C383 Exam 1
Fall 2015

Name Key Seat Number _____

Student ID _____ AI _____

The last page of this exam contains equations, constants, pKa values, and other information you might find useful.
The exam consists of 10 questions worth 100 points plus 5 bonus points on a total of 12 pages. It will be scored out of 100 points.

1-15 _____/30 multiple choice

16-30 _____/30 fill in the blank

31 _____/10

32 _____/10

33. _____/10

34. _____/10

Bonus _____/5

Total:

Regrading: All requests for regrades must be submitted in writing within 48 hours of the return of the exam. You must explicitly state what has been misgraded and why it is an error. The entire exam will be regraded, which could result in points being added or deducted overall.

Section 1: Multiple Choice. 15 questions, 2 points each.

1. A What pairs of atoms in nucleotide bases are involved in hydrogen bonds?

A) N–H and C=O
B) N–H and S–H
C) O–H and P–O
D) O–H and N–H
E) None of the above.

2. C What is the $[A^-]/[HA]$ ratio of an acid with pKa = 5.5 when it is in a solution at pH 6.5?

A) 1:1
B) 1:10
C) 10:1
D) 2:1
E) None of the above.

3. C Citric acid is an important intermediate in glucose metabolism and is synthesized in the mitochondrial matrix. The three pK_a values for each of the carboxylic acids are 3.1, 4.8, and 6.4. What would the charge be on a citrate molecule formed in the mitochondrial matrix where the pH is 7.8?

A) +3
B) +2
C) -3
D) -2
E) None of the above.

4. C Which of the following amino acid residues would most likely be buried in the interior of a water-soluble, globular protein?
A) aspartate
B) serine
C) phenylalanine
D) lysine
E) glutamine

5. D Which of the following is a major stabilizing force in protein secondary structure but not tertiary structure?

A) ionic attractions between oppositely charged side chains.
B) H-bonding between polar side chains.
C) hydrophobic interactions between nonpolar side chains.
D) H-bonding between the oxygen of the backbone carbonyl and the hydrogen of the backbone amine.
E) increase in entropy by exclusion of water from the helix.

6. C Which of the following techniques can be used to determine the size of a target protein?

A) Edman degradation
B) affinity chromatography
C) SDS-PAGE
D) isoelectric focusing gel
E) None of the above

7. A A reaction always occurs spontaneously if …

A) ΔG is negative.
B) ΔG is positive.
C) $\Delta G^{0'}$ is zero.
D) $\Delta G^{0'}$ is negative.
E). $\Delta G^{0'}$ is positive.

8. B The conversion of glucose-6-phosphate to fructose-6-phosphate is catalyzed by an isomerase enzyme. Glucose-6-phosphate was mixed with the enzyme under standard conditions and the reaction was allowed to come to equilibrium. If the K_{eq}' is 0.50, what is the $\Delta G°'$ in kJ/mol?

A) +0.99
B) +1.71
C) 0, as defined by equilibrium conditions
D) –0.99
E) The answer cannot be determined from this data

9. E A polynucleotide is denoted by the shorthand notation pApCpG. Which statement concerning this trinucleotide is false?

A) A phosphate is attached to the 5′ of the adenosine nucleotide unit.
B) A guanine residue is linked to the cytidine residue through a phosphodiester linkage.
C) The cytosine nucleotide has a free hydroxyl group.
D) One of the nucleobases is a pyrimidine.
E) An endonuclease that cleaves only between purine residues would cleave this polynucleotide once.

10. E The mole-fraction composition of a single strand of an RNA molecule is [U] = 0.19 and [C] = 0.33. What can you say about the [A] and [G] of this RNA?

A) [A] = 0.19, [G] = 0.33
B) [A] = 0.33, [G] = 0.19
C) [A] =0.24, [G] = 0.24
D) [A] > [U], [G] > [C]
E) There is not enough information to determine [A] and [G].

11. B After two generations of replication in the Meselson and Stahl experiment, what was the composition of the two bands?

A) One band was all ^{14}N and one band was all ^{15}N.
B) One band was all ^{14}N and one band was half ^{14}N and half ^{15}N.
C) One band was all ^{15}N and one band was half ^{14}N and half ^{15}N.
D) One band was all ^{14}N and one band was one quarter ^{14}N and three quarters ^{15}N.
E) One band was all ^{15}N and one band was one quarter ^{14}N and three quarters ^{15}N.

12. A Which statement is false concerning 2-D gel electrophoresis?

A) It is a highly effective way to determine protein sequence.
B) It is a highly effective way to separate out mixtures of many proteins.
C) It can be used to compare concentrations of proteins from cells in different physiological states.
D) It first separates proteins based on isoelectric point, then based on size.
E) It uses SDS as one if its reagents.

13. C The isoelectric point of the lysine-aspartate dipeptide is about

A) 2
B) 4
C) 6
D) 8
E) 10

14. D Which statement concerning protein tertiary structure is false?

(accept C)

A) In proteins such as Ribonuclease A, the information necessary for the tertiary fold is found in the primary sequence.
B) Loops and turns are generally hydrophilic and tend to exist on the outside of a globular protein.
C) Motifs such as helix-turn-helix are commonly found in ~~protein~~ DNA binding proteins.
D) Disulfide bonds generally stabilize secondary structure more than tertiary structure.
E) Some proteins fold into a number of tertiary structures that are relatively equal in stability.

15. D The active site of an enzyme catalyst

A) Always binds the substrate very tightly.
B) Always binds to a coenzyme.
C) Always has an acidic amino acid sidechain.
D) Always lowers the activation energy of a reaction.
E) Always raises the standard free energy of a reaction.

Section 2: Fill in the blank. 15 questions 2 pointe each

16. The lock and Key model of the enzyme active site does not effectively account for transition state binding.

17. Two amino acids that tend to disrupt α-helical structure are proline and glycine.

18. A helical wheel can be used to show that an alpha-helix is amphipathic if most of the polar and charged residues are on one side while the hydrophobic residues are on the other side of the helix.

19. The melting point (T_M) is the temperature at which a double helix of DNA denatures.

20. The hydrophobic effect explains why it is thermodynamically favorable for a phenylalanine sidechain to become buried in the center of a globular protein.

21. When blood pH drops, the compound bicarbonate ($HO\overset{O}{\overset{\|}{C}}O^-$) reacts with acid to form carbonic acid (H_2CO_3), which is then transformed into carbon dioxide and exhaled. (Write name or structure.)

22. The nucleobases (G) Guanine and C (Cytosine) base pair to each other through three hydrogen bonds.

23. Enzymes that join together two molecules using the energy of ATP hydrolysis belong to the ligase enzyme class.

24. A glycinamide buffer would be effective in the pH range of 7.2 to 9.2.

25. Proteins that bind to DNA are rich in the amino acids arginine and lysine.

26. The one letter abbreviation for the amino acid tryptophan is W.

27. Van der Waals is the intermolecular force that occurs between two nonpolar molecules.

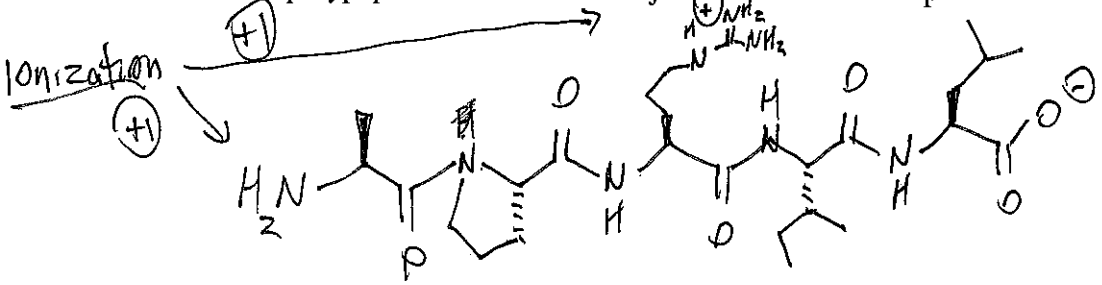
28. A 0.001 M NaOH solution has a pH of 11.

29. Amino acids that must be obtained from the diet are called essential.

30. In a protein, the majority of the amino acids are in the trans conformation because bad steric interactions are minimized.

Section 3. Problems. 4 questions 10 points each.

31. Draw the polypeptide APRIL in its major ionization state at pH 9.



ionization +3
backbone +1
stereo +1
ionization +1
sidechains +3
-1 per error

If there were an R→V mutation in this peptide, how would the peptide solubility at pH 9 be affected? Explain.

+1 Solubility diminished
+1 because it would be more nonpolar (less ionic)

32. Tris buffers are commonly used in biochemistry labs because they have a pKa of about 8.3. To demonstrate the buffering capacity of Tris buffer, your biochemistry lab teaching assistant has given you one liter of a 0.1 M Tris buffer at pH 7.4.

What % of the buffer molecules are in their conjugate base form?

(+4)
$$pH = pK_a + \log \frac{A^-}{HA}$$
$$7.4 = 8.3 + \log \frac{A^-}{HA}$$
$$0.12 = \frac{A^-}{HA}$$

(+2) $\%\ A^- = \frac{0.12}{1.12} = 11\%$

What are the concentrations of the acid and conjugate base in this buffer?

(+2) $89\%\ HA\ (0.1\ M) = 0.089\ M$

$11\%\ A^-\ (0.1\ M) = 0.011\ M$

Add 2 mL of 1M NaOH to this buffer and calculate what the new pH will be.

(+2) $0.002\ L\ (1\ \frac{mol}{L}) = 0.002\ mol\ OH^-$

Final
$$[HA] = 0.089 - 0.002 = 0.087\ M$$
$$[A^-] = 0.011 + 0.002 = 0.013\ M$$

} includes assumptions of negligible volume change

Final pH
$$pH = 8.3 + \log \frac{0.013}{0.087} = 7.5$$

33. The enzyme aldolase catalyzes the following reaction:

Fructose-1,6-bisphosphate ← → dihydroxyacetone phosphate + glyceraldehyde 3-phosphate

When this reaction was run under standard conditions, the free energy of the reaction was determined to be +23.8 kJ/mol. Under normal cellular conditions, typical concentrations of these substances are 0.15 mM fructose 1,6-bisphosphate, 4.3 x 10^{-6}M dihydroxyacetone phosphate, and 9.9 x 10^{-5} M glyceraldehyde 3-phosphate.

(+3) A. What is $\Delta G^{0'}$ for this reaction?

$\Delta G^{0'} = +23.8$ KJ/mol

(+3) B. What ΔG for this reaction?

(accept T = 310K or 298K)

$$\Delta G = \Delta G^{0'} + RT \ln \frac{[DHAP][G\text{-}3\text{-}P]}{[F1,6BP]}$$

$$= +23.8 \frac{KJ}{mol} + 298K\left(8.314 \frac{J}{mol\,K}\right) \ln \frac{(4.3\times10^{-6})(9.9\times10^{-5})}{(0.15\times10^{-3})}$$

$$= +23.8 - 31.6 \frac{KJ}{mol} \quad (\text{or } -32.9)$$

$$= -7.8 \text{ KJ/mol} \quad (\text{or } -9.1 \text{ KJ/mol})$$

(+2) C. Is this reaction spontaneous or nonspontaneous under cellular conditions? Explain.

It is spontaneous (negative ΔG)

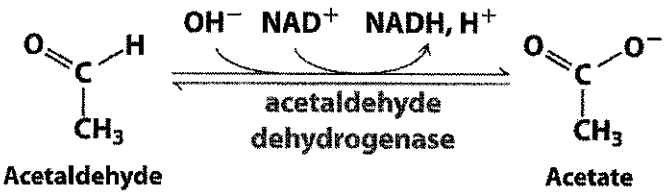
(+2) D. If this reaction were to reach equilibrium in the cell, would the concentration of products increase, or would the concentration of reactant increase? Explain.

It is spontaneous toward forming products, so the [P] would increase.

34. Given the name of the enzyme or the reaction it catalyzes, predict the class to which the enzyme belongs.

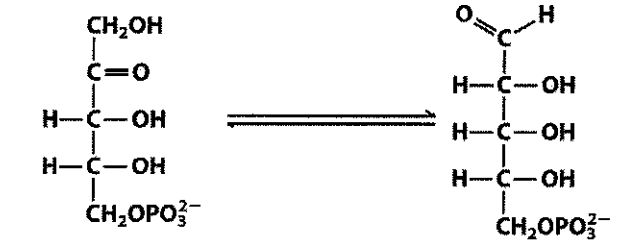
A. phosphoglycerate mutase transferase (+2)

B.



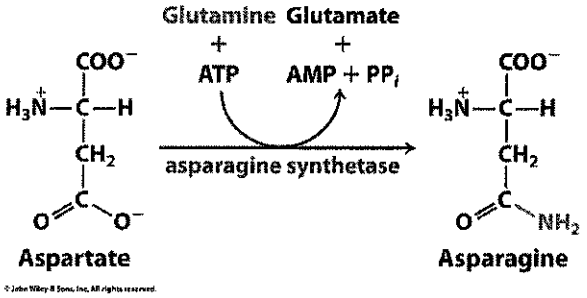
Oxidoreductase (+2)

C.



isomerase (+2)

D.



ligase (+2)

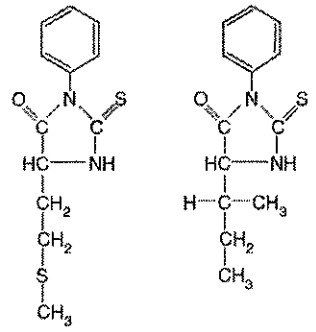
(accept transferase)

E. Ribonuclease A hydrolase (+2)

hydrolysis

Bonus: A hexapeptide that is part of a mouse hormone was hydrolyzed to give the following amino acids: Tyr, Cys, Glu, Ile, Lys, Met. Two cycles of Edman degradation of the intact hexapeptide releases the following PTH-amino acids:

FIGURE 5.1



Cleaving the intact protein with cyanogen bromide yields methionine and a pentapeptide. Treating the hexapeptide with trypsin yields a dipeptide, which contains tyrosine and glutamate, and a tetrapeptide. When the intact hexapeptide is treated with carboxypeptidase A, a tyrosine residue and a pentapeptide are produced. Write the hexapeptide sequence suing both three and one letter abbreviations. **Explain how you arrived at your answer** to receive credit.

(+2) MICKEY

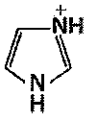
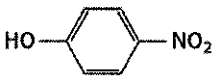
(43)
1) Edman gives M then I
2) Trypsin cuts after #4, which is K
   #5+6 are Y and E
3) Carboxypeptidase gives Y as #6
4) By process of elimination, Cys = #3

Useful Information:

$$\Delta G_{reaction} = \Delta G^{o\prime}_{reaction} + RT \ln \frac{[products]}{[reactants]}$$

$\Delta G^{0'} = -RT \ln K_{eq}$ R = 8.314 J/mol.K

TABLE 2.4 pK Values of Some Acids

Name	Formula [a]	pK
Trifluoroacetic acid	CF_3COOH	0.18
Phosphoric acid	H_3PO_4	2.15[b]
Formic acid	$HCOOH$	3.75
Succinic acid	$HOOCCH_2CH_2COOH$	4.21[b]
Acetic acid	CH_3COOH	4.76
Succinate	$HOOCCH_2CH_2COO^-$	5.64[c]
Thiophenol	C_6H_5SH	6.60
Phosphate	$H_2PO_4^-$	6.82[c]
N-(2-acetamido)-2-aminoethanesulfonic acid (ACES)	$H_2NCOCH_2\overset{+}{N}H_2CH_2CH_2SO_3^-$	6.90
Imidazole		7.00
p-Nitrophenol		7.24
N-2-hydroxyethylpiperazine-N′-2-ethanesulfonic acid (HEPES)		7.55
Glycinamide	$^+H_3NCH_2CONH_2$	8.20
Tris(hydroxymethyl)-aminomethane (Tris)	$(HOCH_2)_3C\overset{+}{N}H_3$	8.30
Boric acid	H_3BO_3	9.24
Ammonium ion	NH_4^+ 9.25	
Phenol	C_6H_5OH	9.90
Methylammonium ion	$CH_3NH_3^+$	10.60
Phosphate	HPO_4^{2-}	12.38[d]

[a]The acidic hydrogen is highlighted in red; [b]pK_1; [c]pK_2; [d]pK_3.

Amino acid pKa values

C-terminal	3.1
N-terminal	8.0
Aspartate, glutamate	4.1
Histidine	6.1
Cysteine	8.3
Tyrosine	10.9
Lysine	10.8
Arginine	12.5

Table 5.3 Specific cleavage of polypeptides

Reagent	Cleavage site
Chemical cleavage	
Cyanogen bromide	Carboxyl side of methionine residues
O-Iodosobenzoate	Carboxyl side of tryptophan residues
Hydroxylamine	Asparagine-glycine bonds
2-Nitro-5-thiocyanobenzoate	Amino side of cysteine residues
Enzymatic cleavage	
Trypsin	Carboxyl side of lysine and arginine residues
Clostripain	Carboxyl side of arginine residues
Staphylococcal protease	Carboxyl side of aspartate and glutamate residues (glutamate only under certain conditions)
Thrombin	Carboxyl side of arginine
Chymotrypsin	Carboxyl side of tyrosine, tryptophan, phenylalanine, leucine, and methionine
Carboxypeptidase A	Amino side of carboxyl-terminal amino acid (not arginine, lysine, or proline)

Table 5.3
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