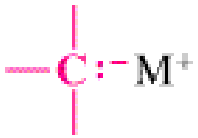
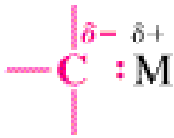
Organometallic Compounds: Alkyllithium Reagent

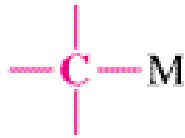
Compounds that contain **carbon-metal bonds** are called **organometallic compounds**.



Primarily ionic
(M = Na^+ or K^+)



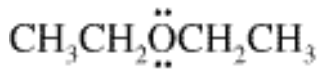
(M = Mg or Li)



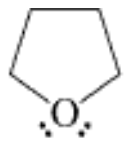
Primarily covalent
(M = Pb, Sn, Hg, or Tl)

$$\mathrm{R{-}X + 2\ Li \xrightarrow{Et_2O} RLi + LiX}$$

(or Ar—X) **(or ArLi)**



Diethyl ether
(Et_2O)



Tetrahydrofuran
(THF)

$$\mathrm{CH_3CH_2CH_2CH_2Br + 2\ Li \xrightarrow[Et_2O]{-10^\circ C} CH_3CH_2CH_2CH_2Li + LiBr}$$

Butyl bromide **Butyllithium (80–90%)**

Organometallic Compounds: Grignard Reagent

Victor Grignard
Nobel Prize (1912)

$$RX + Mg \xrightarrow{Et_2O} RMgX$$

$$ArX + Mg \xrightarrow{Et_2O} ArMgX$$

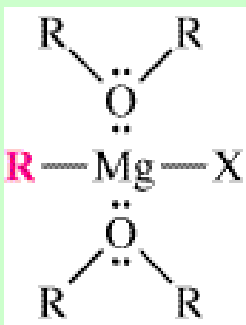
Grignard reagents

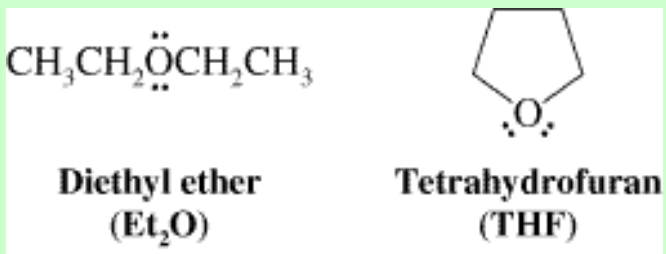
$$CH_3I + Mg \xrightarrow[35°C]{Et_2O} CH_3MgI$$

Methylmagnesium iodide (95%)

$$C_6H_5Br + Mg \xrightarrow[35°C]{Et_2O} C_6H_5MgBr$$

Phenylmagnesium bromide (95%)

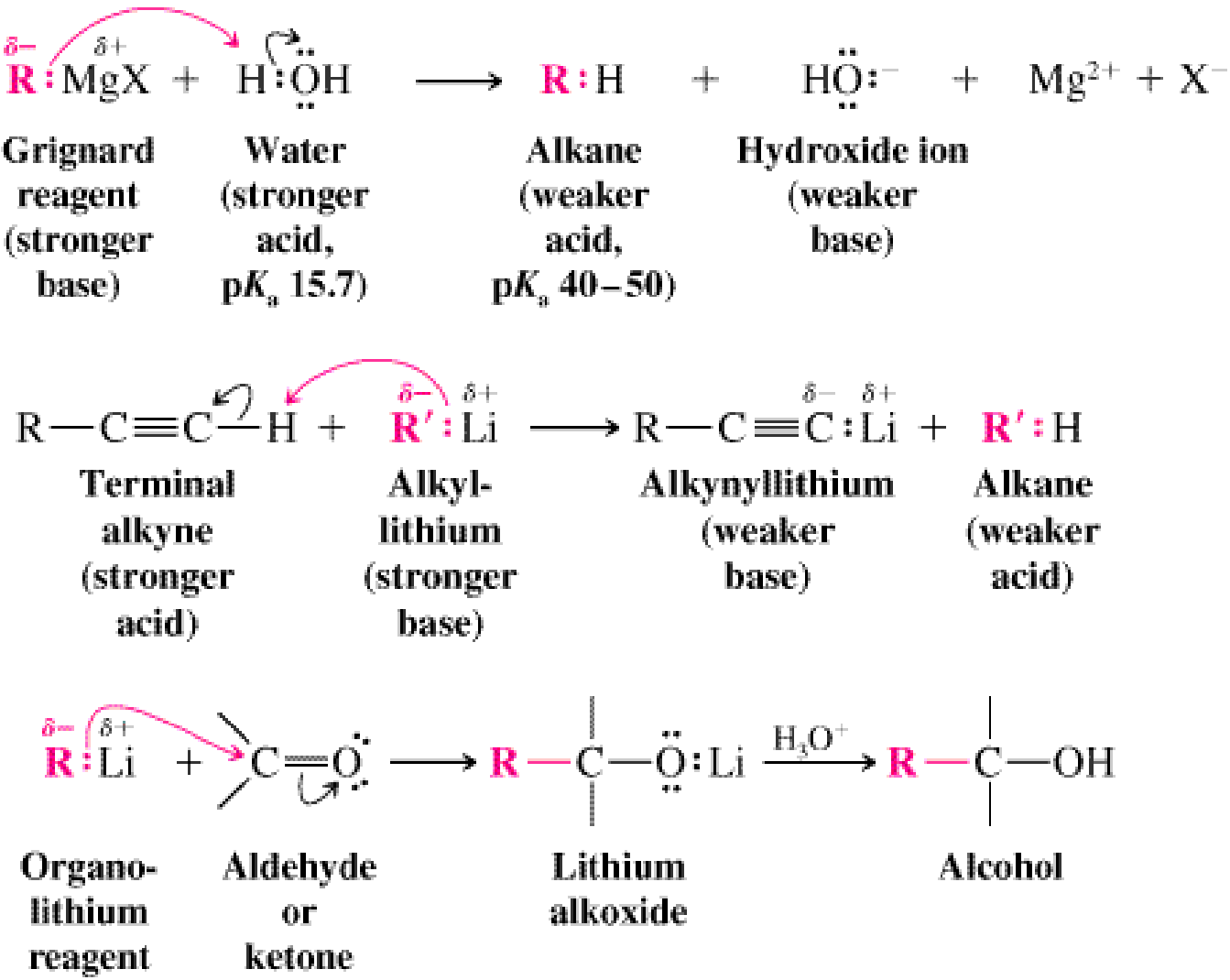




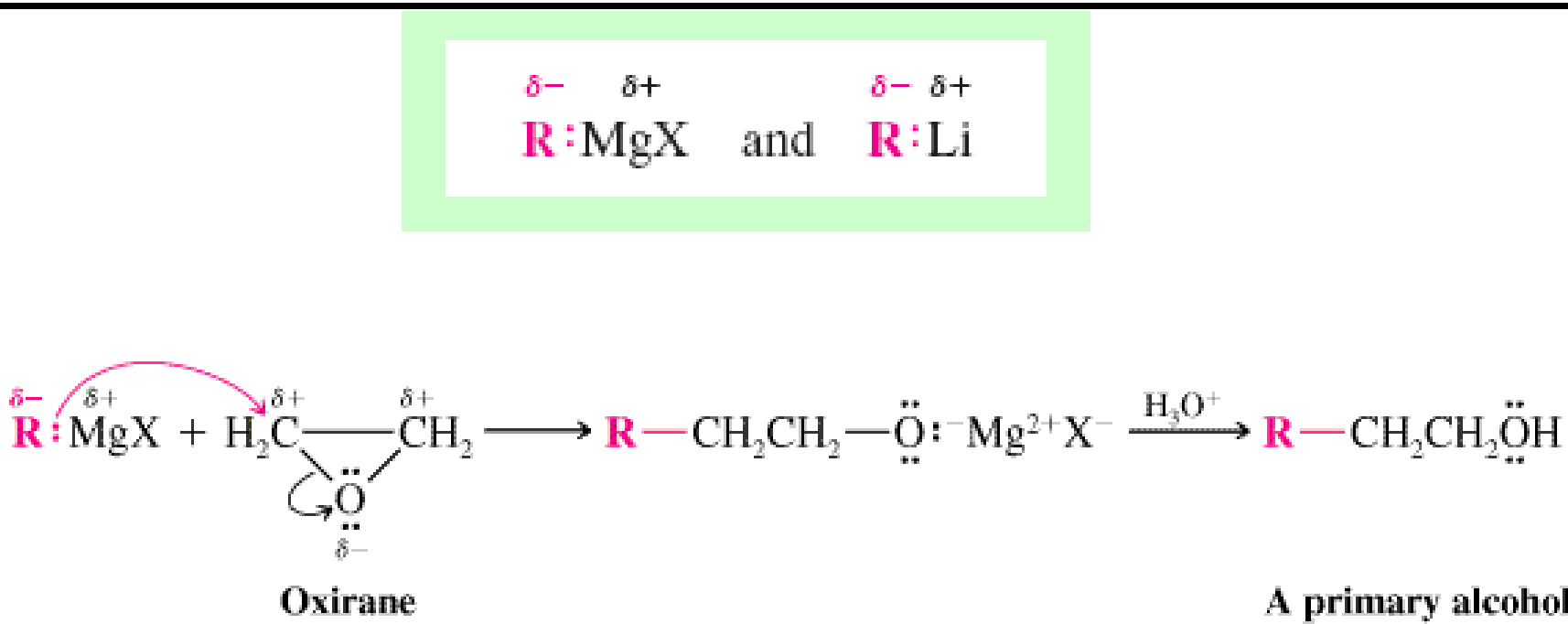
Diethyl ether (Et_2O)

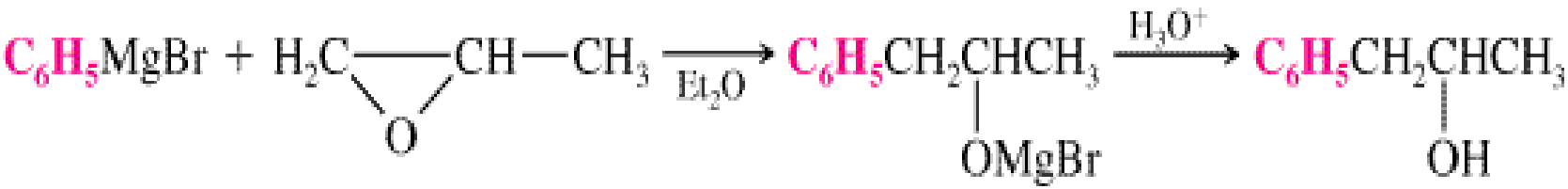
Tetrahydrofuran (THF)

RLi and RMgX as Strong Bases/Nucleophiles

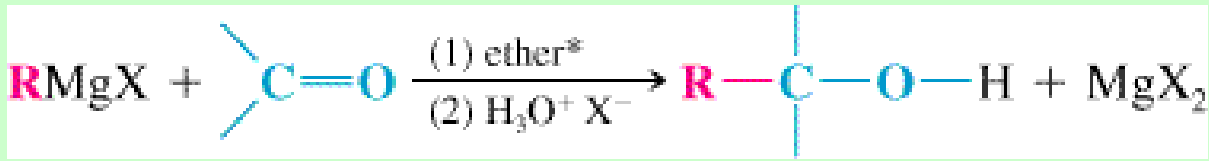


Reactions of RMgX with Epoxides

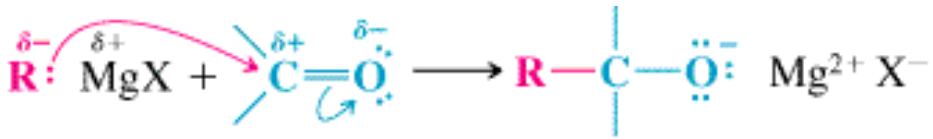




Reactions of RMgX with Carbonyl Groups



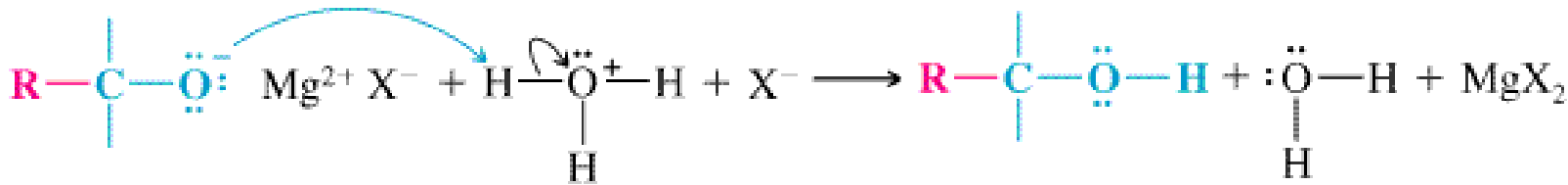
Step 1



Grignard reagent | **Carbonyl compound** | **Halomagnesium alkoxide**

The strongly nucleophilic Grignard reagent uses its electron pair to form a bond to the carbon atom. One electron pair of the carbonyl group shifts out to the oxygen. This reaction is a nucleophilic addition to the carbonyl group, and it results in the formation of an alkoxide ion associated with Mg^{2+} and X^-.

Step 2

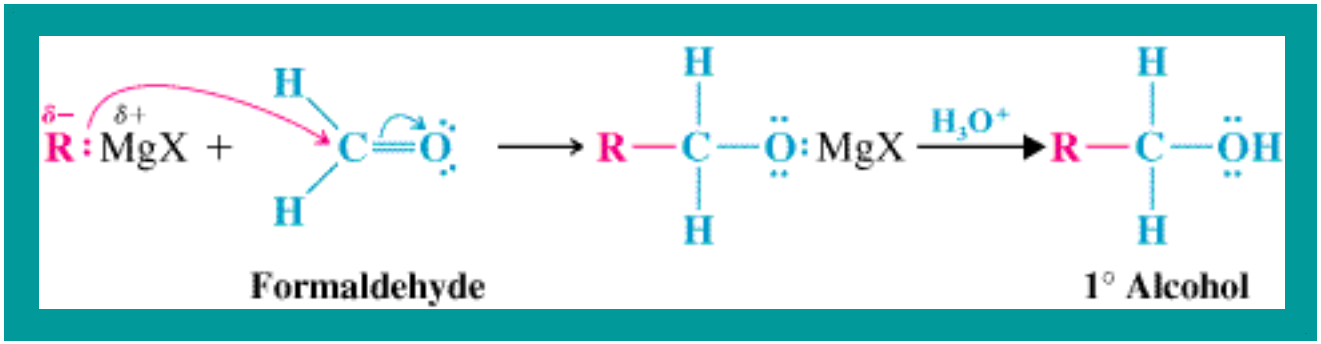


Halomagnesium alkoxide | **Alcohol**

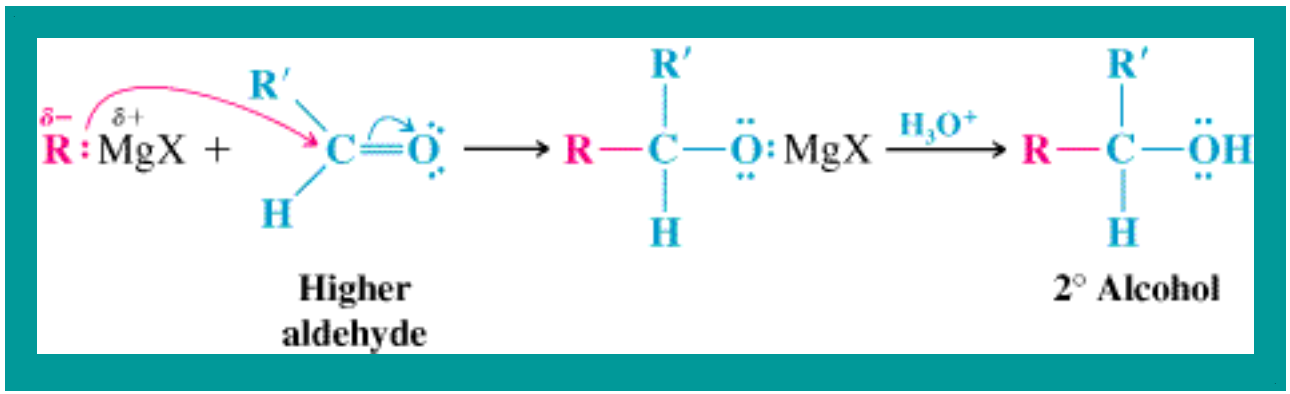
In the second step, the addition of aqueous HX causes protonation of the alkoxide ion; this leads to the formation of the alcohol and MgX_2.

Alcohols from Carbonyls and Grignard Reagents

Grignard reagents react with formaldehyde to give a primary alcohol



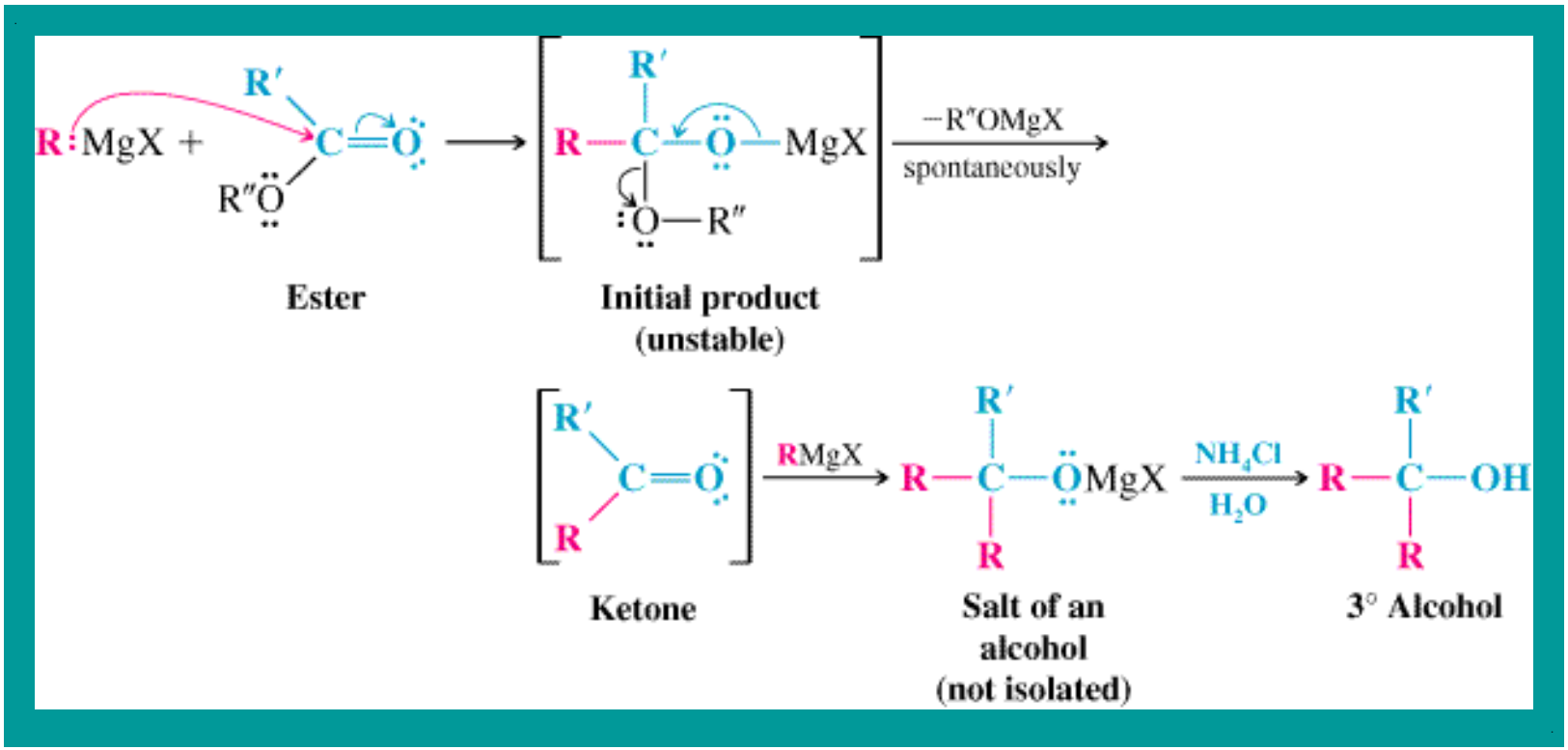
Grignard reagents react with all other aldehydes to give secondary alcohols

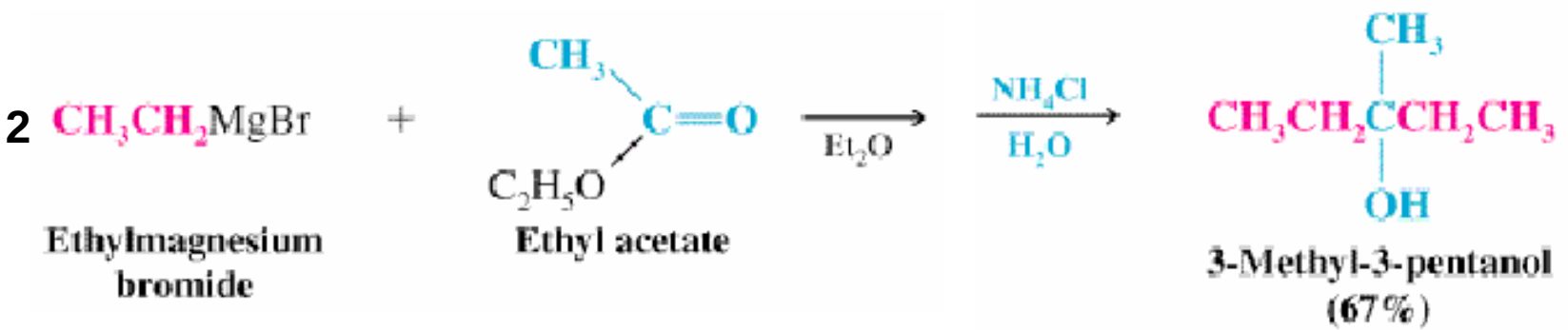


Grignard reagents react with ketones to give tertiary alcohols

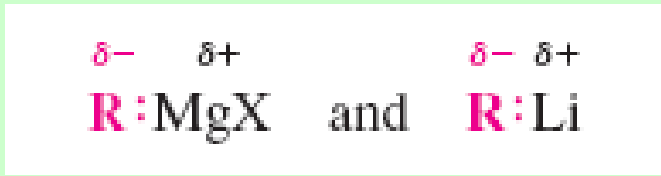
Alcohols from Carbonyls and Grignard Reagents

Esters react with two molecules of Grignard reagents to form *tert*-alcohols

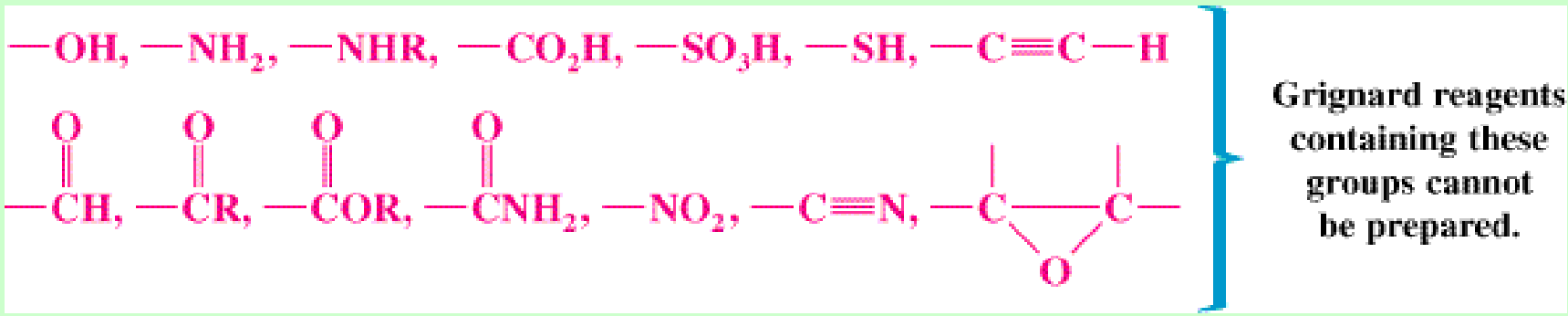


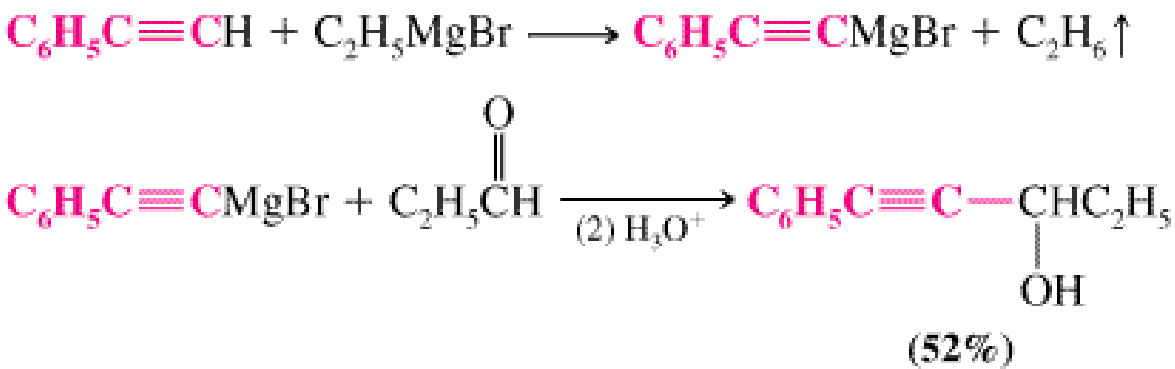


Restrictions on the Use of Grignard Reagents

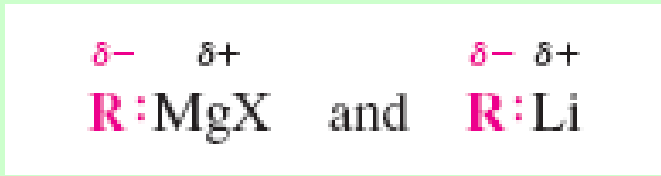


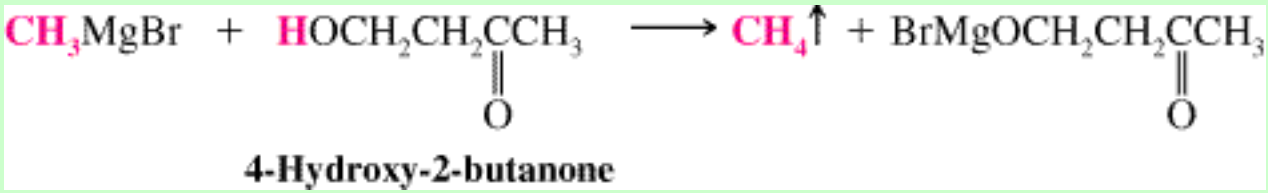
The Grignard reagent is a very powerful base/nucleophile. Thus, it is not possible to prepare a Grignard reagent from an organic group that contains an acidic hydrogen (any hydrogen more acidic than the hydrogen atoms of an alkane or alkene).

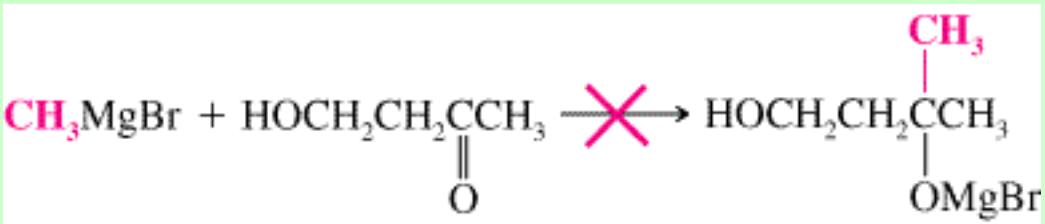


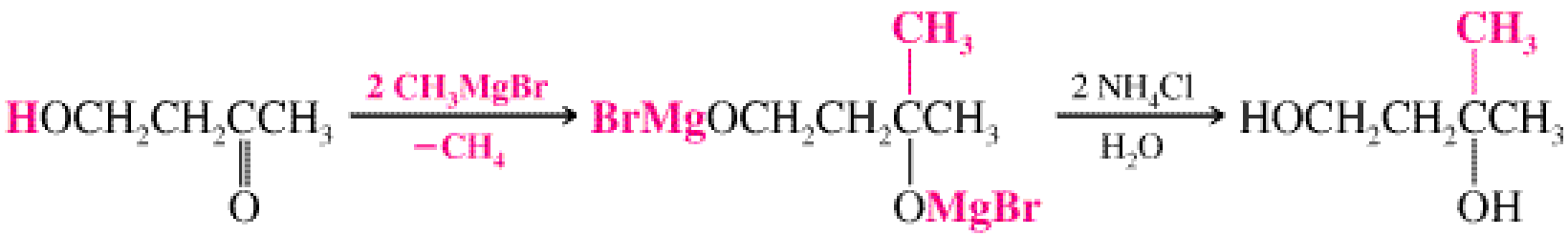


Restrictions on the Use of Grignard Reagents

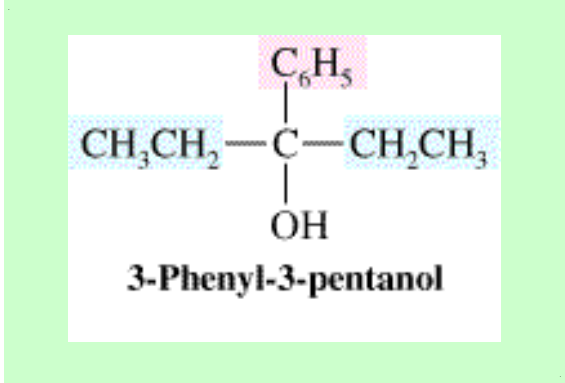








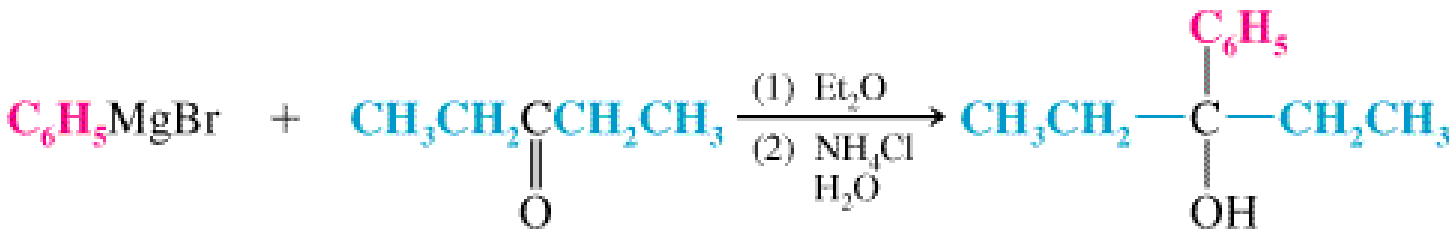
Synthetic Plans Based on Grignard Reaction



3-Phenyl-3-pentanol

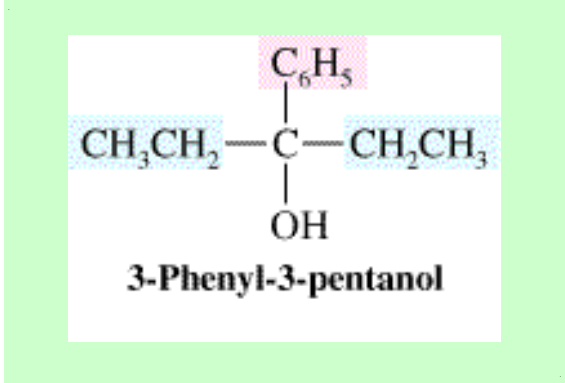
Retrosynthetic Analysis

Synthesis



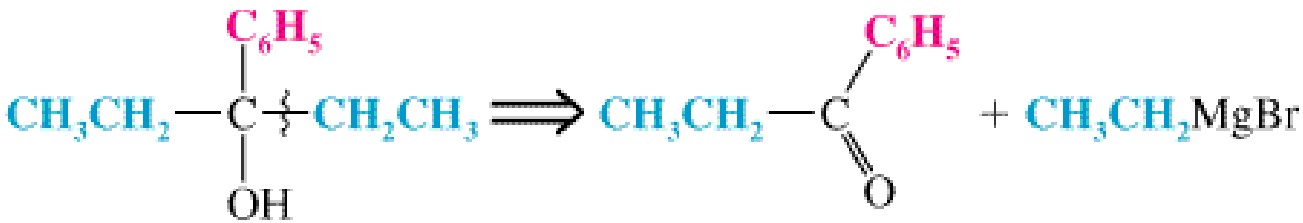
Phenylmagnesium bromide | **3-Pentanone** | **3-Phenyl-3-pentanol**

Synthetic Plans Based on Grignard Reaction

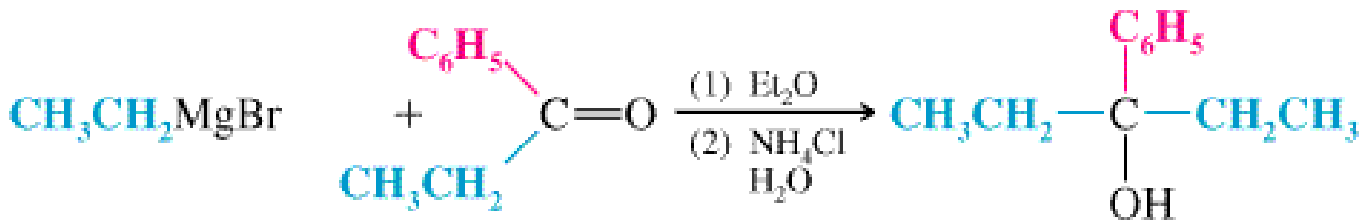


3-Phenyl-3-pentanol

Retrosynthetic Analysis



Synthesis

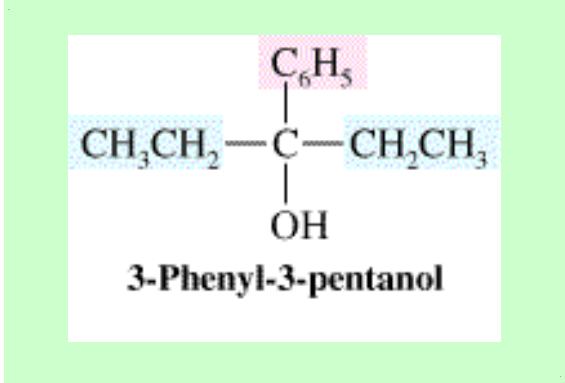


Ethylmagnesium bromide

Ethyl phenyl ketone

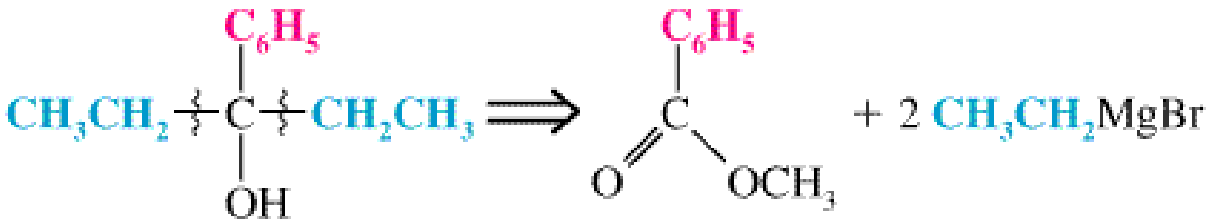
3-Phenyl-3-pentanol

Synthetic Plans Based on Grignard Reaction

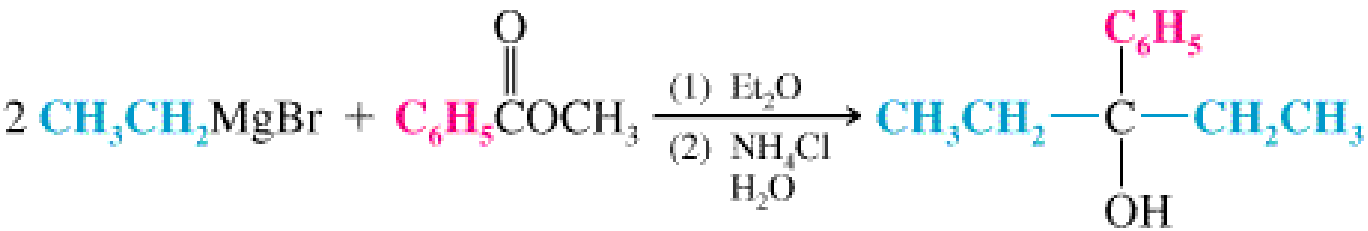


3-Phenyl-3-pentanol

Retrosynthetic Analysis



Synthesis



Ethylmagnesium bromide **Methyl benzoate** **3-Phenyl-3-pentanol**