THE UNIVERSITY OF MANITOBA

DATE: Oct. 26, 1999   Midterm EXAMINATION

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DEPARTMENT & COURSE NO.: 2.277/60.277   Time: 2 HOURS

EXAMINATION: Elem. Of Biochemistry I   EXAMINER: Drs. Burton & Scoot

GENERAL INSTRUCTIONS

1. You must mark the answer sheet with pencil (not pen).
2. Put your name and enter your student number on the answer sheet.
3. The examination consists of multiple choice questions. Choose what you think is the best, correct answer and record your choice on the answer sheet. There is only **ONE CORRECT** answer.
4. This exam will count for 25% of your final mark.

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1. Which of the following amino acids has a methyl (-CH$_3$) group in its side-chain?

    A) arginine B) glutamine C) leucine D) lysine E) serine

2. Which of the following amino acids contains a sulfur atom?

    A) proline B) tryptophan C) methionine D) isoleucine E) tyrosine

3. Which of the following amino acids does NOT possess a hydrophobic (non-polar) side chain?

    A) threonine B) leucine C) valine D) phenylalanine E) isoleucine

4. Which of the following amino acids does NOT contain a nitrogen atom in its side-chain?

    A) asparagine B) alanine C) lysine D) arginine E) histidine

5. The pH of a 0.005M solution of NaOH is:

    A) 4.5 B) 11.7 C) 12.4 D) 14.0 E) 8.8

6. To 100 mL of a 0.1M solution of alanine at pH=pK$_a$ for its amino group, was added X mL of 0.2M HCl. The new pH was found to be equal to the pK$_a$ for its carboxyl group. What is the value of X?

    A) 100 mL B) 50 mL C) 200 mL D) 75 mL E) the problem cannot be solved without knowing the pK$_a$ values.

7. 0.05 mol of NaOH were added to a solution containing 0.1 mol of a weak acid and 0.1 mol of its conjugate base. After mixing, the pH of the solution was found to be 5.18. What is the pK$_a$ of the weak acid?

    A) 4.22 B) 4.40 C) 4.70 D) 5.04 E) 5.18

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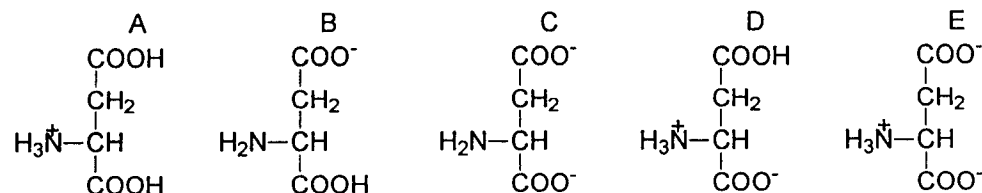PAPER NO.: __   PAGE NO.: 2 of 8

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8. Which of the forms of aspartate shown below CANNOT exist in solution at any pH?

A	B	C	D	E
COOH	COO⁻	COO⁻	COOH	COO⁻

$$
\begin{array}{ccccc}
\text{COOH} & \text{COO}^- & \text{COO}^- & \text{COOH} & \text{COO}^- \\
| & | & | & | & | \\
\text{CH}_2 & \text{CH}_2 & \text{CH}_2 & \text{CH}_2 & \text{CH}_2 \\
| & | & | & | & | \\
\text{H}_3\overset{+}{\text{N}}\text{—CH} & \text{H}_2\text{N—CH} & \text{H}_2\text{N—CH} & \text{H}_3\overset{+}{\text{N}}\text{—CH} & \text{H}_3\overset{+}{\text{N}}\text{—CH} \\
| & | & | & | & | \\
\text{COOH} & \text{COOH} & \text{COO}^- & \text{COO}^- & \text{COO}^-
\end{array}
$$

9. Which pair of the forms of aspartate shown in question 8 will predominate in solution at pH 4.5? (pK, values for aspartate are 1.88, 3.65 (R-group) and 9.60)

    A) A & E   B) A & D   C) B & C   D) D & E   E) A & C

10. The ratio of the concentrations of the conjugate base and weak acid forms of aspartate predominating in solution at pH 4.5 is close to ? (pK, values for aspartate are given in question 9).

    A) 1:3   B) 1:1   C) 3:1   D) 7:1   E) 10:1

11. Which one of the following tetrapeptides has zero net charge at pH 7?

    A) gly-thr-ser-glu   B) lys-val-ala-arg   C) lys-ile-phe-gln   D) arg-ser-leu-asp
    E) trp-pro-asp-gly

12. The regular folding pattern of adjacent (contiguous) portions of the polypeptide chain is called ?

    A) primary structure   B) secondary structure C) tertiary structure
    D) quaternary structure   E) covalent structure

13. The linear sequence of peptide-bonded amino acids in a polypeptide is called ?

    A) primary structure   B) secondary structure C) tertiary structure
    D) random coil structure   E) alpha-helical structure

14. The peptide bond is planar because ?

    A) the large >C=O group causes steric hindrance
    B) the H in the >N-H group is small
    C) free rotation is possible around the bond between the alpha carbon and the carbonyl (>C=O) carbon
    D) the C-N bond has partial double bond character
    E) H-bonds can form with polar amino acid R-groups

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15.   In the alpha helix, the R-groups of the amino acids _?_

A) are found on the outside of the helix
B) generate H-bonds to stabilize the helix
C) stack within the interior of the helix
D) cause only right-handed helices to form
E) alternate between the inside and outside of the helix

16.   Which of the following correctly depicts interchain H-bonding in the β-sheet?

A) >N-H ///// H-N<   B) >C=O ///// H-C-   C) >C=O ///// H-N<
D) >N-H ///// H-R-   E) >C=O ///// O=C<

17.   Which of the following statements about multisubunit (oligomeric) proteins is true?

A) all subunits must be identical
B) all subunits must be different
C) oligomeric proteins are more stable than other proteins
D) all oligomeric proteins contain an even number of subunits
E) the subunits in most oligomeric proteins are held together by weak, non-covalent forces

18.   Which of the following statements about protein structure is true?

A) proteins are generally loosely structured
B) In water-soluble proteins, hydrophobic (non-polar) amino acid side chains are usually buried and not exposed to water
C) In water-soluble proteins, hydrophilic (polar) amino acid side chains are usually buried and not exposed to water
D) proteins that contain alpha helical regions never contain regions of β-sheet
E) fibrous proteins are always exclusively alpha helical

19.   Which of the following does NOT contribute to the formation and stability of tertiary structure in proteins?

A) electrostatic interaction between amino acid R-groups
B) entropy increase resulting from a decrease in the number of ordered water molecules forming a solvent shell ("cage") around non-polar amino acid R-groups
C) formation of disulfide bonds
D) van der Waal's forces
E) formation of covalent bonds between amino acid R-groups containing -OH groups

20.   Which of A), B), C), D) and E) in question 19 above makes the biggest single contribution to the formation and stability of tertiary structure in proteins?

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21.   The polypeptide backbone in the β-sheet conformation is __?__

A) in an extended zig-zag structure   B) an alpha helix   C) a double helix
D) a left-handed helix   D) a randomly coiled structure

22.   True (A) or False (B): Hair is composed mainly of proteins with a β-sheet conformation

23.   The amino acid most likely to disrupt alpha helical structure is _?_

A) arginine B) proline C) isoleucine D) threonine E) tryptophan

24.   Many glutamate residues occuring in a cluster in an alpha helix destabilize the helix at physiological pH because:

A) negatively charged R-groups of adjacent glutamate residues repel one another
B) positively charged R-groups of adjacent glutamate residues repel one another
C) non-polar R-groups of adjacent glutamate residues repel one another strongly
D) glutamate has no functional group in its R-group
E) glutamate is too large to fit into an alpha helix

25.   Which TWO of the following statements are BOTH UNTRUE?

1) H-bonding between amino acid side chains (R-groups) stabilizes the alpha helix
2) The >C=O and >N-H groups of peptide bonds are involved in H-bonding that stabilizes the alpha helix
3) The H-bonds that stabilize the alpha helix are parallel to the axis of the helix
4) About half the peptide bonds in an alpha helix are involved in H-bonding
5) All the peptide bonds in an alpha helix are involved in H-bonding

A) 1 & 2   B) 1 & 3   C) 2 & 4   D) 3 & 5   E) 1 & 4

26.   Weak acids are __?__ ionized (dissociated) in aqueous solution:

A) completely B) only slightly C) not at all D) about 50% E) none of the above

27.   When a weak acid loses a proton (H') it becomes:

A) a strong acid B) a conjugate base C) a conjugate acid D) an ammonium ion
E) an acid anhydride

28.   The role of the enzyme in an enzyme-catalyzed reaction is to:

A) ensure the product is more stable than the substrate
B) make the overall free energy change for the reaction more favourable
C) increase the rate of conversion of substrate to product
D) ensure all the substrate is converted to product
E) increase the equilibrium constant for the reaction

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29.   Enzymes are potent catalysts. They:

A) drive reactions to completion while other catalysts drive reactions to equilibrium
B) are consumed in the reactions they catalyze
C) can prevent the conversion of products back to substrate
D) increase the equilibrium constants for the reactions they catalyze
E) lower the activation energy for the reactions they catalyze

30.   Which of the following statements about enzymes is UNTRUE?

A) weak, non-covalent forces are important in the binding between enzyme and substrate
B) optimal catalysis occurs when the active site binds most strongly with the transition state between the
    substrate and product
C) formation of an enzyme-substrate complex increases the entropy of substrates
D) amino acid R-groups in the active site often participate in enzyme-catalyzed reactions
E) their catalytic activity is affected by pH

31. V_{max} for an enzyme-catalyzed reaction:

A) usually increases when pH increases
B) increases in the presence of a competitive inhibitor
C) is unchanged in the presence of a non-competitive inhibitor
D) is twice the velocity observed when $[S] = K_m$
E) is limited only by the amount of substrate supplied

32.   Which of the following is a correct statement about K_m for an enzyme-catalyzed reaction showing a
       hyperbolic v versus [S] curve?

A) the enzyme's active site is saturated with substrate when $[S] = K_m$
B) If two different substrates can bind to the same active site, the substrate with the smaller K_m will bind
    more strongly
C) the rate of reaction is equal to K_m multiplied by V_{max}

D) $K_m = \frac{V_{max}}{2}$

E) the units of K_m are sec^{-1}

33.   The kinetic data in the table below were obtained using an enzyme known to follow Michaelis-Menten
       kinetics:

[S] mM	0.8	2.0	4.0	6.0	500.0	1000.0
Velocity µmol/min	217	325	433	488	635	647

The K_m for the substrate of this enzyme is approximately:
A) 1 mM   B) 2 mM   C) 3 mM   D) 4 mM   E) 500 mM

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34. In another study on the same enzyme and substrate, but in the presence of an inhibitor, the following data were obtained:

    K_m for the substrate = 4 mM and V_{max} = 650 μmol/min

    The inhibitor is _?_

    A) competitive B) uncompetitive C) a weak base D) Allosteric
    E) non-competitive

35. For an enzyme which follows simple Michaelis-Menten kinetics, what is the V_{max} if v = 35 μmoles/min when [S] = K_m?

    A) 50 μmoles/min   B) 70 μmoles/min   C) 90 μmoles/min
    D) 110 μmoles/min   E) 130 μmoles/min

36. For the enzyme mentioned in the previous question (#35), what is the value of K_m if v = 35 μmoles/min at [S] = 20 μM?

    A) 20 μM B) 22 μM   C) 25 μM   D) 27 μM E) 30 μM

37. An uncompetitive inhibitor will change the kinetic parameters in an enzyme-catalyzed reaction showing simple Michaelis-Menten kinetics as follows:

    A) Increase K_m leaving V_{max} unchanged   B) Decrease both K_m and V_{max}
    C) Increase both K_m and V_{max} D) Decrease V_{max} leaving K_m unchanged
    E) Decrease K_m leaving V_{max} unchanged

38. Allosteric enzymes:

    A) usually have only one active site
    B) usually have more than one polypeptide chain (subunit)
    C) usually show strictly hyperbolic v versus [S] curves.
    D) usually catalyze several different reactions in the same metabolic pathway
    E) usually are active only at acidic pH

39. A compound that decreases the activity of an enzyme by binding to a site other than the catalytic or active site is called:

    A) an alternative inhibitor B) an allosteric inhibitor C) a stereospecific agent
    D) a transition-state analogue   E) an allosteric activator

40. The glycolytic enzyme phosphofructokinase (PFK) is _____ By ATP

    A) allosterically activated   B) competitively inhibited
    C) unaffected   D) allosterically inhibited
    E) denatured

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LAB SECTION (QUESTIONS 41 to 50)

For Questions 41 and 42 please refer to the following: Paper chromatography with a solvent containing ethanol: ammonia: water (8:1:1) was used to separate the three amino acids; aspartate (Asp), isoleucine (Ile) and serine (Ser).

41.   Which of the amino acids would be found closest to the solvent front?

A) Asp   B) Ile   C) Ser   D) Ile and Ser equally close
E) Cannot be determined

42.   Which of the amino acids would have the largest Rf?

A) Asp   B) Ile   C) Ser   D) Ile and Ser equal and largest
E) Cannot be determined

For questions 43 and 44 please refer to the following: When the absorbance of vitamin D_2 (calciferol) is measured at 264 nm, it follows Beer's Law over a wide range of concentrations. $E = 18,200$ $M^{-1}cm^{-1}$ and cell length = 1 cm.

43.   If the absorbance has to be 0.25 or above what is the lowest concentration of vit D_2 that could be used for analysis?

A) 1.45×10^{-2}M   B) 7.28×10^{-4}M   C) 4.55×10^{3}M
D) 1.37×10^{-5}M   E) Cannot be determined

44.   If the absorbance has to be 0.85 or below what is the highest concentration of vit D_2 that could be used for analysis?

A) 1.55×10^{-4}M   B) 2.14×10^{4}M   C) 4.67×10^{-5}M
D) 1.45×10^{-2}M   E) Cannot be determined

45.   Which of the following are required conditions for measuring protein by the Biuret method?

1) Alkaline conditions
2) The presence of Cu^{2+}
3) Titration with acid and base
4) Establishment of a calibration curve
5) Formation of a complex whose absorbance can be determined

A) All of the above   B) 1, 2, 3 and 4   C) 1, 2, 4 and 5   D) 4 and 5   E) 3

46.   Using the Biuret method, the absorbance of a tube containing 0.2 mL of a 1 in 5 dilution of unknown protein solution was found to be 0.300. In the same size cuvette, 1.5 mL of a standard bovine serum albumin solution containing 6 mg BSA/mL, gave an absorbance reading of 0.450. What is the protein concentration of the original protein solution?

A) 1.2 mg/mL   B) 6 mg/mL   C) 30 mg/mL   D) 100 mg/mL   E) 150 mg/mL

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47.   Which of the following would result in a 1 in 50 dilution of an original solution Y?

   1.   A 5 mL aliquot of Y was diluted with 20 mL of buffer. This was further diluted by taking a 2 mL
         aliquot and adding 18 mL buffer.
   2.   A 10 mL aliquot of Y was diluted by adding 40 mL of buffer.
   3.   A 0.5 mL aliquot of Y was diluted with 9.5 mL of buffer. This was further diluted by taking a 0.3
         mL aliquot and adding 8.7 mL buffer.
   4.   All of the above.
   5.   None of the above.

For questions 48, 49 and 50 please refer to the following:

Glutamate can be schematically represented in the following way:
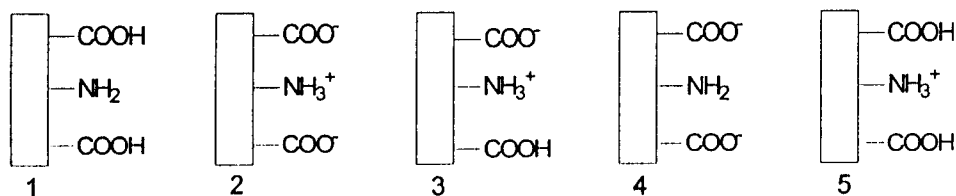
The pka values for glutamate are 2.2, 4.2 and 9.7

48.   Which species would exist at pH 11.0?

       A) 1   B) 2   C) 3   D) 4   E) 5

49.   Which species would not exist in solution?

       A) 1   B) 2   C) 3   D) 4   E) 5

50.   Which species would exist at pH 4.2?

       A) 1 & 2   B) 2 & 3   C) 2 & 4   D) 3 & 5   E) 2

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2.277/60.277   Elements of Biochemistry I

1999/2000 (00R)   **Midterm Exam Answers**   **October 26 , 1999**

1. C	21. A	41. B
2. C	22. B	42. B
3. A	23. B	43. D
4. B	24. A	44. C
5. B	25. E	45. C
6. B	26. B	46. E
7. C	27. B	47. A
8. B	28. C	48. D
9. D	29. E	49. A
10. D	30. C	50. B

11. D	31. D
12. B	32. B
13. A	33. B
14. D	34. A
15. A	35. B
16. C	36. A
17. E	37. B
18. B	38. B
19. E	39. B
20. B	40. D