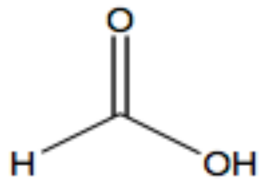
Objective 11. Apply acid-base principles to organic acids.

Skills: Draw structure
ID structural features and reactive sites (alpha C, beta C, LG, etc.)
ID Nu^- and E^+
use curved arrows to show bonds breaking and forming
show delocalized electrons with resonance structures.

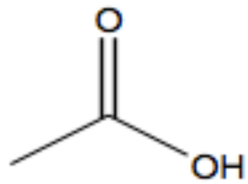
Key ideas:
Organic acids are weak, e.g., acetic acid $pK_a = 5$

The charge on an acid depends on pH and pK (see Chem 1B and biochem)

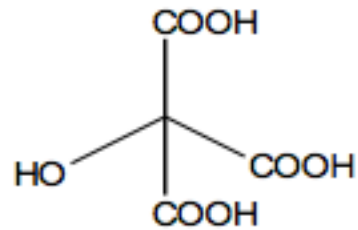
Carboxylic Acids Are Found Almost Everywhere



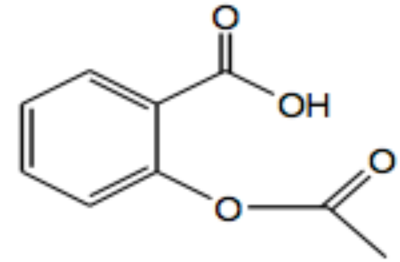
Formic Acid



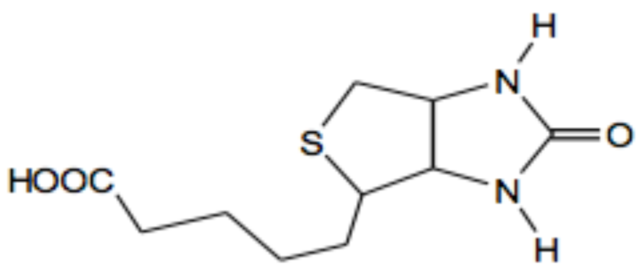
Acetic Acid



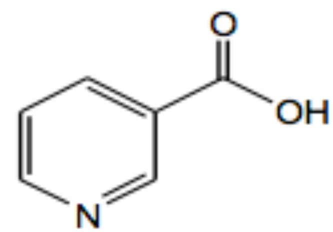
Citric Acid



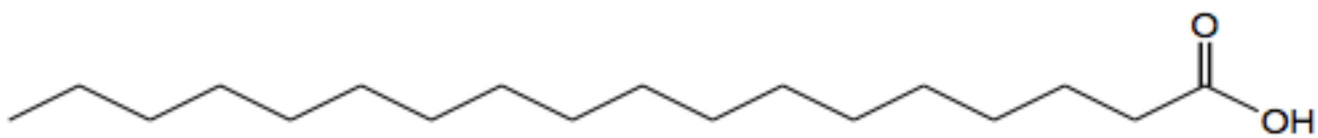
Aspirin



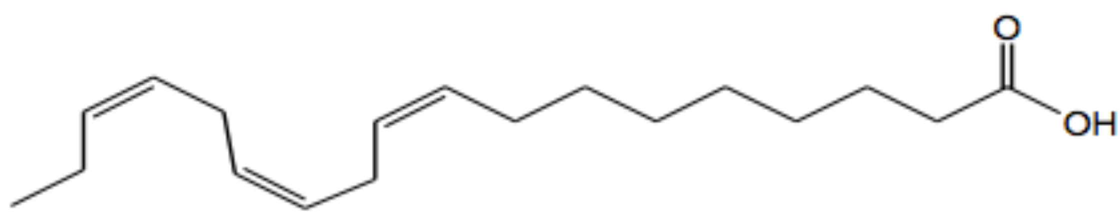
Biotin - cell growth factor



Niacin

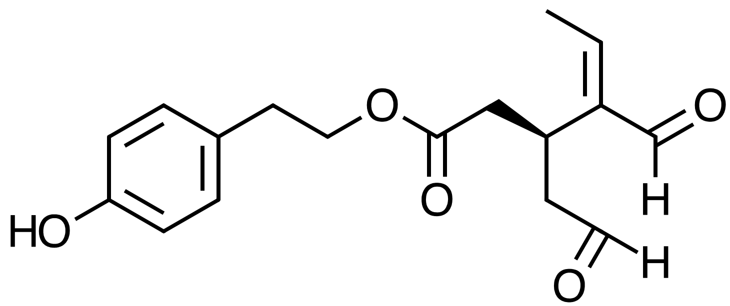


Stearic Acid - saturated fatty acid

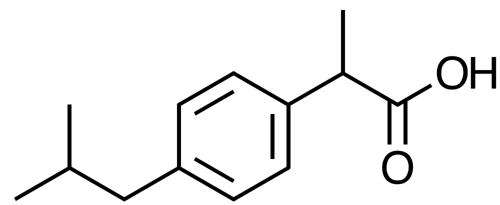


Linolenic Acid - polyunsaturated fatty acid

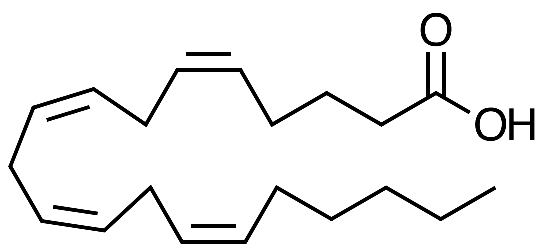
CEN, 3/21/11, p. 46. Olive oil compound (oleocanthal) blocks cyclooxygenase (COX) enzymes like Ibuprofen does.
COX enzymes are involved in inflammation and pain. (Inflammation is our body’s response to injury and infection.)



Oleocanthal
(olive oil)



Ibuprofen

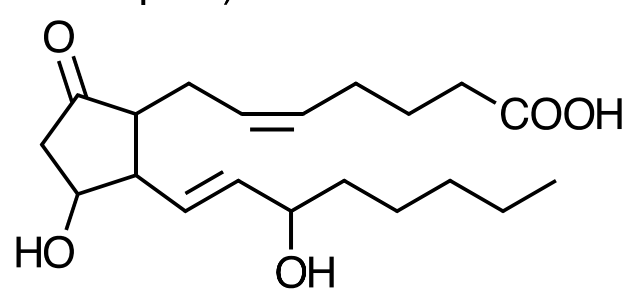


arachidonic acid

O_2

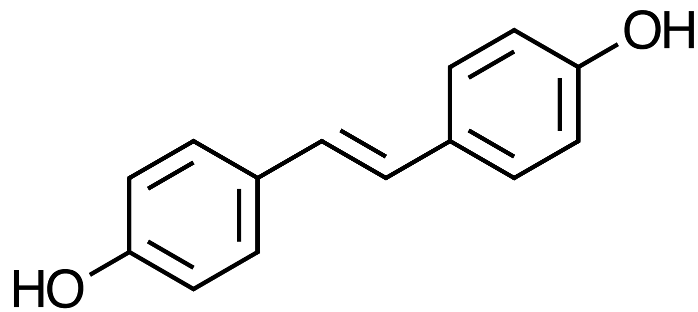
fatty acid
cyclooxygenase

Prostaglandins
(involved in
inflammation
and pain)



Is olive oil good for you?

Resveratrol (from red wine) selectively inhibits COX-1

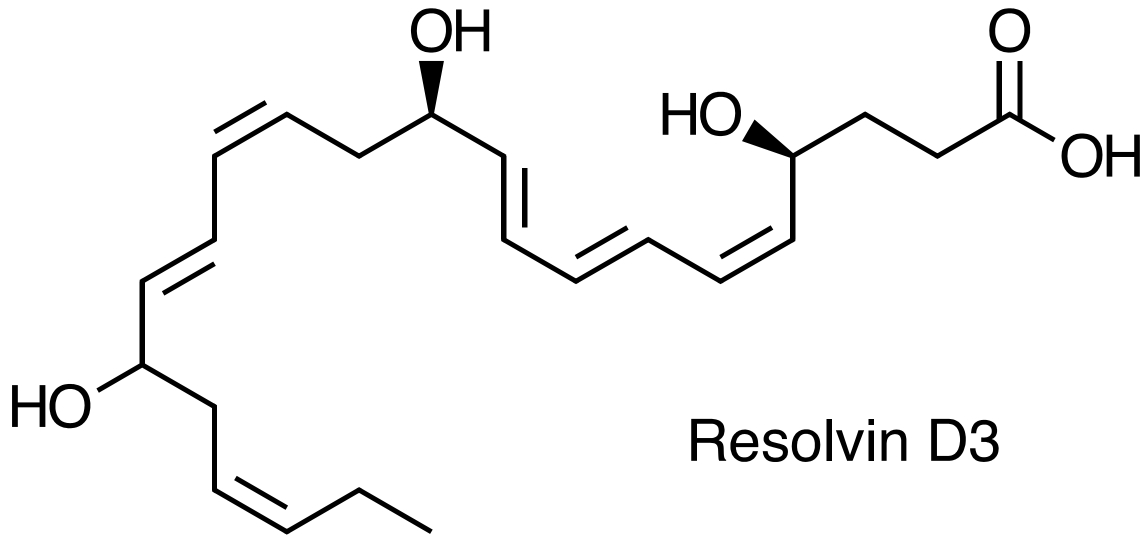


Known to mimic the antidiabetic effects of calorie restriction in rodents, and it boosts life span in flies and worms
Increases levels of cyclic AMP (CEN, 2/6/12, p. 6)
Appears to target antiaging pathway (CEN, 3/11/13, p. 4)

Compare resveratrol structure to olive oil compound.

“Curbing Inflammation with Aspirin and Omega-3s” (CEN, 2/25/13, p. 29)

Inflammation causes or exacerbates heart, lung, and kidney disease



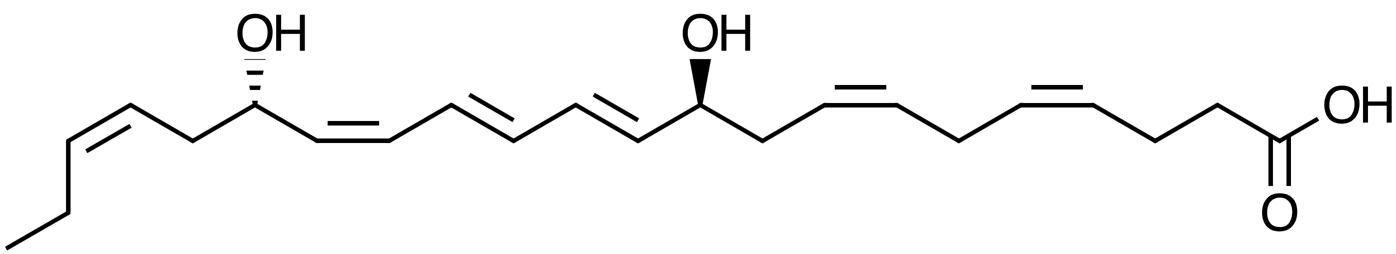
Resolvin D3

Resolvins serve as a signal our bodies use to start shutting down inflammation.

Aspirin helps trigger “aspirin-triggered resolvin D3.”

Omega-3 fatty acids are required as building blocks to create the signal.

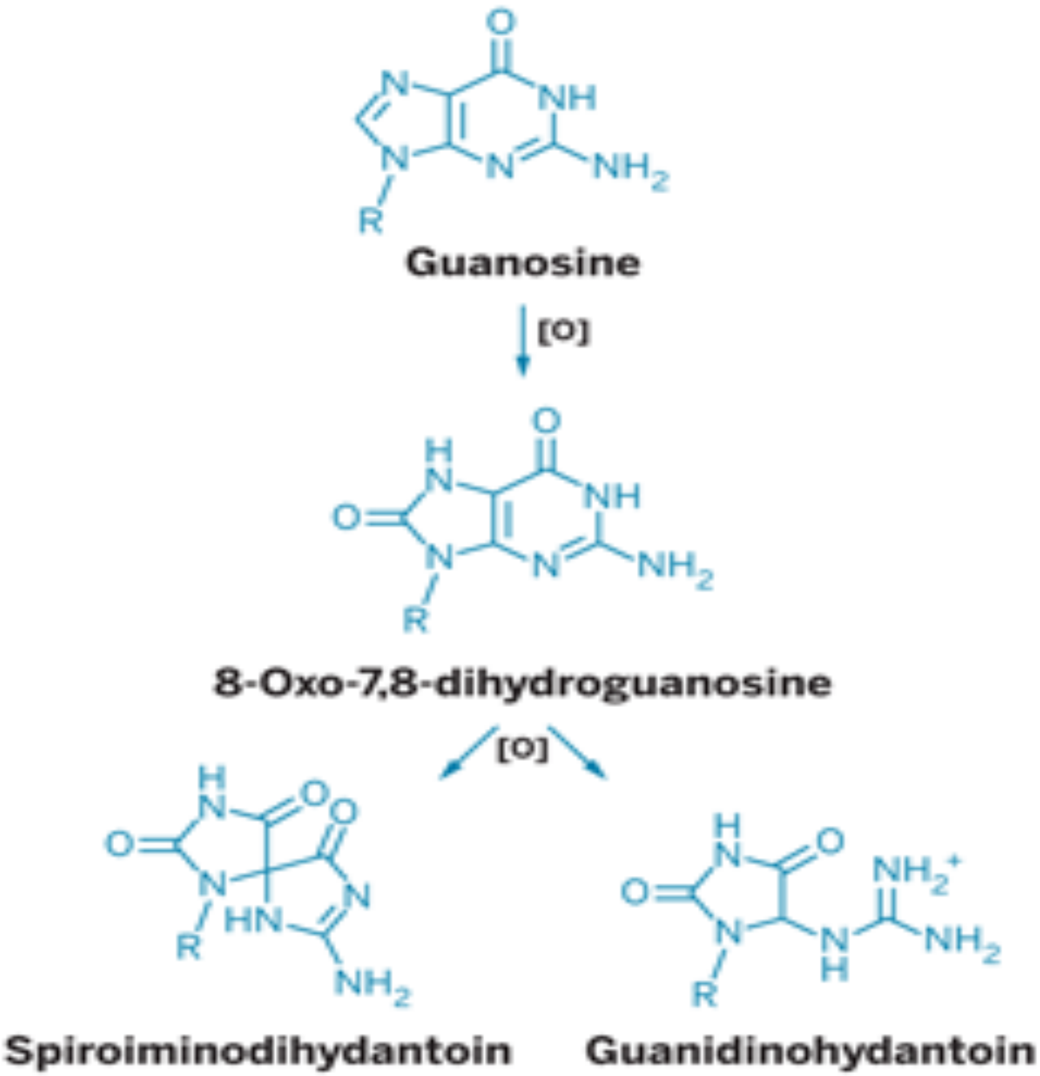
“Fighting Flu With Fish Oil”, (CEN, 3/11/13, p. 6)
Protectin D1 isomer 10S,17S-dihydroxydocosahexaenoic acid blocks replication of flu virus by inhibiting export of viral genomic material from host-cell nuclei.



Protectin D1 isomer

CEN, 3/14/11, p. 40. “Inflammation Stokes Cancer”

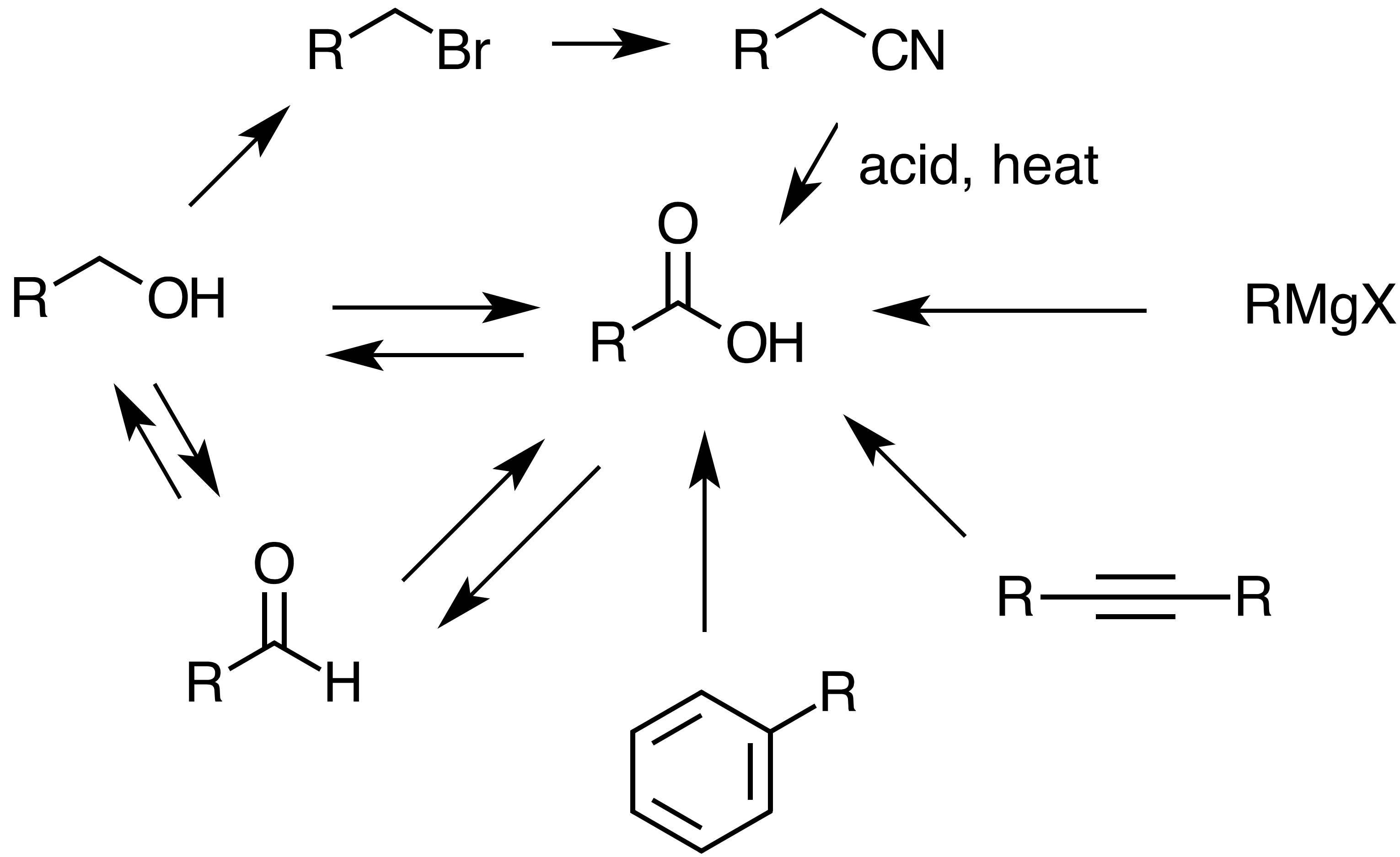
Inflammation -- signal --> neutrophils and macrophages -- release --> reactive O, N, and X species -- damage --> biomolecules



Oxidation of guanosine in DNA leads to 8-oxo-7,8-dihydroguanosine, which can be further oxidized to form spiroiminodihydantoin and guanidinohydantoin.

R = ribose.

Acids are Prepared from Different Functional Groups



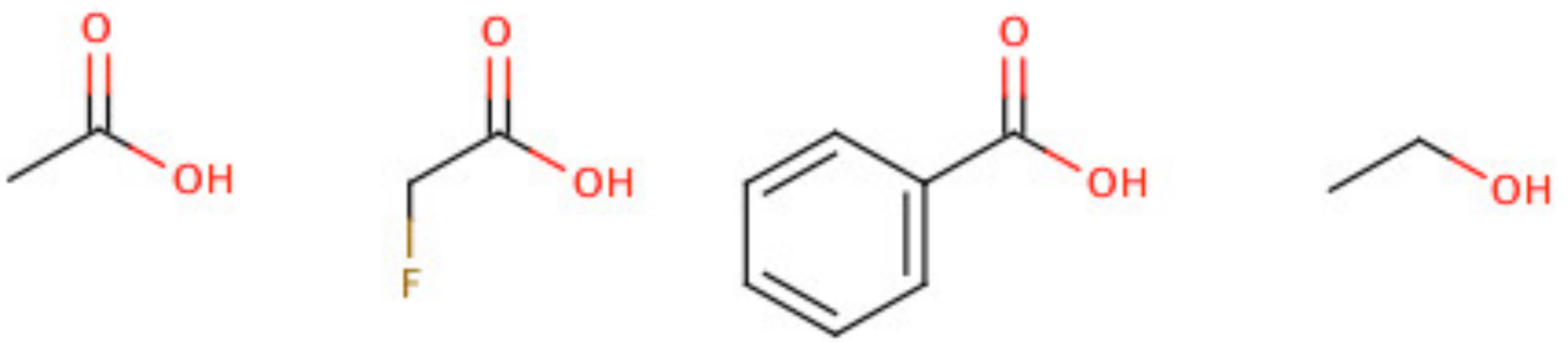
Identify the reaction conditions for each reaction.

HBr NaCN $NaBH_4$ $KMnO_4$ O_3 CO_2

Carboxylic Acids are ***Weak Acids***

The acid strength depends on the group bonded to the carbonyl carbon.

Rank the acids from strongest to weakest:

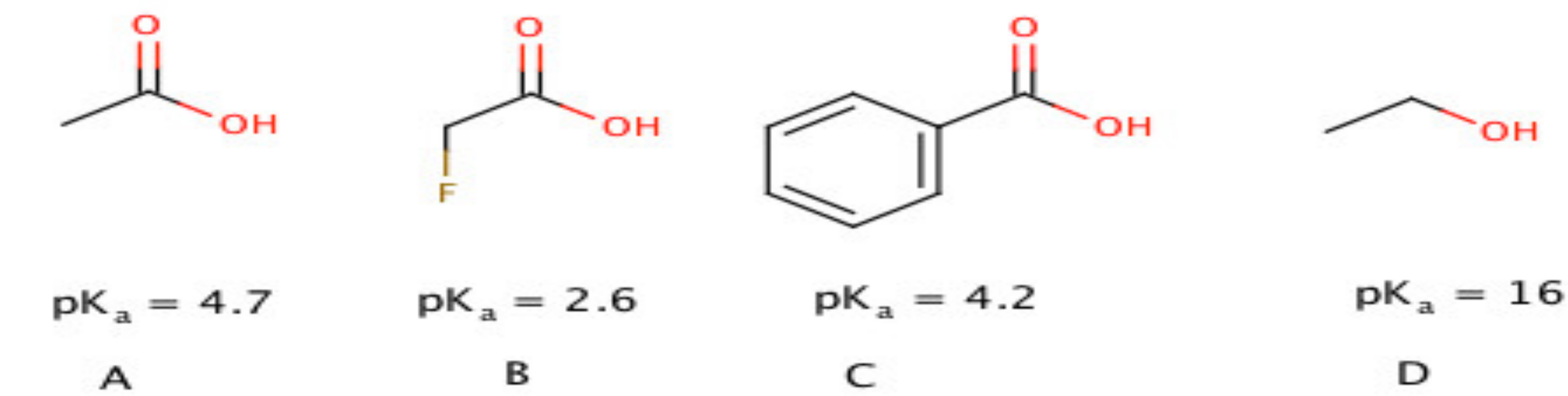


A	B	C	D
$pK_a = 4.7$	$pK_a = 2.6$	$pK_a = 4.2$	$pK_a = 16$

(i) A > B > C > D
(ii) B > C > A > D
(iii) D > A > C > B

Carboxylic Acids are ***Weak Acids***

The acid strength depends on the group bonded to the carbonyl carbon.



(i) A > B > C > D

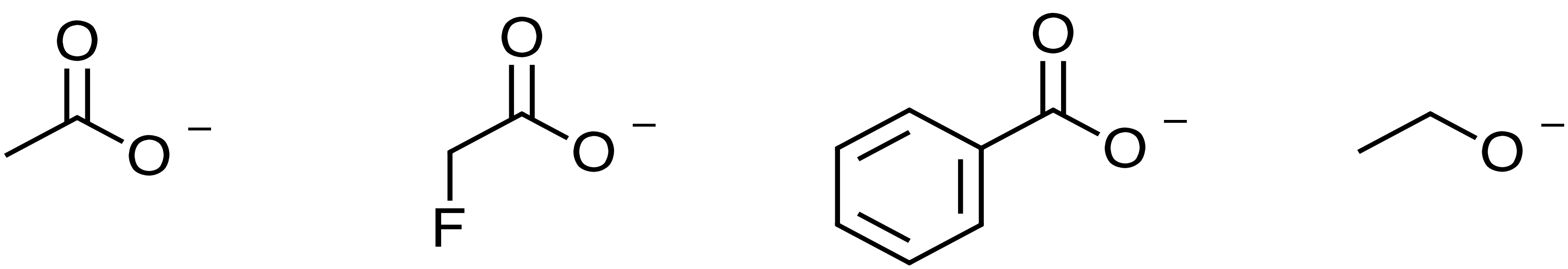
(ii) B > C > A > D

(iii) D > A > C > B

WHY?

Look at stability of conjugate base.

Stronger acid has weaker conj base



Most stable

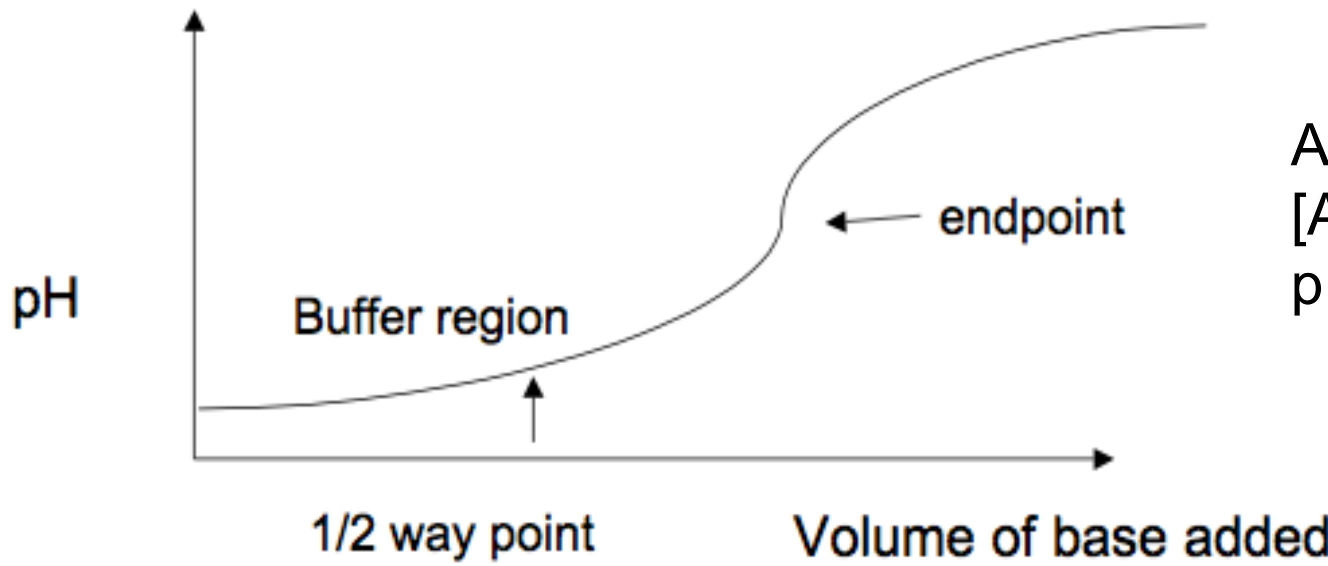
Inductive effect of F

Objective: Determine the charge of acid based on pH

Every Acid (HA) has a Conjugate Base (A^-): $HA \Longleftrightarrow H^+ + A^-$

Biology: pH determines the form (acid or conjugate base) and charge. See pK_a and a titration curve.

Henderson-Hasselback equation: $pH = pK_a + \log \frac{[A^-]}{[HA]}$

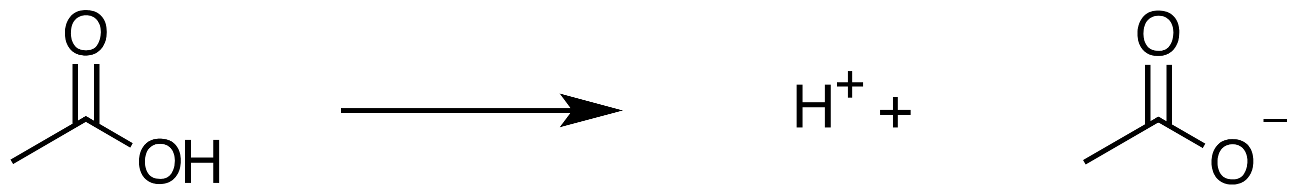


At ½ way point:
$[A^-] = [HA]$
$pH = pK_a$

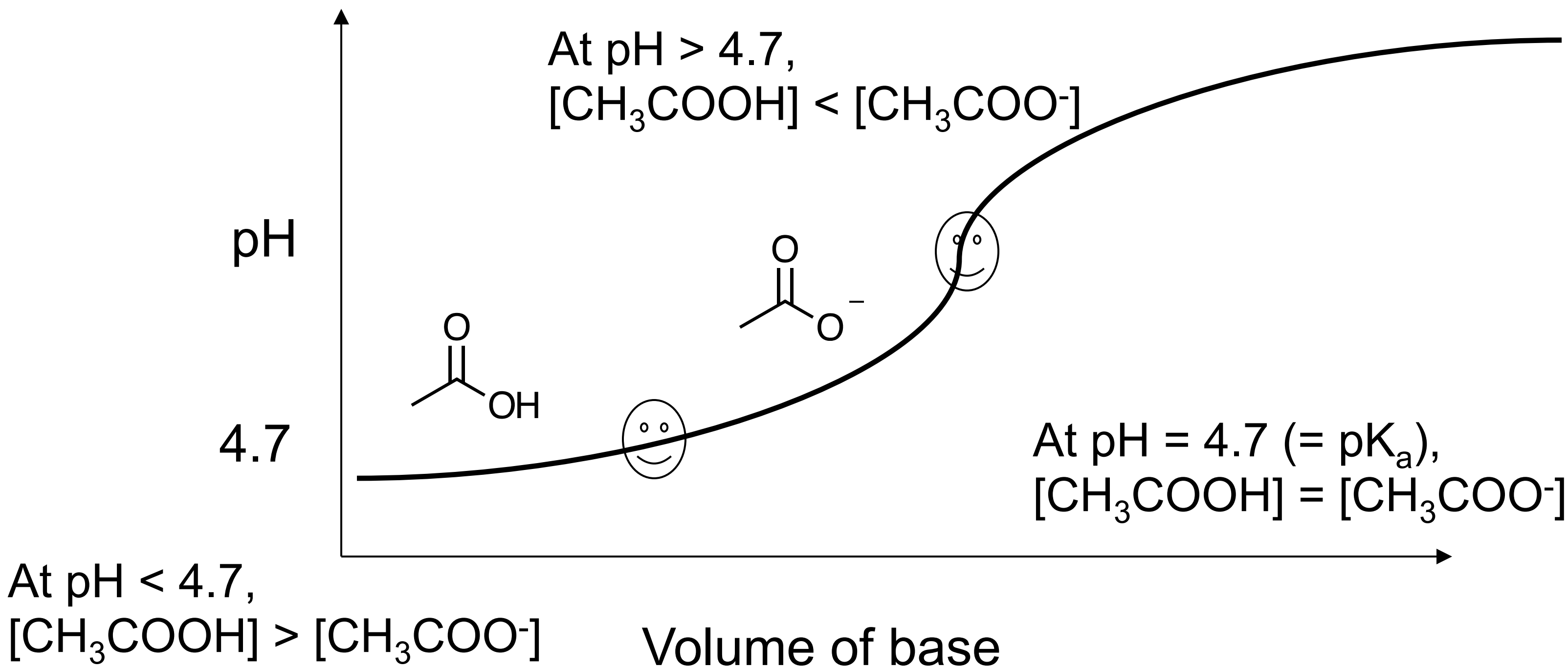
Weak Acids Can be used in Buffers

Objective: Determine the charge of acid based on pH

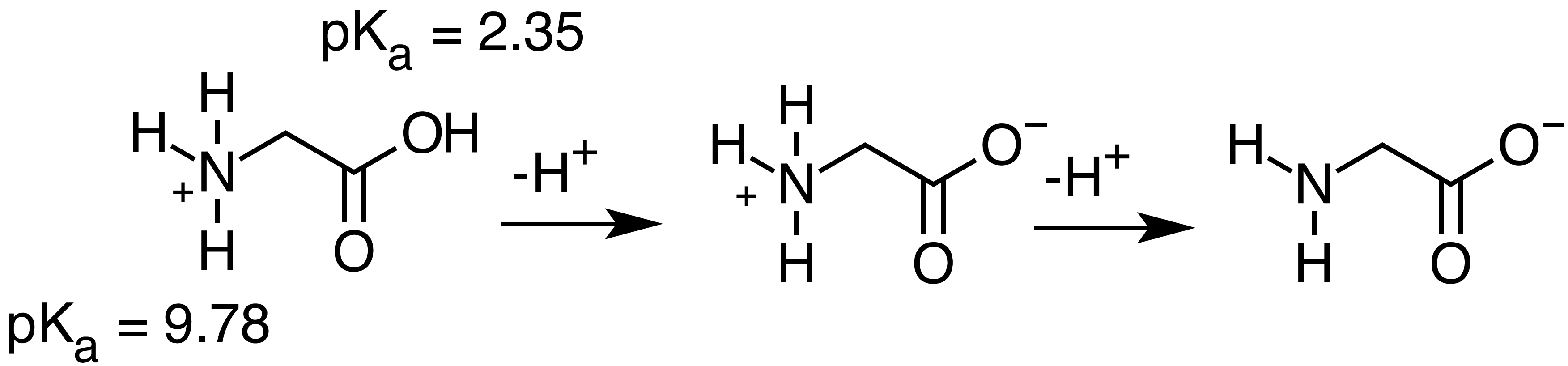
$pK_a = 4.7$



What is the charge on acetic acid at pH 3? (Answer: 0)
What is the charge at pH = 9? (Answer: -1)

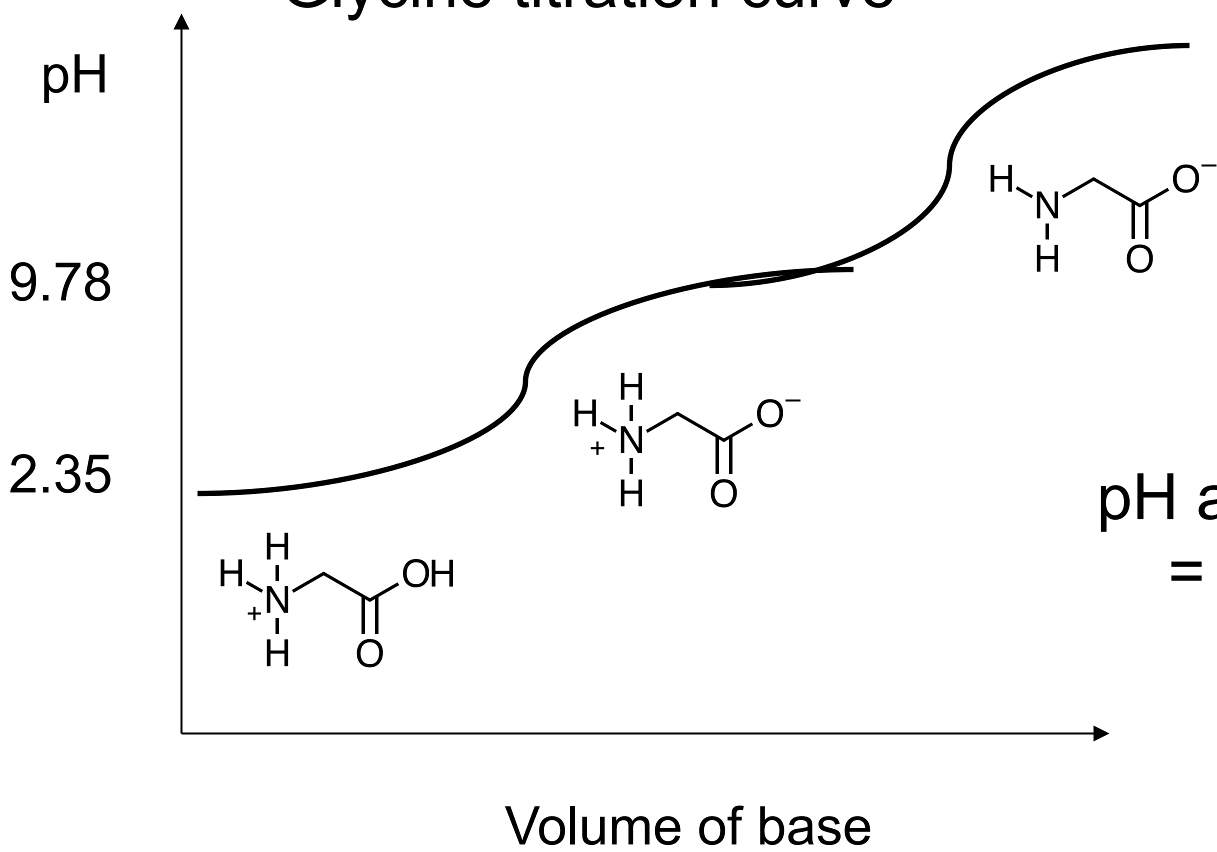


Glycine is the simplest amino acid.



How many protons can glycine donate?
Which H^+ is donated first?
What is the charge on glycine at pH 2? pH 7? pH 10?
What is the isoelectric point of glycine?
At what pH can glycine be used as a buffer?

Glycine titration curve



pH at 1st endpoint:
$= 0.5\ (pK_{ai} + pK_{a(i+1)})$

At pH 2, charge = ______. (+1)

At physiological pH (7.4), charge = ________. (0/-1)

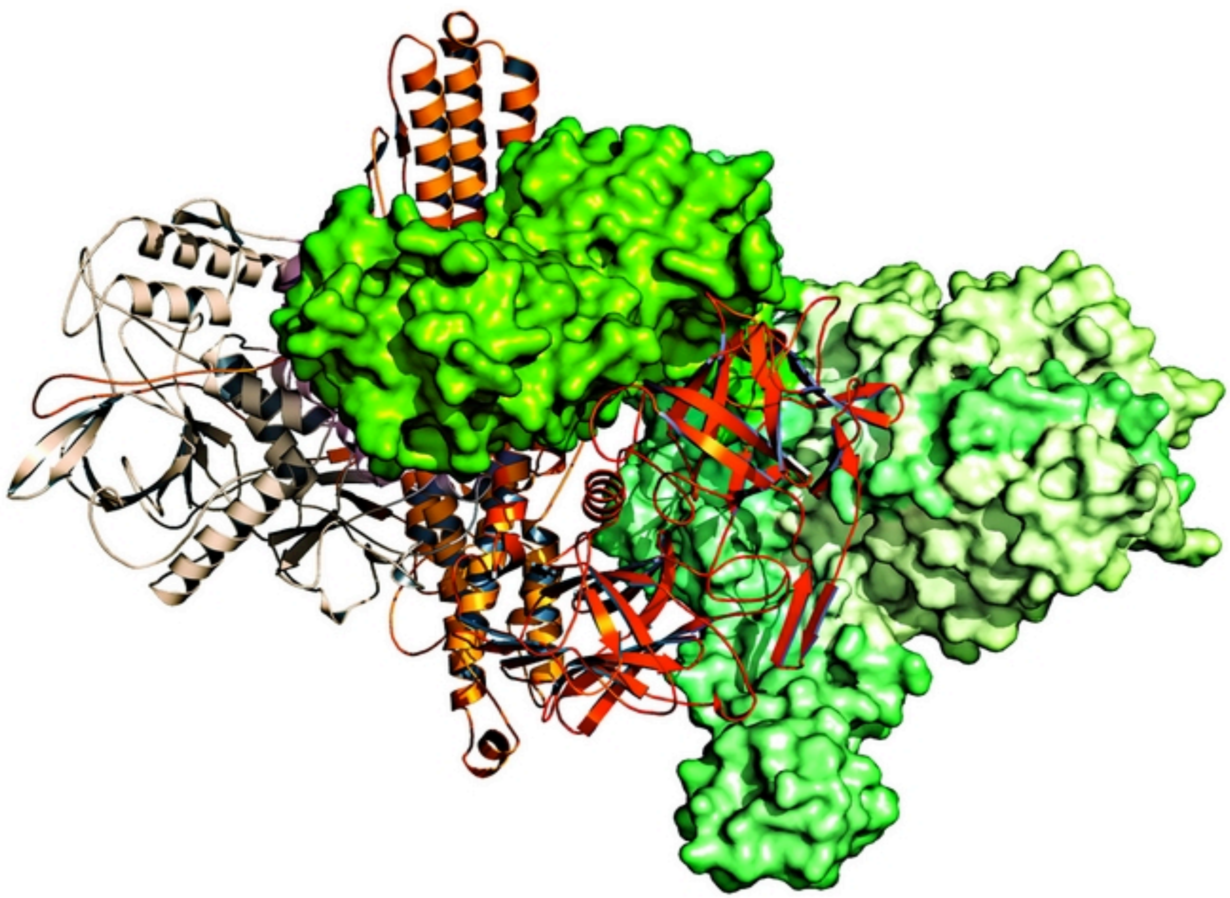
pI of glycine = _________. (6.06)

Buffer region pH = ___________ and __________.

http://cen.acs.org/articles/90/i9/Toxin-Avoids-Digestion.html

2/27/12, CEN, p. 6 "How a Toxin Avoids Digestion"

Botulism is muscle paralysis caused when a neurotoxin produced by the bacterium *Clostridium botulinum* inhibits release of a neurotransmitter. Neurotoxin is protected by another protein, called nontoxic nonhemagglutinin (NTNHA).



At **low pH** (in the gut), key toxin glutamate and aspartate residues would be **protonated**, promoting association with NTNHA.

At **pH 7.5** (in the bloodstream), the residues would be **deprotonated**, allowing release of the toxin from NTNHA.