

C383 Exam 1
Spring 2016

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. Refer to the last page for needed data and equations.

1. C The net charge on tyrosine in a pH 8 solution is approximately
- A) +1
 - B) +1/2
 - C) 0
 - D) -1
 - E) -2
2. A Glycine has pKa values of 2.4 and 9.8. At which of the following pHs would it best serve as a buffer?
- A) 2.1
 - B) 3.1
 - C) 6.1
 - D) 8.1
 - E) 9.1
3. B If the composition of a sample of double stranded DNA is found to be 20% T, then the composition of G would be
- A) 20%
 - B) 30%
 - C) 40%
 - D) 50%
 - E) Cannot be determined from these data.
4. A Which of these amino acids is capable for forming a salt bridge?
- A) aspartate
 - B) serine
 - C) phenylalanine
 - D) leucine
 - E) glutamine

5. D Introducing a nonpolar molecule into water results in _____, which causes the nonpolar molecules to aggregate.

- A) an increase in water hydrogen-bonding
- B) a decrease in water hydrogen bonding.
- C) an increase in the entropy of water
- D) a decrease in the entropy of water

6. D The pH of a solution containing 0.3M weak acid and 0.4 M of its conjugate base is

- A) Below 7
- B) 7
- C) Above 7
- D) Cannot be determined from these data

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. E The sidechains on an alpha-helix that spans the cell membrane will tend to be

- A) rigid
- B) charged
- C) small
- D) aromatic
- E) nonpolar

9. A The residues of a polynucleotide are linked by

- A) Phosphodiester bonds
- B) Peptide bonds.
- C) Phosphoanhydride bonds
- D) Disulfide bonds.
- E) Hydrogen bonds.

10. C Which of the following statements is false concerning DNA double helix structure?

- A) It is composed of two polynucleotide chains that run antiparallel to each other.
- B) Base pairs are stacked closely enough to maximize van der Waals interactions.
- C) Complementary bases pair in a way to minimize H-bonding interactions.
- D) The DNA backbone is on the outside of the helix, exposed to the aqueous environment.
- E) Water is excluded from the middle of the double helix.

11. D An alpha helix

- A) Is a common motif in protein structure.
- B) Is maintained by side chain hydrogen bonding.
- C) Generally contains multiple proline residues.
- D) Is highly polar.
- E) Is left-handed.

12. B^{or}C^{or}D If a protease were known to have an aspartate residue in its specificity pocket, a mutation of this residue to lysine would most likely

- A) Cause the enzyme to be more substrate specific.
- B) Change its substrate specificity.
- C) Make the enzyme more promiscuous.
- D) Cause the enzyme to be less substrate specific.
- E) Favor product binding.

13. D Diseases like mad cow disease and Alzheimer disease are similar in that they are both caused by _____ proteins.

- A) allosteric
- B) highly polar
- C) negatively charged
- D) misfolded

14. A Which of these would be the most effective buffer at pH 4.5?

- A) 1 M acetate/acetic acid
- B) 0.1 m acetate/acetic acid
- C) 1 M ammonia/ammonium
- D) 0.1 M ammonia/ammonium

15. C At its isoelectric point, the major form of alanine has a net charge of

- A) -1
- B) -1/2
- C) 0
- D) +1/2
- E) +1

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

16. The fraction of lysine sidechain that is protonated at pH 9.8 is 90% 91 %.

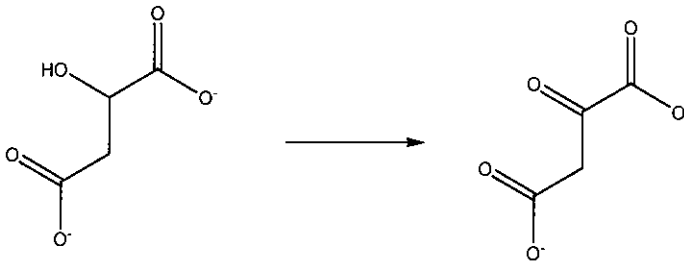
17. An independently folded unit in the tertiary structure of a polypeptide is called a domain.

18. Two polypeptides can be linked covalently through a disulfide peptide bond.

19. A turn (reverse turn) is an irregular secondary structure, often comprised of 4 amino acids, which allows for a reversal in the direction of the peptide chain.

20. Collagen is a fibrous protein with triple helical cable structure comprised mainly of glycine, proline, and hydroxyproline.

21. The only amino acid naturally occurring in humans that is not an L-amino acid is glycine.
22. While catalyzing a reaction, an enzyme binds most strongly to the Transition State structure.
23. Kinases belong to the transferase class of enzymes.
24. Hydrolysis of ATP has a standard free energy of -30 kJ, and hydrolysis of glucose-6-phosphate has a standard free energy of about -14 kJ. If both reactions started at standard state and were allowed to reach equilibrium, ATP would be hydrolyzed to a greater degree.
25. The reaction below would be catalyzed by an enzyme belonging to the Oxidoreductase class of enzymes.



26. Exonucleases, peptidases, and phosphatases are all similar enzymes in that they catalyze hydrolysis reactions. hydrolase (+1)
27. A nucleobase attached to ribose is called a ribonucleoside.
*nucleoside ✓
 ribonucleic acid*
28. A 0.001 M HCl solution has a pH of 3.
29. The specific activity of a protein fraction gets higher (higher/lower) as the protein becomes more purified.
30. The midpoint of a titration curve is used to determine the pKa of an acid.
concentration ✓

Section 3. Problems. 4 questions 10 points each.

problem
2.12

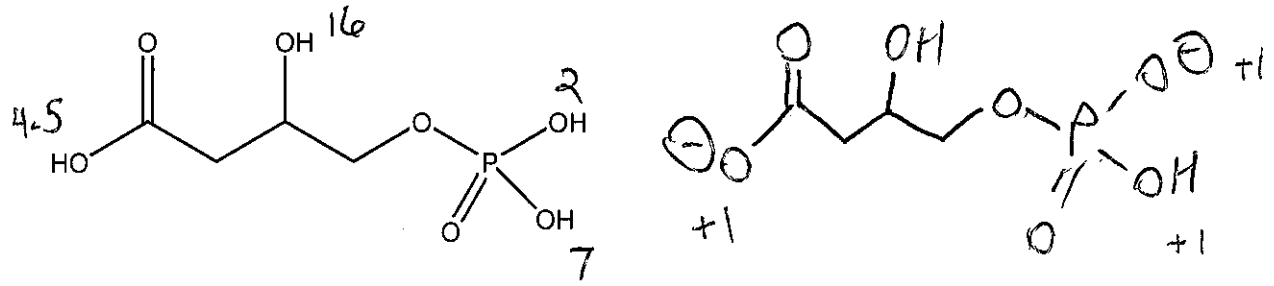
31. Acid-base chemistry: Use the Henderson-Hasselbalch equation to show that, for a weak acid, the pKa is the pH at which the concentration of the acid equals the concentration of the conjugate base.

IF $[HA] = [A^-]$, then $\frac{[A^-]}{[HA]} = 1$

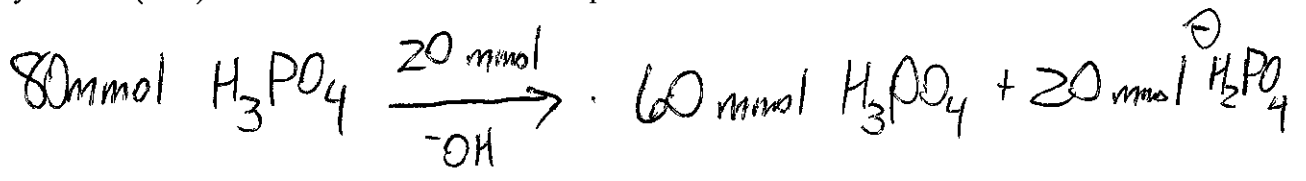
$pH = pK_a + \log 1$

$pH = pK_a$ +3

Draw this molecule in the major ionization state you would expect at pH 6.



80 mmol of phosphoric acid (H_3PO_4 , $pK_{a1} = 2.14$, $pK_{a2} = 6.86$, $pK_{a3} = 12.4$) is treated with 20 mmol of hydroxide (OH^-) to make a buffer. What is the pH of this buffer? Show all work.



$pH = pK_a + \log \frac{[A^-]}{[HA]}$

$pH = 2.14 + \log \frac{20 \text{ mmol}}{60 \text{ mmol}}$

$pH = 2.14 + \log \frac{1}{3}$

$pH = 2.14 - 0.48 = 1.7$

problem 6.19

32. The isomerization of dihydroxyacetone phosphate to glyceraldehyde 3-phosphate has an equilibrium constant of 0.0475 under standard conditions (298 K, pH 7) Calculate the standard free energy for the isomerization.

(+3)

$$\begin{aligned}\Delta G^{\circ'} &= -RT \ln K_{eq} \\ &= (-8.314 \times 10^{-3})(298)(\ln 0.0475) \\ &= \boxed{+7.53 \text{ kJ/mol}}\end{aligned}$$

Calculate the free energy for this reaction when the initial concentration of dihydroxyacetone phosphate is 2×10^{-4} M and the initial concentration of glyceraldehyde 3-phosphate is $3 \mu\text{M}$, which are close to the concentrations found in a typical cell.

(+3)

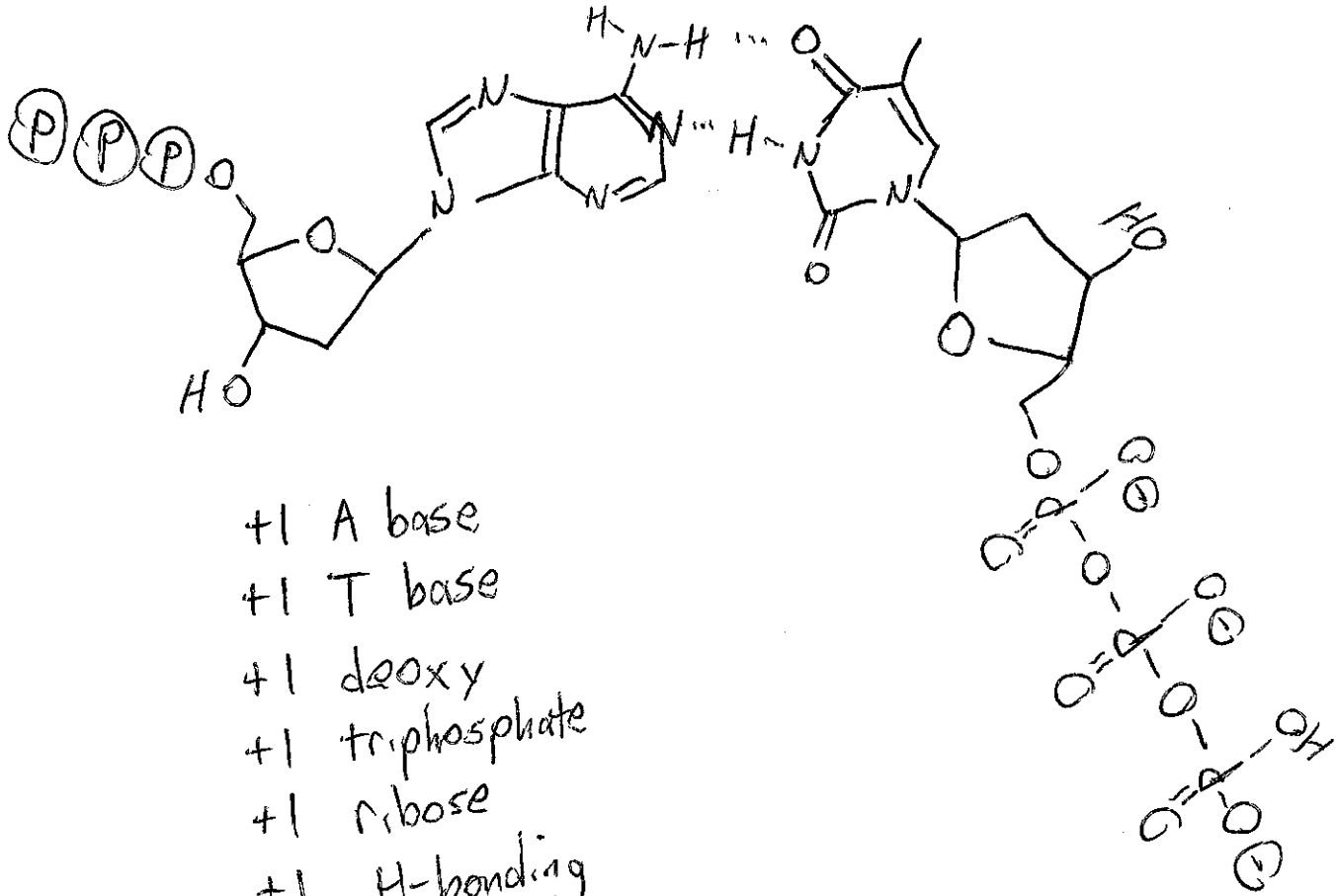
$$\begin{aligned}\Delta G &= \Delta G^{\circ'} + RT \ln \frac{(P)}{(R)} \\ &= 7.53 \text{ kJ/mol} + RT \ln \frac{3 \times 10^{-6}}{2 \times 10^{-4}} \\ &= \boxed{-2.89 \text{ kJ}}\end{aligned}$$

What do the values above tell you about the importance of standard free energy compared with free energy in understanding the thermodynamics of intracellular reactions?

(+4)

Although this rxn is nonspontaneous at standard state, it is spontaneous under cellular conditions, where concentrations are not all 1 M.

33. Draw dATP hydrogen bond through its nucleobase to its complementary deoxyribonucleotide triphosphate in the space below.



- +1 A base
- +1 T base
- +1 deoxy
- +1 triphosphate
- +1 ribose
- +1 H-bonding

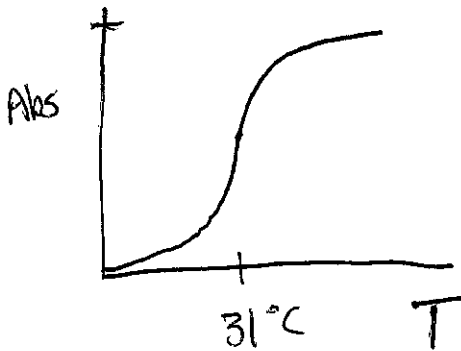
problem 33.7

Write the complementary sequence (in the standard 5' → 3' notation) for GATCAA.

(+2) TTGATC (if 3' → 5' CTAGTT)

If the melting point for this double stranded hexanucleotide is 31°C, draw a melting curve graph with appropriate axes labels.

(+2)



(+1) Sigmoidal

(+1) axes

problem 5.6

34. The octapeptide AVGWRVKS was digested with the enzyme trypsin. Write its fragments below using three letter abbreviations.

Ala - Val - Gly - Trp - Arg Val - Lys Ser

(+3) correct cuts (+1) three letter abbrev.

Would ion exchange or size exclusion chromatography be most appropriate for separating the trypsin digest products? Explain.

+3 The three all differ in size - use
Size exclusion

Suppose the fragment had, instead, been digested by chymotrypsin. What would be the optimal separation technique?

+3 AVGW ⁽⁺⁾ ⁽⁺⁾
RVKS

Size exclusion would not work, but
they are differently charged -
use ion exchange

problem 5.9

Bonus: A protein purification scheme was conducted as outlined below, and the purification data is summarized in the table.

| Procedure | Total protein (mg) | Total activity (units) | Specific activity (units/mg) | Purification level | Yield (%) |
|-------------------------------|--------------------|------------------------|------------------------------|--------------------|-----------|
| Crude extract | 20,000 | 4,000,000 | 200 | 1 | 100 |
| Salt precipitation | 5,000 | 3,000,000 | 600 | 3 | 75 |
| Ion exchange chromatography | 1500 | 1,000,000 | 667 | 3.3 | 25 |
| Gel-filtration chromatography | 500 | 750,000 | 1500 | 7.5 | 19 |
| Affinity Chromatography | 45 | 675,000 | 15000 | 75 | 17 |

(+2)

Which of these steps was least effective in the purification scheme? Explain how you came to this answer. **If you have a reasonable guess, go for it! You may receive up to 5 points bonus on this problem with possibility of partial credit, but answers that show no understanding will receive a -1 penalty. Better to leave it blank than to make a wild guess.**

(+3) Ion exchange wasn't that effective - it cut out a lot of protein but also lost a lot of activity. The specific activity only increase a little bit. (Or purification level only went up 10%.)