BIO 325 TEST 1 Name_ Score_
May 11, 2005

MULTIPLE CHOICE: CHOOSE THE ONE BEST ANSWER AND CIRCLE THE LETTER (1pt each)

1. "Living systems transcend the properties of their component molecules." This means:
   a. that a vital spirit mixes with and alters the properties of the component molecules
   b. that life is a human illusion, and that such systems are no different than non-living systems.
   c. that the systems perpetuate themselves by a molecular logic of the living state
   d. that they violate the laws of physics and chemistry

2. The laws of physics and chemistry, such as the 1st & 2nd laws of thermodynamics, conservation of momentum, law of mass action etc, are valid
   a. in both living and nonliving systems of molecules
   b. in living systems, but not in non-living systems of molecules
   c. in non-living systems, but not in living systems of molecules
   d. in neither living nor nonliving systems of molecules

3. A certain researcher has determined that a certain 1000 of the 30,000 genes are being actively transcribed in a certain human tissue, and the other 29,000 are not. How much information has (s)he gained?
   a. 1,000 bits
   b. 2,000 bits
   c. 29,000 bits
   d. 30,000 bits
   e. $(2)^{30,000}$ bits

4. Which is the weakest of these four interactions?
   a. A hydrogen bond between two water molecules
   b. A covalent bond between the O and H atoms of water
   c. An ionic interaction between a carboxylic acid and a nearby amine (in aqueous solution)
   d. A van der Waals interaction between two methyl groups

5. How are vitalism and systems theory different?
   a. Vitalists believe that organisms are living; systems theorists believe they are non-living.
   b. Vitalists believe an extra non-physical spirit must be added to matter to make it living; systems theorists believe life arises from the organization of the matter.
   c. Vitalists believe that the fundamental principle of life is "negative feedback"; systems theorists think it is "DNA."

6. Which of these four forces is stronger, the more linear the bond?
   a. van der Waals interactions
   b. Hydrogen bonds
   c. Ionic interactions
   d. Hydrophobic interactions

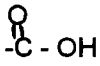
7. Which of these four forces fits the description: The only one of the forces to require an aqueous milieu.
   a. Van der Waals interactions
   b. Hydrogen bonds
   c. Ionic interactions
   d. Hydrophobic interactions

8. The Powers of Ten web site that I asked you to view demonstrates:
   a. that the Power of the universe is vitalistic
   b. that Nature is a nested, embedded, and inclusive organizational hierarchy
   c. scientists must use holistic rather than reductionistic inquiry in order to understand the universe
   d. that most systems have ten subsystems

9. The whole point of the Bioxerox machine was to illustrate

a. that life can be defined as the sum of its atoms
b. that life is an illusion
c. that life is an emergent property of properly organized physical-chemical systems
d. that cooling a human being to -273°C will generally kill them

10. Which functional group is WRONG?

a. amino group  b. carboxyl group 

c. carbonyl group  d. sulfhydryl group - SH

11. Which is larger, covalent radii or van der Waals radii?
a. covalent radii
b. van der Waals radii

12. The closest water molecules to a hydrated sodium ion will be oriented
a. randomly
b. with their hydrogen atoms closer to the sodium
c. with their oxygen atoms closer to the sodium

13. The van der Waals radius of an atom:
a. equals half the length of the covalent bond
b. is the radius of its nucleus, i.e., the atom stripped of its electrons
c. determines how far away energy radiates from the atom
d. defines the region of electron repulsion

14. Here are approximate energies, but one is wildly wrong. Which is wrong?
a. covalent single bond average energy – 400 kilojoules/mole
b. weak bond average energy – 200 kilojoules/mole
c. thermal energy – 3 kilojoules/mole

15. Which of the following statements about water is FALSE?
a. The water molecule is dipolar because of the polarity of the O-H bond.
b. Cold water has almost as many hydrogen bonds at any instant as ice does.
c. Water is the most prevalent molecule in the cells, both by weight and number.
d. The cohesiveness of water is a consequence of its strong hydrogen-bonding ability.
e. The specific heat of water is about 1000 calories per gram per degree

16. The answer is: "Random diffusion and stereospecific selection." Therefore the question is:
a. What kind of long-range force does biological structure depend on?
b. What process is responsible for the buildup of order in biological systems?
c. What is the molecular basis of dialysis?
d. What is the molecular basis of osmosis?
e. When a water molecule ionizes, what determines where the proton goes?

17. If one methyl group is 0.2 nm from another methyl group,
a. they will be too far apart to interact
b. they will attract by an ionic bond
c. they will attract by a hydrogen bond
d. they will attract by a van der Waals force based on transient-dipole induced-dipole interaction
e. they will attract only if they are in water

18. A buffer resists changes in pH best when:
a. the pH is more than 2.0 pH units from the pK
b. a base is added to the solution rather than when an acid is added
c. pH = pKa (i.e., the pK of the weak acid)

(cont'd)

d. [conjugate base] + [weak acid] = 1

19. The Henderson-Hasselbalch equation is:
    a. pH = pK + log [base]/[acid]
    b. pK = pH + log [base]/[acid]
    c. pH = pK - log [base]/[acid]
    d. pH = pK + log [acid]/[base]
    e. log pH = log pK + [base]/[acid]

20. The pH of saliva is 6.6. Therefore, its $[H^+]$ is:
    a. 6.6×10^{-6}
    b. 2.5×10^{-7}
    c. 4×10^{-1}
    d. 4×10^{-8}

21. The major blood-buffering compounds include all BUT WHICH of the following?
    a. hemoglobin
    b. proteins in the blood serum
    c. bicarbonate ion
    d. phosphate ions
    e. micelles

22. Harold Blum says: "The small local decrease in entropy represented in the building of the organism is coupled with a much larger increase in the entropy of the universe." What does he mean by the "small local decrease in entropy"?
    a. the order that arises from the construction of an organism
    b. the disorder that arises due to the emanation of heat and sweat from a metabolizing person

23. Is Blum saying that $\Delta G = \Delta H - T\Delta S$ is violated?
    a. Yes b. No

24. The standard free energy of hydrolysis of ATP is given as -30.5 kJ/mol. Nevertheless, hydrolysis of ATP in vivo can release 50 kJ/mol, and the cost of producing ATP is 50 kJ/mol. What is the reason for this difference (between 30.5 and 50)?
    a. ATP in vitro is measured without Mg^{++} ion complexed with it.
    b. The cellular milieu is more energetic than the test tube solution of ATP
    c. The ATP system is not at standard concentrations, but rather there is a lot more ATP than ADP.
    d. The calculation for in vivo ATP hydrolysis assumes that not only the terminal (third) phosphate is released, but also the second phosphate.

25. The second law of thermodynamics can be stated, that in an isolated system,
    a. the quality of energy = the quantity of energy
    b. the quality of energy increases
    c. the quality of energy declines
    d. the quantity of energy decreases

26. In the hydraulic analogy, the depth of the water represents:
    a. the free energy G
    b. the concentration of molecules in that state
    c. the enthalpy in the chemical bonds of the molecules in that state
    d. the entropy of the molecules

27. We might properly call ATP an intermediate-energy compound because:
    a. some phosphorylated compounds have larger ΔG's, some have smaller
    b. some phosphorylated compounds have larger molecular weights, some have smaller
    c. some phosphorylated compounds arose earlier in evolution, some later

28. In a compost pile, the signs of the these three quantities are as given:
    $\Delta G = \Delta H + (-T\Delta S)$ $\Delta S = -$

a.	+	–	–
b.	+	–	+
c	+	+	–
d.	–	–	–
e	–	–	+

40. All of the amino acids EXCEPT ___ have both free α-amino and free α -carboxyl groups.
    a. aspartic acid
    b. proline
    c. asparagine
    d. lysine
    e. valine

41. The amino acid with a side-chain pKa near neutrality and which therefore plays an important role as proton donor and acceptor in many enzyme-catalyzed reactions is:
    a. histidine
    b. cysteine
    c. proline
    d. serine
    e. methionine

42. The pKa of the a-carboxyl group of amino acids is ___ by the nearby presence of the a-amino group.
    a. increased
    b. decreased
    c. unchanged

43. The zwitterion form of an amino acid:
    a. contains an NH2 and a COOH
    b. contains an NH3+ and a COOH
    c. contains an NH3+ and a COO-
    d. contains an NH2 and a COO-

44. Glutamic acid has pKa's at 2.2, 4.3, and 9.7. Calculate the isoelectric point for glutamic acid.
    a. 3.25
    b. 4.3
    c. 5.4
    d. 5.95
    e. 7.0

45. Which of these peptides would absorb light at 280 nm?
    a. ala-lys-his
    b. ser-gly-asn
    c. ala-ala-trp
    d. val-pro-leu
    e. ser-val-ile

46. Using a cation exchange resin, a mixture of four amino acids is separated using an elution gradient of increasing NaCl solution. Given the pK_R's on the right, what would be the correct elution sequence?

    a. asp, arg, ser, lys
    b. arg, asp, lys, ser
    c. lys, arg, asp, ser
    d. asp, ser, lys, arg
    e. ser, asp, lys, arg

	pK_R
Arg	12.5
Asp	3.9
Lys	10.5
Ser	-

47. Chapter 4 contains diagrams of over 40 amino acids. What is true of this list?
    a. The genetic code inserts just 20 different amino acids, but other amino acids are either formed by post-translational modification, or are active in the cell as free amino acids.

b. The study of amino acid composition is relatively new so we are discovering that more and more amino acids are inserted via protein biosynthesis than we had originally guessed.
c. Although the list is over 40, only 20 have one amino and one carboxyl group; the others are odd in that some have two amino groups and no carboxyl groups, and others have two carboxyl groups and no amino groups.

48. What is a conjugated protein?
A protein which can bind to a ligand
A protein which has more than one different kind of AA
A protein which contains some other kind of chemical group besides amino acids
An extracellular protein

49. A particular enzyme, call it X, is isolated from ten different organisms. There are variations in the amino acids at many sites in the sequence. But the 4th AA is always His. Therefore His appears to be:
a. a conservative residue
b. a variable residue
c. an invariant residue

50. When the equation, $\Delta G = \Delta H - T\,\Delta S$, is applied to biochemical problems, the ΔH represents
a. the increase in entropy of the system
b. the work done by the system
c. the change in temperature of the system
d. the change in bond energies of the system

NON-MULTIPLE CHOICE QUESTIONS
51. (5) Give approximate numbers for the following:

a. # bits of information in one codon_____

b. average length of a hydrogen bond, from Donor atom to Acceptor atom_

c. the S-value (in svedberg units) of an average sized protein___ ___

d. the number of possible dipeptides, assuming just 20 AA possibilities ___

e. the number of classes of proteins _

52. (10) One wishes to make a 10 mM solution of formic acid (HCOOH).
a. Using 1, 12, & 16 for the atomic masses, how much formic acid powder should be added to make one liter of this 10 mM solution?

b. When this solution dissociates, the resulting pH is 2.88. What is the [H+]?

c. Calculate the Keq of formic acid.

d. What is the pK_a of formic acid?

e. If NaOH is added to adjust the pH to 4.0, calculate the ~~concentration of~~ resulting $HCOO^-$ concentration.

53. (4) An enzymatic hydrolysis of AMP

AMP + H2O → Adenosine + Pi

was allowed to proceed to equilibrium at 25oC. The original concentration of AMP was 0.3 M but when the system reached equilibrium, the concentration of AMP was only 0.0022 M. Calculate the equilibrium constant for this reaction and the free energy of hydrolysis of Glc-6-P. (Take RT to be 2.48 kJ/mol.)

54. (4) The 3rd step of glycolysis is the phosphorylation of Fruc-6-P by ATP:

Fructose-6-P + ATP → Fructose-1,6-BP + ADP $\Delta G^{o'} = -14.2$ kJ/mol

Under actual cellular conditions, the ratio of F-1,6-B-P to F-6-P is about 50 to 1.
Assuming that the ATP and ADP concentrations are 4.5 mM and 0.6 mM respectively, calculate the (physiological, or in vivo) ΔG for this reaction.

55. (3) Use the data from #56, and the data that [AMP] = 0.07 mM to calculate the energy charge of this cell.

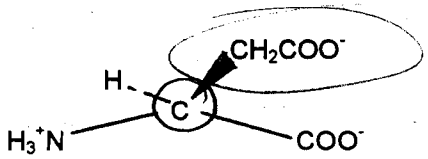
56. (2) What is special about the amino acid cysteine?

57. (4) Put X's in the proper boxes to indicate the class of each of the following amino acids

	Nonpolar	Polar uncharged	Acidic	Basic
Threonine				
Lysine				
Valine				
Phenylalanine				

9½

58. (2) The next five questions concern Aspartic Acid. Is this L-Asp or D-Asp?



59. (2) Circle all atoms that are chiral in the above molecule.

60. (3) Draw a titration curve of Aspartic acid given that pK_R of Asp = 3.9, pK_N = 9.9, and pK_C = 1.99.

61 (3) Calculate the ratio of the basic and acidic forms of the Asp R group at pH 7.

62. (3) The average occurrence of Asp in proteins is 5.3%. How many Asp residues would we predict in an average size protein? (Show your assumptions.)

63. (6) Draw the structure of Ser.Ala.Glu.Gly. at pH 7 given that the R-groups are: $-CH_2OH$, $-CH_3$, $-CH_2-CH_2-COOH$, and $-H$, respectively.

64. (4) Calculate the pI of the tetrapeptide in the previous question, given that pK_R of Glu = 4.07, and assuming standard values for the terminal amino and carboxyl groups..

65. (4) Here are four experimental techniques or terms that might be used during protein fractionation. Before each technique insert the letter of the corresponding basis of the technique or term.

SDS-PAGE	a. differential solubility in salt solutions
Ammonium sulfate precipitation	b. differential affinity for solid/mobile phases
UV absorption at 280 nm	c. differential response to external applied electric field
Anion exchange chromatography	d. differential response to electromagnetic radiation

66. (2) Why must one have an assay before attempting protein purification?

67. (4) A small peptide is isolated and cleaved with either trypsin or chymotrypsin.

The trypsin fragments are:	The chymotrypsin fragments are:
His.Trp.Ala.Arg	Asp.Met.
Leu.Phe.Asp.Met.	Ser.Gly.Cys.Lys.His.Trp
Ser.Gly.Cys.Lys.	Ala.Arg.Leu.Phe.

Determine the amino acid sequence of the original peptide.

68. (4) One wants to separate a solution of the following four proteins. Answer "a" thru "d" by a checkmark in the appropriate box. (Just one checkmark per column)

	MW	pI	SEC	CEC	Electroph	SDS-PAGE
Myoglobin	16,890	7				
Cytochrome c	13,000	10.7				
Lysozyme	13,930	11				
Hexokinase	102,000	8.3				

SEC = size exclusion chromatography or gel filtration
CEC = cation exchange chromatography

a. Which protein will elute first off of a size exclusion column?
b. Which protein will elute first off of a cation-exchange column?
c. Which protein(s) would migrate toward the anode during electrophoresis at pH 8.0?
d. Which protein would migrate furthest during SDS-PAGE?

69. (4) The AA sequence of the cytochrome c molecules from chimpanzee and tuna are the same except at 21 sites.
(a). Are these two molecules homologous? (Yes or no)

(b) What is the explanation for why they are or aren't?

70. (12) You intend to isolate and study one of the enzymes of glycolysis, fructose-1,6-bisphosphate (abbreviated FBP). You are following a protocol from your mentor. Answer the following questions by putting the numbers 1 to 12 in the slots, choosing the numbers from the second list below. Use each number only once.

___(a) You start with two liters of a yeast cell culture grown in the lab. Why so many cells?
___(b) You chill the cells and carry out all further steps at 4°C. Why so cold?
___(c) You whirr them in a Waring blender for 5 minutes. Why?
___(d) You slow-speed centrifuge and throw away the pellet. Why?
___(e) You dialyze the supernatant against a buffer. Why?
___(f) You add ammonium sulfate to a specific concentration and throw away the resulting pellet. Why?
___(g) You add more ammonium sulfate and save the pellet. Why?
___(h) You run the resuspended pellet through a size-exclusion chromatographic column. The instructions tell you to save the first sample and toss the rest of the samples. What does this tell you about the enzyme?
___(i) You test that this first sample really contains protein by UV absorption at 280 nm. Why does this work?
___(j) After several more fractionations, you use isoelectric focusing and find 3 bands. Why are there 3 bands?
___(k) The instructions tell you to save the one at pI = 8.1. You cut that out and subject it to SDS-PAGE. There is only one resulting band. What does that tell you?
___(l) You treat part of your sample with 6 M HCl for 24 hours. Why?

1. get rid of small MW contaminants
2. Phe, Trp, Tyr are aromatic components of proteins
3. FBP is at low concentration in living cells
4. May be pure
5. prevent FBP denaturation
6. FBP does ppt at this salt concentration, and some other proteins don't
7. FBP doesn't ppt at this salt concentration, and some other proteins do
8. break open cells
9. Prep for AA composition studies
10. subcellular organelles and pieces of membrane
11. There are at least two contaminants
12. It's a large protein

71. (6) You finish preparing your sample of FBP, and present the following table to your mentor.

Fill in the last two columns.

Procedure or step	Fraction volume (ml)	Total Protein (mg)	Activity (units)	Spec.Act. (units/mg)	Purification
Crude cellular extract	1,800	9,000	100,000		
Ammon.Sulf. steps	235	2,500	94,000		
Size-Excl Chrom.	110	260	80,000		
Ion-Exchange Chrom	100	45	70,000		
Isoelectric focusing	15	7	60,000		
SDS PAGE	8	5	44,000		