

Chapter 11. Carbonyl compound I

Learning objectives:

1. Provide both IUPAC and common names carboxylic acids.
2. Recognize the physical properties of for carboxylic acids.
3. Recognize the reagents and conditions for the following reactions: reagents for the reduction of carboxylic acids to alcohols and transformation of carboxylic acids to acid chlorides.
4. Write the electron-pushing (arrow-pushing) mechanism for Fisher esterification.
5. Recognize the names and structures for the following functional groups: acid halide, acid anhydride, ester, amide, lactone, and lactam.
6. Write the general electron-pushing (arrow-pushing) mechanisms for the nucleophilic acyl substitution of acid halide, acid anhydride, ester, and amide.
7. Explain the order of reactivity toward nucleophilic acyl substitution among acid halide, acid anhydride, ester, and amide based on the pK_a of the conjugate acid of the leaving groups on these four acid derivatives.
8. Provide appropriate reagents and reaction conditions for the feasible interconversions among acid halide, acid anhydride, carboxylic acid, ester, and amide.
9. Be able to describe the structures of fats, oils, and soaps, and be able to explain how detergents and surfactants work.

Sections to be covered (in the order of delivery):

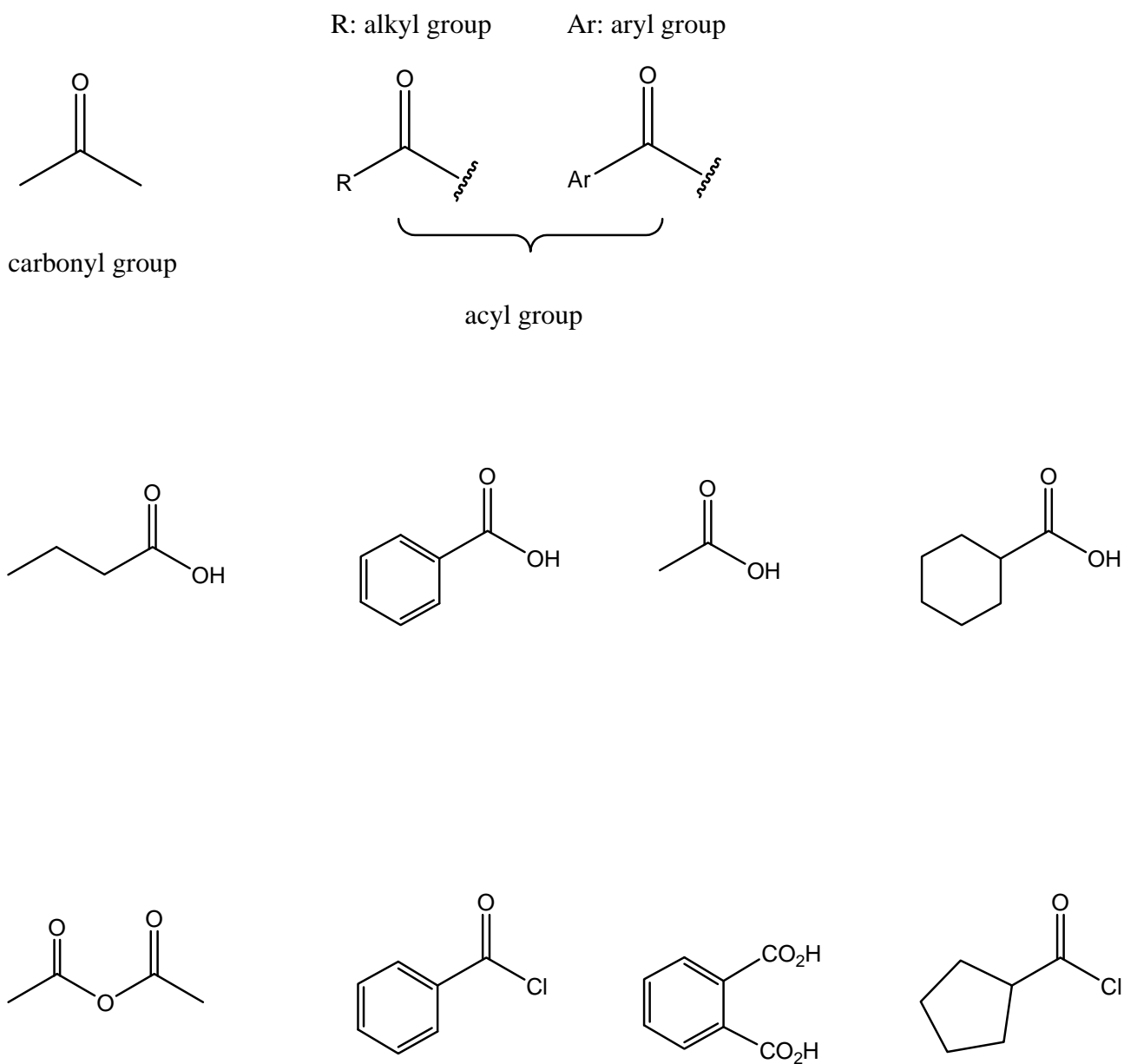
- 11.1 The nomenclature of carboxylic acids and carboxylic acid derivatives
- 11.2 The structures of carboxylic acid and carboxylic acid derivatives
- 11.3 The physical properties of carbonyl compounds
- 11.4 The structures of carboxylic acid and carboxylic acid derivatives found in nature
- 11.5 How carboxylic acid and carboxylic acid compounds react
- 11.6 Relative reactivities of carboxylic acid and carboxylic acid derivatives
- 11.7 The reaction of acyl chloride
- 11.8 The reaction of esters
- 11.9 Acid-catalyzed ester hydrolysis
- 11.10 Soaps, detergents, and micelles
- 11.11 The reaction of carboxylic acids
- 11.12 The reactions of amides
- 11.13 Acid-catalyzed amide hydrolysis
- 11.14 The synthesis of carboxylic acid derivatives
- 11.15 Nitriles[#]

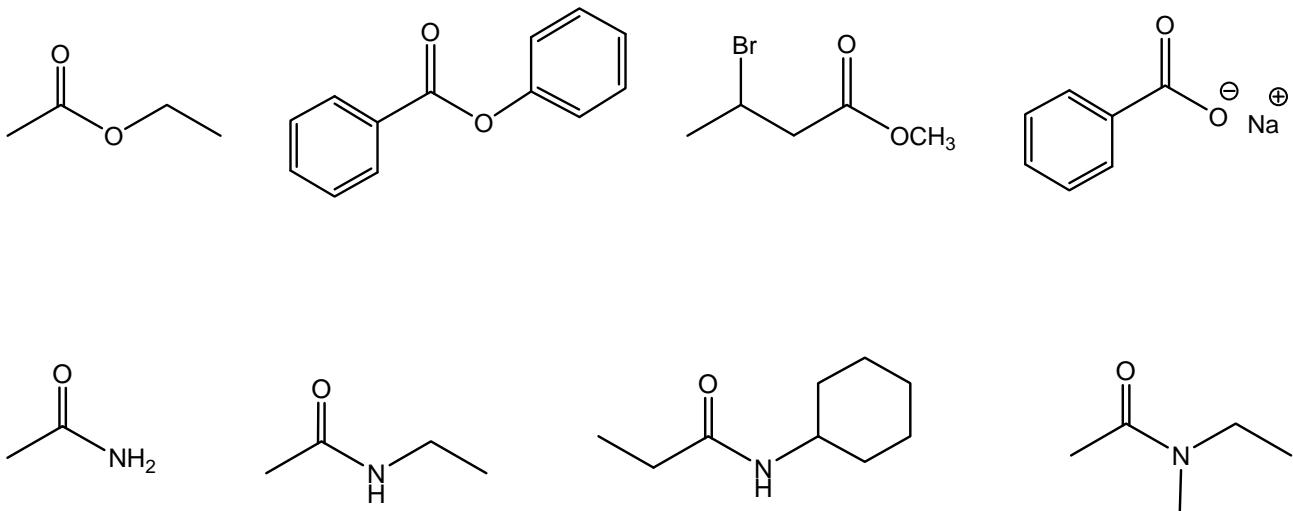
[#] Sections that will be skipped

Recommended additional problems

26, 27, 35, 36, 38, 42, 45

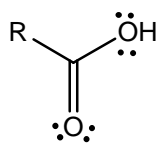
11.1 The nomenclature of carboxylic acids and carboxylic acid derivatives





11.2 The structures of carboxylic acid and carboxylic acid derivatives

A. Carboxylic acid



B. Acyl Halides

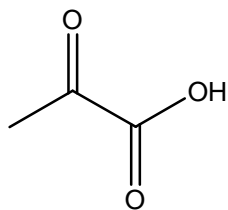
C. Acid Anhydrides

D. Esters and Lactones

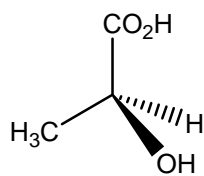
E. Amides and Lactams

11.3 The physical properties of carbonyl compounds

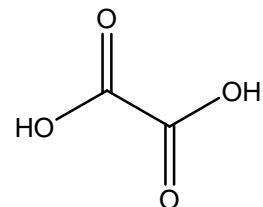
11.4 The structures of carboxylic acid and carboxylic acid derivatives found in nature



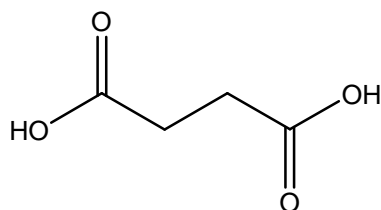
Pyruvate



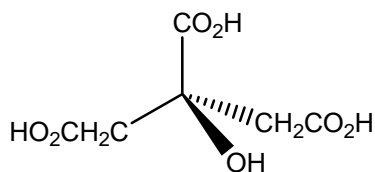
(S)-(+)-lactic acid



oxalic acid



Succinic acid



citric acid

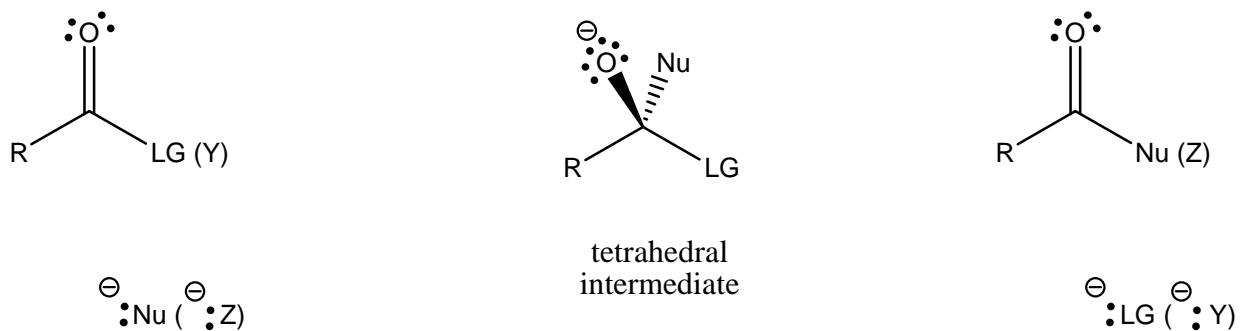
11.5 How carboxylic acid and carboxylic acid compounds react

11.6 Relative reactivities of carboxylic acid and carboxylic acid derivatives

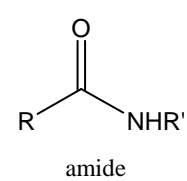
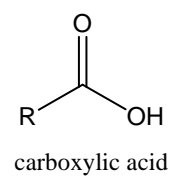
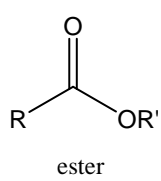
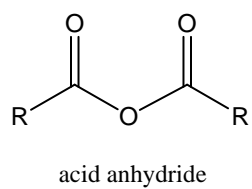
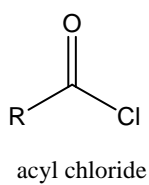
Know the relative strength of nucleophile (nucleophilicity) and leaving group

Know the relative relationship of nucleophilicity, basicity, and pKa

A. Nucleophilic acyl substitution reaction (an addition-elimination reaction)



B. Relative reactivities of carboxylic acid derivatives



(i) Inductive effect vs. resonance effect

(ii) Nucleophilicity, basicity, and pK_a

11.7 The reaction of acyl chloride

A. Reactions

B. Why two equivalents of amine are needed for the formation of amide?

11.8 The reaction of esters

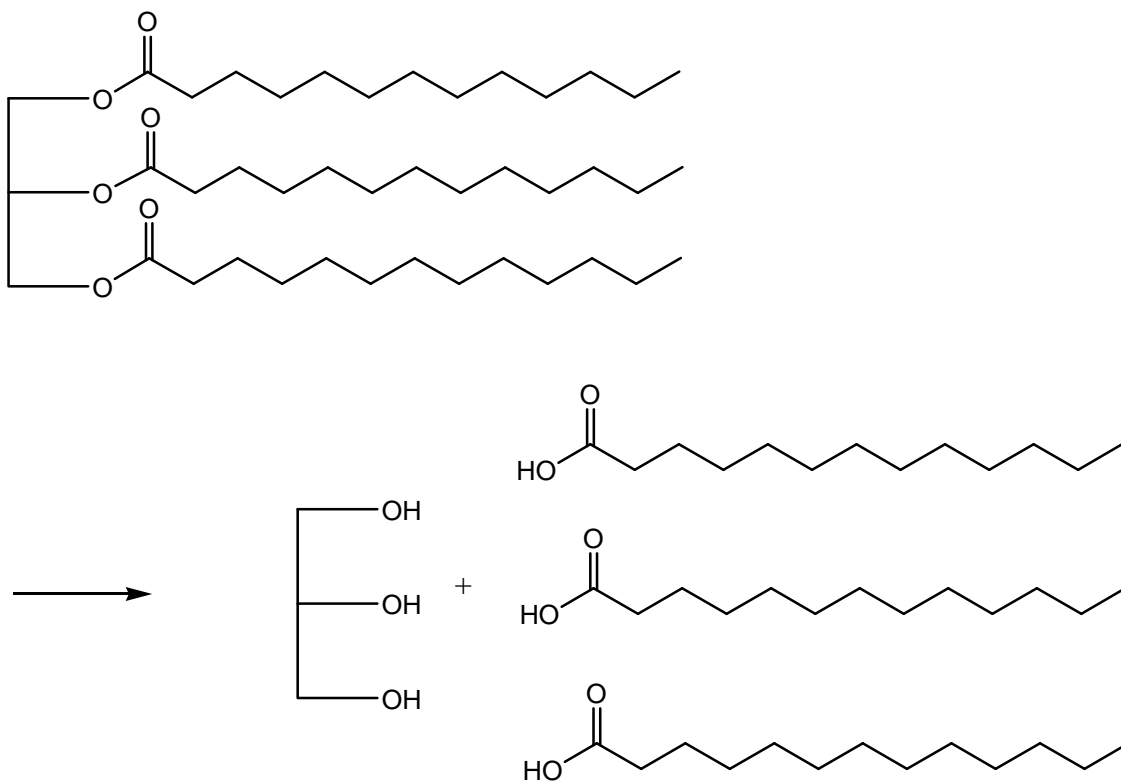
11.9 Acid-catalyzed ester hydrolysis

A. Reactions with water or alcohols

B. Reaction with amines

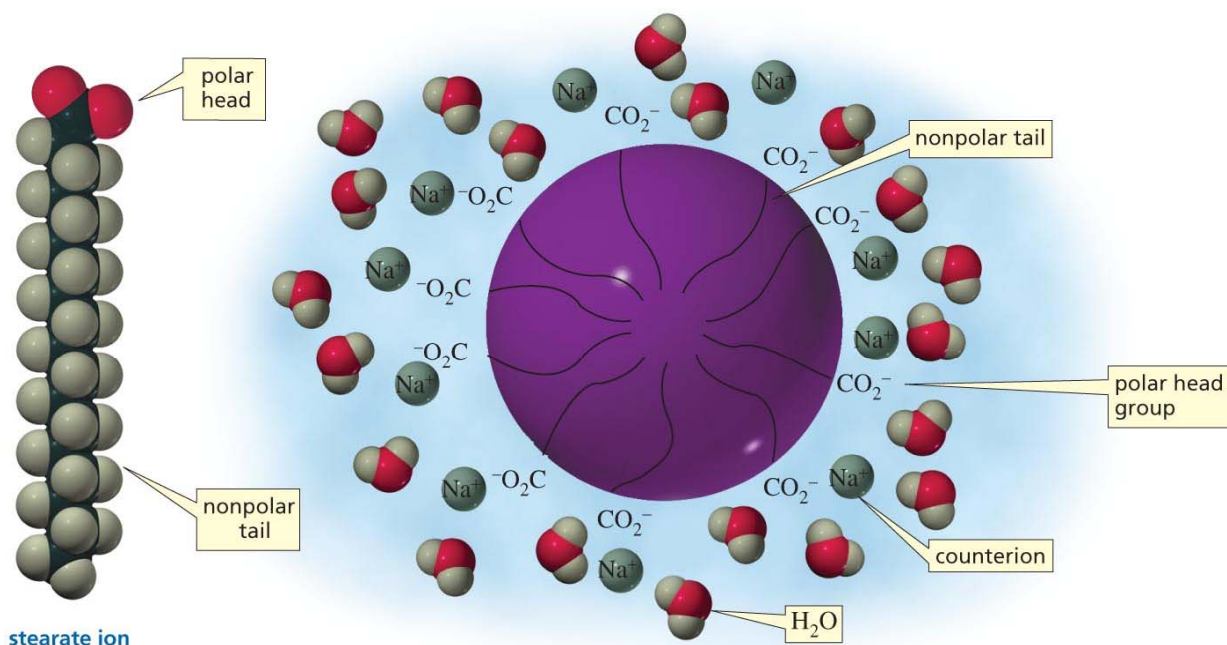
11.10 Soaps, detergents, and micelles

A. Saponification (basic condition)

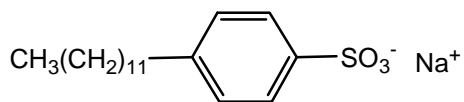


B. How does soap work?

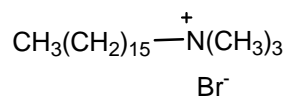
Recognize amphiphilic compounds (compounds that possess both hydrophilic and lipophilic (hydrophobic) properties.)



C. Detergents and antibiotics



a detergent

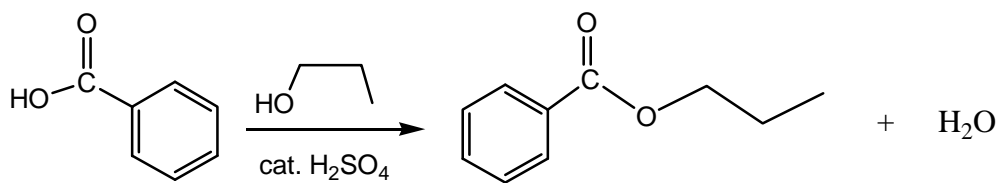


Cetrimonium bromide
(hexadecyltrimethylammonium bromide)
a topical antiseptic

11.11 The reaction of carboxylic acids

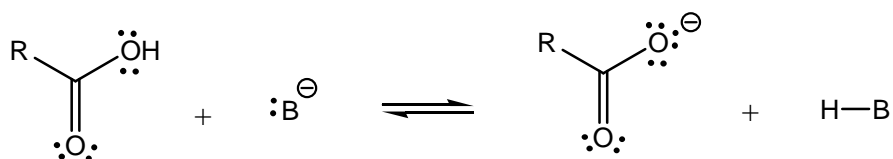
A. Fisher esterification

(i) Example



(ii) Mechanism

B. Reaction with bases

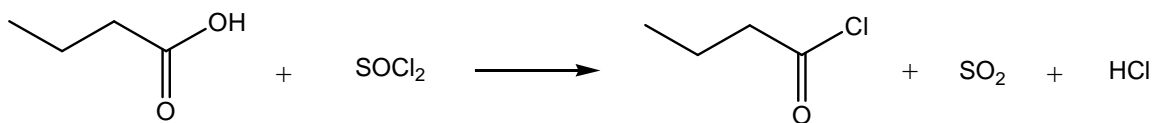


11.12 The reactions of amides

11.13 Acid-catalyzed amide hydrolysis

11.14 The synthesis of carboxylic acid derivatives

A. Use of SOCl_2



B. Overview

