
15

Organic Chemistry

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15-1

15

Aldehydes & Ketones

Chapter 15

15-2

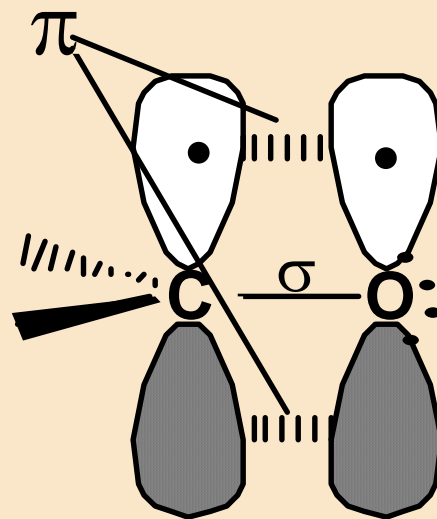
15 The Carbonyl Group

u In this and several following chapters we study the physical and chemical properties of classes of compounds containing the carbonyl group, **C=O**

- aldehydes and ketones (Chapter 15)
- carboxylic acids (Chapter 16)
- acid halides, acid anhydrides, esters, amides (Chapter 17)
- enolate anions (Chapter 18)

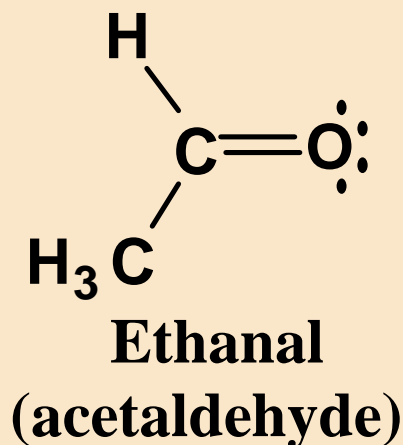
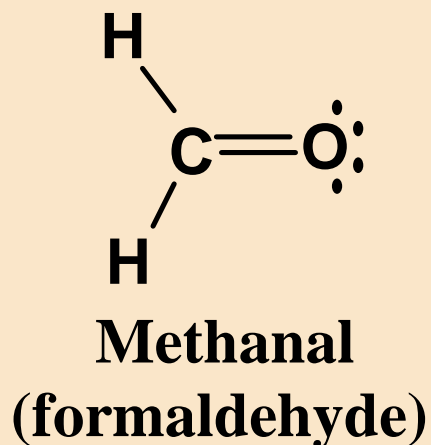
15 The Carbonyl Group

- u The carbonyl group consists of
- one sigma bond formed by the overlap of sp^2 hybrid orbitals, and
 - one pi bond formed by the overlap of parallel 2p orbitals



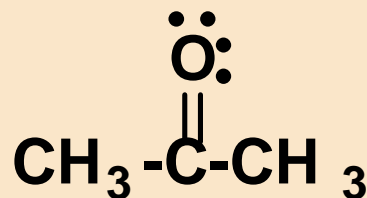
15 Structure of Aldehydes

- u The functional group of an aldehyde is a carbonyl group bonded to a H atom
 - in methanal, it is bonded to two H atoms
 - in all other aldehydes it is bonded to one H and one carbon atom

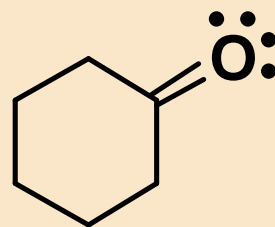


15 Structure of Ketones

- u The functional group of a ketone is a carbonyl group bonded to two carbon atoms



Propanone
(Acetone)

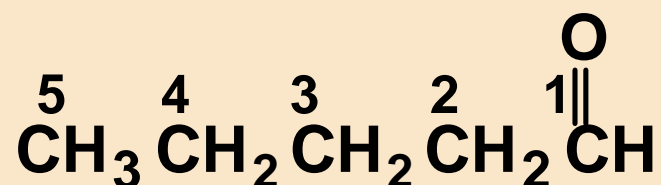


Cyclohexanone

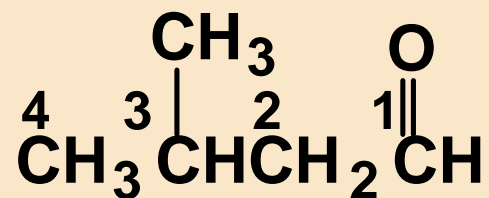
15 Nomenclature-Aldehydes

- u **IUPAC names:** select as the parent alkane the longest chain of carbon atoms that contains the carbonyl group
 - because the carbonyl group of the aldehyde must be on carbon 1, there is no need to give it a number
- u For unsaturated aldehydes, show the presence of the C=C by changing the infix **-an-** to **-en-**
 - the location of the suffix determines the numbering pattern

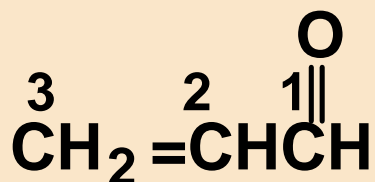
15 Nomenclature-Aldehydes



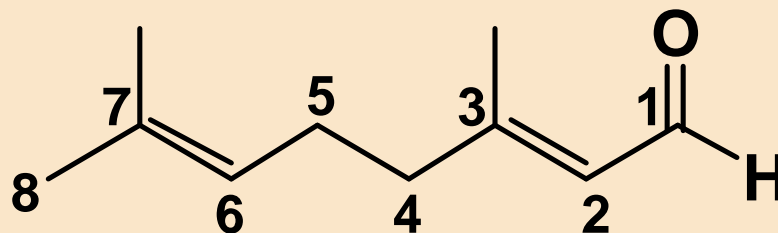
Pentanal



3-Methylbutanal



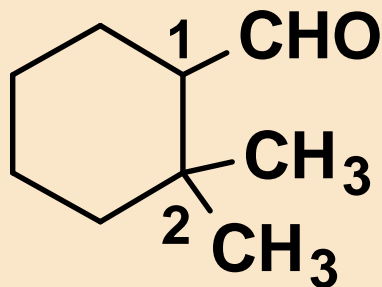
2-Propenal
(Acrolein)



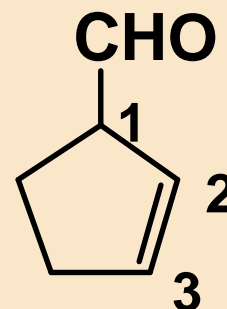
(2E)-3,7-Dimethyl-2,6-octadienal
(Geranial)

15 Nomenclature-Aldehydes

- u For cyclic molecules in which the -CHO group is attached to the ring, the name is derived by adding the suffix **-carbaldehyde** to the name of the ring



2,2-Dimethylcyclohexanecarbaldehyde

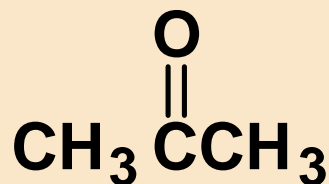


2-Cyclopentene-carbaldehyde

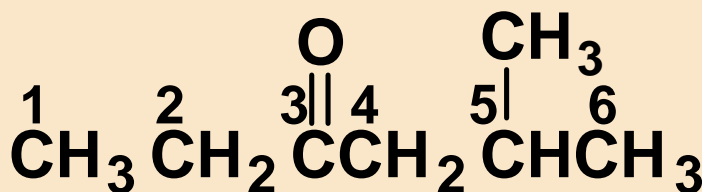
15 Nomenclature-Ketones

u IUPAC names:

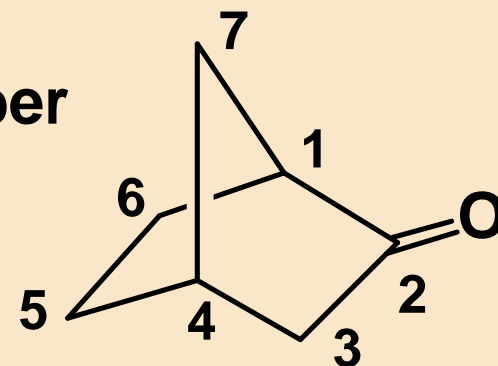
- select as the parent alkane the longest chain that contains the carbonyl group,
- indicate its presence by changing the suffix **-e** to **-one**, and
- number to give C=O the smaller number



Propanone
(Acetone)



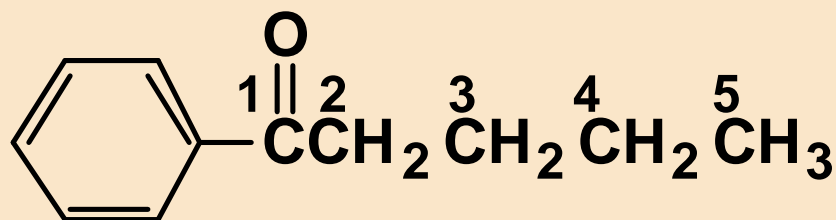
5-Methyl-3-hexanone



Bicyclo[2.2.1]-2-heptanone

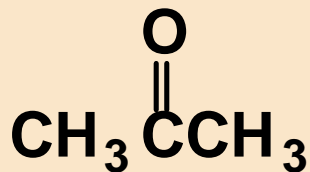
15-10

15 Nomenclature-Ketones

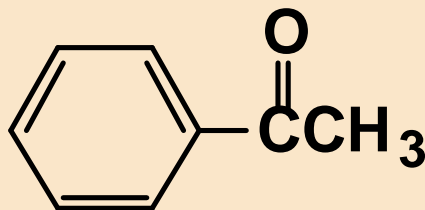


1-Phenyl-1-pentanone

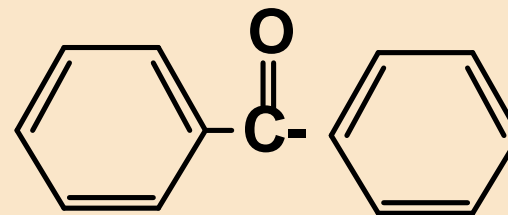
- u The IUPAC system retains the names acetone, acetophenone, and benzophenone



Acetone




Acetophenone



Benzophenone

15 Order of Precedence

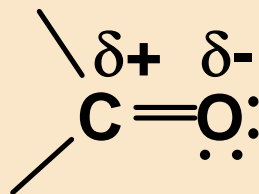
- u For compounds that contain more than one functional group indicated by a suffix

	Functional Group	Suffix if Higher in Precedence	Prefix if Lower in Precedence
	$-\text{CO}_2\text{H}$	-oic acid	_____
	$-\text{CHO}$	-al	oxo-
	$\begin{array}{l} \diagup \\ \diagdown \end{array} \text{C}=\text{O}$	-one	oxo-
	$-\text{OH}$	-ol	hydroxy-
	$-\text{NH}_2$	-amine	amino-
	$-\text{SH}$	-thiol	mercapto-

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15 Physical Properties

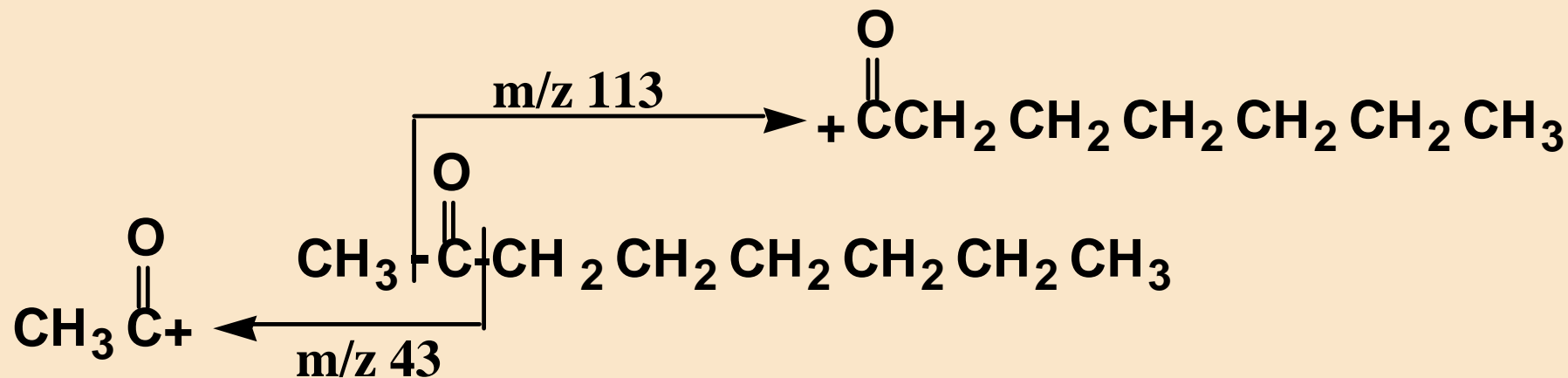
- u Oxygen is more electronegative than carbon (3.5 vs 2.5) and, therefore, a C=O group is polar



- aldehydes and ketones are polar compounds and interact in the pure state by dipole-dipole interaction
- they have higher boiling points and are more soluble in water than nonpolar compounds of comparable molecular weight

15 Mass Spectrometry

- u A characteristic fragmentation pattern of aliphatic aldehydes and ketones is cleavage of one of the bonds to the carbonyl group (α -cleavage)



15 NMR Spectroscopy

u ^1H -NMR

- the pi system of the C=O group causes a large downfield shift in the signal of the aldehyde hydrogen, typically to δ 9.5-10.1
- hydrogens on the α -carbon of aldehydes and ketones typically appear at δ 2.2-2.6

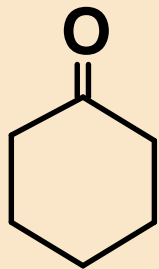
u ^{13}C -NMR

- the carbonyl carbon of aldehydes and ketones is readily identifiable by the position of its signal between δ 180 and 210

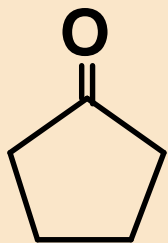
15-16

15 IR Spectroscopy

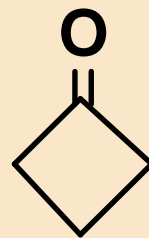
- u Aldehydes and ketones show strong IR absorption between 1630 and 1810 cm^{-1} associated with the $\text{C}=\text{O}$ stretching vibration
- u The position of this vibration is quite sensitive to the molecular environment of the $\text{C}=\text{O}$ group



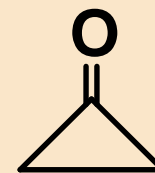
1715 cm^{-1}



1745 cm^{-1}



1780 cm^{-1}

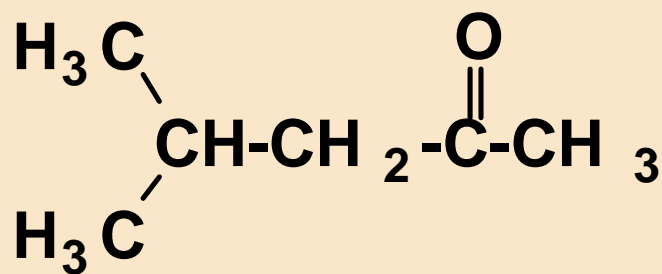


1850 cm^{-1}

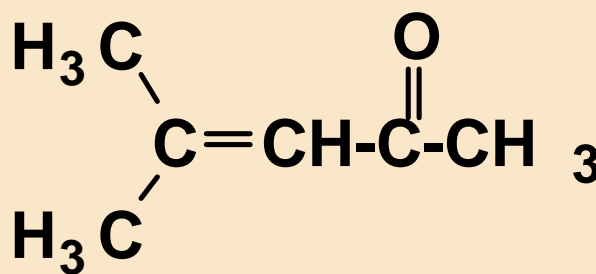
15-17

15 IR Spectroscopy

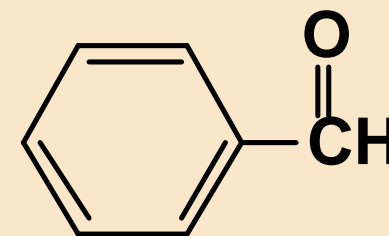
- u The presence of a carbon-carbon double bond or a benzene ring in conjugation with the carbonyl group causes a shift in the C=O absorption to a lower wavenumber



1717 cm^{-1}



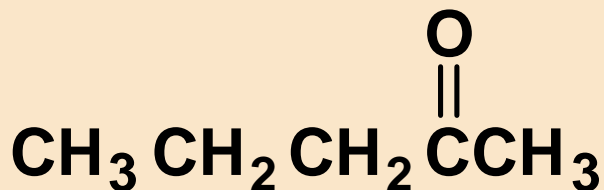
1690 cm^{-1}



1700 cm^{-1}

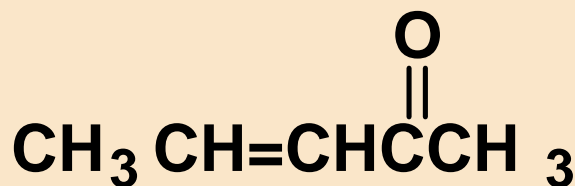
15 UV-Vis Spectroscopy

- u Simple aldehydes and ketones show only weak UV absorption due to an n to π^* transition
- u If, however, the carbonyl group is conjugated with one or more carbon-carbon double bonds, intense π to π^* absorption occurs



3-Pentanone

λ_{max} 180 nm (ϵ 900)

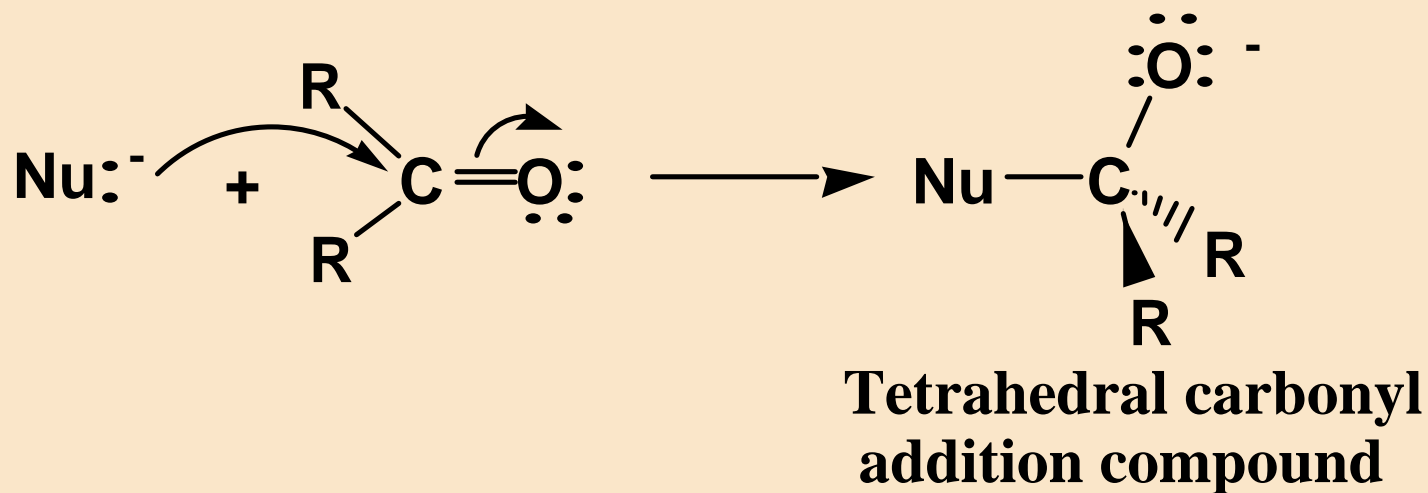


3-Penten-2-one

λ_{max} 224 nm (ϵ 12,590)

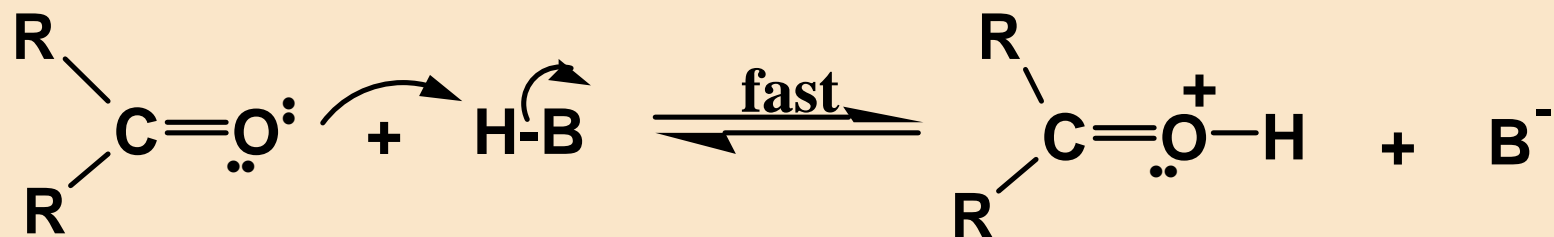
15 Reaction Themes

- u One of the most common reaction themes of a carbonyl group is addition of a nucleophile to form a tetrahedral carbonyl addition compound



15 Reaction Themes

- u A second common theme is reaction with a proton or Lewis acid to form a resonance-stabilized cation



- protonation in this manner increases the electron deficiency of the carbonyl carbon and makes it more reactive toward nucleophiles

15 Add'n of C Nucleophiles

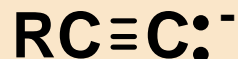
- u Addition of carbon nucleophiles is one of the most important types of nucleophilic additions to a C=O group; a new carbon-carbon bond is formed in the process
- u We study addition of these carbon nucleophiles



A Grignard reagent



An organolithium reagent



An anion of a terminal alkyne



Cyanide ion

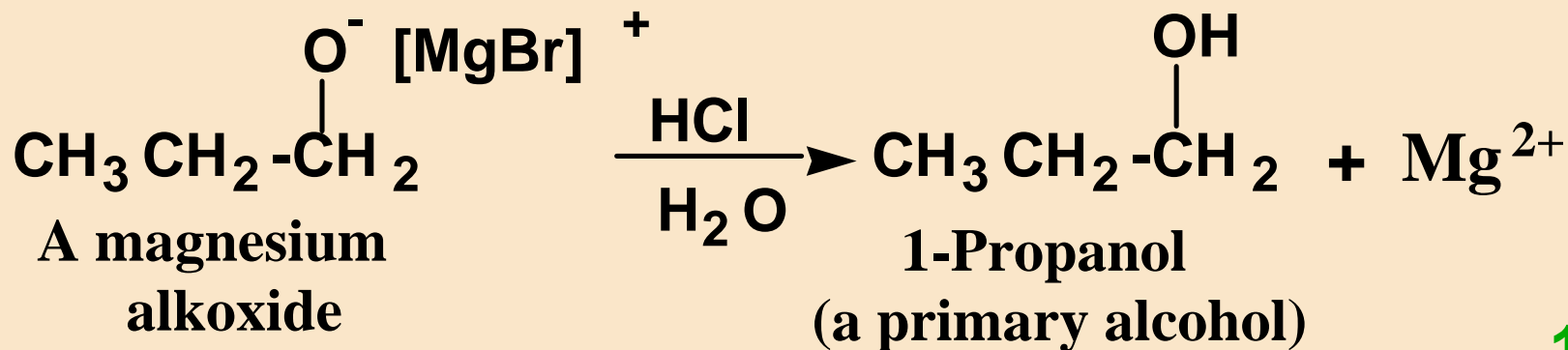
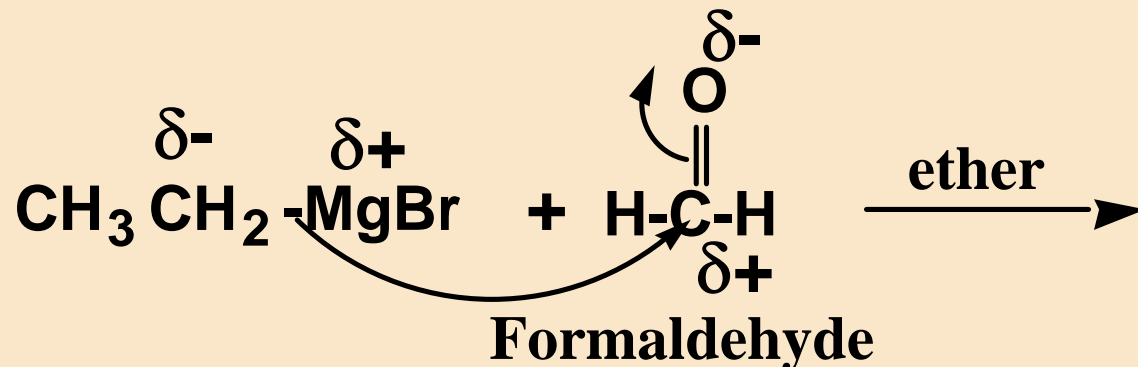
15 Grignard Reagents

- u Given the difference in electronegativity between carbon and magnesium (2.5 - 1.3), the C-Mg bond is polar covalent, with $C\delta^-$ and $Mg\delta^+$
 - in its reactions, a Grignard reagent behaves as a carbanion
- u **Carbanion:** an anion in which carbon has an unshared pair of electrons and bears a negative charge
 - a carbanion is a good nucleophile and adds to the carbonyl group of aldehydes and ketones

15-23

15 Grignard Reagents

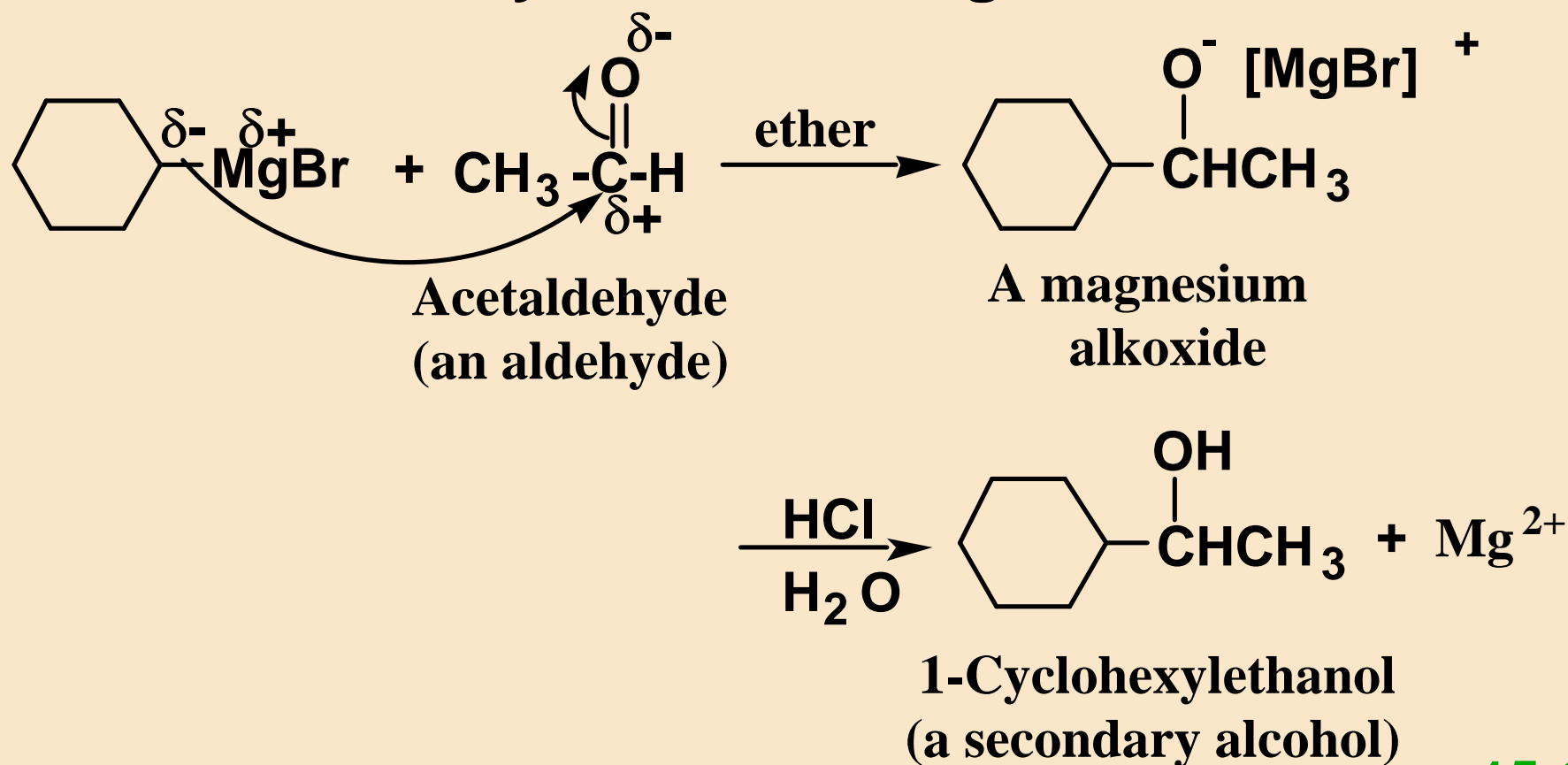
- u Addition of a Grignard reagent to formaldehyde followed by H_3O^+ gives a 1° alcohol



15-24

15 Grignard Reagents

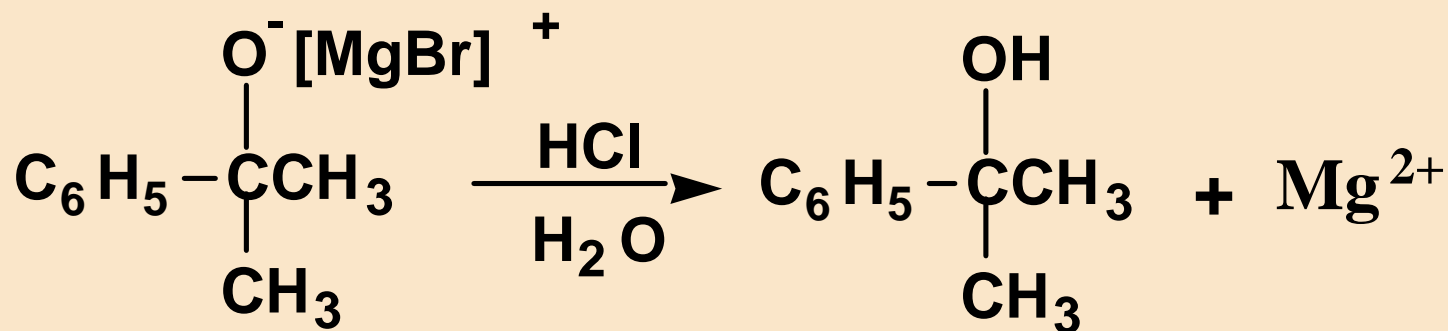
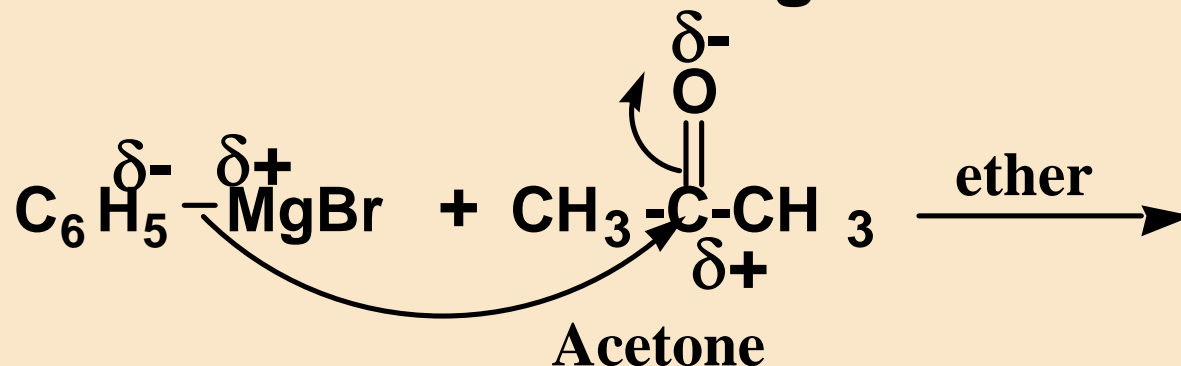
u Addition to any other RCHO gives a 2° alcohol



15-25

15 Grignard Reagents

u Addition to a ketone gives a 3° alcohol



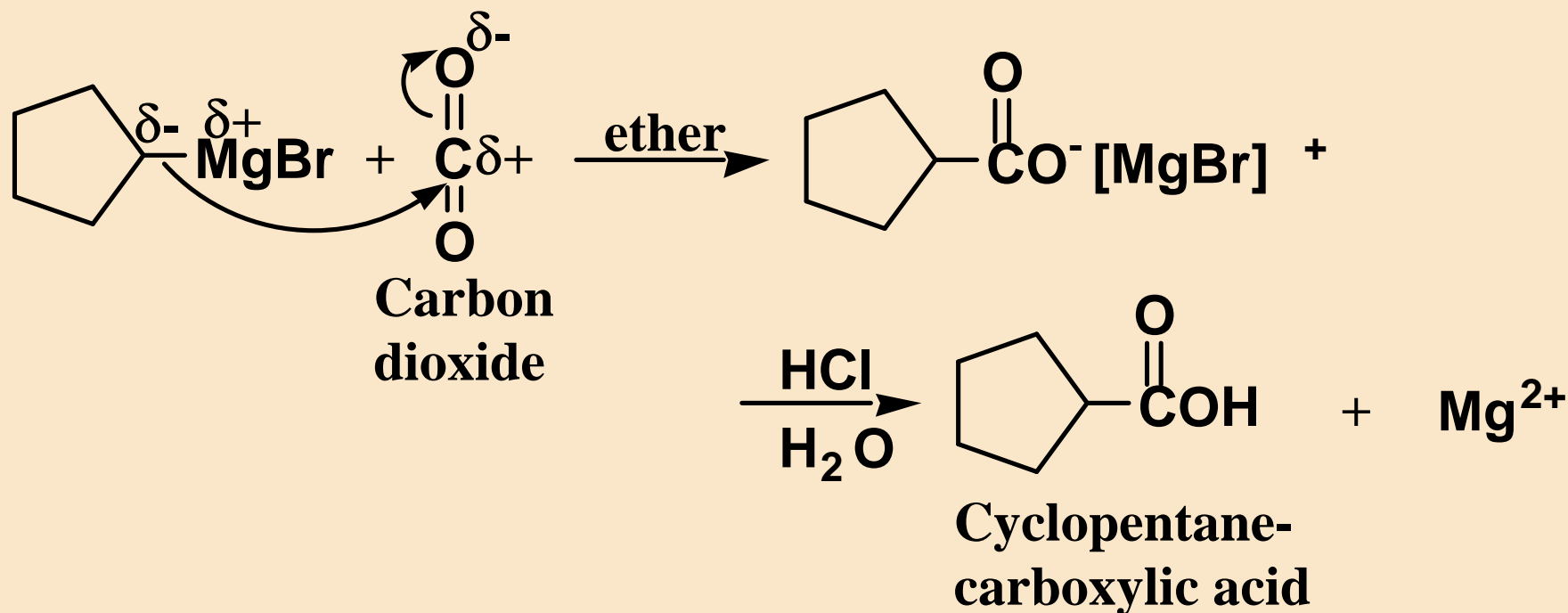
A magnesium
alkoxide

2-Phenyl-2-propanol
(a tertiary alcohol)

15-26

15 Grignard Reagents

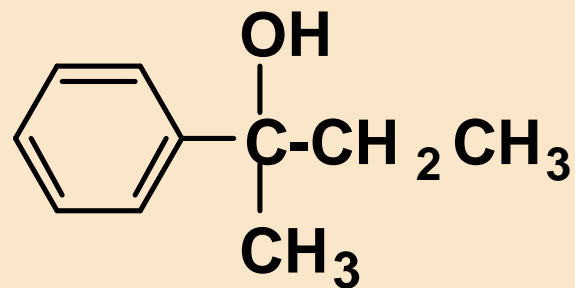
u Addition to CO_2 gives a carboxylic acid



15-27

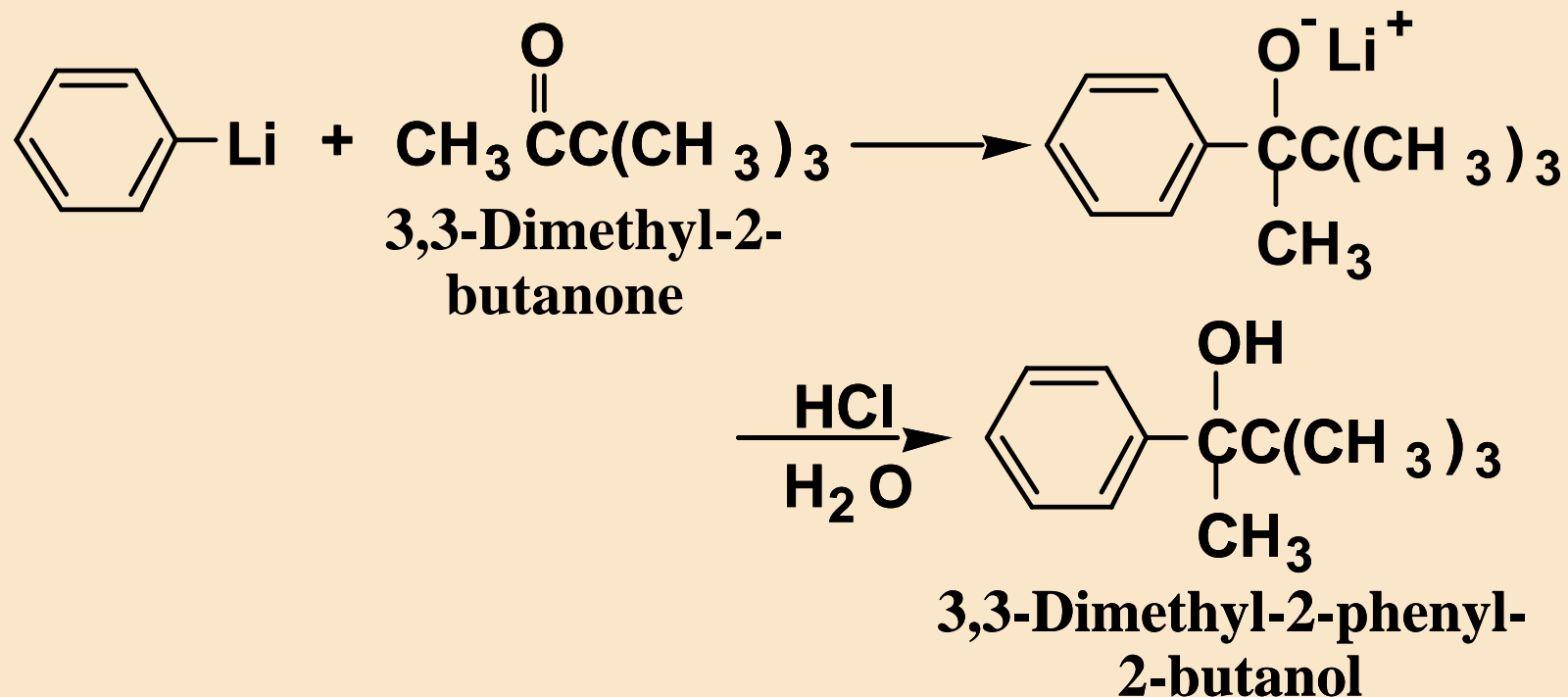
15 Grignard Reagents

- u **Problem:** 2-phenyl-2-butanol can be synthesized by three different combinations of a Grignard reagent and a ketone. Show each combination



15 Organolithium Compounds

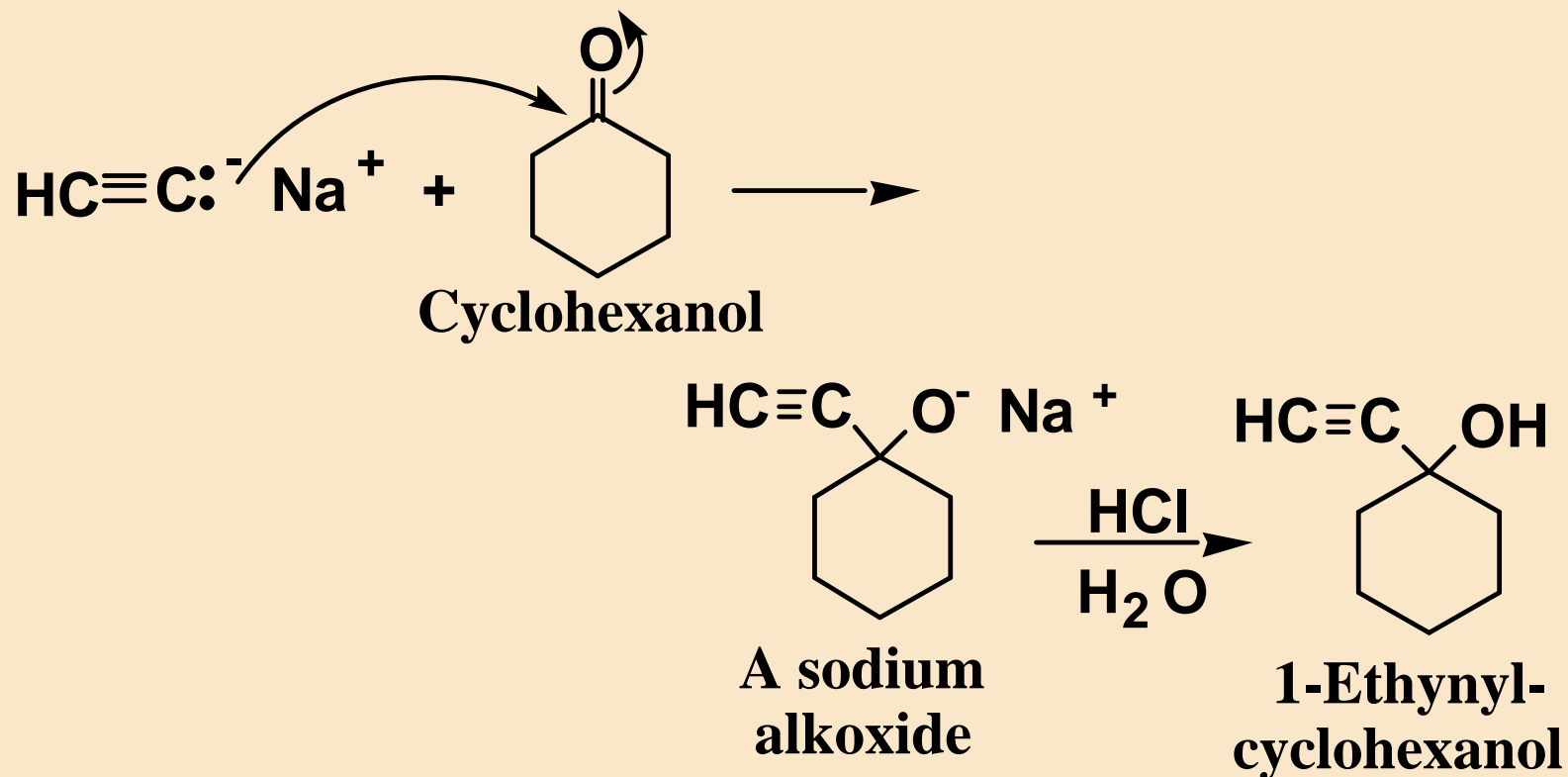
- u Organolithium compounds are generally more reactive in C=O addition reactions than RMgX, and typically give higher yields



15-29

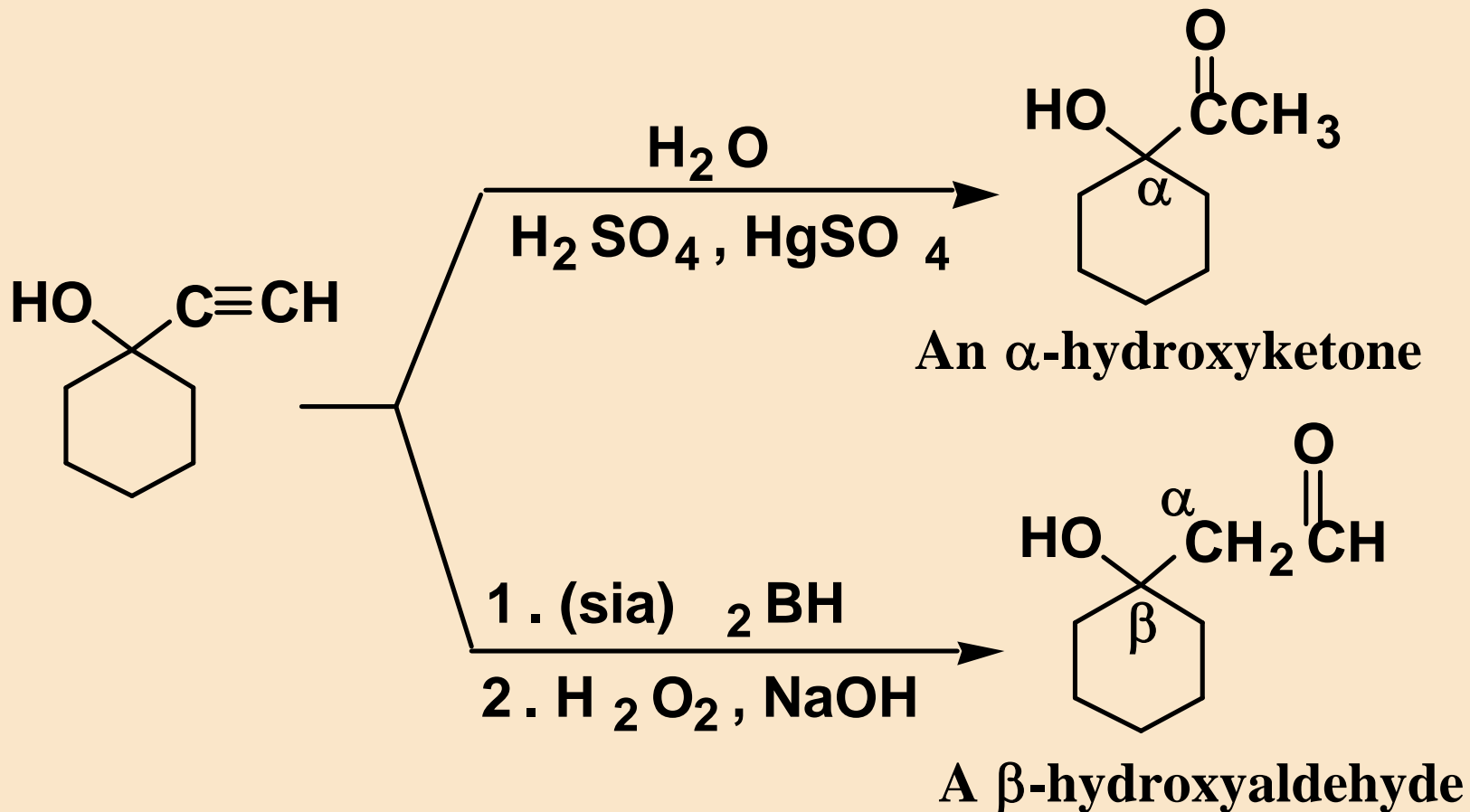
15 Salts of Terminal Alkynes

- u Addition of an acetylide anion followed by H_3O^+ gives an α -acetylenic alcohol



15-30

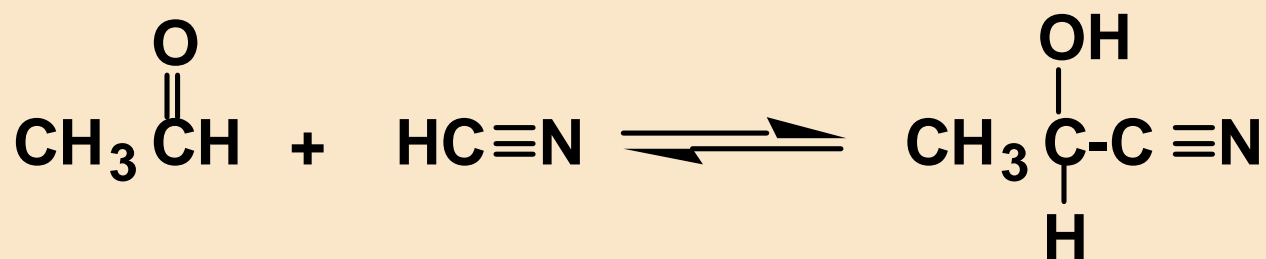
15 Salts of Terminal Alkynes



15-31

15 Addition of HCN

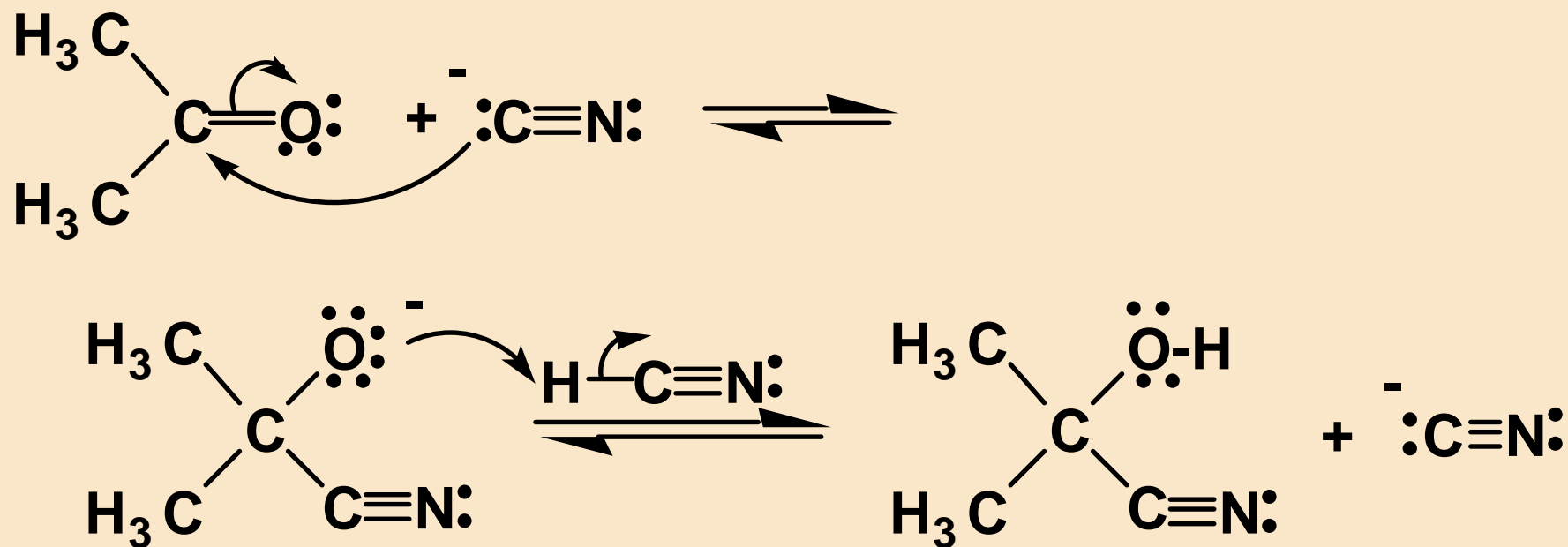
- u HCN adds to the C=O group of an aldehyde or ketone to give a cyanohydrin
- u **Cyanohydrin:** a molecule containing an -OH group and a -CN group bonded to the same carbon



2-Hydroxypropanenitrile
(Acetaldehyde cyanohydrin)

15 Addition of HCN

u Mechanism of cyanohydrin formation

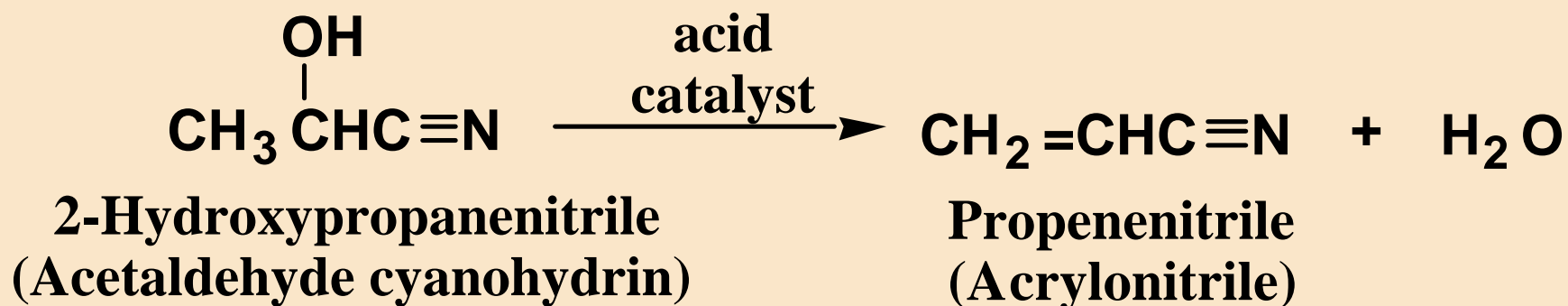


2-Hydroxy-2-methylpropanenitrile
(Acetone cyanohydrin)

15-33

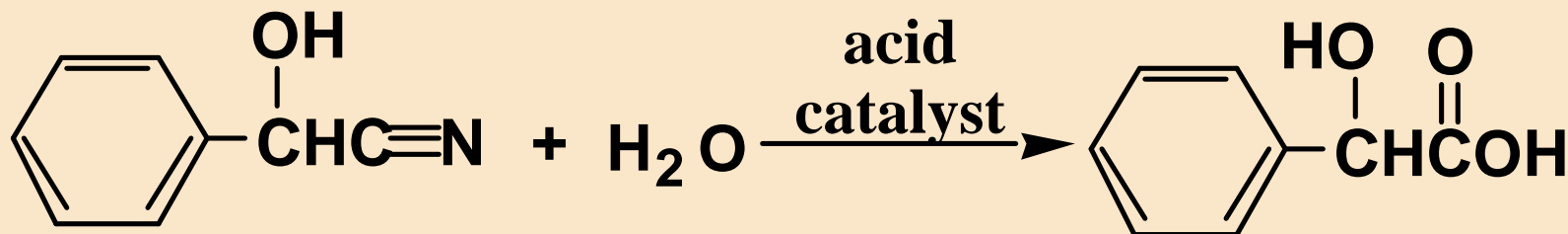
15 Cyanohydrins

- u The value of cyanohydrins is for the new functional groups into which they can be converted
 - acid-catalyzed dehydration of the 2° or 3° alcohol



15 Cyanohydrins

- acid-catalyzed hydrolysis of the cyano group gives a carboxylic acid

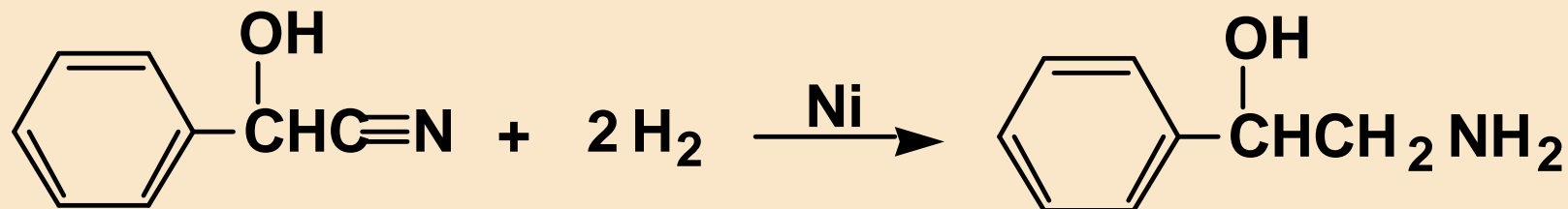


**Benzaldehyde cyanohydrin
(Mandelonitrile)**

**2-Hydroxy-2-phenyl-
ethanoic acid
(Mandelic acid)**

15 Cyanohydrins

- catalytic reduction of the carbon-nitrogen triple bond converts the cyano group gives a 1° amine

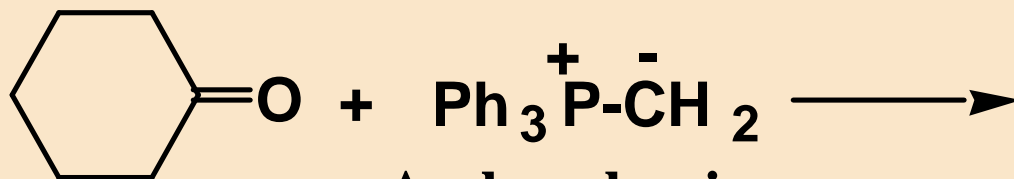


Benzaldehyde cyanohydrin

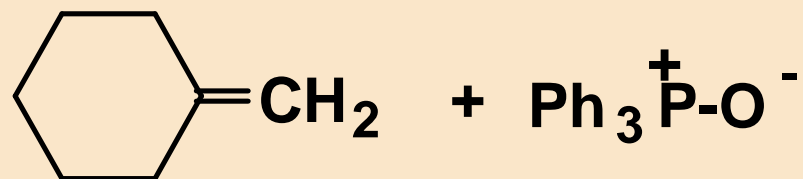
2-Amino-1-phenylethanol

15 Wittig Reaction

- u The Wittig reaction is a very versatile synthetic method for the synthesis of alkenes from aldehydes and ketones.



A phosphonium
ylide



Methylene-
cyclohexane

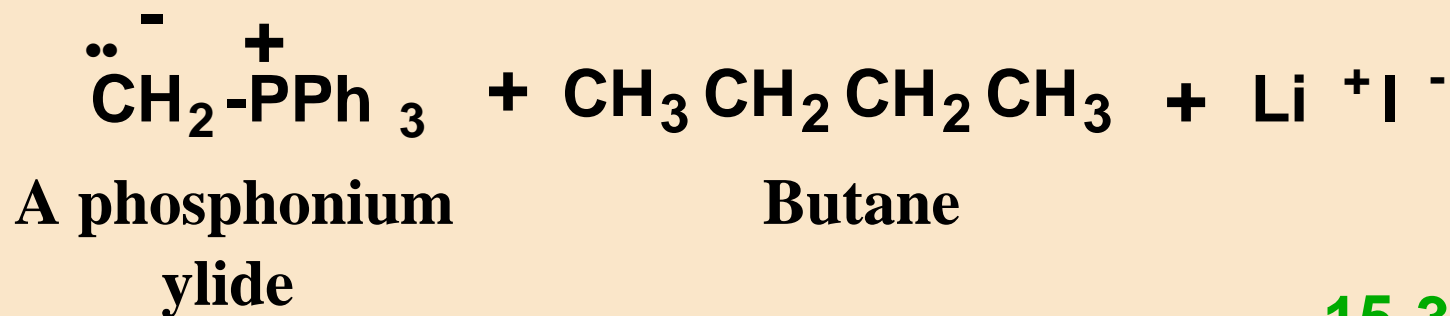
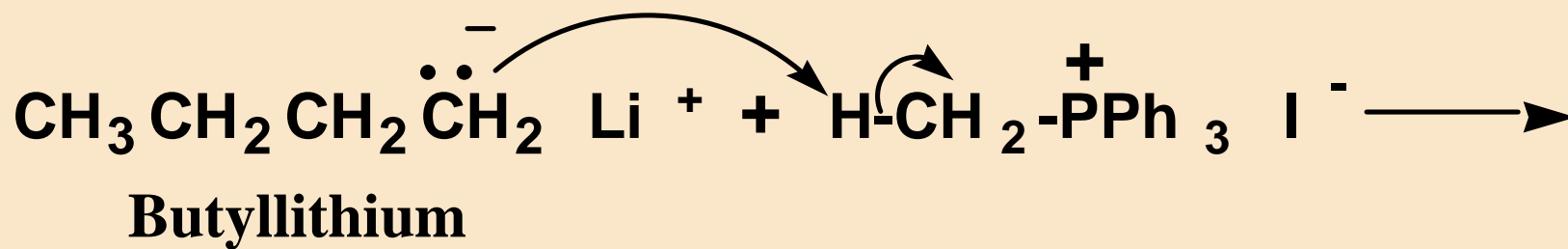
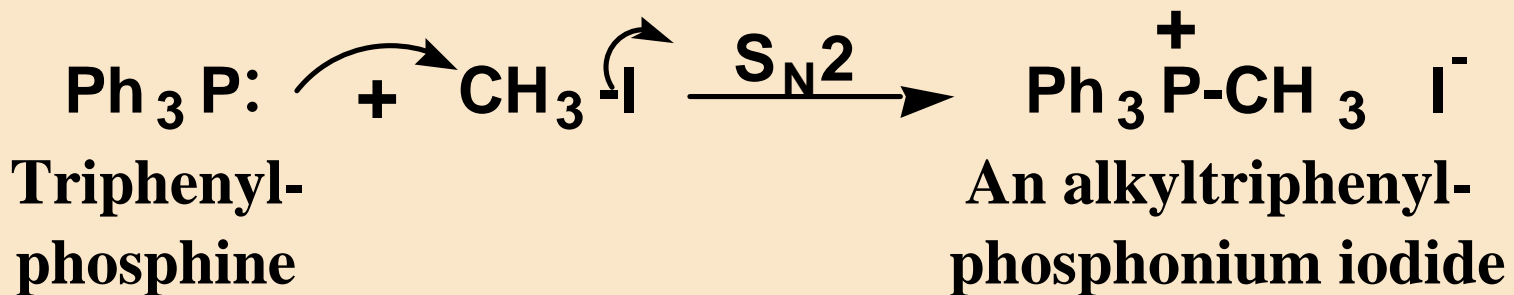
Triphenyl-
phosphine oxide

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15 Phosphonium Ylides

- u **Ylide:** a molecule which, when written in a Lewis structure showing all atoms with complete valence shells, has positive and negative charges on adjacent atoms
- u **Phosphonium ylides** are formed in two steps:
 1. treatment of triphenylphosphine with a 1° or 2° alkyl halide to form a phosphonium salt followed by
 2. treatment of the phosphonium salt with strong base, typically butyllithium

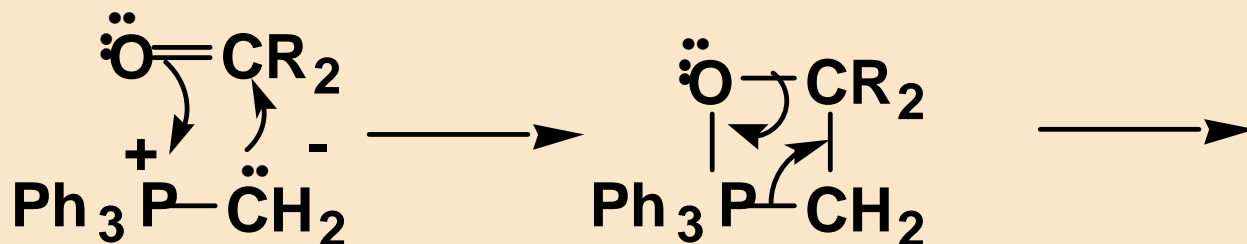
15 Phosphonium Ylides



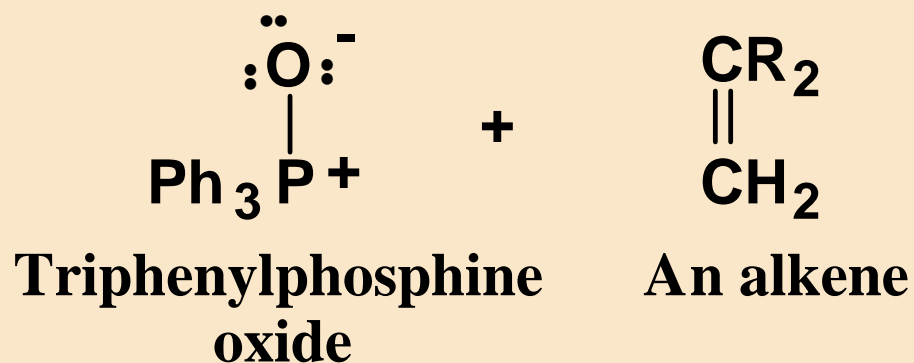
15-39

15 Wittig Reaction

- u Phosphonium ylides react with the C=O group of an aldehyde or ketone to give an alkene



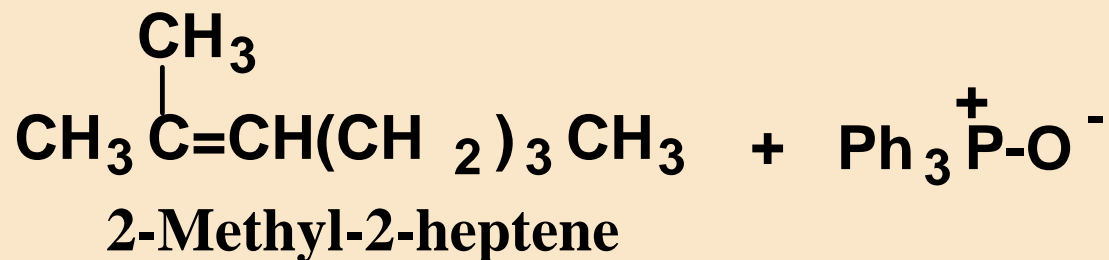
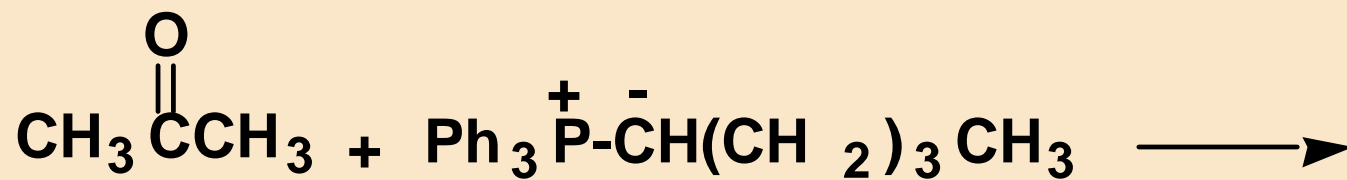
An oxaphosphetane



15-40

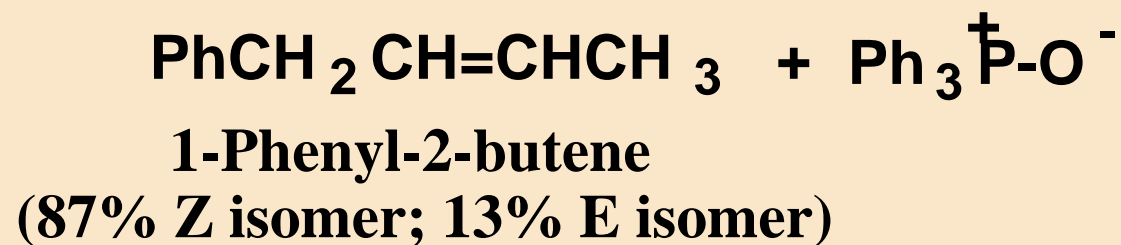
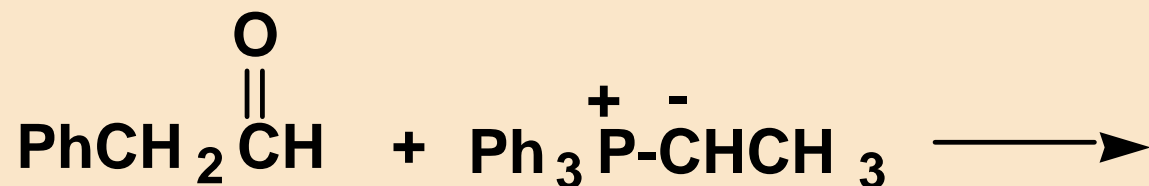
15 Wittig Reaction

u Examples:



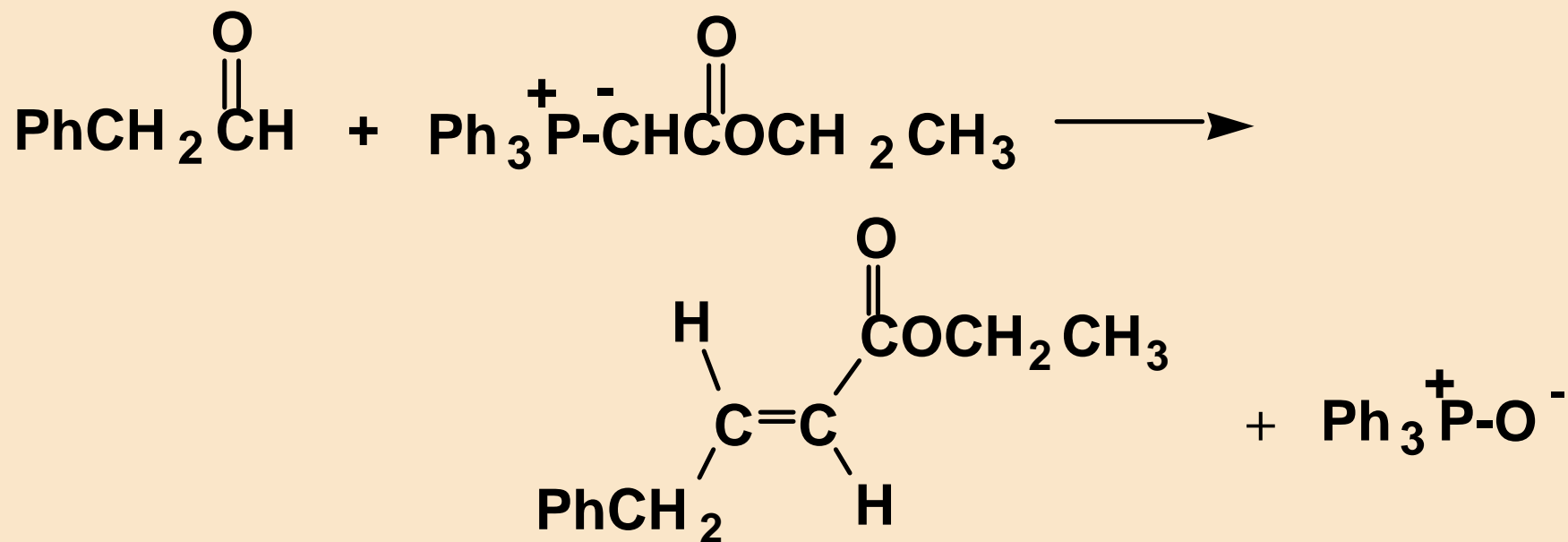
15 Wittig Reaction

u Examples (contd.)



15 Wittig Reaction

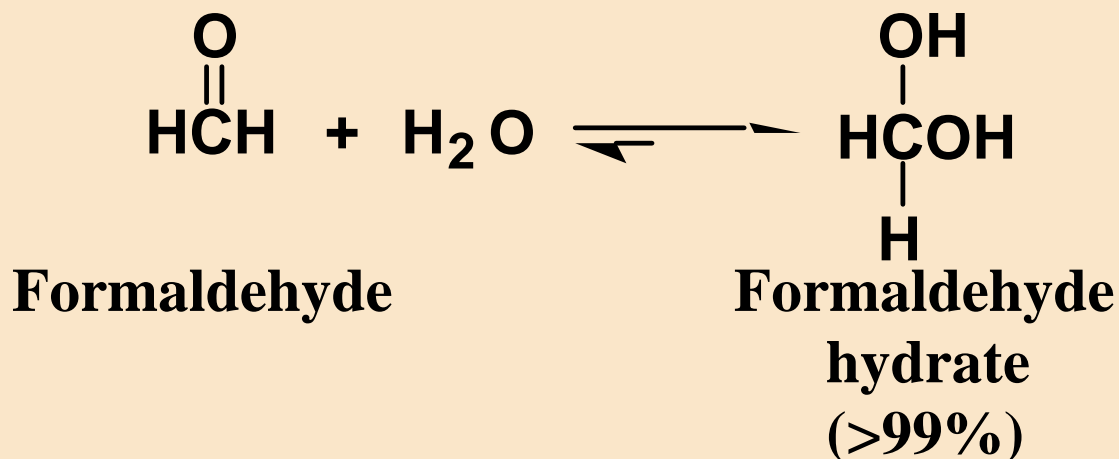
u Examples (contd.)



Ethyl (E)-4-phenyl-2-butenolate
(only the E isomer is formed)

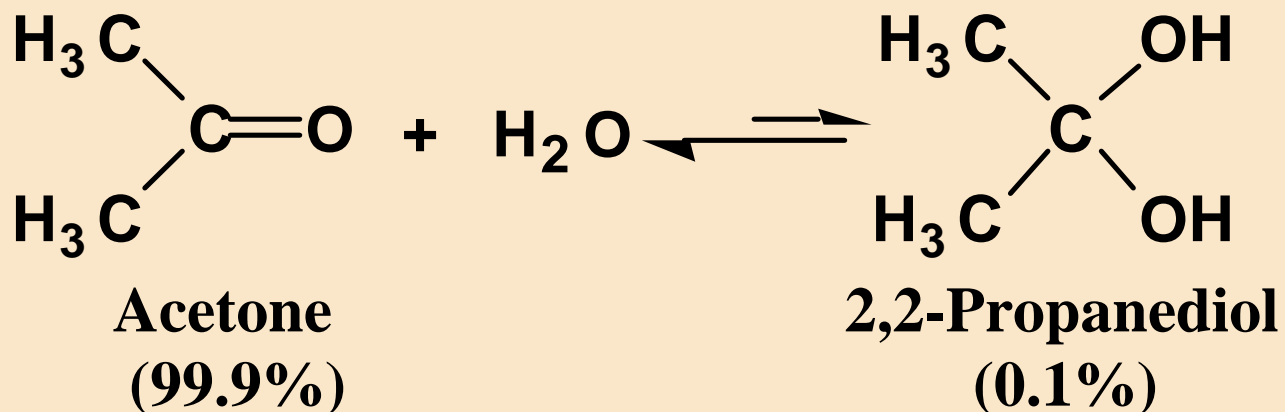
15 Addition of H₂O

- u Addition of water (hydration) of a carbonyl group of an aldehyde or ketone forms a 1,1-diol, commonly referred to as a hydrate
 - when formaldehyde is dissolved in water at 20°C, the carbonyl group is more than 99% hydrated



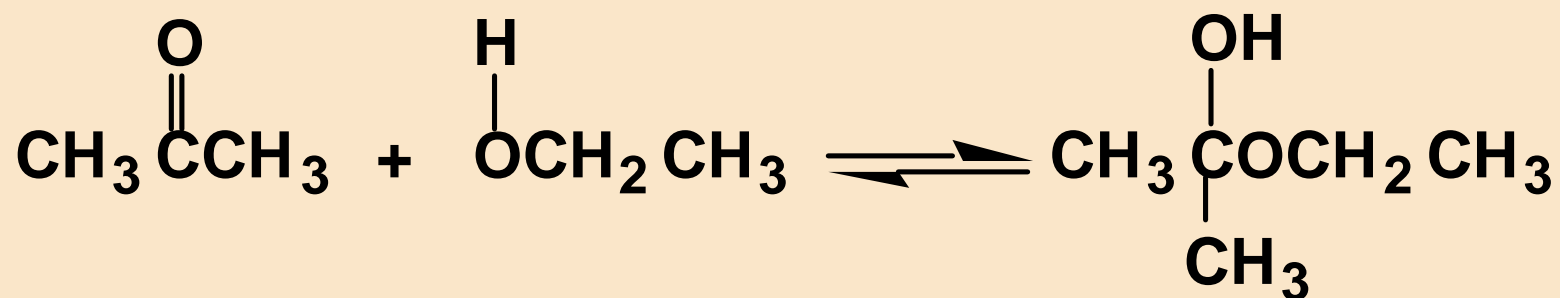
15 Addition of H₂O

- the equilibrium concentration of hydrated ketone is considerably smaller



15 Addition of Alcohols

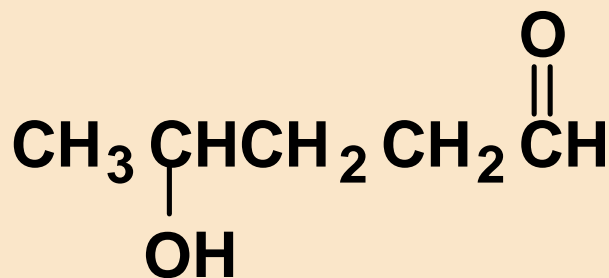
- u Addition of one molecule of alcohol to the C=O group of an aldehyde or ketone gives a hemiacetal
- u **Hemiacetal:** a molecule containing an -OH and an -OR or -OAr bonded to the same carbon



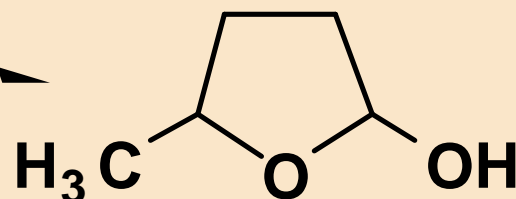
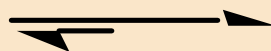
A hemiacetal

15 Addition of Alcohols

- u Hemiacetals are only minor components of an equilibrium mixture, except where a five- or six-membered ring can form
(the trans isomer is shown here)



4-Hydroxypentanal



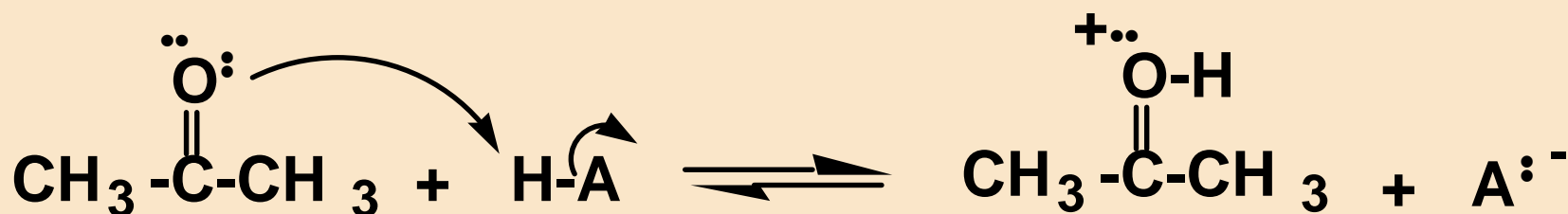
A cyclic hemiacetal
(major form present
at equilibrium)

15-47

15 Addition of Alcohols

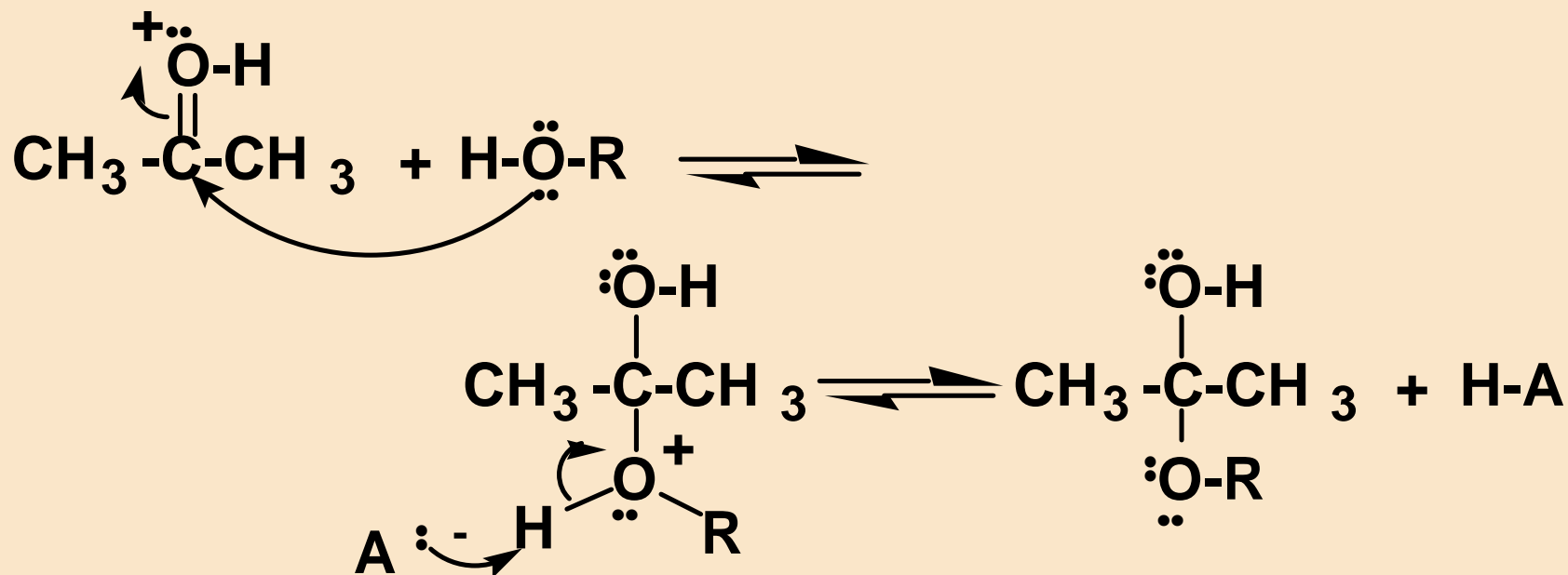
u Formation of a hemiacetal is acid-catalyzed

Step 1: proton transfer from the acid, HA, to the carbonyl oxygen



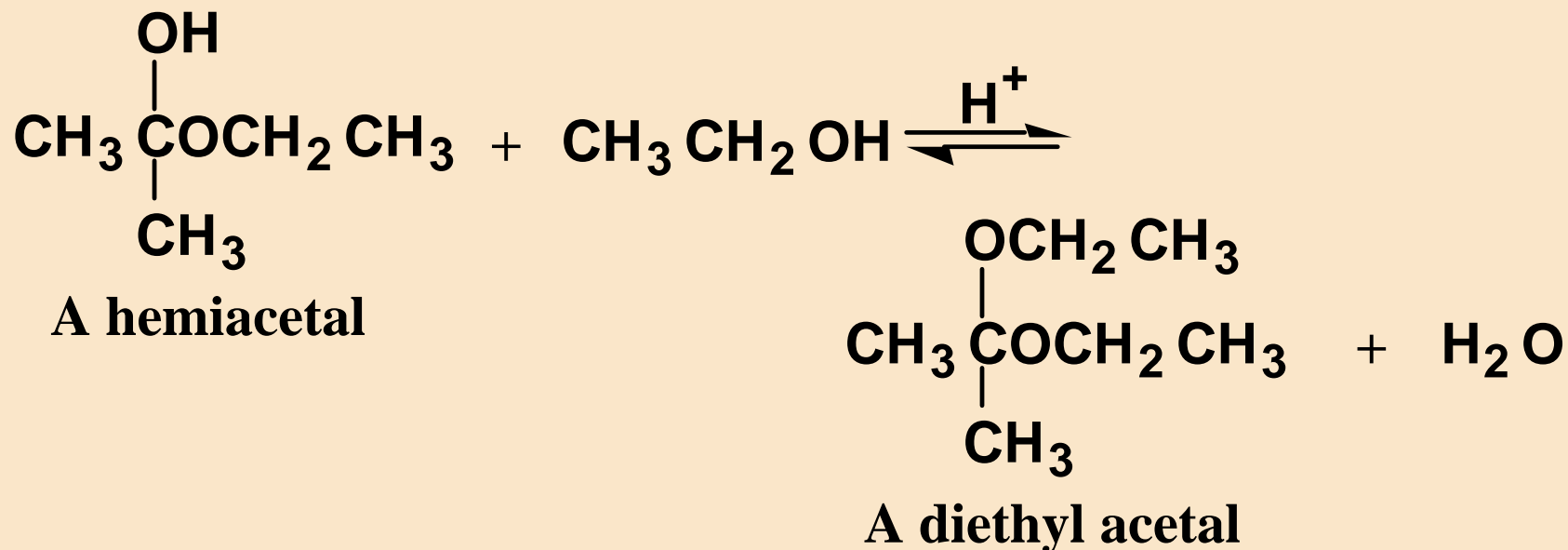
15 Addition of Alcohols

Step 2: attack of ROH on the carbonyl carbon followed by proton transfer to A⁻ to regenerate the acid catalyst



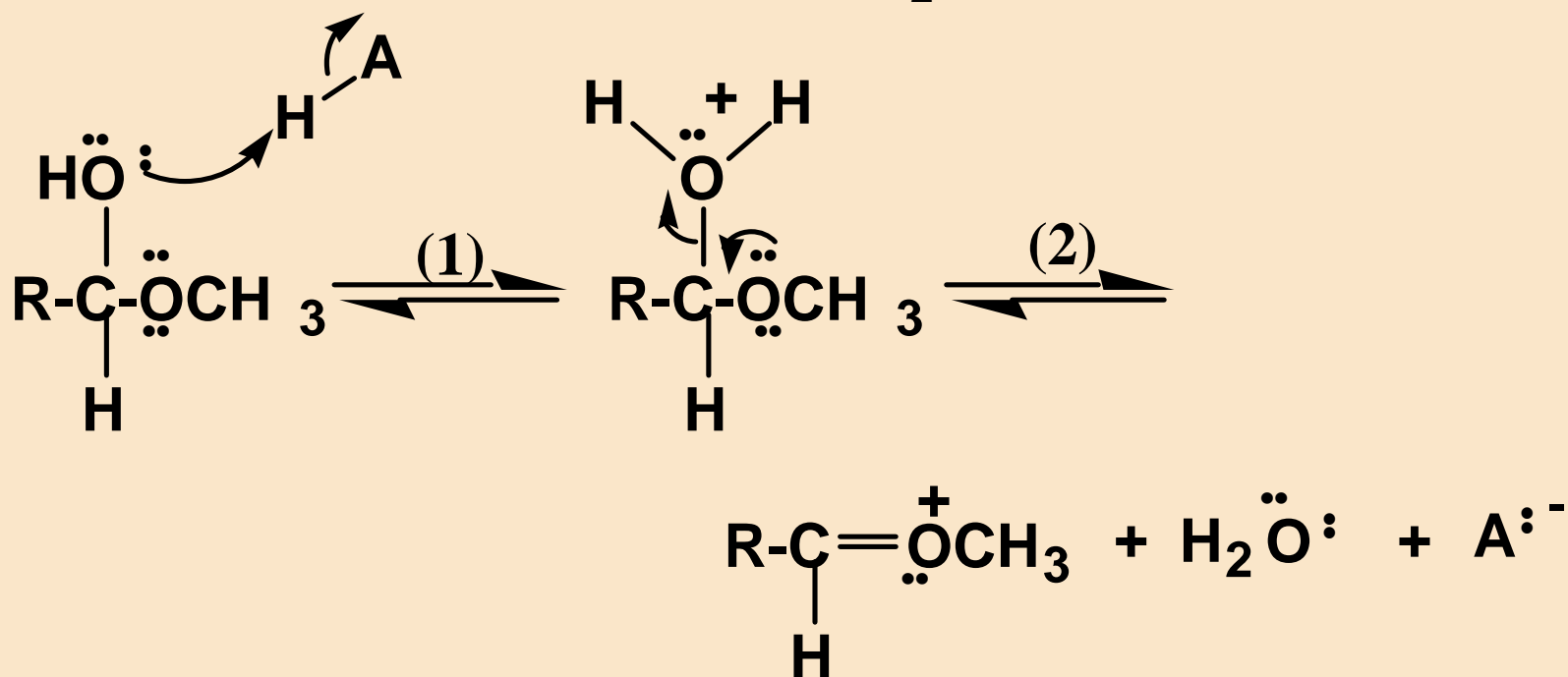
15 Addition of Alcohols

- u Hemiacetals react with alcohols to form acetals
- u **Acetal:** a molecule containing two -OR or -OAr groups bonded to the same carbon



15 Addition of Alcohols

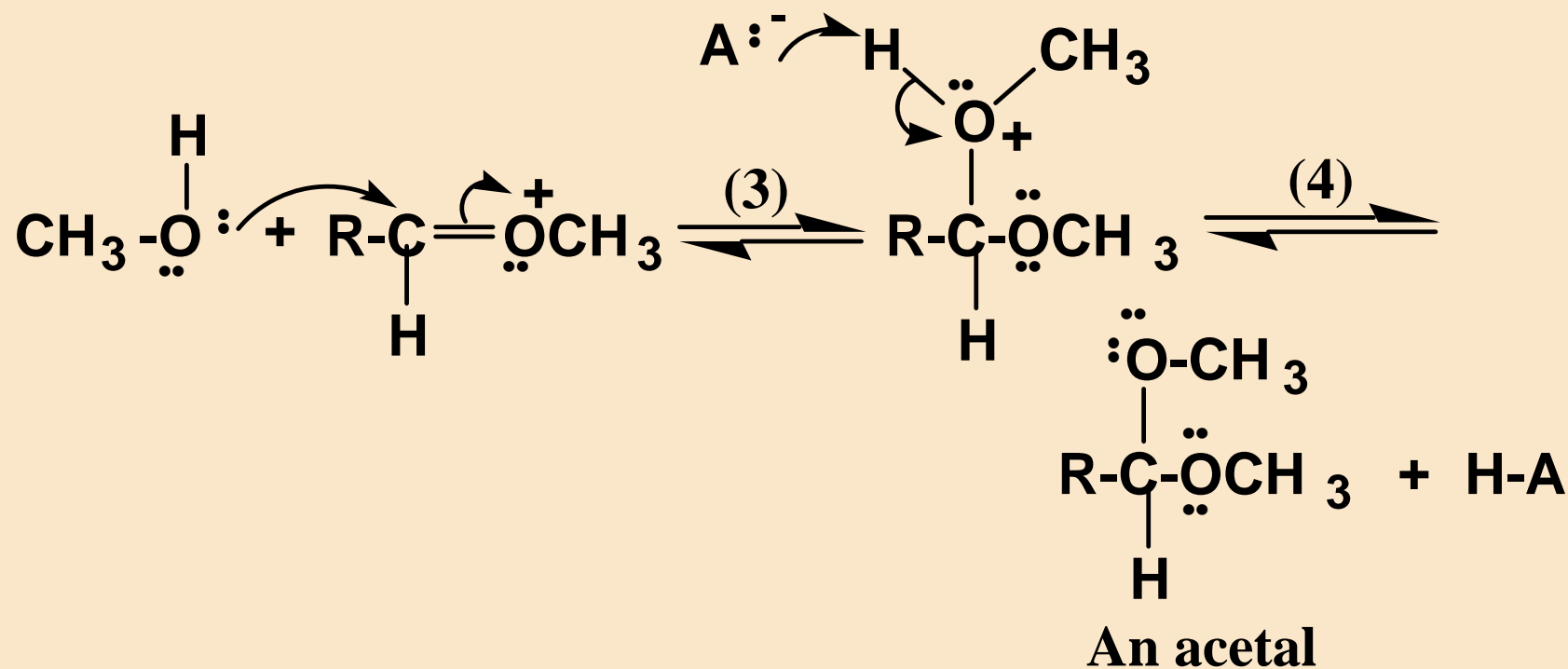
Steps 1 and 2: proton transfer from HA to the carbonyl oxygen followed by loss of H₂O



An oxonium ion

15 Addition of Alcohols

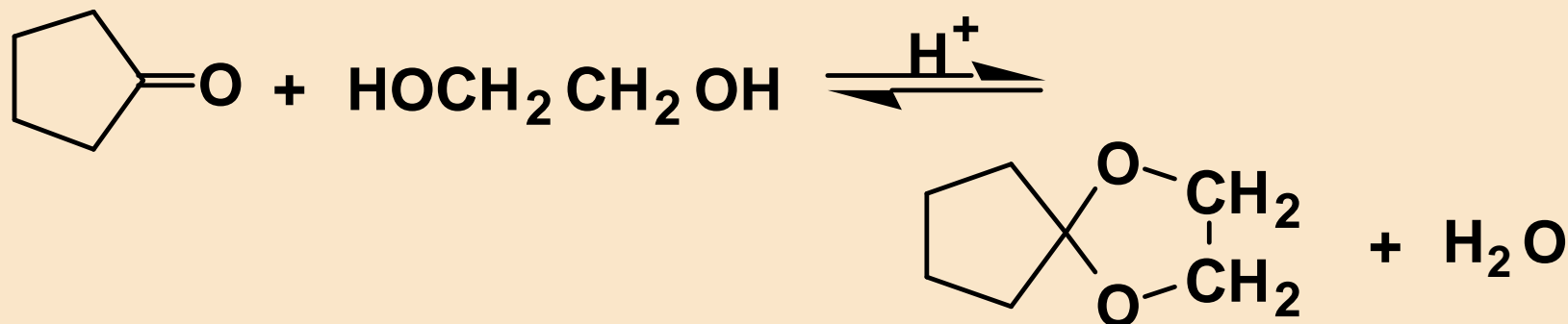
Steps 3 and 4: reaction of the oxonium ion with ROH followed by proton transfer to A⁻



15-52

15 Addition of Alcohols

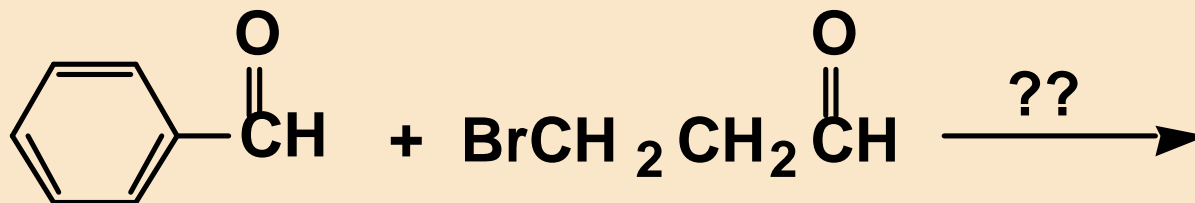
- u With a glycol, such as ethylene glycol, the product is a five-membered cyclic acetal



A cyclic acetal

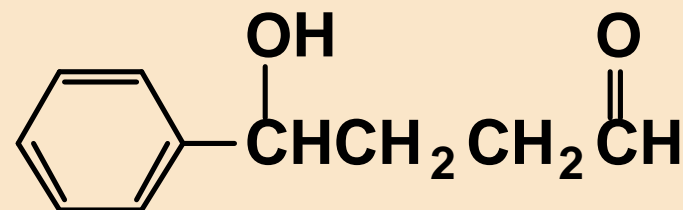
15 Acetals as Protecting Grps

- u Suppose you wish to bring about a Grignard reaction between these compounds



Benzaldehyde

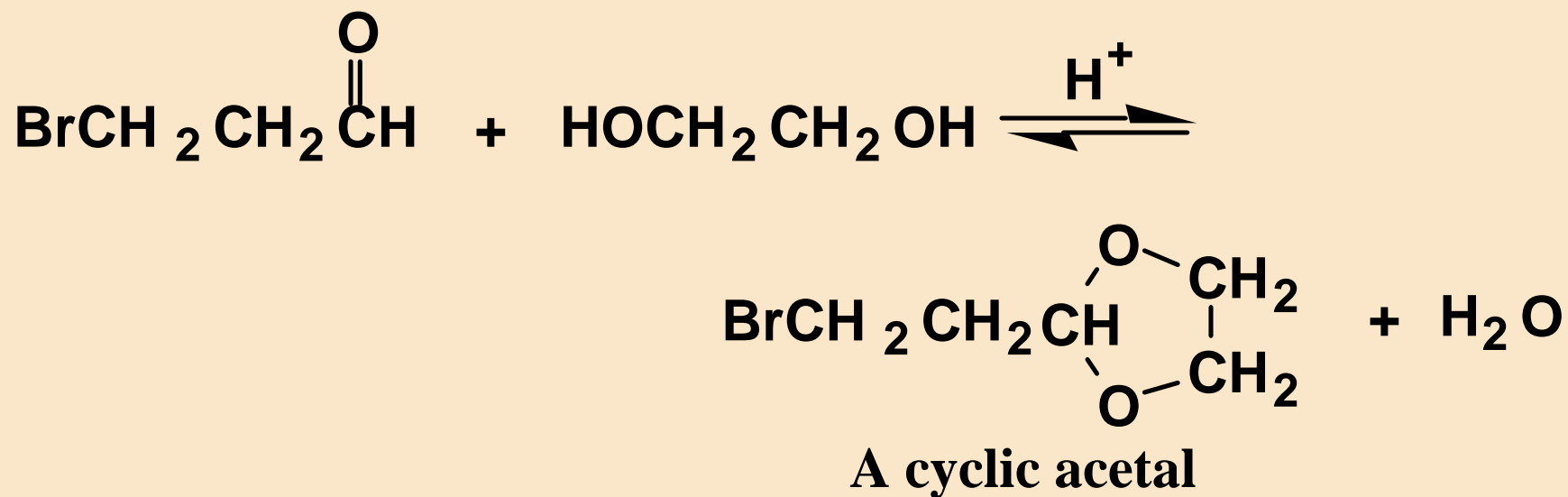
3-Bromopropanal



4-Hydroxy-4-phenylbutanal

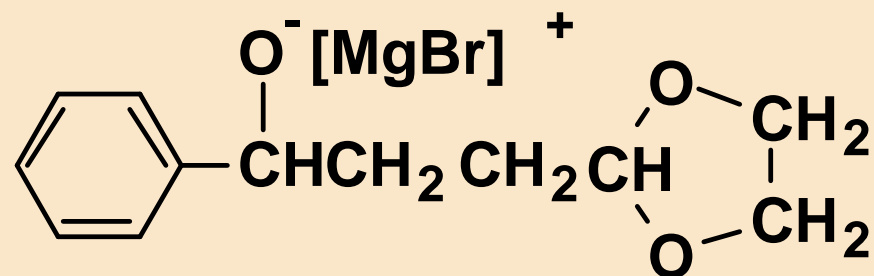
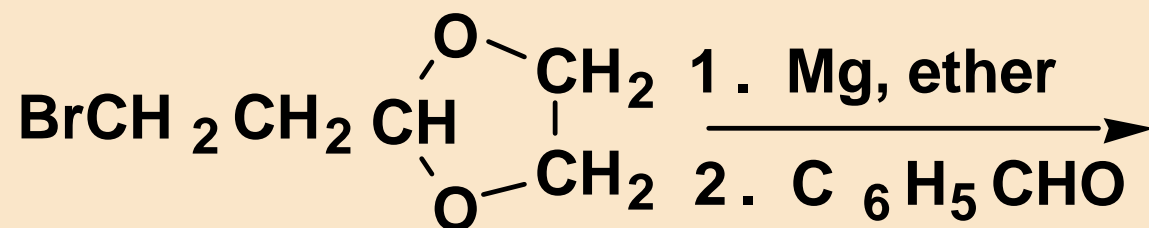
15 Acetals as Protecting Grps

- u If the Grignard reagent were prepared from 3-bromopropanal, it would self-destruct!
- u First protect the -CHO group as an acetal



15 Acetals as Protecting Grps

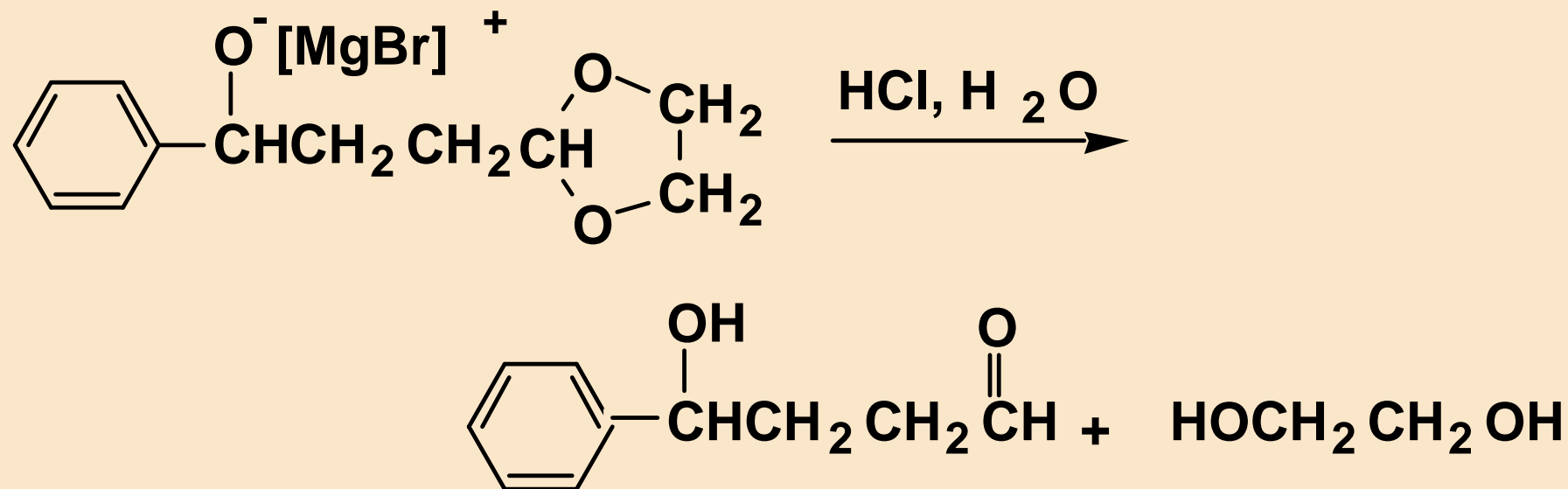
u Then do the Grignard reaction



15-56

15 Acetals as Protecting Grps

- u Hydrolysis gives the alcohol and regenerates the -CHO group

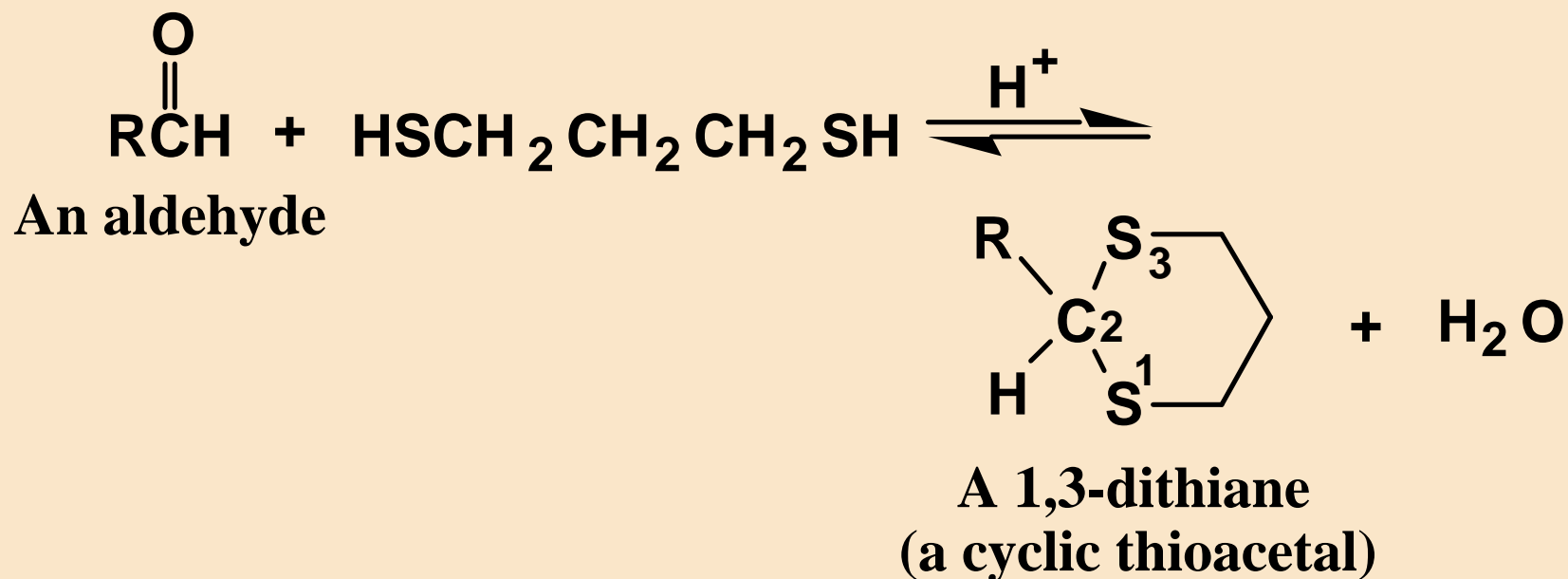


15 Addn of S Nucleophiles

- u Thiols, like alcohols, add to the C=O of aldehydes and ketones to give tetrahedral carbonyl addition products
- u The sulfur atom of a thiol is a better nucleophile than the oxygen atom of an alcohol
- u A common sulfur nucleophile used for this purpose is 1,3-propanedithiol

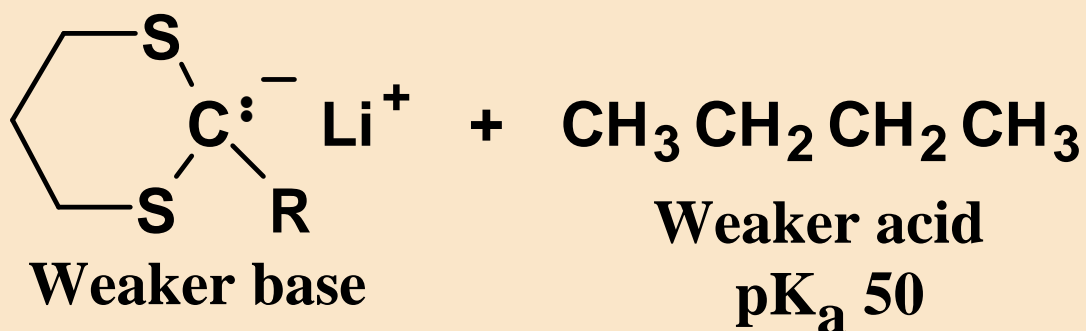
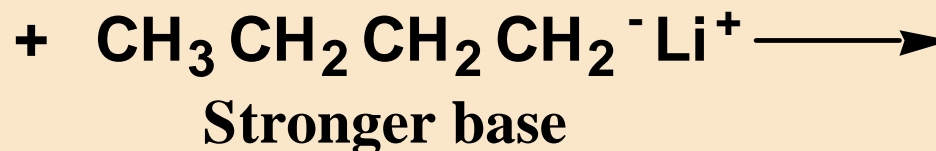
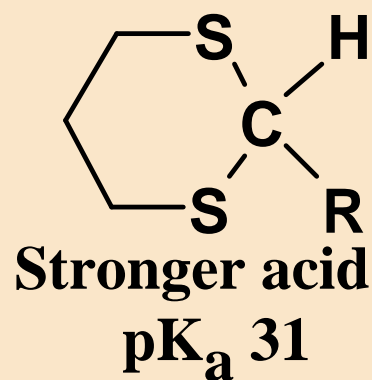
15 Addn of S Nucleophiles

u The product is a 1,3-dithiane



15 Addn of S Nucleophiles

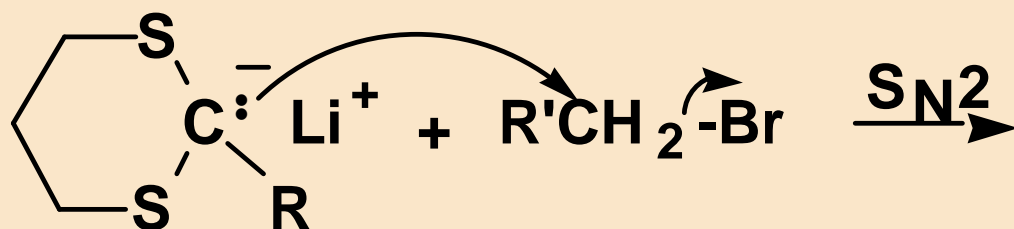
- u The hydrogen on carbon 2 of the 1,3-dithiane ring is weakly acidic, pK_a approximately 31



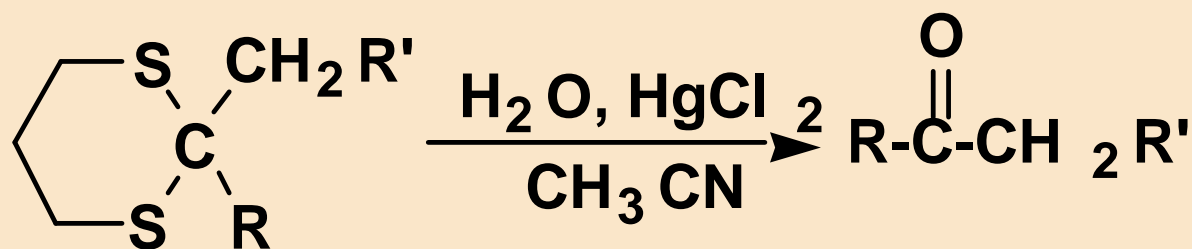
15-60

15 Addn of S Nucleophiles

- u A 1,3-dithiane anion is a good nucleophile and undergoes S_N2 reactions with 1° alkyl and benzylic halides. Hydrolysis gives a ketone



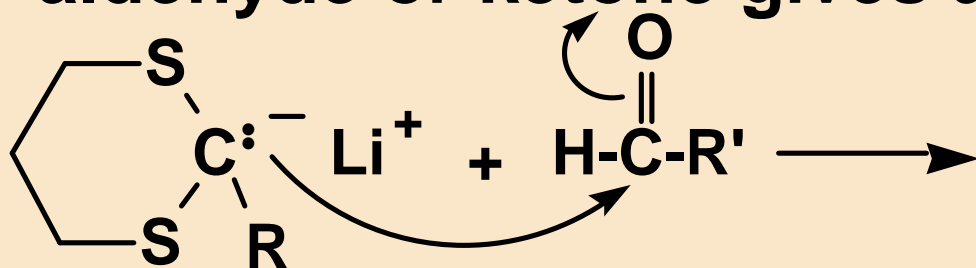
Lithium salt of
a 1,3-dithiane



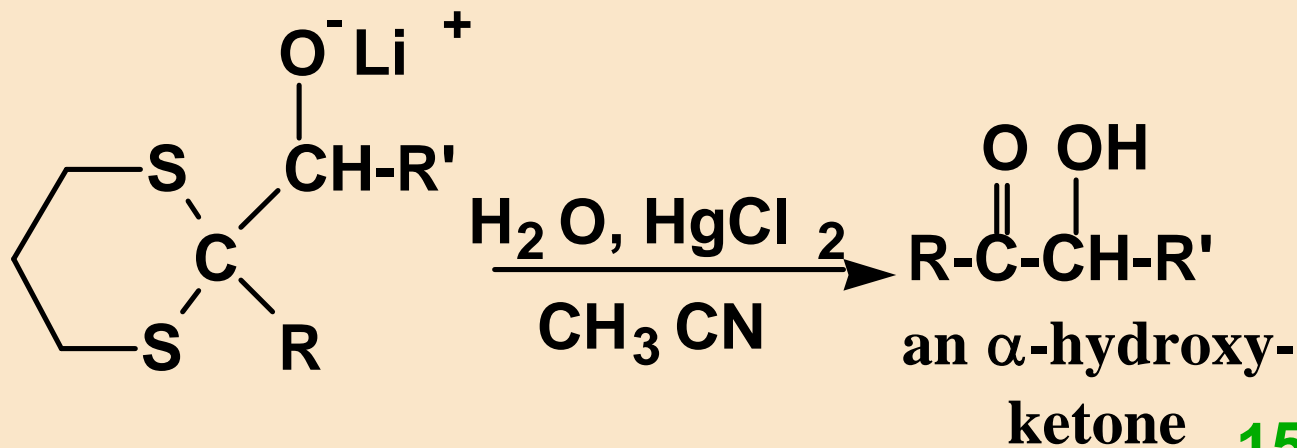
15-61

15 Addn of S Nucleophiles

- u Treatment of the 1,3-dithiane anion with an aldehyde or ketone gives an α -hydroxyketone



Lithium salt of
a 1,3-dithiane

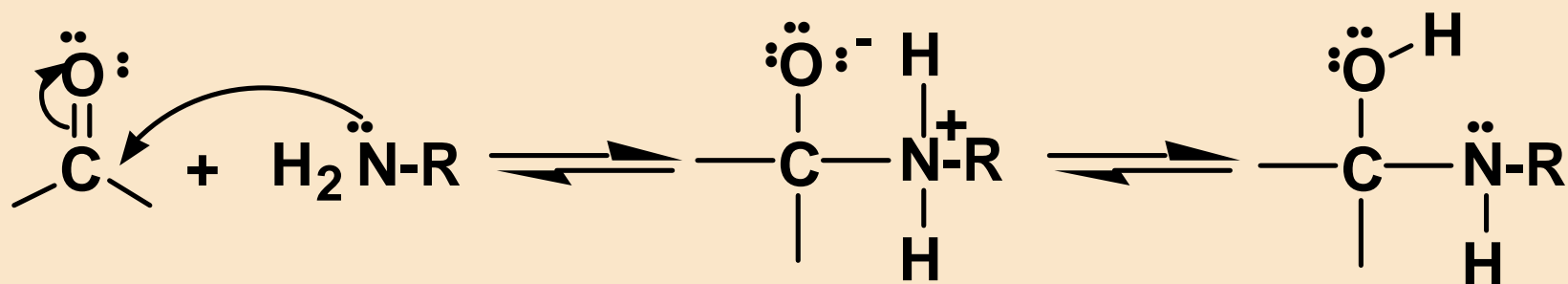


15-62

15 Addn of N Nucleophiles

u Formation of an imine occurs in two steps

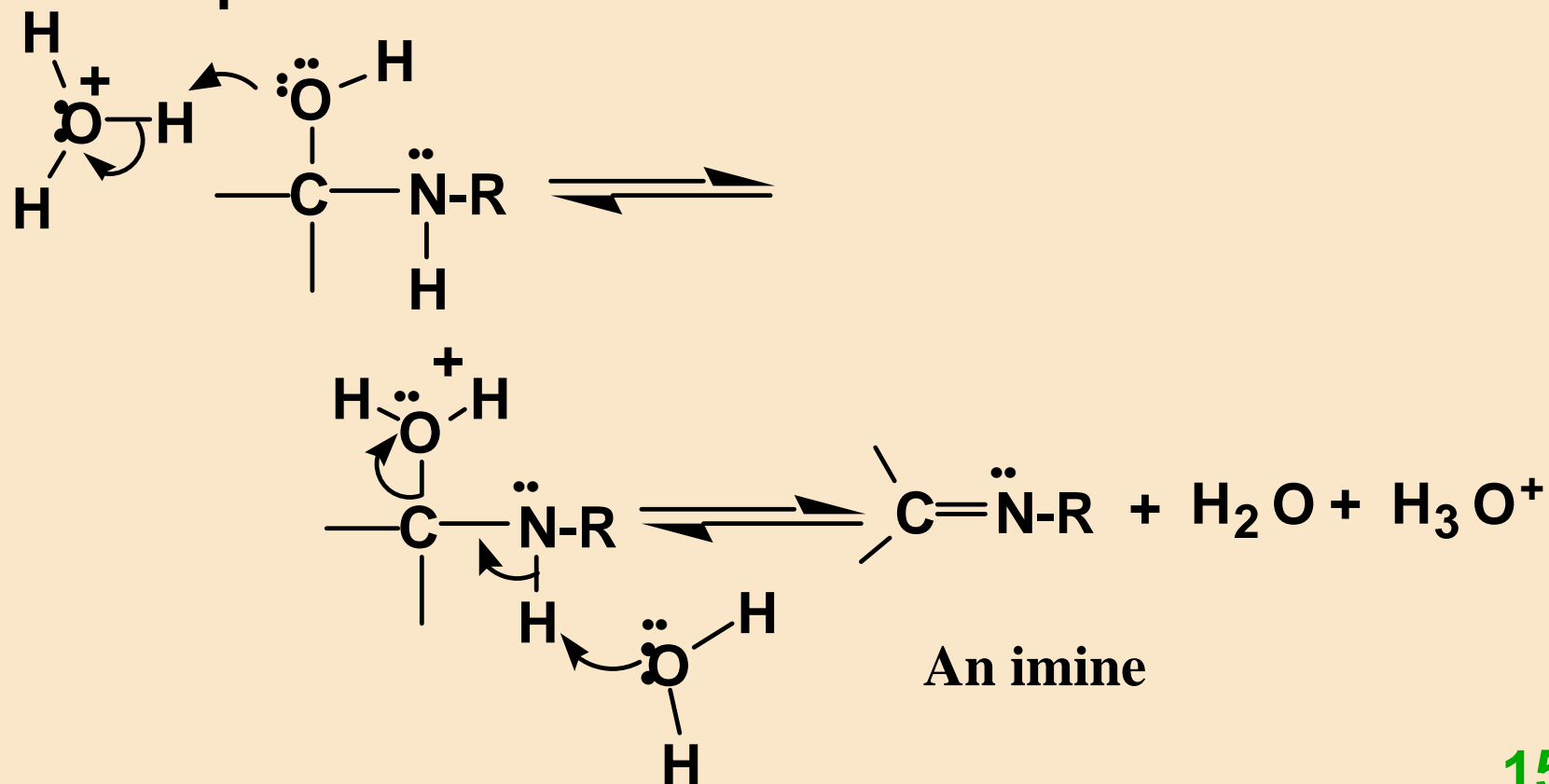
Step 1: addition of the nitrogen nucleophile to the carbonyl carbon followed by proton transfer



A tetrahedral carbonyl addition compound

15 Addn of N Nucleophiles

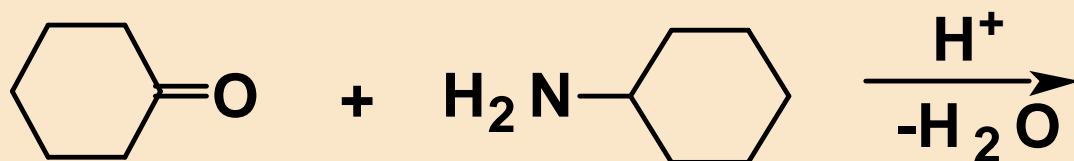
Step 2: protonation of the -OH followed by loss of H₂O and proton transfer to solvent



15-65

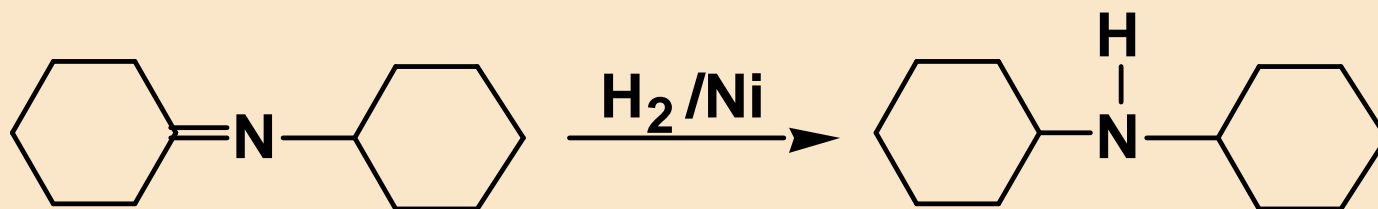
15 Addn of N Nucleophiles

- u A value of imines is that the carbon-nitrogen double bond can be reduced to a carbon-nitrogen single bond



Cyclohexanone

Cyclohexylamine



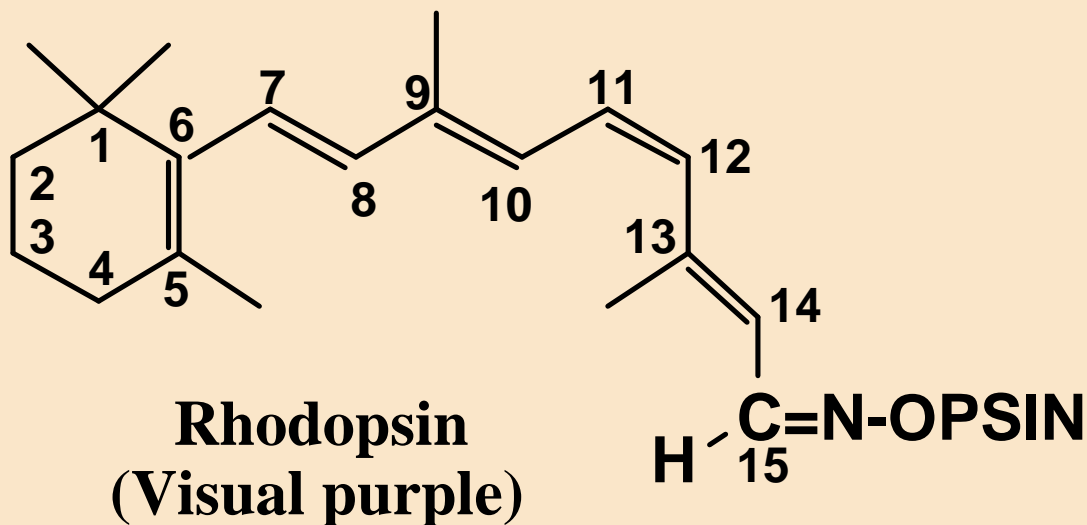
(An imine)

Dicyclohexylamine

15-66

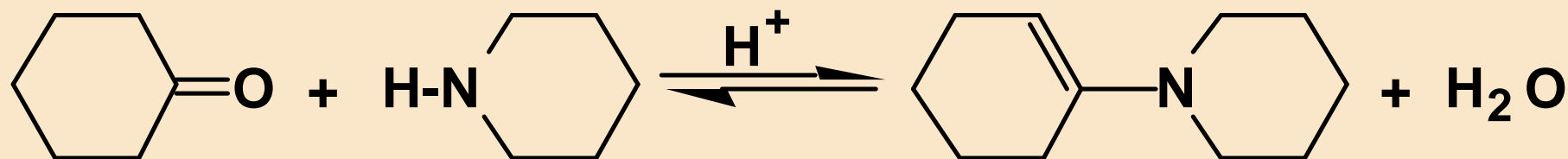
15 Addn of N Nucleophiles

- u Rhodopsin (visual purple) is the imine formed between 11-cis retinal (vitamin A aldehyde) and the protein opsin



15 Addn of N Nucleophiles

- u Secondary amines react with the C=O group of aldehydes and ketones to form enamines



Piperidine
(a secondary amine)

An enamine

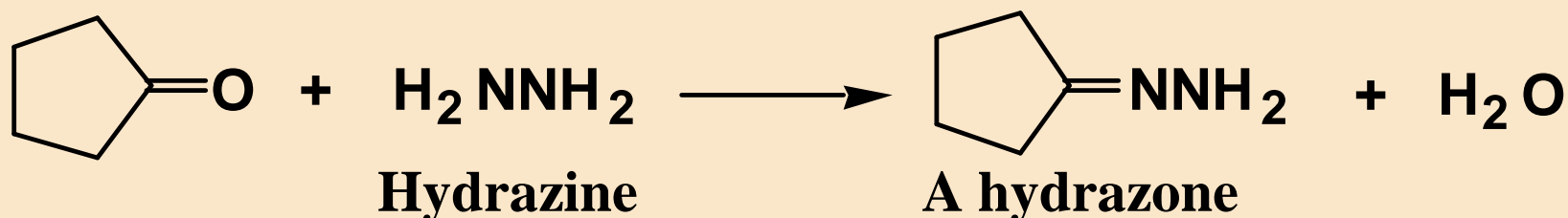
15 Addn of N Nucleophiles

- u The mechanism of enamine formation involves
 - formation of a tetrahedral carbonyl addition compound followed by
 - its acid-catalyzed dehydration

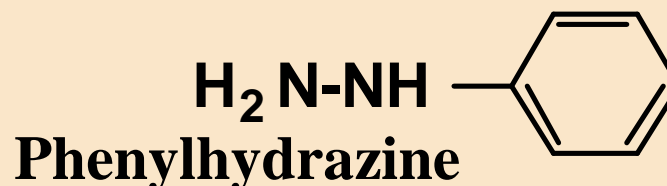
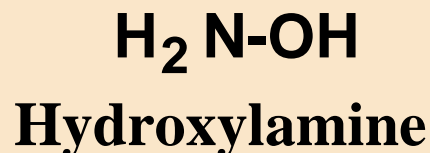
- u We discuss the chemistry of enamines in more detail in Chapter 18

15 Addn of N Nucleophiles

- u The carbonyl group of aldehydes and ketones reacts with hydrazine and its derivatives in a manner similar to its reactions with 1° amines



- Hydrazine derivatives include



15-70

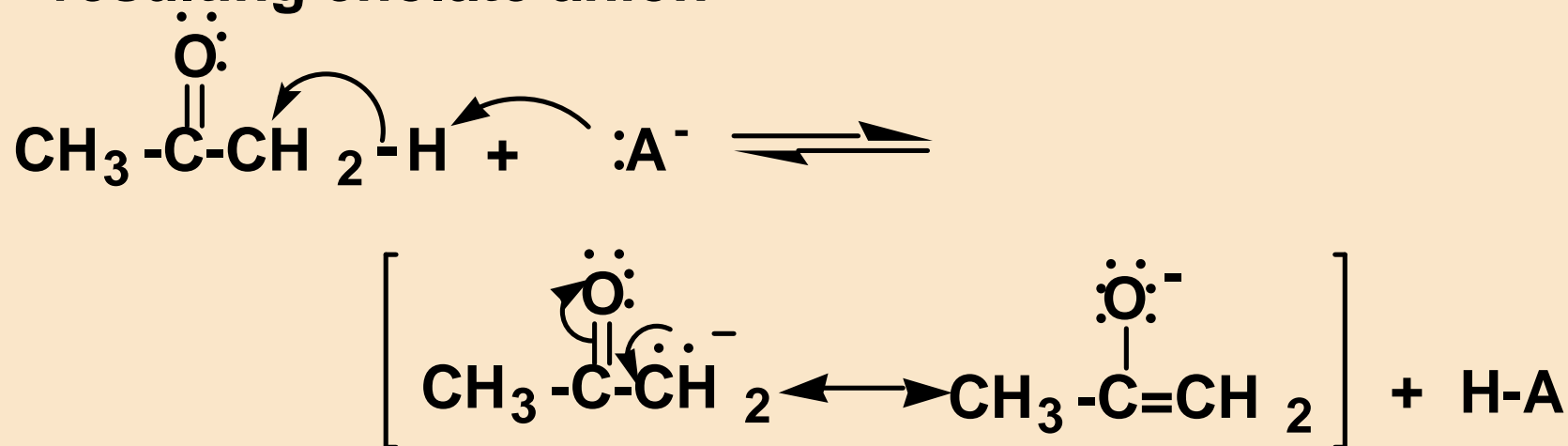
15 Acidity of α -Hydrogens

- u Hydrogens alpha to a carbonyl group are more acidic than hydrogens of alkanes, alkenes, and alkynes but less acidic than the hydroxyl hydrogen of alcohols

Type of Bond	pK _a
CH ₃ CH ₂ O-H	16
CH ₃ $\overset{\text{O}}{\parallel}$ CCH ₂ -H	20
CH ₃ C \equiv C-H	25
CH ₂ =CH-H	44
CH ₃ CH ₂ -H	51

15 Acidity of α -Hydrogens

- α -Hydrogens are more acidic because of
 - the electron-withdrawing inductive effect of the adjacent carbonyl group weakens the C-H bond and
 - delocalization of the negative charge stabilizes the resulting enolate anion

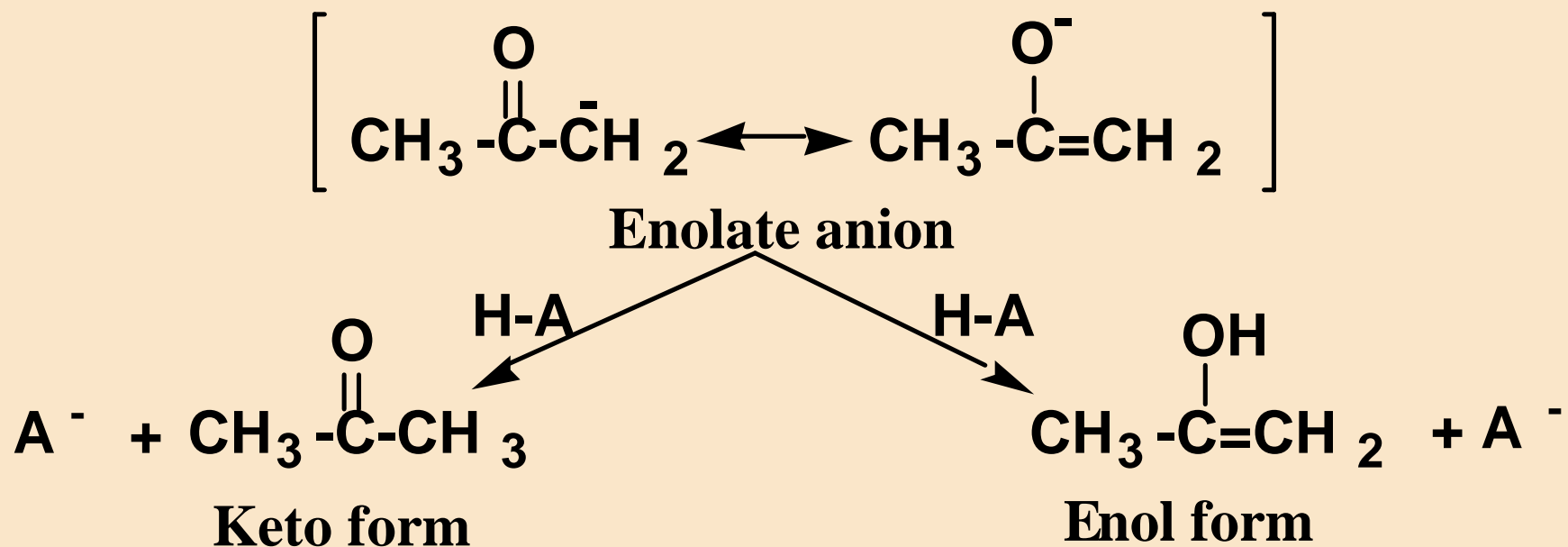


Resonance-stabilized enolate anion

15-72

15 Keto-Enol Tautomerism

- u Protonation of the enolate anion on oxygen gives the enol form; protonation on carbon gives the keto form

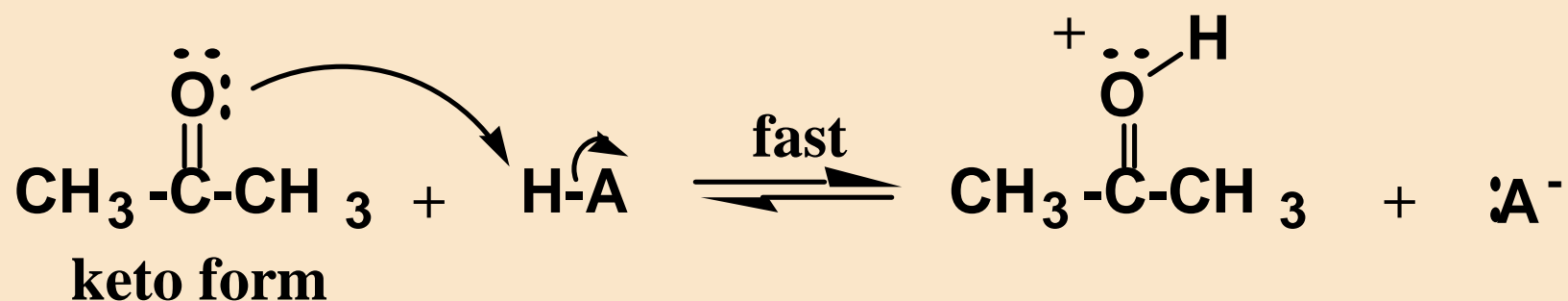


15-73

15 Keto-Enol Tautomerism

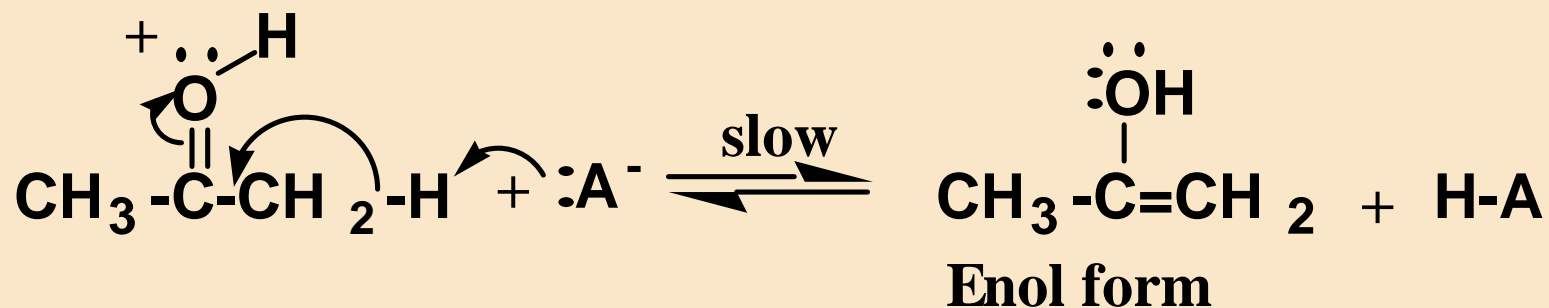
- u Acid-catalyzed equilibration of keto and enol tautomers occurs in two steps

Step 1: proton transfer to the carbonyl oxygen



15 Keto-Enol Tautomerism

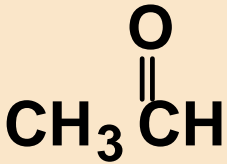
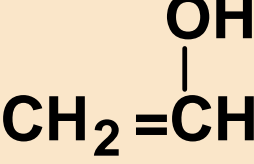
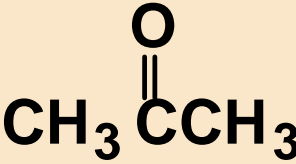
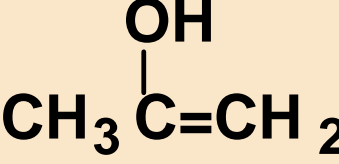
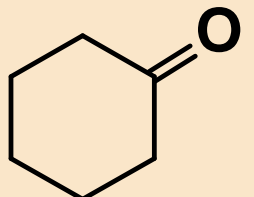
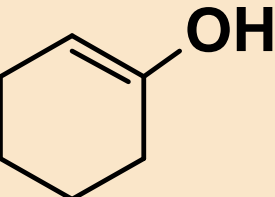
Step 2: proton transfer to A⁻ to give the enol



15-75

15 Keto-Enol Tautomerism

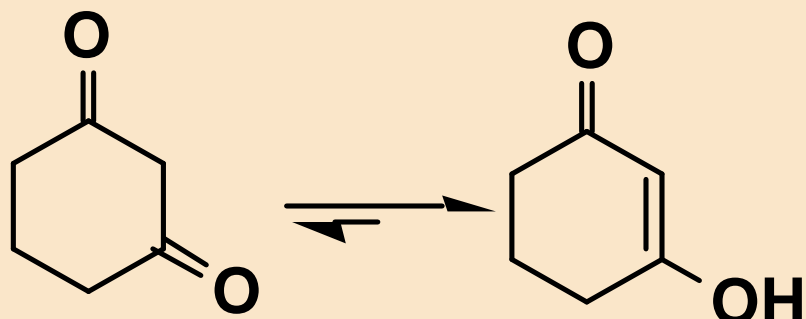
u Keto-enol equilibria for simple aldehydes and ketones lie far toward the keto form

Keto form	Enol form	% Enol at Equilibrium
		6×10^{-5}
		6×10^{-7}
		4×10^{-5}

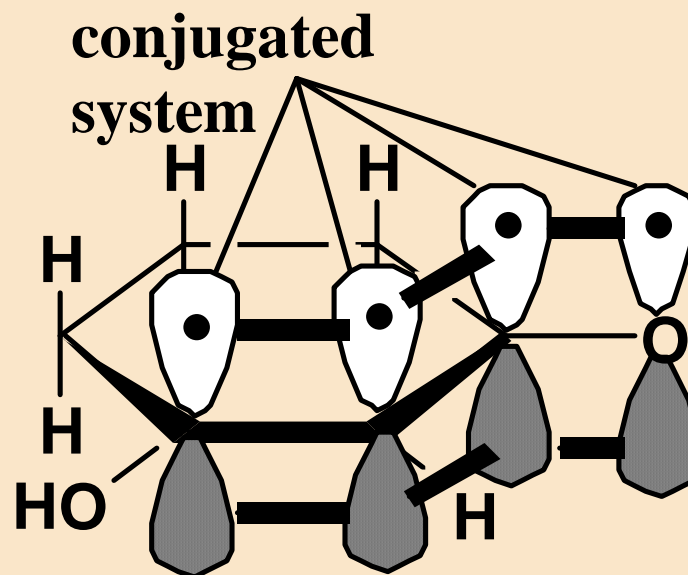
15-76

15 Keto-Enol Tautomerism

- u For certain types of molecules, however, the enol is the major form present at equilibrium
 - for β -diketones, the enol is stabilized by conjugation of the pi system of the carbon-carbon double bond and the carbonyl group



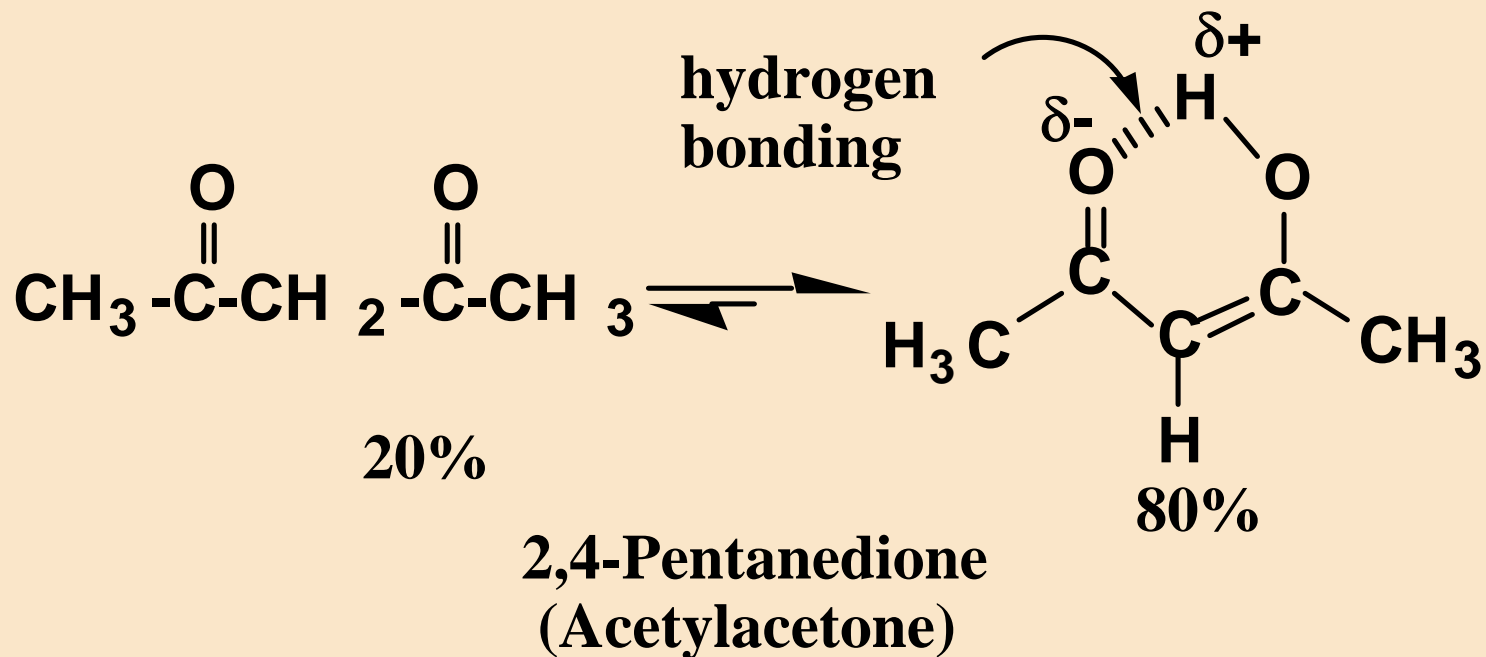
1,3-Cyclohex-
anedione



15-77

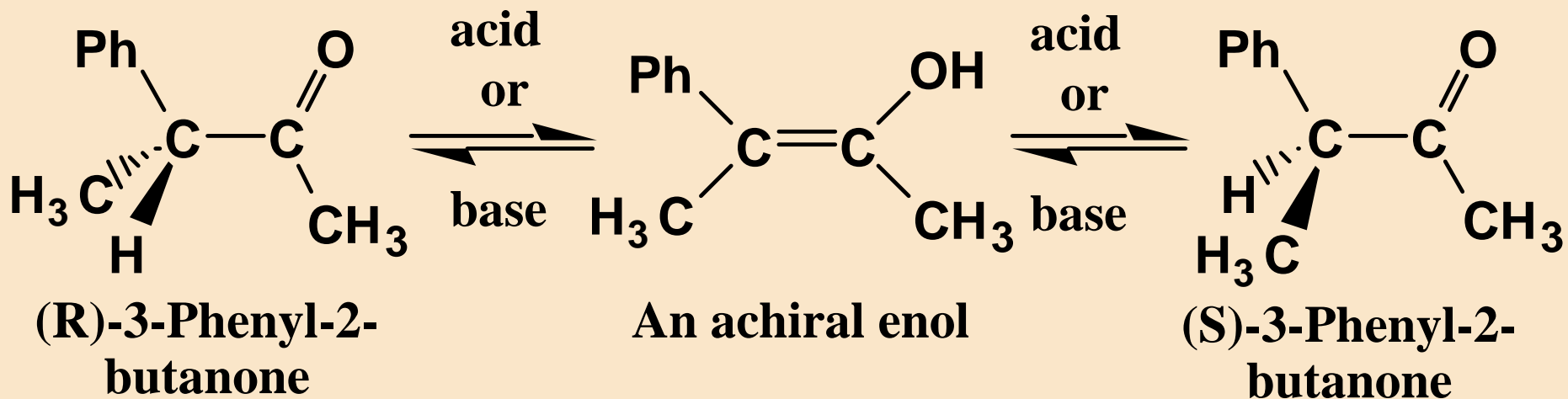
15 Keto-Enol Tautomerism

- u Open-chain β -diketones are further stabilized by intramolecular hydrogen bonding



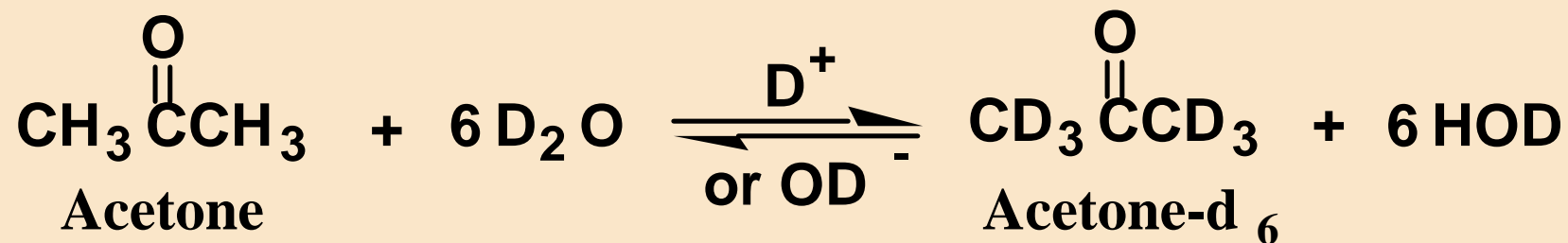
15 Racemization

- u Racemization at an α -carbon may be catalyzed by either acid or base



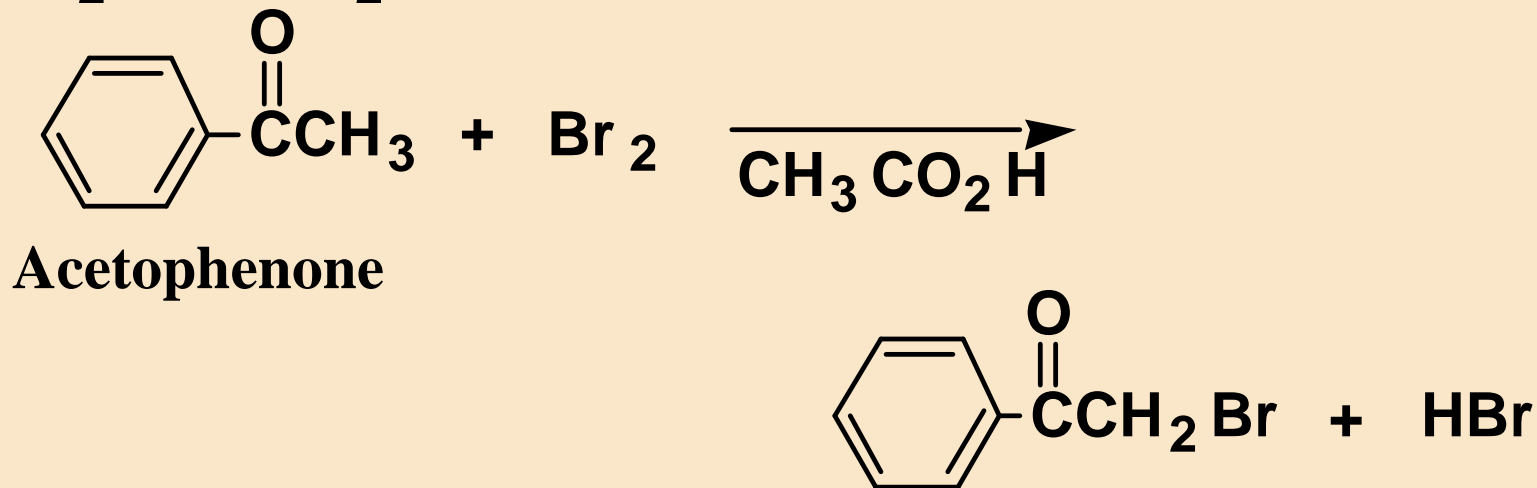
15 Deuterium Exchange

- u Deuterium exchange at an α -carbon may be catalyzed by either acid or base



15 α -Halogenation

- α -Halogenation: aldehydes and ketones with at least one α -hydrogen react at an α -carbon with Br_2 and Cl_2

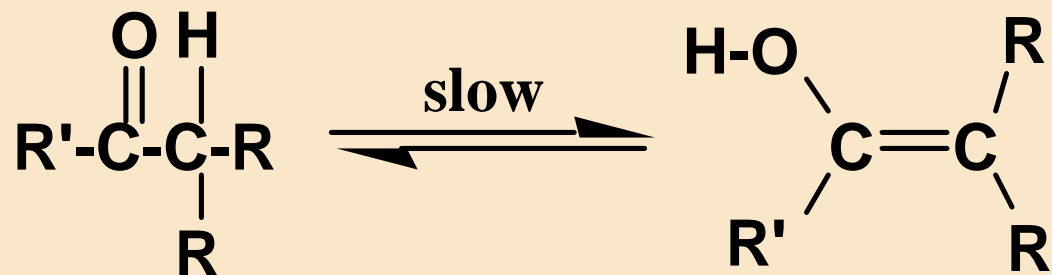


- reaction is catalyzed by both acid and base

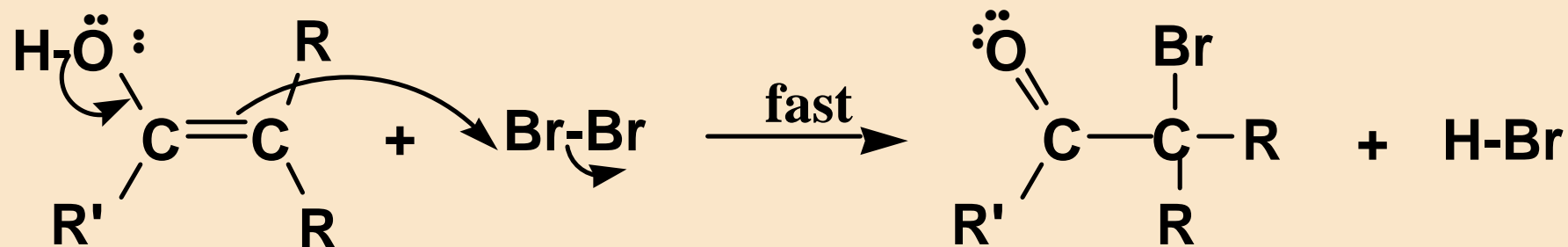
15 α -Halogenation

u Acid-catalyzed α -halogenation

Step 1: acid-catalyzed enolization



Step 2: Nucleophilic attack of the enol on halogen

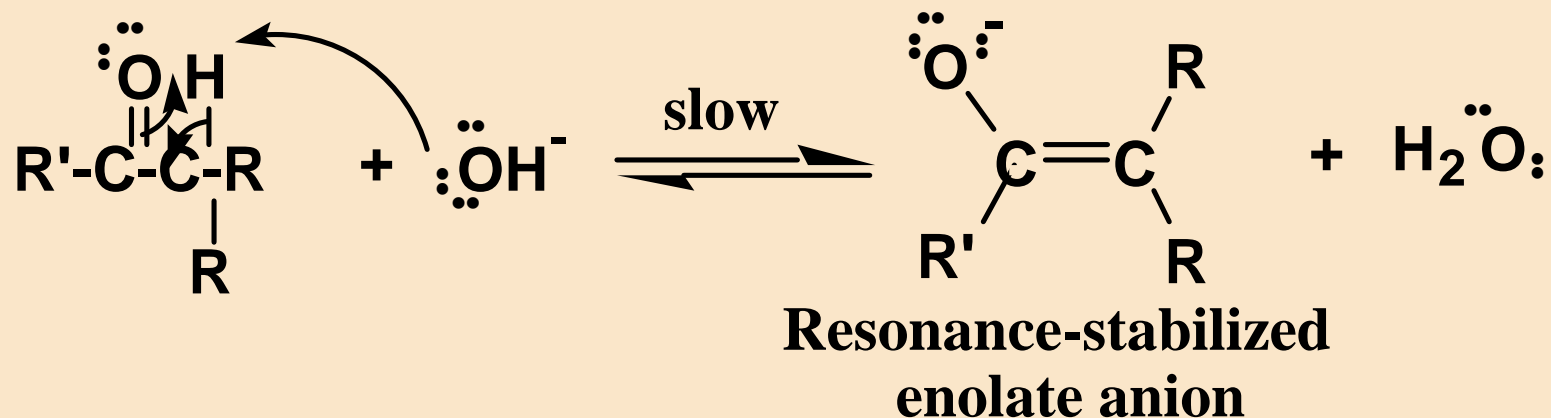


15-82

15 α -Halogenation

u Base-promoted α -halogenation

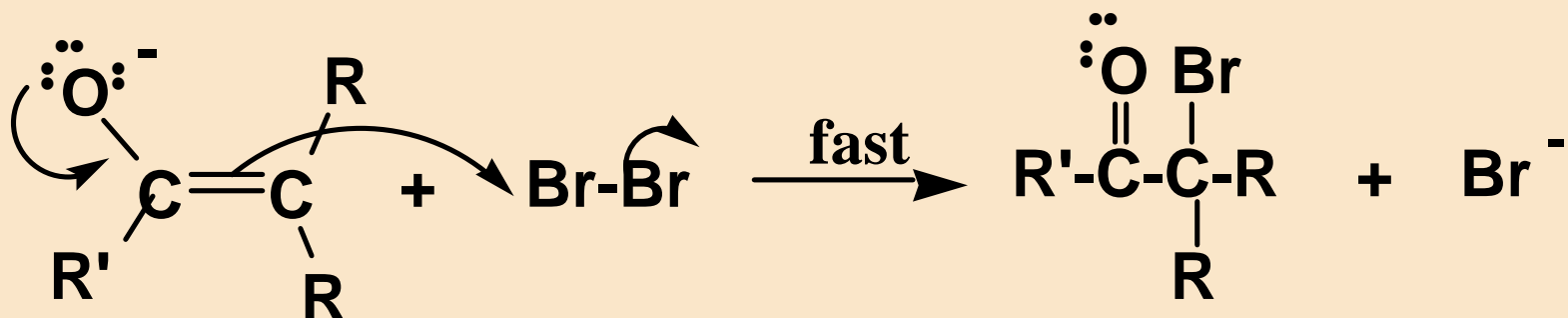
Step 1: formation of an enolate anion



15 α -Halogenation

u Base-promoted α -halogenation (contd.)

Step 2: nucleophilic attack of the enolate anion on halogen



15 α -Halogenation

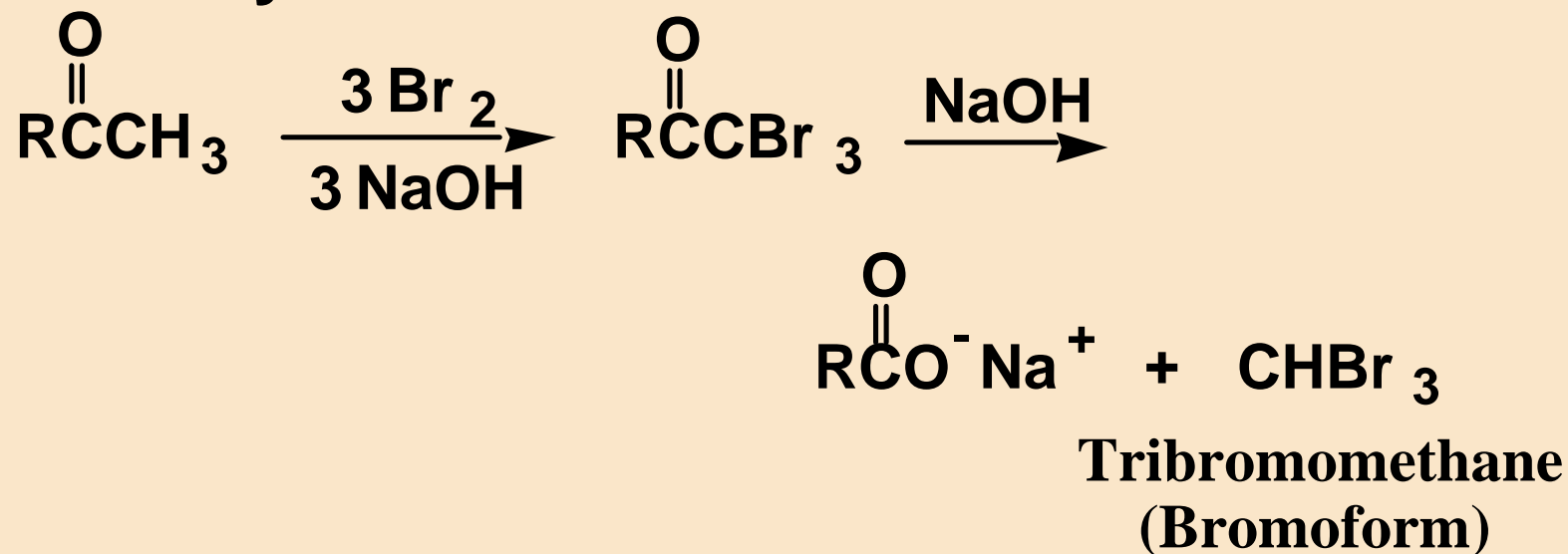
- u There is a major difference between acid-catalyzed and base-promoted α -halogenation
- u The rate of acid-catalyzed introduction of a second halogen is slower than the first
 - introduction of the electronegative halogen on the α -carbon decreases the basicity of the carbonyl oxygen toward protonation

15 α -Halogenation

- u For base-promoted α -halogenation, each successive halogenation is more rapid than the previous one
 - the introduction of the electronegative halogen on the α -carbon increases the acidity of the remaining α -hydrogens and, thus, each successive α -hydrogen is removed more rapidly than the previous one

15 Haloform Reaction

- u In the presence of base, a methyl ketone reacts with three equivalents of halogen to form a 1,1,1-trihaloketone, which then reacts with an additional mol of hydroxide ion to form a carboxylic salt and a trihalomethane

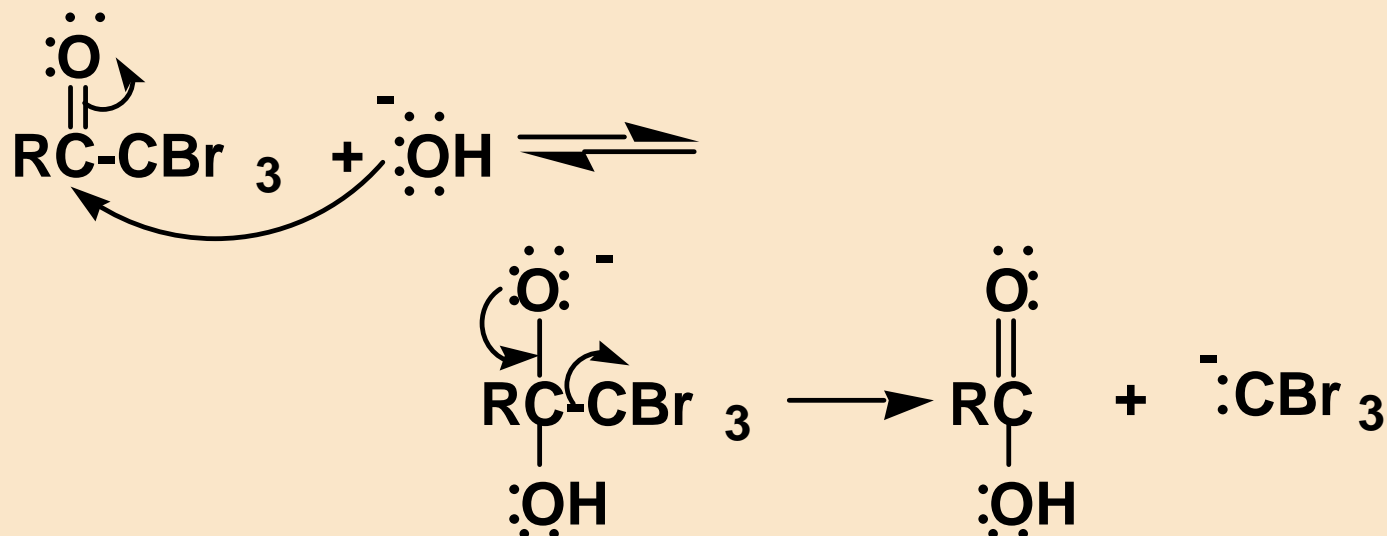


15-87

15 Haloform Reaction

- u The final stage is divided into two steps

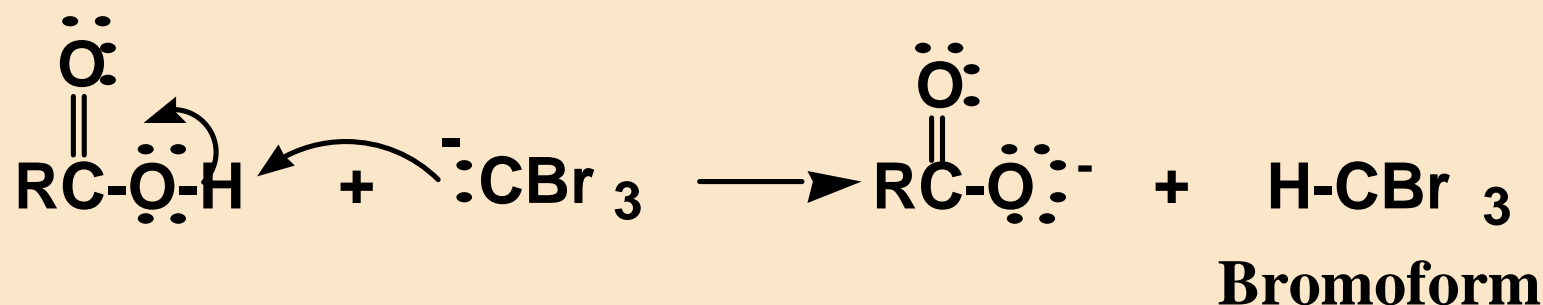
Step 1: addition of OH^- to the carbonyl group to form a tetrahedral carbonyl addition intermediate, followed by its collapse



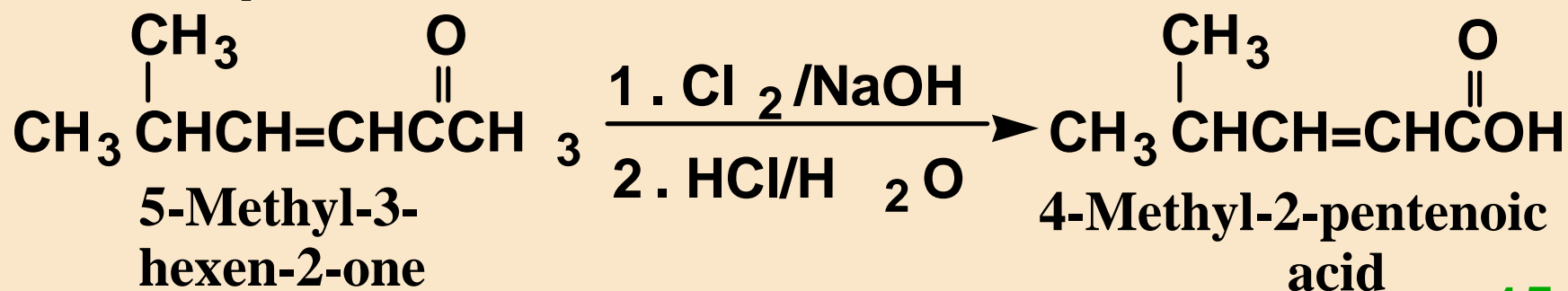
15-88

15 Haloform Reaction

Step 2: proton transfer from the carbonyl group to the haloform anion



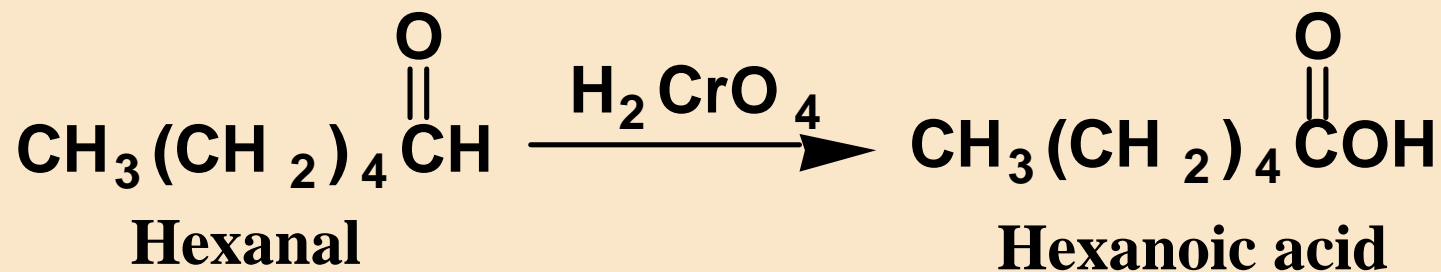
u Example:



15-89

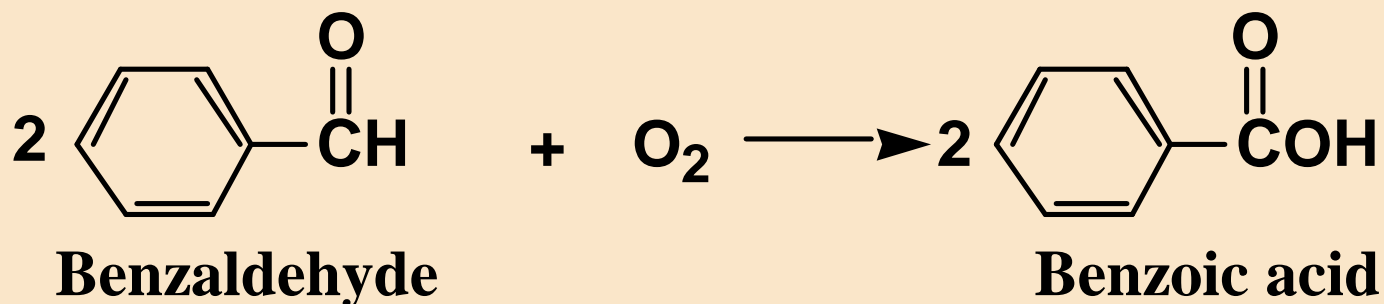
15 Oxidation of Aldehydes

- u Aldehydes are oxidized to carboxylic acids by a variety of oxidizing agents, including H_2CrO_4



15 Oxidation of Aldehydes

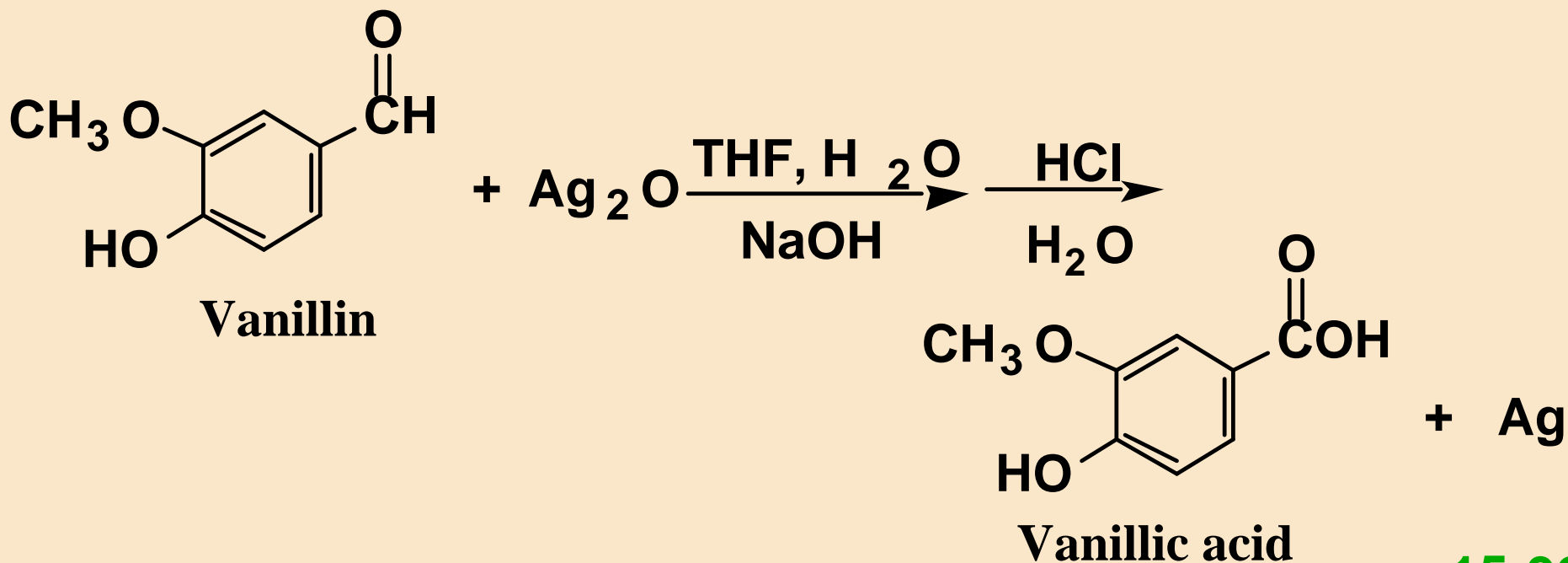
- u Aldehydes are oxidized by O_2 in a radical chain reaction
 - liquid aldehydes are so sensitive to air that they must be stored under N_2



15 Oxidation of Aldehydes

u Aldehydes are also oxidized by Ag(I)

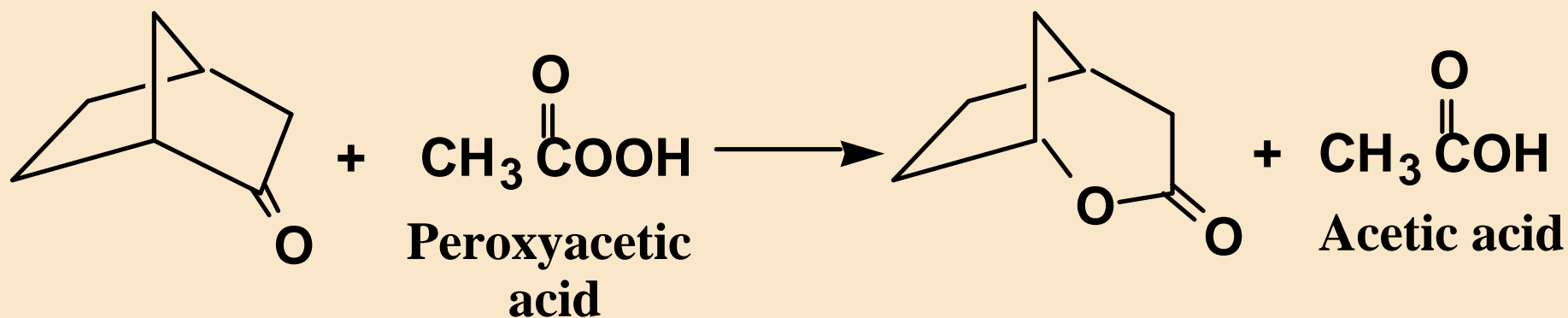
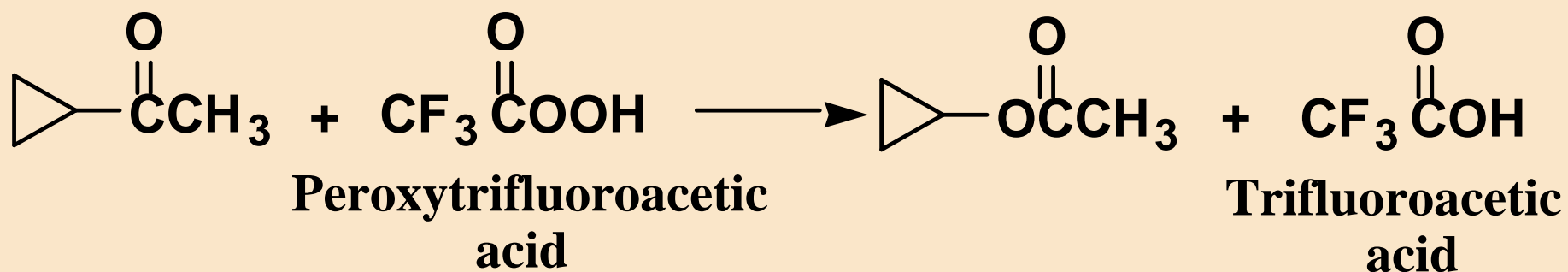
- in one method, a solution of the aldehyde in aqueous ethanol or THF is shaken with a slurry of silver oxide



15-92

15 Baeyer-Villiger Oxidation

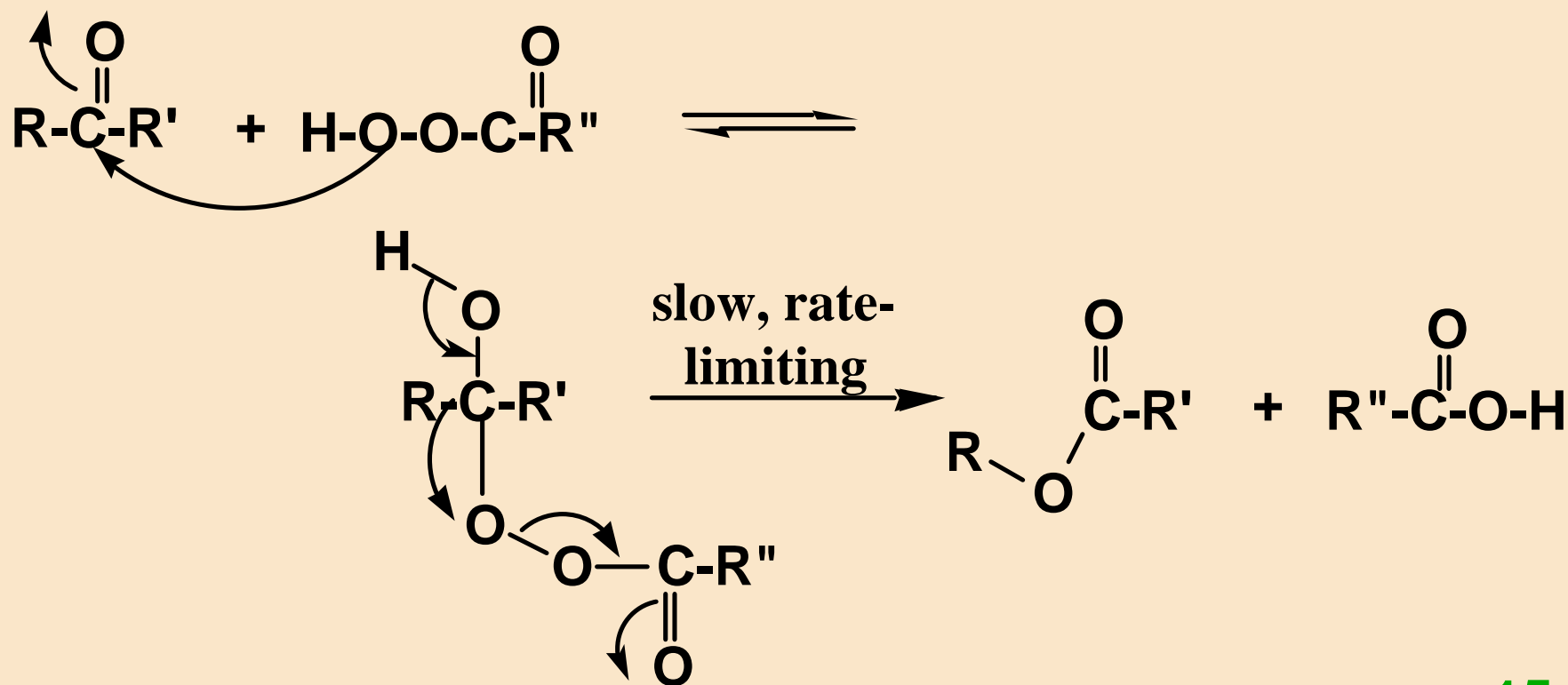
u Ketones are oxidized using peroxyacids



15-93

15 Baeyer-Villiger Oxidation

- u B-V oxidation involves formation and collapse of a tetrahedral carbonyl addition intermediate



15-94

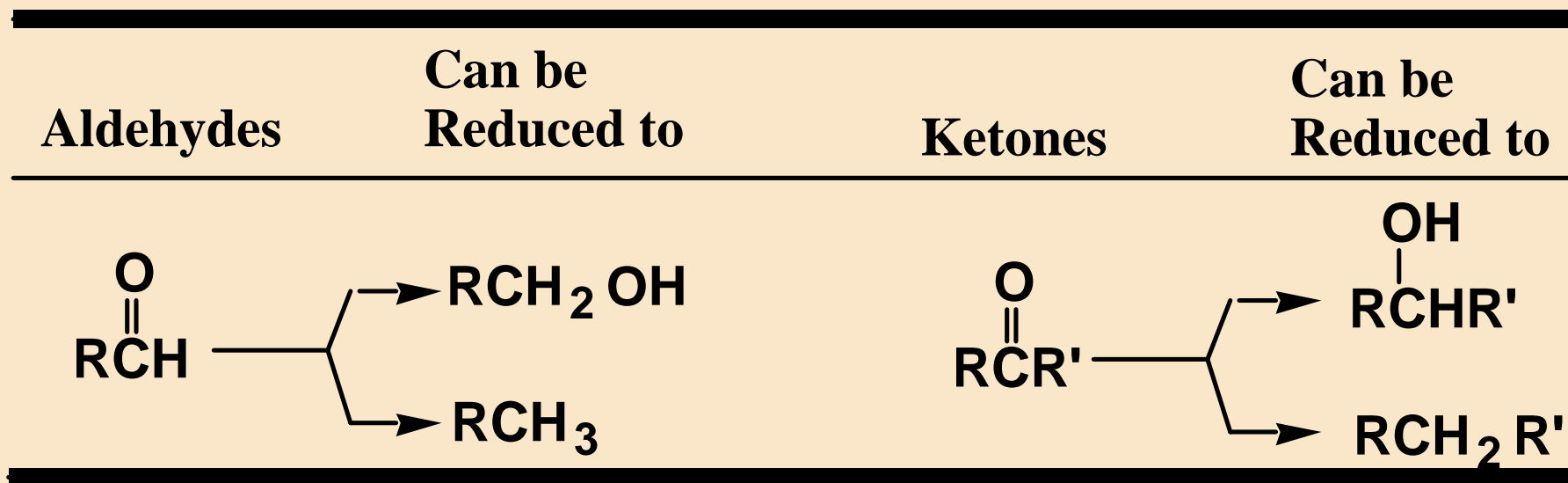
15 Baeyer-Villiger Oxidation

- u With symmetrical ketones, there is no ambiguity about which group migrates
- u With unsymmetrical ketones, the following migratory aptitudes are observed

3° alkyl > 2° alkyl, aryl > 1° alkyl > methyl

15 Reduction

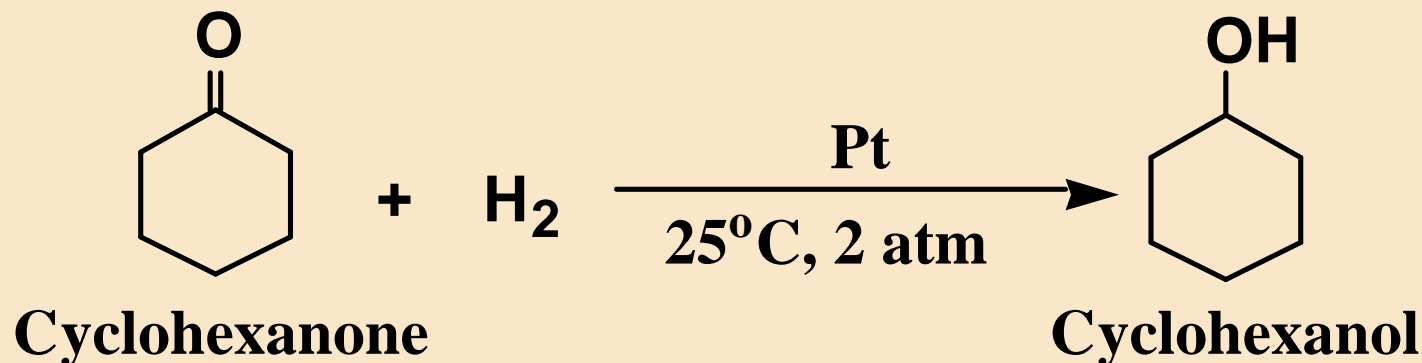
- u Aldehydes can be reduced to 1° alcohols and ketones to 2° alcohols. In addition, the C=O group can be reduced to a -CH₂- group



15-96

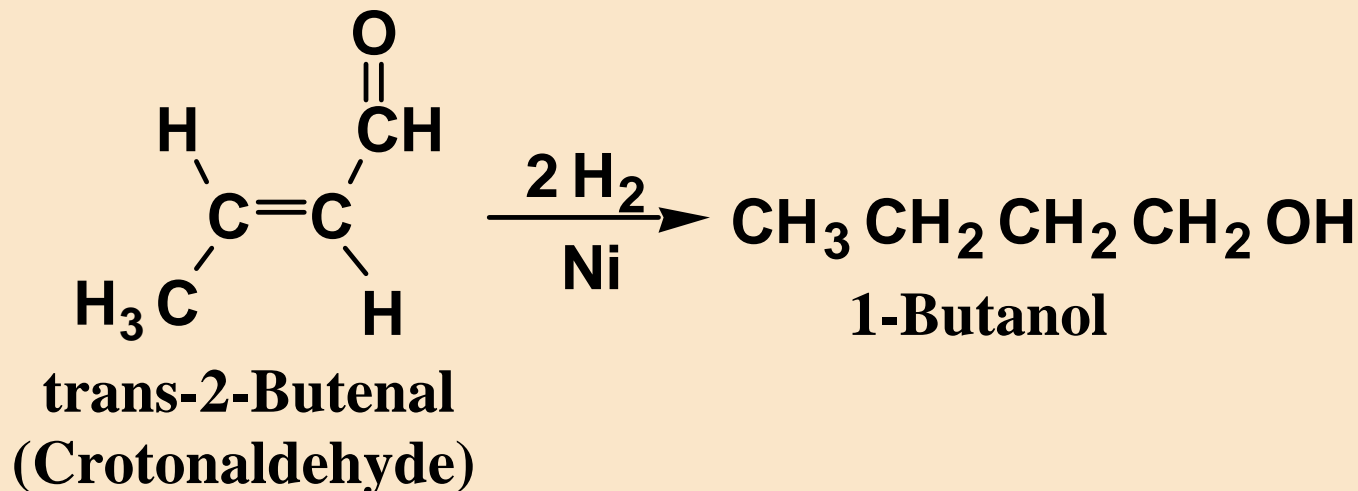
15 Catalytic Reduction

- u Catalytic reductions are generally carried out from 25° to 100°C and from 1 to 5 atm H₂



15 Catalytic Reduction

- u A carbon-carbon double bond may also be reduced under these conditions

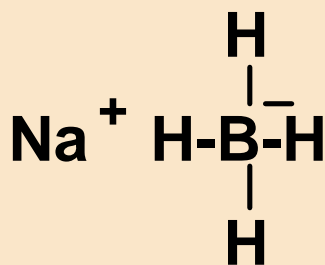


- by careful choice of experimental conditions, it is often possible to selectively reduce a carbon-carbon double in the presence of an aldehyde or ketone

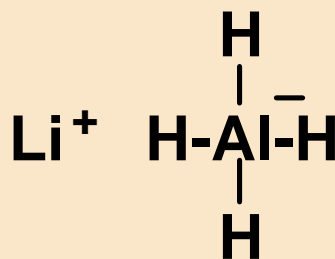
15-98

15 Metal Hydride Reduction

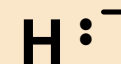
- u The most common laboratory reagents for the reduction of aldehydes and ketones are NaBH_4 and LiAlH_4
 - both reagents are sources of hydride ion, H^- , a very powerful nucleophile



Sodium
borohydride



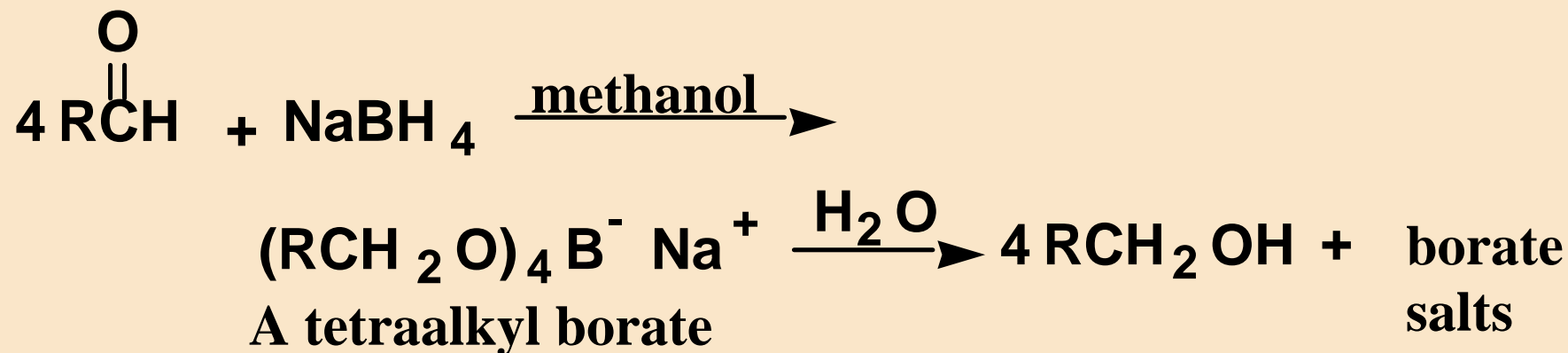
Lithium aluminum
hydride (LAH)



Hydride ion

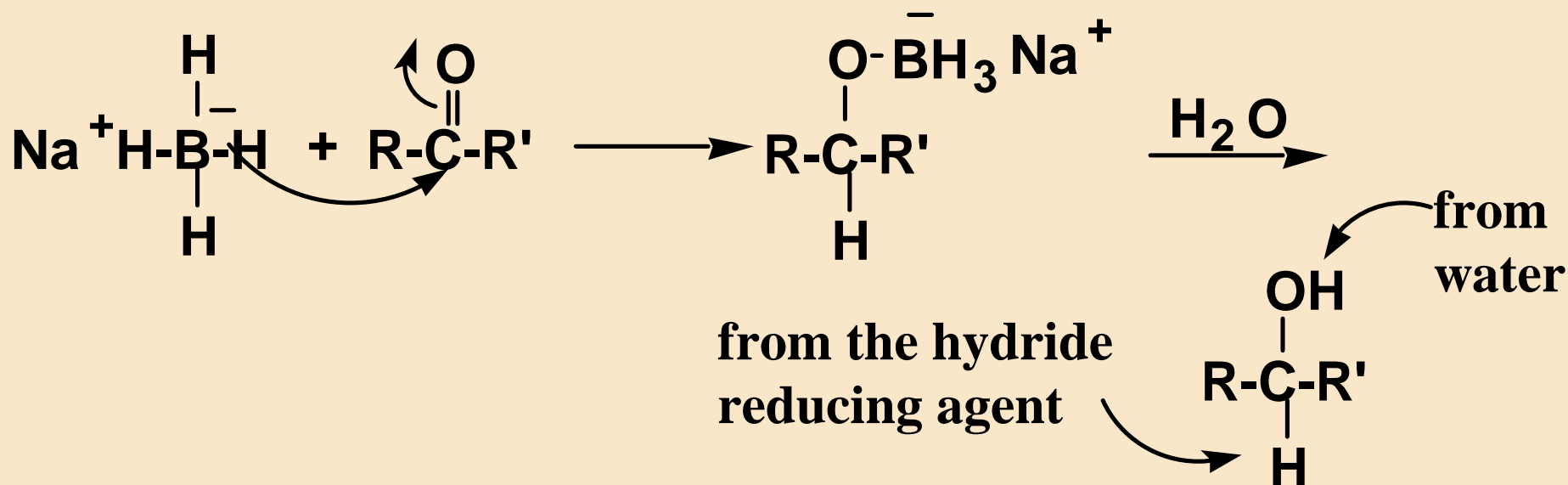
15 NaBH₄ Reduction

- u Reductions with NaBH₄ are most commonly carried out in aqueous methanol, in pure methanol, or in ethanol
- u One mol of NaBH₄ reduces four mol of aldehyde or ketone



15 NaBH₄ Reduction

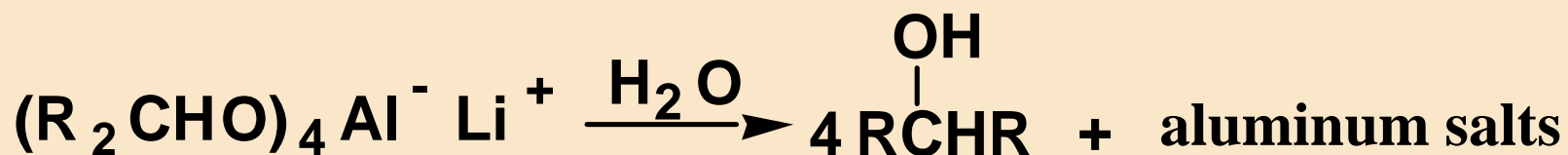
- The key step in metal hydride reduction is transfer of a hydride ion to the C=O group to form a tetrahedral carbonyl addition compound



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15 LiAlH_4 Reduction

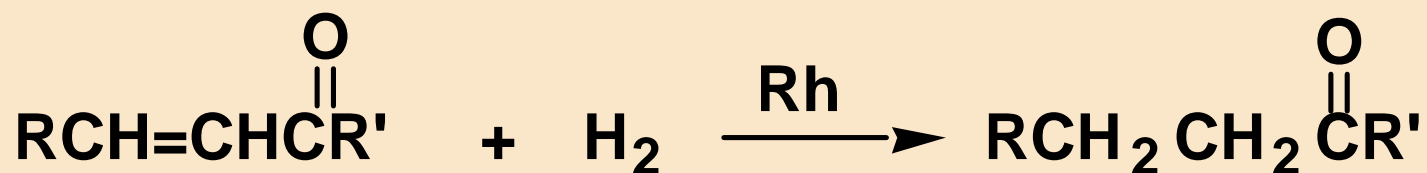
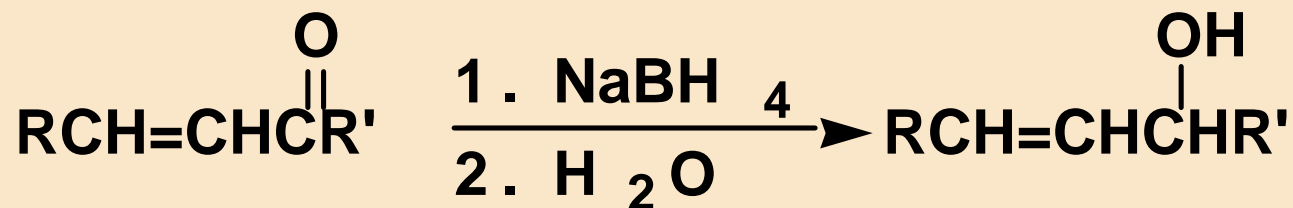
- u Unlike NaBH_4 , LiAlH_4 reacts violently with water, methanol, and other protic solvents. Reductions using it are carried out in diethyl ether or tetrahydrofuran (THF)



A tetraalkyl aluminate

15 Metal Hydride Reduction

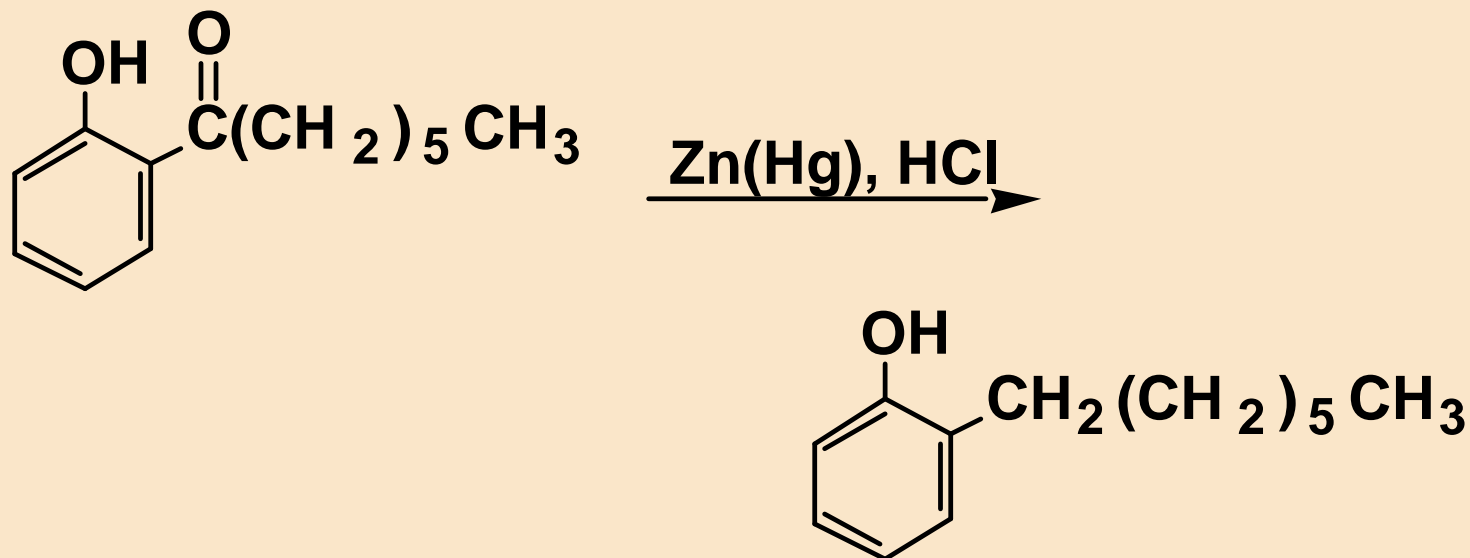
- u Metal hydride reducing agents do not normally reduce carbon-carbon double bonds, and selective reduction of C=O or C=C is often possible



15-103

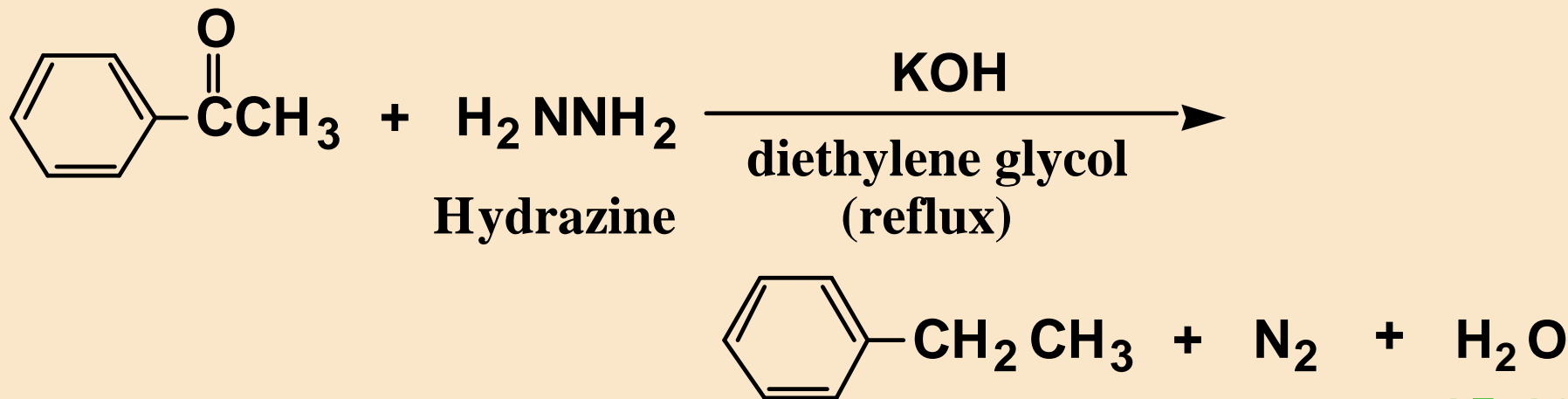
15 Clemmensen Reduction

- u Refluxing an aldehyde or ketone with amalgamated zinc in concentrated HCl converts the carbonyl group to a methylene group



15 Wolff-Kishner Reduction

- u In the original procedure, the aldehyde or ketone and hydrazine are refluxed with KOH in a high-boiling solvent. The same reaction can be brought about using hydrazine and potassium tert-butoxide in DMSO



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15

Aldehydes & Ketones

End Chapter 15

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