(10) 1. Given the following data on three different proteins:

<table>
<thead>
<tr>
<th>Protein</th>
<th>hemoglobin</th>
<th>chymotrypsinogen</th>
<th>urease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Molecular Weight (M)</td>
<td>64,500</td>
<td>23,250</td>
<td>482,000</td>
</tr>
<tr>
<td>Diffusion Coefficient (D)</td>
<td>6.9</td>
<td>9.5</td>
<td>3.5</td>
</tr>
<tr>
<td>Isoelectric pH (pI)</td>
<td>6.8</td>
<td>9.5</td>
<td>5.0</td>
</tr>
</tbody>
</table>

Indicate in the blanks which of the three proteins will:

_______________(a) Elute first from a gel filtration column.
_______________(b) Elute first from a diethylaminoethyl cellulose ion exchange column.
_______________(c) Have the smallest frictional coefficient (f).
_______________(d) Migrate fastest upon electrophoresis in sodium dodecyl sulfate (SDS).
_______________(e) Migrate fastest to the anode in a native electrophoresis experiment at pH 6.0.

(6) 2. For the following common secondary structures of a protein, identify the \( \Phi \) and \( \Psi \) angles associated with that structure from the list in the middle. Place the letter corresponding to the correct \( \Phi \) and \( \Psi \) angles in the blank to the left of the secondary structure. (A Ramachandran map is shown at the right for reference to angle values).

_____ alpha helix
_____ beta sheet
_____ collagen helix

a. \( \Phi = -51^\circ \) \( \Psi = 153^\circ \)
b. \( \Phi = 90^\circ \) \( \Psi = 90^\circ \)
c. \( \Phi = -57^\circ \) \( \Psi = -47^\circ \)
d. \( \Phi = 180^\circ \) \( \Psi = 0^\circ \)
e. \( \Phi = -139^\circ \) \( \Psi = 135^\circ \)

(6) 3. Fill in the following blanks with \( \alpha \) helix or disordered to represent the primary conformation of the indicated synthetic polypeptide at the indicated pH.

<table>
<thead>
<tr>
<th>Polypeptide</th>
<th>pH 2</th>
<th>pH 7</th>
<th>pH 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>polyglutamate</td>
<td>______</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>polylysine</td>
<td>______</td>
<td>______</td>
<td>______</td>
</tr>
</tbody>
</table>
(10) 4. You have isolated an octapeptide with the amino acid composition 
(Lys₂, Asp, Tyr, Phe, Gly, Ser, Ala)
Reaction of the intact peptide with FDNB yields DNP-alanine. Cleavage with trypsin yields 
peptides with compositions (Lys, Ala, Ser) and (Gly, Phe, Lys) plus a dipeptide. Reaction 
with chymotrypsin releases free aspartic acid, a tetrapeptide with composition (Lys, Ser, Phe, 
Ala) and a tripeptide with composition (Gly, Lys, Tyr). What is the sequence? (Explain your 
reasoning).

(8) 5 What is the key structural difference between the two substances in each of the following 
pairs?

(a) amylose and amylopectin

(b) amylose and cellulose

(c) chitin and cellulose

(d) α-D-fructose and β-D-fructose (draw the structures of each in the Haworth projection).

(6) 6. Glycoproteins contain oligosaccharides attached to proteins. Describe the two types of 
chemical linkage and the amino acids involved.
(12) 7. Complete the following table by supplying the missing information on each fatty acid. Be sure to show the double bonds in the correct cis or trans orientation.

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Common Name</th>
<th>Systematic Name</th>
<th>Structure</th>
<th>Omega designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>9,12-C\textsubscript{18:2}</td>
<td>Arachidonic Acid</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9-Hexadecenoic Acid</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(8) 8. Sufficiently strong acid treatment will hydrolyze most of the linkages in lipids, including fatty acid esters, phosphate esters, and amides. Give the structures of the products formed by each of the following lipids. You may abbreviate a fatty acid structure as RCOOH, but if two fatty acids are released so indicate.

**phosphatidyl serine**

**sphingomyelin**

(6) 9. Four types of lipid-linked anchors are known that attach proteins to membranes. Describe two of them, including the lipid involved and the manner in which the lipid is attached to the protein.
10. Classify each of the following transport systems according to the terms in the list at the right by putting the appropriate letter or letters in the blank next to the transport system. More than one term may apply.

_______ glucose transporter of erythrocytes
_______ anion transporter of erythrocytes
_______ Na\(^+\)/K\(^+\) ATPase of plasma membrane
_______ Ca\(^{2+}\) ATPase of sarcoplasmic reticulum
_______ amino acid uptake driven by a Na\(^+\) gradient

a. primary active transport
b. secondary active transport
c. symport
d. antiport
e. uniport
f. facilitated diffusion

For questions 11 to 15, put a check by the best answer. (2 points each)

11. In the Edman degradation, the peptide to be degraded is reacted with
____ dansyl chloride
____ phenylthiohydantoin
____ fluorodinitrobenzene
____ phenylisothiocyanate
____ ninhydrin

12. A common method for chemical cleavage of a protein into peptides is to
____ cleave at methionine with performic acid.
____ cleave at proline with sodium hydroxide.
____ cleave at lysine with cyanogen bromide.
____ cleave at methionine with cyanogen bromide.
____ cleave at arginine with phenylisothiocyanate.

13. \(\alpha\)-D-glucose and \(\alpha\)-D-mannose are
____ epimers at the 4 position
____ anomers
____ enantiomers
____ epimers at the 2 position
____ ketohexoses

14. A plasmalogen
____ contains sphingosine
____ is a sterol
____ contains an ether linkage to glycerol
____ contains a vinyl ether linkage to glycerol
____ contains sialic acid

15. Which of the following does not contain an isoprenoid chain?
____ vitamin K
____ vitamin E
____ cerebroside
____ coenzyme Q
____ dolichol

16. Sucrose is
____ a reducing sugar.
____ a disaccharide
____ a fructoside
____ a galactoside
____ a sugar alcohol

17. D-erythrose and D-threose are
____ ketotetroses
____ aldotetroses
____ epimers at the 2 position
____ epimers at the 3 position
____ reducing sugars

18. D-ribitol-1-phosphate and L-ribitol-5-phosphate are
____ enantiomers
____ anomers
____ derivatives of a sugar alcohol
____ aldopentose derivatives
____ negatively charged at pH 7
____ the same compound