

## Chapter 12: Carbonyl Compounds II

### Learning Objectives:

1. Recognize and assign names to aldehydes and ketones.
2. Write the mechanism for nucleophilic addition and nucleophilic addition-elimination reactions of aldehydes and ketones, and be able to predict the products of such reactions.
3. Be able to explain the relative reactivity of carbonyl compounds toward nucleophilic addition.
4. Be able to describe the concept of employing protecting groups.
5. Predict the products of the reactions of carbonyl compounds with Grignard reagents and hydride ion donors.
6. Be able to write the reactions and electron-pushing mechanisms for the formation of geminal diol, hemiacetal (hemiketal), acetal (ketal), and imine.

### Sections:

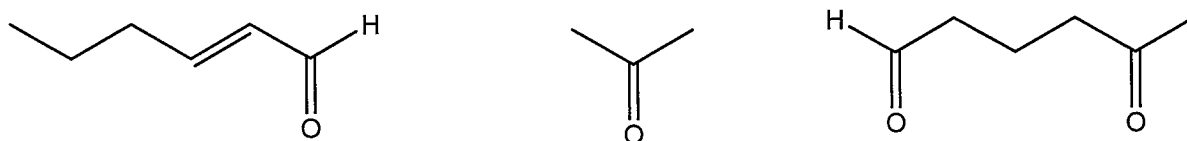
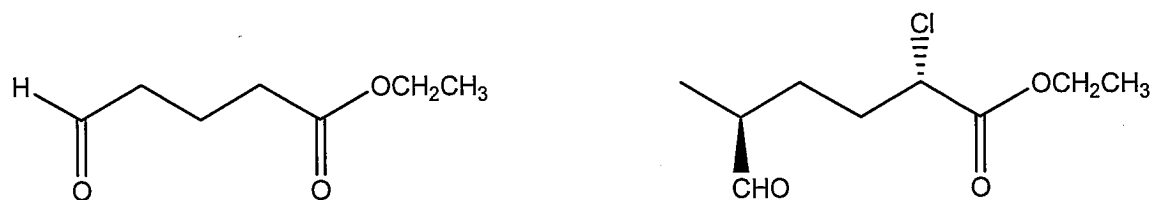
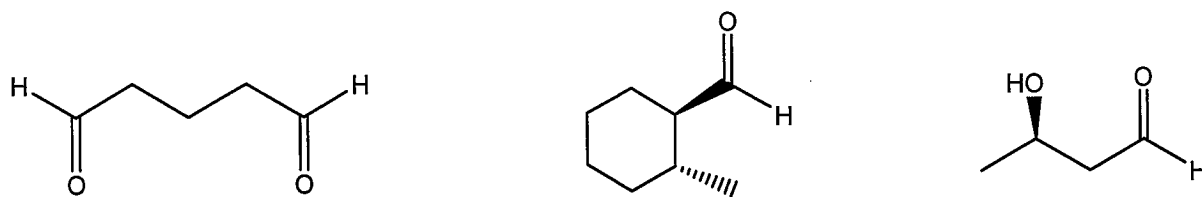
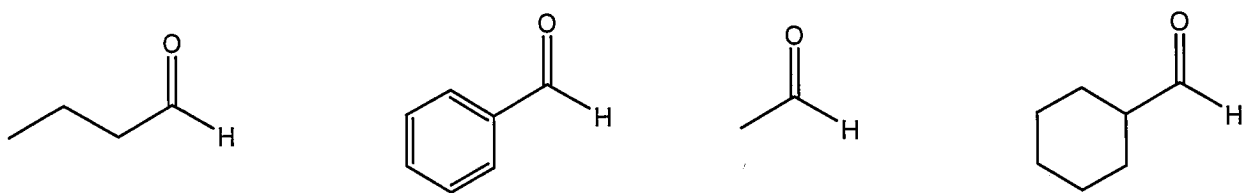
- 12.1 The nomenclature of aldehydes and ketones
- 12.2 Relative reactivities of carbonyl compounds
- 12.3 How aldehydes and ketones react
- 12.4 Grignard reagent
- 12.5 The reactions of carbonyl compounds with Grignard reagents
- 12.6 The reactions of carbonyl compounds with hydride ion
- 12.7 The reactions of aldehydes and ketones with amines
- 12.8 The reactions of aldehydes and ketones with water
- 12.9 The reactions of aldehydes and ketones with alcohols
- 12.10 Nucleophilic addition to  $\alpha,\beta$ -unsaturated aldehydes and ketones<sup>#</sup>
- 12.11 Conjugate addition reactions in biological systems<sup>#</sup>

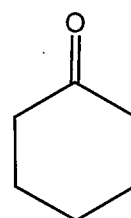
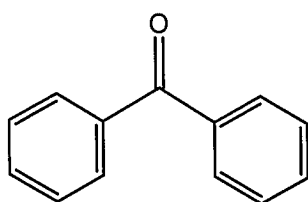
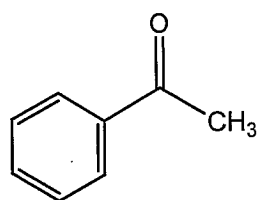
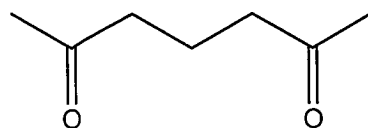
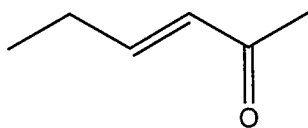
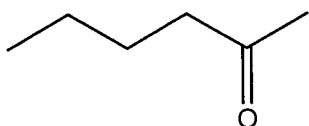
<sup>#</sup> Sections that will be skipped

### Recommended additional problems

19-21, 23, 24, 30, 31, 34-36, 40

## 12.1 The nomenclature of aldehydes and ketones



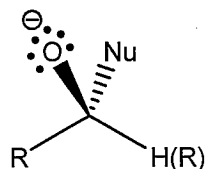
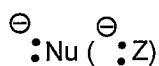
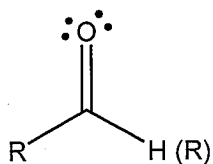


12.2 Relative reactivities of carbonyl compounds

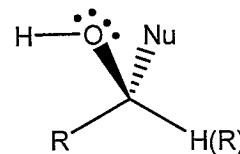
12.3 How aldehydes and ketones react

*Know the difference of nucleophilic addition in basic and acidic conditions.*

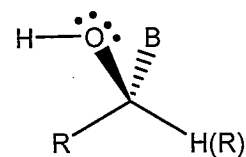
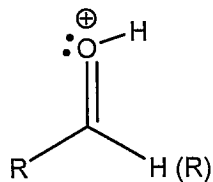
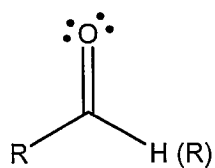
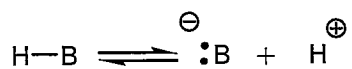
A. In basic condition (two separated steps)



tetrahedral intermediate



B. In acidic condition (usually in one step)



**12.4 Grignard reagent**

**12.5 The reactions of carbonyl compounds with Grignard reagents**

A. Formation and structure of organomagnesium compounds: carbon nucleophile (basic or acidic?)

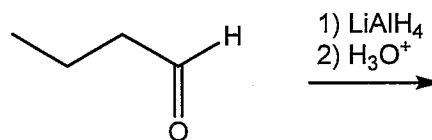
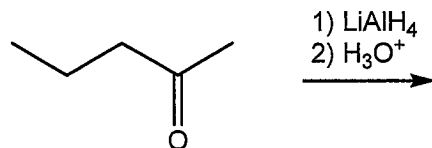
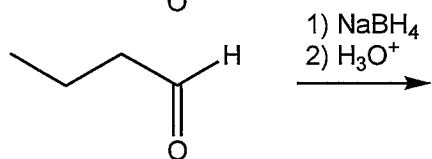
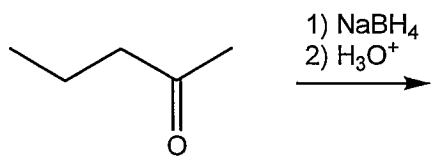
B. Reaction with protic acids

C. Reaction of aldehydes and ketones with Grignard reagent

## 12.6 The reactions of carbonyl compounds with hydride ion

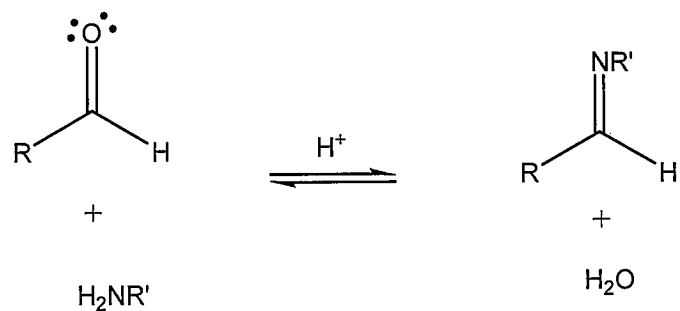
### A. Hydride-based reducing agents

### B. Examples



## 12.7 The reactions of aldehydes and ketones with amines

### A. Formation of Imines from primary amines

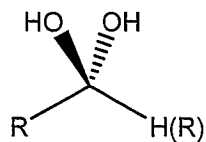
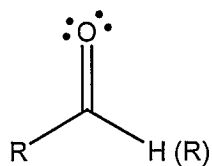


### B. Mechanism

**Skip the addition of secondary amines.**

## 12.8 The reactions of aldehydes and ketones with water

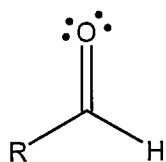
A. Addition of water (formation of hydrate, *gem*-diol, geminal diol)



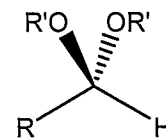
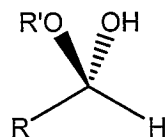
B. Mechanism

## 12.9 The reactions of aldehydes and ketones with alcohols

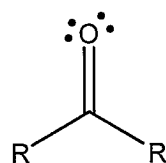
### A. Addition of alcohol (formation of hemiacetal, acetal, hemiketal, and ketal)



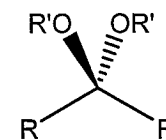
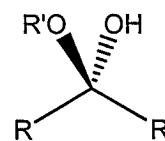
HOR'  
(2 equivalents)



H<sub>2</sub>O



HOR'  
(2 equivalents)



H<sub>2</sub>O

### B. Mechanism

### C. Stability of acetals and ketals