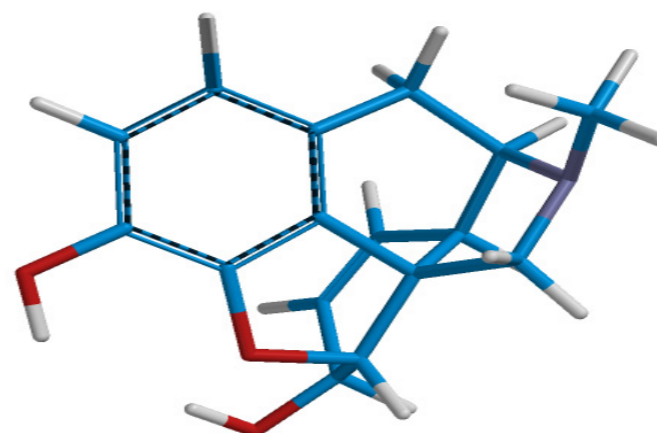


21

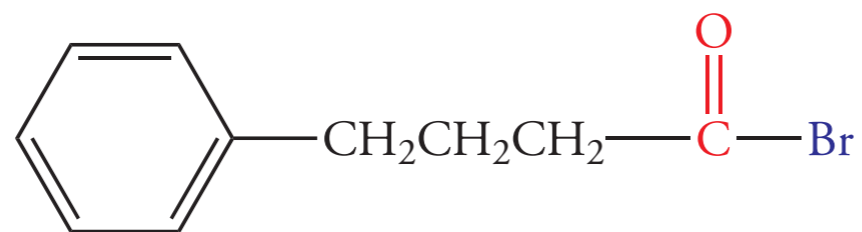
CARBOXYLIC ACID DERIVATIVES



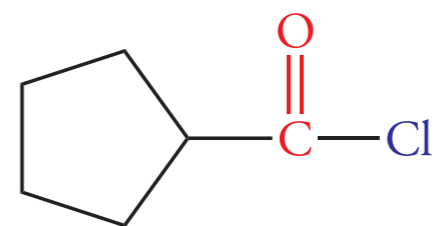
PENICILLIN G

21.1 NOMENCLATURE OF CARBOXYLIC ACID DERIVATIVES

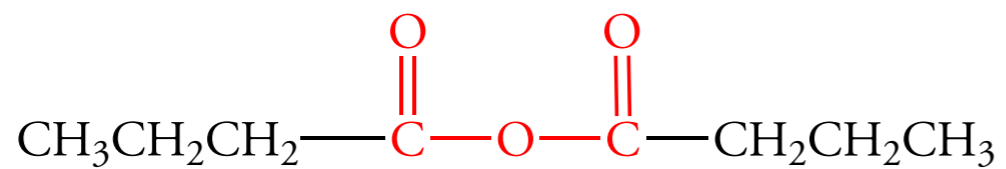
Names of Acid Halides and Acid Anhydrides



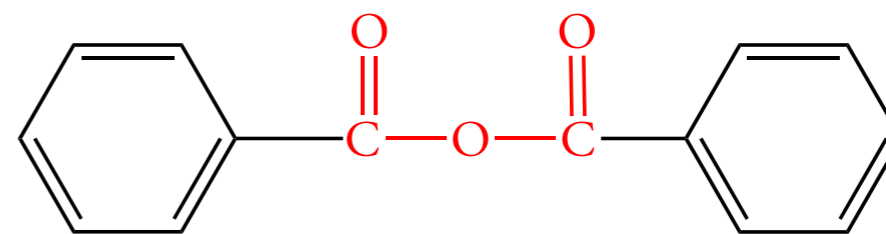
4-phenylbutanoyl bromide



cyclopentanecarbonyl chloride



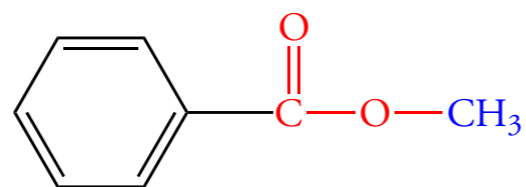
butanoic anhydride



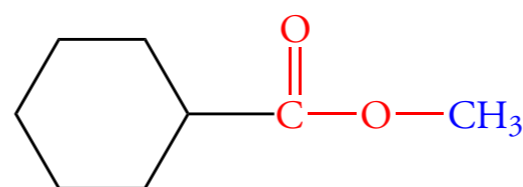
benzoic anhydride

21.1 NOMENCLATURE OF CARBOXYLIC ACID DERIVATIVES

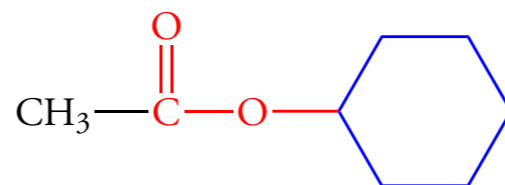
Names of Esters



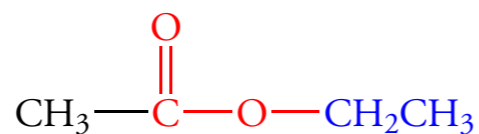
methyl benzoate



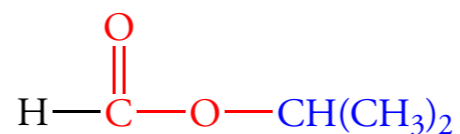
methyl cyclohexanecarboxylate



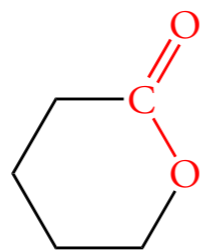
cyclohexyl ethanoate



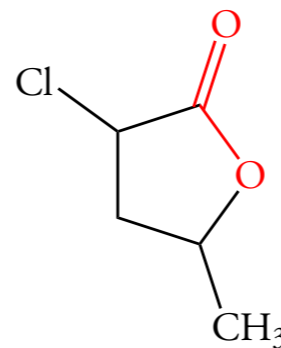
ethyl acetate



isopropyl formate



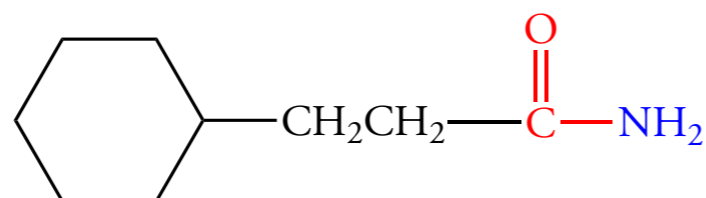
5-hydroxypentanoic acid lactone
(δ -valerolactone)



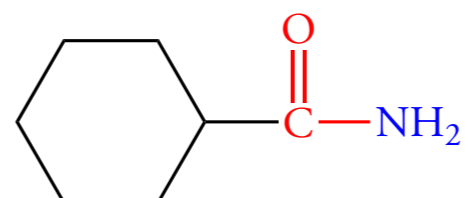
4-hydroxy-2-chloropentanoic acid lactone
(α -chloro- γ -valerolactone)

21.1 NOMENCLATURE OF CARBOXYLIC ACID DERIVATIVES

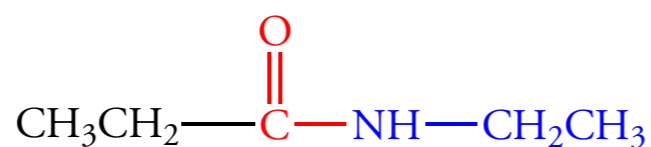
Names of Amides



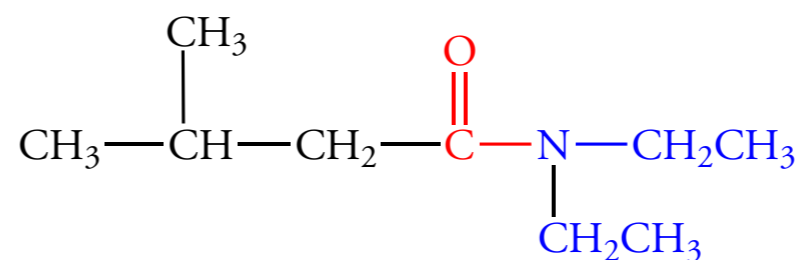
3-cyclohexylpropanamide



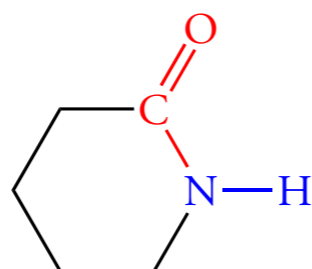
cyclohexanecarboxamide



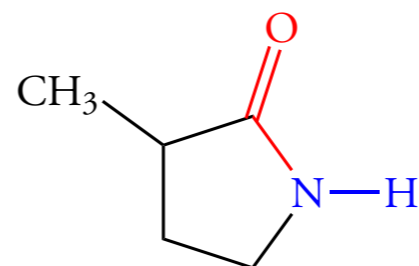
N-ethylpropanamide
(*N*-ethylpropionamide)



N,N-diethyl-3-methylbutanamide
(*N,N*-diethyl- β -methylbutyramide)



5-aminopentanoic acid lactam
(δ -valerolactam)



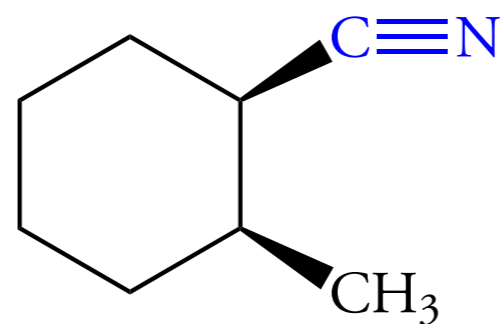
4-amino-2-methylbutanoic acid lactam
(α -methyl- γ -butyrolactam)

21.1 NOMENCLATURE OF CARBOXYLIC ACID DERIVATIVES

Names of Nitriles



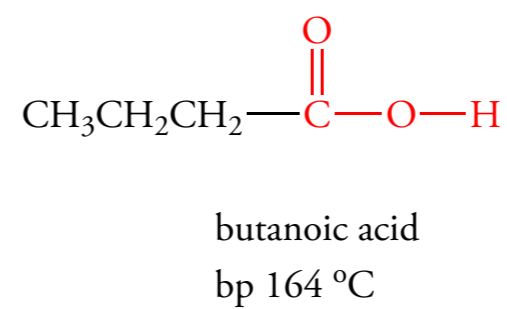
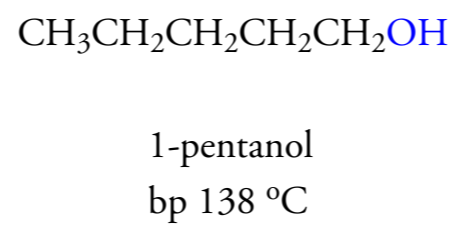
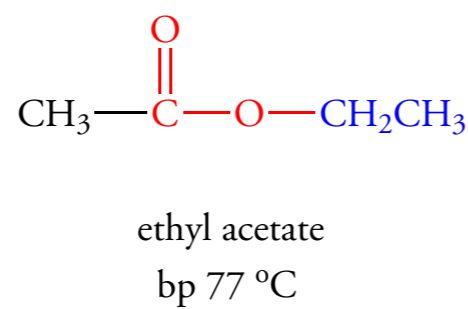
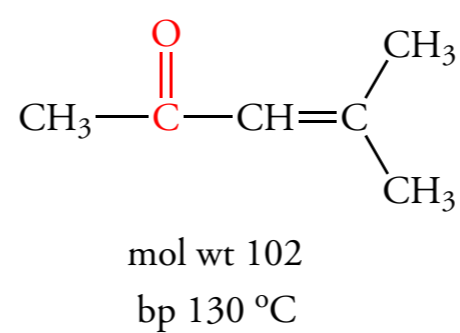
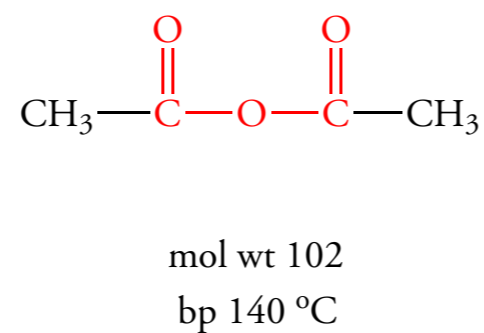
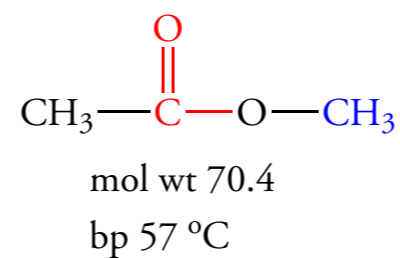
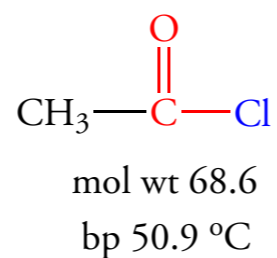
4-chlorobutanenitrile



cis-2-methylcyclohexanecarbonitrile

21.2 PHYSICAL PROPERTIES OF ACYL DERIVATIVES

Esters



21.2 PHYSICAL PROPERTIES OF ACYL DERIVATIVES

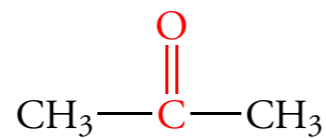
Esters

Table 21.1
Physical Properties of Esters

IUPAC Name	Boiling Point, °C	Solubility, g/100 g H ₂ O
methyl methanoate	32	miscible
methyl ethanoate	57	24.4
methyl propanoate	80	1.8
methyl butanoate	102	0.5
methyl pentanoate	126	0.2
methyl hexanoate	151	0.06
ethyl methanoate	54	miscible
ethyl ethanoate	77	7.4
ethyl propanoate	99	1.7
ethyl butanoate	120	0.5
ethyl pentanoate	145	0.2
propyl ethanoate	102	1.9
butyl ethanoate	125	1.0
methyl benzoate	199	0.1
ethyl benzoate	213	0.08

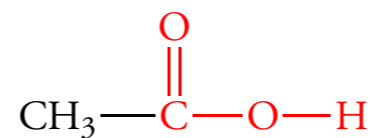
21.2 PHYSICAL PROPERTIES OF ACYL DERIVATIVES

Amides



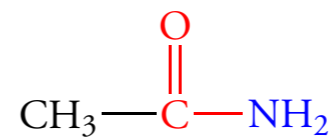
bp 56.5 °C

mp -94 °C



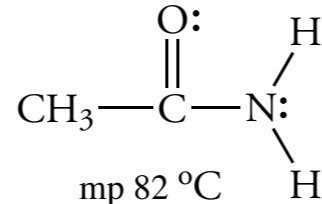
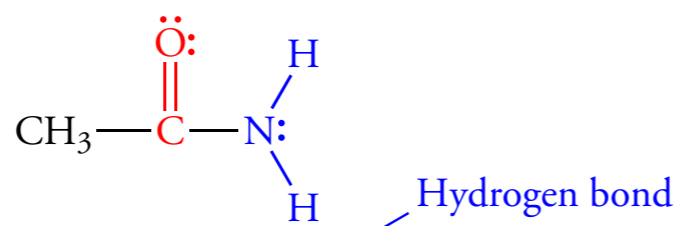
bp 118 °C

mp 16.7 °C



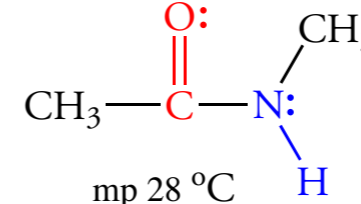
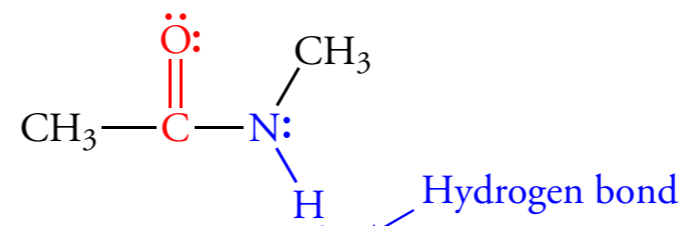
bp 221 °C

mp 82 °C



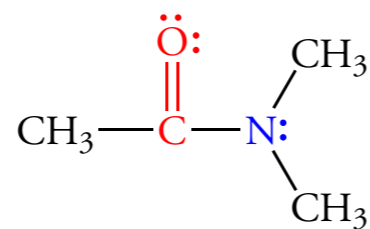
mp 82 °C

bp 221 °C



mp 28 °C

bp 204 °C

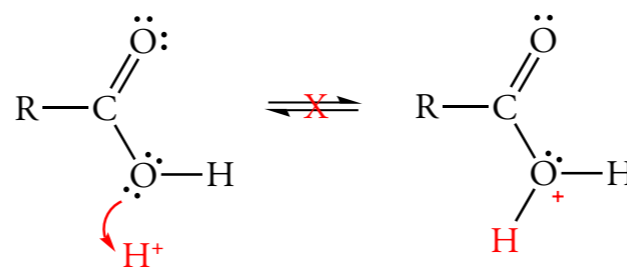


No hydrogen bond is possible.

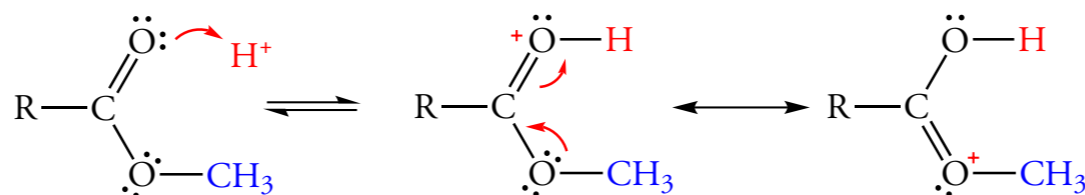
mp -20 °C

bp 166 °C

21.3 BASICITY OF CARBOXYLIC ACID DERIVATIVES

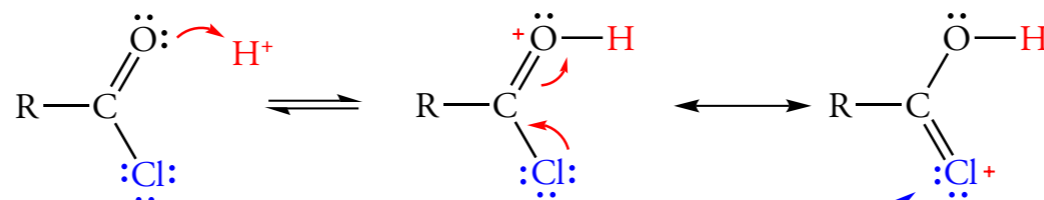


conjugate acid, *not* resonance-stabilized

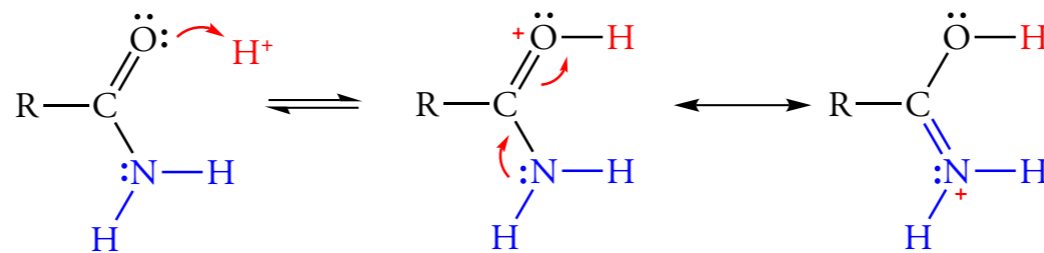


resonance-stabilized conjugate acid of an ester

$\text{pK}_a = -6$

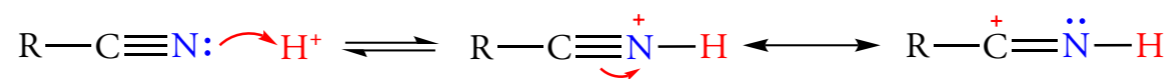


poor resonance-stabilization



resonance-stabilized conjugate acid of an amide

$\text{pK}_a = -1$

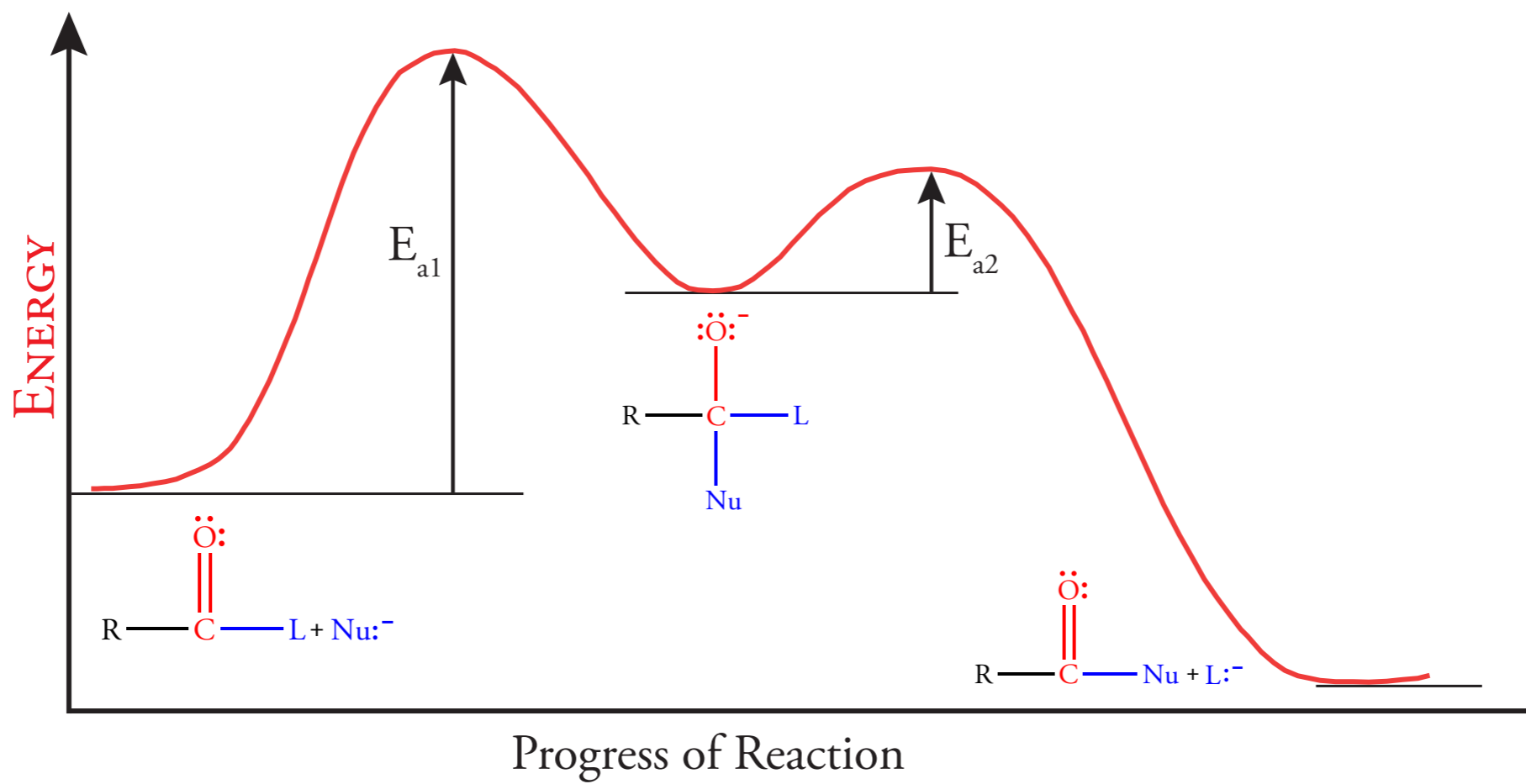
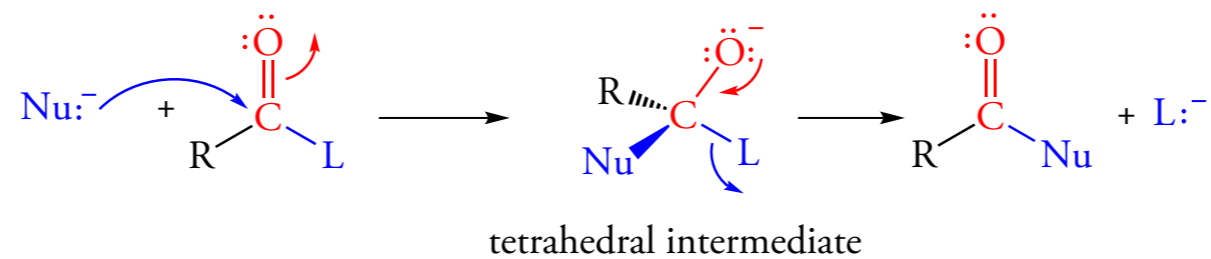


resonance-stabilized conjugate acid of a nitrile

$\text{pK}_a = -10$

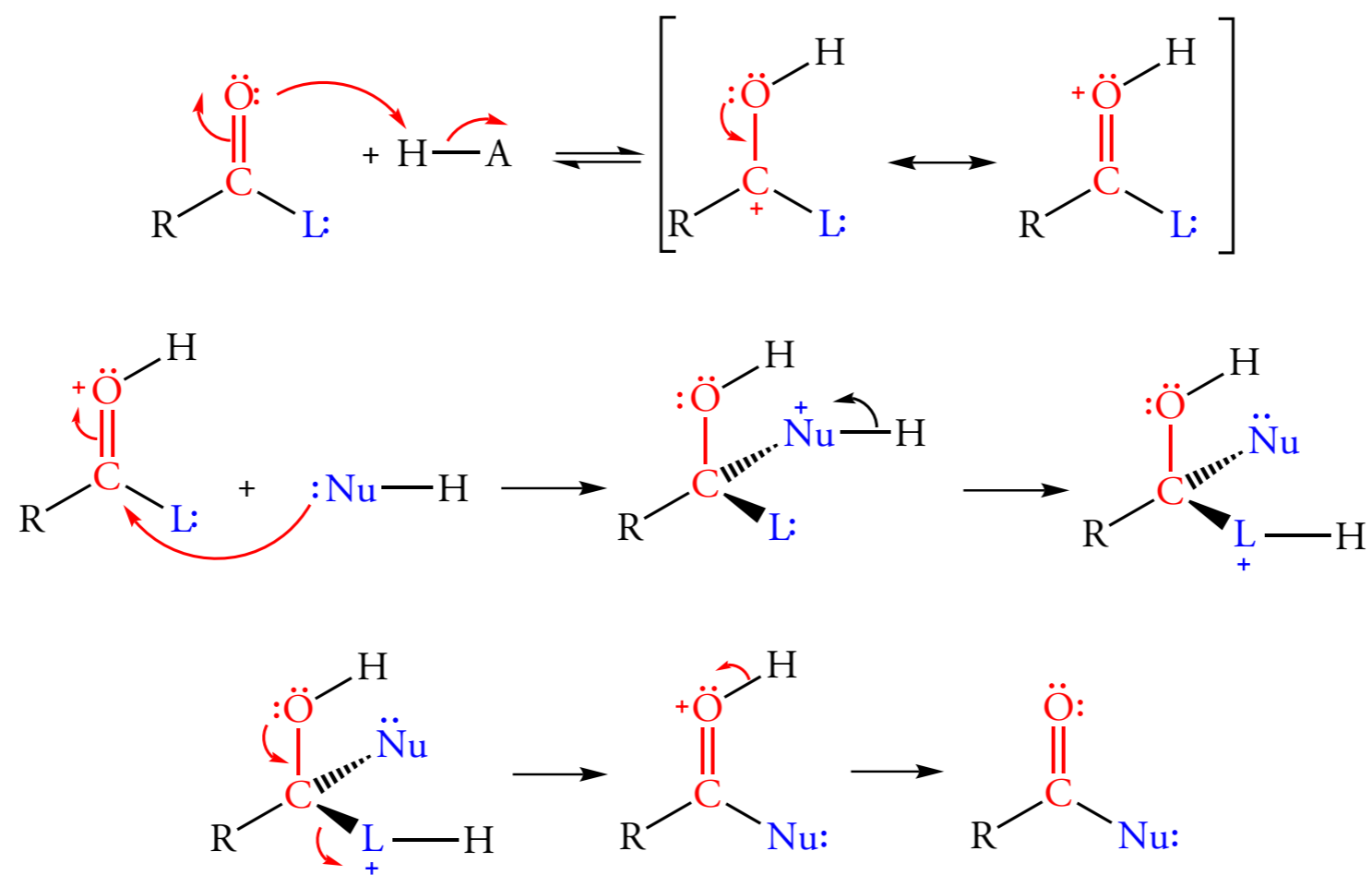
21.4 MECHANISM OF NUCLEOPHILIC ACYL SUBSTITUTION

Figure 21.1 Mechanism of Nucleophilic Acyl Substitution



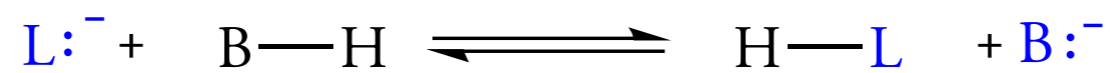
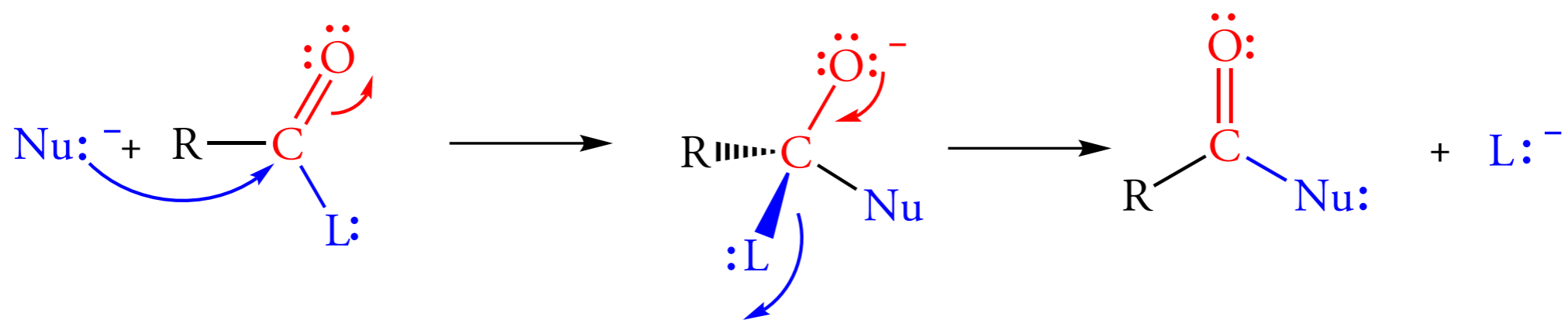
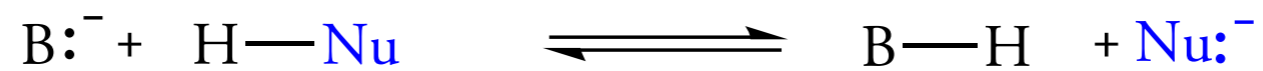
21.4 MECHANISM OF NUCLEOPHILIC ACYL SUBSTITUTION

Acid-Catalyzed Acyl Substitution Reactions



21.4 MECHANISM OF NUCLEOPHILIC ACYL SUBSTITUTION

Base-Catalyzed Acyl Substitution Reactions



21.4 MECHANISM OF NUCLEOPHILIC ACYL SUBSTITUTION

Relative Reactivity of Acyl Derivatives

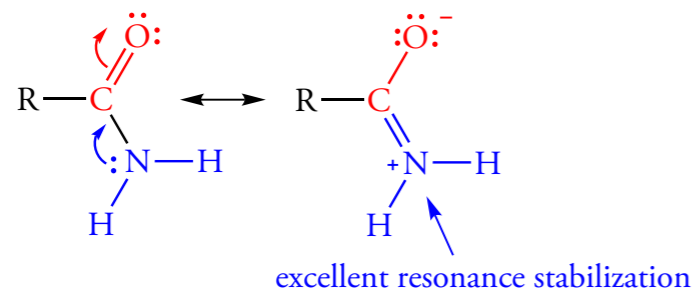
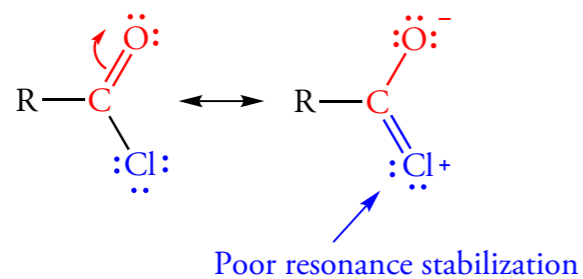
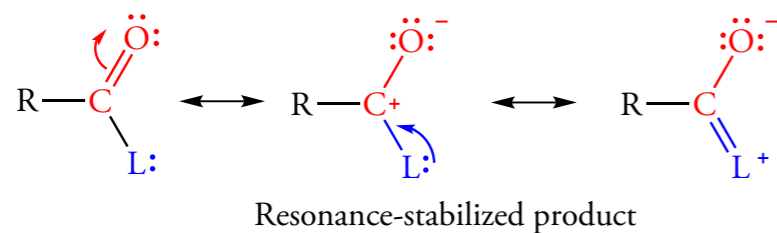
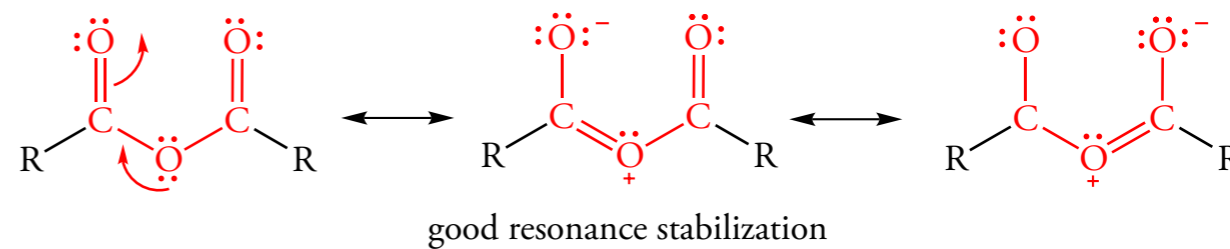
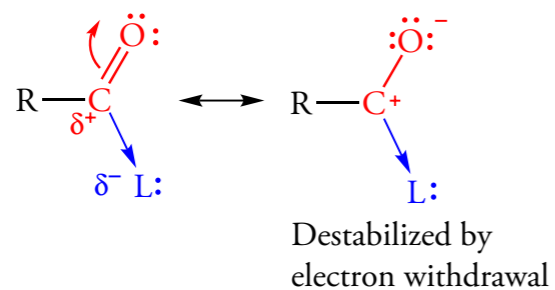
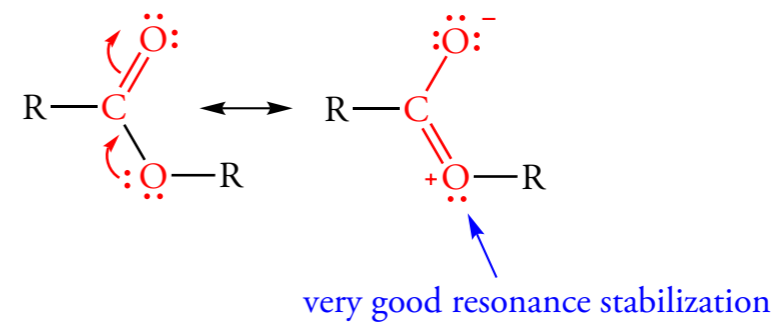
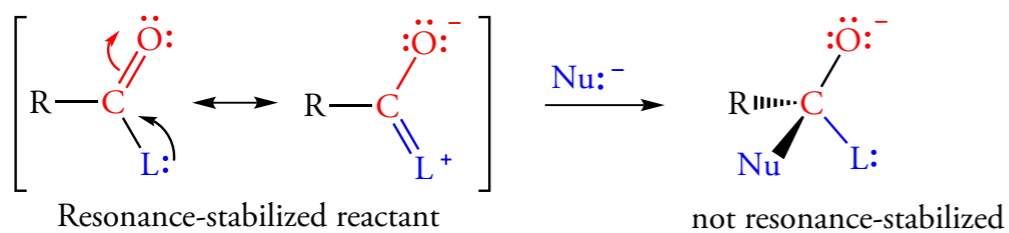
Table 21.3

Relative Reactivities of Acyl Derivatives

Acyl Compound	Relative rate of hydrolysis
acetyl chloride	10^{13}
acetic anhydride	10^9
ethyl acetate	10^2
acetamide	1

21.4 MECHANISM OF NUCLEOPHILIC ACYL SUBSTITUTION

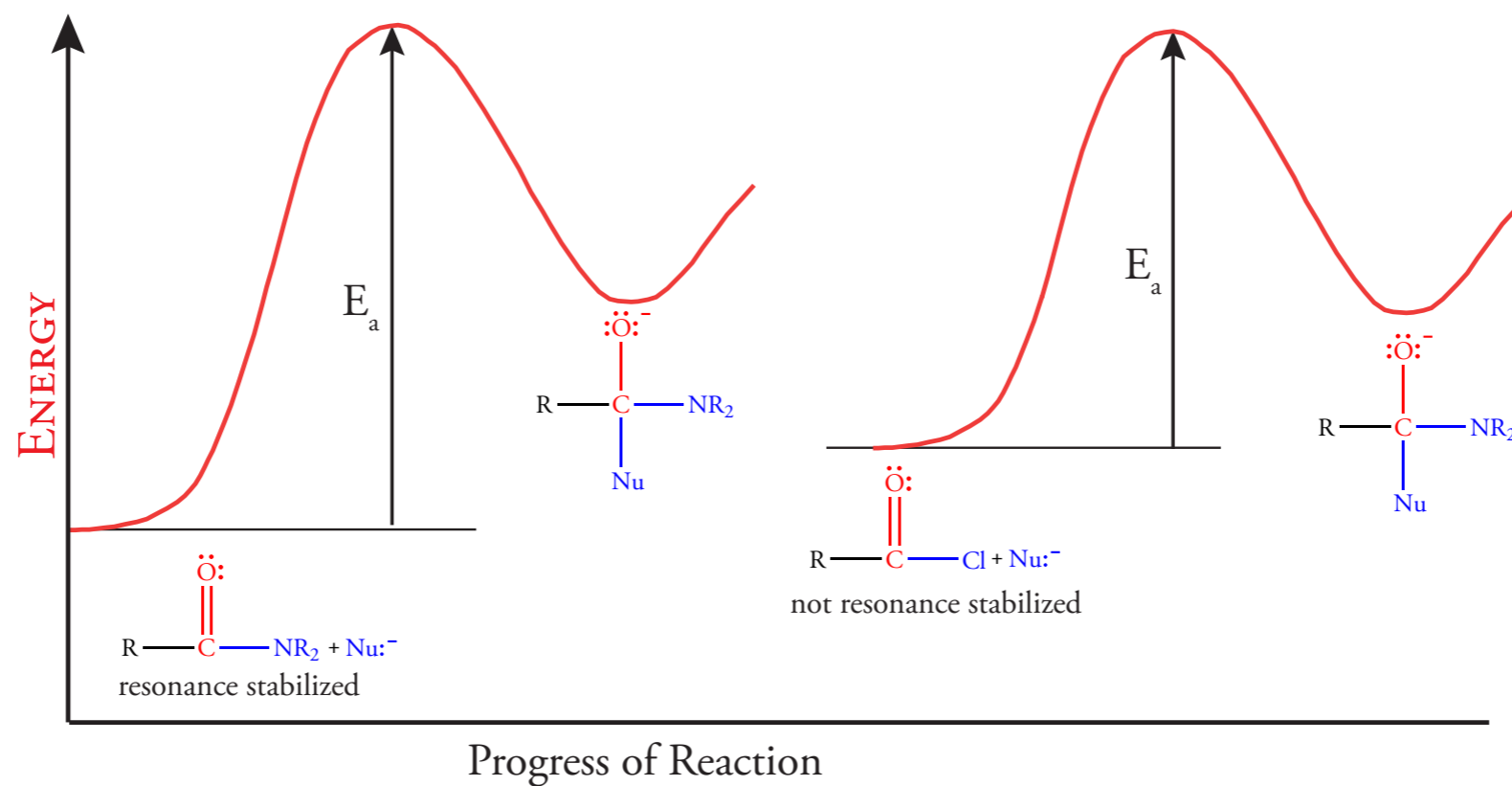
Relative Reactivity of Acyl Derivatives



21.4 MECHANISM OF NUCLEOPHILIC ACYL SUBSTITUTION

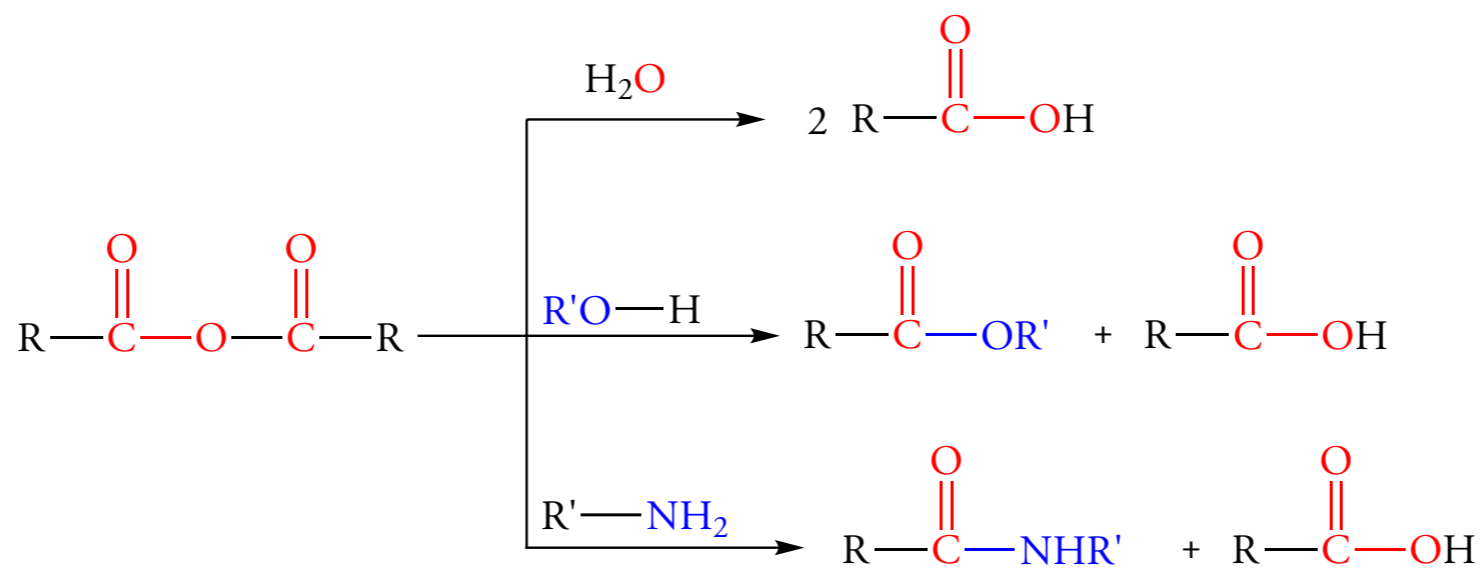
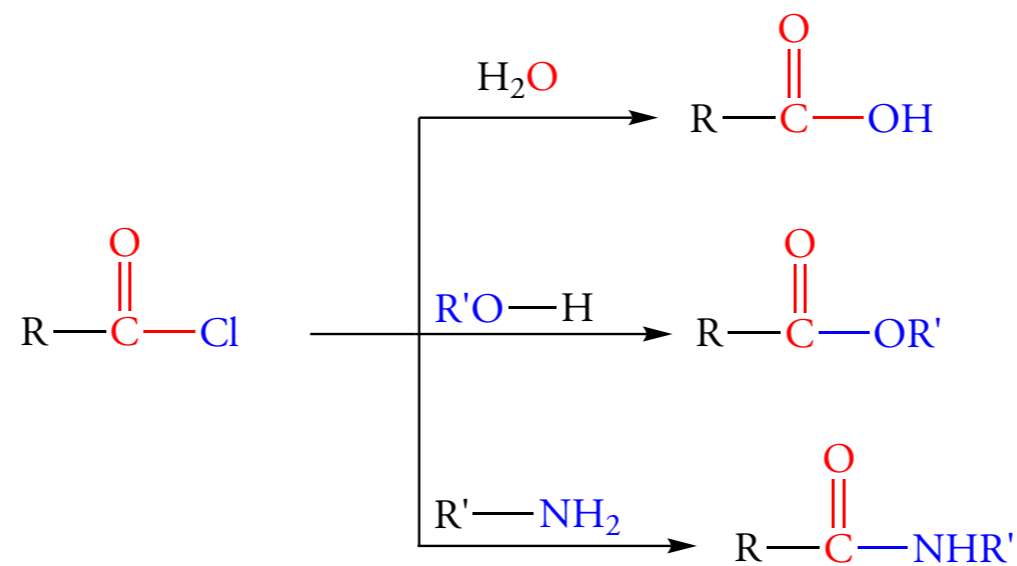
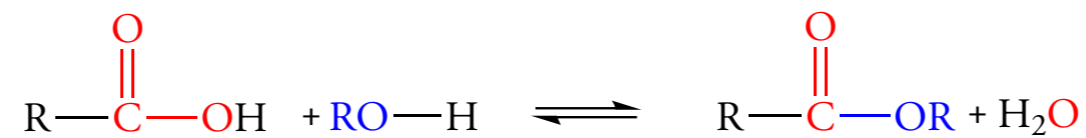
Relative Reactivity of Acyl Derivatives

Figure 21.1 Reactivity of Acyl Derivatives



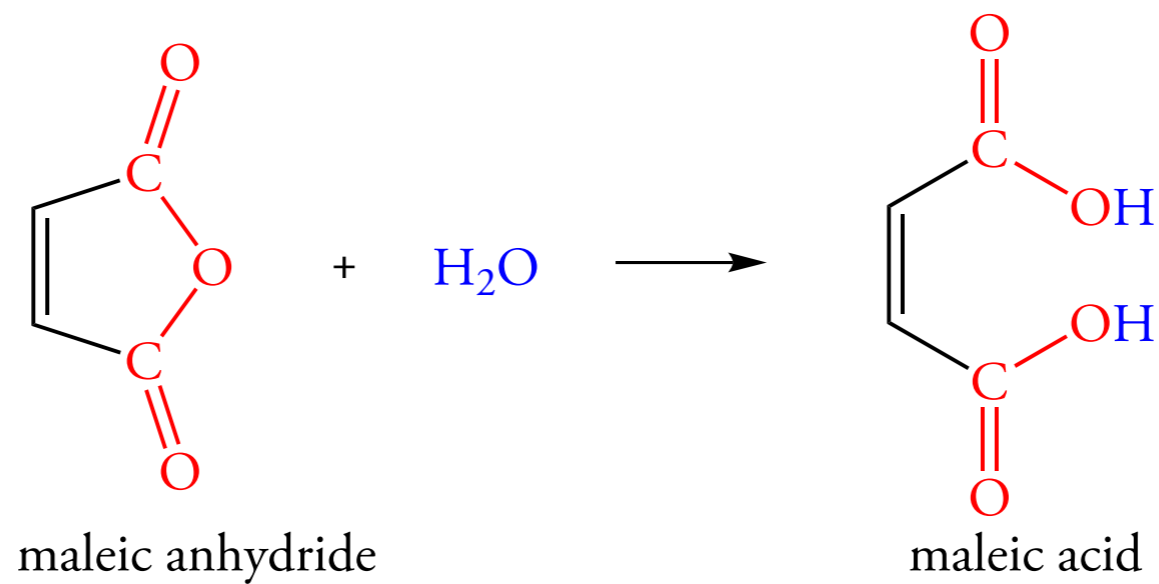
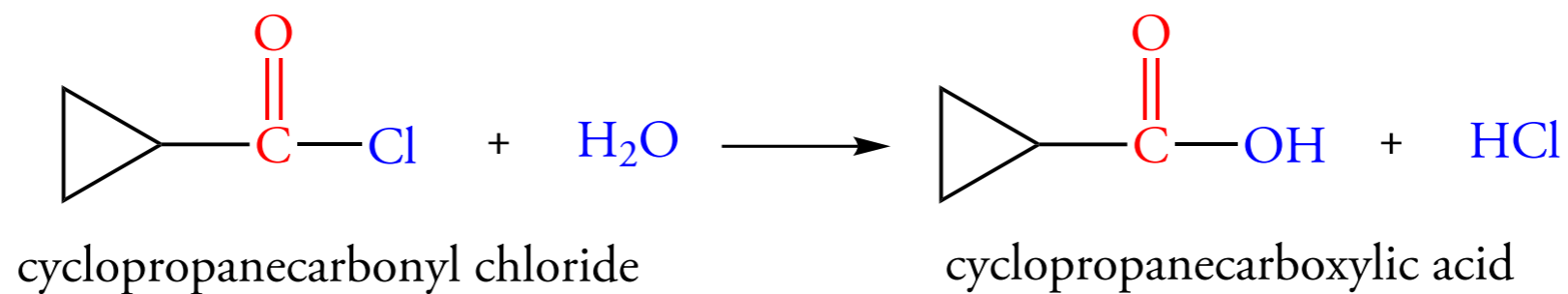
21.4 MECHANISM OF NUCLEOPHILIC ACYL SUBSTITUTION

Predicting the Direction of a Nucleophilic Acyl Substitution Reaction



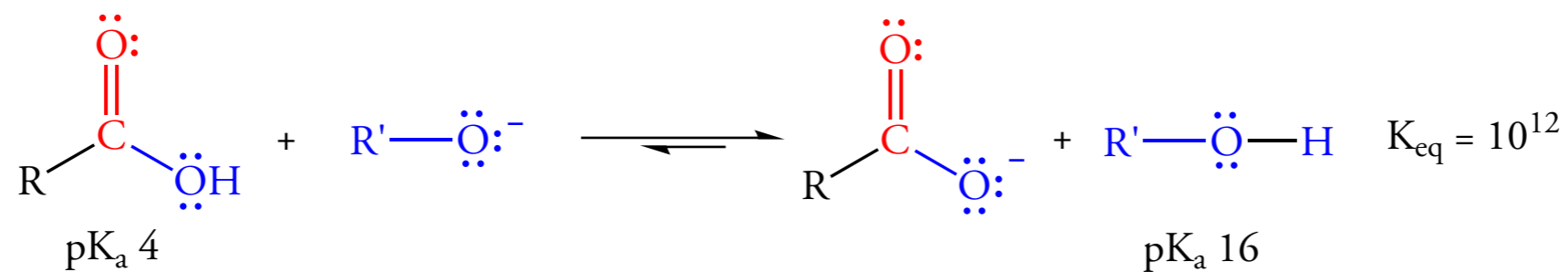
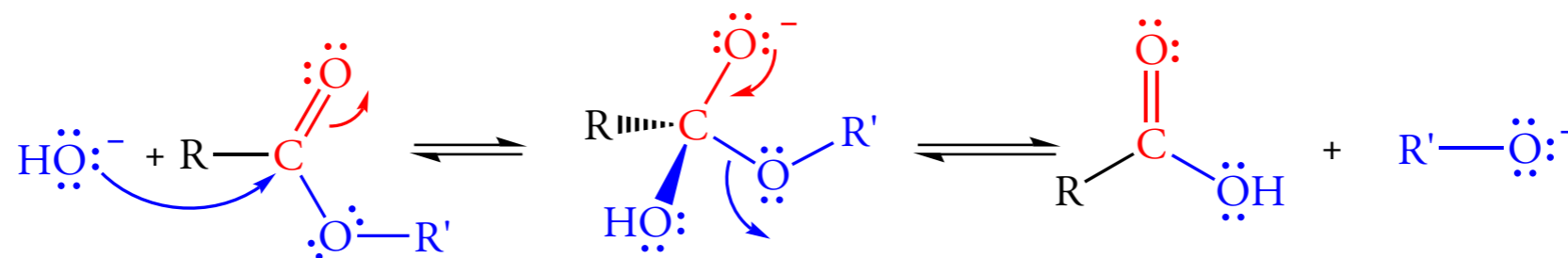
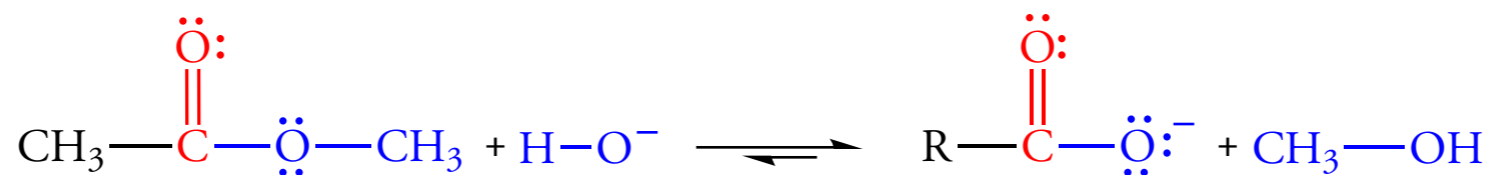
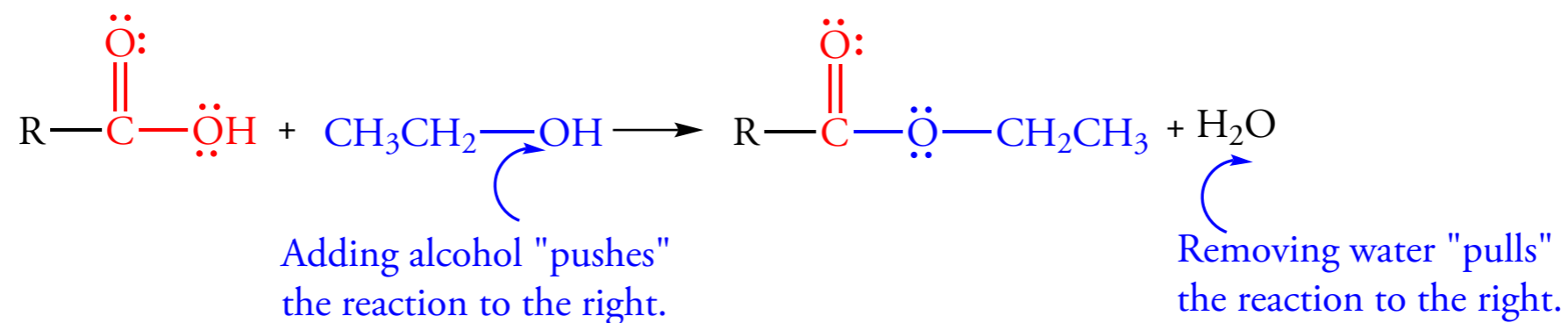
21.5 HYDROLYSIS OF ACYL DERIVATIVES

Hydrolysis of Acid Chlorides and Anhydrides



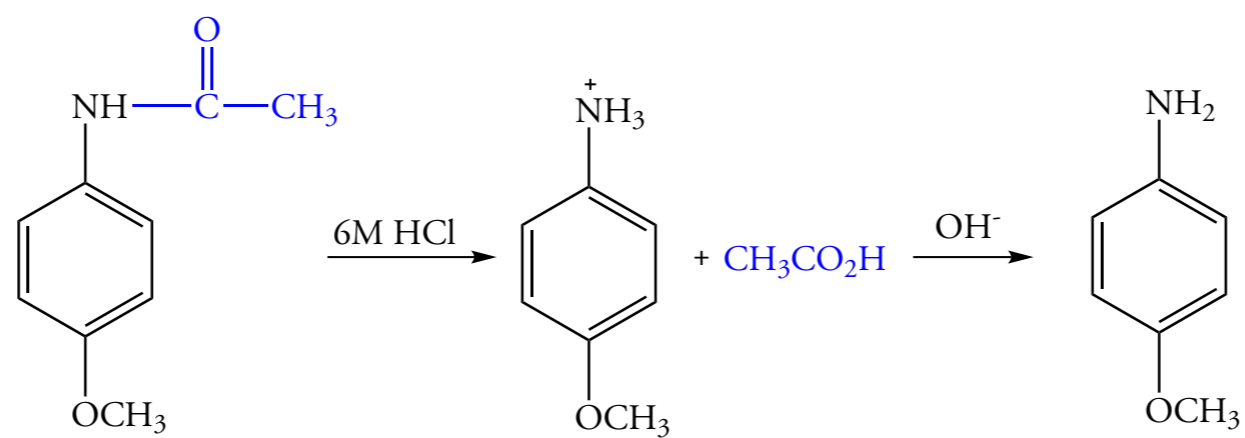
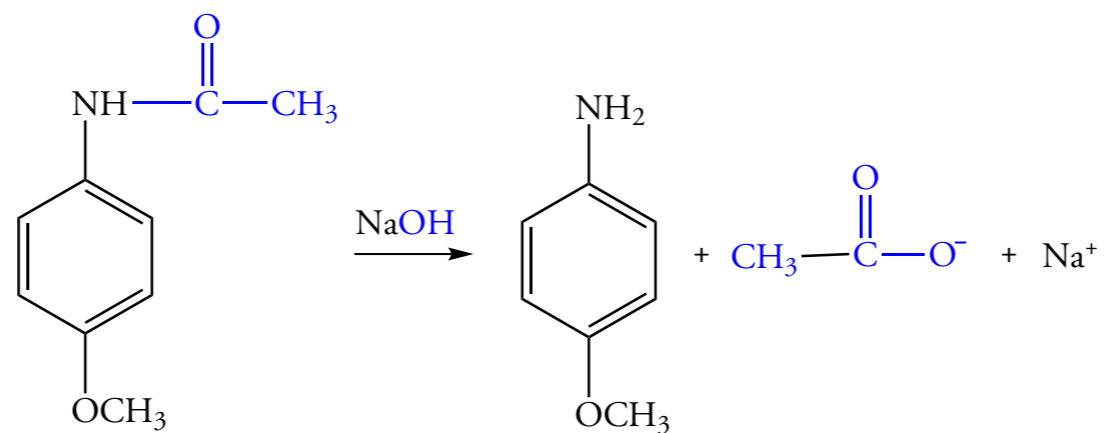
21.5 HYDROLYSIS OF ACYL DERIVATIVES

Hydrolysis of Esters



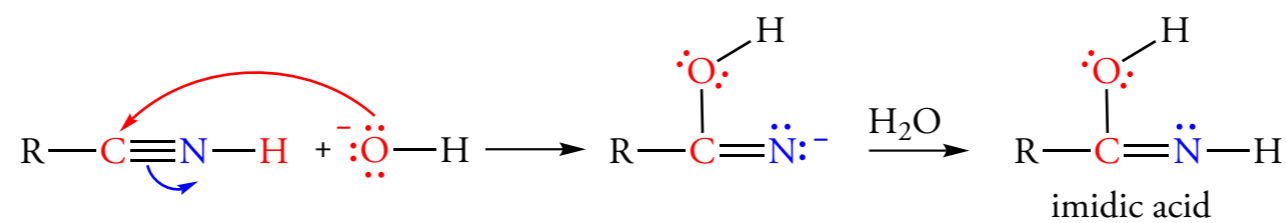
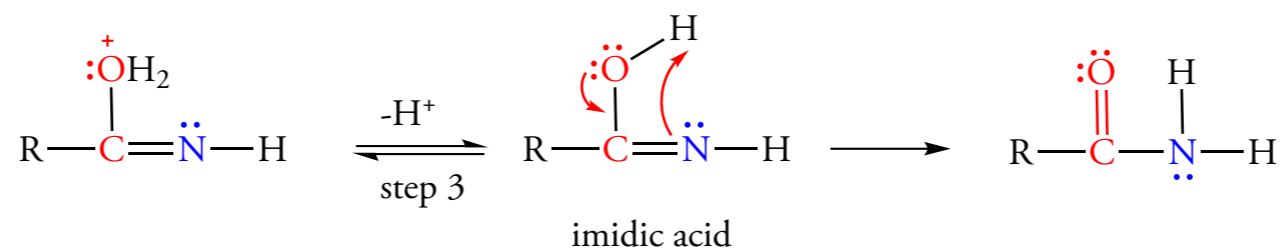
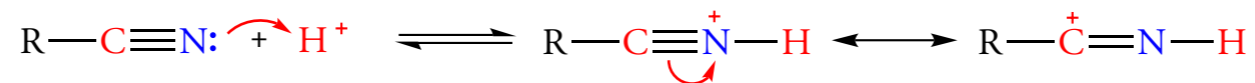
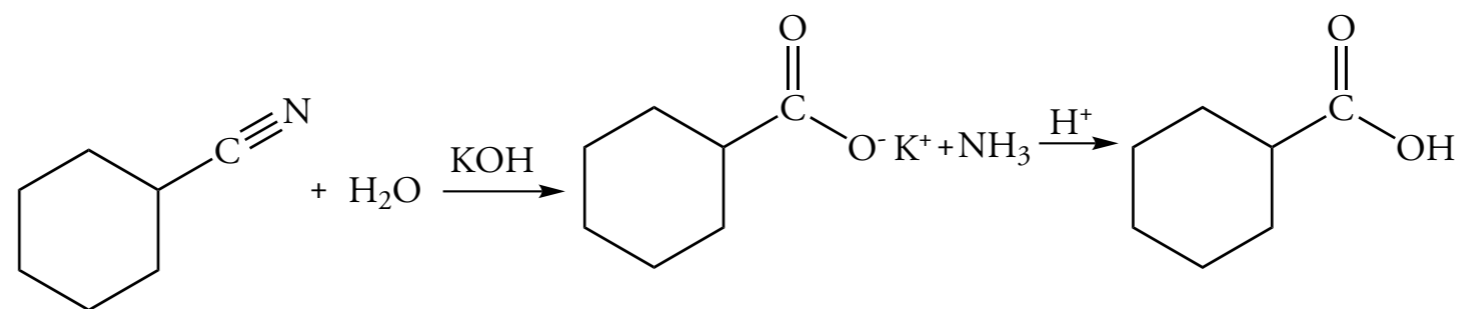
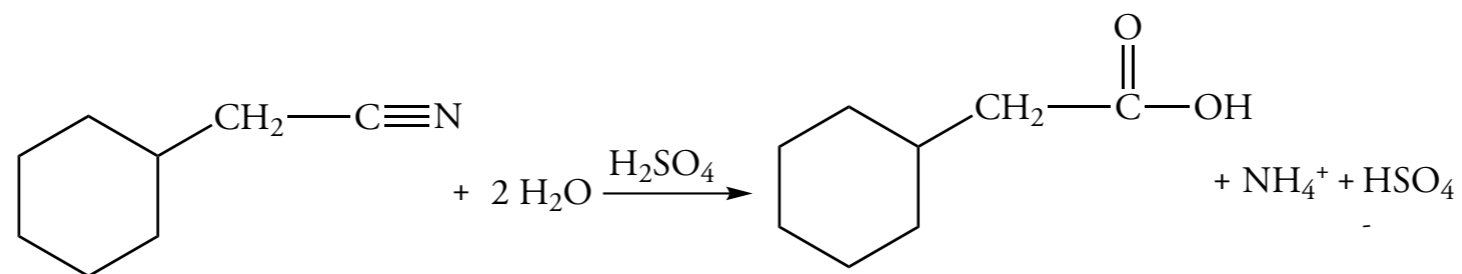
21.5 HYDROLYSIS OF ACYL DERIVATIVES

Hydrolysis of Amides



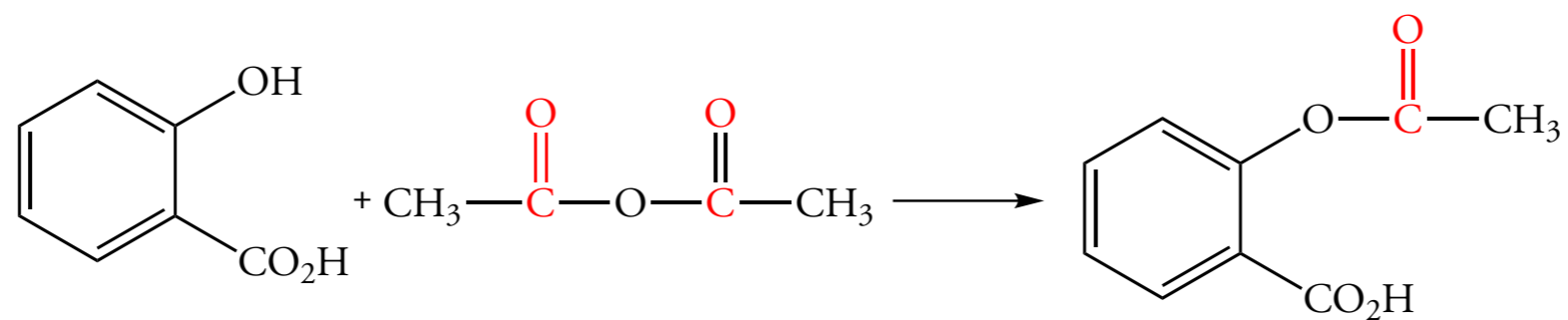
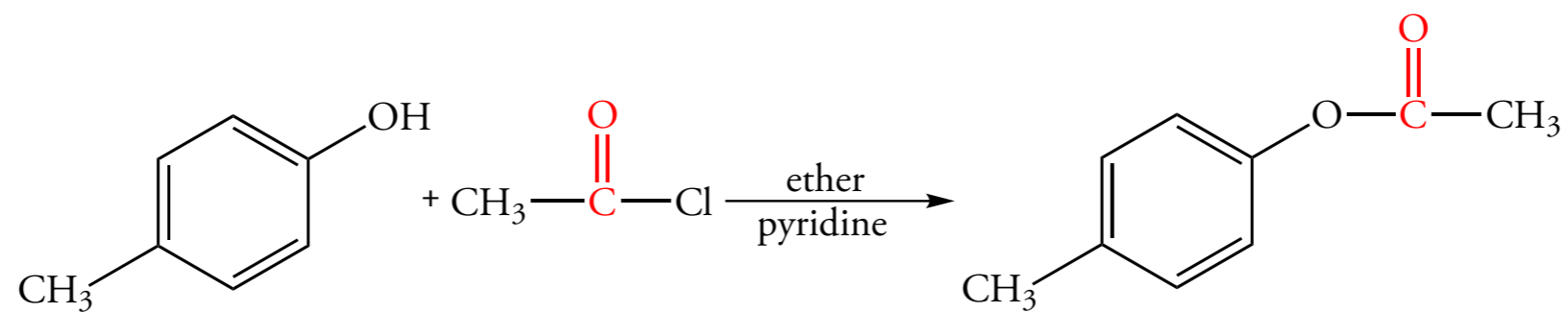
21.5 HYDROLYSIS OF ACYL DERIVATIVES

Hydrolysis of Nitriles

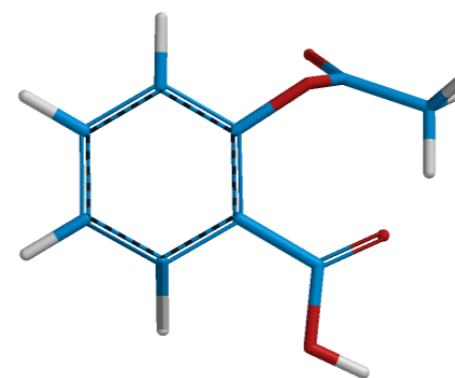


21.6 REACTION OF ACYL DERIVATIVES WITH ALCOHOLS

Acid Chlorides and Anhydrides



acetyl salicylic acid (aspirin)

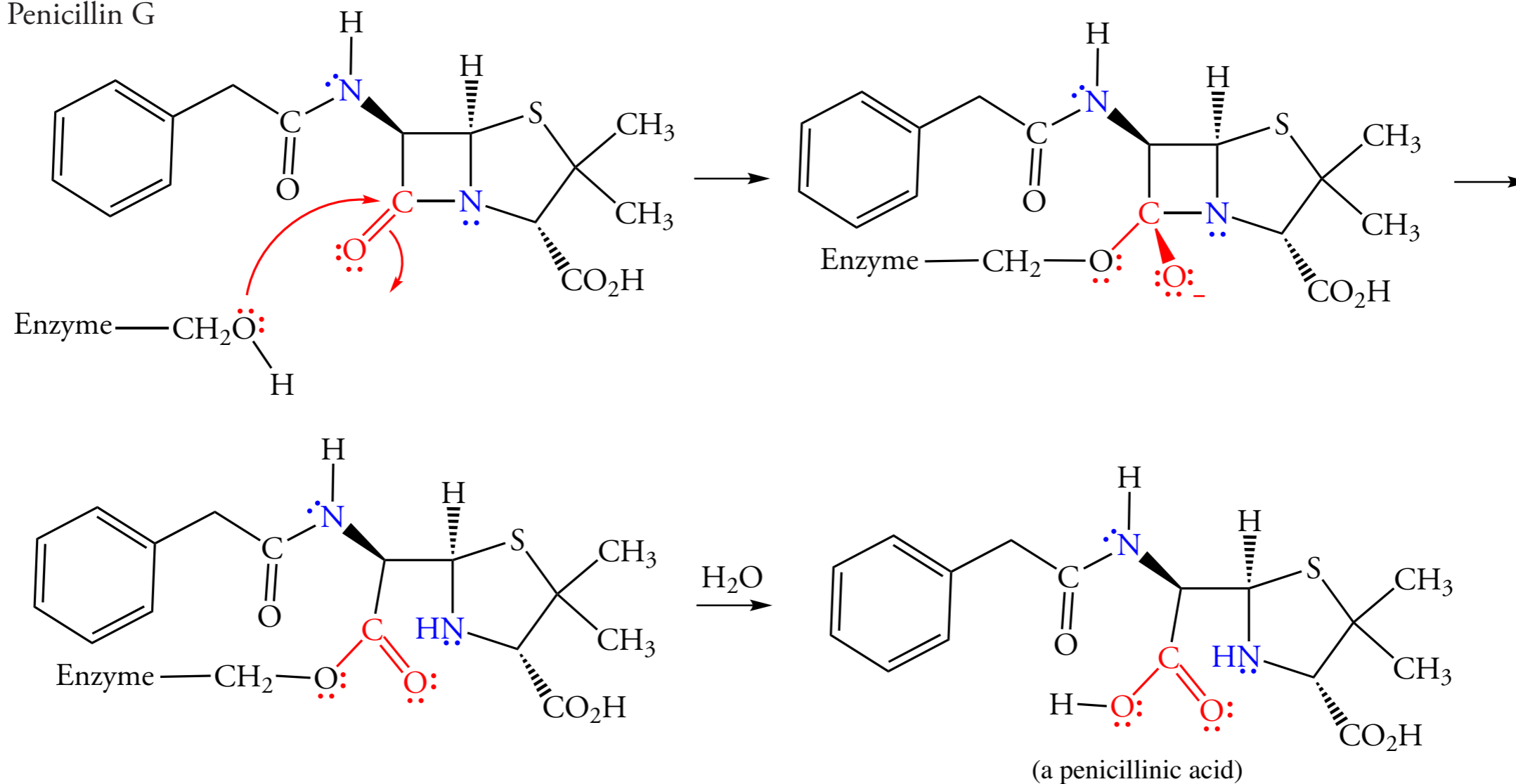


aspirin

21.6 REACTION OF ACYL DERIVATIVES WITH ALCOHOLS

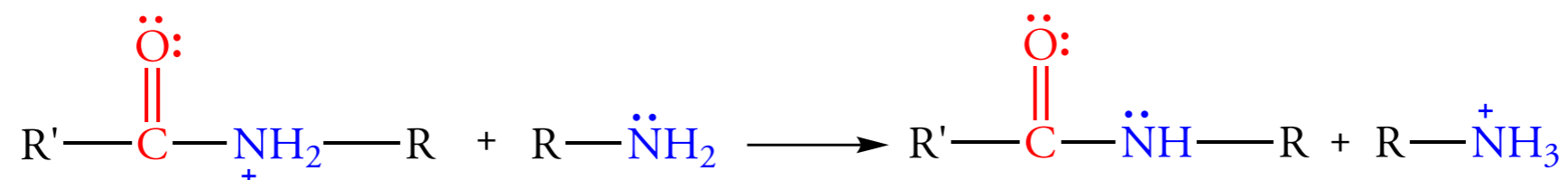
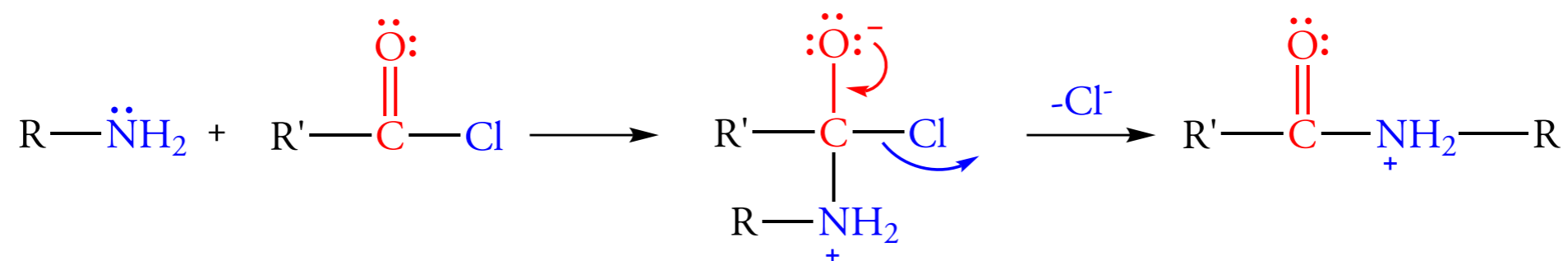
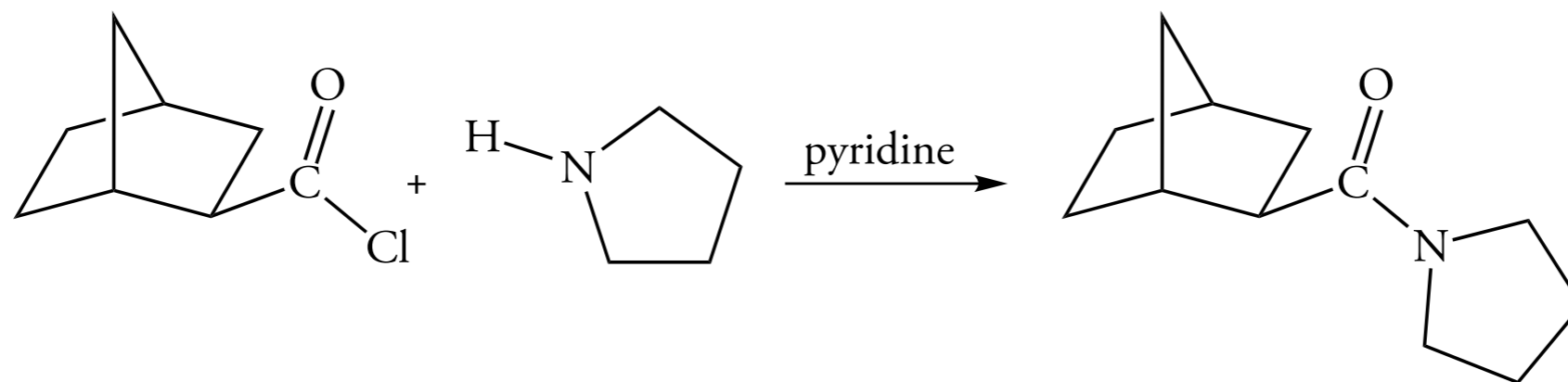
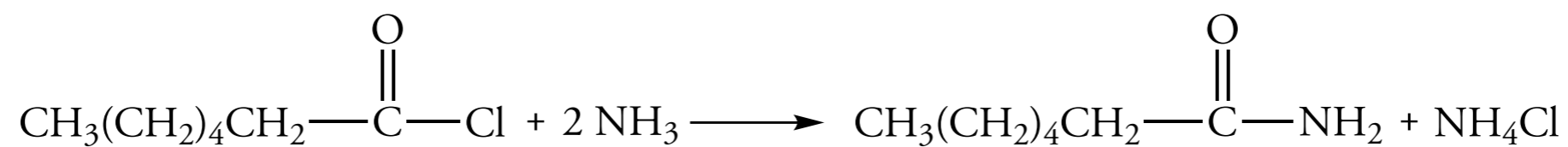
Biochemical Hydrolysis of Penicillin

Penicillin G



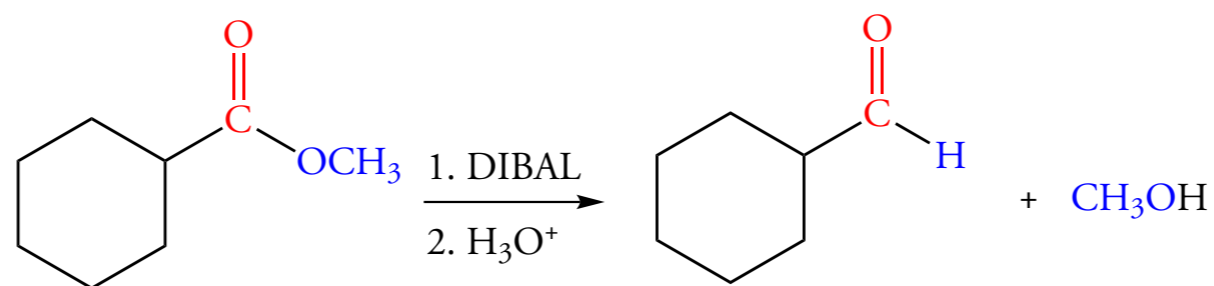
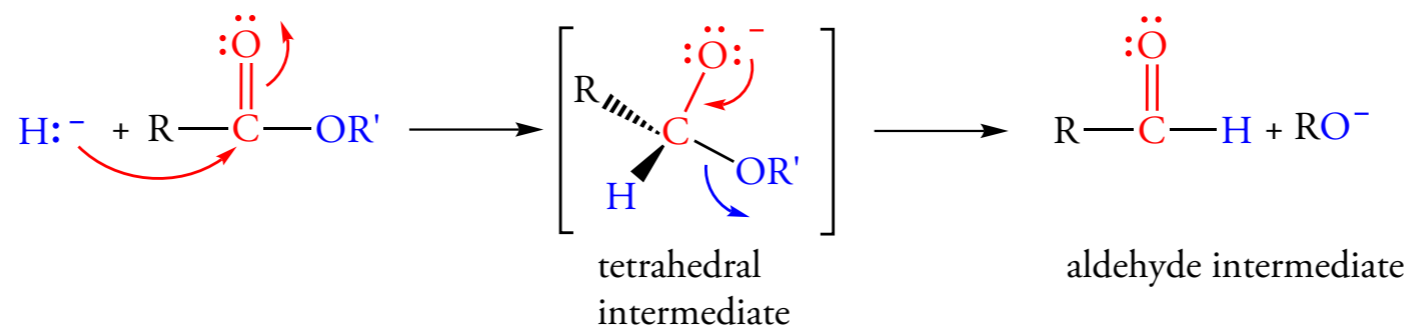
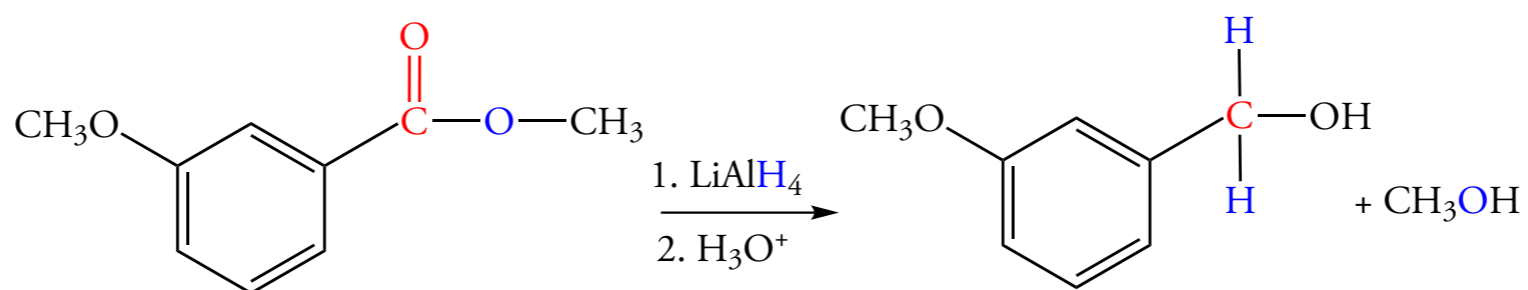
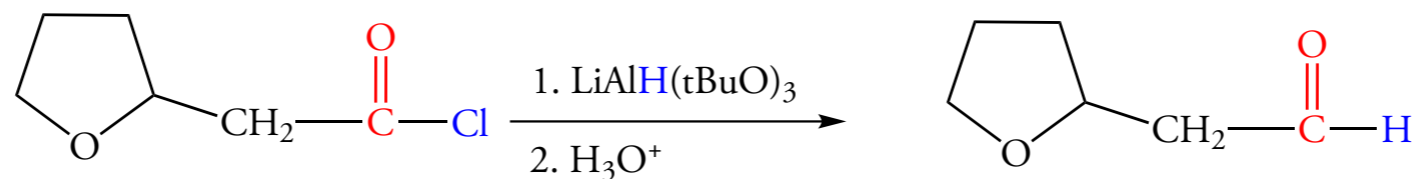
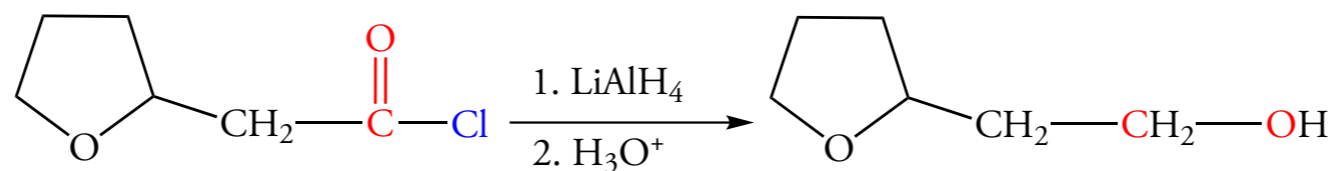
21.7 REACTION OF ACYL DERIVATIVES WITH AMINES

Acid Chlorides



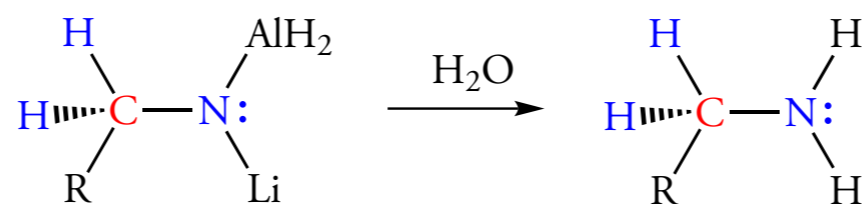
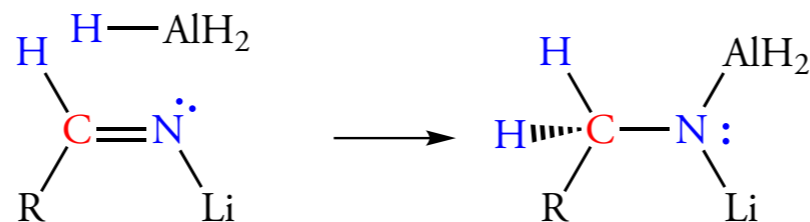
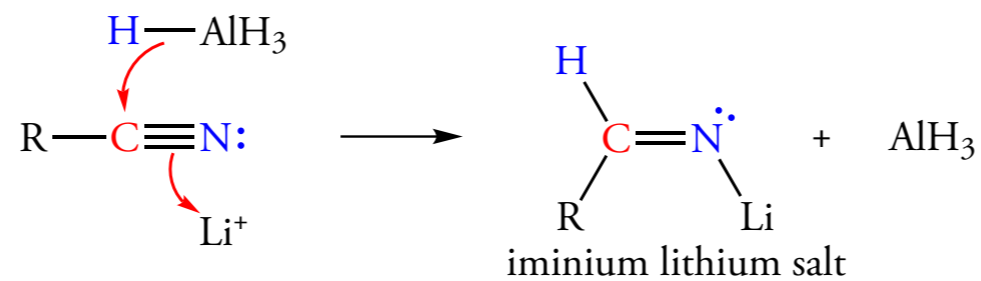
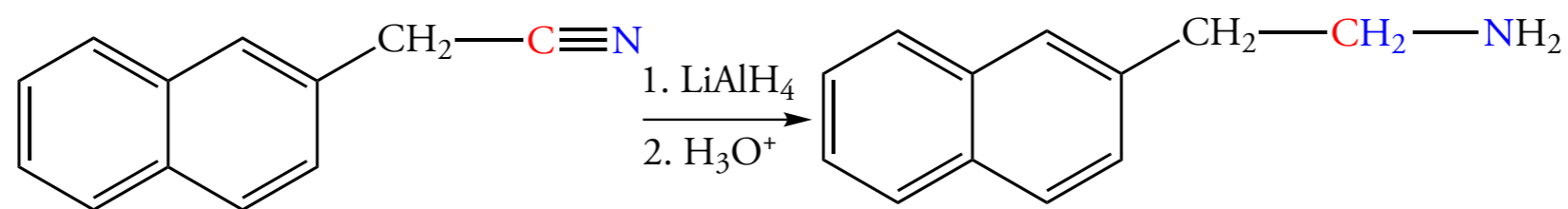
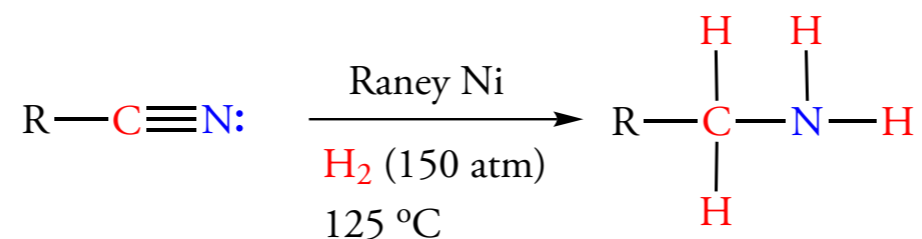
21.7 REACTION OF ACYL DERIVATIVES WITH AMINES

Reduction of Acid Chlorides and Esters



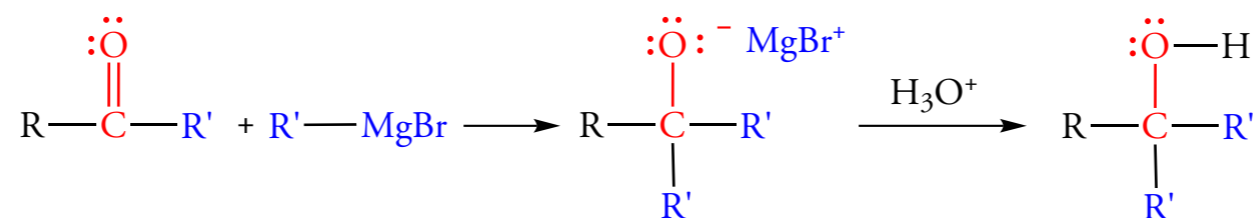
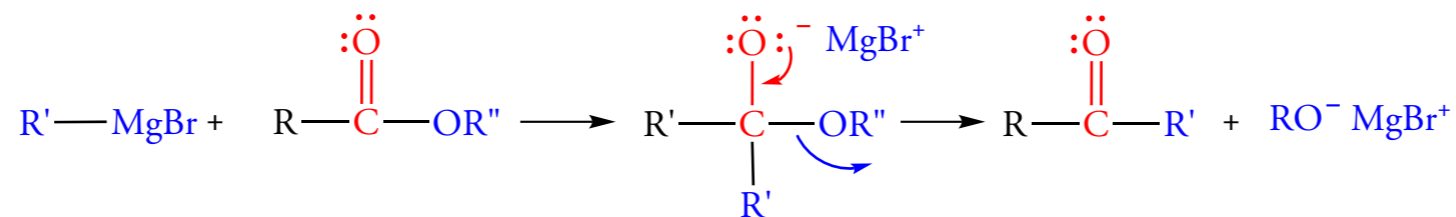
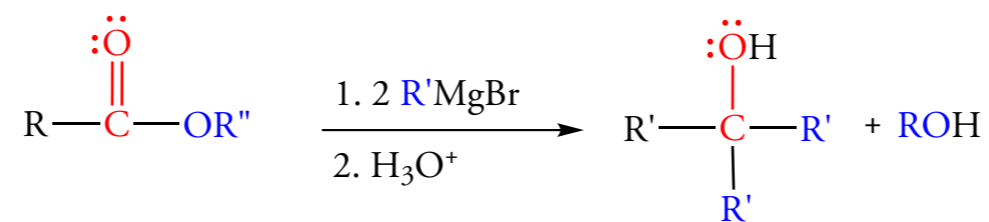
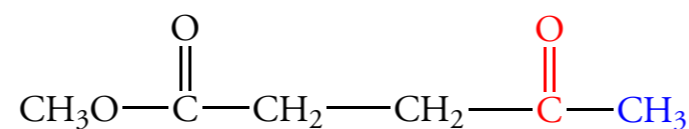
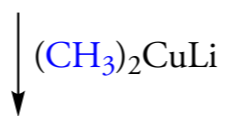
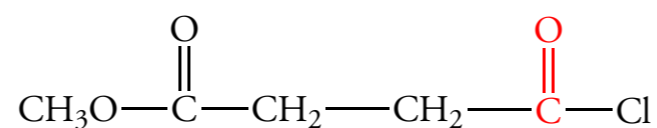
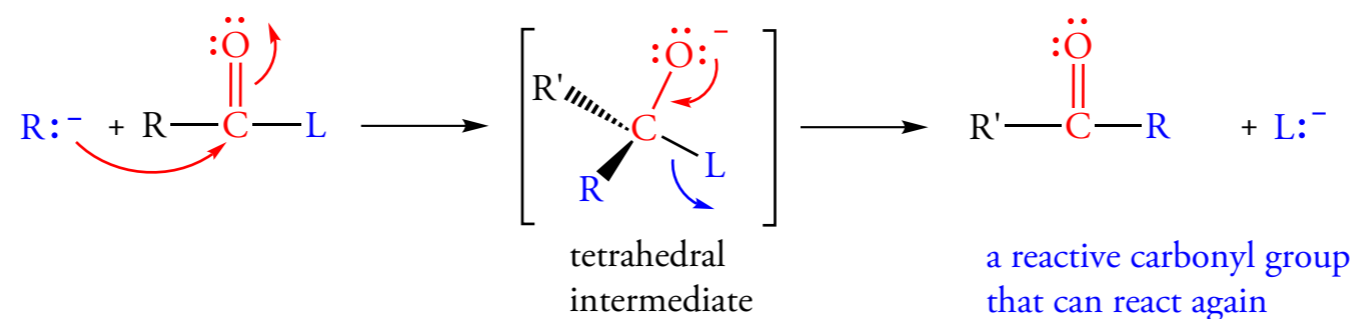
21.7 REACTION OF ACYL DERIVATIVES WITH AMINES

Reduction of Nitriles



21.9 REACTION OF ACYL DERIVATIVES WITH ORGANOMETALLIC REAGENTS

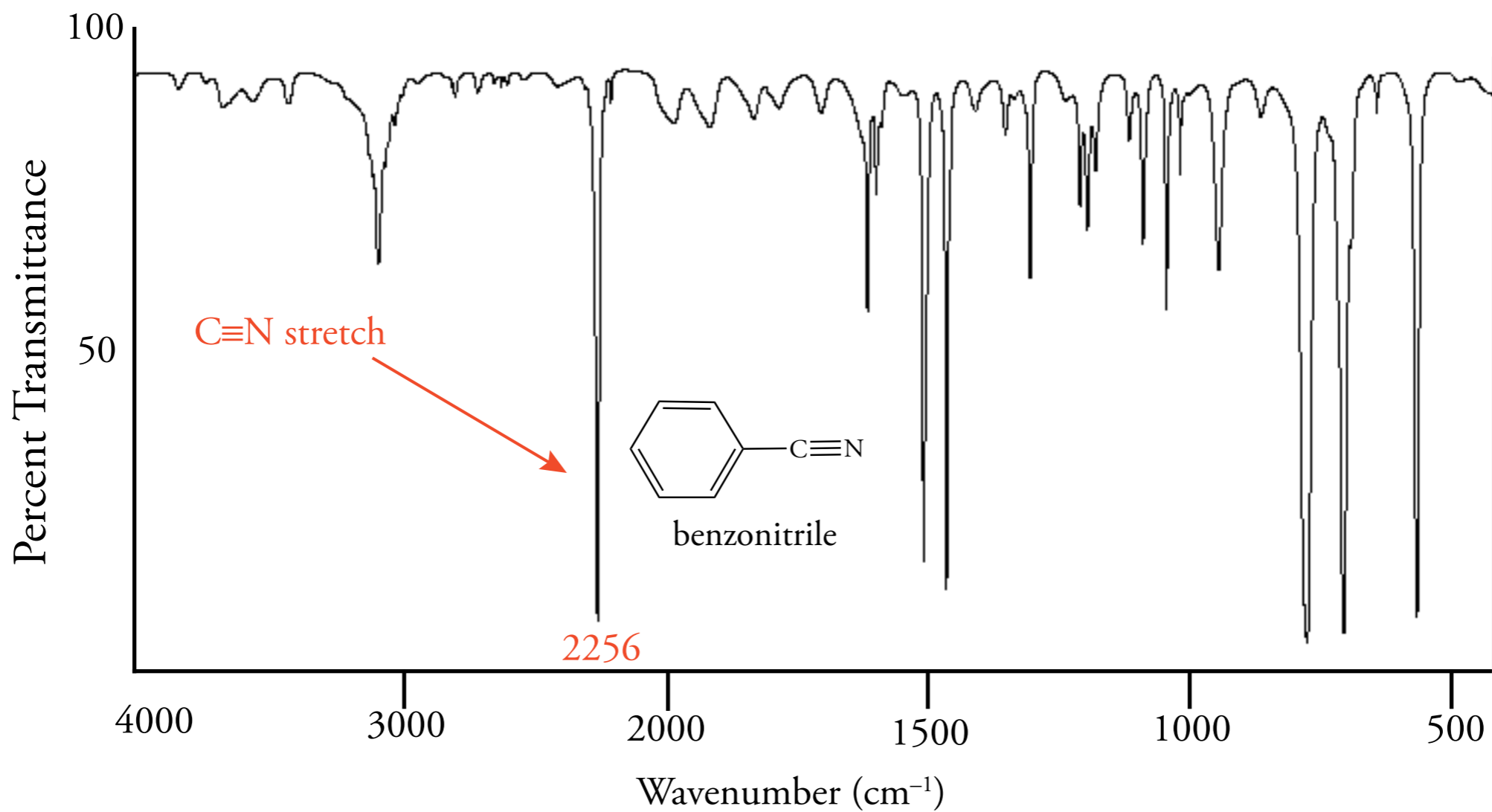
Acid Chlorides and Esters



21.10 INFRARED SPECTROSCOPY OF ACYL DERIVATIVES

Nitriles

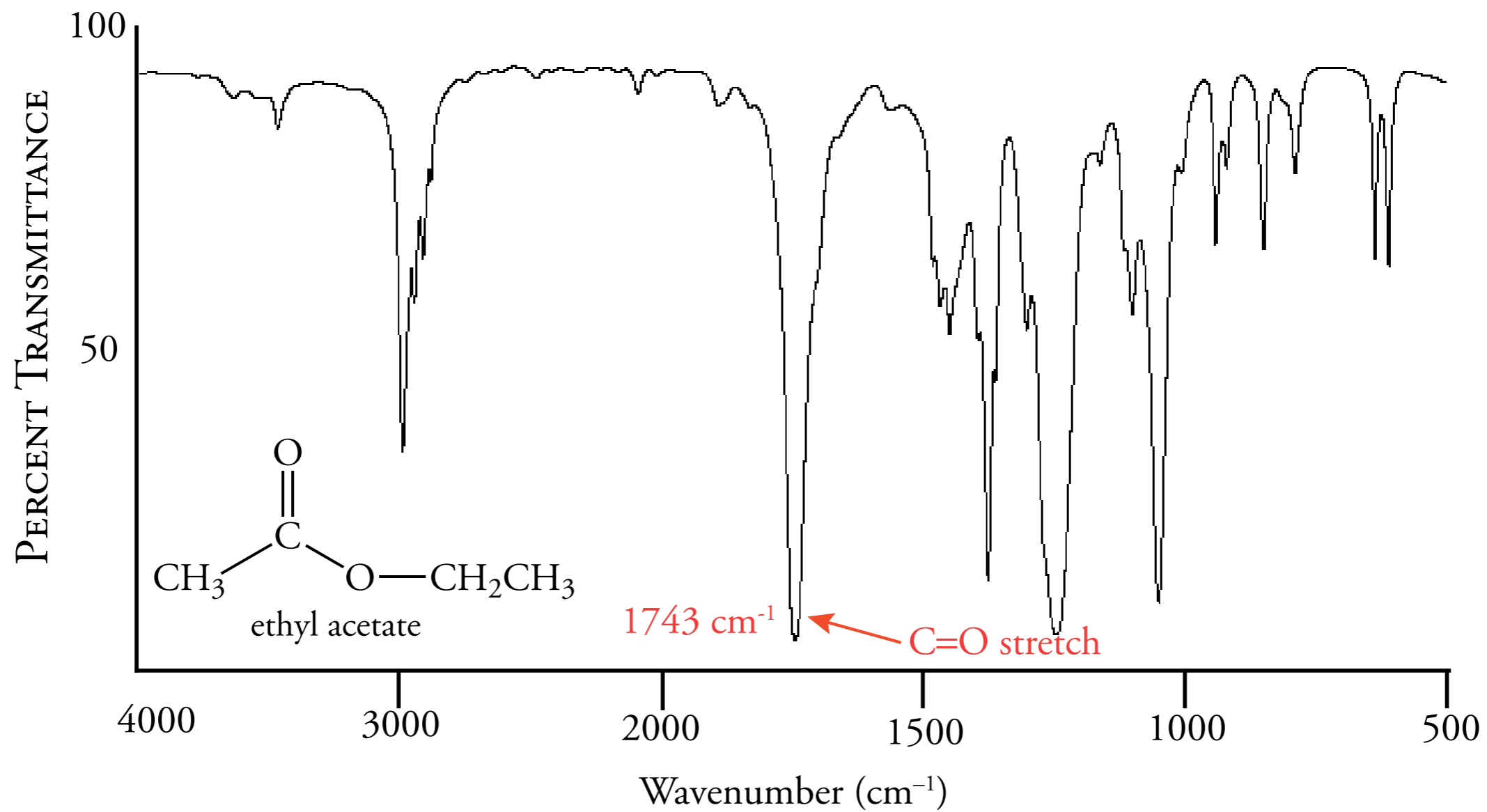
Figure 21.2 Infrared Spectrum of Benzonitrile



21.10 INFRARED SPECTROSCOPY OF ACYL DERIVATIVES

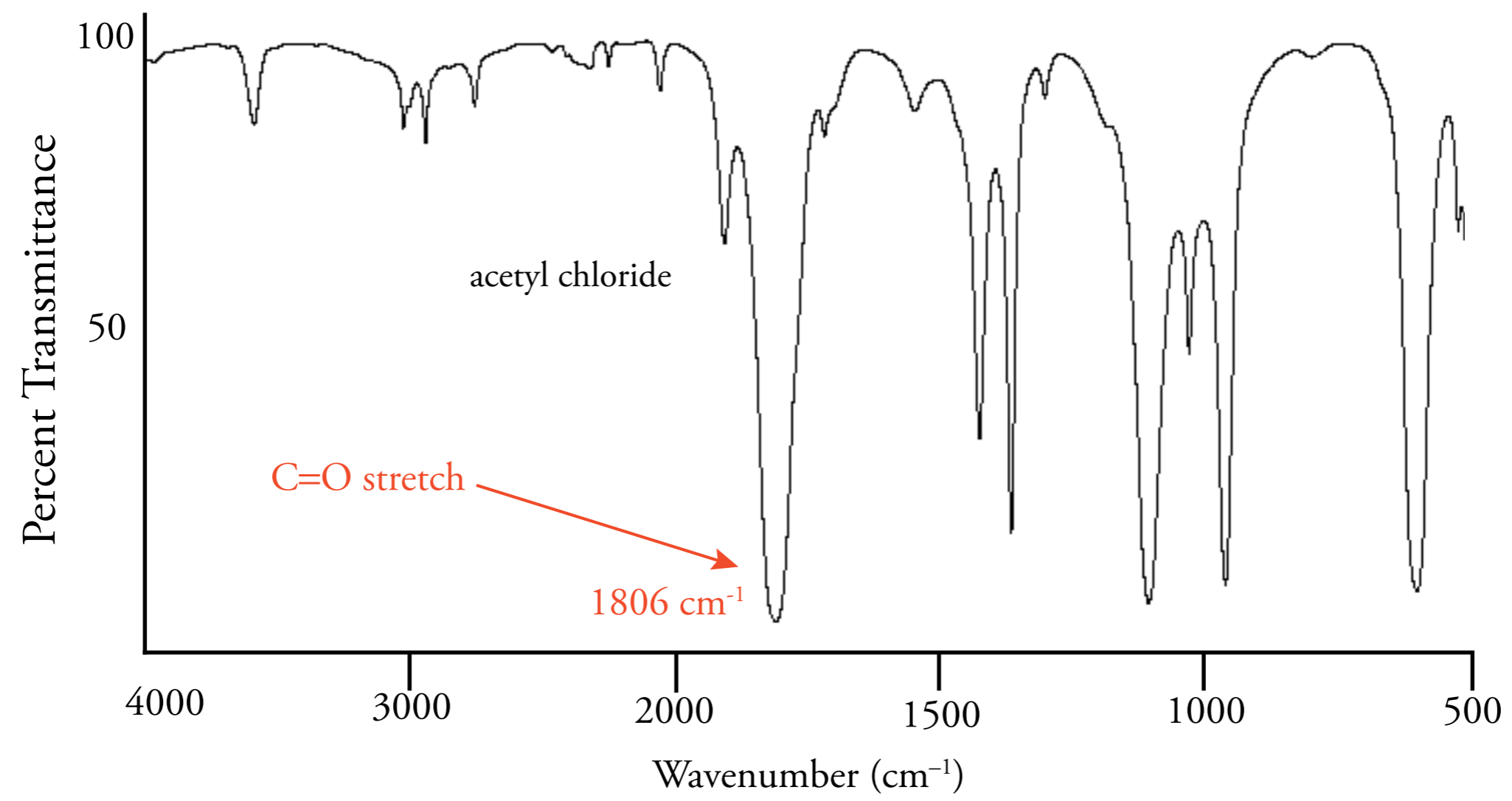
Esters

Figure 21.3 Infrared Spectrum of Ethyl Acetate



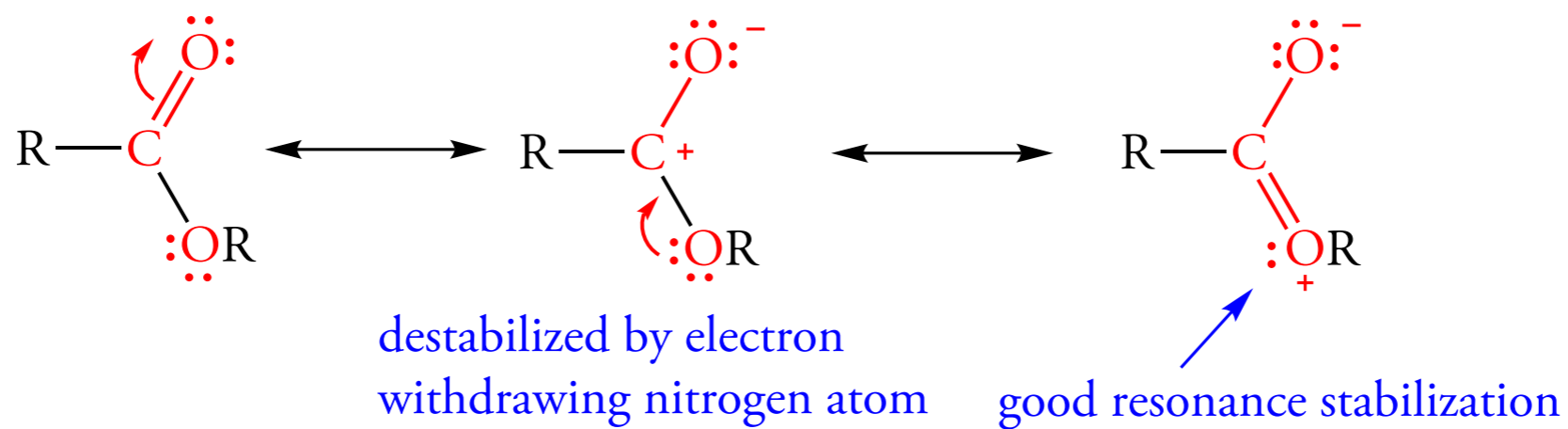
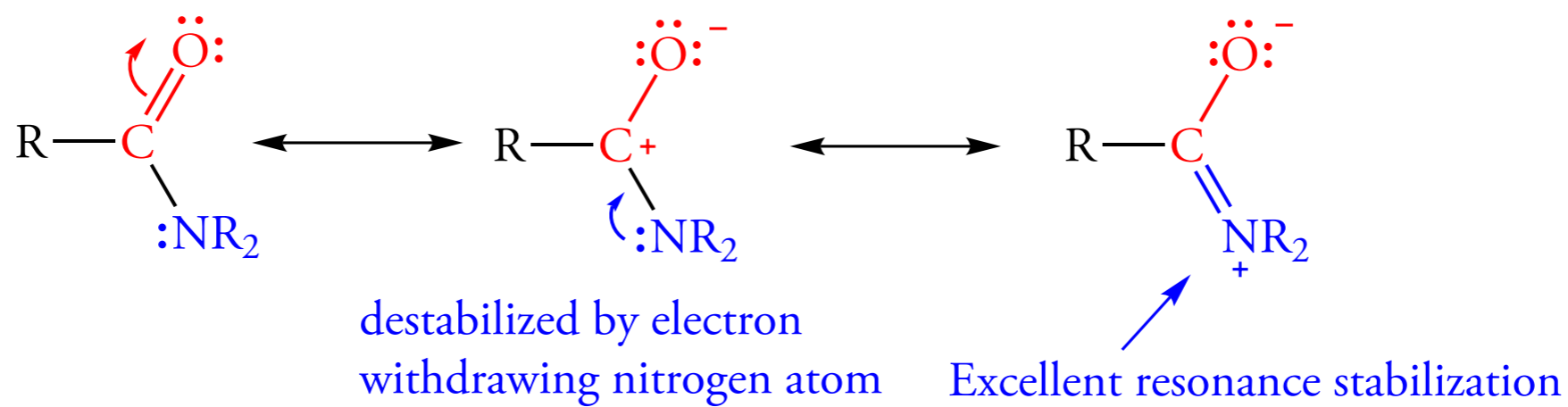
21.10 INFRARED SPECTROSCOPY OF ACYL DERIVATIVES
Acid Chlorides

Figure 21.4 Infrared Spectrum of Acetyl Chloride



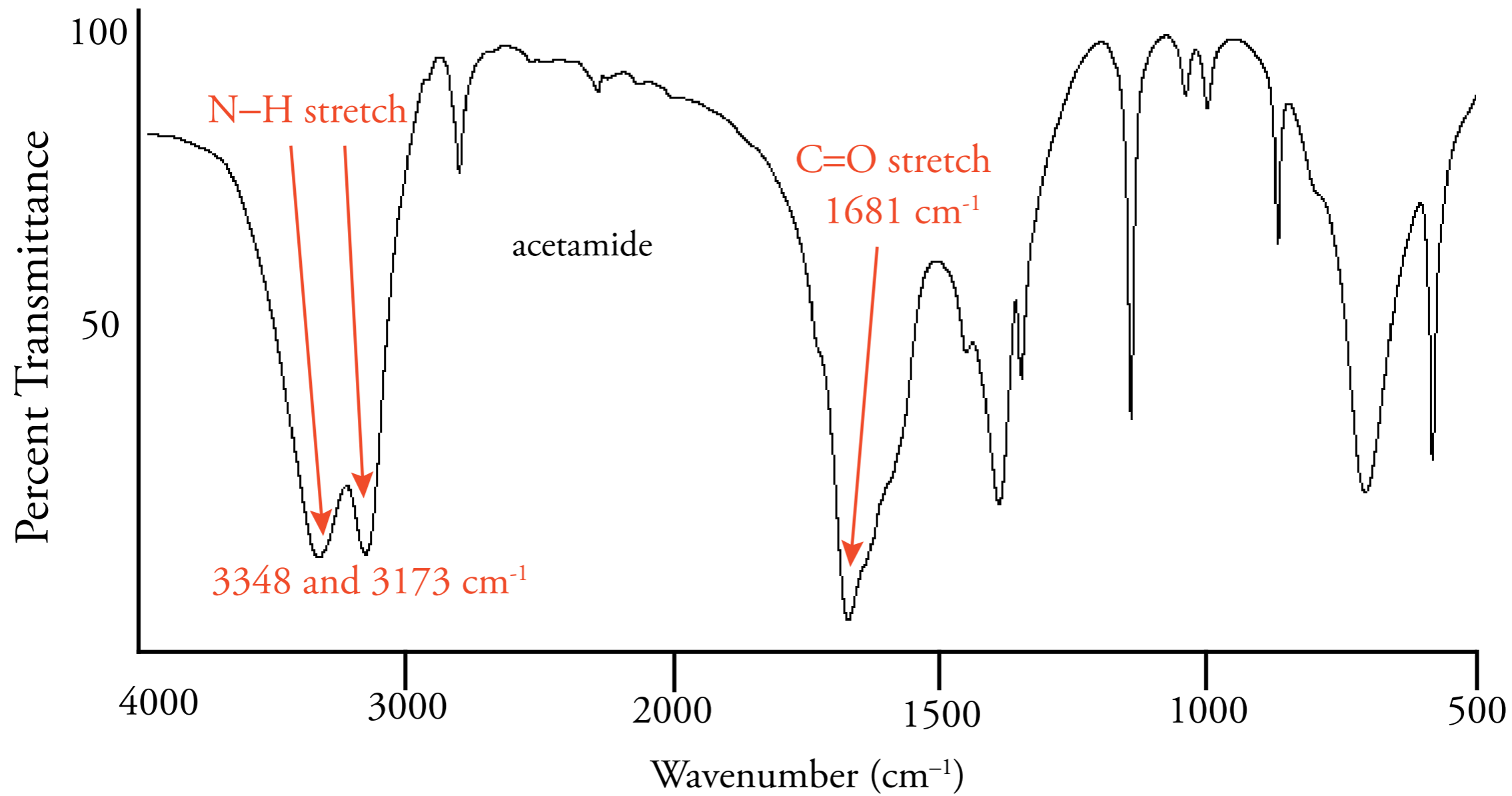
21.10 INFRARED SPECTROSCOPY OF ACYL DERIVATIVES

Amides



21.10 INFRARED SPECTROSCOPY OF ACYL DERIVATIVES
Amides

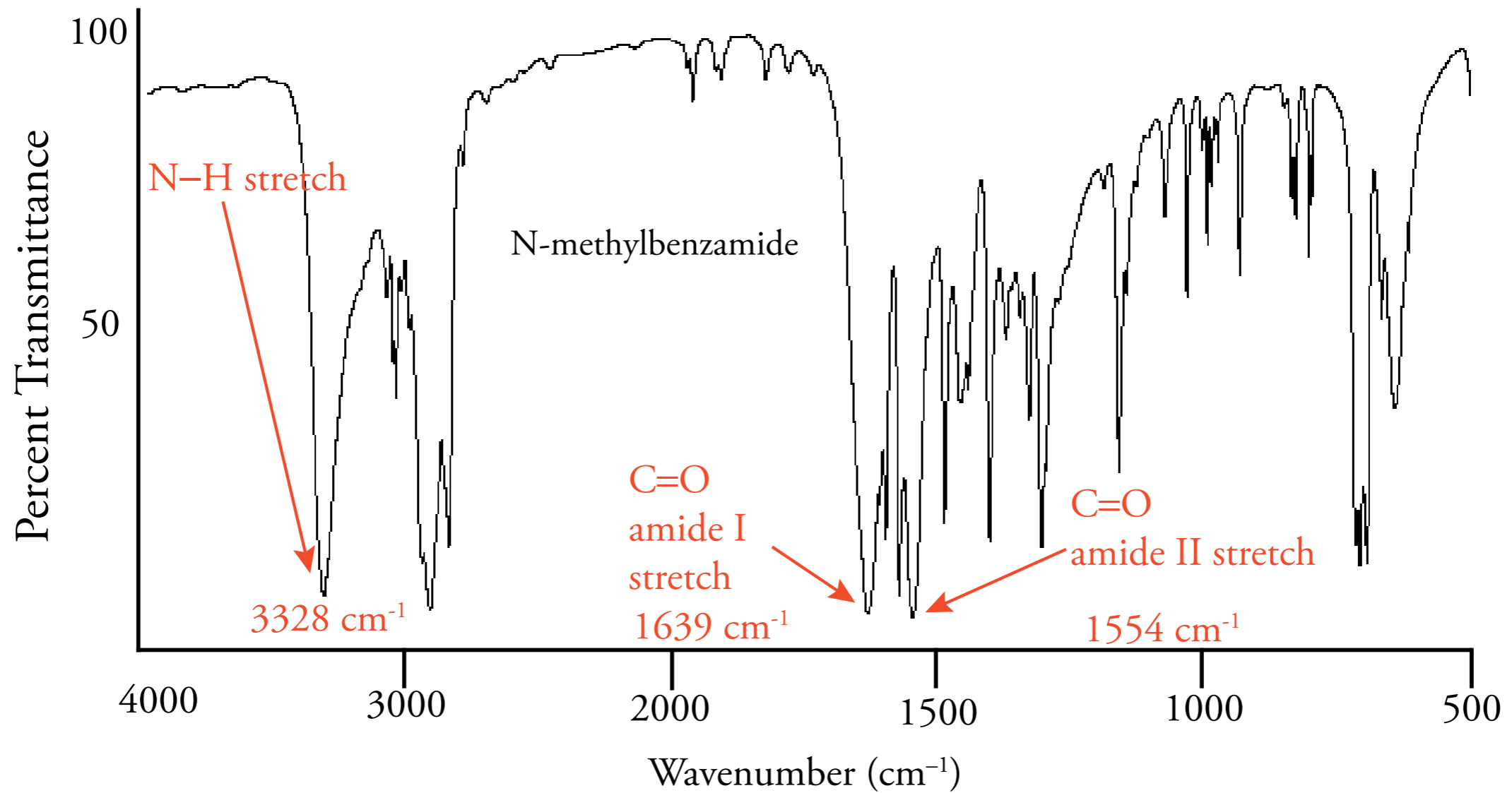
Figure 21.5 Infrared Spectrum of Acetamide



21.10 INFRARED SPECTROSCOPY OF ACYL DERIVATIVES

Amides

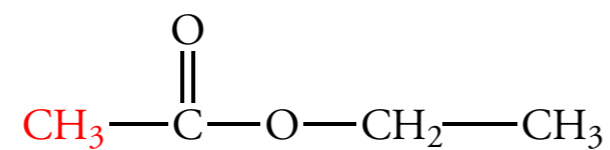
Figure 21.6 Infrared Spectrum of N-Methyl Benzamide



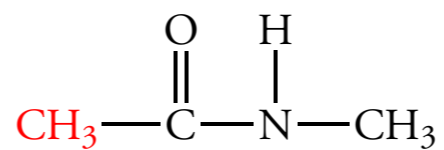
21.11 NMR SPECTROSCOPY OF ACYL DERIVATIVES

Proton NMR Spectroscopy

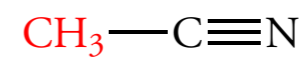
Figure 21.7 Proton NMR Spectrum of Ethyl Acetate



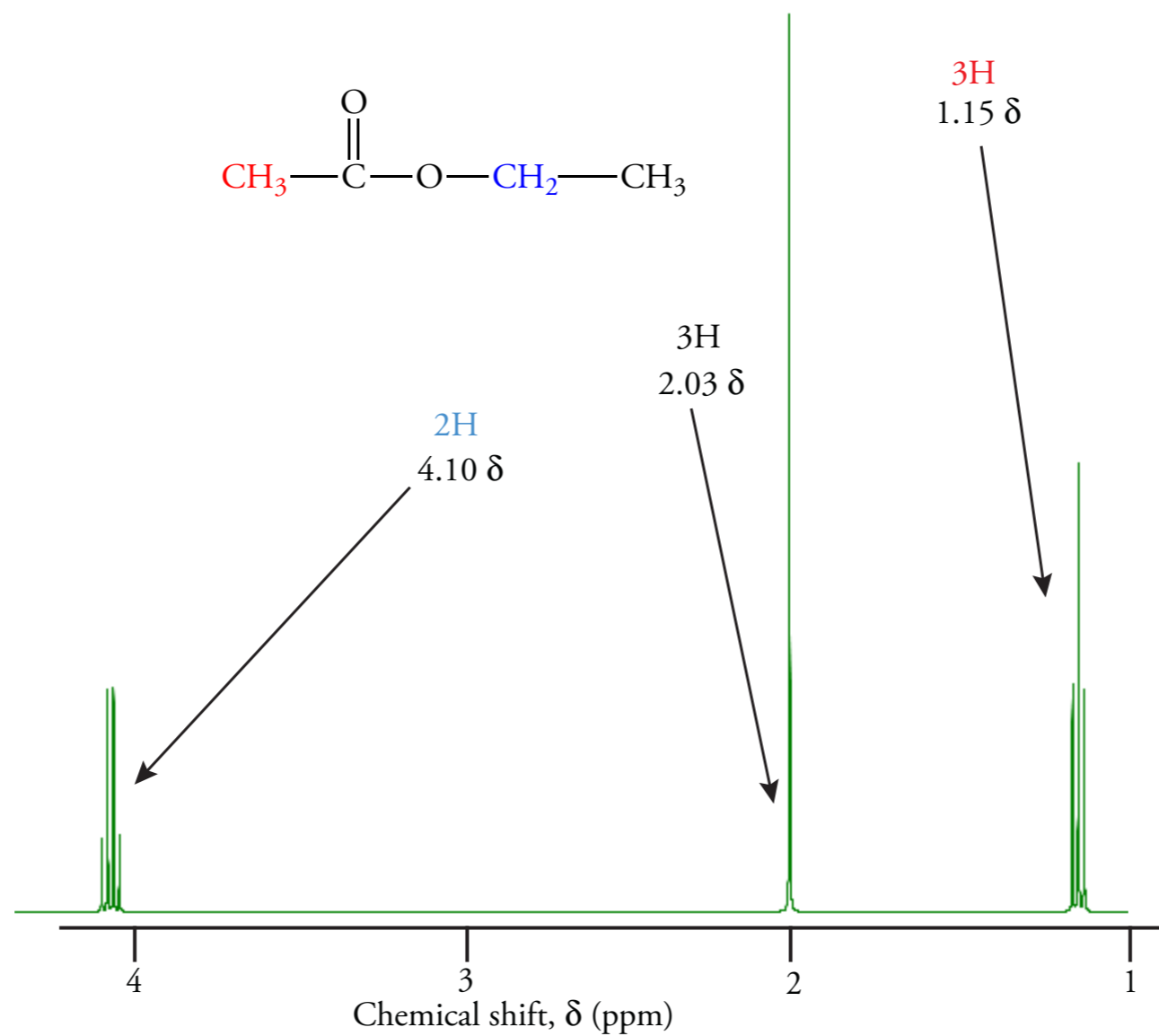
$\delta \sim 2.0$ ppm



$\delta \sim 2.0$ ppm



$\delta \sim 2.0$ ppm



21.11 NMR SPECTROSCOPY OF ACYL DERIVATIVES

C-13 NMR Spectroscopy

