If a compound has more than one functional group, the one(s) with the lower priority is indicated by its prefix:

Table 18.1 Summary of Functional Group Nomenclature

<table>
<thead>
<tr>
<th>Class</th>
<th>Suffix name</th>
<th>Prefix name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carboxylic acid</td>
<td>-oic acid</td>
<td>Carboxy</td>
</tr>
<tr>
<td>Ester</td>
<td>-oate</td>
<td>Alkoxy carbonyl</td>
</tr>
<tr>
<td>Amide</td>
<td>-amide</td>
<td>Amido</td>
</tr>
<tr>
<td>Nitrile</td>
<td>-nitrile</td>
<td>Cyano</td>
</tr>
<tr>
<td>Aldehyde</td>
<td>-al</td>
<td>Oxo ((\equiv O))</td>
</tr>
<tr>
<td>Aldehyde</td>
<td>-al</td>
<td>Formyl ((\text{CH}\equiv\text{O}))</td>
</tr>
<tr>
<td>Ketone</td>
<td>-one</td>
<td>Oxo ((\equiv O))</td>
</tr>
<tr>
<td>Alcohol</td>
<td>-ol</td>
<td>Hydroxy</td>
</tr>
<tr>
<td>Amine</td>
<td>-amine</td>
<td>Amino</td>
</tr>
<tr>
<td>Alkene</td>
<td>-ene</td>
<td>Alkenyl</td>
</tr>
<tr>
<td>Alkyne</td>
<td>-yne</td>
<td>Alkynyl</td>
</tr>
<tr>
<td>Alkane</td>
<td>-ane</td>
<td>Alkyl</td>
</tr>
<tr>
<td>Ether</td>
<td>—</td>
<td>Alkoxy</td>
</tr>
<tr>
<td>Alkyl halide</td>
<td>—</td>
<td>Halo</td>
</tr>
</tbody>
</table>
Naming for compounds with multiple functional groups -- examples

systematic name: 4-oxopentanal

methyl 3-oxobutanoate

2-(3-oxopentyl)-cyclohexanone
Compounds with more than one functional group

3-hydroxybutanal

methyl 5-oxopentanoate

ethyl 4-formylhexanoate

3-pentenal
Reactions for ketones/aldehydes:
relative reactivities

most reactive

formaldehyde

an aldehyde

a ketone

least reactive

[Chemical structures and reactions described here]
Steric effect:

relative reactivities

$\text{most reactive}$

$\text{least reactive}$
relative reactivities of carbonyl compounds

acyl halide > acid anhydride > aldehyde > ketone > ester ~ carboxylic acid > amide > carboxylate ion

most reactive

least reactive
Reactions you have learned from Ch17:

\[ \text{O} \text{C}_{\text{R}} \text{Y} + \text{Z}^- \overset{\text{product of nucleophilic substitution}}{\rightleftharpoons} \text{R}_{\text{C}} \text{Y} \overset{\text{a group that can be replaced by another group}}{\rightleftharpoons} \text{O} \text{C}_{\text{R}} \text{Z}^- + \text{Y}^- \]
Reactions for ketone/aldehyde – type I:

A nucleophile that is a strong base

The reaction is irreversible because Z is too basic to be expelled

Product of nucleophilic addition
Reactions for ketone/aldehyde - type II:

A nucleophile that is a relatively weak base

The reaction is reversible because Z can be expelled

Product of nucleophilic addition
Reactions for ketone/aldehyde - type III:

product of nucleophilic addition

\[ \text{OH} \quad \text{R} - \text{C} - \text{R}' \quad \overset{\text{HB}^+}{\leftrightarrow} \quad \text{H} + \text{OH} \]

water is expelled

\[ \text{R} - \text{C} - \text{R}' \quad \overset{\text{HB}^+}{\leftrightarrow} \quad \text{R}_2\text{C} = \text{R}' \quad + \quad \text{H}_2\text{O} \]

the nucleophile has a lone pair

product of nucleophilic addition–elimination
Grignard reagents

\[
\text{CH}_3\text{CH}_2\text{Br} \xrightarrow{\text{Mg, Et}_2\text{O}} \text{CH}_3\text{CH}_2\text{MgBr}
\]

\[
\text{CH}_3\text{CH}_2\text{MgBr} \quad \text{reacts as if it were} \quad \text{CH}_3\tilde{\text{C}}\text{H}_2 \quad \text{MgBr}^+
\]
Reaction of an aldehyde with a Grignard reagent

\[
\begin{align*}
\text{propanal} + \text{propylmagnesium bromide} & \rightarrow \text{3-hexanol} \\
\text{a secondary alcohol}
\end{align*}
\]
Reaction of a ketone with a Grignard reagent

2-pentanone + ethylmagnesium bromide → \( \text{product} \) (3-methyl-3-hexanol)

\( \text{CH}_3\text{C}^\text{\cdot}\text{\cdot} - \text{CH}_2\text{CH}_2\text{CH}_3 \) + \( \text{CH}_3\text{CCH}_2\text{CH}_2\text{CH}_3 \text{MgBr} \) → \( \text{CH}_3\text{CCH}_2\text{CH}_2\text{CH}_3 \text{CH}_2\text{CH}_3 \) (product)
Grignard reagents could contain alkyl or aryl group.

3-pentanone

\[
\text{CH}_3\text{CH}_2\text{C} = \text{CH}_2\text{CH}_3 \\
\text{1. CH}_3\text{MgBr} \\
\text{2. H}_3\text{O}^+ \\
\text{CH}_3\text{CH}_2\text{CCH}_2\text{CH}_3
\]

3-methyl-3-pentanol

butanal

\[
\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3 \\
\text{1. Phenyl-MgBr} \\
\text{2. H}_3\text{O}^+ \\
\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}
\]

1-phenyl-1-butanol
Reactions of CO$_2$ with Grignard reagents
-- preparation of carboxylic acids

\[
\text{carbon dioxide} + \text{propylmagnesium bromide} \rightarrow \text{butanoic acid}
\]
Reaction of an ester with a Grignard reagent

An ester $\text{RC(\text{O})\text{OCH}_3}$ reacts with a Grignard reagent $\text{CH}_3\text{MgBr}$ to produce a ketone $\text{RC(\text{CH}_3)}\text{CH}_3$ and an alcohol $\text{CH}_3\text{OH}$. A group is expelled from the tetrahedral intermediate, resulting in a tertiary alcohol $\text{RC(\text{CH}_3)}\text{CH}_3\text{CH}_3$. The product of nucleophilic acyl substitution is also indicated.
Reactions of acyl chlorides with Grignard reagents

\[
\begin{align*}
\text{CH}_3\text{CH}_2\text{CH}_2\text{Cl} & \quad \text{butyryl chloride} \\
\text{1. } 2\text{ CH}_3\text{CH}_2\text{MgBr} & \quad \rightarrow \\
\text{2. } \text{H}_3\text{O}^+ & \quad \rightarrow \\
\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{C(\text{CH}_2\text{CH}_3)\text{OH}} & \quad \text{3-ethyl-3-hexanol}
\end{align*}
\]
Grignard reagents do not add to the carbonyl carbon of a carboxylic acid.

\[
\text{R-CO-} + \text{CH}_3\text{CH}_2\text{MgBr} \rightarrow \text{R-CO}^\ominus + \text{CH}_3\text{CH}_3\text{MgBr}
\]
Grignard reagents
Hydride ion as the nucleophile

mechanism for the reaction of an aldehyde or a ketone with hydride ion

\[
\text{R}-\overset{\text{O}}{\text{C}}-\overset{\text{OH}}{\text{H}} \quad \overset{\text{HB}^+}{\overset{\text{H}}{\text{B}}} \quad \text{product of nucleophilic addition}
\]
Sources of hydride ion

NaBH₄ (less reactive)

LiAlH₄ (very reactive)

DIBALH (specially used for ester → aldehyde)

diisobutylaluminum hydride