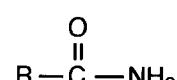
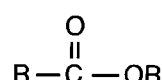
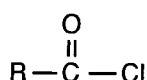
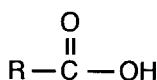
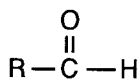
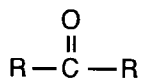
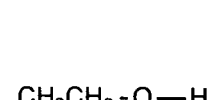
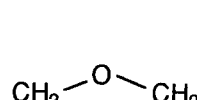
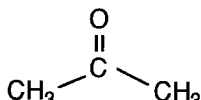
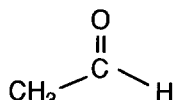
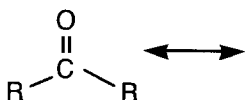


## CHAPTER 18: KETONES AND ALDEHYDES

Carbonyl compounds: reagents / solvents / and constituents of fabrics / flavorings / plastics / drugs / proteins / carbohydrates / nucleic acids

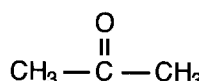
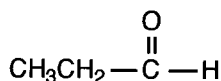
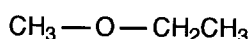
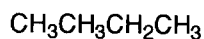


### I. Structure:

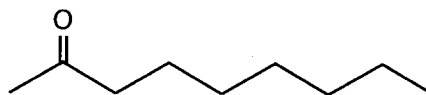
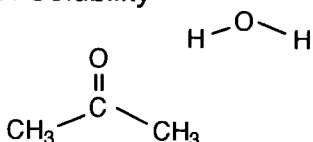


### II. Physical Properties:

#### A. Boiling Point

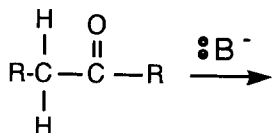


#### B. Solubility

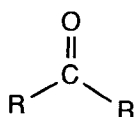
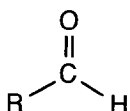


### III. Reactivity:

#### A. Acidity of Alpha Hydrogens



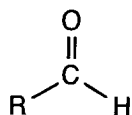
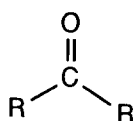
#### B. Reactivity of Aldehyde vs Ketone



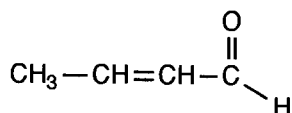
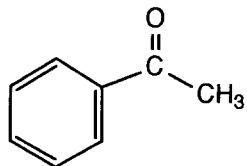


## V. Spectroscopy of Aldehydes and Ketones (Summary)

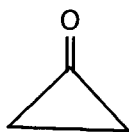
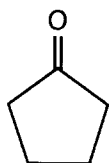
A. IR - look for carbonyl stretch



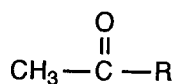
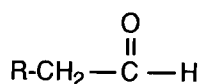
conjugation lowers frequency:



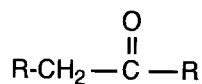
ring strain raises frequency:



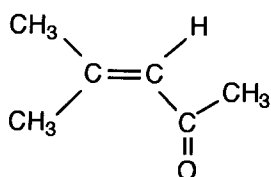
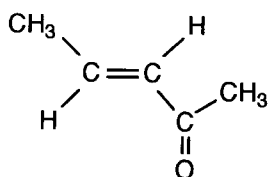
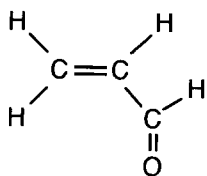
B.  $^1\text{H}$  NMR

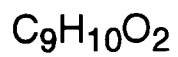
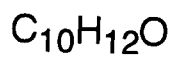
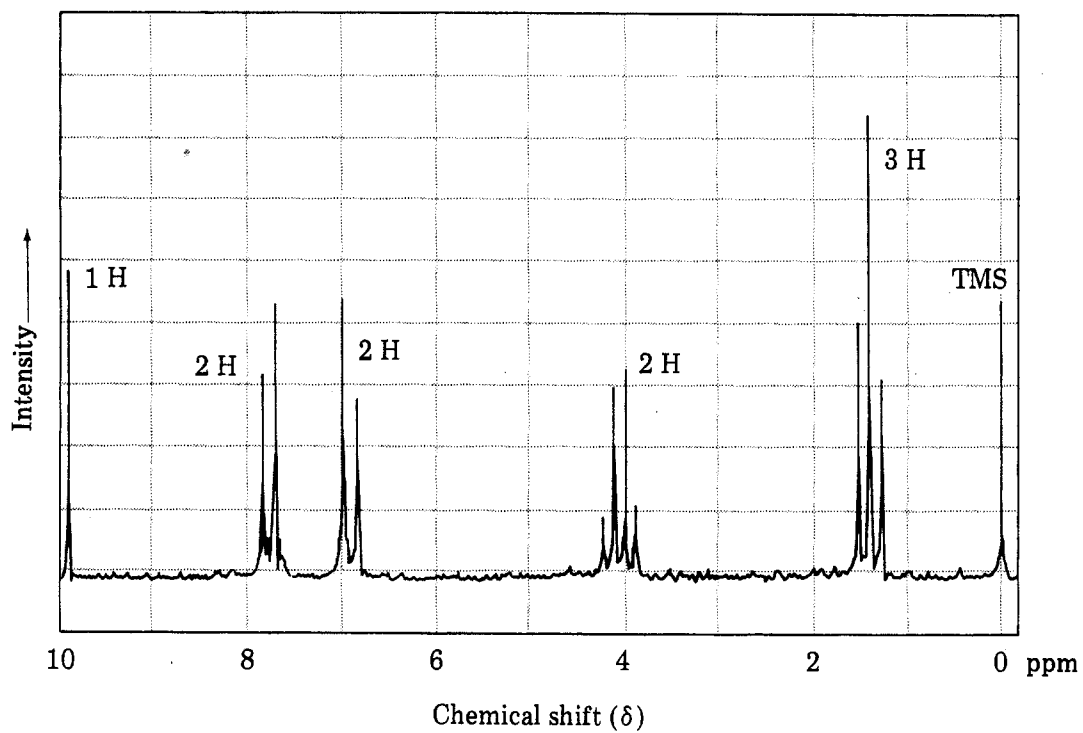
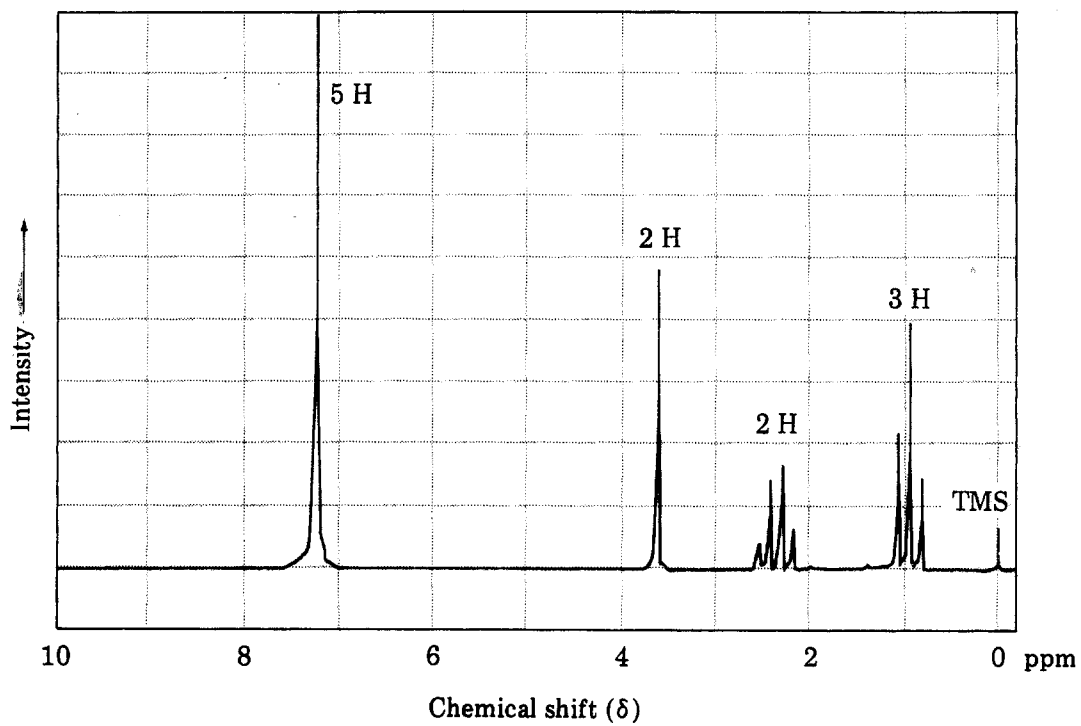


C.  $^{13}\text{C}$  NMR



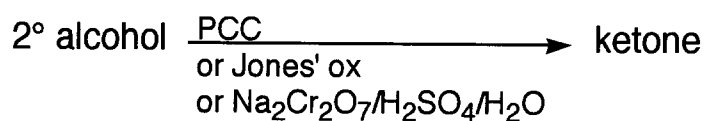
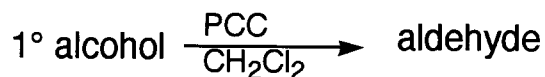
D. UV



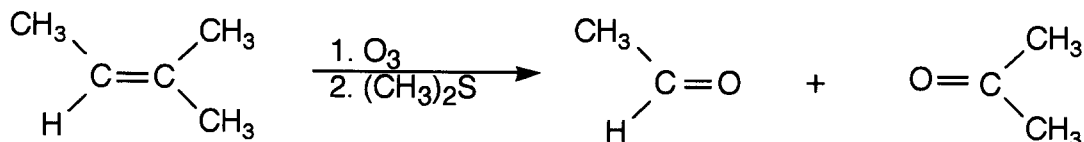
IR:  $1695\text{ cm}^{-1}$ IR:  $1710\text{ cm}^{-1}$ 

## VI. Aldehyde and Ketone Synthesis: (A-D are Review)

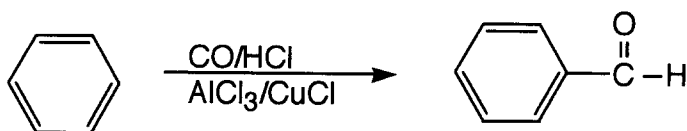
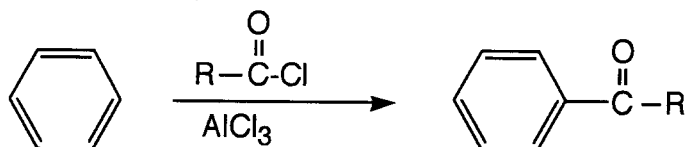
### A. Oxidation of Alcohols



### B. Cleavage of Alkenes by Ozonolysis

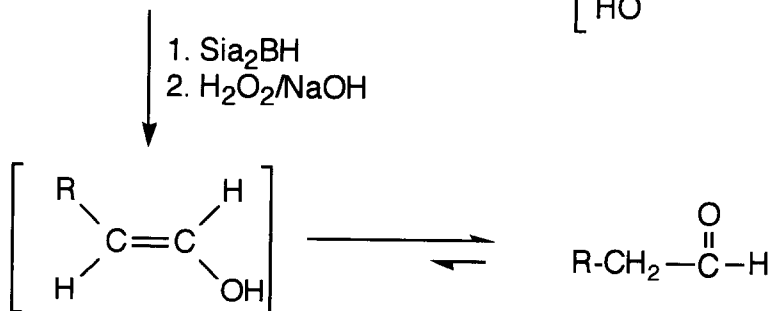
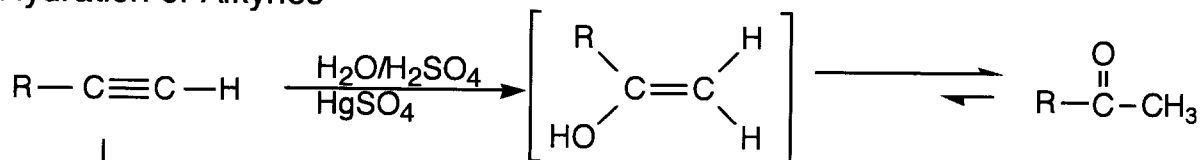


### C. Friedel-Crafts Acylation



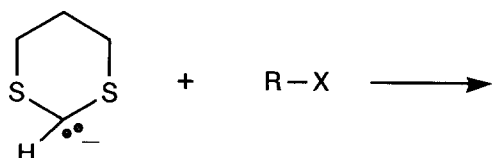
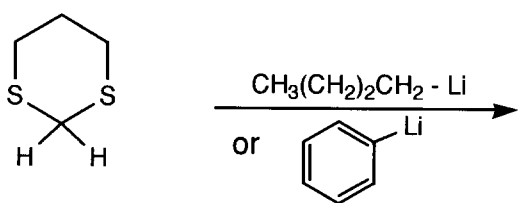
No strong deactivators on ring (halogens OK)  
No amino groups on ring

### D. Hydration of Alkynes

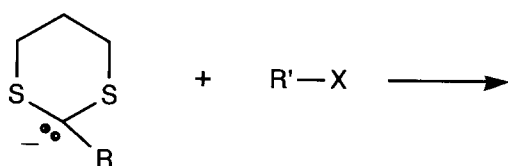
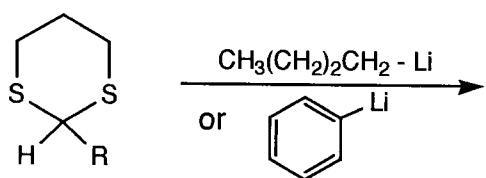


## E. 1, 3 - Dithiane Synthesis of Aldehydes and Ketones

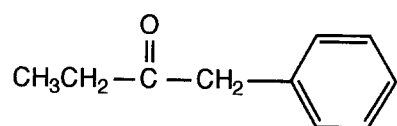
a multi-step synthesis:



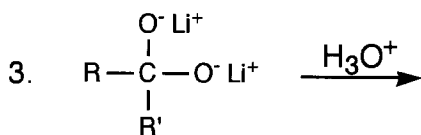
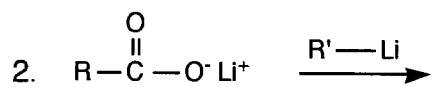
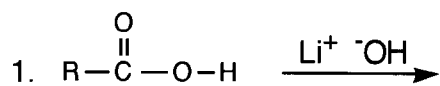
OR



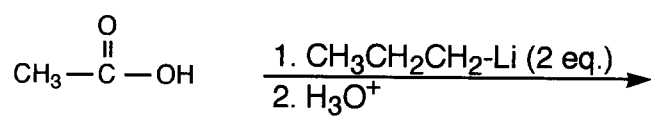
Example:



F. Ketones from Carboxylic Acids  
a multi-step synthesis



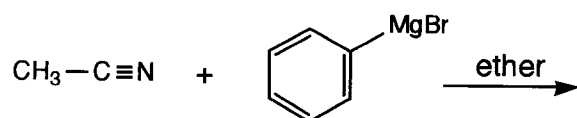
Example:



G. Ketones from Nitriles

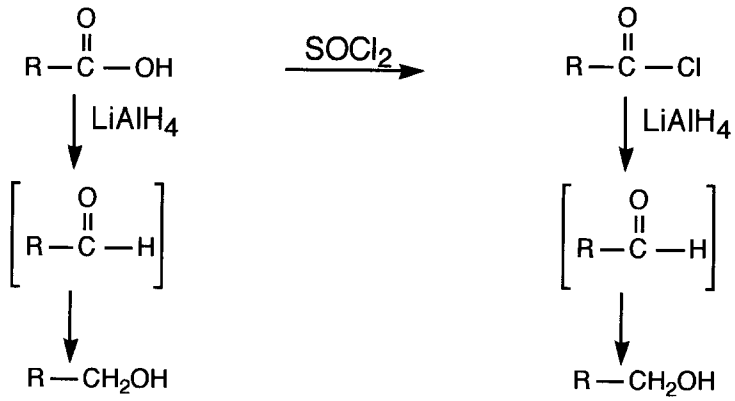


Example:

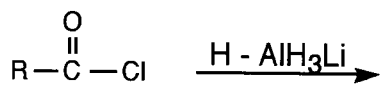


## H. Aldehydes and Ketones from Acid Chlorides

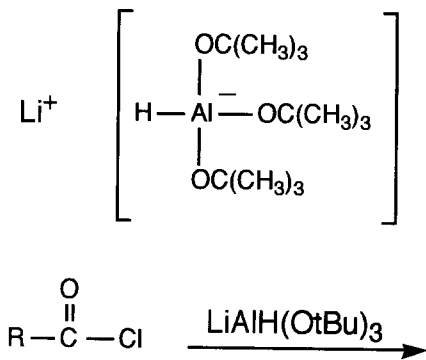
### 1. reduction to aldehydes



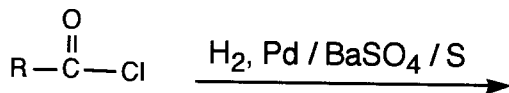
mechanism:



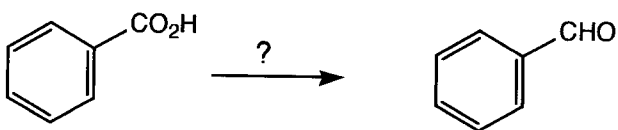
a) a milder reagent: lithium aluminum tri(t-butoxy)hydride



b) The Rosenmund Reduction

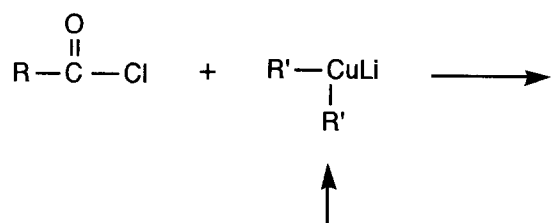


Example:

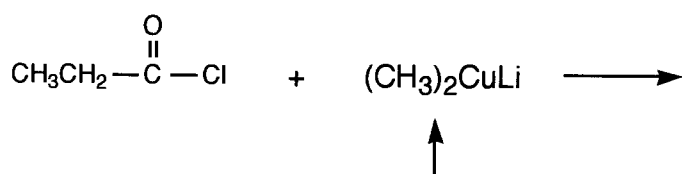




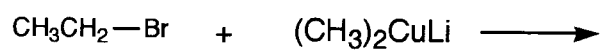
## 2. conversion to ketones with lithium dialkylcuprates (Gilman reagent)



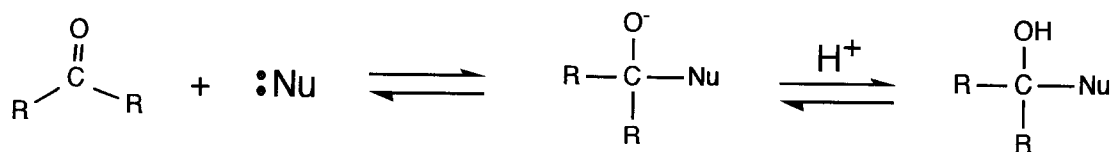
Example:



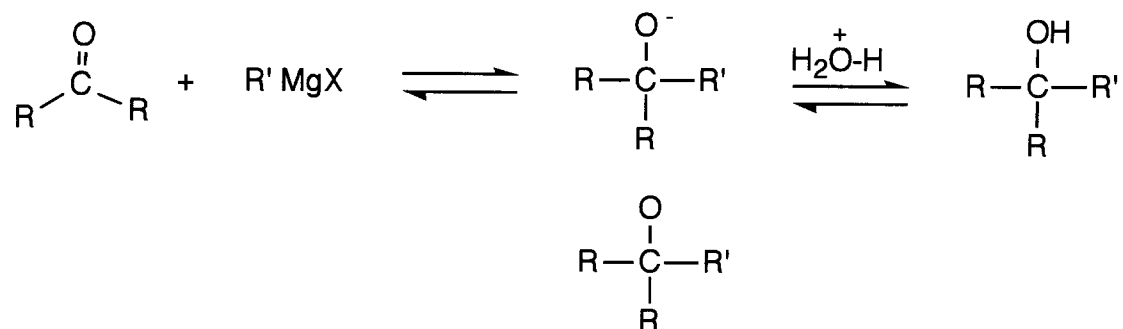
A Reminder: Use of Gilman reagent in the Corey-House Reaction:

**VII. Reactions of Aldehydes and Ketones**A. Alpha-Carbon Reactions - covered in Chapter 22 :  $\text{R}-\overset{\text{O}}{\parallel}{\text{C}}-\text{CH}_2-\text{R}$ 

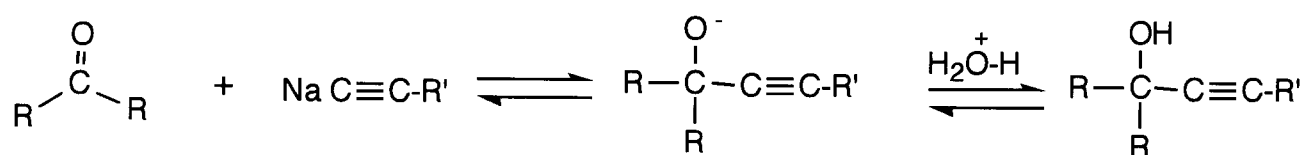
B. Nucleophilic Addition Reactions



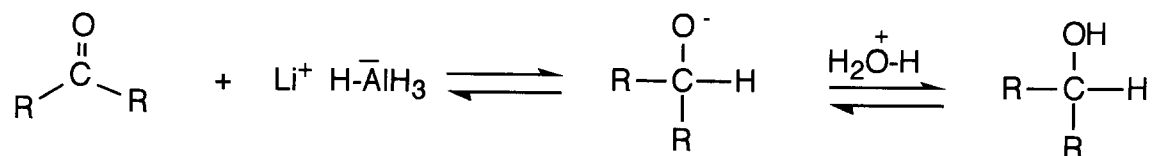
## 1. Grignard Reaction:



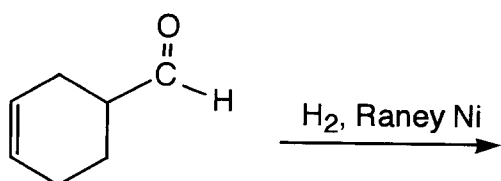
## 2. Addition of Acetylide:



## 3. Addition of Hydride:

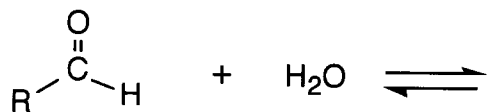
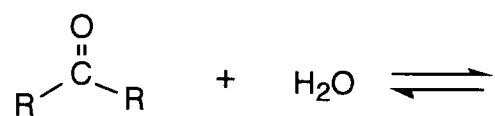


## 4. Catalytic Hydrogenation: similar to hydrogenation of alkenes, but aldehydes and ketones are less reactive

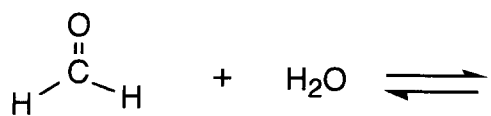
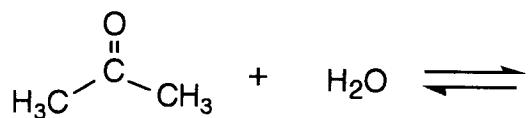


## 5. Hydration:

## a. The reaction

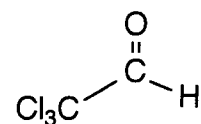
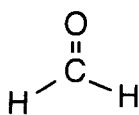
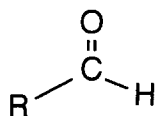
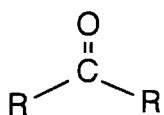


## b. Position of EQ depends on the structure of the aldehyde or ketone:



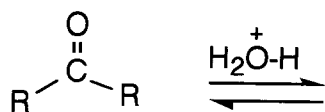
## How to predict EQ?

- the more stable the aldehyde or ketone, the more the EQ lies to the aldehyde or ketone, not the hydrate
- the less positive the carbonyl carbon, the more stable the aldehyde or ketone

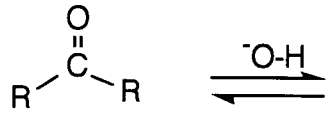


## c. Reaction Rate and Catalysis

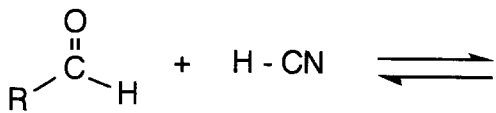
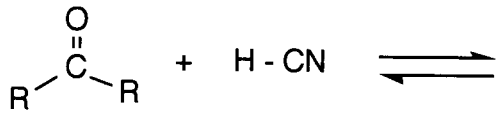
## 1) acid catalyst



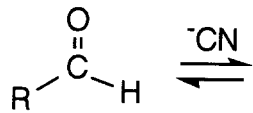
2) base catalyst



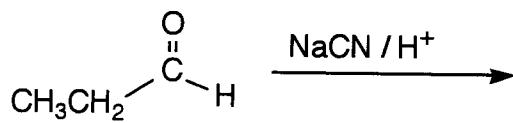
6. Addition of HCN



Mechanism:



Example:

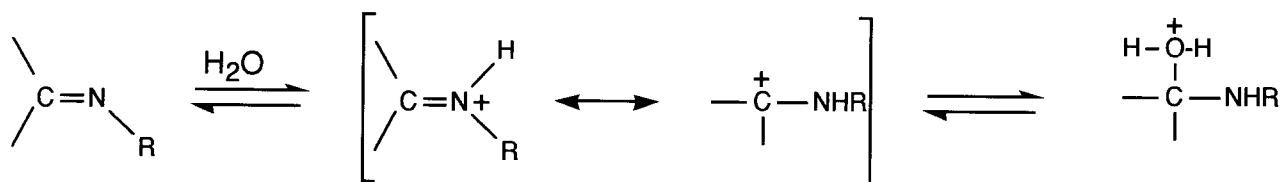
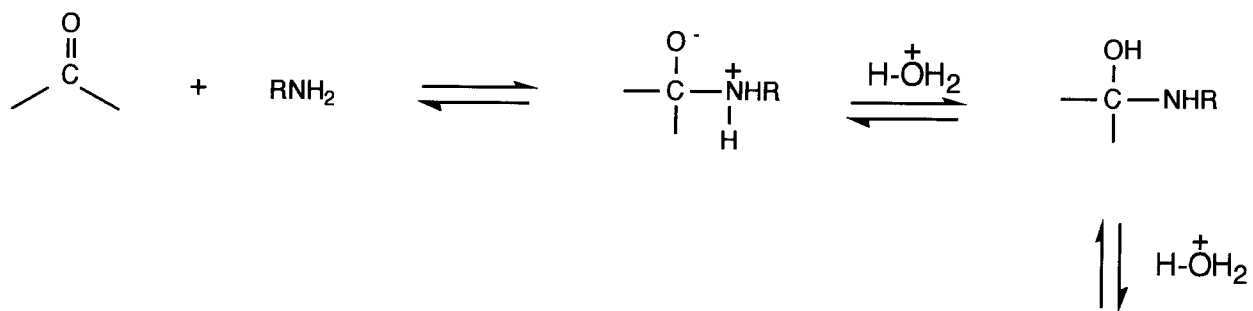


7. Addition of Amines

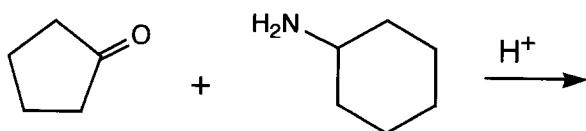
a. 1° amines:



Mechanism of Imine Formation:

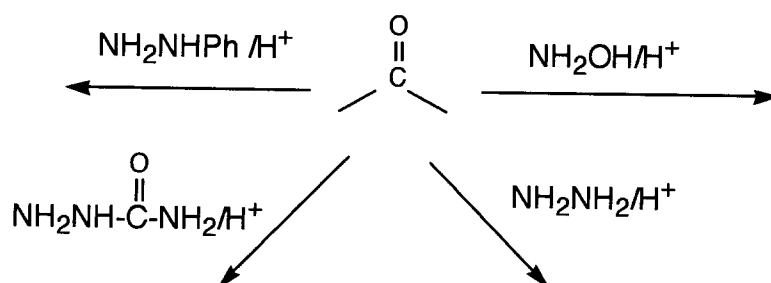


Example:

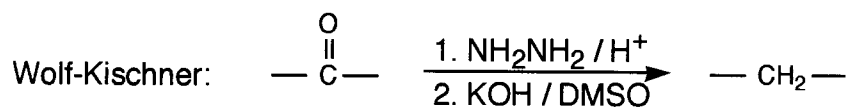


Important Uses of Imines:

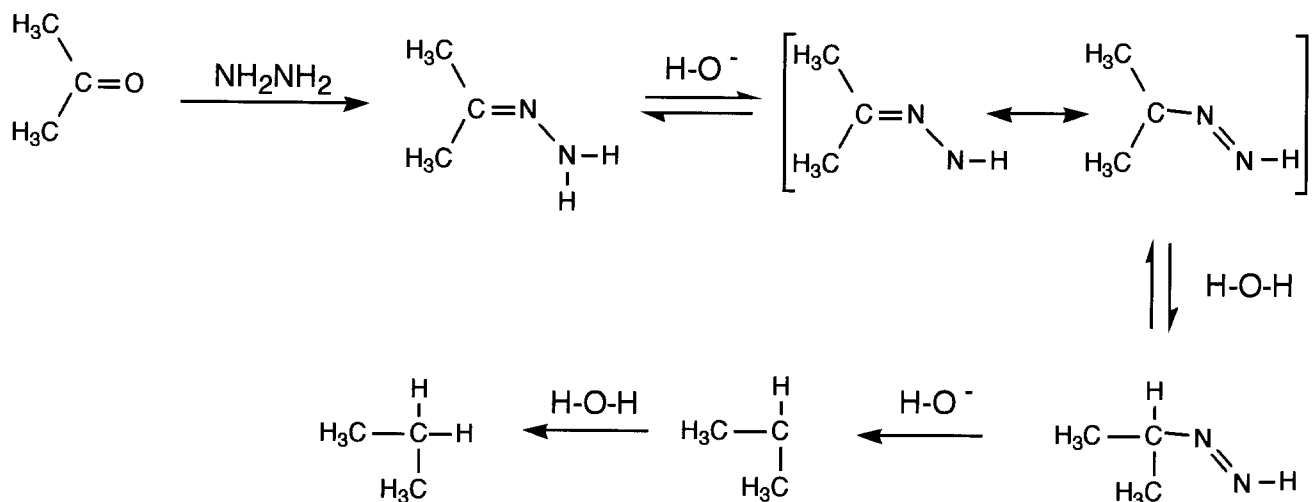
1) product characterization (derivatives):



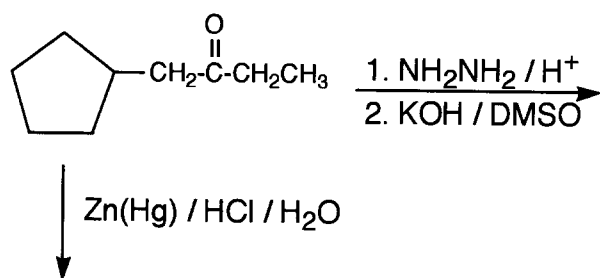
## 2) "deoxygenation" of carbonyls



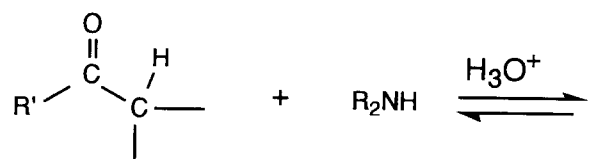
Mechanism:



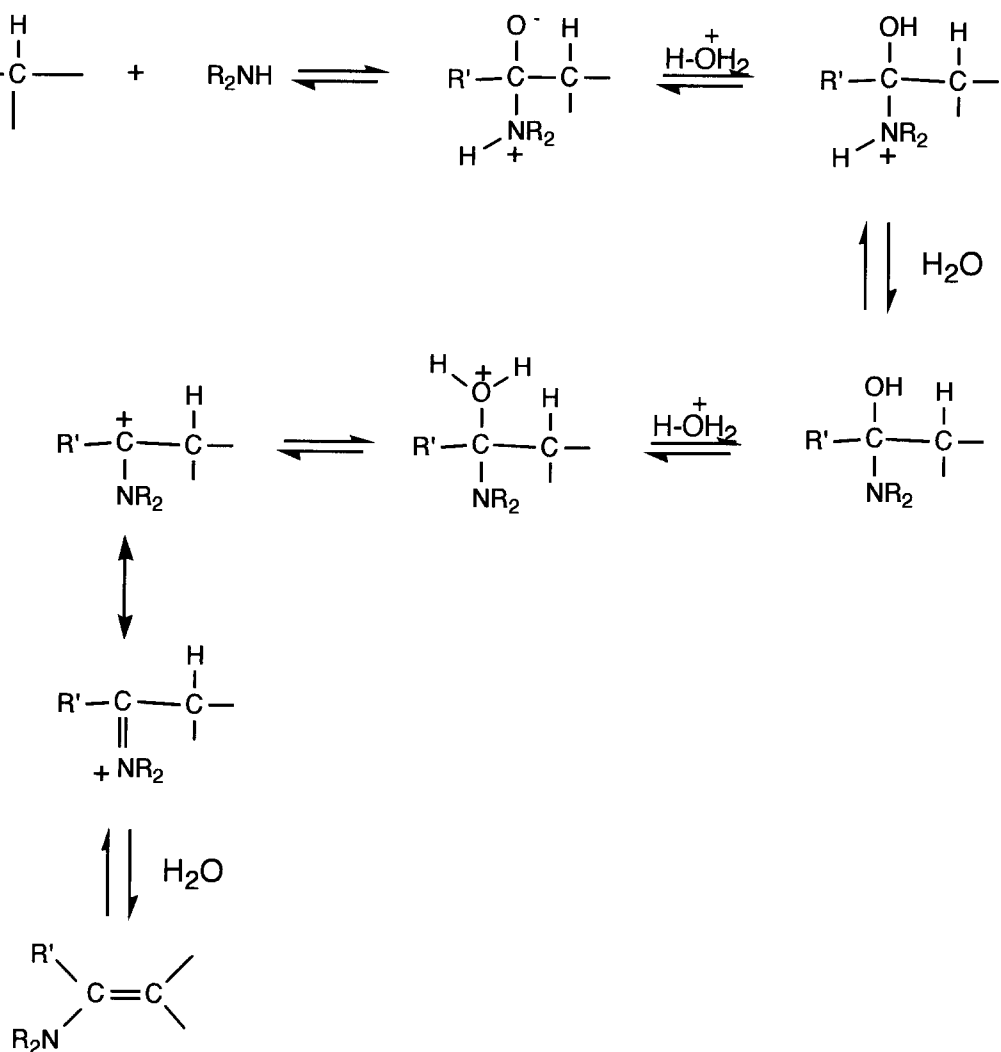
Example:



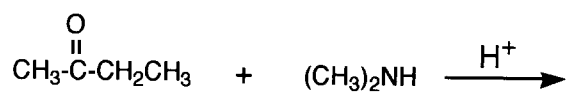
## b. addition of 2° amines to aldehydes/ketones



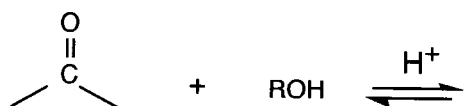
## Mechanism of Enamine Formation:



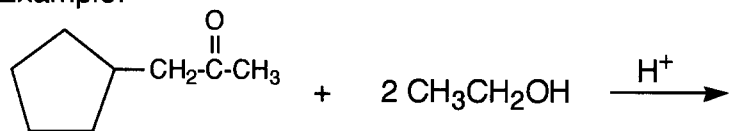
## Example:



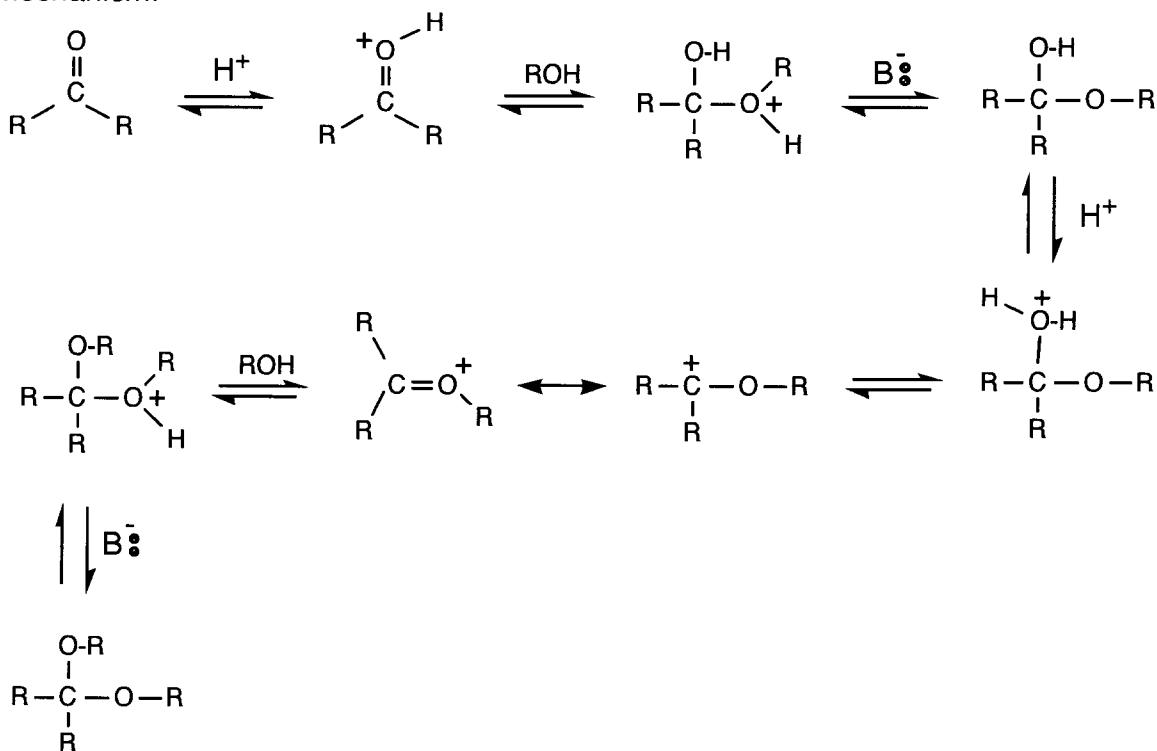
## 8. Addition of Alcohols (Acetal Formation)



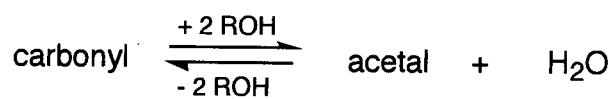
Example:



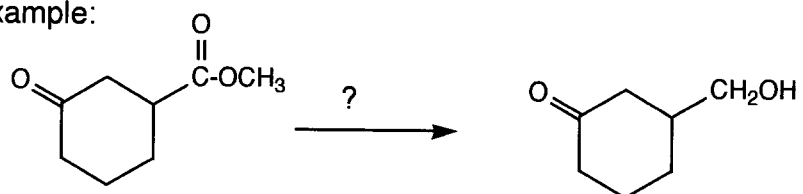
Mechanism:



Acetals are "protected carbonyls":



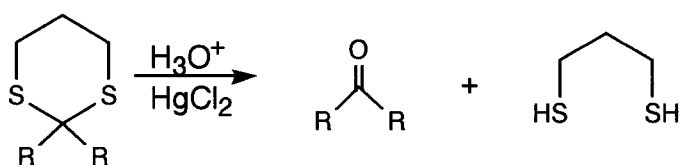
Example:



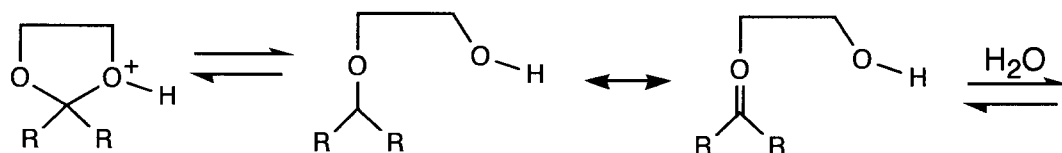
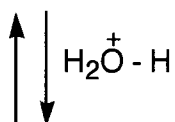
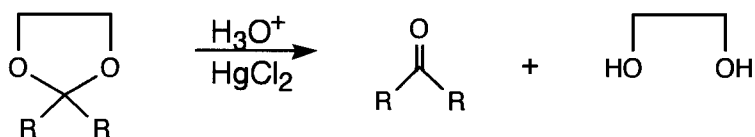


### Mechanism of deprotection is the reverse of acetal formation.

Remember the hydrolysis below?



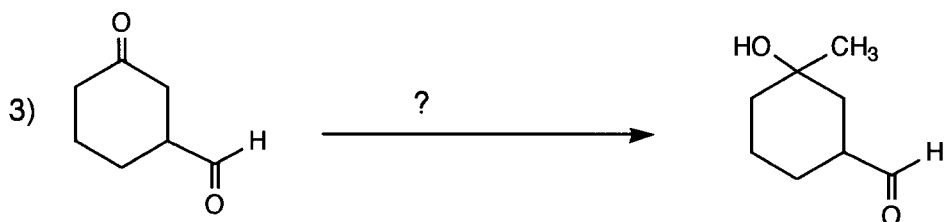
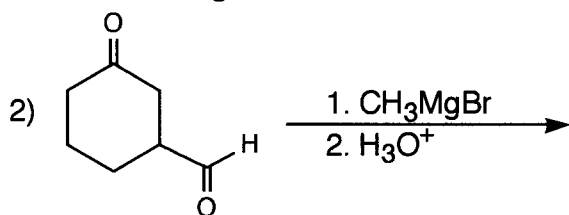
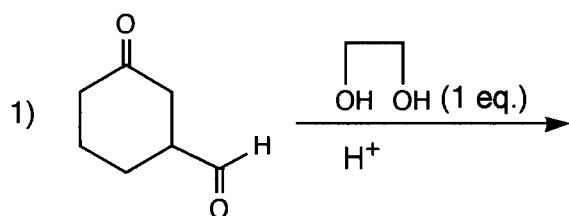
Similar:



### Selective Acetal Formation

- alcohols are **weak** nucleophiles, therefore **selective** nucleophiles
- aldehydes are more reactive than ketones, therefore alcohols selectively react with aldehydes to form acetals in the presence of ketones

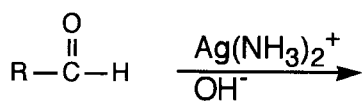
Examples:



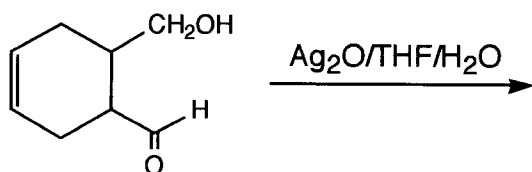
## 9. Oxidation of Aldehydes to Carboxylic Acids



## b. Silver Reagents

1)  $\text{Ag}_2\text{O}/\text{THF}/\text{H}_2\text{O}$ 2) Tollen's Reagent:  $\text{Ag}(\text{NH}_3)_2^+ \text{OH}^-$ 

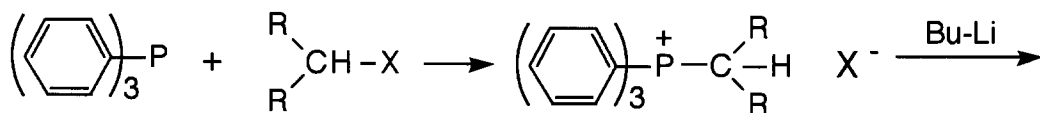
Example:



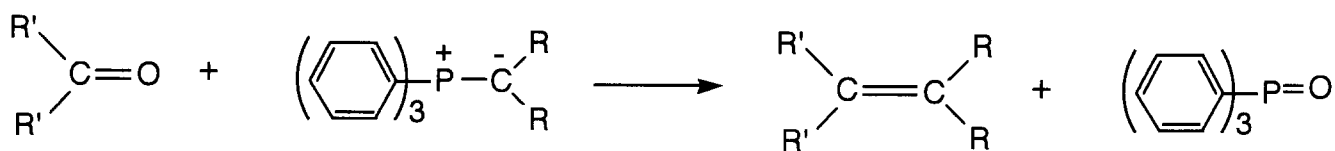
## 10. Addition of phosphorous ylides: The Wittig Reaction



Prep. of the Ylide: S<sub>N</sub>2 reaction of triphenylphosphine with methyl, 1° or unhindered 2° alkyl halide



The Wittig Reaction:



Examples:

