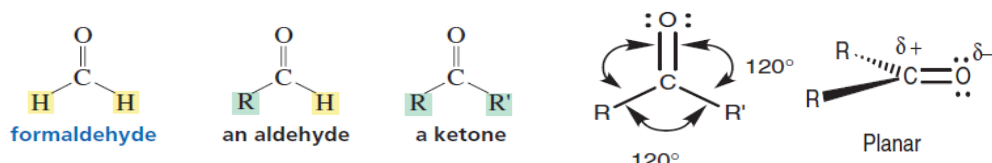


Aldehydes and Ketones

Compounds that possess a carbonyl group (C=O) can be divided into two classes:

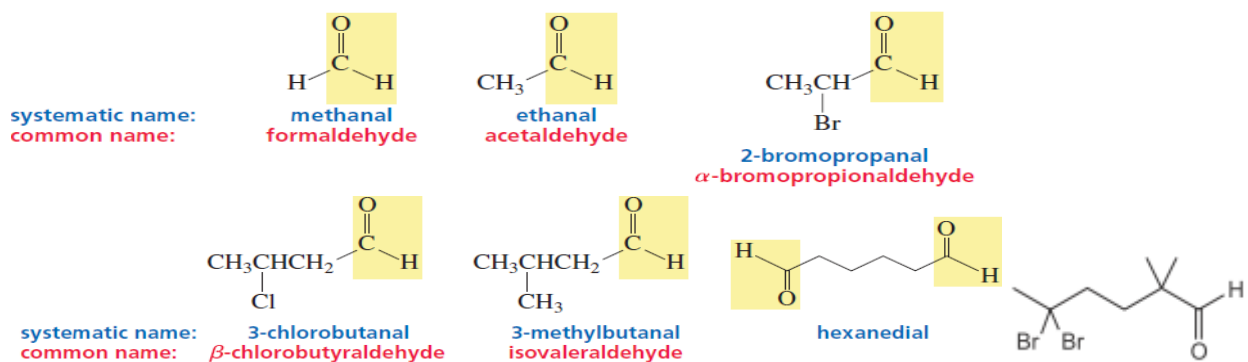
Class I carbonyl compounds, which have a group that can be replaced by a nucleophile, and **Class II** carbonyl compounds, which comprise aldehydes and ketones, do not have a group that can be replaced by a nucleophile?

The Aldehydes (RCHO) and ketones (R₂CO) are similar in structure in that both classes of compounds possess a C=O bond, called a **carbonyl group**, the R group may be aliphatic or aromatic. The geometry of the carbonyl group is planar with bond angles of 120°. The carbon and oxygen atoms of the carbonyl group are *sp*² hybridized. The carbonyl group is more reactive than a C–O single bond due to the relatively weak π bond. The carbonyl group is polarized such that the oxygen is slightly negative and the carbon is slightly positive. Both the **polarity** of the carbonyl group and the presence of the **weak π bond** explain much of the chemistry and the physical properties of aldehydes and ketones.

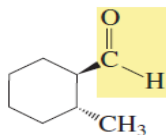


Nomenclature of Aldehydes

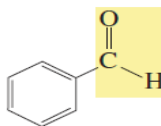
The systematic name of an aldehyde is obtained by replacing the terminal “e” from the name of the parent hydrocarbon with “al.” For example, a one-carbon aldehyde is *methanal*; a two-carbon aldehyde is *ethanal*. The position of the carbonyl carbon does not have to be designated, because it is always at the end of the parent hydrocarbon and therefore always has the 1-position. When common names are used, the position of a substituent is designated by a lowercase Greek letter. The carbonyl carbon is not designated; the carbon adjacent to the carbonyl carbon is the α -carbon.



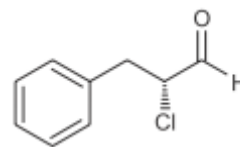
Notice that the terminal “e” is not removed in hexanedial; the “e” is removed only to avoid two successive vowels. If the aldehyde group is attached to a ring, the aldehyde is named by adding “carbaldehyde” to the name of the cyclic compound.



trans-2-methylcyclohexanecarbaldehyde

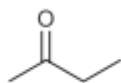


benzenecarbaldehyde
benzaldehyde

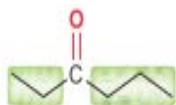


Ketones

The systematic name of a ketone is obtained by removing the “e” from the name of the parent hydrocarbon and adding “one.” The chain is numbered in the direction that gives the carbonyl carbon the smaller number. In the case of cyclic ketones, a number is not necessary because the carbonyl carbon is assumed to be at the 1-position. Frequently, derived names are used for ketones—the substituents attached to the carbonyl group are cited in alphabetical order, followed by “ketone.”

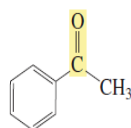


Butanone

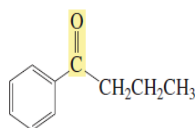


Ethyl propyl ketone

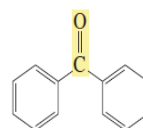
common name: acetophenone
derived name: methyl phenyl ketone



acetophenone
methyl phenyl ketone

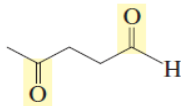


butyrophenone
phenyl propyl ketone

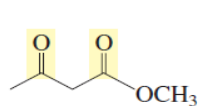


benzophenone
diphenyl ketone

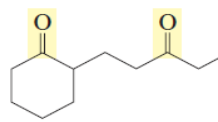
If the ketone has a second functional group of higher naming priority, the ketone oxygen is indicated by the prefix “oxo.”



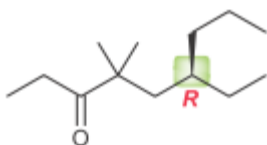
systematic name: 4-oxopentanal



methyl 3-oxobutanoate



2-(3-oxopentyl)-
cyclohexanone



Q: Draw and five ketones of the general formula C_6H_8O

Q: Give the structure formula of:

4-methyl-3-pentene -2-one, 1,3-diphenyl-2-propene-1-one.

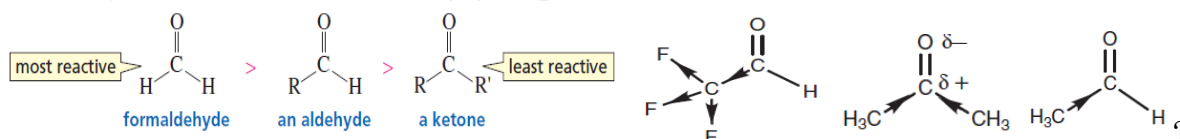
Physical properties:

Aldehydes and ketones have higher boiling points than alkanes of comparable molecular weight due to the polarity of the carbonyl group. However, they have lower boiling points than comparable alcohols or carboxylic acids due to the absence of hydrogen bonding. Aldehydes and ketones of small molecular weight are soluble in aqueous solution since they can participate in intermolecular hydrogen bonding with water. Higher molecular weight aldehydes and ketones are not soluble in water since the hydrophobic character of the alkyl chains or aromatic rings outweighs the polar character of the carbonyl group.

Reactivity, Electronic and steric factors

Generally it is found that aldehydes are more reactive to nucleophiles than ketones. There are two factors (electronic and steric) which explain this difference in reactivity.

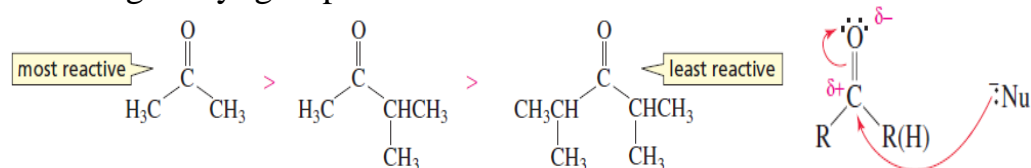
Electronic factor: The carbonyl carbon in aldehydes is more electrophilic than it is in ketones due to the substituents attached to the carbonyl carbon, alkyl groups are electron donating. A ketone has two electron donating alkyl groups that can stabilize the δ^+ on the carbon atom of the carbonyl group. In contrast, aldehydes have only one electron-donating group:



Electron inductive effects can be used to explain different reactivity's between different aldehydes. For example the fluorinated aldehyde is more reactive than ethanal. The fluorine atoms are electronegative and have an electron with-drawing effect on the neighboring carbon, making it electron deficient. This in turn has an inductive effect on the neighboring carbonyl carbon. Since electrons are being withdrawn, the electrophilicity of the carbonyl carbon is increased, making it more reactive to nucleophiles.

Steric factor:

A ketone has two alkyl groups (one on either side of the carbonyl) that contribute to steric hindrance in the transition state of a nucleophilic attack. In contrast, an aldehyde has only one alkyl group, so the transition state is less crowded and lower in energy. Steric factors also become important in the tetrahedral transition state because the bond angles are 109.5° ; therefore, the alkyl groups are closer to one another than they are in the carbonyl compound, in which the bond angles are 120° . Ketones have greater steric crowding in their transition states, so they have less stable transition states than aldehydes have. For the same reason, ketones with small alkyl groups bonded to the carbonyl carbon are more reactive than ketones with large alkyl groups.



Q: Which ketone is more reactive?

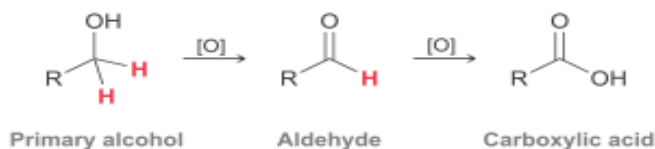
- 2-heptanone or 4-heptanone
- p*-nitroacetophenone or *p*-methoxyacetophenone

Preparation of aldehydes and ketones:

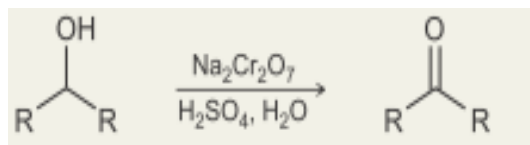
Functional group transformations:

Functional group transformations allow the conversion of a functional group to an aldehyde or a ketone without affecting the carbon skeleton of the molecule.

1-Oxidation of primary and secondary alcohols:



::



Aldehydes are easily oxidized to carboxylic acids by the same reagent, acidic dichromate, that is used in their synthesis. How, is it possible, then, to stop the oxidation of a primary alcohol or a methyl benzene at the aldehyde stage?

2- Friedel- Crafts acylation:

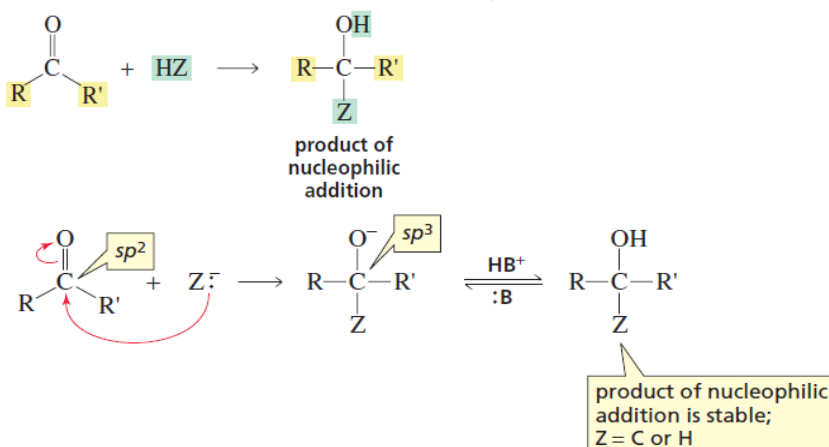
3- Hydration of alkyenes:

Reactions of aldehydes and ketones:

The carbonyl group, C=O, governs the chemistry of aldehydes and ketones.

It does this in two ways: **(a)** by providing a site for nucleophilic addition and **(b)** by increasing the acidity of the hydrogen atoms attached to the alpha carbon.

Aldehydes and ketones undergo **nucleophilic addition** reactions, whereas carboxylic acid derivatives undergo **nucleophilic acyl substitution** reactions.

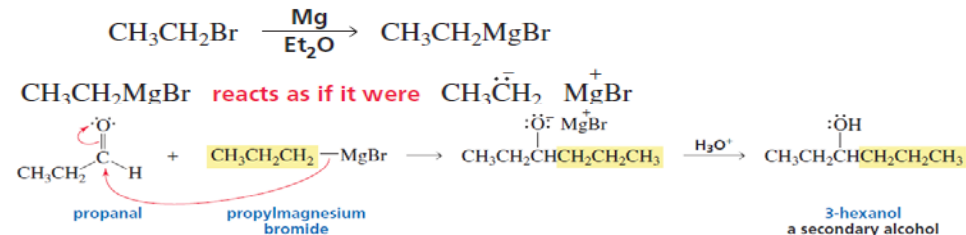


Therefore, if the nucleophile that adds to the aldehyde or ketone is one in which Z *is not* electronegative (Z is an H or a C nucleophile), the tetrahedral addition product will be stable.

If the nucleophile that adds to the aldehyde or ketone is one in which Z *is* electronegative (Z is an O or an N nucleophile), the tetrahedral addition product will *not* be stable. Water will be eliminated from the addition product. This is called a **nucleophilic addition–elimination reaction**.

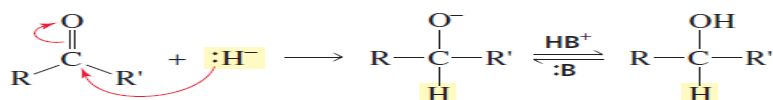
1- Reaction with Grignard Reagents:

The reaction can produce compounds with a variety of structures because both the structure of the carbonyl compound and the structure of the Grignard reagent can be varied.

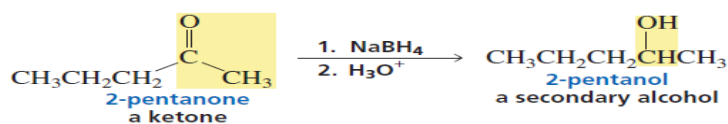


2- Reactions of Carbonyl Compounds with Hydride Ion:

Addition of hydride ion to an aldehyde or ketone forms an alkoxide ion. Subsequent protonation by an acid produces an alcohol. The overall reaction adds to the carbonyl group. Recall that the addition of hydrogen to an organic compound is a **reduction reaction**:

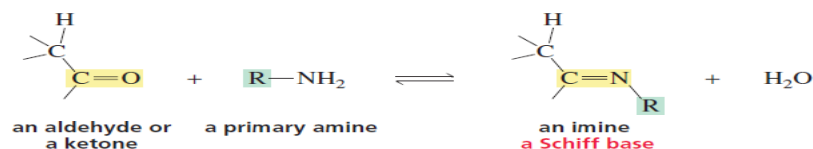


Aldehydes and ketones are generally reduced using sodium borohydride (NaBH_4) as the source of hydride ion. Aldehydes are reduced to primary alcohols, and ketones are reduced to secondary alcohols. Notice that the acid is not added to the reaction mixture until the reaction with the hydride donor is complete.

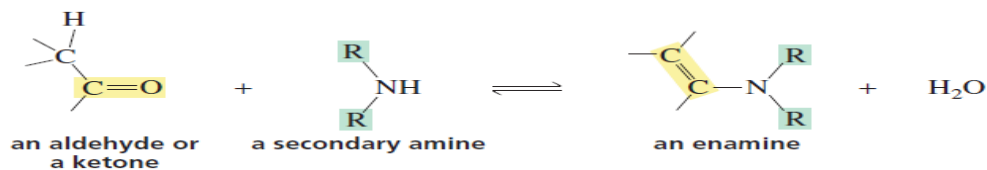


3- Reactions of Aldehydes and Ketones with Nitrogen Nucleophiles:

Aldehydes and ketones react with a *primary amine* (RNH_2) to form an imine. An **imine** is a compound with a carbon–nitrogen double bond. The imine obtained from the reaction of a carbonyl compound and a primary amine is often called a **Schiff base**.



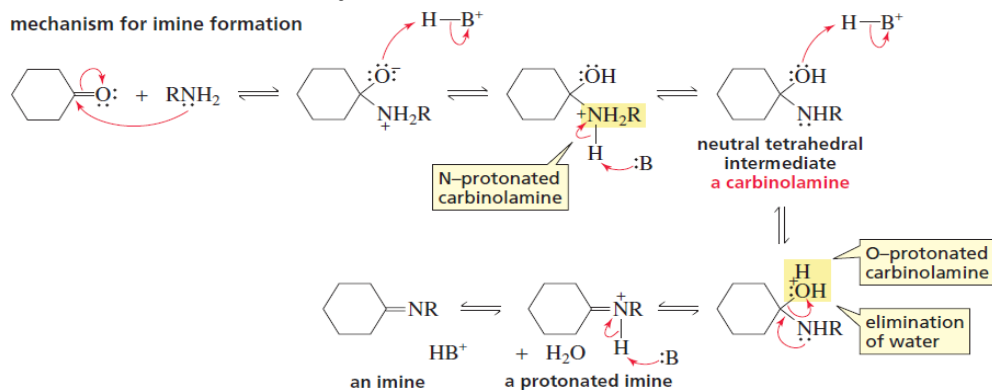
Aldehydes and ketones react with a *secondary amine* to form an enamine (pronounced “ene-amine”). The name “enamine” comes from “ene” “amine,” with the “e” omitted in order to avoid two successive vowels.



Overall, the addition of a nitrogen nucleophile to an aldehyde or a ketone is a *nucleophilic addition–elimination reaction*: nucleophilic addition of an amine to form an unstable tetrahedral intermediate, followed by elimination of water.

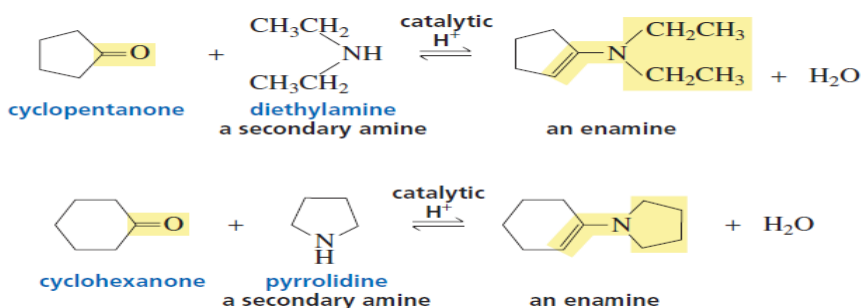
a-Addition of Primary Amines:

mechanism for imine formation



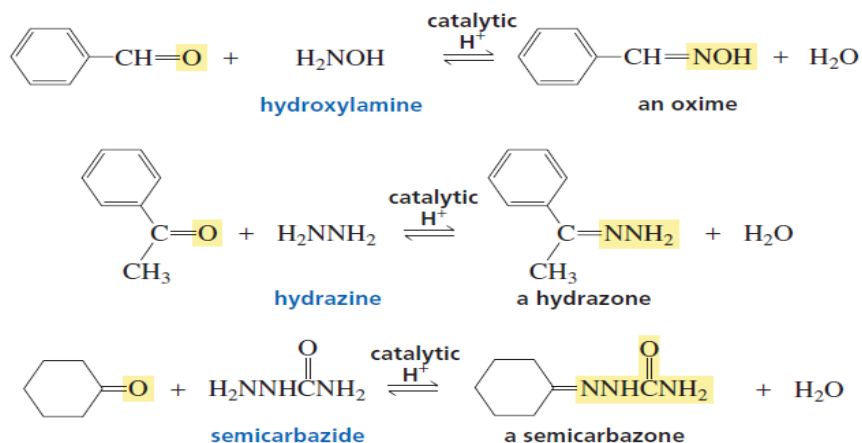
b- Addition of Secondary Amines

Aldehydes and ketones react with secondary amines to form enamines. Like imine formation, the reaction requires a trace amount of an acid catalyst.



c- Formation of Imine Derivatives:

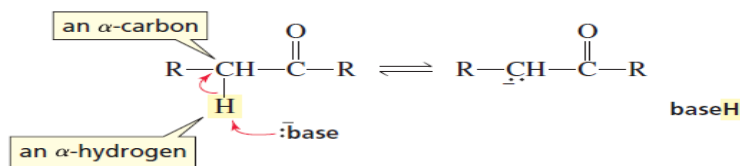
Compounds such as hydroxylamine, hydrazine and semicarbazide are similar to primary amines in that they all have an amine group. Thus, like primary amines, they react with aldehydes and ketones to form imines often called *imine derivatives* because the substituent attached to the imine nitrogen is not an R group. The imine obtained from the reaction with hydroxylamine is called an **oxime**, the imine obtained from the reaction with hydrazine is called **hydrazone**, and the imine obtained from the reaction with semicarbazide is called a semicarbazone.



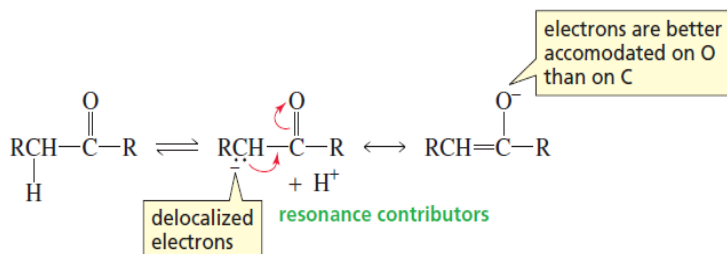
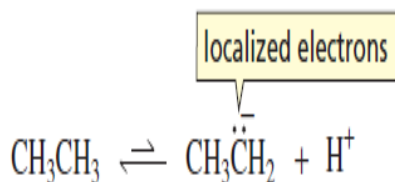
Acidity of alpha hydrogen, Aldol condensation

In addition to the partially positively charged carbonyl carbon, which is attacked by nucleophiles, aldehydes and ketones have second site of reactivity. The hydrogen bonded to

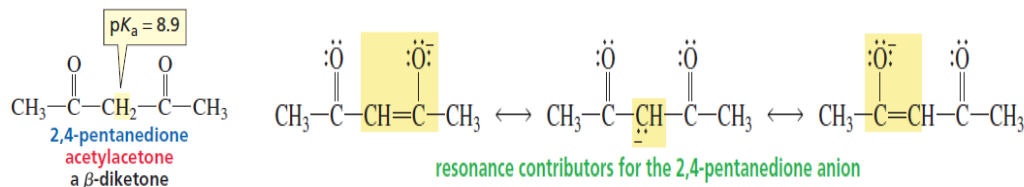
α -carbon adjacent to a carbonyl carbon is sufficiently acidic to be removed by a strong base. The carbon adjacent to a carbonyl carbon is called **α -carbon**. The hydrogen bonded to **α -carbon** is called α -Hydrogen.



A compound that contains a relatively acidic hydrogen bonded to an sp^3 hybridized carbon is called a **carbon acid**.



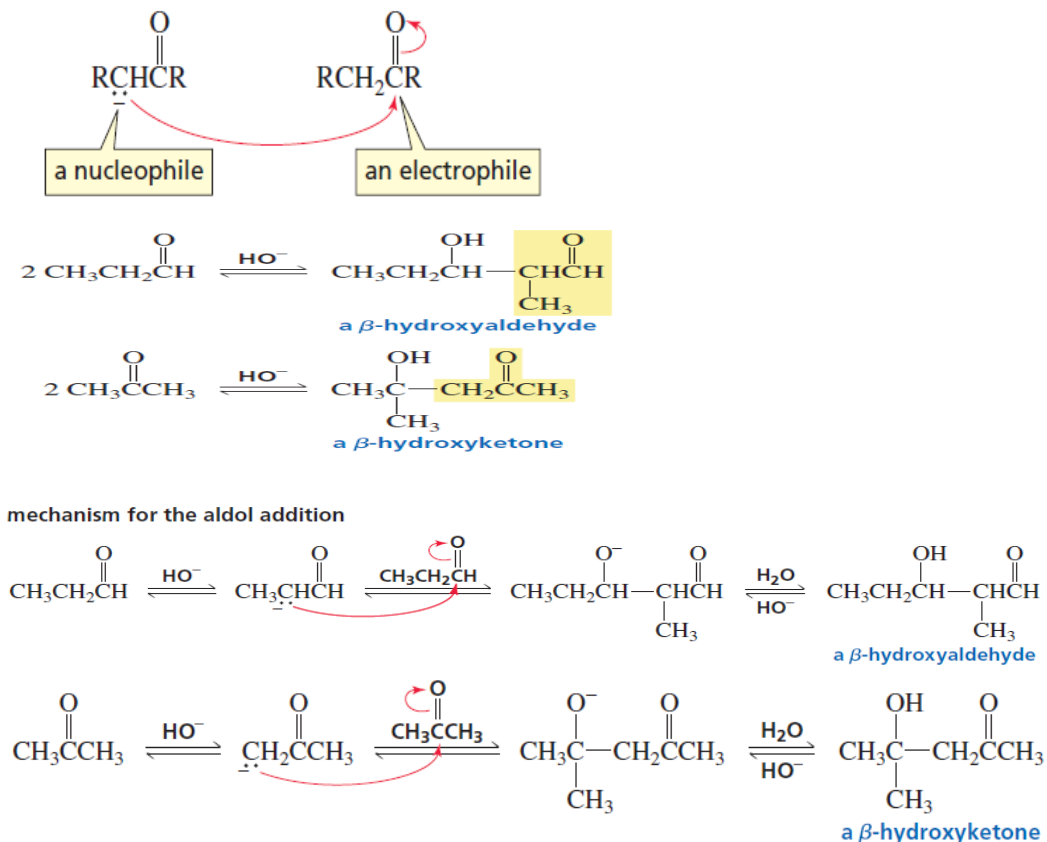
If the α -carbon is *between* two carbonyl groups, the acidity of an α -hydrogen is even greater. An α -hydrogen of 2,4-pentanedione, β -**diketone** a compound with an α -carbon between two ketone carbonyl groups, has a pK_a of 8.9.



The Aldol Addition

When a proton is removed from the α -carbon of an aldehyde or a ketone, the resulting anion is a nucleophile and therefore reacts with electrophiles. An **aldol addition** is a reaction between two molecules of an *aldehyde* or two molecules of a *ketone*. When the reactant is an aldehyde, the addition product is a β -hydroxyaldehyde, which is why the reaction is called an aldol addition (“ald” for aldehyde, “ol” for alcohol). When the reactant is a ketone, the addition product is a β -hydroxyketone.

Because the addition reaction is reversible, good yields of the addition product are obtained only if it is removed from the solution as it is formed

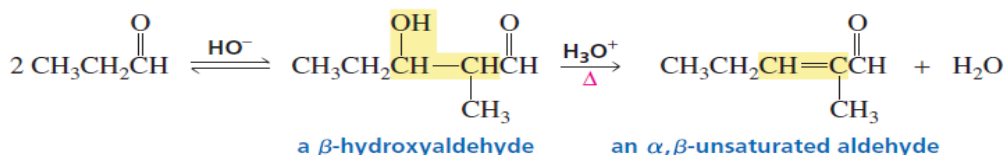


Dehydration of Aldol Addition Products:

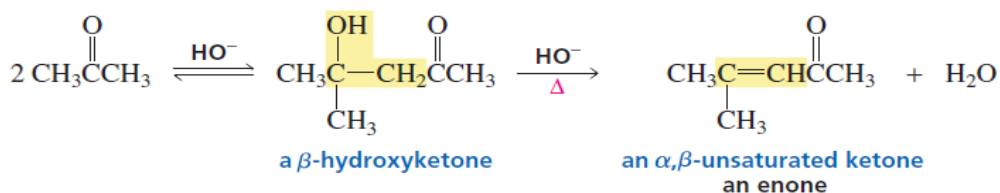
Formation of α,β -Unsaturated Aldehydes and Ketones

The β -hydroxyaldehyde and β -hydroxyketone products of aldol addition reactions are easier to dehydrate than many other alcohols because the double bond formed

as the result of dehydration is conjugated with a carbonyl group. If the product of an aldol addition is dehydrated, the overall reaction is called an **aldol condensation**. A **condensation reaction** is a reaction that combines two molecules while removing a small molecule (usually water or an alcohol).

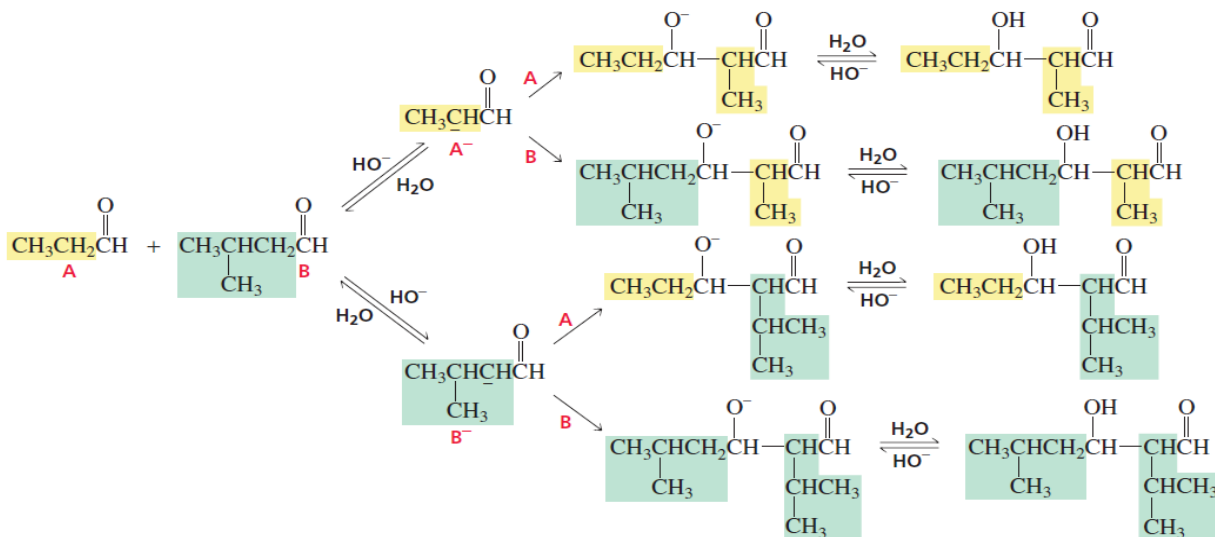


The β -hydroxyaldehyde and β -hydroxyketone can also be dehydrated under basic conditions, so heating the aldol addition product in either acid or base leads to dehydration. The product of dehydration is called an enone—"ene" for the double bond and "one" for the carbonyl group.

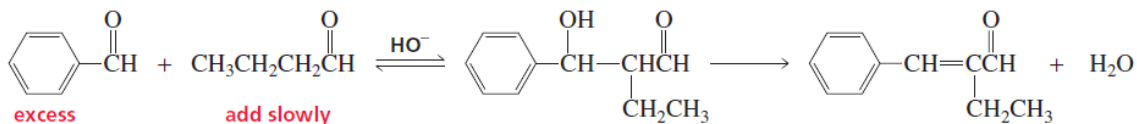


The Mixed Aldol Addition:

If two different carbonyl compounds are used in an aldol addition, four products can be formed.



The preceding reaction is called a **mixed aldol addition** or a **crossed aldol addition**. The four products have similar physical properties, making them difficult to separate. Consequently, a mixed aldol addition that forms four products is not a synthetically useful reaction. Under certain conditions, a mixed aldol addition can lead primarily to one product. How?

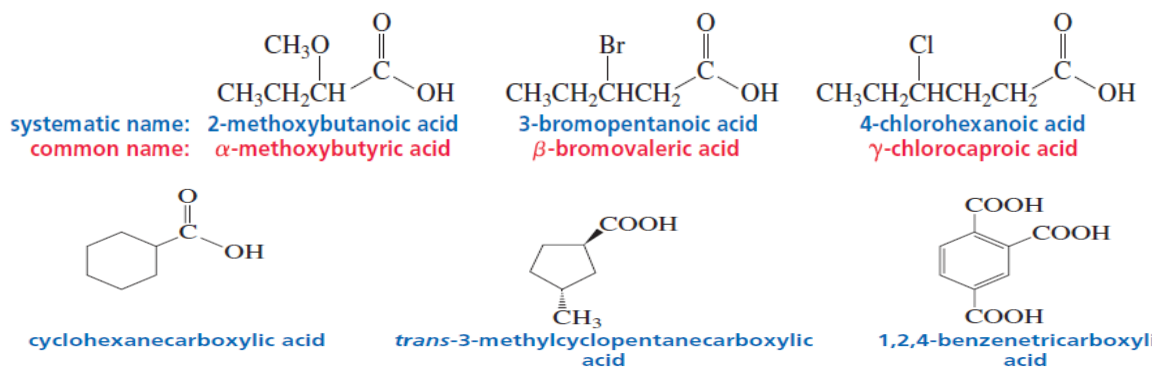
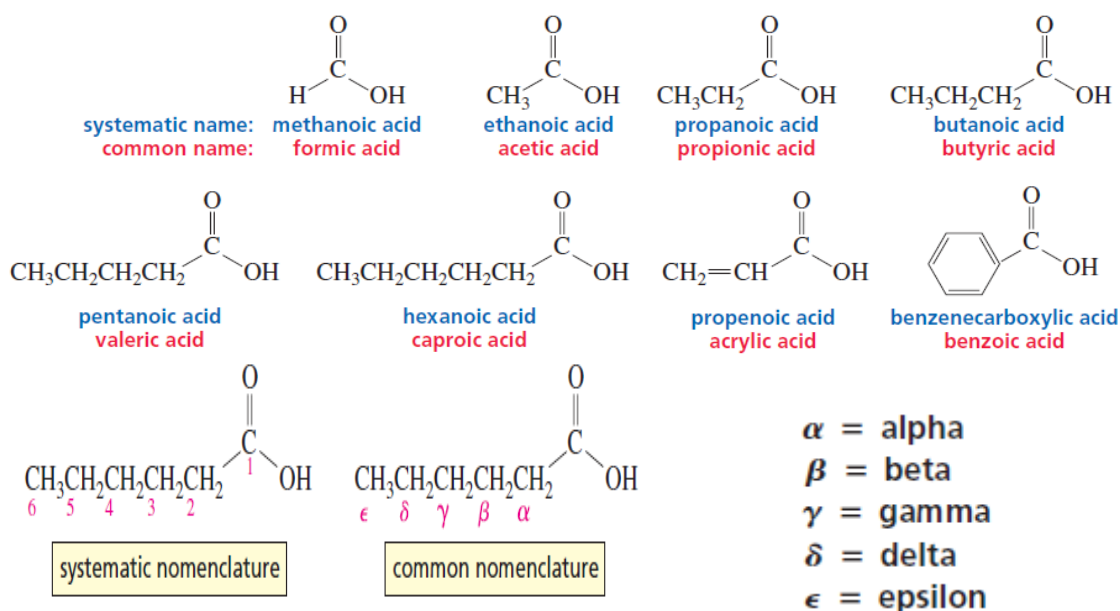


Carboxylic acid

Compounds contain the carboxyl group attached to either an alkyl group (RCOOH) or an aryl group (ArCOOH).

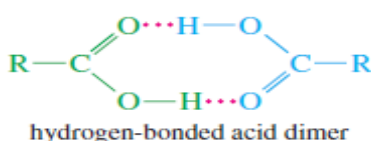
Nomenclature

In systematic nomenclature, a **carboxylic acid** is named by replacing the terminal “e” of the alkane name with “oic acid.” For example, the one-carbon alkane is methane, so the one-carbon carboxylic acid is methanoic acid.



Physical properties:

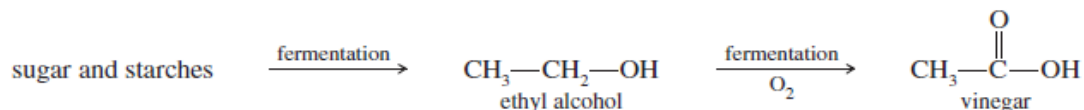
Carboxylic acid molecules are polar, and like alcohol molecules can form hydrogen bonds with each other and with other kinds of molecules. The simplest aromatic acid, benzoic acid, contains too many carbon atoms to show appreciable solubility in water. Carboxylic acids (more than six carbons) are soluble in less polar solvents like ether, alcohol, benzene, etc. Carboxylic acids are even higher boiling than alcohols. For example, propionic acid (b.p. 141) boils more than twenty degrees higher than the alcohol of comparable molecular weight, n-butyl alcohol (b.p. 118). These very high boiling points are due to the fact that a pair of carboxylic acid molecules are held together not by one but by two hydrogen bonds: The odors of the lower aliphatic acids progress from the sharp, irritating odors of formic and acetic acids to the distinctly unpleasant odors of butanoic acid, pentanoic acid, and hexanoic acids; the higher acids have little odor because of their low volatility.



Preparation of carboxylic acids

The most important commercial aliphatic acid is acetic acid. *Vinegar* is a 5% aqueous solution of acetic acid used in cooking and in prepared foods such as pickles, ketchup, and salad dressings. Vinegar for food is produced by fermentation of sugars and starches.

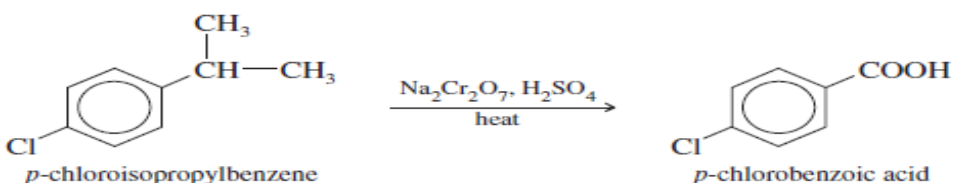
An intermediate in this fermentation is ethyl alcohol. When alcoholic beverages such as wine and cider are exposed to air, the alcohol oxidizes to acetic acid. This is the source of “wine vinegar” and “cider vinegar.”



1. Oxidation of primary alcohols.

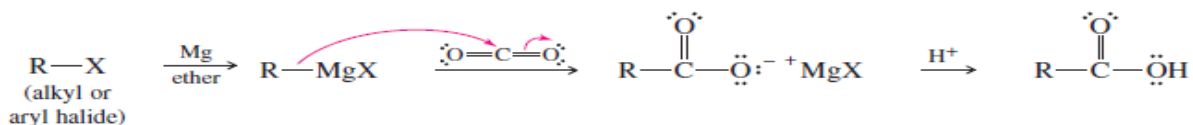


2. Oxidation of alkylbenzene.

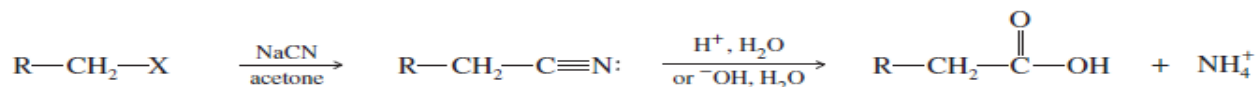


Q: different alkylbenzenes are oxidized to benzoic acid?

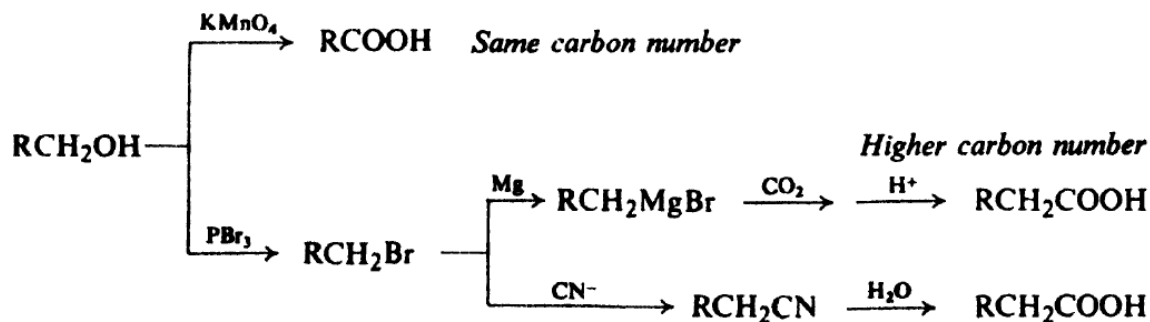
3. Carboxylation of Grignard reagents.



4. Hydrolysis of nitriles.



The Grignard synthesis and the nitrile synthesis have the special advantage of increasing the length of a carbon chain, and thus extending the range of available materials. In the aliphatic series both Grignard reagents and nitriles are prepared from halides, which in turn are usually prepared from alcohols. Preparation of carboxylic acids from alcohols the product contains one less carbon atom.

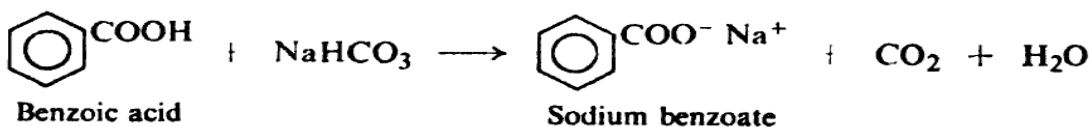


Q: Prepare the following acids from alkyl halides or dihalides of fewer C's. (a)

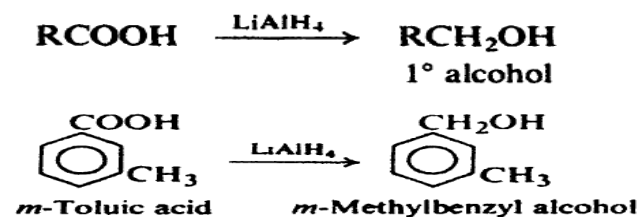
$\text{C}_6\text{H}_5\text{CH}_2\text{COOH}$, (b) $(\text{CH}_3)_3\text{CCOOH}$, (c) $\text{HOCH}_2\text{CH}_2\text{CH}_2\text{COOH}$, (d) $\text{HOOCCH}_2\text{CH}_2\text{COOH}$ (succinic acid).

Reactions of carboxylic acids:

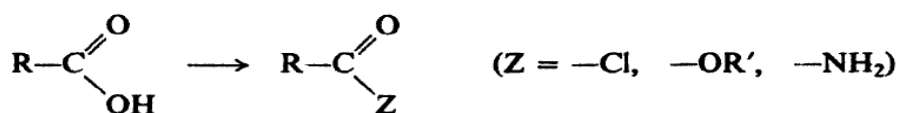
1. Acidity. (Salt formation):



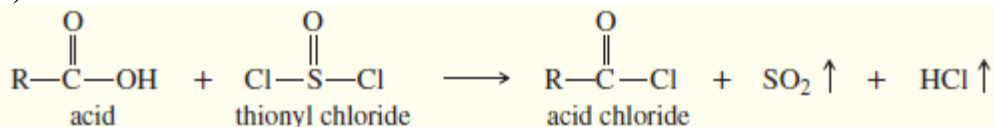
2. Reduction:



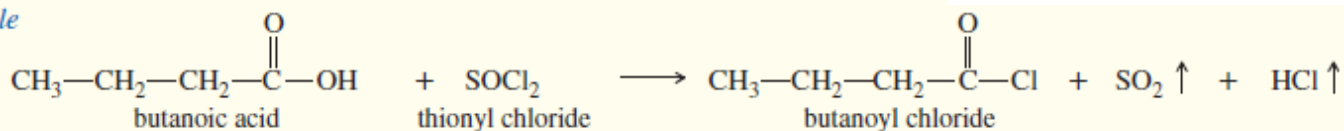
3. Conversion into functional derivatives:



(a) Conversion into acid chlorides

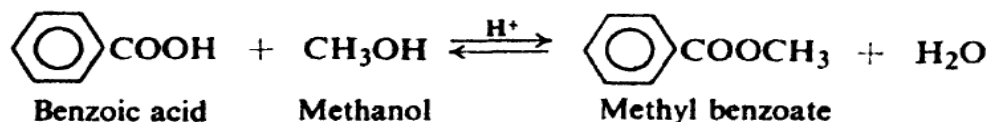
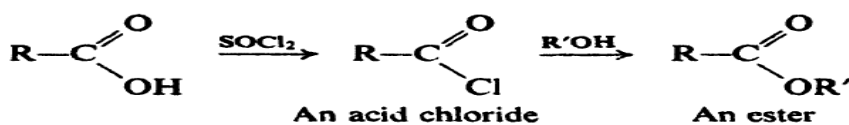
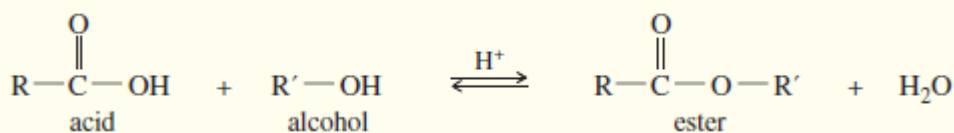


Example

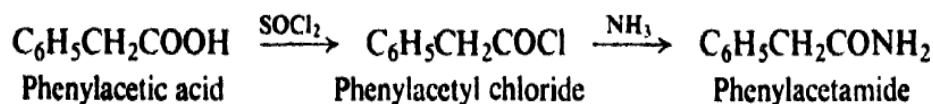
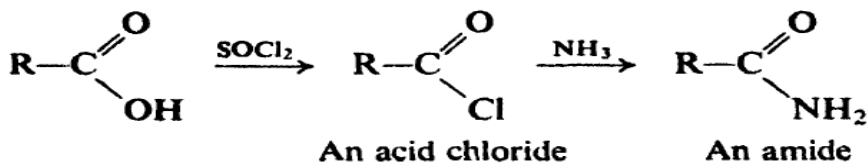
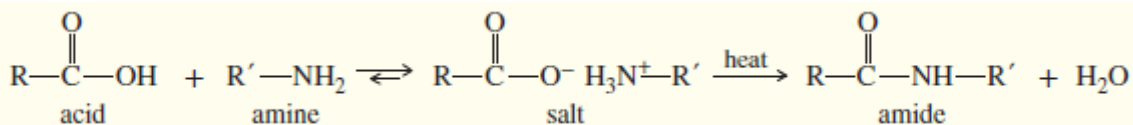


(b) Conversion into esters:

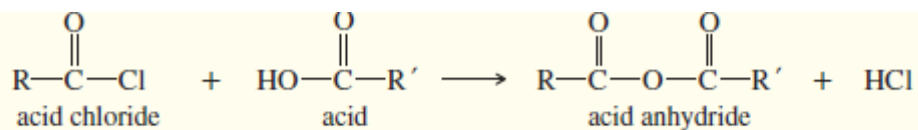
Fischer esterification:



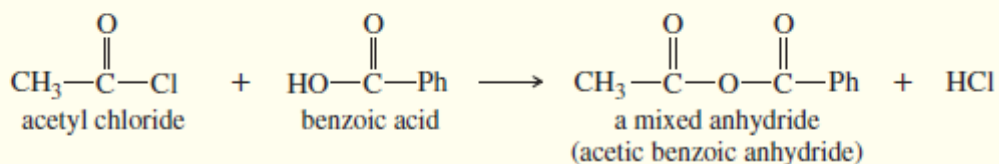
c- Conversion into amides:



d- Conversion into anhydrides:

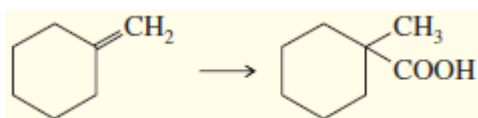


Example

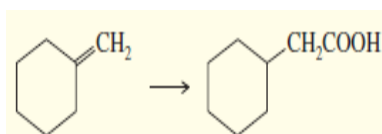


Q/ Show how you would accomplish the following multistep syntheses. You may use any additional reagents and solvents you need.

a.

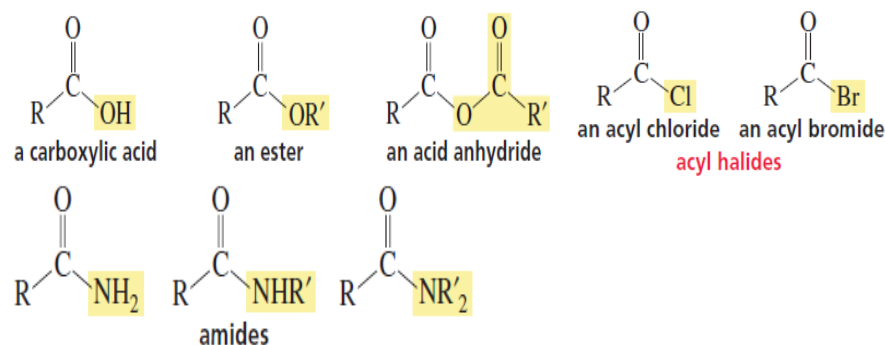


b.



Functional derivatives of carboxylic acids (acyl halides, anhydrides, esters and amides), general formula, structures, nomenclatures, physical properties

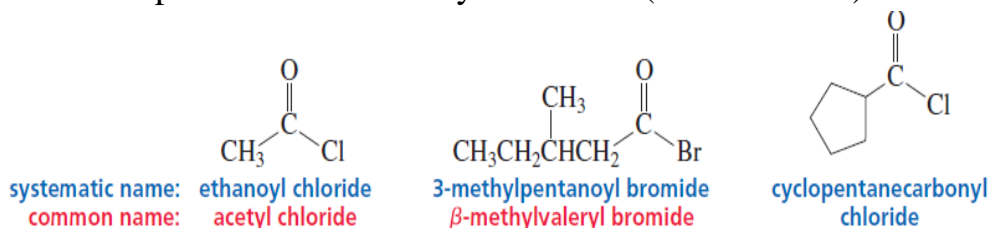
Class I carbonyl compounds are those in which the acyl group is attached to an atom or a group that *can* be replaced by another group. **Carboxylic acids, acyl halides, acid anhydrides, esters, and amides** belong to this class. All of these compounds contain a group (OH, Cl, Br, O(CO)R, OR, NH₂, NHR, NR₂) that can be replaced by a nucleophile. Acyl halides, acid anhydrides, esters, and amides are all called **carboxylic acid derivatives** because they differ from a carboxylic acid only in the nature of the group that has replaced the OH group of the carboxylic acid.



Nomenclature: 1. Acyl Halides

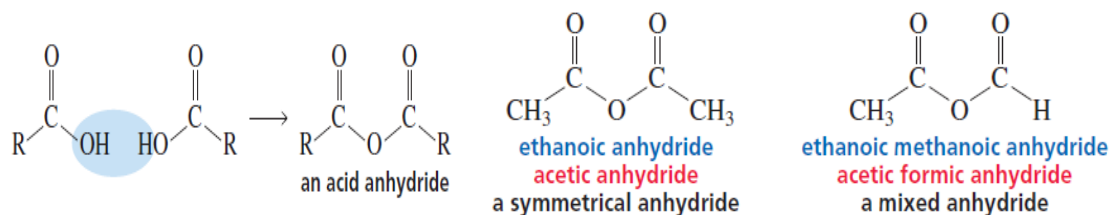
Acyl halides are compounds that have a halogen atom in place of the OH group of a carboxylic acid. The most common acyl halides are acyl chlorides and acyl

bromides. Acyl halides are named by using the acid name and replacing “ic acid” with “yl chloride” (or “yl bromide”). For acids ending with “carboxylic acid,” “carboxylic acid” is replaced with “carbonyl chloride” (or “bromide”).



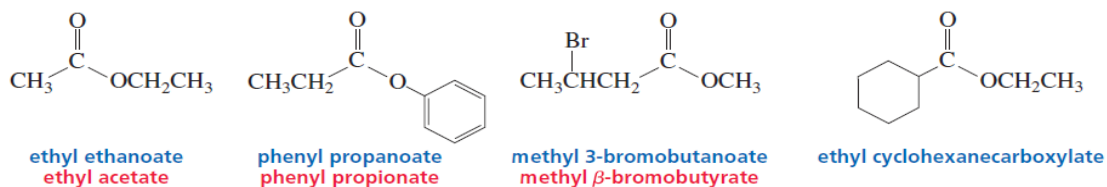
2. Acid Anhydrides

Loss of water from two molecules of a carboxylic acid results in an **acid anhydride**. “Anhydride” means “without water.” If the two carboxylic acid molecules forming the acid anhydride are the same, the anhydride is a **symmetrical anhydride**. If the two carboxylic acid molecules are different, the anhydride is a **mixed anhydride**. Symmetrical anhydrides are named by using the acid name and replacing “acid” with “anhydride.” Mixed anhydrides are named by stating the names of both acids in alphabetical order, followed by “anhydride.”

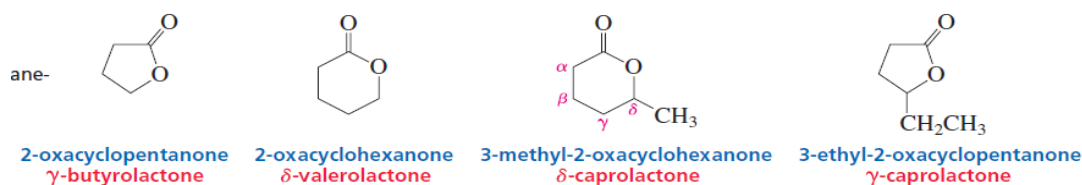


3. Esters

An **ester** is a compound that has an OR` group in place of the OH group of a carboxylic acid. In naming an ester, the name of the group (R`) attached to the **carboxyl oxygen** is stated first, followed by the name of the acid, with “ic acid” replaced by “ate.”

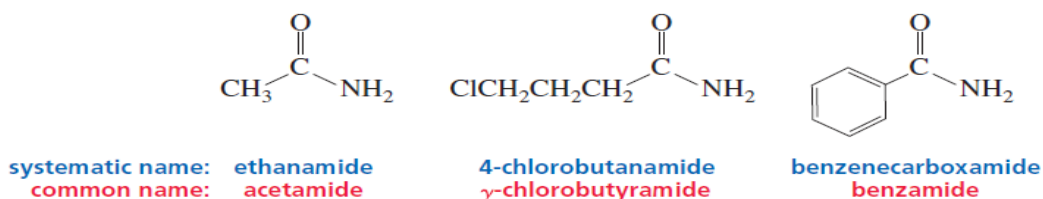


Cyclic esters are called **lactones**. In systematic nomenclature, they are named as **“2-oxacycloalkanones.”** Their common names are derived from the common name of the carboxylic acid, which designates the length of the carbon chain, and a Greek letter to indicate the carbon to which the carboxyl oxygen is attached. Thus, four-membered ring lactones are β -lactones (the carboxyl oxygen is on the β -carbon), five-membered ring lactones are γ -lactones and six-membered ring lactones are δ -lactones.

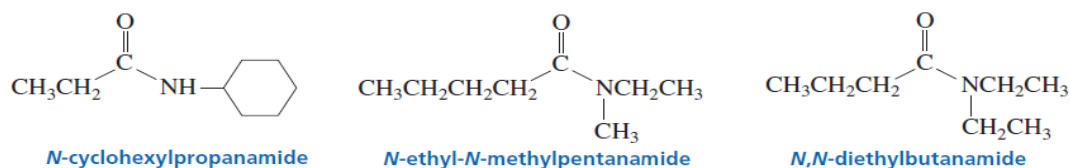


4. Amides

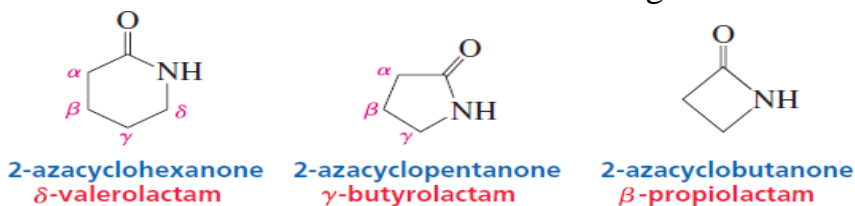
An **amide** has an NH_2 , NHR , or NR_2 group in place of the OH group of a carboxylic acid. Amides are named by using the acid name, replacing “oic acid” or “ic acid” with “amide.” For acids ending with “carboxylic acid,” “ylic acid” is replaced with “amide.”



If a substituent is bonded to the nitrogen, the name of the substituent is stated first (if there is more than one substituent bonded to the nitrogen, they are stated alphabetically), followed by the name of the amide. The name of each substituent is preceded by a capital *N* to indicate that the substituent is bonded to a nitrogen.



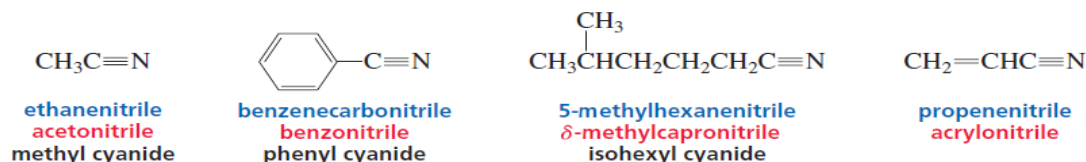
Cyclic amides are called **lactams**. Their nomenclature is similar to that of lactones. They are named as “2-azacycloalkanones” in systematic nomenclature (“aza” is used to designate the nitrogen atom). In their common names, the length of the carbon chain is indicated by the common name of the carboxylic acid, and a Greek letter indicates the carbon to which the nitrogen is attached.



5. Nitriles

Nitriles are compounds that contain a $\text{C}\equiv\text{N}$ functional group. Nitriles are considered carboxylic acid derivatives because, like all Class I carbonyl compounds, they react with water to form carboxylic acids. In systematic

nomenclature, nitriles are named by adding “nitrile” to the parent alkane name. Notice that the triple bonded carbon of the nitrile group is counted in the number of carbons in the longest continuous chain. In common nomenclature, nitriles are named by replacing “ic acid” of the carboxylic acid name with “onitrile.” They can also be named as alkyl cyanides—stating the name of the alkyl group that is attached to the $C\equiv N$ group.

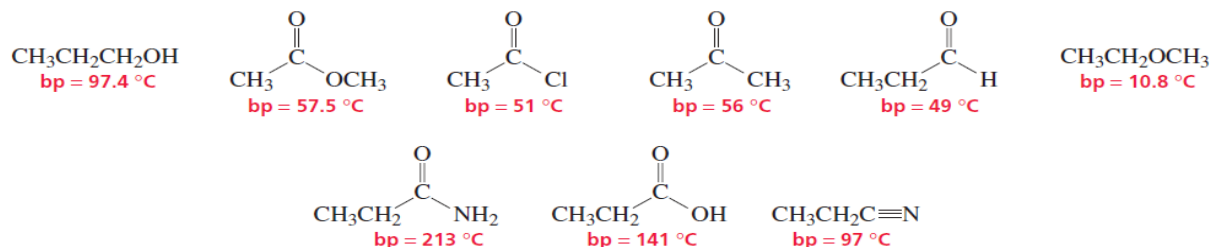


Physical Properties of Carbonyl Compounds

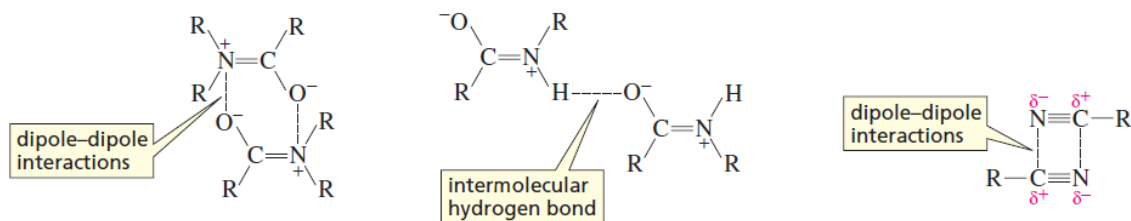
Carbonyl compounds have the following relative boiling points:

amide > carboxylic acid > nitrile > ester ~ acyl chloride ~ aldehyde ~ ketone.

The boiling points of the ester, acyl chloride, ketone, and aldehyde are lower than the boiling point of the alcohol with a comparable molecular weight because the molecules of those carbonyl compounds are unable to form hydrogen bonds with each other. The boiling points of the carbonyl compounds are higher than the boiling point of the ether because of the polar carbonyl group.



Amides have the highest boiling points, because they have strong dipole–dipole interactions since the resonance contributor with separated charges contributes significantly to the overall structure of the compound. If the nitrogen of an amide is bonded to a hydrogen, hydrogen bonds will form between the molecules. The boiling point of a nitrile is similar to that of an alcohol because a nitrile has strong dipole–dipole interactions

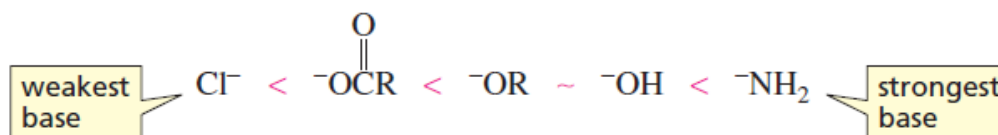


Esters, *N,N*-disubstituted amides, and nitriles are often used as solvents because they are polar, but do not have reactive hydroxyl or amino groups. We have seen that dimethylformamide (DMF) is a common aprotic polar solvent.

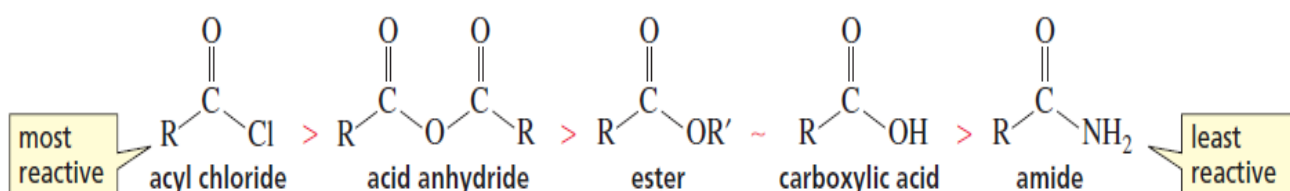
Relative Reactivity's of Carboxylic Acids and Carboxylic Acid Derivatives

The reactivity of a carboxylic acid derivative depends on the basicity of the substituent attached to the acyl group: The less basic the substituent, the more reactive the carboxylic acid derivative.

relative basicities of the leaving groups

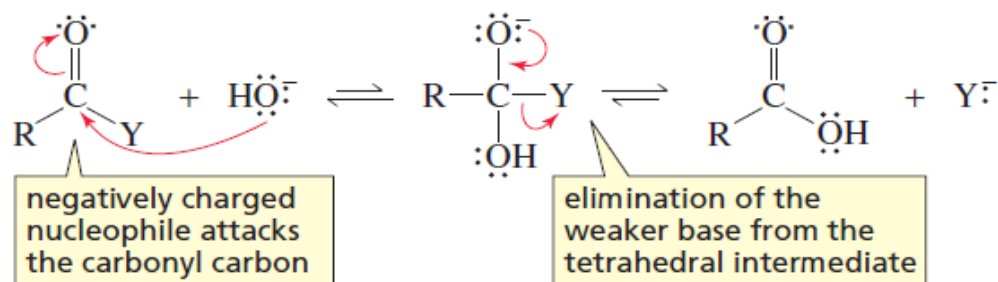


relative reactivities of carboxylic acid derivatives

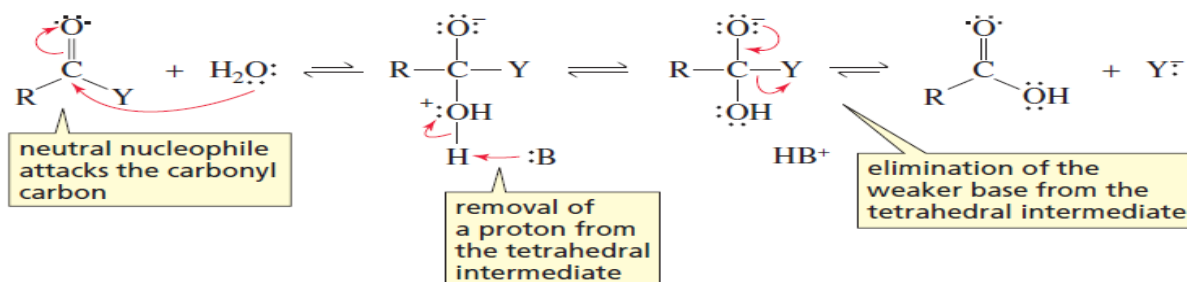


General Mechanism for Nucleophilic Acyl Substitution Reactions

All carboxylic acid derivatives undergo nucleophilic acyl substitution reactions by the same mechanism: a- if Nu is negatively charged:

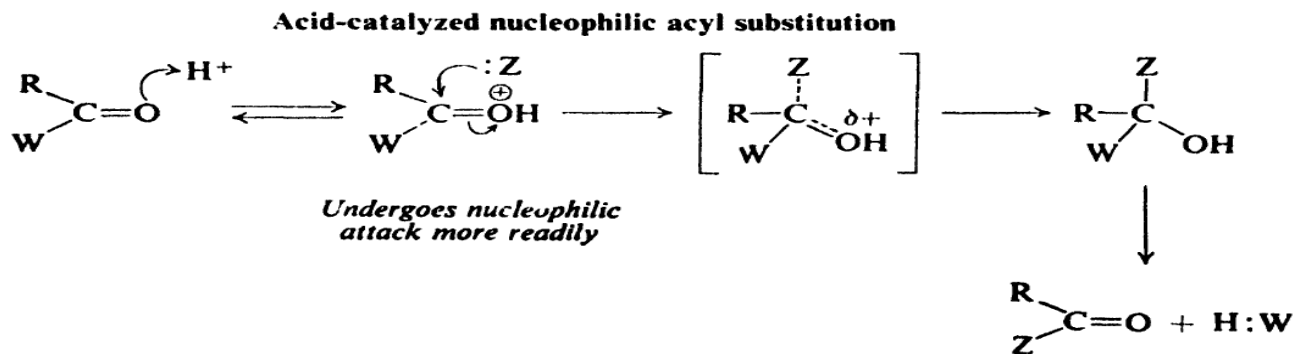


b- if Nu is neutral:



The nucleophilic acyl substitution reactions can be acid catalyzed, thus renders the molecule vulnerable to attack by the weakly nucleophilic reagent such as water.

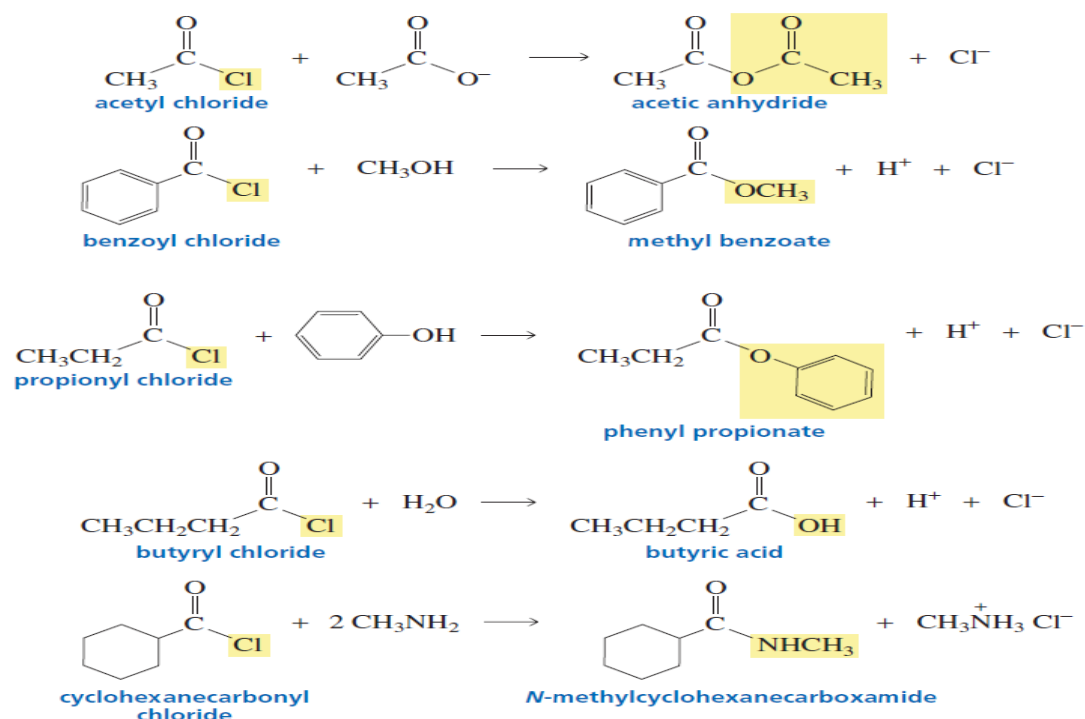
mechanism ?



Preparations and reactions of functional derivatives of carboxylic acids

Because acyl halides are the most reactive of the carboxylic acid derivatives, the easiest way to synthesize any other carboxylic acid derivative is to add the appropriate nucleophile to an acyl halide

1: Reaction of acyl halides:

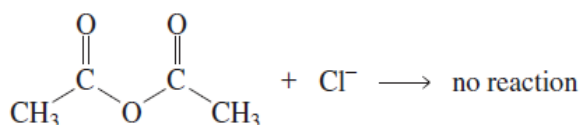
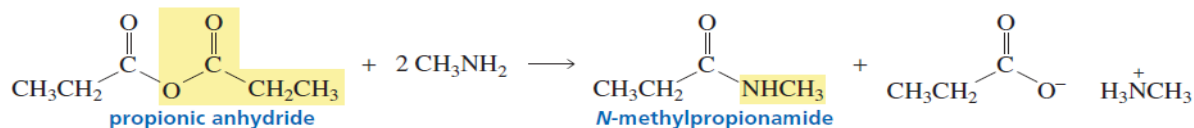
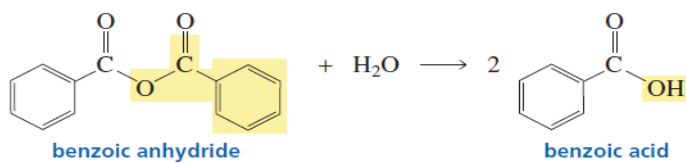
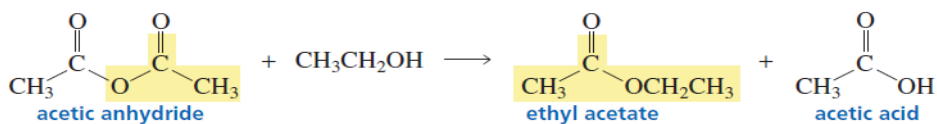


Q / why is one mole of acyl halide react with 2 moles of ammonia or amines?

Q/ Only one amide is obtained from the reaction of acetyl chloride with a mixture of ethylamine and pyridine. Why is only one amide obtained? Or why 1:1 mole.

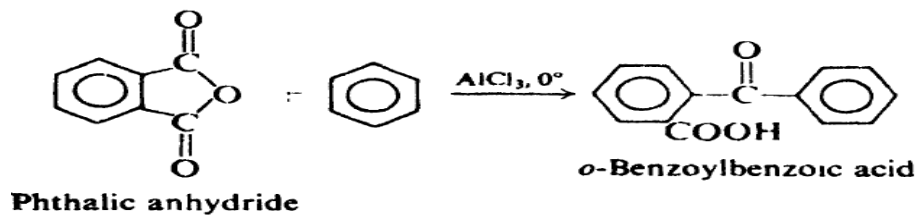
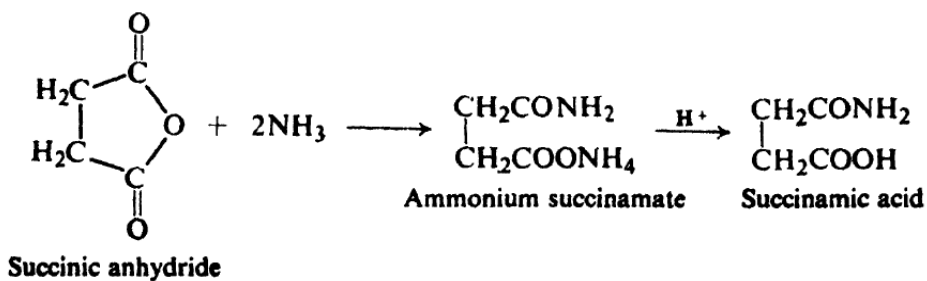
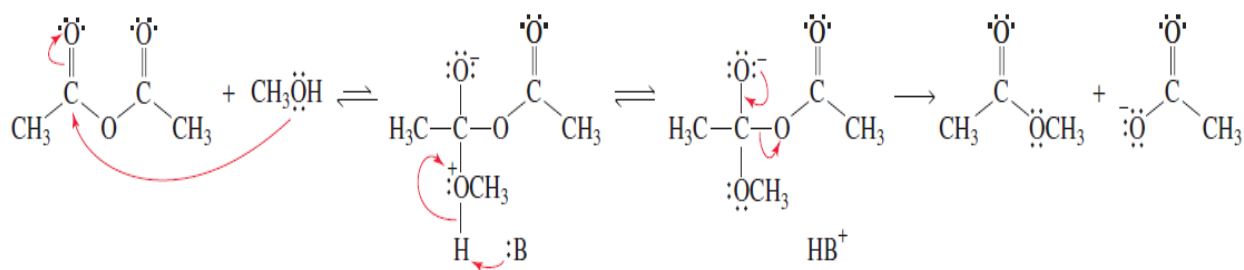
Q/ Although excess amine is necessary in the reaction of an acyl chloride with an amine, explain why it is not necessary to use excess alcohol in the reaction of an acyl chloride with an alcohol.

2. Reaction of anhydrides:

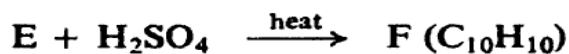
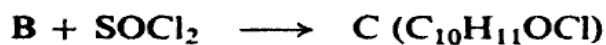
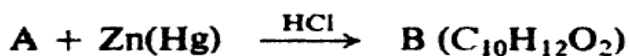


Q/ no reaction, why?

mechanism for the conversion of an acid anhydride into an ester (and a carboxylic acid)

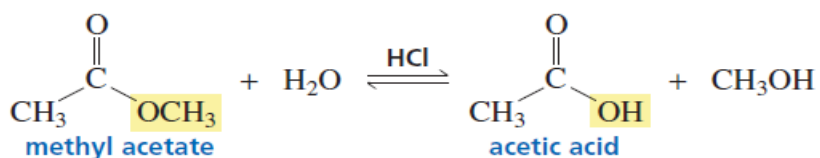


Q: Give structural formulas for compounds A through G.



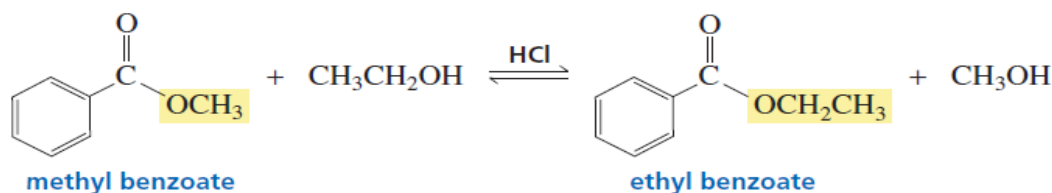
3. Reactions of Esters:

Esters do not react with halide ions or with carboxylate ions because these nucleophiles are much weaker bases than the (RO^-) leaving group of the ester. Esters react with water to form a carboxylic acid and an alcohol. This is an example of a **hydrolysis** reaction—a reaction with water that converts one compound into two compounds (*lysis* is Greek for “breaking down”).



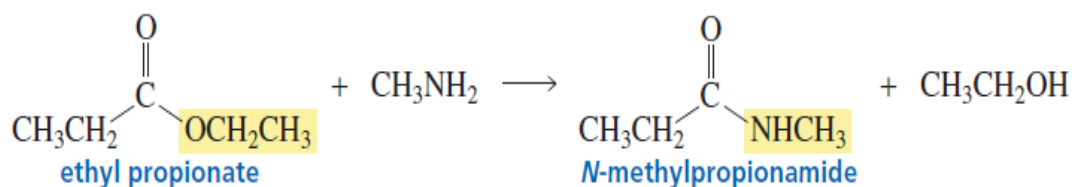
mechanism ?

a transesterification reaction



An ester reacts with an alcohol to form a new ester and a new alcohol. This is an example of an **alcoholysis** reaction. This particular alcoholysis reaction is also called a **transesterification reaction** because one ester is converted to another ester. Both the hydrolysis and the alcoholysis of an ester are very slow reactions because water and alcohols are poor nucleophiles and esters have very basic leaving groups. These reactions, therefore, are always catalyzed when carried out in the laboratory.

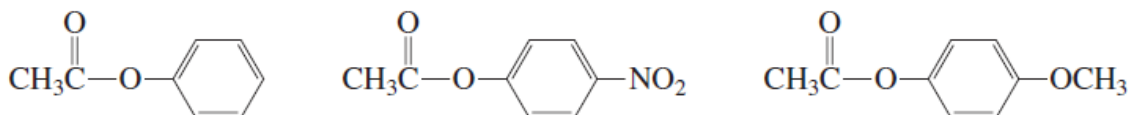
an aminolysis reaction



Phenols are stronger acids than alcohols. Therefore, phenoxide ions (ArO^-) are weaker bases than alkoxide ions (RO^-) which means that phenyl esters are more reactive than alkyl esters.

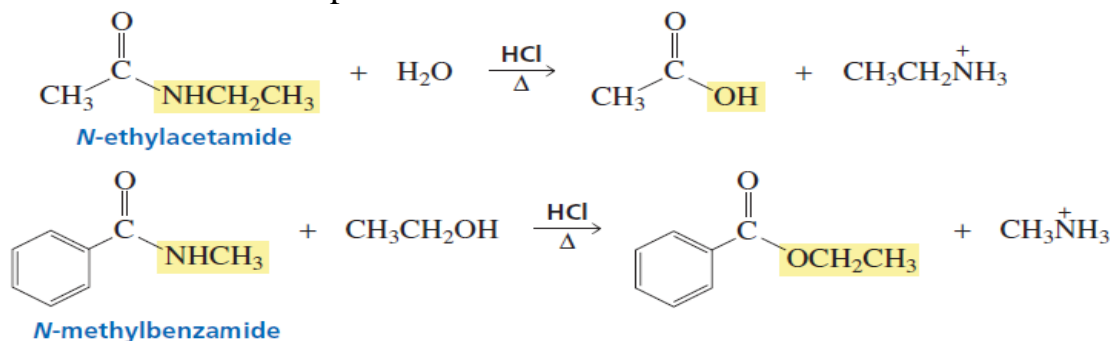
Q:

a. List the following esters in order of decreasing reactivity toward hydrolysis:

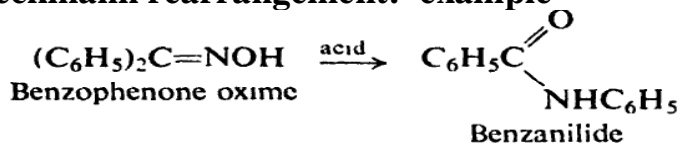


4. Reactions of Amides

Amides do not react with halide ions, carboxylate ions, alcohols, or water because, in each case, the incoming nucleophile is a weaker base than the leaving group of the amide. Amides do however react with water and alcohols if the reaction mixture is heated in the presence of an acid.

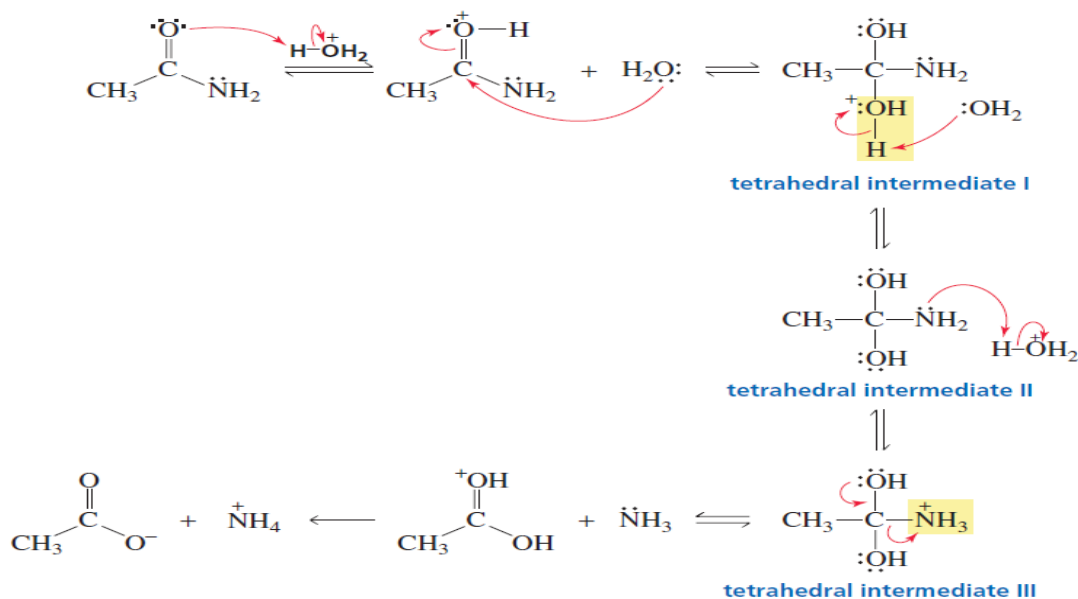


Beckmann rearrangement: example



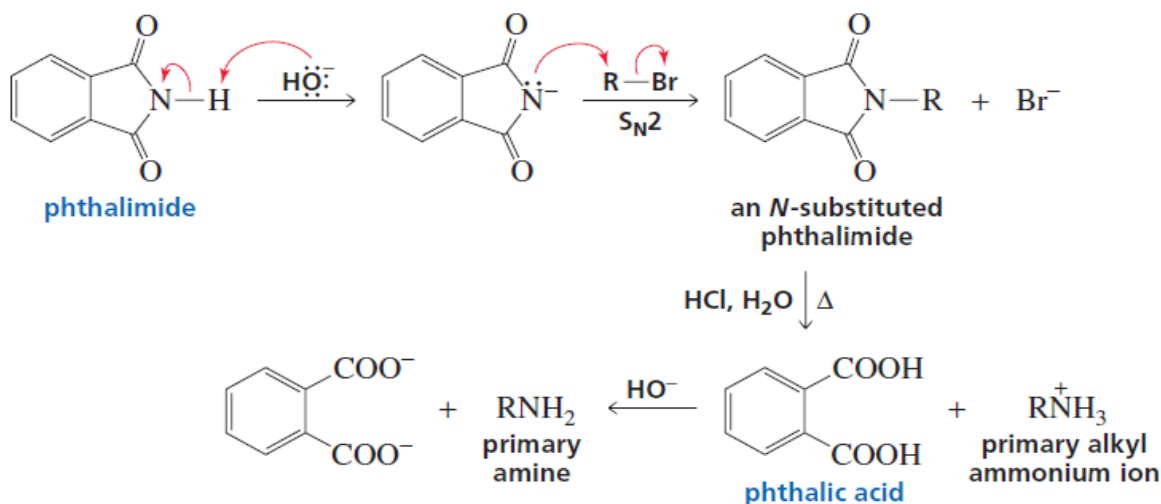
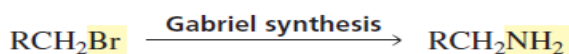
mechanism?

mechanism for acid-catalyzed hydrolysis of an amide



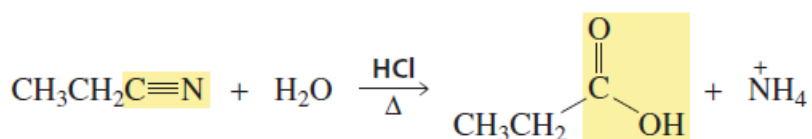
Hydrolysis of an Imide: The Gabriel Synthesis

An **imide** is a compound with two acyl groups bonded to a nitrogen. The **Gabriel synthesis**, which converts alkyl halides into primary amines, involves the hydrolysis of an imide.

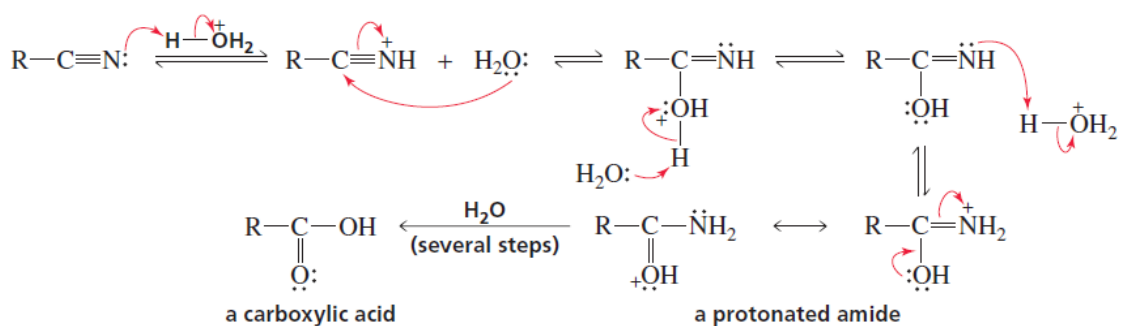


5: Hydrolysis of Nitriles

Nitriles are even harder to hydrolyze than amides. Nitriles are slowly hydrolyzed to carboxylic acids when heated with water and an acid.



mechanism for acid-catalyzed hydrolysis of a nitrile



Q/Complete the following reactions:

