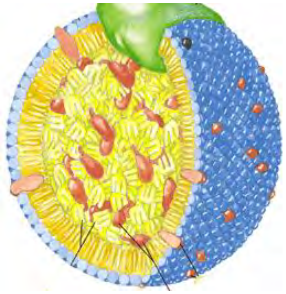
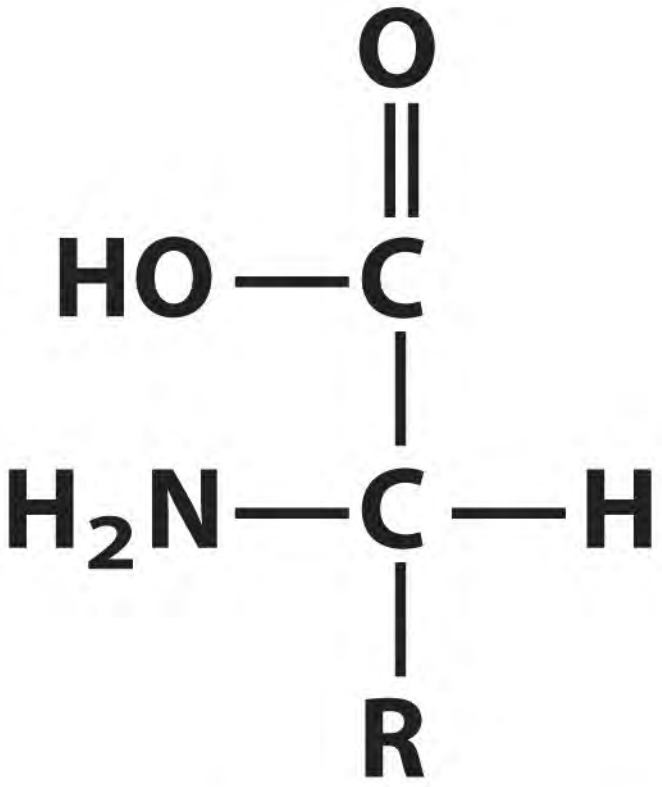
BIOCHEMISTRY REVIEW

Overview of Biomolecules

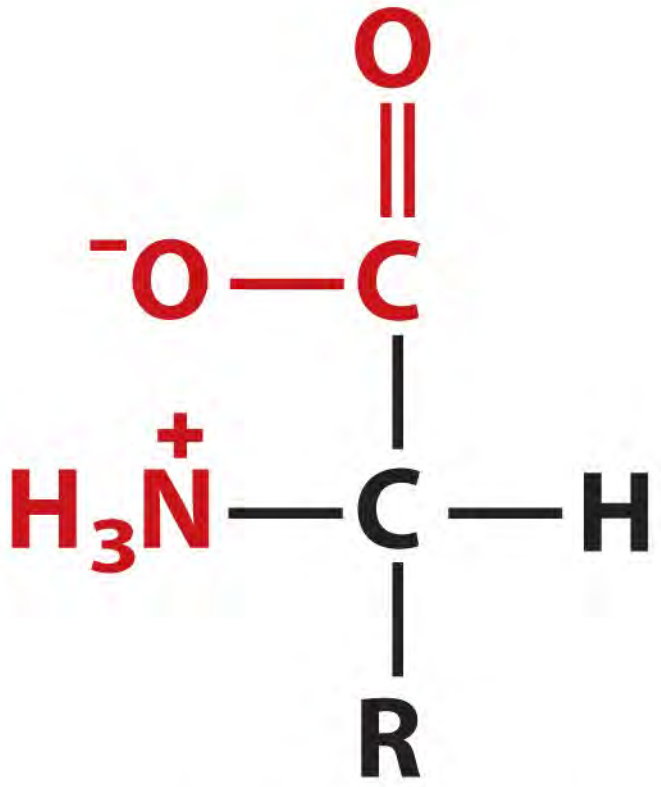
Chapter 2

Amino Acids





Nonionic form

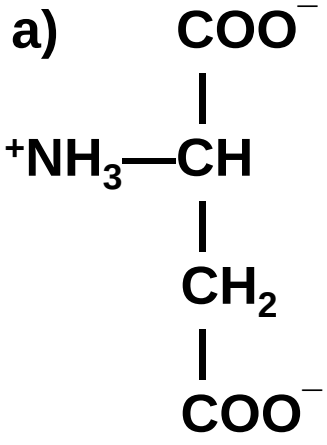


Zwitterionic form

Are You Getting It??

Which of the following is the zwitterion form of aspartic acid?

a)



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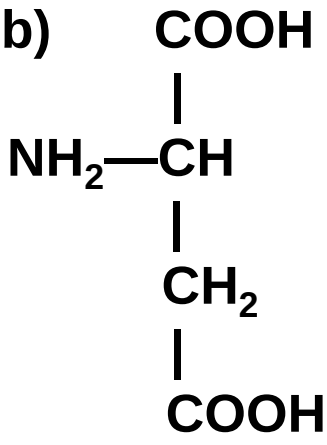

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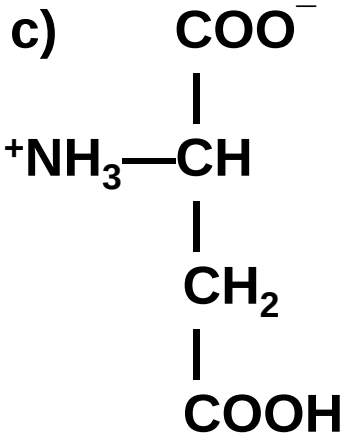

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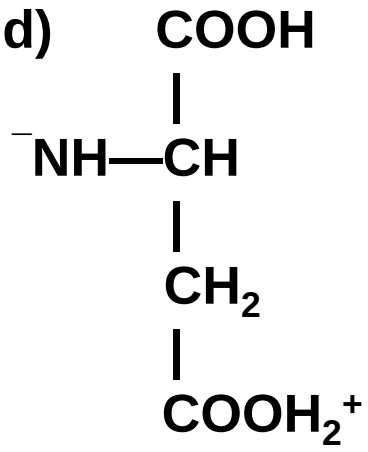
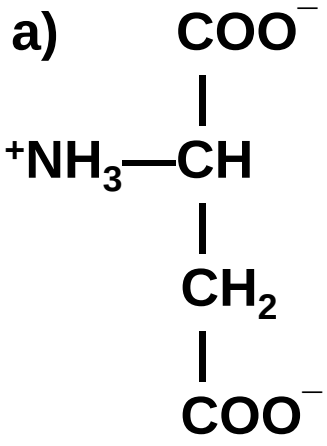


Are You Getting It??

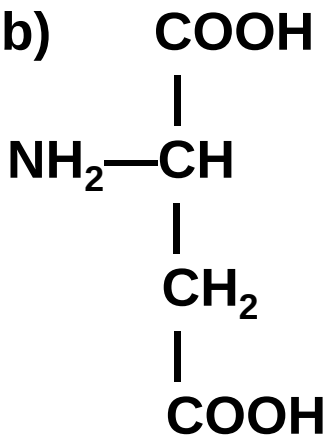
Answer

Which of the following is the zwitterion form of aspartic acid?

a)



b)



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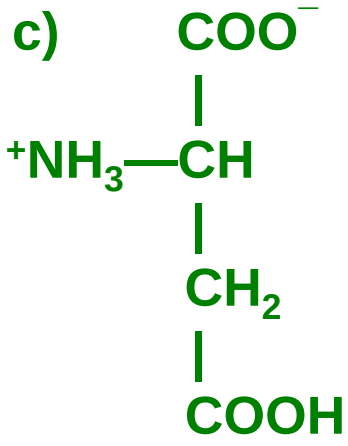

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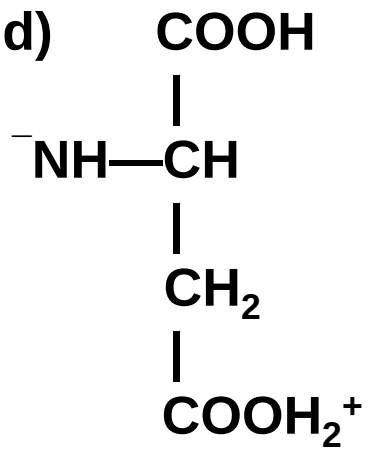
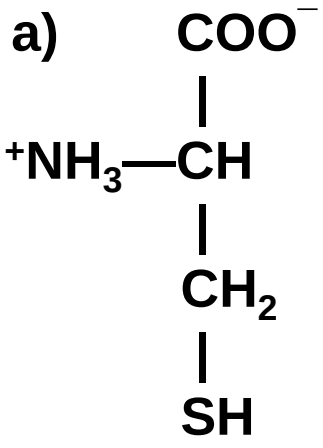


Are You Getting It??

Which of the following is the zwitterion form of cysteine?

a)



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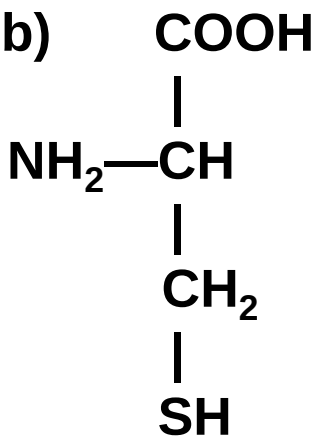

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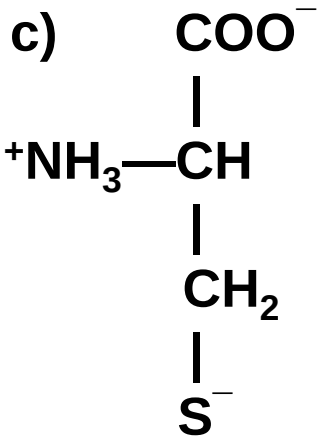

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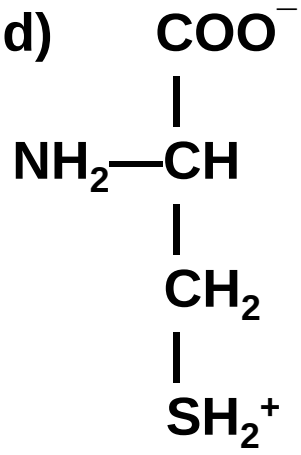
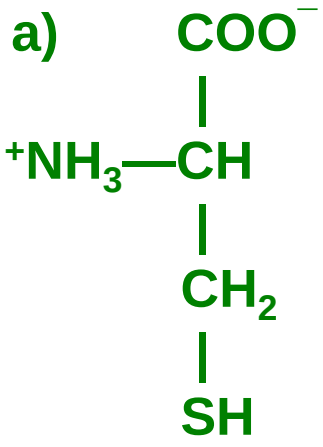


Are You Getting It??

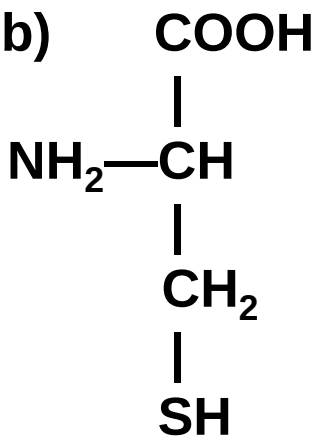
Answer

Which of the following is the zwitterion form of cysteine?

a)



b)



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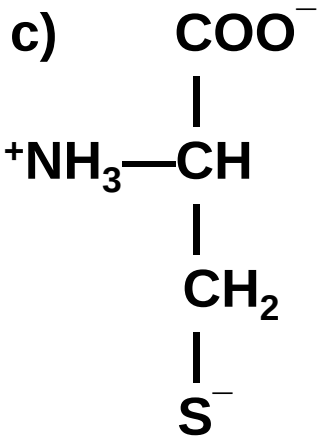

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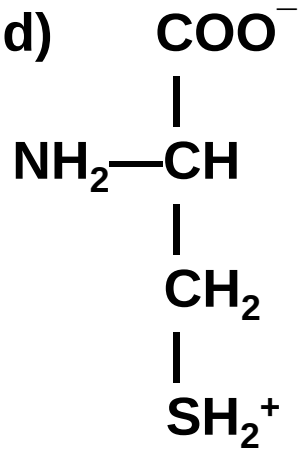
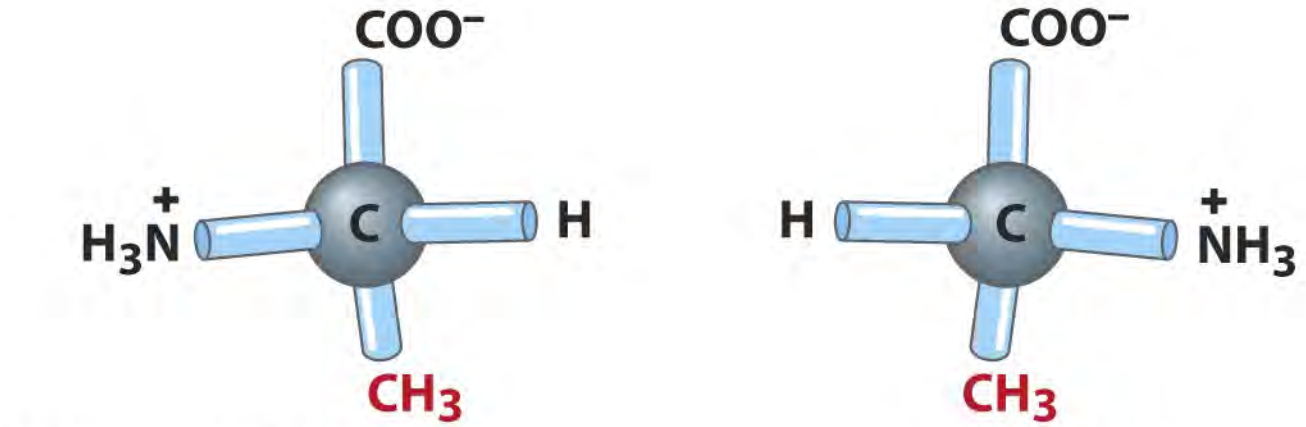
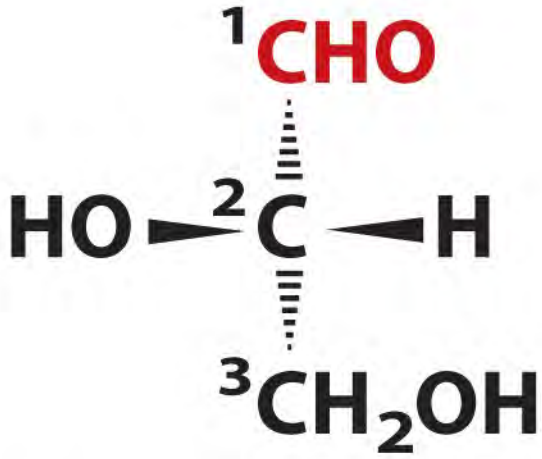
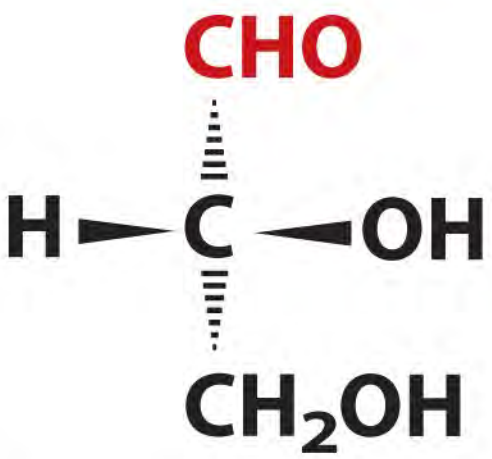


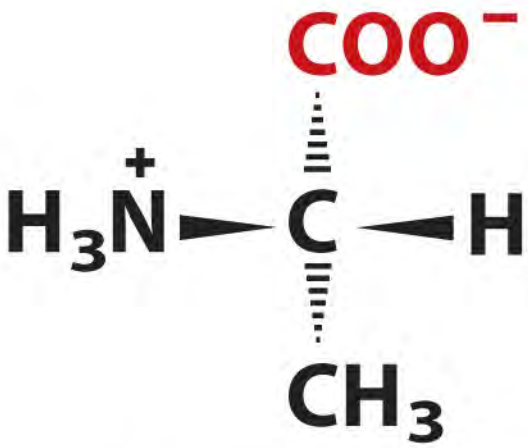

COO⁻
+
H3N
C
H
CH3
(a)
L-Alanine
COO⁻
H
C
+
NH3
CH3
D-Alanine
COO⁻
+
H3N
C
H
CH3
(b)
L-Alanine
COO⁻
H
C
+
NH3
CH3
D-Alanine
COO⁻
+
H3N
C
H
CH3
(c)
L-Alanine
COO⁻
H
C
+
NH3
CH3
D-Alanine



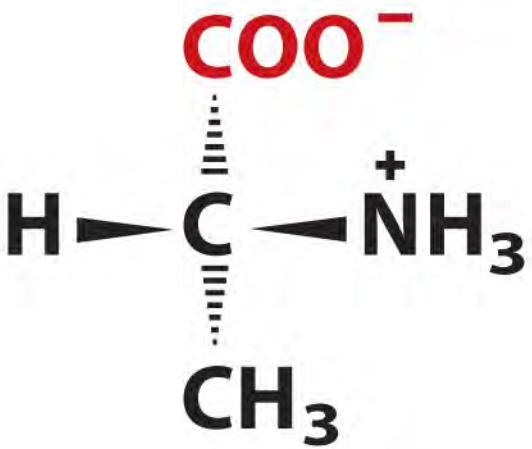
L-Glyceraldehyde



D-Glyceraldehyde



L-Alanine

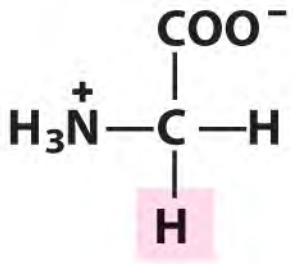


D-Alanine

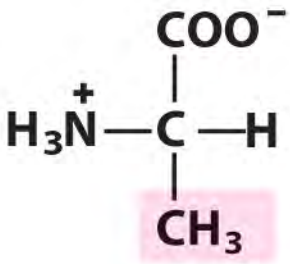
TABLE 3.2 Abbreviations for amino acids

Amino acid	Three-letter abbreviation	One-letter abbreviation	Amino acid	Three-letter abbreviation	One-letter abbreviation
Alanine	Ala	A	Methionine	Met	M
Arginine	Arg	R	Phenylalanine	Phe	F
Asparagine	Asn	N	Proline	Pro	P
Aspartic Acid	Asp	D	Serine	Ser	S
Cysteine	Cys	C	Threonine	Thr	T
Glutamine	Gln	Q	Tryptophan	Trp	W
Glutamic Acid	Glu	E	Tyrosine	Tyr	Y
Glycine	Gly	G	Valine	Val	V
Histidine	His	H	Asparagine or aspartic acid	Asx	B
Isoleucine	Ile	I			
Leucine	Leu	L	Glutamine or glutamic acid	Glx	Z
Lysine	Lys	K			

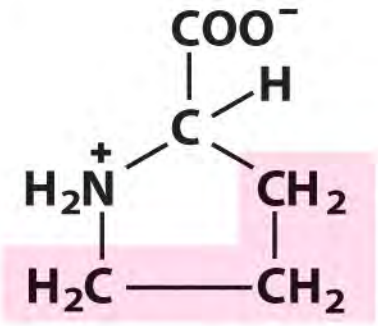
Nonpolar, aliphatic R groups



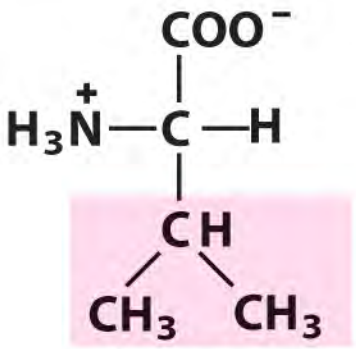
Glycine



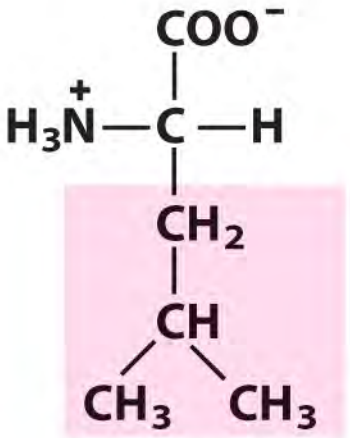
Alanine



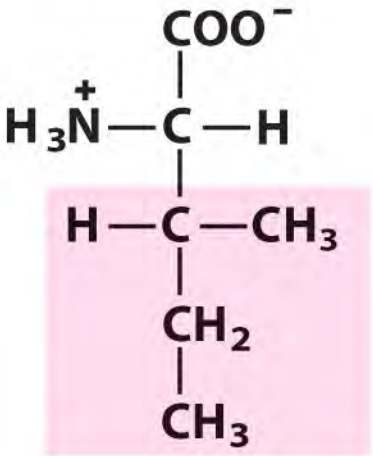
Proline



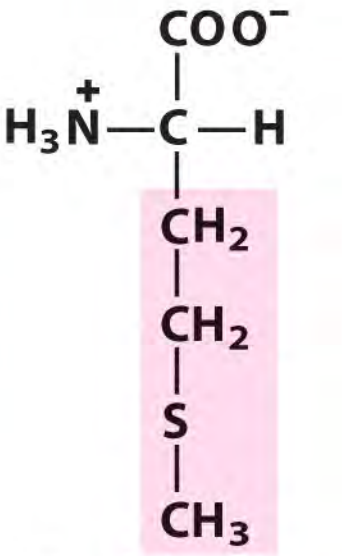
Valine



Leucine

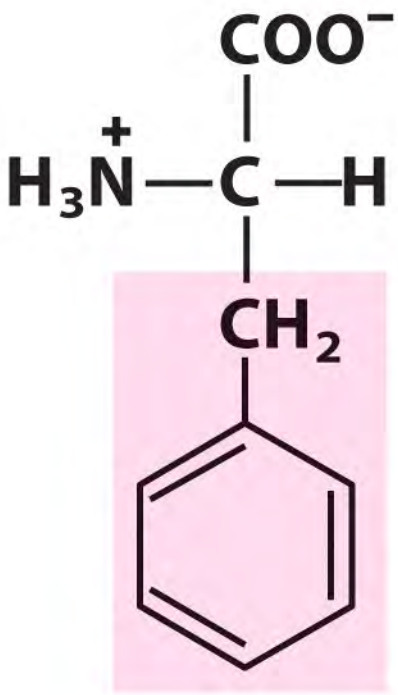


Isoleucine

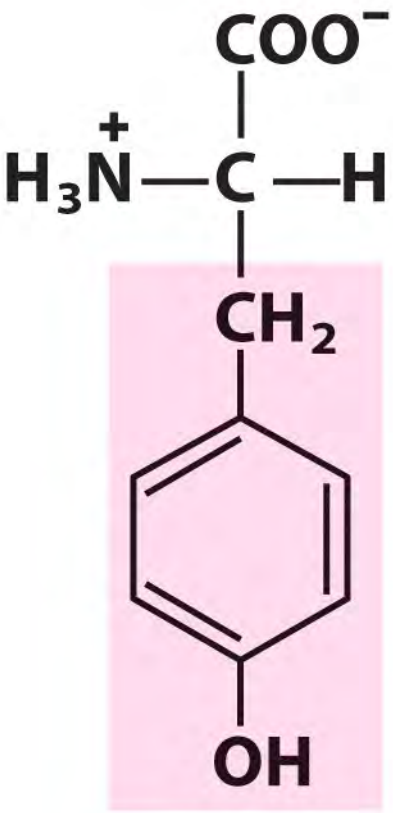


Methionine

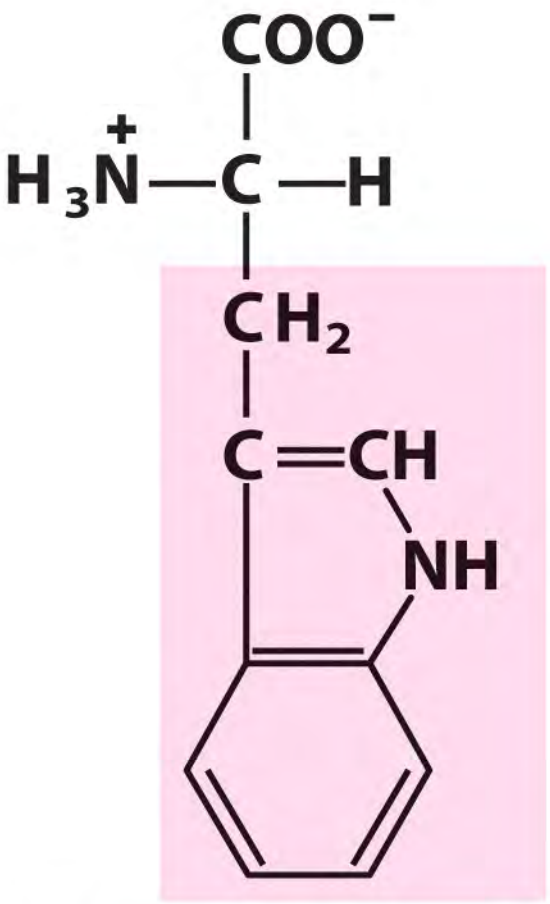
Aromatic R groups



Phenylalanine

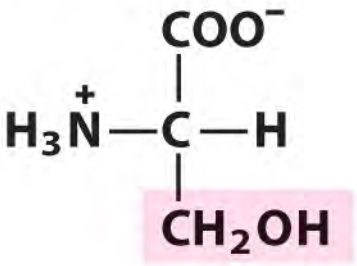


Tyrosine

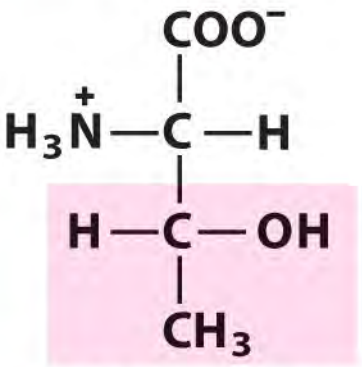


Tryptophan

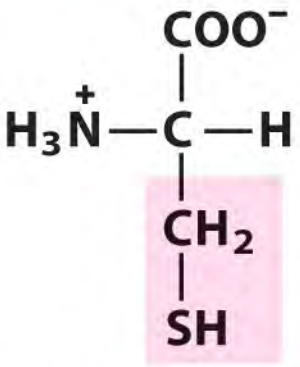
Polar, uncharged R groups



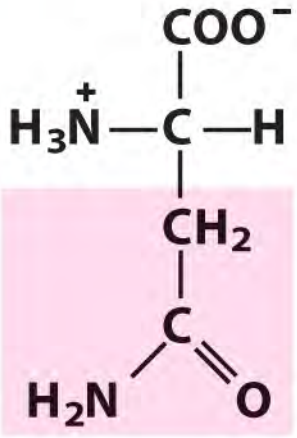
Serine



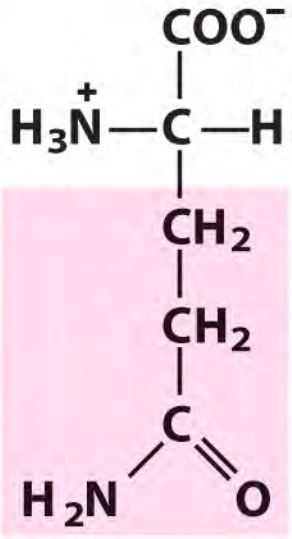
Threonine



Cysteine

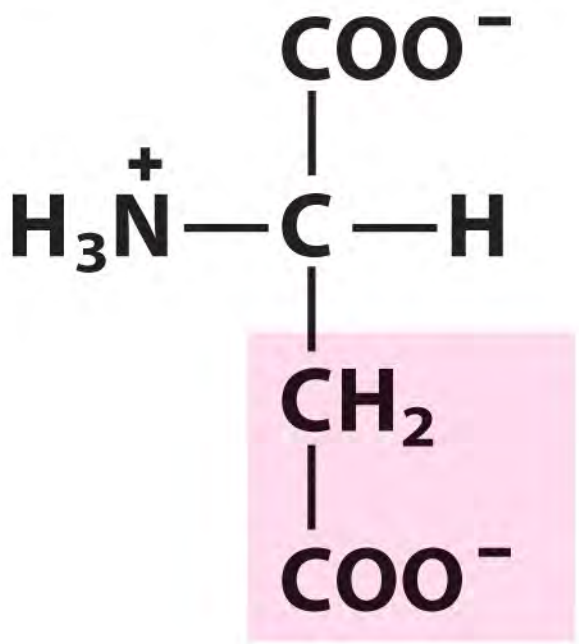


Asparagine

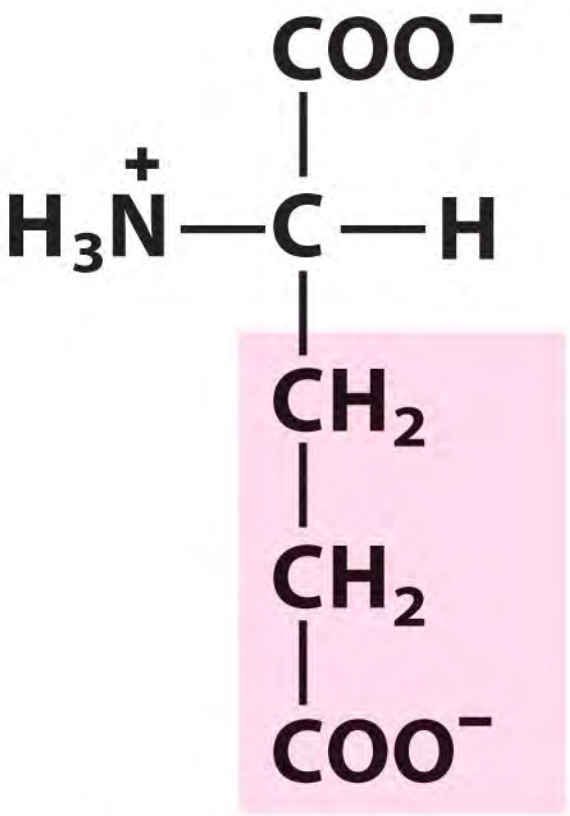


Glutamine

Negatively charged R groups

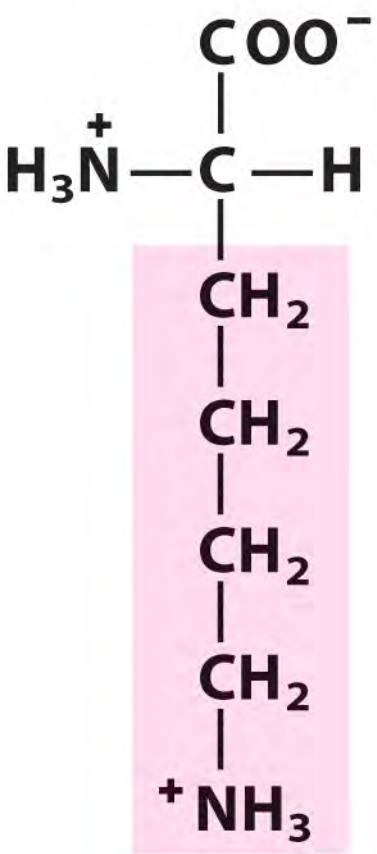


Aspartate

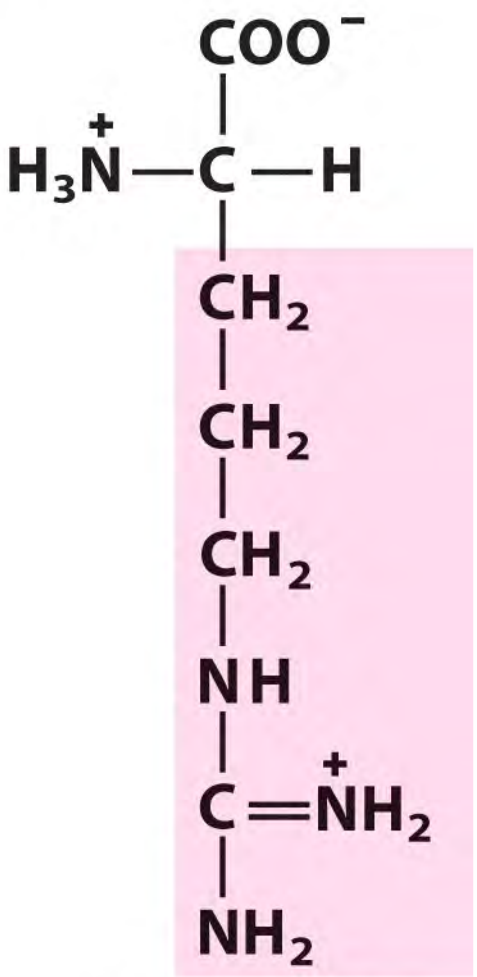


Glutamate

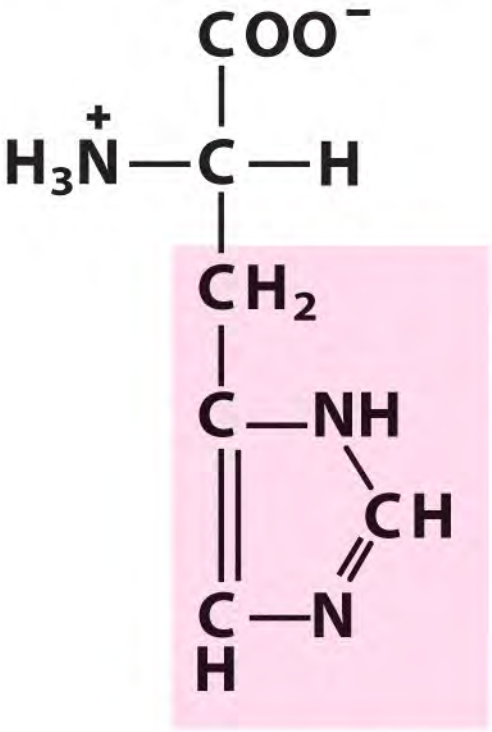
Positively charged R groups



Lysine



Arginine

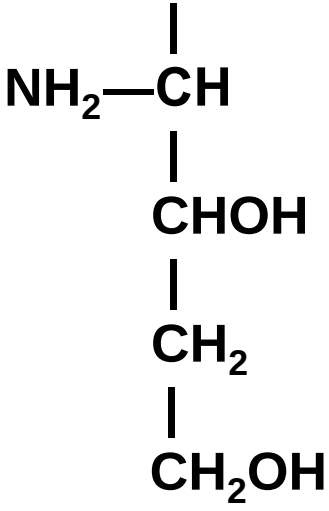


Histidine

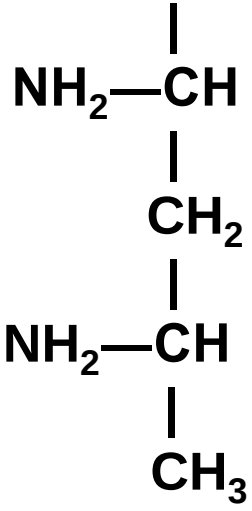
Are You Getting It??

Categorize the R-groups of the following amino acids:

a)



b)



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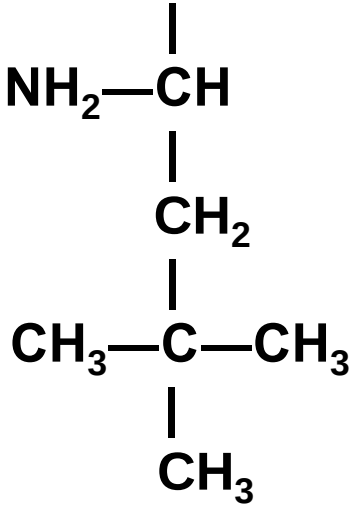
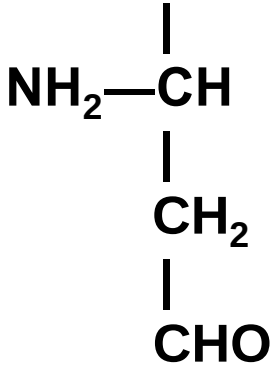


d)

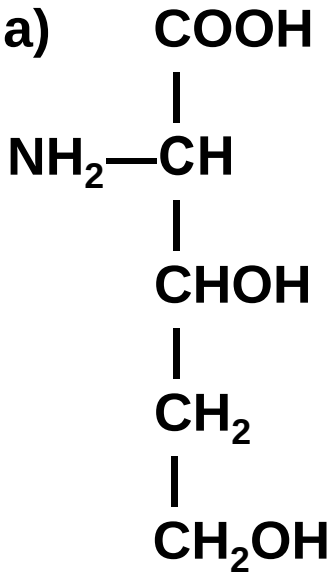


Are You Getting It??

Answer

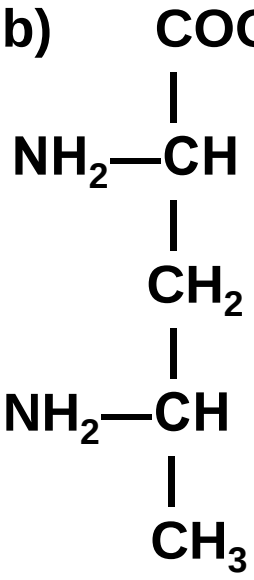
Categorize the R-groups of the following amino acids:

a)



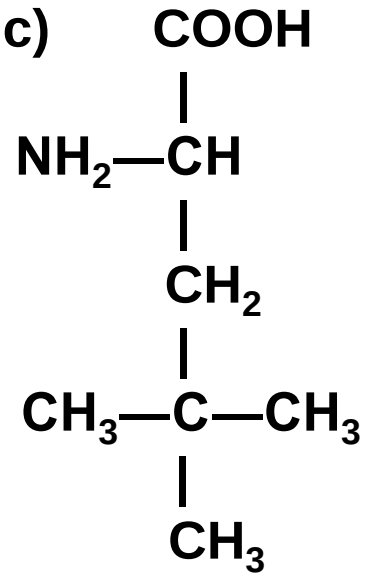
polar uncharged

b)



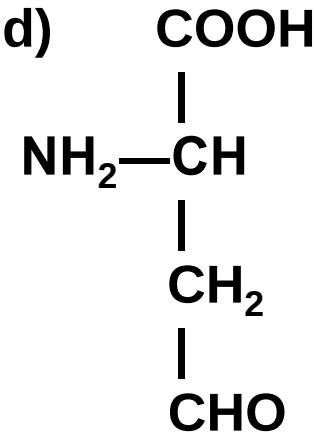
(+) charged

c)



non-polar

d)

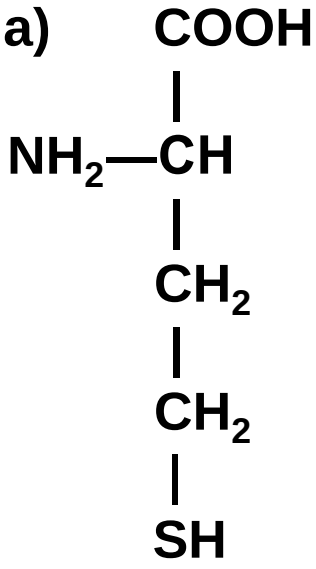


polar, uncharged

Are You Getting It??

Categorize the R-groups of the following amino acids:

a)



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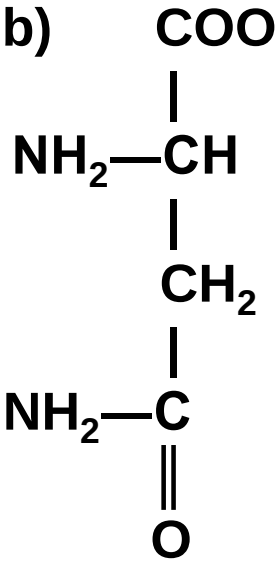
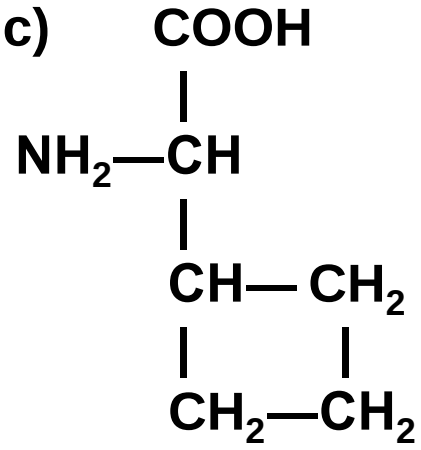
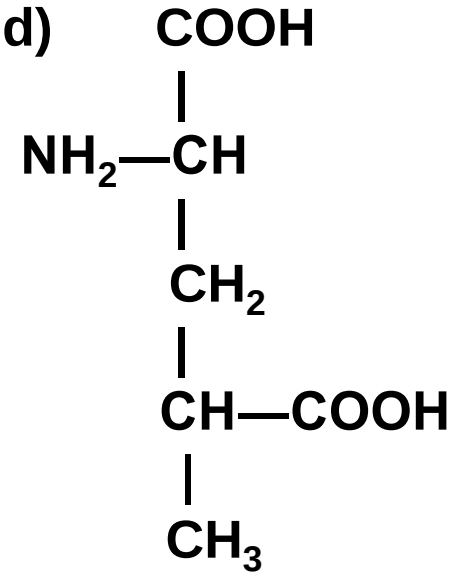


c)



d)

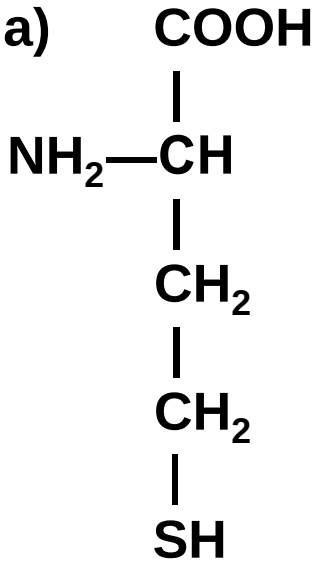


Are You Getting It??

Answer

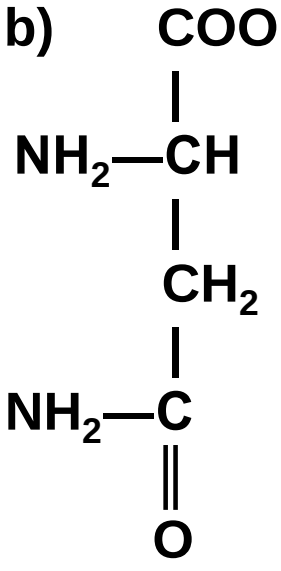
Categorize the R-groups of the following amino acids:

a)



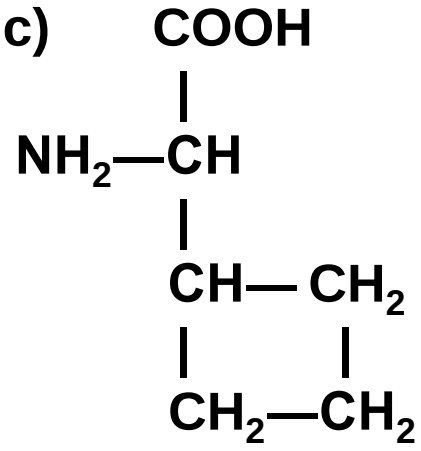
polar, uncharged

b)



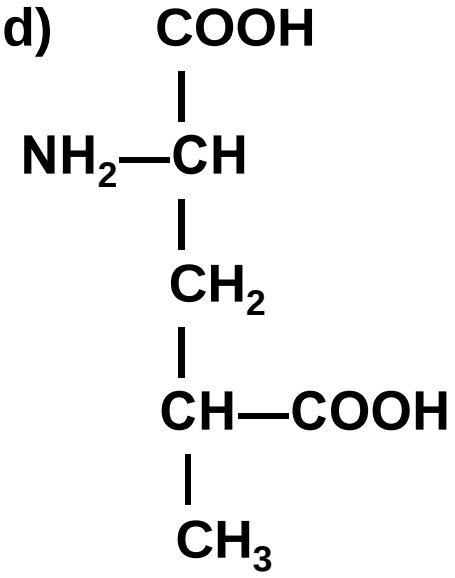
polar, uncharged

c)

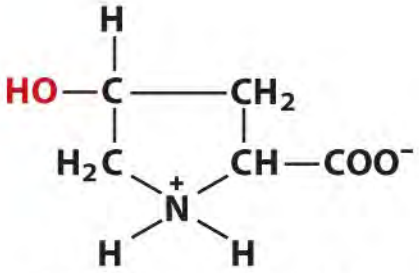


non-polar

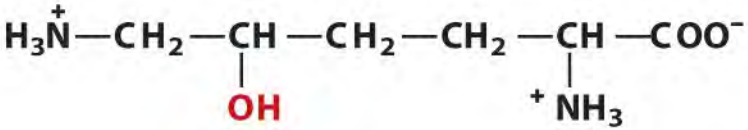
d)



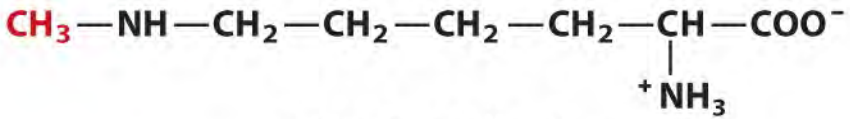
(-) charged



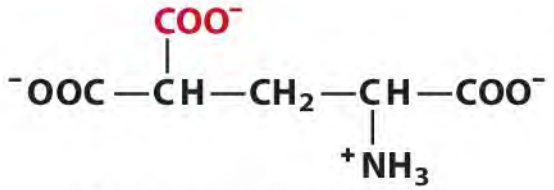
4-Hydroxyproline



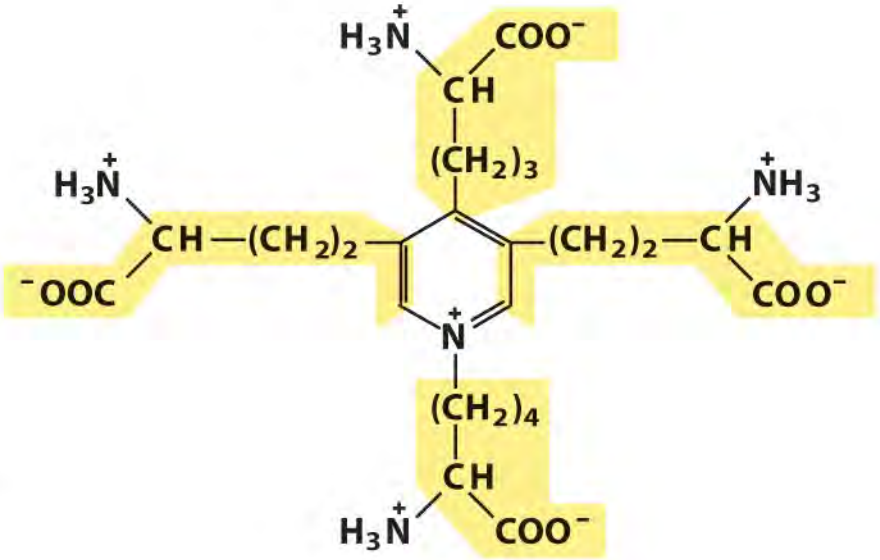
5-Hydroxylysine



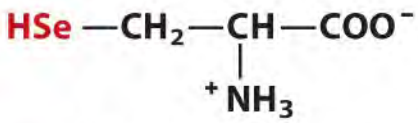
6-*N*-Methyllysine



γ-Carboxyglutamate



Desmosine



Selenocysteine

ACID DISSOCIATION CONSTANT

$$HA + H_2O \leftrightarrow H_3O^+ + A^-$$

$$K_a = \frac{[H_3O^+][A^-]}{[HA]}$$

BASE DISSOCIATION CONSTANT

$$B + H_2O \leftrightarrow BH^+ + OH^-$$

$$K_b = \frac{[BH^+]\,[OH^-]}{[B]}$$

pK_a & pK_b

$$HA + H_2O \leftrightarrow H_3O^+ + A^-$$

$$pK_a = -\log K_a$$

$$pK_b = -\log K_b$$

$$pK_a + pK_b = 14$$

Are You Getting It??

Compound X has a pKa value of 3.0 while Compound Y has a pKa value of 5.0. What characteristics do these two compounds have in water?

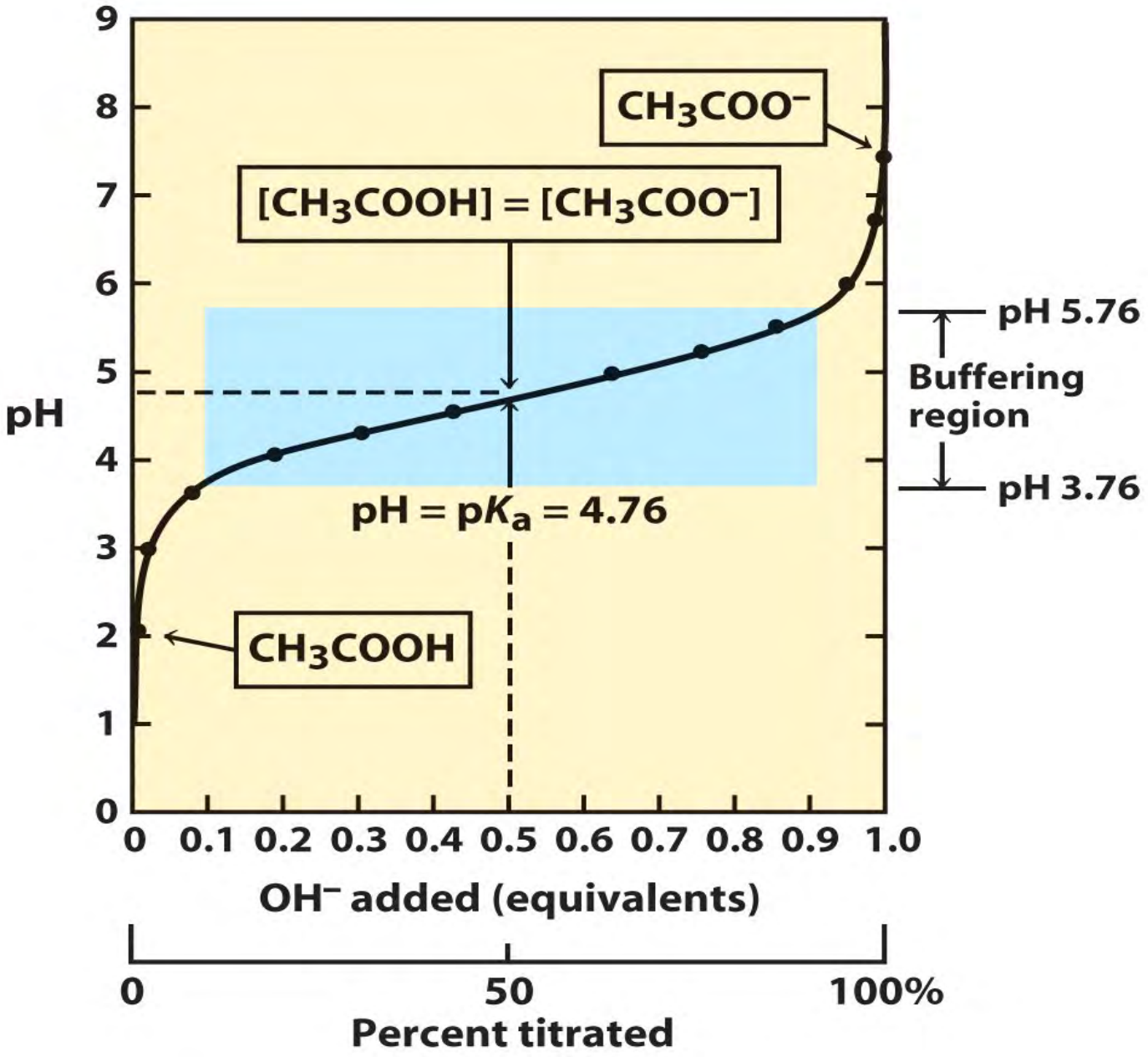
a) X is an acid while Y is a base.
b) X is a proton acceptor while Y is a proton donor.
c) X and Y are both acids but X is stronger than Y.
d) X and Y are both acids, but Y dissociates more than X.

Are You Getting It??

Answer

Compound X has a pKa value of 3.0 while Compound Y has a pKa value of 5.0. What characteristics do these two compounds have in water?

a) X is an acid while Y is a base.
b) X is a proton acceptor while Y is a proton donor.
c) X and Y are both acids but X is stronger than Y.
d) X and Y are both acids, but Y dissociates more than X.


9
8
7
6
5
4
3
2
1
0
pH
CH_3COO^-
$[CH_3COOH] = [CH_3COO^-]$
pH 5.76
Buffering region
pH 3.76
$pH = pK_a = 4.76$
CH_3COOH
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
OH^- added (equivalents)
0
50
100%
Percent titrated

$$Ka = \frac{[A^-]\,[H^+]}{[AH]} \qquad (I)$$

$$\log Ka = \log [H^+] \frac{[A^-]}{[AH]} \qquad (II)$$

$$\log Ka = \log [H^+] + \log \frac{[A^-]}{[AH]}$$

$$- \log [H^+] = - \log Ka + \log \frac{[A^-]}{[AH]} \qquad (III)$$

$$pH = pKa + \log \frac{[A^-]}{[AH]} \qquad (IV)$$

Are You Getting It??

At the pKa value of the weak acid HA,

a) all the molecules will be protonated.

b) all the molecules will be deprotonated.

c) there will be an equivalence point in the titration curve.

d) there will be equal amounts of acid and conjugate base.

Are You Getting It??

Answer

At the pKa value of the weak acid HA,

a) all the molecules will be protonated.

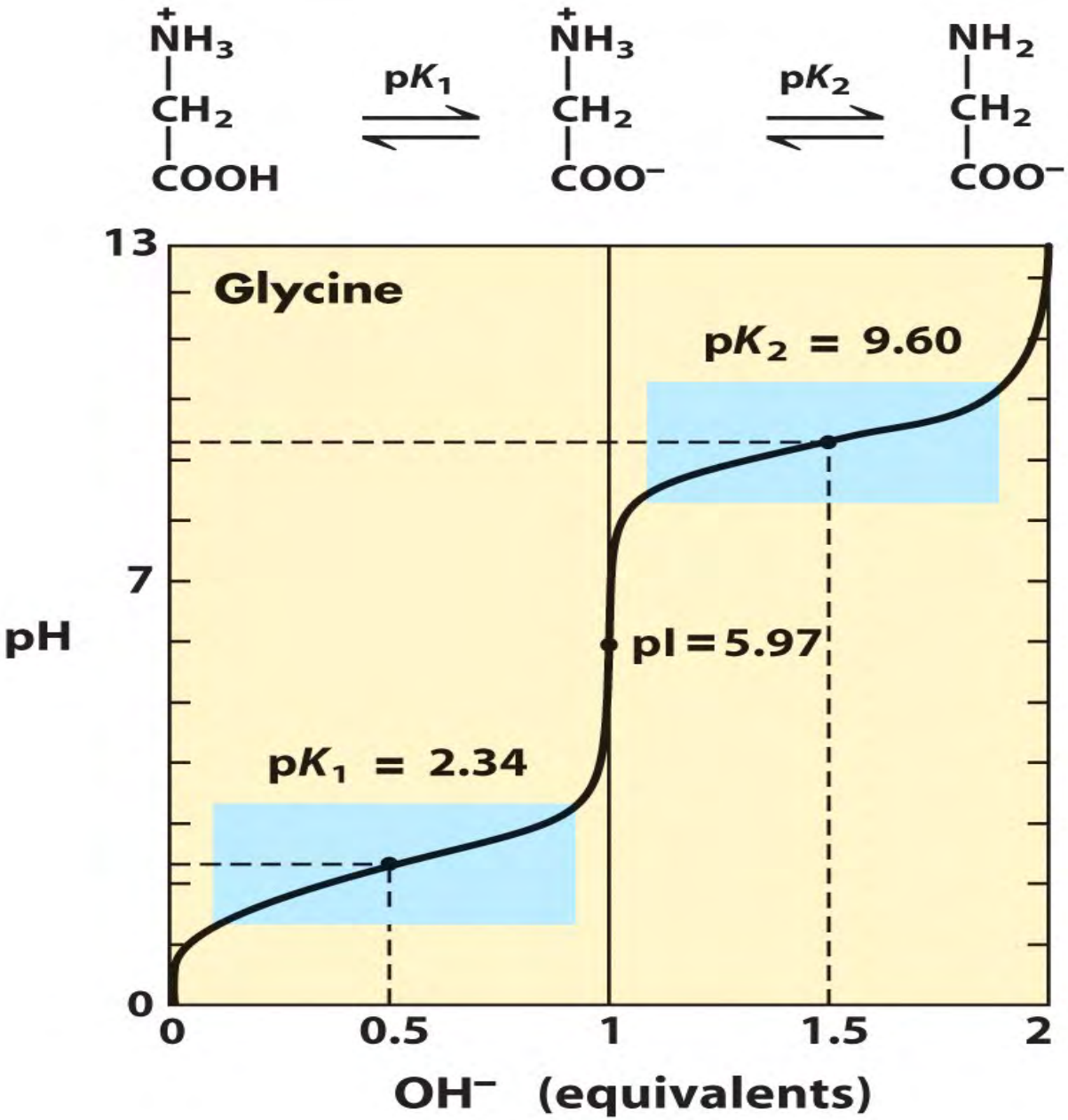
b) all the molecules will be deprotonated.

c) there will be an equivalence point in the titration curve.

d) there will be equal amounts of acid and conjugate base.

ISOIONIC POINT (pI)

$$pI = \frac{pK_{a1} + pK_{a2}}{2}$$


NH3+
CH2
COOH
pK1
NH3+
CH2
COO−
pK2
NH2
CH2
COO−
Glycine
pK2 = 9.60
pI = 5.97
pK1 = 2.34
pH
13
7
0
0
0.5
1
1.5
2
OH− (equivalents)

Are You Getting It??

What properties will be observed during the titration of an amino acid with 2 pKa values? *(multiple answers)*

a) There will be a pKa value close to pH = 2.
b) There will be an isoionic point close to pH = 9-10.
c) The amino acid can have a charge of +1, 0, or -1.
d) There will be two half-equivalence points in the titration curve.
e) There will be a mixture of two forms of the amino acid at each equivalence point.

Are You Getting It??

Answer

What properties will be observed during the titration of an amino acid with 2 pKa values?

a) There will be a pKa value close to pH = 2.

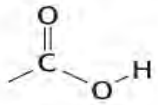
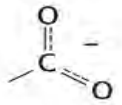
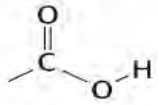
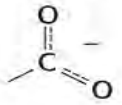
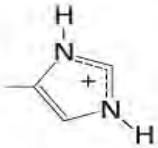
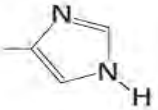
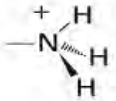
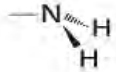
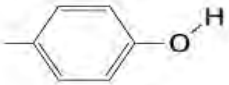
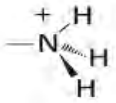
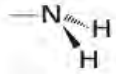
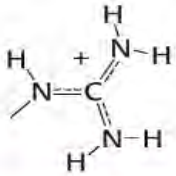
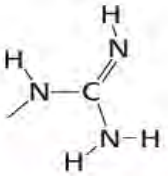
b) There will be an isoionic point close to pH = 9-10.

c) The amino acid can have a charge of +1, 0, or -1.

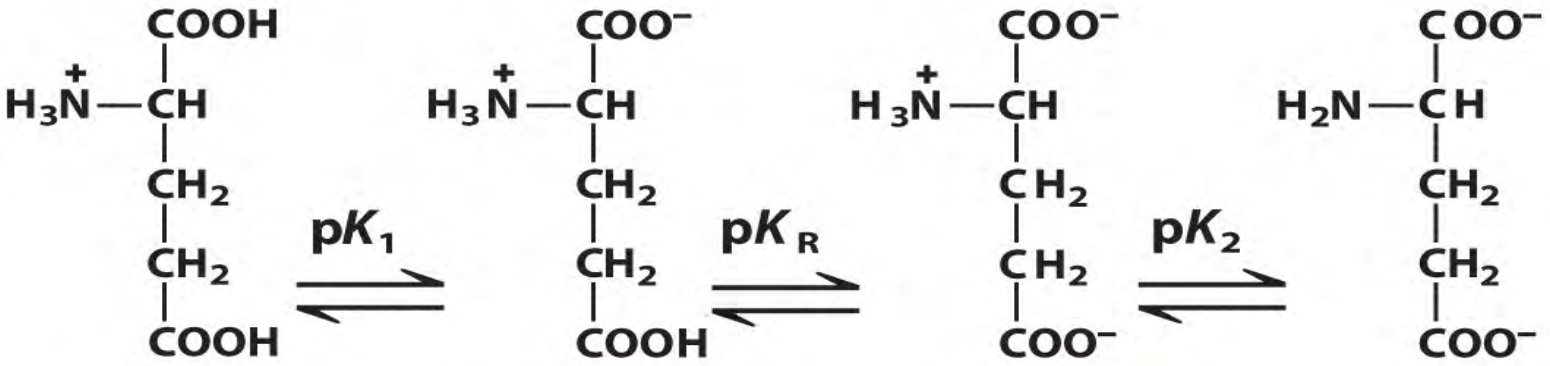
d) There will be two half-equivalence points in the titration curve.

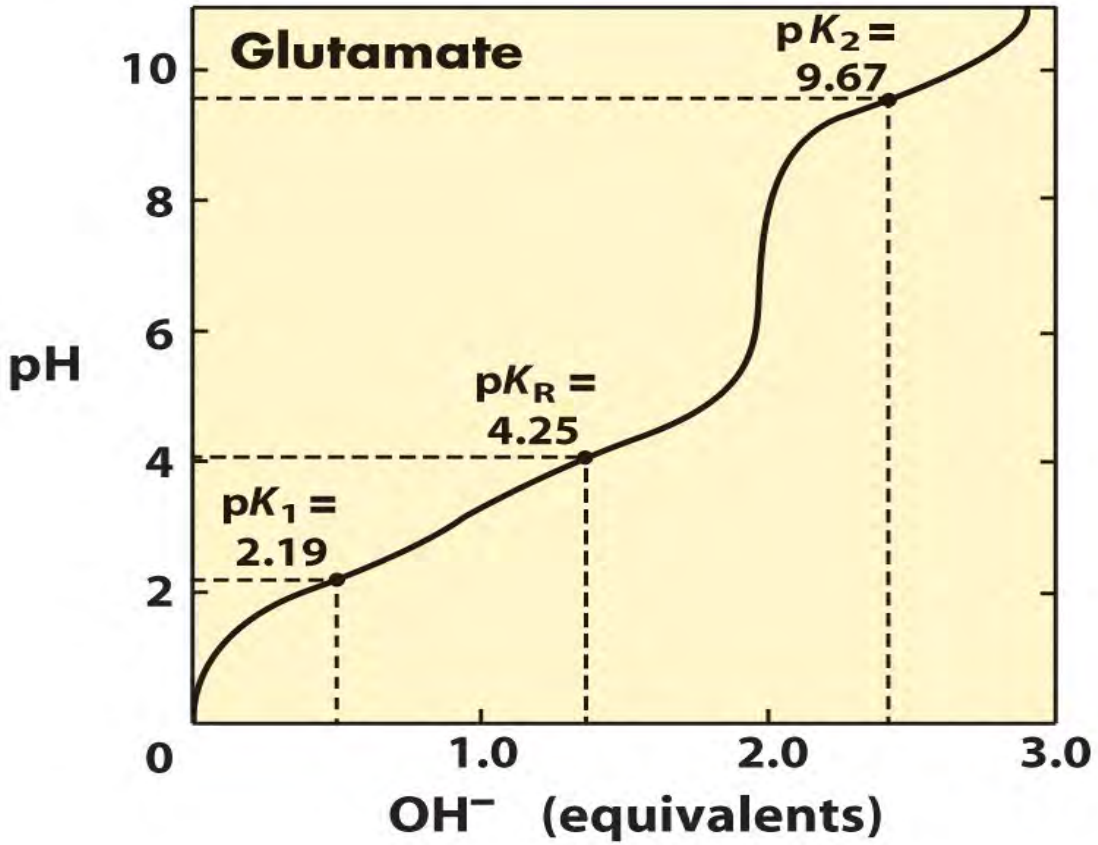
e) There will be a mixture of two forms of the amino acid at each equivalence point.

TABLE 3.1 Typical pK_a values of ionizable groups in proteins

Group	Acid		Base	Typical pK_a*
Terminal α-carboxyl group		⇌		3.1
Aspartic acid Glutamic acid		⇌		4.1
Histidine		⇌		6.0
Terminal α-amino group		⇌		8.0
Cysteine		⇌		8.3
Tyrosine		⇌		10.9
Lysine		⇌		10.8
Arginine		⇌		12.5

*pK_a values depend on temperature, ionic strength, and the microenvironment of the ionizable group.

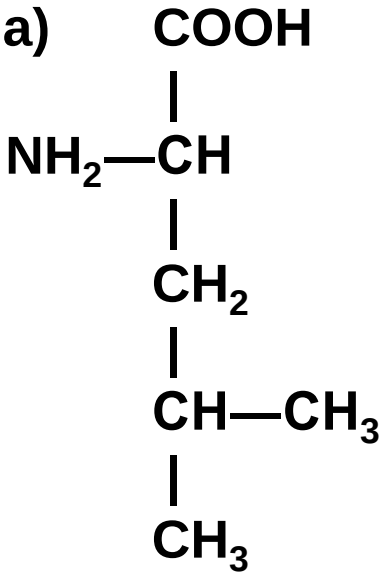

COOH
+
H3N—CH
CH2
CH2
COOH
pK1
COO−
+
H3N—CH
CH2
CH2
COOH
pKR
COO−
+
H3N—CH
CH2
CH2
COO−
pK2
COO−
H2N—CH
CH2
CH2
COO−


Glutamate
pK2 = 9.67
pKR = 4.25
pK1 = 2.19
pH
10
8
6
4
2
0
1.0
2.0
3.0
OH− (equivalents)

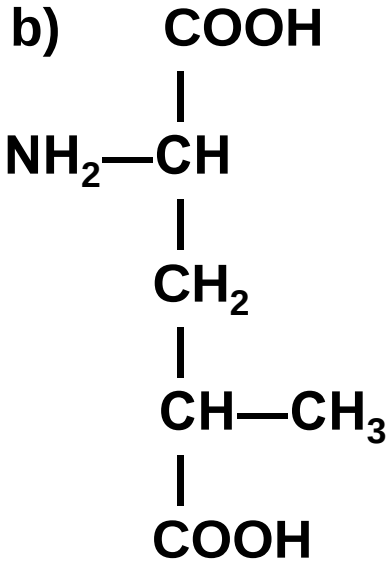
Are You Getting It??

What will be the charge on these amino acids at high pH?

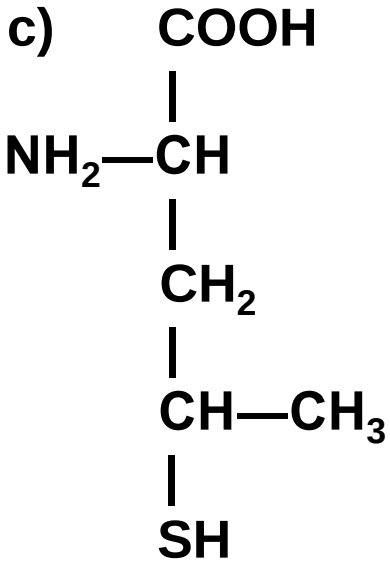
a)



b)



c)

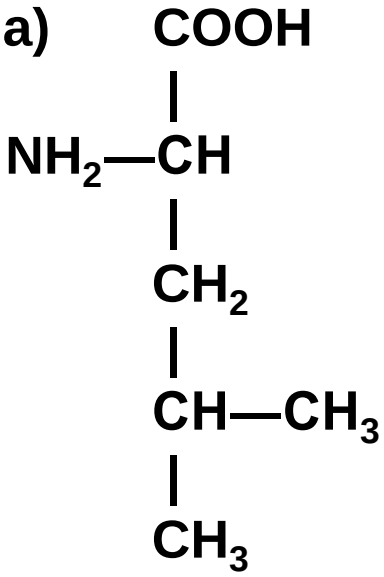


Are You Getting It??

Answer

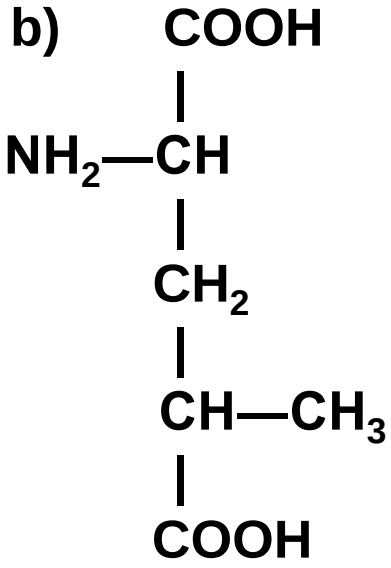
What will be the charge on these amino acids at high pH?

a)



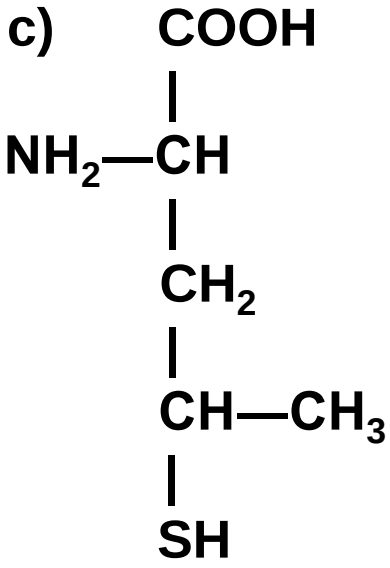
-1

b)



-2

c)

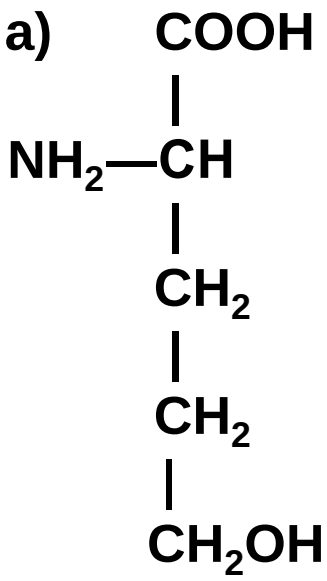


-2

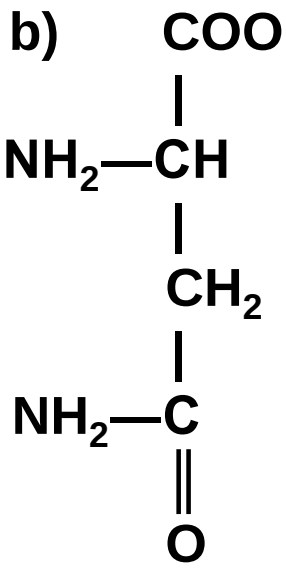
Are You Getting It??

What will be the charge on these amino acids at low pH?

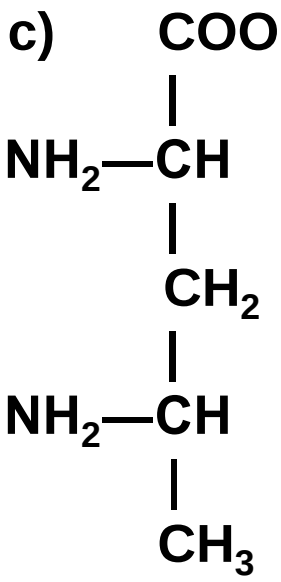
a)



b)



c)

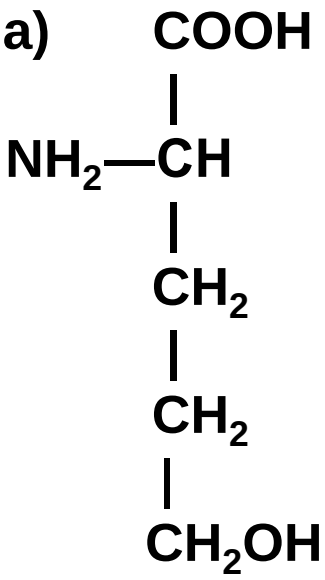


Are You Getting It??

Answer

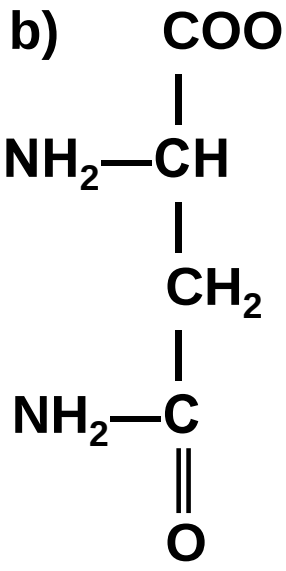
What will be the charge on these amino acids at low pH?

a)



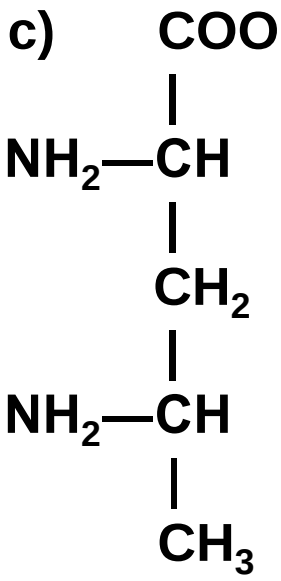
+1

b)

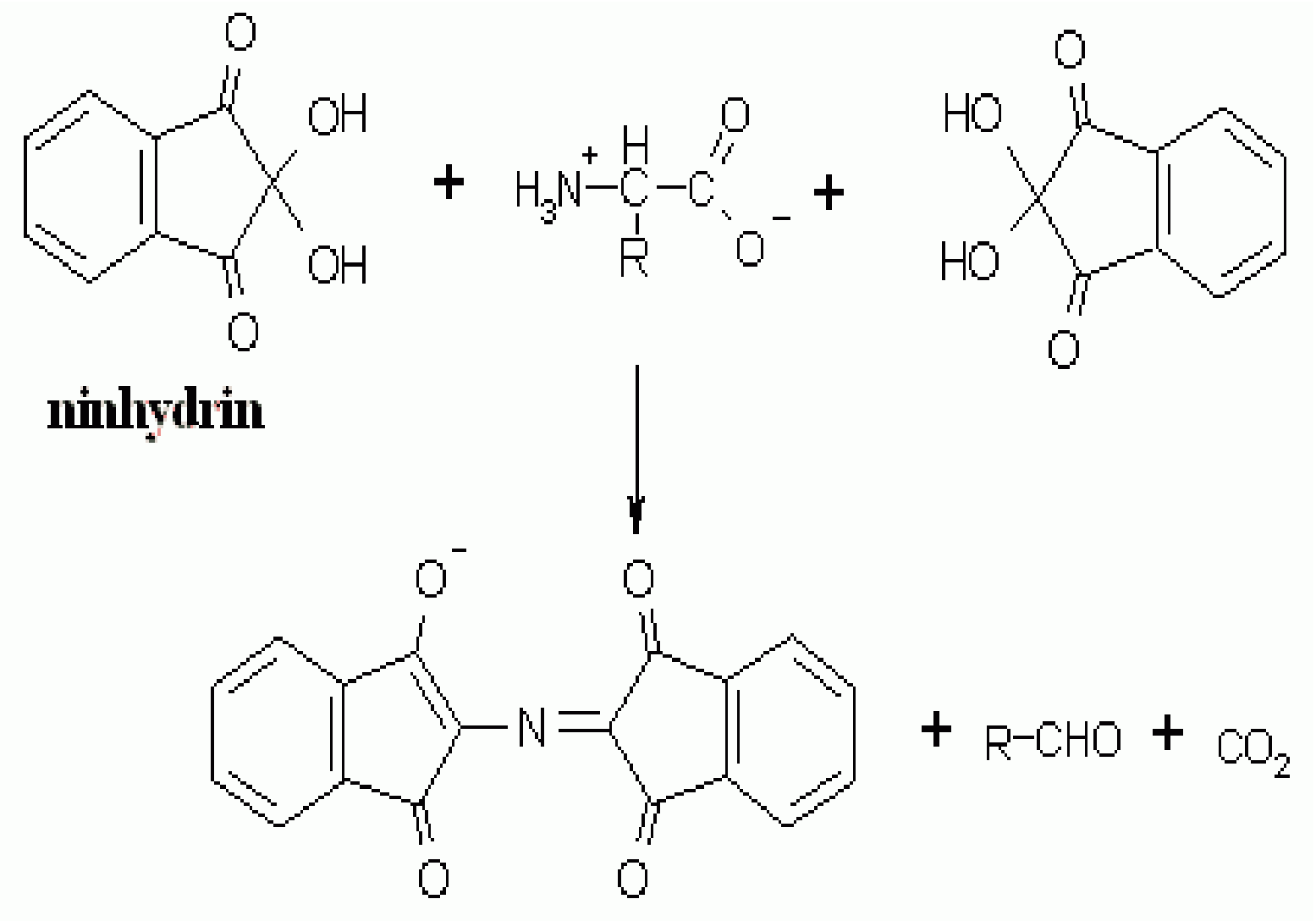


+1

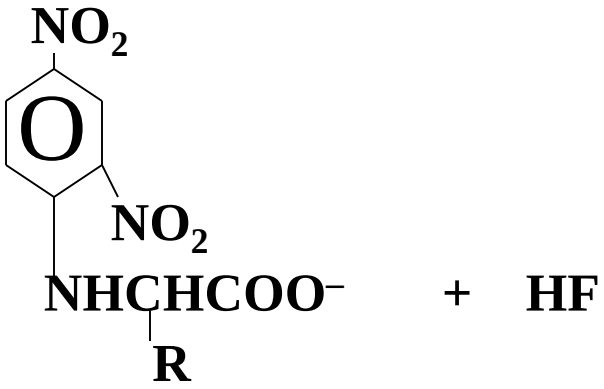
c)



+2


ninhydrin
R–CHO
CO2

SANGER'S REAGENT



DANSYL CHLORIDE