



University of Alberta
Department of Biochemistry

BIOCH 200

Midterm II

Thursday March 21st 2013

Name: _____
ID#: _____

If this examination booklet is **NOT** returned, you will be assigned a mark of **ZERO (0)** for this midterm.

IF YOU CONTINUE WRITING THIS EXAM AFTER THE ALLOTTED TIME YOU WILL BE GIVEN A SCORE OF ZERO

SPECIAL CODE

111 Dr. Dixon MWF 12-12:50 B1
221 Drs. Wright/Parrish T/R 11-12:20 B2/B3
331 Dr. Wright MWF 9-5:50 B4

Time Limit: 60 minutes

INSTRUCTIONS

- CLEARLY ENTER **YOUR NAME, SPECIAL CODE AND I.D.#** ON THIS EXAM BOOKLET AND ON THE ANSWER SHEET PROVIDED.
- USE **HB PENCIL** ONLY AND MAKE HEAVY BLACK MARKS THAT FILL THE CIRCLE COMPLETELY.
- CHOOSE THE **ONE** BEST ANSWER TO EACH QUESTION.
- THERE ARE **40** QUESTIONS IN THIS EXAM.
- CHECK THAT YOU HAVE **12 PAGES** IN THIS EXAM, AND 1 ANSWER SHEET

1. In the following α -helix which of the following amino acids is the backbone amino group of Arg hydrogen bonded to?

Gly-Pro-Gln-His-Leu-Arg-Ile-Thr-Ser-Met-Val-Ala-Ile

- A. Asn
B. Ser
C. Pro
D. Met
E. None of the above
2. Which of the following statements regarding amino acids is/are FALSE?
- A. Thr and Ser may be phosphorylated.
B. The side chain of the amino acid histidine usually acts as a base at pH 5.5.
C. Arg contains four nitrogens.
D. B and C
E. All of the above statements are false.
3. Which of the following statements regarding amino acids is/are FALSE?
- A. Asparagine can act as a H-bond donor and acceptor with water.
B. Every amino acid residue has at least two pKa values.
C. When the pH of a solution is above the pKa value of an ionizable group, the protonated form of that group predominates.
D. Statements B and C are false.
E. All of the above statements are false.
4. Which of the following does NOT contain a sulfur atom?
- A. The amino acid Ser.
B. The amino acid Thr.
C. The amino acid Cys.
D. A and B
E. B and C.

5. A short peptide has the following sequence:

Gln-Glu-Val-His-Asn-Cys-Tyr-Ile-Leu-Phe

What is the net charge of this peptide at pH 1?

- A. -2
- B. -1
- C. 0
- D. +1
- E. +2

6. Which of the following statements regarding human hemoglobin is true?

- A. Hemoglobin is a heterotetramer.
- B. Fetal hemoglobin has a higher BPG affinity than adult hemoglobin does.
- C. At higher pH's deoxyhemoglobin is stabilized.
- D. A and B are both true.
- E. All the above statements are true.

7. Which of the following is true regarding the structures of myoglobin and the subunits of fetal hemoglobin?

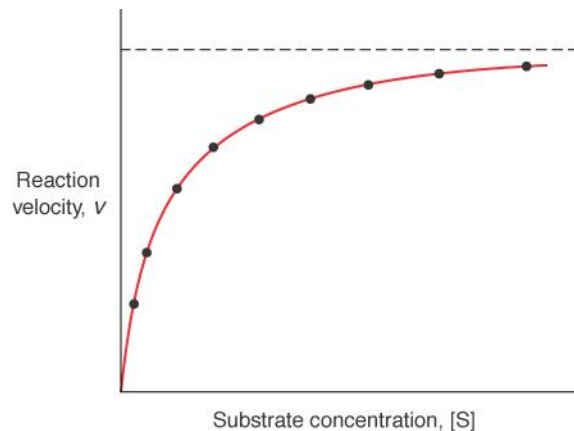
- A. They have no obvious structural relationship.
- B. They have very different primary and secondary structures.
- C. They have identical primary and tertiary structures.
- D. They have very similar secondary structures, but different tertiary structures.
- E. They have very similar tertiary structures, but different primary structures.

8. Which of the following statements about enzymes is false?

- A. An enzyme increases reaction rates by lowering $\Delta G_{\text{reaction}}$.
- B. Enzyme active sites bind their products reversibly.
- C. Enzymes can be denatured.
- D. Competitive inhibitors are non-covalently bound to enzymes.
- E. Statements A and C are both false

9. The enzyme 2,3-BPG mutase produces 1,3-BPG in red blood cells through an isomerisation (rearrangement) reaction. What amino acids would you predict to find in the active site of 2,3-BPG mutase?
- Leu
 - Arg
 - His
 - B and C
 - A, B and C
10. Which of the following statements is FALSE regarding the interaction of oxygen with myoglobin?
- Oxygen binds at the 6th coordination position of the Fe^{2+} ion in the heme.
 - Oxygen binding alters hemoglobin conformation.
 - Oxygen is a homoallosteric effector of myoglobin.
 - Oxygen binds reversibly and with high affinity to the heme prosthetic group.
 - C and D are false.

The following graph shows the rate of product formation as a function of substrate concentration for an enzyme.

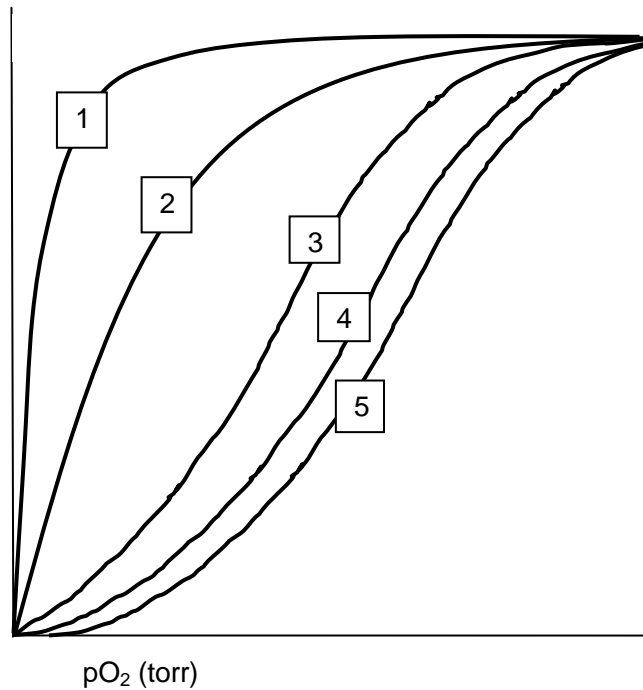


11. Which of the following statements BEST explains why the curve plateaus at high substrate concentration?
- At high concentrations of substrate the enzyme can no longer bind the substrate.
 - The reverse reaction is also catalyzed by the enzyme.
 - At high concentrations the amount of substrate greatly exceeds the number of enzymes.
 - A and B
 - B and C

12. A reaction, under particular conditions, has $\Delta G_{\text{reaction}} < 0$. What does this tell you about the reaction?
- A. The reaction will proceed only in the presence of an enzyme.
 - B. An enzyme will decrease the value of $\Delta G_{\text{reaction}}$.
 - C. Product formation is thermodynamically favored.
 - D. Product formation will occur at a reasonable rate.
 - E. C and D
13. Which of the following statements about prosthetic groups is/are FALSE?
- A. A prosthetic group is a tightly bound cofactor required for enzyme activity.
 - B. Prosthetic groups increase the inherent chemical reactivity of proteins.
 - C. Prosthetic groups are not peptides.
 - D. Prosthetic groups are required by all globular enzymes.
 - E. All the above statements are true.
14. Which amino acid(s) is/are likely to be involved in reactions in an enzyme active site?
- A. His
 - B. Gly
 - C. Trp
 - D. B and C
 - E. All of the above
15. How many ionizable groups does a Gly residue at the C-terminal end of a polypeptide chain contain?
- A. 0
 - B. 1
 - C. 2
 - D. 3
16. How many chiral carbons does a C4:0 fatty acid at pH 3 contain?
- A. 0
 - B. 1
 - C. 2
 - D. 3

17. Which of the following statements is FALSE with respect to hemoglobin's transition from the T state to the R state?
- A. Contacts between the subunits of hemoglobin change on binding of oxygen.
 - B. Fe^{3+} is pulled into the plane of the heme when oxygen binds to hemoglobin.
 - C. Helix F structure changes between the T and R states.
 - D. BPG is an allosteric effector of hemoglobin that stabilizes the R state.
 - E. B and D are both false.
18. Which of the following is TRUE about the distal histidine of hemoglobin?
- A. It forms a strong covalent bond with the Fe^{2+} atom coordinated by heme.
 - B. It prevents helix F from moving in response to oxygen binding.
 - C. It forms bonding interactions with bound oxygen.
 - D. It covalently bonds heme into the hemoglobin subunit.
 - E. It is not conserved in myoglobin.
19. Which of the following describes the relationship between the pO_2 and its binding to hemoglobin?
- A. hyperbolic
 - B. cooperative
 - C. allosteric
 - D. A and C
 - E. B and C
20. Doubling the activation energy will increase the rate of an enzyme catalyzed reaction. This statement is:
- A. Always true.
 - B. Sometimes true.
 - C. Never true.

21. Which of the following amino acids contain exactly 5 carbons?
1. Glu
 2. Met
 3. Asn
 4. Pro
 5. Leu
- A. 1 and 3
B. 1, 2 and 4
C. 1, 3 and 4
D. 2, 3 and 5
E. 2, 3, 4 and 5
22. An enzyme is tested and the K_m is found to be 1 mM. After further purification, the enzyme is tested again and the K_m is found to be 0.5 mM. What is the most likely explanation for these results?
- A. The enzyme denatured during purification.
 - B. The enzyme became phosphorylated.
 - C. A competitive inhibitor was present in the initial preparation.
 - D. A positive allosteric effector was present in the initial preparation.
 - E. All of these could explain the results.
23. For biological membranes the transition from the ordered crystalline state to the fluid state occurs over a broad temperature range rather than as a sharp transition. Why?
- A. Biological membranes lack cholesterol.
 - B. Biological membranes contain complex mixtures of lipids.
 - C. Biological membranes have a homogenous glycerophospholipid content.
 - D. Biological membranes are stabilized by covalent bonds.
 - E. C and D are both true.
24. Which of the following statements is/are true regarding the transition state (TS) of an enzyme catalyzed reaction?
- A. The TS of an enzyme catalyzed reaction is higher in free energy than the TS for an uncatalyzed reaction.
 - B. The TS is bound with very high affinity to the enzyme.
 - C. The TS is lower in free energy than the reactants.
 - D. A and B are true.



25. Assume curve 2 in the graph above is the plot of % Oxygen bound for myoglobin at pH 7.6. Which curve(s) represents the behavior of this protein at pH 7.2?
- 1
 - 2
 - 3
 - 4
 - None of the above
26. Assuming curves 1 and 2 in the graph above are the plots of reaction velocity versus substrate concentration for enzymes 1 and 2, respectively. Which of the following statements is false?
- Enzyme 1 has a higher affinity for its substrate than enzyme 2.
 - Enzyme 1 has a higher V_{\max} than enzyme 2.
 - The K_m value for enzyme 1 is smaller than that for enzyme 2.
 - Curve 2 could represent enzyme 1 in the presence of a competitive inhibitor.

27. A newly-identified protein shows a hyperbolic binding curve in a graph of fractional saturation versus ligand concentration. Which of the following statements about that protein is FALSE?

- A. The protein binds the ligand reversibly.
- B. The protein does not undergo significant conformational changes in tertiary structure when the ligand binds.
- C. When the ligand binds to one subunit, the affinity of the other subunits for the same ligand is increased.
- D. The amount of protein binding ligand varies with ligand concentration.

28. Evidence that a peptide bond displays resonance includes all of these reasons, except:

- A. It is planar.
- B. Rotation around the N-C bond in the peptide is restricted.
- C. Rotation around the N-C α bond is limited.
- D. It has partial double bond character.

29. Which of the following determine the binding of O₂ by myoglobin?

- A. Oxygen concentration.
- B. The K_d value of oxygen for myoglobin.
- C. The hemoglobin concentration.
- D. A and B.
- E. A, B and C.

30. Which of the following are classified as having tertiary structure?

- A. An α -helix
- B. A β -sheet
- C. A subunit
- D. A monomer
- E. Both C and D

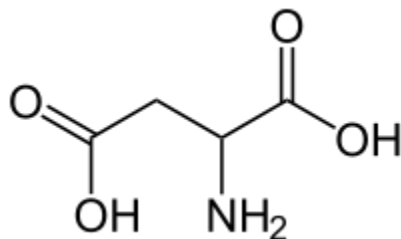
31. Why is BPG essential for the delivery of O₂ to the tissues?
- A. BPG enables hemoglobin to bind O₂.
 - B. BPG enables hemoglobin to adopt the R state conformation.
 - C. BPG enables hemoglobin to stabilize the R state conformation.
 - D. BPG enables hemoglobin to adopt the T state conformation.
 - E. B and C.
32. Which of the following statements is false?
- A. In fetal hemoglobin the central cavity is lined with less histidines than in adult hemoglobin, which results in preferential stabilization of the T-state.
 - B. Fetal hemoglobin has a weaker affinity for BPG than maternal hemoglobin, resulting in a shift of the oxygen-binding curve to the left.
 - C. As [H⁺] decreases, the O₂ binding curve of hemoglobin shifts to the right, because a greater proportion of hemoglobin molecules exist in the T-state at a given ppO₂.
 - D. Actively respiring tissues have a relatively low pH and low ppO₂, which favors the T-state of hemoglobin.
 - E. A and B are both false
33. Which of the following methods of altering enzyme activity can be reversed?
- A. Enzyme denaturation.
 - B. Binding of allosteric effectors to enzymes.
 - C. Phosphorylation of enzymes.
 - D. B and C
 - E. All of the above.
34. Which one of the following statements regarding enzymes is/are TRUE?
- A. The substrate binding site of an enzyme contains residues without sidechains.
 - B. Enzymes make the free-energy change for a reaction more favorable.
 - C. Enzymes ensure that the transition state is preferentially stabilized compared to the substrate.
 - D. B and C are true.
 - E. All of the above statements are true.

35. A solution of a fatty acid (16:2) has an overall neutral charge at pH 3.5. This means:

- A. The pKa of the fatty acid is < 3.5 .
- B. The pKa of the fatty acid is > 3.5 .
- C. The pKa of the fatty acid is 3.5.
- D. The pKa may be any of the above choices.

36. In humans, the fatty acid composition of membrane lipids in skin cells is different from the fatty acid composition of membrane lipids in the internal organs, because the internal organs function at a slightly higher temperature. Which of the following differences in fatty acid composition is most likely to be observed?

- A. Skin cells show lower levels of 20:0 relative to 18:0 AND lower levels of 18:2 relative to 18:0.
- B. Skin cells show higher levels of 18:2 relative to 18:0 AND lower levels of 20:0 relative to 18:0.
- C. Skin cells show lower levels of 18:2 relative to 18:0 AND higher levels of 20:0 relative to 18:0.
- D. Skin cells show higher levels of 20:0 relative to 18:0 AND higher levels of 18:2 relative to 18:0.



37. If the molecule shown above is placed in an aqueous solution, the pH of that solution will

- A. Increase
- B. Decrease
- C. Stay the same

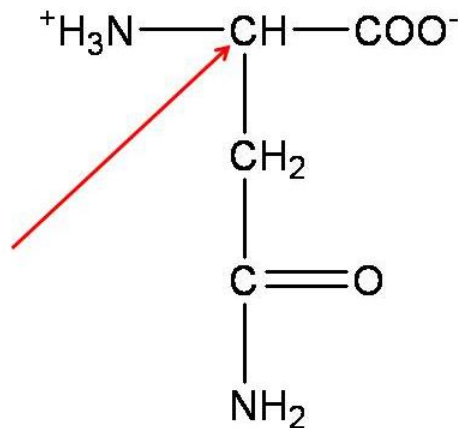
38. As the pH of a solution is changed from pH 1 through pH 14, which of the following net charge forms of lysine will exist in this solution?

- A. +2
- B. +1
- C. -1
- D. A and B
- E. All of the above

39. Which of the following molecules are associated with myoglobin switching to the T state?

- A. H^+
- B. CO_2
- C. 2,3-BPG
- D. All of the above
- E. None of the above

40. Which statement below is false with respect to the atom shown by the arrow?



- A. In a polypeptide this atom is not part of the backbone.
- B. This atom is chiral.
- C. This atom is designated the α carbon atom.
- D. This atom is not part of the peptide bond.
- E. The R group attached to the atom does not have a pKa value.