MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1) All of the following can be classified as biomolecules except
   A) lipids.
   B) proteins.
   C) carbohydrates.
   D) nucleic acids.
   E) All of the above are biomolecules.

2) Which functional group is least important in biochemistry?
   A) amine
   B) ester
   C) hydroxyl
   D) aromatic
   E) amide

3) The protein configuration that is primarily determined from interactions between R groups is the
   A) primary structure.
   B) tertiary structure.
   C) quaternary structure.
   D) secondary structure.
   E) none of the above

4) All of the following are major functions of proteins except
   A) transport of necessary chemicals.
   B) support for organs or tissues.
   C) protection against foreign substances.
   D) storage of energy.
   E) control of biochemical reactions.

5) Members of which class of biomolecules are the building blocks of proteins?
   A) fatty acids
   B) glycerols
   C) amino acids
   D) monosaccharides
   E) nucleic acids

6) The peptide bond joining amino acids into proteins is a specific example of the ________ bond.
   A) amide
   B) ester
   C) glycosidic
   D) carbonyl
   E) hydrogen

7) Serum albumin is an example of a(an)
   A) enzyme.
   B) transport protein.
   C) protective protein.
   D) structural protein.
   E) storage protein.

8) Collagen is an example of a(an)
   A) structural protein.
   B) transport protein.
   C) hormone.
   D) enzyme.
   E) storage protein.
9) Insulin is an example of a(an)
   A) enzyme.
   B) transport protein.
   C) hormone.
   D) storage protein.
   E) structural protein.

10) Which molecule is an alpha amino acid?
   A) \[ \text{HO-CCH}_2\text{-C-NH}_2 \]
   B) \[ \text{HO-CCH}_2\text{-O-CCH}_2\text{CH}_3 \]
   C) \[ \text{HO-CCH}_2\text{CH}_2\text{CH}_2\text{NH}_2 \]
   D) \[ \text{HO-C-C-NH}_2 \]
   E) \[ \text{HO-CCH}_2\text{NH}_2 \]

11) The side chains or R groups of amino acids can be classified into each of the following categories except
   A) basic.
   B) acidic.
   C) polar.
   D) non-polar.
   E) isoelectric.

12) Which category of amino acid contains R groups that are hydrophobic?
   A) non-polar
   B) acidic
   C) basic and acidic
   D) basic
   E) polar

13) Which amino acid is a secondary amine with its nitrogen and the alpha-carbon joined as part of a ring structure?
   A) proline    B) arginine    C) glycine    D) lysine    E) histidine
14) Non-polar R groups on amino acids are said to be ________ because they are not attracted to water molecules.
   A) hydrophobic  
   B) hydrophilic  
   C) unreactive  
   D) ionized  
   E) none of these 

15) Polar R groups, along with acidic and basic R groups, are said to be ________ because they are attracted to water molecules.
   A) ionized  
   B) hydrophilic  
   C) unreactive  
   D) hydrophobic  
   E) none of these 

16) Two functional groups that are present in **all** amino acids are the ________ group and the ________ group.
   A) hydroxyl; amide  
   B) carboxyl; phosphate ester  
   C) acetal; amine  
   D) carboxyl; amine  
   E) carbonyl; amide 

17) An amino acid whose R group is predominantly hydrocarbon would be classified as
   A) non–polar.  
   B) basic.  
   C) isoelectric.  
   D) acidic.  
   E) polar. 

18) Which amino acid is classified as neutral and non-polar?
   A) aspartic acid  
   B) tyrosine  
   C) phenylalanine  
   D) lysine  
   E) histidine 

19) Which amino acid is classified as basic?
   A) threonine  
   B) valine  
   C) glutamic acid  
   D) phenylalanine  
   E) lysine 

20) Amino acids found in proteins all have the following features.
   A) all are D– amino acids  
   B) all are L–amino acids  
   C) all are α–amino acids  
   D) all are correct  
   E) none are correct
21) Which of these amino acids has a thiol group as part of its side chain?
   A) threonine
   B) histidine
   C) methionine
   D) tyrosine
   E) cysteine

SHORT ANSWER. Write the word or phrase that best completes each statement or answers the question.

22) 

This question has four parts:
   a. For the amino acid shown above in zwitterion form, circle the carboxyl group, underline the amine group, label the alpha carbon, and draw a box around the R group.
   b. Write the name and abbreviation of your amino acid.
   c. Classify the amino acid as polar, non-polar, acidic, or basic. Explain the basis for your classification.
   d. Draw the structure of the amino acid at a pH well below its isoelectric point and well above its isoelectric point.
MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

23) Which structure represents a zwitterion?

A)

\[ \begin{align*}
\text{RCHCO}^+ \\
\text{NH}_3^-
\end{align*} \]

B)

\[ \begin{align*}
\text{RCHCO}^- \\
\text{NH}_2
\end{align*} \]

C)

\[ \begin{align*}
\text{RCHCOOH}^+ \\
\text{NH}^-
\end{align*} \]

D)

\[ \begin{align*}
\text{RCHCO}^+ \\
\text{OH}^-
\end{align*} \]

E)

\[ \begin{align*}
\text{RCHCO}^- \\
\text{OH}_2^-
\end{align*} \]

24) The isoelectric point of an amino acid is

A) the pH at which it exists in the basic form.
B) the pH equal to its pK_b.
C) the pH equal to its pK_a.
D) the pH at which it exists in the zwitterion form.
E) the pH at which it exists in the acid form.

25) An amino acid has the form shown at

A) a pH greater than its isoelectric point.
B) a pH less than its isoelectric point.
C) any pH other than 7.0.
D) its isoelectric point.
E) a pH of 7.0.
26) An amino acid will have the form shown at

\[
\begin{align*}
\text{R} & \quad \text{CH} \quad \text{C} \quad \text{OH} \\
\text{NH}_3^+ & \\
\end{align*}
\]

A) its isoelectric point.  
B) a pH greater than its isoelectric point.  
C) a pH of 7.0.  
D) any pH other than 7.0.  
E) a pH less than its isoelectric point.

27) Proteins are least soluble in water ________.
   A) at high pH  
   B) at low pH  
   C) at their isoelectric point  
   D) at neutral pH  
   E) at both high and low pH

28) Which of the following objects is chiral?
   A) a fork  
   B) a windowpane  
   C) a nail  
   D) a shoe  
   E) a ping-pong ball

29) Which object is not chiral?
   A) a dog  
   B) a clock  
   C) a truck  
   D) a thumbtack  
   E) a boot

30) Which amino acid is not chiral?
   A) arginine  
   B) cysteine  
   C) glycine  
   D) phenylalanine  
   E) alanine

31) Which molecule is chiral?
   A) CH₂Cl₂  
   B) CH₃OH  
   C) CH₂CH₂OH  
   D) CHCl₂Br  
   E) CHFClBr
32) Enantiomers are a form of stereoisomer in which each molecule in the pair of isomers has
   A) a plane of symmetry perpendicular to the carbon skeleton so that the bottom half and top half
   of the molecule are mirror images.
   B) its functional groups situated in different configurations with respect to a double bond.
   C) the same functional groups, but a different carbon skeleton.
   D) the same carbon skeleton and the same functional groups, but the functional groups are
   attached at different sites.
   E) a carbon atom bonded to four different groups and the isomers are mirror images.

SHORT ANSWER. Write the word or phrase that best completes each statement or answers the question.

33) List three properties of enantiomers that are the same and three properties that are
different.

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

34) The amino acid sequence of a protein is known as its
   A) quaternary structure.
   B) secondary structure.
   C) tertiary structure.
   D) primary structure.
   E) none of the above

35) The tripeptide represented as ala-leu-gly is named
   A) alanine-leucine-glycine.
   B) alanylglycyleucine.
   C) alanine-glycine-leucine.
   D) alanylleucylglycine.
   E) none of these

36) The N-terminal amino acid in the peptide ala-leu-gly-his-pro is
   A) glycine.
   B) proline.
   C) leucine.
   D) histidine.
   E) alanine.

37) The C-terminal amino acid in the peptide ala-leu-gly-his-pro is
   A) histidine.
   B) proline.
   C) leucine.
   D) alanine.
   E) glycine.

38) How many different tripeptides can be formed from one molecule each of the amino acids tyrosine,
   valine, and alanine?
   A) 3
   B) 12
   C) 6
   D) 9
   E) 24

39) In the tetrapeptide Ala-Cys-Val-Leu, the N-terminal amino acid is
   A) Ala
   B) Val
   C) Cys
   D) Leu
   E) none of the above
40) In the tetrapeptide Ala-Cys-Val-Leu, the C-terminal amino acid is ________.
   A) Cys
   B) Ala
   C) Leu
   D) Val
   E) none of the above

41) The two protein chains in insulin are held together by ________.
   A) salt bridges
   B) hydrophobic interactions
   C) disulfide linkages
   D) hydrogen bonds
   E) all of the above

42) All of the following are non-covalent interactions important in maintaining the secondary, tertiary, and quaternary aspects of amino acids except
   A) hydrogen bonding along the backbone.
   B) sulfur-sulfur bonds.
   C) hydrophobic interactions between R groups.
   D) hydrogen bonding between R groups.
   E) salt bridges between R groups.

43) Which amino acid can form covalent sulfur-sulfur bonds?
   A) phenylalanine
   B) cysteine
   C) glycine
   D) proline
   E) methionine

44) Which pair of amino acids can have hydrophobic interactions?
   A) glutamic acid and serine
   B) glycine and asparagine
   C) aspartic acid and lysine
   D) leucine and alanine
   E) arginine and glutamic acid

45) Which pair of amino acids can have ionic interactions?
   A) glutamic acid and serine
   B) glycine and asparagine
   C) leucine and alanine
   D) asparagine and lysine
   E) arginine and glutamic acid

46) Which pair of amino acids can form hydrogen bonds between their R groups?
   A) arginine and glutamic acid
   B) glutamine and serine
   C) aspartic acid and lysine
   D) leucine and alanine
   E) glycine and asparagine
47) The beta-pleated sheet is an example of
   A) secondary structure.
   B) quaternary structure.
   C) tertiary structure.
   D) primary structure.
   E) none of the above

48) The type of bond that is most important in maintaining secondary structure of a protein is
   A) hydrogen bonding between R groups.
   B) hydrophobic interactions.
   C) disulfide bridges.
   D) salt bridges.
   E) hydrogen bonding within the backbone.

49) All of the following are examples of fibrous proteins except
   A) wool.
   B) insulin.
   C) skin.
   D) bones.
   E) fingernails.

50) All of the following are globular proteins except
   A) albumin.
   B) hemoglobin.
   C) immunoglobulin.
   D) ribonuclease.
   E) myosin.

51) Which protein is considered to be a globular protein?
   A) keratin    B) myosin    C) collagen    D) albumin

52) Which type of interaction is not directly involved in maintaining tertiary structure?
   A) hydrogen bonding
   B) peptide bonds
   C) salt bridges
   D) hydrophobic interactions
   E) disulfide bridges

53) All of the following are conjugated proteins except
   A) myoglobin.
   B) casein.
   C) cytochrome oxidase.
   D) low-density lipoproteins.
   E) collagen.
54) Proteins that consist of two or more chains assembled into a large 3-dimensional structure are said to display
   A) tertiary structure.
   B) secondary structure.
   C) primary structure.
   D) quaternary structure.
   E) none of the above

55) When a protein is ________, its primary structure is destroyed, thus destroying the other aspects of its structure.
   A) denatured
   B) ionized
   C) esterified
   D) hydrolyzed
   E) polymerized

56) When a protein is ________, its primary structure is maintained, but other aspects of its structure are disrupted.
   A) denatured
   B) esterified
   C) hydrolyzed
   D) polymerized
   E) ionized

57) All of the following are examples of denaturing proteins except
   A) a mild sunburn.
   B) digestion of a meal.
   C) pounding meat to tenderize it.
   D) souring of milk.
   E) using a curling iron on your hair.

58) All of the following can denature proteins without hydrolysis except
   A) lowering of pH.
   B) heat.
   C) mechanical stress.
   D) enzyme treatment.
   E) heavy metal ions.

59) When a glycoprotein is hydrolyzed, the products would include
   A) amino acids plus RNA.
   B) amino acids plus metal ions.
   C) amino acids only.
   D) amino acids plus carbohydrates.
   E) amino acids plus lipids.

**SHORT ANSWER. Write the word or phrase that best completes each statement or answers the question.**

60) List three denaturing agents that can act on proteins and explain how each one disrupts the protein’s structure.
MATCHING. Choose the item in column 2 that best matches each item in column 1.

Match the following:

<table>
<thead>
<tr>
<th>61) hydrophobic</th>
<th>A) a protein that is usually water soluble, having a hydrophilic exterior and hydrophobic interior, and an overall rounded shape</th>
</tr>
</thead>
<tbody>
<tr>
<td>62) zwitterion</td>
<td>B) a protein that produces only amino acids upon hydrolysis</td>
</tr>
<tr>
<td>63) hydrophilic</td>
<td>C) a protein that produces amino acids and other biomolecules or inorganic substances upon hydrolysis</td>
</tr>
<tr>
<td>64) chiral carbon</td>
<td>D) refers to R groups which form hydrogen bonds with water because of their polarity</td>
</tr>
<tr>
<td>65) globular protein</td>
<td>E) the form of an amino acid in which both the carboxyl group and the amine group are charged, but the overall molecule remains neutral</td>
</tr>
<tr>
<td>66) fibrous protein</td>
<td>F) a carbon atom bonded to four different groups and therefore able to form enantiomers</td>
</tr>
<tr>
<td>67) conjugated protein</td>
<td>G) a protein with the tertiary structure in which it normally occurs in living systems</td>
</tr>
<tr>
<td>68) simple protein</td>
<td>H) a protein that is usually insoluble in water, is very tough, and has a long shape</td>
</tr>
<tr>
<td>69) native protein</td>
<td>I) refers to R groups that do not interact readily with water because they are non-polar</td>
</tr>
</tbody>
</table>
1) E  
2) D  
3) B  
4) D  
5) C  
6) A  
7) B  
8) A  
9) C  
10) E  
11) E  
12) A  
13) A  
14) A  
15) B  
16) D  
17) A  
18) C  
19) E  
20) C  
21) E  
22) Any amino acid may be drawn in. This question is answered for leucine.
   a.  
   b. leucine, leu  
   c. Leucine is non-polar because its R group is composed of hydrocarbons.  
   d. Below its isoelectric point, leucine would be written as

\[
\begin{align*}
\alpha
\begin{array}{c}
(CH_3)_2-CH-CH_2-CH-COO^- \\
\mid \ \
NH_3^+
\end{array}
\end{align*}
\]

b. leucine, leu  
   c. Leucine is non-polar because its R group is composed of hydrocarbons.  
   d. Below its isoelectric point, leucine would be written as

\[
\begin{align*}
(CH_3)_2-CH-CH_2-CH-COO^- & \quad (CH_3)_2-CH-CH_2-CH-COO^- \\
\mid \ \
NH_3^+ & \quad \mid \ \
NH_2
\end{align*}
\]

low pH \quad high pH  
23) A  
24) D  
25) A  
26) E  
27) C  
28) D  
29) D  
30) C  
31) E  
32) E  

Answer Key
Testname: UNTITLED2

33) Same: molecular formula, connections between atoms, melting point, boiling point, water solubility, isoelectric point, density
   Different: interaction with plan-polarized light, reaction with other chiral molecules, placement of groups in space, biological activity, odor, taste, other physiological interactions

34) D
35) D
36) E
37) B
38) C
39) A
40) C
41) C
42) B
43) B
44) D
45) E
46) B
47) A
48) E
49) B
50) E
51) D
52) B
53) E
54) D
55) D
56) A
57) B
58) D
59) D

60) 1. heat; affects weak interactions between R groups
    2. mechanical stress; shifts R groups into different positions in relation to each other
    3. detergents; affect hydrophobic interactions
    4. organic compounds; affect hydrogen bonding or hydrophobic interactions
    5. pH change; changes nature of acidic or basic R groups, thus changing their interactions; also can affect sulfur-sulfur interactions and hydrogen bonding
    6. metal ions; disrupt sulfur-sulfur interactions

61) I
62) E
63) D
64) F
65) A
66) H
67) C
68) B
69) G