

Questions with Answers- Proteins & Enzymes

- A. A peptide with 12 amino acids has the following amino acid composition:  
2 Met, 1 Tyr, 1 Trp, 2 Glu, 1 Lys, 1 Arg, 1 Thr, 1 Asn, 1 Ile, 1 Cys

Reaction of the intact peptide with fluorodinitrobenzene followed by acid hydrolysis creates a derivative of Ile.

A specific cleavage of the intact peptide produces fragments with the following sequences:

Glu-Cys-Asn-Met-Lys  
Met-Glu-Thr-Arg-Trp  
Ile-Tyr

(Questions 1-5)

1. \_\_\_\_\_ Which reagent was used for the specific cleavage?
    - a) *chymotrypsin*
    - b) trypsin
    - c) V8 protease
    - d) cyanogen bromide
  
  2. \_\_\_\_\_ Which amino acids would be released when the intact peptide was treated first with V8 protease followed by treatment with cyanogen bromide?
    - a) Glu and Met
    - b) *Glu and Lys*
    - c) Met and Lys
    - d) Glu, Met, and Lys
  
  3. \_\_\_\_\_ Which treatment would result in the release of Lys and Arg from the intact peptide?
    - a) trypsin
    - b) trypsin followed by dansyl chloride
    - c) *trypsin followed by carboxypeptidase*
    - d) trypsin followed by mild acid
  
  4. \_\_\_\_\_ If this intact peptide is sequenced using the Edman degradation, which step will be part of the procedure?
    - a) The Edman reagent will react with all 12 amino acids simultaneously.
    - b) Lithium borohydride will react with an  $\alpha$ -carboxyl group.
    - c) *Phenylisothiocyanate will react with an  $\alpha$ -amino group.*
    - d) Strong acid will be used to cleave off one modified amino acid.
  
  5. \_\_\_\_\_ If this peptide is normally part of a multimeric protein composed of four identical subunits, what procedure might be needed prior to performing the Edman degradation?
    - a) The four subunits should be separated and sequenced individually.
    - b) Two specific cleavages should be done to create two sets of fragments.
    - c) Peptide bonds should be broken using hydrazine.
    - d) *Disulfide bonds should be reduced with mercaptoethanol.*
-

- B. A peptide has the following amino acid composition:  
2 Met, 2 Phe, 2 Glu, 1 Arg, 1 Lys, 1 Val, 1 Leu, 1 Gly, 1 Ser

Reaction of the intact peptide with dansyl chloride followed by acid hydrolysis creates a derivative of Met.

A specific cleavage of the intact peptide produces fragments with the following sequences:

Fragment A: Glu-Gly-Lys-Phe

Fragment B: Met-Ser-Leu-Arg

Fragment C: Met-Val-Glu-Phe

(Questions 6-10)

6. \_\_\_\_\_ Which reagent was used for the specific cleavage?
- a) cyanogen bromide
  - b) V8 protease
  - c) **chymotrypsin**
  - d) trypsin
7. \_\_\_\_\_ Which reagent would break only one peptide bond in the intact peptide?
- a) cyanogen bromide
  - b) V8 protease
  - c) chymotrypsin
  - d) **trypsin**
8. \_\_\_\_\_ Which amino acid would be released if the intact peptide was treated with a combination of trypsin and chymotrypsin?
- a) Lys
  - b) **Phe**
  - c) Glu
  - d) Met
9. \_\_\_\_\_ What information do these result give about the sequence of the peptide?
- a) **The sequence is: Met-Val-Glu-Phe-Glu-Gly-Lys-Phe-Met-Ser-Leu-Arg**
  - b) The sequence is: Met-Ser-Leu-Arg-Met-Val-Glu-Phe-Glu-Gly-Lys-Phe
  - c) The sequence is: Met-Val-Glu-Phe-Met-Ser-Leu-Arg-Glu-Gly-Lys-Phe
  - d) The sequence is: Met-Ser-Leu-Arg-Glu-Gly-Lys-Phe-Met Val-Glu-Phe
10. \_\_\_\_\_ This peptide is one polypeptide chain of a multimeric protein that contains two non-identical subunits. What problem might be seen when analyzing the primary structure of the protein if the subunits were not separated?
- a) **Fluorodinitrobenzene might react with two different amino acids.**
  - b) Carboxypeptidase might not react with the C-terminals.
  - c) Mercaptoethanol might not reduce disulfide bonds.
  - d) Lithium borohydride might cleave peptide bonds randomly.
-

C. Protein A is an  $\alpha$ -keratin while Protein B is a transport protein. (Questions 11-15)

11. \_\_\_\_\_ Which characteristic could be shared by Protein A and Protein B?
- a) Both could be fibrous proteins containing multiple polypeptide chains.
  - b) Both could be globular proteins with similar primary structures.
  - c) Both could contain disulfide bridges linking methionine residues.
  - d) Both could contain hydrogen bonds between peptide bond atoms.**
12. \_\_\_\_\_ When comparing Protein A to a  $\beta$ -keratin
- a) the  $\alpha$ -keratin has a parallel structure while the  $\beta$ -keratin has an antiparallel structure.
  - b) the  $\alpha$ -keratin has a compact structure while the  $\beta$ -keratin has a more extended structure.**
  - c) both have similar secondary structures that are low-energy states for the proteins.
  - d) both contain hydroxyproline which functions as a prosthetic group.
13. \_\_\_\_\_ When comparing Protein B to collagen,
- a) both are stabilized by van der Waals interactions.**
  - b) both are stabilized by extensive regions of left-handed coils.
  - c) both contain regions of random secondary structures.
  - d) both contain  $\alpha$ -helices as well as  $\beta$ -pleated sheets.
14. \_\_\_\_\_ Which interaction is likely to occur in Protein B?
- a) A hydrophobic interaction could form between the R-groups of Val and Leu.**
  - b) A hydrogen bond could form between the R-groups of Ser and Phe.
  - c) A salt bridge could form between the R-groups of Arg and His.
  - d) An ionic bond could form between the R-groups of Gln and Trp.
15. \_\_\_\_\_ When comparing Protein A to Protein B,
- a) both could be denatured by using heat to break amide bonds.
  - b) both could have primary structures that form with the help of chaperones.
  - c) both have conformations stabilized by numerous non-covalent bonds.**
  - d) both contain the same proportions of hydrophilic and hydrophobic R-groups.
-

D. Protein A is a structural component while Protein B is an enzyme. The secondary structures of both proteins are studied. (Questions 16-19)

16. \_\_\_\_\_ Which could be characteristics of Protein A and Protein B?
- a) Protein A could have a low energy conformation while Protein B could have a high energy conformation.
  - b) Protein A could be a globular protein while Protein B could be a fibrous protein.
  - c) *Protein A could contain mainly  $\alpha$ -helix while Protein B could contain equal amounts of  $\alpha$ -helix and  $\beta$ -sheet.***
  - d) Protein A could be a type of collagen while Protein B could be a type of keratin.
17. \_\_\_\_\_ Which could be found within the structure of Protein B?
- a) A disulfide bond could form between two prosthetic groups.
  - b) A salt bridge could form between two chaperones.
  - c) Protein B could contain areas of random secondary structure stabilized by van der Waals forces.
  - d) *Protein B could contain areas of repeating secondary structure stabilized by hydrogen bonds.***
18. \_\_\_\_\_ Which is a characteristic of both an  $\alpha$ -helix and a  $\beta$ -pleated sheet?
- a) Both can be anti-parallel structures.
  - b) *Both form interactions involving the oxygens of peptide bonds.***
  - c) Both are found only within multimeric proteins.
  - d) Both are denatured when heat breaks peptide bonds.
19. \_\_\_\_\_ Which is a difference between an  $\alpha$ -helix and a  $\beta$ -pleated sheet?
- a) An  $\alpha$ -helix is a right-handed structure containing disulfide bonds while a  $\beta$ -pleated sheet is a left-handed structure containing ionic bonds.
  - b) An  $\alpha$ -helix has a relatively extended spiral shape while a  $\beta$ -pleated sheet has a relatively compact zig-zag shape.
  - c) *An  $\alpha$ -helix has non-covalent bonds between amino acids near each other in the sequence while a  $\beta$ -pleated sheet has non-covalent bonds between amino acids far apart in the sequence.***
  - d) An  $\alpha$ -helix contains mainly amino acids with polar R-groups while a  $\beta$ -pleated sheet contains mainly amino acids with non-polar R-groups.
-

E. Two proteins, myoglobin and hemoglobin, are compared. (Questions 20-30)

20. \_\_\_\_\_ Which characteristics are shared by these two proteins?

- a) ***They both are globular proteins containing the common amino acids, porphyrin, and iron.***
- b) They both have closely related primary, secondary, tertiary, and quaternary structures.
- c) They both are composed of multiple subunits each of which contains a heme prosthetic group.
- d) They both have similar molecular weights and bind one oxygen molecule per protein molecule.

21. \_\_\_\_\_ Which is a property of protein tertiary structure?

- a) Tertiary structures usually contain hydrocarbon R-groups in the interior of the protein where they can form hydrogen bonds.
- b) ***Tertiary structures usually contain hydroxyl R-groups on the exterior of the protein where they can favorably interact with water.***
- c) A protein's tertiary structure can be predicted if the amino acid sequence is known by performing the Edman degradation.
- d) A protein's tertiary structure can be maintained by covalent salt bridges and non-covalent disulfide bridges.

22. \_\_\_\_\_ Which is a characteristic of protein quaternary structure?

- a) A protein composed of identical subunits has quaternary structure but not tertiary structure.
- b) A protein composed of non-identical subunits contains two polypeptide chains with opposite charges.
- c) The quaternary structure of a multimeric protein always includes covalent crosslinks between the subunits.
- d) ***The quaternary structure of a multimeric protein always depends upon the primary structure of the subunits.***

23. \_\_\_\_\_ Which is a property of tertiary structure and quaternary structure?

- a) Both structures are stabilized by numerous covalent hydrophobic and hydrophilic interactions.
- b) ***Both structures have specific shapes that depend upon the amino acid sequence of the protein.***
- c) Both structures form so that polar amino acid R-groups are found mainly in the interior of the protein.
- d) Both structures must contain multiple  $\alpha$ -helices and  $\beta$ -pleated sheets connected by turns.

24. \_\_\_\_\_ Which property is shared by both myoglobin and hemoglobin?
- a) Both are saturated with oxygen at low oxygen concentrations.
  - b) Both display cooperative binding when transporting oxygen.
  - c) Both contain strands of  $\beta$ -pleated sheet with a zig-zag shape.
  - d) ***Both contain segments of  $\alpha$ -helix with a spiral shape.***
25. \_\_\_\_\_ Which occurs when a hemoglobin molecule binds oxygen?
- a) Oxygen molecules in the lungs bind irreversibly to the protein's heme groups.
  - b) ***The second oxygen molecule binds more easily than the first oxygen molecule.***
  - c) The  $\alpha$  subunits bind oxygen while the  $\beta$  subunits control cooperativity.
  - d) Ionic bonds form between subunits which changes the quaternary structure.
26. \_\_\_\_\_ Which change occurs when a hemoglobin subunit binds oxygen?
- a) ***A histidine residue changes position within the subunit.***
  - b) An iron atom is removed from a porphyrin group.
  - c) The oxygen binds to amino acids within a segment of  $\alpha$ -helix.
  - d) The oxygen causes a covalent crosslink to form within the subunit.
27. \_\_\_\_\_ Which occurs when a hemoglobin molecule binds oxygen in the lungs?
- a) Each iron-porphyrin group can reversibly bind four oxygen molecules.
  - b) ***Salt bridges between subunits break as the first oxygen binds.***
  - c) The first oxygen molecule binds more easily than the last oxygen molecule.
  - d) Cooperative binding of oxygen causes the four subunits to dissociate.
28. \_\_\_\_\_ When myoglobin is denatured using heat
- a) its amino acid composition will change.
  - b) its amino acid sequence will change.
  - c) ***its tertiary structure will change.***
  - d) its C-terminal will change.
29. \_\_\_\_\_ When hemoglobin is treated with urea and  $\beta$ -mercaptoethanol
- a) its molecular weight will be unchanged.
  - b) its quaternary structure will be unchanged.
  - c) ***its primary structure will be unchanged.***
  - d) its conformation will be unchanged.
30. \_\_\_\_\_ Protein Z functions as an oxygen transport protein, and shares 60% of its primary structure with myoglobin while the other 40% is different. Which is likely to be a characteristic of Protein Z?
- a) It probably contains one heme group that can bond two oxygen molecules.
  - b) It probably contains both  $\alpha$  subunits and  $\beta$  subunits.
  - c) It probably could function even if a mutation changes one of the amino acids in part of the primary structure that is shared with myoglobin.
  - d) ***It probably could function even if a mutation changes one of the amino acids in part of the primary structure that is different from myoglobin.***
-

F. Enzyme X and Enzyme Y are both involved in monosaccharide metabolism. Enzyme X uses glucose as a substrate while Enzyme Y uses fructose as a substrate. At pH=7.0, Enzyme X has a  $V_{max}$  of 10  $\mu\text{M/s}$  while Enzyme Y has a  $V_{max}$  of 20  $\mu\text{M/s}$ . Both enzymes have a  $K_M$  of 3.0 mM for their respective substrates.(Questions 31-37)

31. \_\_\_\_\_ Which aspects of its reaction will be changed by Enzyme Y?
- a) the activation energy of the reaction and the energy of the product
  - b) *the rate of the reaction and the energy of the transition state***
  - c) the equilibrium position of the reaction and the energy of the substrate
  - d) the reversibility of the reaction and the energy of the active site
32. \_\_\_\_\_ When its reaction is carried out at pH = 2.0, the  $V_{max}$  of Enzyme X is 1.0  $\mu\text{M/s}$  because
- a) the enzyme is inhibited by its product at low pH.
  - b) the enzyme is saturated with substrate at low pH.
  - c) the enzyme is able to stabilize the transition state at low pH.
  - d) *the enzyme is partially denatured as R-groups protonate at low pH.***
33. \_\_\_\_\_ When the reaction is carried out at pH = 7.0 and the substrate concentration is equal to the  $K_M$  value
- a) X will produce more product than Y.
  - b) *Y will produce more product than X.***
  - c) X and Y will produce the same amount of product.
  - d) X and Y will both work at their  $V_{Mmax}$  value.
34. \_\_\_\_\_ Enzyme Y can also use the monosaccharide galactose as a substrate with a  $K_M$  of 8.0 mM. Which will be a characteristic of Y as it binds galactose compared to its binding to fructose?
- a) Y will form more non-covalent bonds with galactose.
  - b) Y will form more covalent bonds with galactose.
  - c) *Y will have an active site that is less complementary to galactose.***
  - d) Y will undergo a greater conformational change as it binds galactose.
35. \_\_\_\_\_ Which interaction is likely to occur as Enzyme X carries out its reaction?
- a) *A hydrogen bond could form between a serine R-group in the active site and a carbonyl group in the transition state.***
  - b) An ionic bond could form between a glutamate R-group in the active site and a carboxyl group in the substrate.
  - c) A hydrophobic interaction could form between an asparagine R-group in the active site and a methyl group in the substrate.
  - d) A hydrogen bond could form between a valine R-group in the active site and a hydroxyl group in the transition state.

36. \_\_\_\_\_ Which kinetic property would Enzyme X display as it binds its normal substrate and catalyzes its reaction?
- a) It could have an initial velocity independent of  $[S]$  when  $[S] < K_M$ .
  - b) It could have a  $K_M$  value that decreases as  $[S]$  decreases from 3.0 mM to 0.3 mM.
  - c) *It could double the rate of its reaction as  $[S]$  increases from 3.0 mM to 30 mM.***
  - d) It could have a  $V_{max}$  value that is dependent on  $[S]$  when  $[S] < K_M$ .

37. \_\_\_\_\_ Enzyme Y is allosterically inhibited by ribose and also inhibited by covalent modification with phosphate. Which is a characteristic of its regulation?
- a) Y can covalently bind both ribose and phosphate to specific amino acids within the protein.
  - b) Y can establish an equilibrium with either ribose or phosphate to reduce the activity of the enzyme.
  - c) Y can bind both ribose and phosphate to a regulatory subunit with the help of extra enzymes.
  - d) *Y can undergo reversible conformational changes when either ribose or phosphate binds to the enzyme.***
- 

G. The reactions of two enzymes, Enzyme A and Enzyme B, are studied at  $\text{pH} = 7.0$ . Both enzymes produce glucose and have the same  $V_{max}$ . Enzyme A has a  $K_M$  of 2.0 mM while Enzyme B has a  $K_M$  of 5.0 mM. (Questions 38-44)

38. \_\_\_\_\_ Which characteristic will be shared by these two enzymes?
- a) Both will increase the rate of their reaction by increasing the energy of the substrate molecules.
  - b) Both will properly orient the substrate for their reaction by forming covalent bonds with the substrate.
  - c) *Both will decrease the activation energy of their reaction by being complementary to the transition state.***
  - d) Both will shift the equilibrium of their reaction by lowering the energy level of the product.

39. \_\_\_\_\_ Which property will Enzyme A likely have in common with most other enzymes?
- a) *It can bind the substrate reversibly using specific amino acids.***
  - b) It can contain a dozen active sites each of which can bind a substrate molecule.
  - c) It can undergo a small change in primary structure as the substrate binds.
  - d) It can be required in stoichiometric amounts in order to bind the correct substrate.

40. \_\_\_\_\_ When Enzyme B carries out its reaction with a substrate concentration of 5.0 mM, the reaction velocity gradually decreases 5 minutes after the reaction starts. What could cause this change in reaction rate?
- a) Enzyme B catalyzes an irreversible reaction.
  - b) Enzyme B becomes saturated with substrate.
  - c) *Enzyme B is inhibited by its product.***
  - d) Enzyme B is working at its  $V_{\max}$  value.
41. \_\_\_\_\_ Which will occur when Enzyme A and Enzyme B both carry out their reaction at pH = 7.0?
- a) *Enzyme A will produce more glucose than Enzyme B when [S] = 5.0 mM.***
  - b) Enzyme B will produce more glucose than Enzyme A when [S] = 5.0 mM.
  - c)  $V_o$  for Enzyme A will double as [S] increases from 5.0 mM to 10.0 mM.
  - d)  $V_o$  for Enzyme B will double as [S] increases from 5.0 mM to 10.0 mM.
42. \_\_\_\_\_ Which kinetic property will be shared by Enzyme A and Enzyme B?
- a) Their  $K_M$  values will decrease as the substrate concentration decreases.
  - b) Their  $V_{\max}$  values will increase as the substrate concentration increases.
  - c) Their  $K_M$  values will depend upon the concentration of the enzymes.
  - d) *Their  $V_{\max}$  values will depend upon the slowest step of their reaction mechanisms.***
43. \_\_\_\_\_ The substrate for Enzyme A is a sugar phosphate while the substrate for Enzyme B is a sugar alcohol. Which amino acid is likely to be found in the active site of both enzymes?
- a) leucine
  - b) tryptophan
  - c) aspartate
  - d) *glutamine***
44. \_\_\_\_\_ Enzyme A is an allosteric enzyme inhibited by galactose while Enzyme B is a covalently modified enzyme inhibited by phosphate. Which will occur during their regulation?
- a) Enzyme B will become more inhibited as the concentration of phosphate increases.
  - b) *Enzyme A will become more inhibited as the concentration of galactose increases.***
  - c) Both enzymes will undergo an irreversible conformational change as their regulating molecule binds.
  - d) Both enzymes will bind their regulating molecule to a specific active site on a catalytic subunit.
-