

DATE: Oct. 24, 2000Midterm EXAMINATIONPAPER NO.: PAGE NO.: 1 of 10DEPARTMENT & COURSE NO.: 2.277/60.277Time: 2 HOURSEXAMINATION: Elements of Biochemistry IEXAMINER: Drs. D. Burton and A. 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.

1. Which of the following amino acids **does not have** a nitrogen atom in its side-chain (R- group)?
A) arginine B) glutamine C) leucine D) lysine E) asparagine
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 statement is **incorrect** about the classification of amino acids?
A) At pH 7, lysine, arginine and tryptophan have positively charged R-groups.
B) Alanine and valine have nonpolar, aliphatic R-groups.
C) At pH 7, aspartate and glutamate have negatively charged R-groups.
D) At pH 7, threonine, serine and cysteine have polar, uncharged R-groups.
E) None of the above are incorrect.
5. A 10 mL sample of HCl solution requires 7.2 mL of 0.1M NaOH solution for complete titration. What is the concentration of the HCl?
A) 0.72 M B) 0.072 M C) 0.0072 M D) 0.036 M E) 0.36 M
6. What is the pH of the HCl solution referred to in question 5?
A) 7.0 B) 1.1 C) 3.1 D) 11.1 E) 1.5
7. To 50 mL of a 0.1M solution of alanine at $\text{pH}=\text{pK}_a$ for its carboxyl group, was added X mL of 0.2M NaOH. The new pH was found to be equal to the pK_a for its amino group. What is the value of X?
A) 100 mL B) 25 mL C) 50 mL D) 75 mL
E) the problem cannot be solved without knowing the pK_a values.

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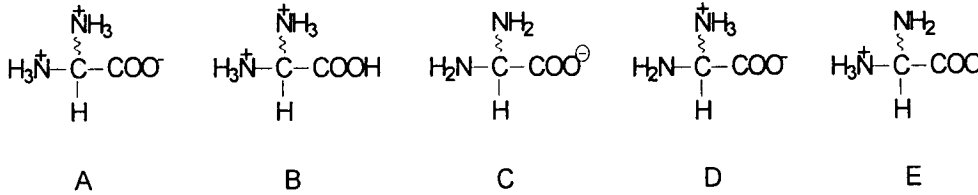
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EXAMINATION: Elements of Biochemistry I

EXAMINER: Drs. D.Burton and A. Scoot

8. 0.05 mol of HCl was 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 4.28. What is the pK_a of the weak acid?
- A) 4.28 B) 4.40 C) 4.76 D) 5.04 E) 5.18

9. Which of the forms of lysine shown below CANNOT exist in solution at any pH?



- 10. Which pair of the forms of lysine shown in question 9 will predominate in solution at pH 3? The pK_a values for lysine are 2.16, 9.18 and 10.79 (R-group).

- A) A & E B) A & D C) B & C D) A & B E) A & C
11. The ratio of the concentrations of the conjugate base and weak acid forms of lysine predominating in solution at pH 3 is close to ? (pK_a values for lysine are given in question 10).
- A) 1:3 B) 1:1 C) 3:1 D) 5:1 E) 7:1
12. Which one of the following tetrapeptides has net charge = +2 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

13. 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

14. 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

15. 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 between polar R-groups

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16. In the alpha helix, the R-groups of the amino acids ___?
- are found on the outside of the helix
 - generate H-bonds to stabilize the helix
 - stack within the interior of the helix
 - cause only right-handed helices to form
 - alternate between the inside and outside of the helix
17. Repeating secondary structures such as the alpha-helix are formed as a result of predominantly which of the following?
- Intramolecular hydrogen bonding
 - Electrostatic interactions
 - Hydrophobic interactions
 - Intrastrand disulfide bonds
 - None of the above
18. Quaternary structure is associated with which of the following?
- The overall shape of a polypeptide chain
 - The sum of the secondary and tertiary interactions
 - Simple proteins with only one subunit
 - The relative orientation of one polypeptide to another polypeptide in a multi-subunit protein
 - None of the above
19. Which factors will influence the native conformation of a protein?
- | | |
|--|---------------------|
| 1) pH of the solution | A) 1, 2 and 4 |
| 2) Temperature | B) 1, 2 and 3 |
| 3) Its sequence of amino acids | C) 1, 2, 3 and 4 |
| 4) The presence of ethanol in the solution | D) 1, 2, 3 and 5 |
| 5) Applying an electric field across the solution | E) All of the above |
- replace*
→
20. Which of the following correctly depicts interchain H-bonding in the Beta-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< | |
21. Which of the following statements about the fibrous protein silk fibroin are TRUE?
- Fibroin consists of stacked beta-sheets
 - Fibroin consists of right handed helices
 - Fibroin has a high content of glycine
 - Disulfide bonds are important in stabilizing the structure of fibroin
 - The stacked beta-sheets of fibroin are held together by van der Waal's forces
- A) 1,2 & 5 B) 2,4 &5 C) 1, 2 &4 D) 1,3 & 5 E) 2,3 & 4

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22. Which of the following statements about the fibrous protein keratin are UNTRUE?
- 1) Keratin consists of stacked beta-sheets
 - 2) Keratin consists of right-handed helices arranged into left-handed superhelices
 - 3) Keratin has a high content of hydrophobic amino acids
 - 4) The stability of keratin is due to electrostatic interaction between adjacent helical chains
 - 5) Disulfide bonds are important in stabilizing the structure of keratin
- A) 1 & 2 B) 1, 2 & 4 C) 1 & 4 D) 2, 3 & 5 E) 1 & 5
23. Which ONE 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) Globular proteins that contain alpha helical regions never contain regions of beta-sheet
 - E) Fibrous proteins are always exclusively alpha helical
24. 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
25. Which of A), B), C), D) and E) in question 24 above makes the biggest single contribution to the formation and stability of tertiary structure in proteins?
26. The polypeptide backbone in the alpha helix conformation is ___?
- A) in an extended zig-zag structure
 - B) a right handed helix
 - C) a double helix
 - D) a left-handed helix
 - D) a randomly coiled structure
27. The amino acid most likely to disrupt alpha helical structure is ___?
- A) arginine
 - B) tryptophan
 - C) isoleucine
 - D) threonine
 - E) proline

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28. Which of the following statements are TRUE?
- 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) 1,2 & 3 C) 2 & 4 D) 2, 3 & 5 E) 3 & 4
29. 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
30. Which of the following statements are true when a weak acid and its conjugate base are present in equal concentrations in solution?
- 1) $pH = pK_a$ for the acid
 - 2) the solution is neutral
 - 3) $pH = pI$
 - 4) the solution is a buffer
 - 5) OH^- and H^+ concentrations are equal
- A) 1 & 2 B) 3 & 4 C) 2 & 5 D) 1 & 4 E) 3 & 5
31. The role of the enzyme in an enzyme-catalyzed reaction is to:
- A) ensure all the substrate is converted to product
 - B) make the overall free energy change for the reaction more favourable
 - C) increase the rate of conversion of substrate to product
 - D) ensure the product is more stable than the substrate
 - E) increase the equilibrium constant for the reaction
32. Enzymes are potent catalysts. They:
- A) lower the activation energy for the reactions they catalyze
 - 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) drive reactions to completion while other catalysts drive reactions to equilibrium
33. 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

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34. Which of the following are true in relation to the Michaelis - Menten equation and its constants?
- 1) The rate equation assumes that the system is in a steady state, ie [ES] is constant
 - 2) The amount of S bound by E at any given time is negligible compared to the total concentration of S.
 - 3) K_m is the substrate concentration at which enzyme velocity is equal to V_{max}
 - 4) The affinity of an enzyme for a substrate increases as K_m increases.
 - 5) All enzymes that follow Michaelis - Menten kinetics exhibit a sigmoidal dependence of v on [S]
- A) 1 and 2 B) 1, 2 and 3 C) 1, 2, 3 and 4 D) 3, 4 and 5
E) All of the above
35. 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 for the substrate is decreased in the presence of a competitive inhibitor
 - E) the units of K_m are sec^{-1}
36. For an enzyme which follows simple Michaelis-Menten kinetics, what is the V_{max} if $v = 65 \mu\text{mol}/\text{min}$ when $[S] = K_m$?
- A) $50 \mu\text{mol}/\text{min}$ B) $65 \mu\text{mol}/\text{min}$ C) $90 \mu\text{mol}/\text{min}$ D) $110 \mu\text{mol}/\text{min}$
E) $130 \mu\text{mol}/\text{min}$
37. A non-competitive 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. The following results were obtained with an enzyme known to follow Michaelis-Menten kinetics:
- i) K_m for the substrate = 5 mM ; $V_{max} = 900 \mu\text{mol}/\text{min}$.
 - ii) In the presence of an inhibitor, $K_m = 8 \text{ mM}$ and $V_{max} = 900 \mu\text{mol}/\text{min}$. The type of inhibition shown is ?
- A) uncompetitive B) allosteric C) competitive D) non-competitive E) irreversible

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An enzyme-catalyzed reaction was carried out with a substrate concentration 2000 times greater than the K_m for the substrate. After 12 minutes, only 0.5% of the substrate had been consumed and 15 μmol of product had been formed.

39. If one third as much enzyme and twice as much substrate were used, how long would it take for the same amount of product (15 μmol) to be formed?
- A) 4 min B) 6 min C) 18 min D) 24 min E) 36 min
40. If the enzyme concentration was doubled and the substrate concentration halved, how long would it take for the same amount of product (15 μmol) to be formed?
- A) 4 min B) 6 min C) 18 min D) 24 min E) 36 min

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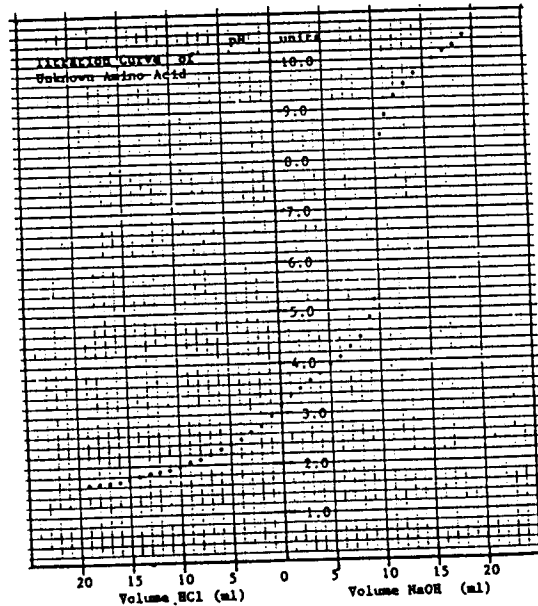
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LAB SECTION (Questions 41 to 50)

For questions 41, 42, 43, 44, 45 and 46 please refer to the following:

The titration curve for 30.0 mL of 0.05 M unknown amino acid with 0.15 M HCl and 0.15 M NaOH is shown below.



41. Which of the five amino acids listed below is the unknown amino acid?

	$pK_a(\alpha\text{-COOH})$	$pK_a(\alpha\text{-NH}_3^+)$	$pK_a(\text{R-gp})$
A) Arginine	2.2	9.0	12.5
B) Aspartic acid	2.4	9.8	4.0
C) Phenylalanine	1.8	9.1	----
D) Serine	2.2	9.1	----
E) Alanine	2.4	9.8	----

42. What is the pI for this unknown amino acid?

- A) 1.4 B) 3.2 C) 4.0 D) 6.1 E) 7.0

43. A solution of this amino acid at a pH of 10.6 would be which of the following?

- A) A more effective buffer for H^+ ions
 B) A more effective buffer for OH^- ions
 C) An equally effective buffer for H^+ and OH^- ions
 D) An effective buffer for neither H^+ nor OH^- ions
 E) None of the above

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- 44. To 100 mL of a 0.1 M solution at pH 9.8 of the same unknown amino acid from question ~~46 and 47~~⁴¹ was added 25 mL of 0.2 M HCl. What is the new pH of the solution?
- A) 3.2 B) 4.0 C) 5.4 D) 6.1 E) 6.9
45. In order to confirm the identity of the unknown amino acid it was subjected to paper chromatography together with the five amino acids listed in question 41 using ethanol: ammonia: water (8:1:1) as the solvent. Which of the following would best describe the resulting position of the unknown amino acid in relation to the other amino acids?
- A) Close[†] to the solvent front
 → B) Close[‡] to the origin
 C) Farthest from the origin
 D) Neither close nor far from the origin but in the middle
 E) At the same position as all the other amino acids
46. After paper chromatography of the amino acids it was necessary to visualise the spots in order to measure the R_f. This was achieved by which of the following?
- A) Staining with biuret reagent to produce purple spots
 B) Adding phenol red to give a colour change
 C) Changing the pH to a highly alkaline pH to bring about a colour change
 D) Adding phenolphthalein and changing the pH to give a colour change
 E) None of the above

For questions 47 and 48 please refer to the following:

An enzyme assay was done by measuring the concentrations of NAD⁺ and NADH in the same sample using a spectrophotometer. Readings were taken for a 1 in 200 dilution of the original sample at two wavelengths, 260 nm and 340 nm, using a 1.2 cm sample holder. The following absorbances were obtained:

0.495 at 260 nm and 0.155 at 340 nm.

The molar extinction coefficients for these two compounds at these two wavelengths are shown below:

	ε, M ⁻¹ cm ⁻¹	
	<u>260 nm</u>	<u>340 nm</u>
NAD ⁺	18,000	0
NADH	15,000	6300

47. What was the molar concentration of the reduced form of the electron carrier in the original sample?
- A) 4.10x10⁻³ M B) 1.16x10⁻³ M C) 5.50x10⁻⁵ M
 D) 2.75x10⁻⁵ M E) 2.05 x 10⁻⁵ M
48. What was the molar concentration of the oxidised form of the electron carrier in the original sample?
- A) 4.58 x 10⁻³ M B) 1.16 x 10⁻³ M C) 2.29 x 10⁻⁵ M
 D) 0.58 x 10⁻⁵ M E) 0.00 M

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49. Which of the following are required conditions of 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

50. 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