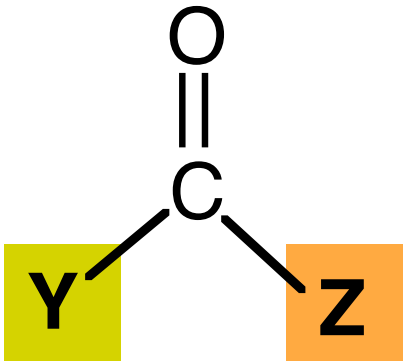
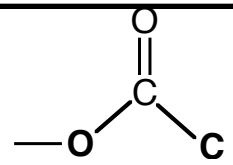
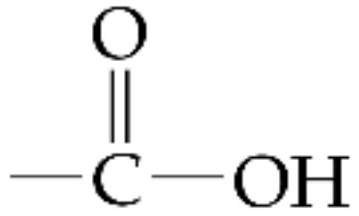
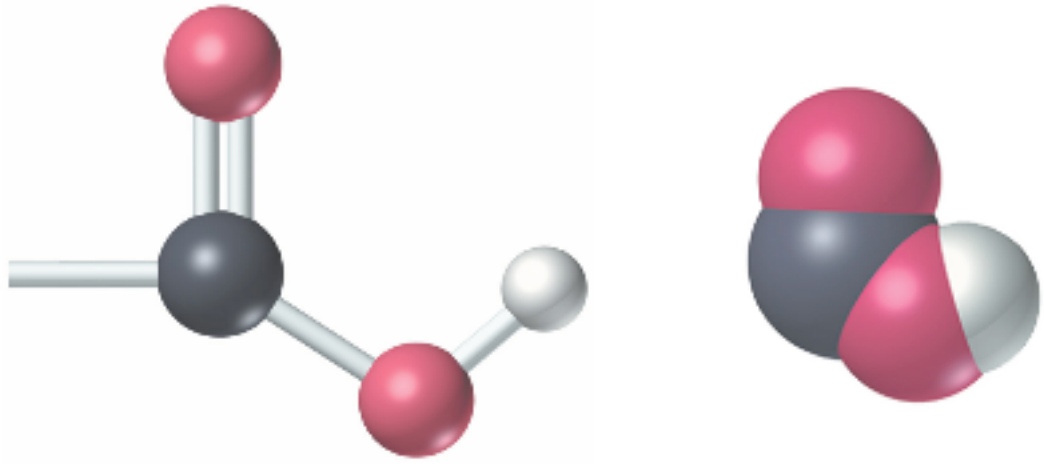
Families Containing the Carbonyl Group



Family	Y	Z
aldehyde	H or C	H
ketone	C	C
carboxylic acid	H or C	-O-H
ester	H or C	-O-C
acid halide	H or C	-F,-Cl,-Br,-I
acid anhydride	H or C	
amide	H or C	-N

Carboxylic Acid Functional Group





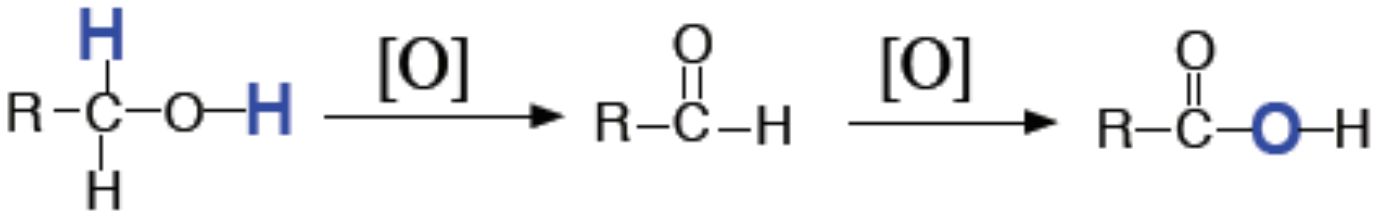
Carbonyl + hydroxyl = "Carboxyl"

General Formula: R-COOH $\neq$ **R–C–O–O–H**

The carbonyl carbon and oxygen are sp^2 hybridized.
The hydroxyl oxygen is sp^3 hybridized.

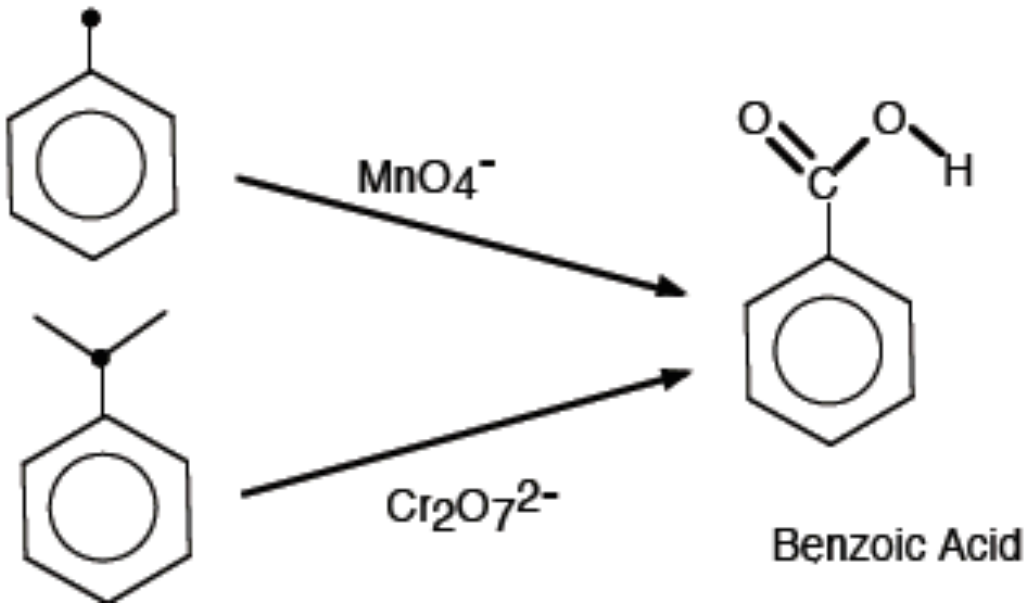
Sources of Carboxylic Acids

Oxidation of Primary Alcohols and Aldehydes



primary alcohol aldehyde carboxylic acid

Substituted Benzenes as a Source of Substituted Benzoic Acids



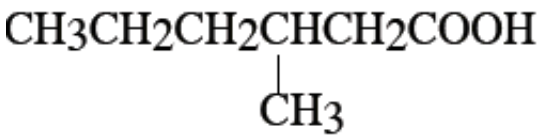
Benzoic Acid

Nomenclature of Carboxylic Acids

Names of the Simplest Carboxylic Acids

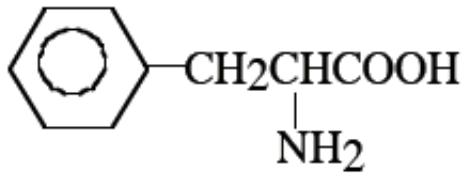
Compound	Systematic Name	Trivial (Common) Name
$HCOOH$	Methanoic Acid	Formic Acid
CH_3COOH	Ethanoic Acid	Acetic Acid
CH_3CH_2COOH	Propanoic Acid	Propionic Acid
$CH_3CH_2CH_2COOH$	Butanoic Acid	Butyric Acid
$CH_3CH_2CH_2CH_2COOH$	Pentanoic Acid	Valeric Acid
$CH_3CH_2CH_2CH_2CH_2COOH$	Hexanoic Acid	Caproic Acid
$CH_3CH_2CH_2CH_2CH_2CH_2COOH$	Heptanoic Acid	Enanthic Acid

Systematic Nomeclature



3-methyl hexanoic acid

β-methyl caproic acid



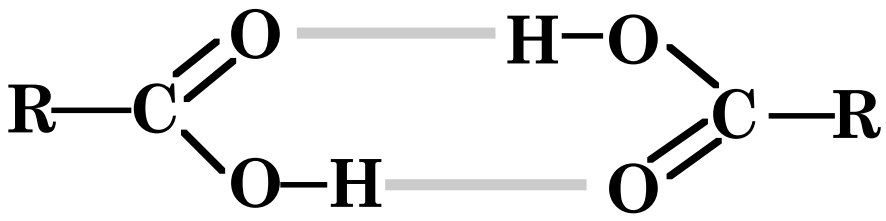
2-amino-3-phenylpropanoic acid

phenylalanine

Physical Properties of Carboxylic Acids

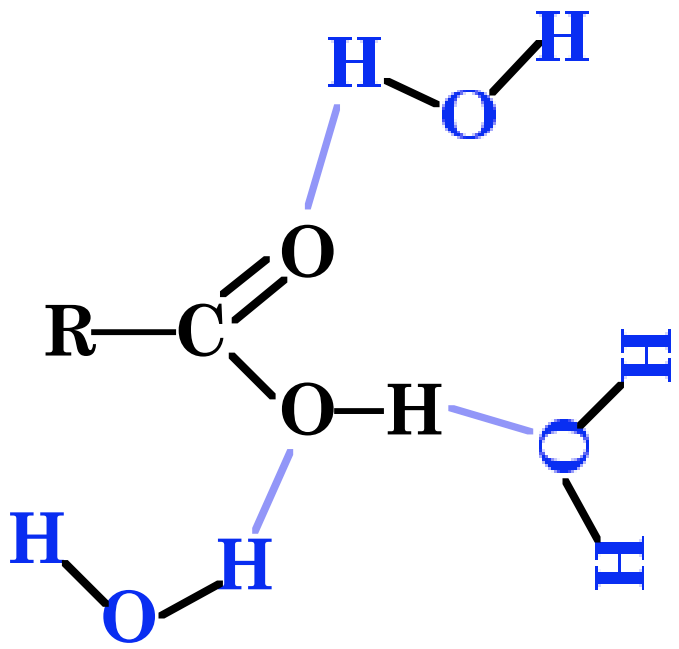
Boiling Points - Higher than alcohols of similar molecular weight

Carboxylic acids "self associate" through hydrogen bonds.

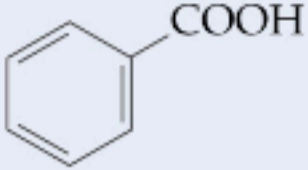
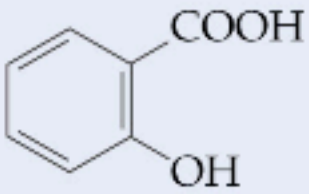


Water Solubility- More water soluble than ethers, aldehydes, ketones and alcohols of similar molecular weight

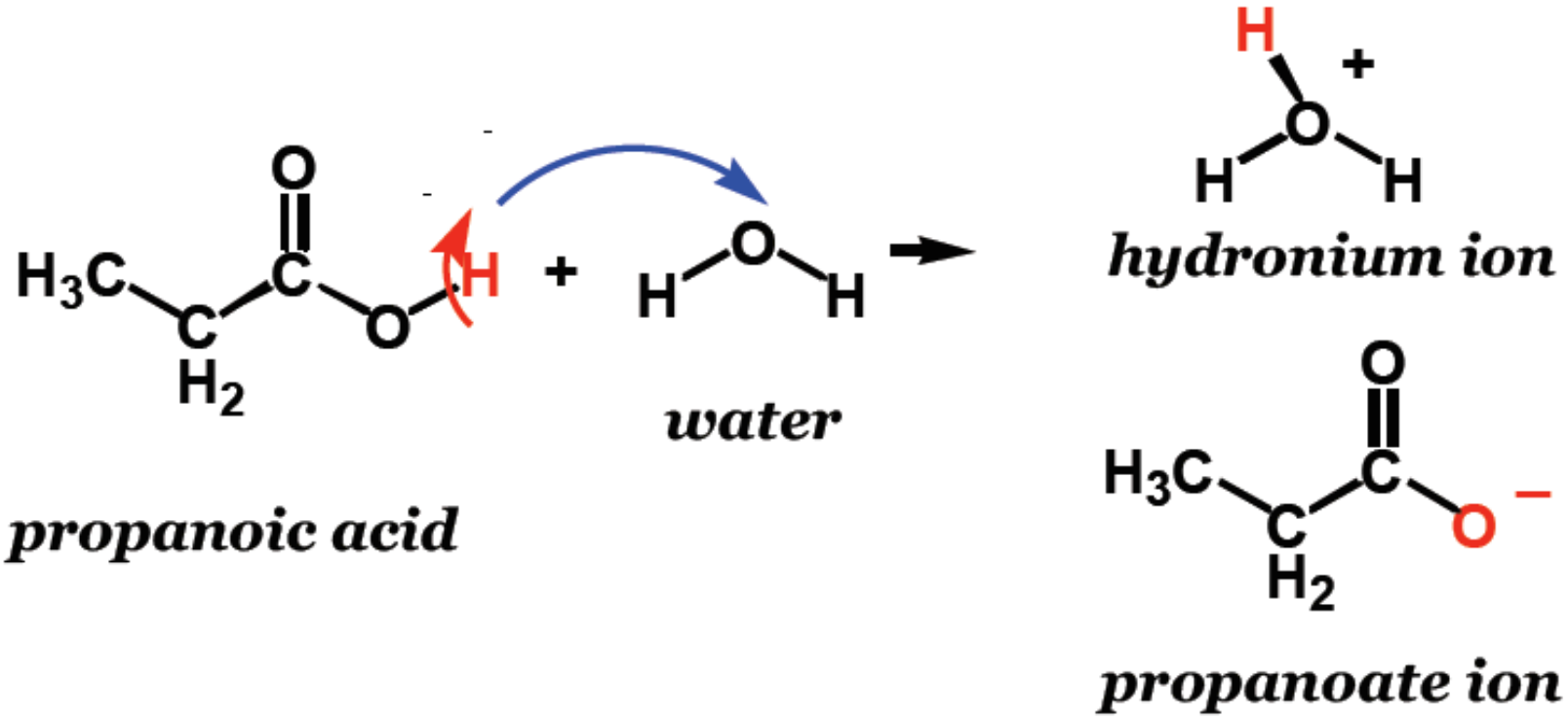
Carboxylic acids have three opportunities for hydrogen bonding.



Physical Properties of Some Carboxylic Acids

Structure	Common Name	Melting Point (°C)	Boiling Point (°C)
$HCOOH$	Formic	8	101
CH_3COOH	Acetic	17	118
CH_3CH_2COOH	Propionic	−22	141
$CH_3CH_2CH_2COOH$	Butyric	−4	163
$CH_3CH_2CH_2CH_2COOH$	Valeric	−34	185
$CH_3(CH_2)_{16}COOH$	Stearic	70	383
$HOOCCOOH$	Oxalic	190	Decomposes
$HOOCCH_2COOH$	Malonic	135	Decomposes
$HOOCCH_2CH_2COOH$	Succinic	188	Decomposes
$HOOCCH_2CH_2CH_2COOH$	Glutaric	98	Decomposes
$H_2C{=}CHCOOH$	Acrylic	13	141
$CH_3CH{=}CHCOOH$	Crotonic	72	185
	Benzoic	122	249
	Salicylic	159	Decomposes

Acidity of Carboxylic Acids



Acidity of Carboxylic Acids

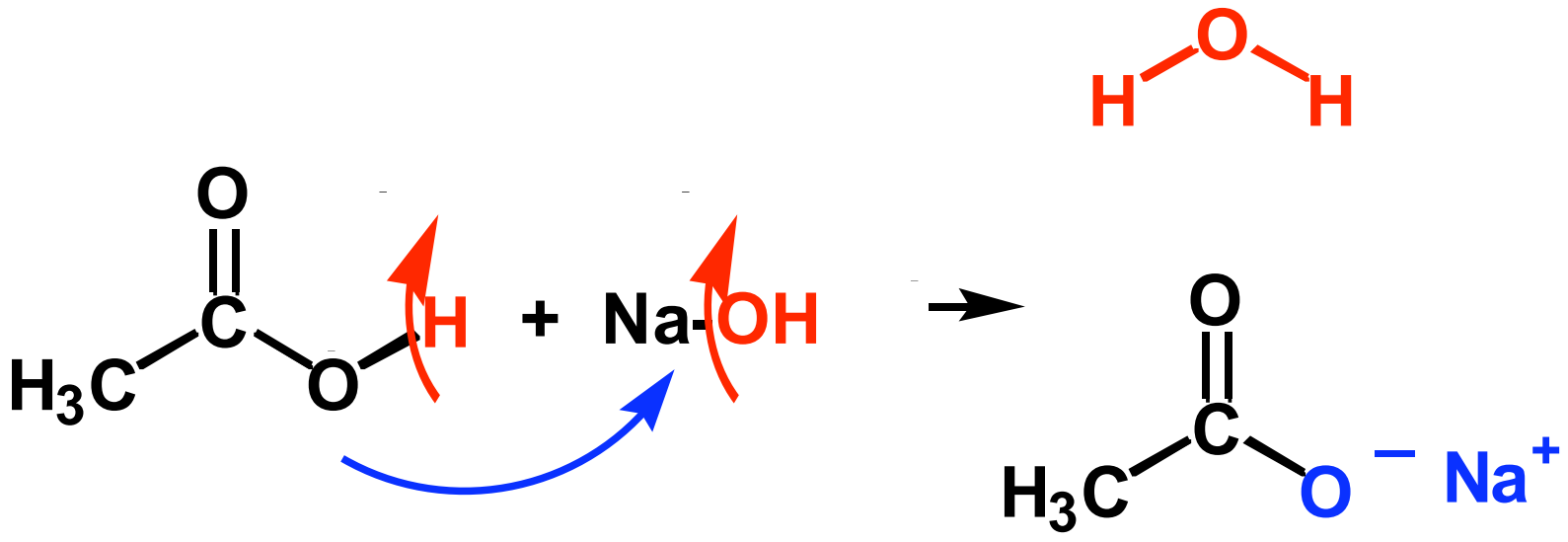
Carboxylic acids are generally stronger acids than phenols but weaker than mineral acids.

Relative Acidities of Organic Compounds

Compound	Structure	Values for 0.10 *M* aqueous solution		
		$[H_3O^+]$	pH	Ionization (%)
hydrochloric acid	HCl	0.10	1.00	100
benzoic acid	C_6H_5COOH	2.5×10^{-3}	2.60	2.5
acetic acid	CH_3COOH	1.3×10^{-3}	2.89	1.3
phenol	C_6H_5OH	3.3×10^{-6}	5.48	0.0033
ethanol	CH_3CH_2OH	1.0×10^{-7}	7.00	0.00010
water	H_2O	1.0×10^{-7}	7.00	0.00010

Chemical and Physical Properties of Carboxylic Acids

Carboxylic acids react with bases.

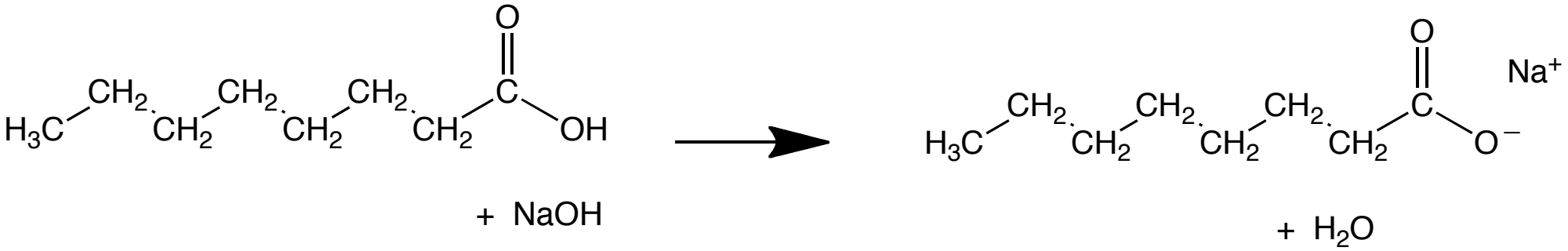


acetic acid ***sodium acetate***

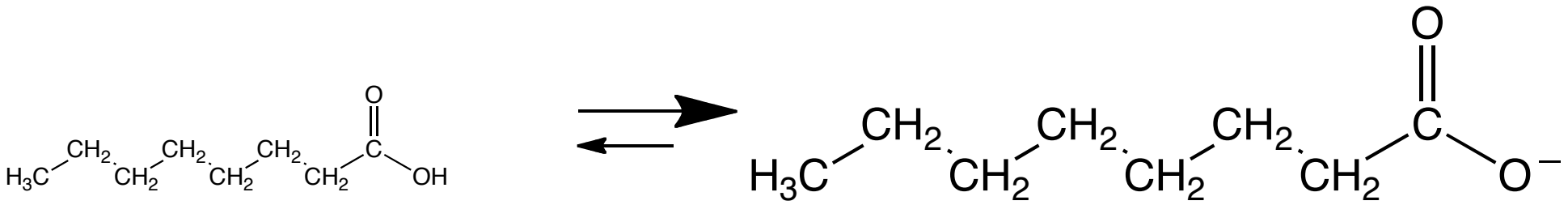
Carboxylate salts are ionic and possess much higher boiling and melting points than those of the corresponding carboxylic acids (Ionic forces are much stronger than secondary forces).

Sodium acetate: MP 324°C, solid at room temperature
Acetic acid: MP 17°C, liquid at room temperature

Chemical and Physical Properties of Carboxylic Acids



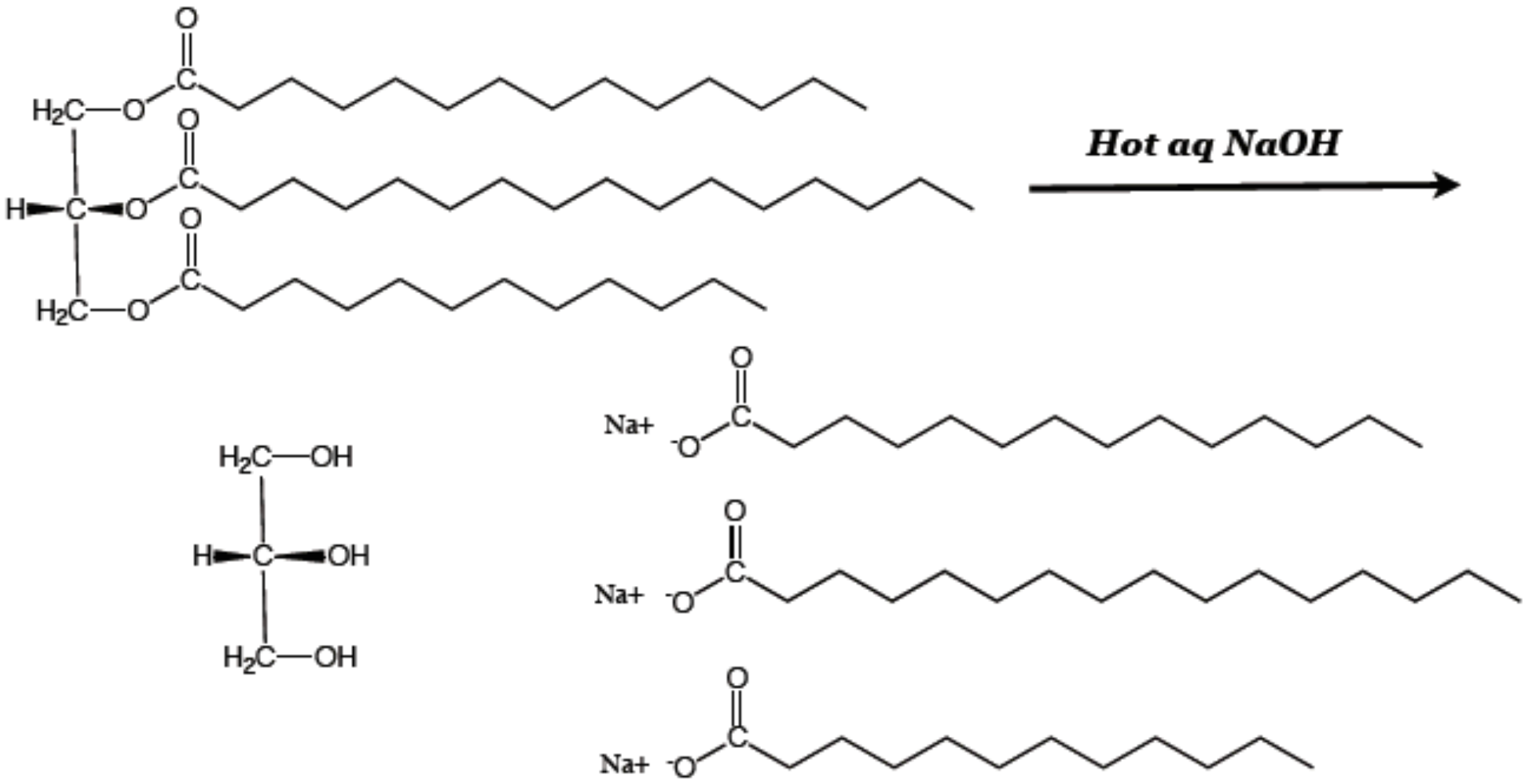
Carboxylic acids that have 6 or more carbons are only slightly soluble or insoluble in water**.** **Carboxylate salts** are much more soluble than their corresponding carboxylic acids because of their ionic nature.



Carboxylic acids have increased solubilities in neutral or basic environments because the acids are converted into their carboxylate ions.

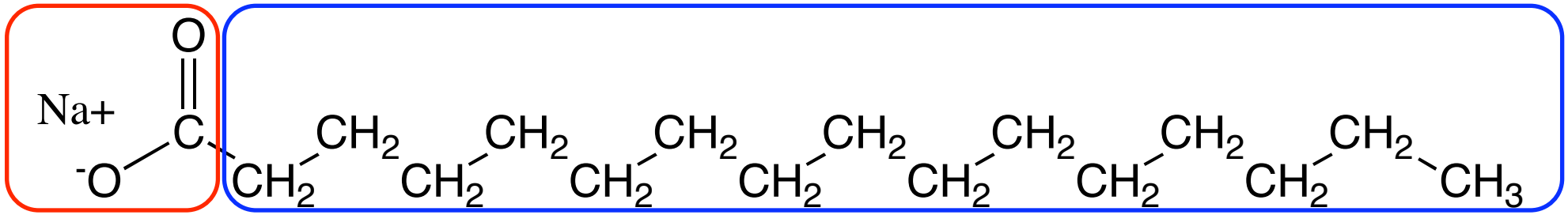
Soaps

Soaps are produced by a process called "saponification" (technically "basic hydrolysis of fats")



Soaps

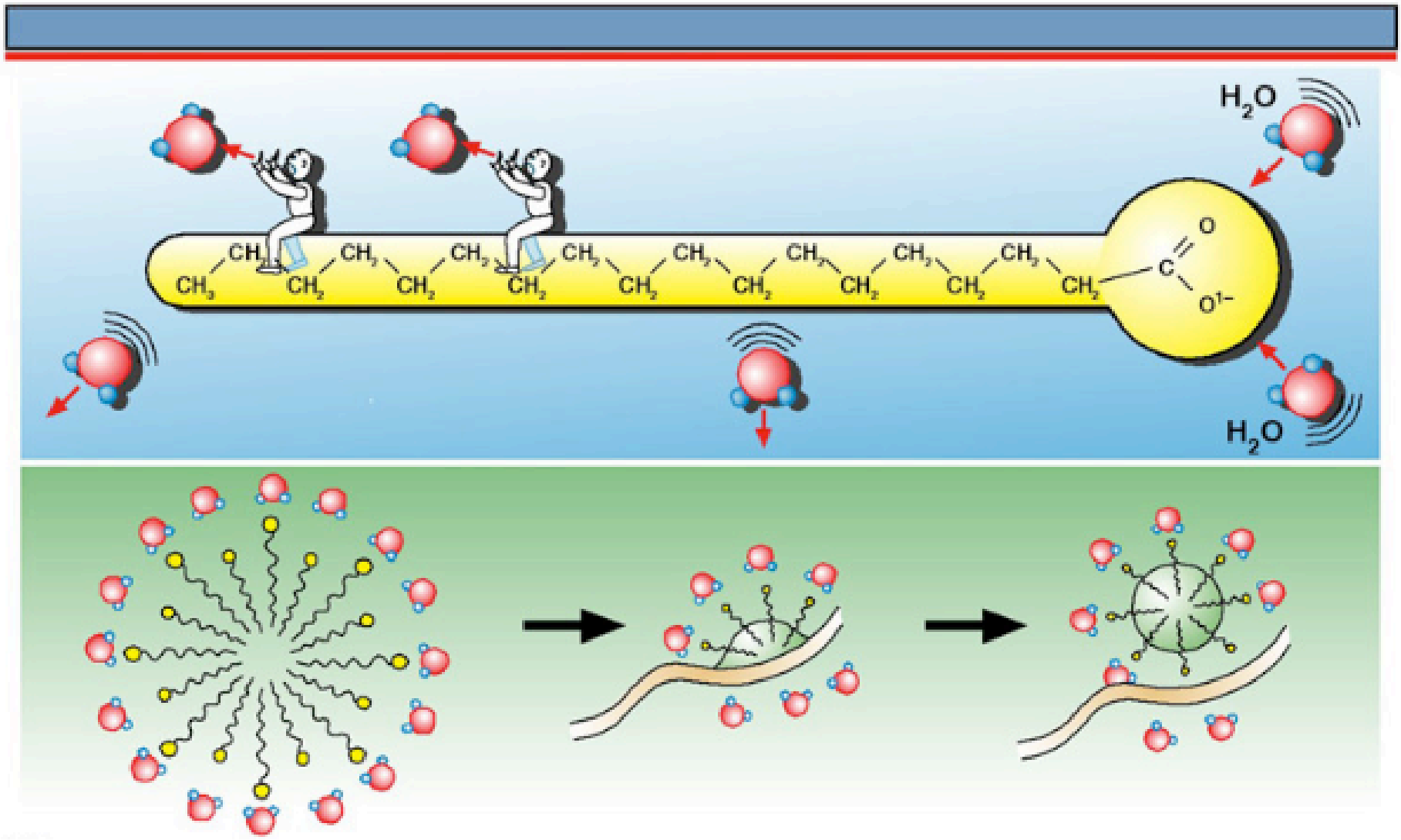
<u>Soaps</u> are the sodium or potassium salts of long-chain fatty acids.



hydrophilic region

hydrophobic region

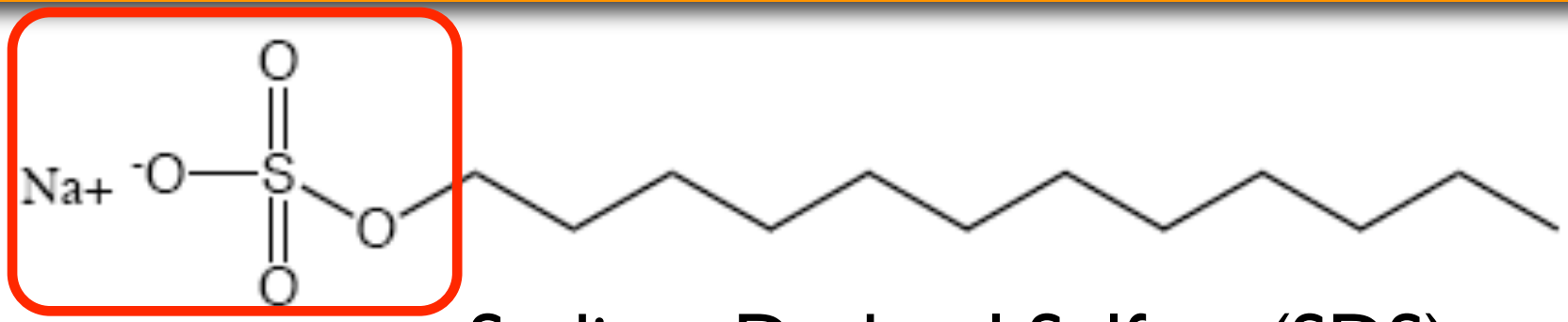
How Do Soaps Work?



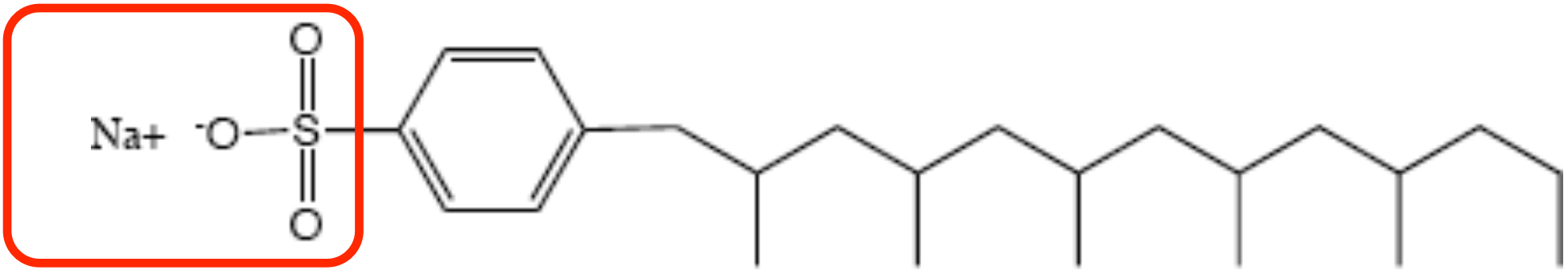
micelle

micelle+grease

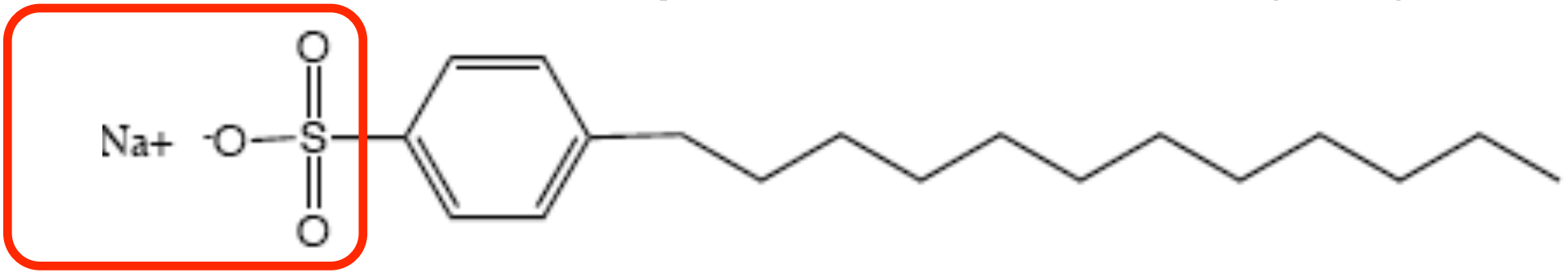
Synthetic Detergents



Sodium Dodecyl Sulfate (SDS)



Sodium Alkyl Benzene Sulfonate (ABS)



Sodium Dodecyl Benzene Sulfonate (LAS)

Synthetic Detergents