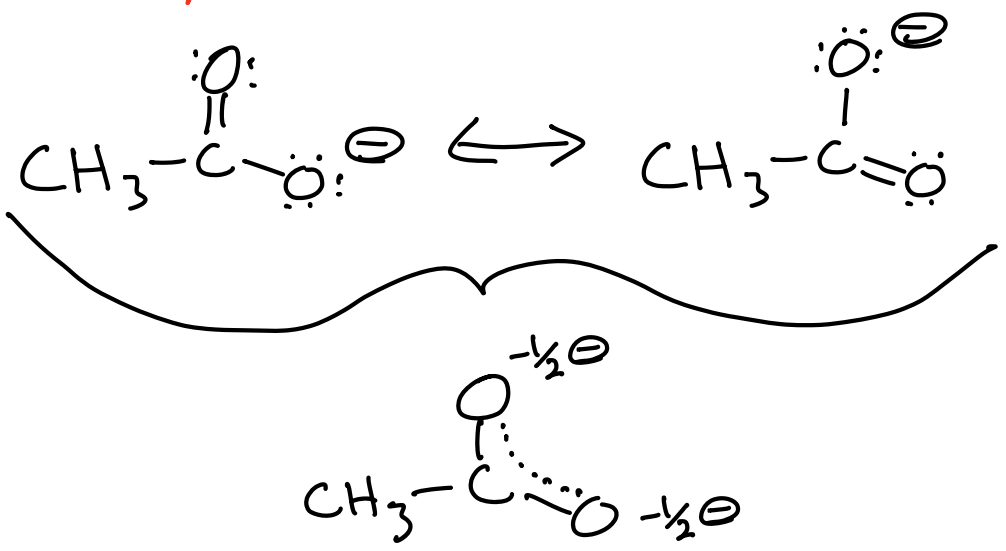
at pH 2.0



Protonated

In biochemistry → at or near neutral pH, carboxylic acids are deprotonated and negatively charged!

Stability of anion Part II



Not only is the negative charge delocalized (split) between both O atoms, there is a "π-way" → namely a pi bond that extends over 3 atoms (–C(=O)–O) and contains 2 electrons ⇒ STABILIZING!
(Golden Rule of Chemistry #7)

→ Formed from overlap of the 2p orbitals on the –C(=O)–O atoms