

## EXAM 2, Form A KEY

Place your name at the top of this page of the exam. On the F-1712 Scantron form, use a no. 2 pencil to enter your test form letter, A or B. Also print and encode your name and last 8 numbers of your UTD ID (starting in the first column on the left and leaving the last spaces blank). Select the best answer for the following multiple-choice questions and enter the corresponding letter on the Scantron sheet. You may use these test pages to make notes and work problems. You may use a non-graphing calculator or a graphing calculator you have shown has been cleared of all stored data.

1. Which of these categories is not one of the six major classes of enzymes as designated by the International Union of Biochemistry?
  - a. ligase
  - b. transferase
  - c. cyclase
  - d. isomerase
  - e. lyase
2. Which of the following amino acids is capable of forming an unstable covalent intermediate during catalysis? Hint: a lone pair of electrons is need for the nucleophilic attack.
  - a. glu
  - b. phe
  - c. tyr
  - d. a and b
  - e. a and c
3. Calculate the  $[S]/K_m$  ratio when the velocity of a Michaelis enzyme-catalyzed reaction is 75% of  $V_{max}$ .
  - a. 1/9
  - b. 1/3
  - c. 1/1
  - d. 3/1
  - e. 9/1
4. Sulfa drugs are analogs of p-aminobenzoic acid (aka PABA). They function by
  - a. competitively inhibiting biotin synthesis
  - b. uncompetitively inhibiting biotin synthesis
  - c. competitively inhibiting folic acid synthesis.
  - d. irreversibly inhibiting folic acid synthesis
  - e. noncompetitively inhibiting peptidoglycan synthesis
5. For a ping pong double displacement reaction, the Lineweaver-Burk plot consists of
  - a. a set of parallel lines with axis intercepts that increase with increasing  $[I]$
  - b. a set of lines with slopes that increase with increasing  $[I]$
  - c. a set of lines that intercept the  $1/v$  axis at the same point
  - d. a set of lines that intercept one another at the same point behind the  $1/v$  axis
  - e. none of the above.

E is the correct answer, but A also accepted for full credit since it is partially correct and we didn't discuss inhibition of bisubstrate reactions.

6. Which of the following supersecondary structures can be found in  $\beta$ -barrels?

- a. Greek key  $\beta$
- b.  $\beta$ -hairpins (i.e.,  $\beta$ -meanders)
- c.  $\beta$ - $\alpha$ - $\beta$
- d. b & c
- e. all of the above

7. The principal secondary structures of a protein are

- a.  $\alpha$  helix
- b.  $\beta$  strand
- c.  $\pi$  helix
- d. a & b
- e. a & c

8. The Hsp60 and Hsp70 proteins

- a. are prolyl isomerases
- b. serve as templates for protein folding
- c. are chaperones that catalyze correct protein folding
- d. degrade denatured proteins
- e. are cis-trans isomerases

9. Viagra works by

- a. stimulating NO synthesis
- b. competitively inhibiting the breakdown of NO
- c. irreversibly inhibiting a phosphodiesterase
- d. stimulating cGMP synthesis
- e. competitively inhibiting the hydrolysis of cGMP

10. Which of the following is a way enzymes catalyze reactions?

- a. lowering the Arrhenius activation energy
- b. forming better weak interactions with the transition state than with the substrate
- c. forming an unstable covalent link to a part of a substrate
- d. a & b
- e. all of the above

11. For an enzyme that obeys Michaelis-Menten kinetics, what is the  $K_m$  if its initial velocity is half of  $V_{max}$  when  $[S] = 70 \times 10^{-6} \text{ M}$ ?

- a. 50  $\mu\text{mol/L}$
- b. 70  $\mu\text{mol/L}$
- c. 140  $\mu\text{mol/L}$
- d. 175  $\mu\text{mol/L}$
- e. 205  $\mu\text{mol/L}$

12. Enzymes that transfer electrons between substrates belong to which class of enzymes?

- a. oxidoreductase
- b. transferase
- c. hydrolase
- d. isomerase
- e. lyase

13. Partial inhibition by penicillin and other irreversible inhibitors produces double reciprocal kinetic plots which are indistinguishable from those observed with
- a. competitive inhibitors
  - b. uncompetitive inhibitors
  - c. classic noncompetitive inhibitors
  - d. mixed noncompetitive (aka nonlinear noncompetitive) inhibitors
  - e. Ping Pong BiBi reactions

C is the correct answer but question was deleted since a majority of the class missed it. We discussed it in class but it was not in the notes or text.

14. Lineweaver-Burk plots (aka. double reciprocal plots) can be used to
- a. determine  $K_m$  values
  - b. distinguish between single and double displacement reaction mechanisms
  - c. distinguish between competitive and noncompetitive inhibitors
  - d. determine  $K_i$  if  $[I]$  is known
  - e. all of the above

15. A measure of the specificity and efficiency of an enzyme is given by
- a.  $k_{cat}[E]_{total}$
  - b.  $k_{cat}/K_m$
  - c.  $k_1/k_{-1}$
  - d.  $(k_{-1} + k_{cat})/k_1$
  - e. the rate of catalysis at high  $[S]$

16. The active site of the cysteine-protease papain contains His-125 ( $pK_a$  8.5) and Cys-25 ( $pK_a$  3.3) both of which must be charged for catalysis to occur. What is the optimal pH for catalysis?
- a. <3.3
  - b. 5.9
  - c. 6.4
  - d. 8.5
  - e. >8.5

17. The  $\beta$  and  $\gamma$  bends represent a type of
- a. sheet structure
  - b. domain structure
  - c. secondary structure
  - d. supersecondary structure
  - e. random coil

18. How many amino acids are there per repeat of a  $\beta$  strand, i.e. what is the pitch of a  $\beta$  strand?
- a. 2
  - b. 3
  - c. 3.6
  - d. 4.2
  - e. 5

19. CM-cellulose is used for

- a. gel filtration
- b. affinity chromatography
- c. hydrophobic chromatography
- d. anion exchange chromatography
- e. cation exchange chromatography

20. In what order will the following proteins elute from a gel filtration (aka gel exclusion) column?

Protein A,  $M_r$  48,000, pI 7.8; protein B,  $M_r$  16,000, pI 6.4; protein C  $M_r$  41,000, pI 5.6

- a. A, B, C
- b. A, C, B
- c. C, A, B
- d. C, B, A
- e. B, C, A

Bonus question

21. In what order will the proteins in the above problem elute from a DEAE-cellulose (diethylaminoethyl-cellulose) anion exchange column at pH 8.5?

- a. A, B, C
- b. A, C, B
- c. C, A, B
- d. C, B, A
- e. B, C, A

22. In what order will the proteins in the above problem band in SDS-PAGE starting with the one closest to the bottom of the gel?

- a. A, B, C
- b. A, C, B
- c. C, A, B
- d. C, B, A
- e. B, C, A

23. If a protease ( $M_r$  50,000) at a concentration of  $0.25 \mu\text{g/ml}$  and one active site per molecule has a  $V_{\max}$  of  $1.0 \times 10^{-4} \text{ M/min}$ , what will its turnover number be?

- a.  $1.2 \times 10^2 / \text{min}$
- b.  $1.2 \times 10^3 / \text{min}$
- c.  $2.0 \times 10^3 / \text{min}$
- d.  $4.8 \times 10^3 / \text{min}$
- e.  $2.0 \times 10^4 / \text{min}$

24. If the concentration of the protease in the previous question is decreased to  $0.05 \mu\text{g/ml}$ , what will the  $V_{\max}$  be?

- a.  $1.4 \times 10^{-5} \text{ M/min}$
- b.  $2.0 \times 10^{-5} \text{ M/min}$
- c.  $7.5 \times 10^{-5} \text{ M/min}$
- d.  $4.5 \times 10^{-6} \text{ M/min}$
- e.  $6.0 \times 10^{-6} \text{ M/min}$

25. What is the  $K_i$  of a competitive inhibitor if its presence at  $1 \times 10^{-3} \text{ M}$  in an enzyme-catalyzed reaction yields an apparent  $K_m$  that is 11 times higher than the true  $K_m$ ?
- a.  $1 \times 10^{-7} \text{ M}$
  - b.  $1 \times 10^{-6} \text{ M}$
  - c.  $1 \times 10^{-5} \text{ M}$
  - d.  $1 \times 10^{-4} \text{ M}$
  - e.  $1 \times 10^{-3} \text{ M}$
26. The turnover number of an enzyme is also known as
- a.  $k_{-1}$
  - b.  $k_{cat}$
  - c.  $k_{cat}/K_m$
  - d.  $(k_{-1} + k_{cat})/k_1$
  - e.  $K_m$
27. What is the  $K_m$  for a Michaelis enzyme if the  $1/[S]$  intercept is  $-5 \times 10^5 \text{ M}^{-1}$  on a Lineweaver-Burk plot of its reaction kinetics?
- a.  $5 \times 10^{-7} \text{ M}$
  - b.  $2 \times 10^{-6} \text{ M}$
  - c.  $1 \times 10^{-6} \text{ M}$
  - d.  $5 \times 10^{-4} \text{ M}$
  - e.  $1 \times 10^{-3} \text{ M}$
28. The  $\psi$  angle refers to the amount of rotation about which bond(s) in the peptide backbone?
- a.  $\text{N}-\text{C}_\alpha$
  - b.  $\text{C}_\alpha-\text{C}_{\text{carbonyl}}$
  - c.  $\text{C}_{\text{carbonyl}}-\text{N}$
  - d. a & b
  - e. a & c
29. In uncompetitive inhibition
- a. the inhibitor can bind equally well to either the free enzyme or the ES complex
  - b. the inhibitor binds to the ES complex better than to the free enzyme
  - c. the inhibitor binds to the free enzyme better than to the ES complex
  - d. the inhibitor can bind only to the free enzyme
  - e. the inhibitor can bind only to the ES complex
30. A leucine zipper is an example of
- a. a leu-rich  $\beta$  ribbon
  - b. layered  $\beta$  sheets with interlocking leu groups
  - c. a coiled coil comprised of collagen helices with leu at positions 2 or 3 of triad repeats
  - d. a coiled coil comprised of  $\alpha$  helices with leu at positions 1 and 4 of heptad repeats
  - e. a Greek key  $\beta$  sheet with alternating leu in the center strands
31. Connections between strands of a  $\beta$  sheet
- a. are always  $\beta$  bends
  - b. are always random coil
  - c. are usually right handed
  - d. are usually left handed
  - e. none of the above

32. To produce an S100 fraction from a cell homogenate, you would use
- differential centrifugation
  - salting out
  - density gradient centrifugation
  - gel filtration
  - isoelectric focusing
33. The homoheptameric vessel formed by chaperonin in is an example of which level of protein structure?
- primary
  - secondary
  - super-secondary
  - tertiary
  - quaternary
34. Enzymes with kinetics that produce an S-shaped (i.e., sigmodal) curve on a  $v_o$  vs.  $[S]$  plot are
- Michaelis-Menten enzymes
  - Lineweaver-Burk enzymes
  - allosteric enzymes
  - perfect enzymes
  - Scatchard enzymes
35. Which E.C. class of enzyme requires the breakdown of a high-energy molecule such as ATP to drive a coupled reaction?
- transferase
  - isomerase
  - ligase
  - lyase
  - hydrolase
36. To be activated, organophosphorus insecticides such as malathion and parathion must
- have a phosphorus-bound sulfur replaced with oxygen
  - be joined to glutamic acid
  - be reduced
  - be hydrolyzed
  - have an acetyl group added to it
37. Metal ion catalysis can
- generate  $\text{OH}^-$  at physiological pH
  - introduce electronic strain in the substrate
  - involve a coordination link between the metal ion and the transition state
  - b & c
  - all of the above
38. The cellular concentration of the substrate of an enzyme is often found to be
- much greater than its  $K_m$  value
  - much less than its  $K_m$  value
  - approximately equal to its  $K_m$  value
  - equal to  $k_{\text{cat}}/K_m$
  - equal to  $k_{\text{cat}}$

39. Intrinsically unstructured proteins?

- a. adopt well-defined structures in complexes with their target proteins
- b. are characterized by an abundance of hydrophobic residues
- c. are globular in shape
- d. typically are extracellular
- e. typically are embedded in membranes

40. Estimate the molecular weight of a  $\beta$ - $\alpha$ - $\beta$  supersecondary element that is 3 nm high? Ignore any residues in the bends connecting the parts of the element.

- a. 3400
- b. 4500
- c. 5800
- d. 1200
- e. 8400

41. A Scatchard plot is

- a.  $[S]_{\text{bound}}/[S]_{\text{free}}$  vs.  $[S]_{\text{bound}}$  for a protein-ligand interaction
- b. used to determine the Arrhenius activation energy for an enzyme-catalyzed reaction
- c. used to determine the dissociation constant for an enzyme-ligand complex
- d. a & c
- e. all of the above

42. Five competitive inhibitors of an enzyme were found to exhibit the following  $K_m/K_i$  ratios. Which is the best inhibitor?

- a.  $1 \times 10^2$
- b.  $3 \times 10^3$
- c.  $3 \times 10^5$
- d.  $7 \times 10^8$
- e.  $5 \times 10^9$

43. General base catalysis begins by

- a. electrophilic attack by the conjugate base
- b. withdrawal of  $\text{OH}^-$  from the substrate
- c. addition of  $\text{H}^+$  to the substrate
- d. withdrawal of  $\text{H}^+$  from the substrate
- e. withdrawal of a hydrogen from the substrate

44. For a Michaelis enzyme,  $k_1 = 1.0 \times 10^9 \text{ M}^{-1} \text{ s}^{-1}$ ,  $k_{-1} = 5.0 \times 10^4 \text{ s}^{-1}$ , and  $k_2 = 4.0 \times 10^3 \text{ s}^{-1}$ . What is its  $K_m$ ?

- a. 38 mM
- b. 13 mM
- c. 75  $\mu\text{M}$
- d. 54  $\mu\text{M}$
- e. 2.5  $\mu\text{M}$

45. The collagen helix

- a. is frequently found in globular proteins
- b. is left-handed
- c. is comprised of long segments where every third residue is gly
- d. a & b
- e. b & c

46. Consider the oligopeptide, THISISEASY, which forms a  $\beta$ -strand. Which of the following amino acid residues would be on the same side of the  $\beta$ -strand as the tyr residue?
- I at position 3
  - I at position 5
  - S at position 6
  - S at position 9
  - none of the above

Answer the following questions on the back of your Scantron sheert.

47. Draw the diagnostic Lineweaver-Burk plot for a Michaelis enzyme in the absence and presence of 2 different concentrations of a competitive inhibitor:  $[I]_A$  and  $[I]_B$ , where  $[I]_B > [I]_A$ . Label the axes and lines, and indicate next to all intercepts what they correspond to in terms of  $V_{max}$ ,  $K_m$ ,  $K_i$ ,  $[I]_A$  and  $[I]_B$ .

See diagnostic slide in class notes. The slope and thus the apparent  $K_m$  will be greater with the higher concentration of inhibitor.

48. State two characteristics of the peptide bond that result in polypeptides forming alpha helices and  $\beta$  strands.

1. Planar due to partial double bond
2. H-bond donor
3. H-bond acceptor
4. Usually has trans configuration
5. Dipolar

49. What is the geometric change that occurs in the peptide substrate when it is converted to the transition state in the active site of a serine protease such as chymotrypsin?

Trigonal, planar to tetrahedral

50. What is a Ramachandran plot?

Angle Psi vs. Phi