

# Key

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

1. D The least polar of the major classes of biomolecules is
  - A) carbohydrates
  - B) nucleic acids
  - C) proteins
  - D) lipids
  - E) none of the above.
  
2. B The amide group of the dipeptide Val-Pro can serve as a
  - A) hydrogen bond donor
  - B) hydrogen bond acceptor
  - C) both hydrogen bond donor and acceptor
  - D) neither hydrogen bond donor nor acceptor
  
3. B The process of nonpolar molecules spontaneously assembling in an aqueous environment can best be explained thermodynamically by
  - A) the negative  $\Delta S$  of process.
  - B) the negative  $\Delta G$  of the process.
  - C) the positive  $\Delta H$  of the process.
  - D) the maximization of van der Waals forces.
  - E) None of the above
  
4. E What is the pH of a 0.1 M succinate/succinic acid buffer?
  - A) 3.2
  - B) 4.2
  - C) 4.9
  - D) 5.6
  - E) cannot be determined from this information
  
5. B The amino acid methionine best fits into the \_\_\_\_\_ class of amino acids.
  - A) polar
  - B) hydrophobic
  - C) positively charged
  - D) negatively charged
  - E) zwitterionic

6. D Base stacking contributes to the stability of the double helix by
- A) The hydrophobic effect.
  - B) Maximizing van der Waals interactions
  - C) Hydrogen bonding
  - D) Both A and B
  - E) A, B, and C

7. C All of these statements are true of the DNA denaturation curve except

- A) It is sigmoidally shaped.
- B) It can be used to determine the melting point of a DNA double helix.
- C) It is measured by absorbance of light by nucleobases as a function of concentration of DNA added.
- D) It is affected by the relative percent of GC base pairs in the DNA.

8. A An alpha helix with a sequence of AWLIIMFAWV is likely to be found
- A) In the protein core.
  - B) On the protein surface.
  - C) In a disordered loop.
  - D) In the active site
  - E) In a zinc finger.

9. D Anfinsen's experiment in which he treated RNase A with urea and mercaptoethanol and then dialyzed it supports the principle that
- A) Replication is semiconservative.
  - B) Protein folding is directed by way of a folding funnel .
  - C) Misfolded proteins can lead to various pathologies such as Alzheimer's disease.
  - D) The information needed for protein folding is found in the primary sequence.
  - E) Some proteins are metamorphic and can exist in an equilibrium ensemble of energetically similar folds.

10. D Which disease/syndrome is not matched with its biochemical cause?
- A) Scurvy: lack of a vitamin necessary to maintain collagen structure
  - B) Kwashiorkor: insufficient protein intake
  - C) Parkinson's disease: amyloid fibers form from misfolded protein
  - D) All of the above are properly matched.
  - E) None of the above are properly matched.

11. B Which reaction will occur fastest under enzyme catalyzed conditions? Refer to the table below.

Reaction	Uncatalyzed rate (s <sup>-1</sup> )	Catalyzed rate (s <sup>-1</sup> )	Rate enhancement
A → B	$2.8 \times 10^{-16}$	39	$1.4 \times 10^{17}$
C → D	$1.7 \times 10^{-7}$	66,000	$3.9 \times 10^{11}$
E → F	$2.6 \times 10^{-5}$	50	$1.9 \times 10^6$

- A) A → B
- B) C → D
- C) E → F
- D) They will all proceed equally fast because they are all enzyme catalyzed.
- E) Cannot be determined from these data.

12. A A reaction, which has a negative  $\Delta G^{\circ}$ , starts under conditions in which the ratio of product to reactants is less than one. What is true for the reaction starting under these conditions?

- A) It is spontaneous.
- B) It is nonspontaneous.
- C) It can be either spontaneous or not spontaneous.
- D) It is at equilibrium.
- E) Cannot be determined from this information.

13. C The binding energy of the enzyme is maximized when it binds to the

- A) substrate.
- B) cofactor.
- C) transition state.
- D) product.
- E) active site.

14. C What is the major conjugate base component of the blood buffer?

- A)  $\text{HPO}_4^{-2}$
- B)  $\text{H}_2\text{PO}_4^{-1}$
- C)  $\text{HCO}_3^{-1}$
- D)  $\text{CO}_2$
- E)  $\text{H}_2\text{CO}_3$

15. D Proteases and nucleases are similar in all of these ways except:

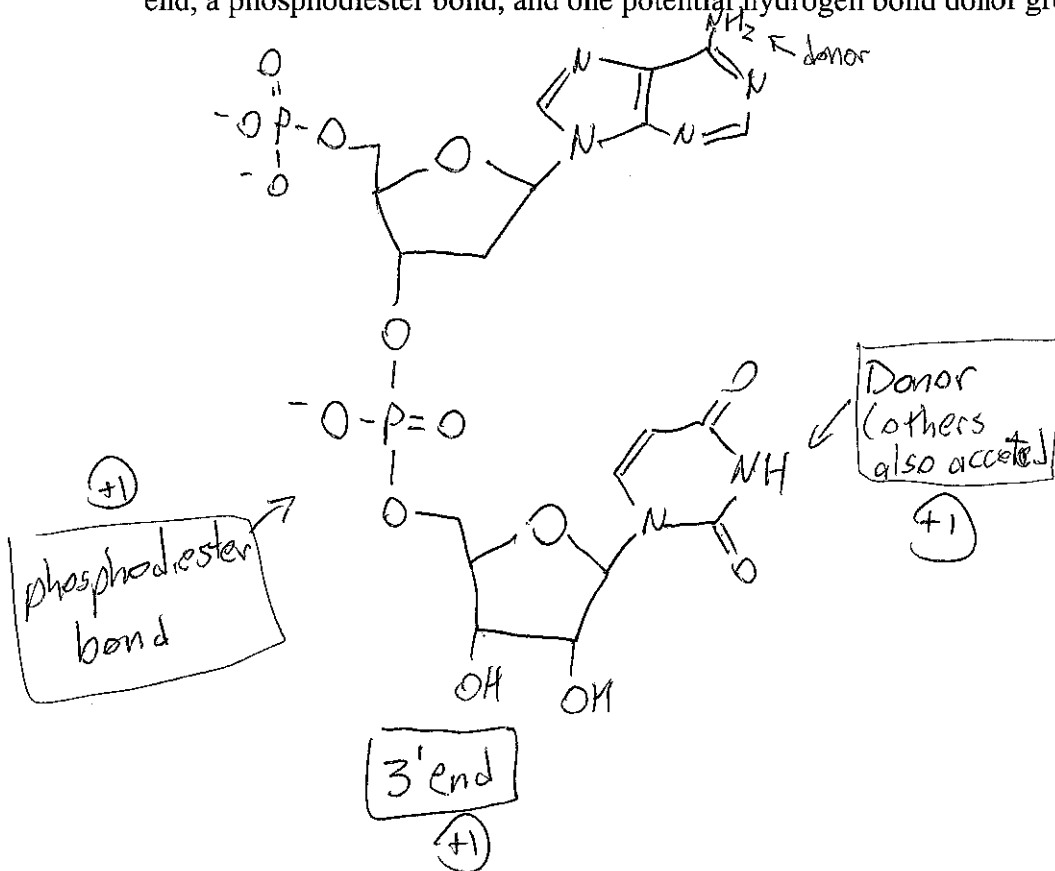
- A) Both are enzymes.
- B) Both act on polymeric substrates.
- C) Both catalyze hydrolysis reactions.
- D) Both cleave amide bonds.
- E) Both have active sites.

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

16. According to the Henderson-Hasselbalch equation, the pH of a solution is related to the pKa of the acid and the ratio of the concentration of the acid and its conjugate base.
17. The net charge of arginine at pH 9.0 is approximately +1/2.
18. Asn and Gln are two amino acids with amide sidechains.
19. If a  $\beta$ -sandwich motif is found on the surface of a protein, it must be amphipathic so that one face can interact with the water favorably while the other face forms favorable interactions with the core of the protein.
20. Uracil (U) is a nucleobase found in RNA but not DNA.
21. A domain is a compact, independently folded unit of a larger protein. (accept subunit)
22. The cyclic DNA of bacteria is underwound so that it can replicate, but it is stabilized by supercoiling.
23. A hairpin turn is likely to contain the amino acids pro and gly to facilitate the tight turn between two secondary structures.
24. There are two major types of electrophoresis. In SDS-PAGE, proteins are separated on the basis of size. In isoelectric focusing, proteins are separated on the basis of charge.
25. The specific activity of a protein sample reflects its purity because it is a measure of the sample's activity relative to how much protein is in the sample.
26. In gel-filtration chromatography, proteins are separated on the basis of size, with large proteins coming off of the column first.
27. The technique called the Edman Degradation can be used to sequence polypeptides by identifying the amino acid at the N-terminal end of the peptide.
28. The lock and key model of enzyme/substrate binding is inadequate because the molecules are not static; substrate binding causes an induced fit.
29. An enzyme can increase the rate of reaction by changing the activation energy or pathway, but it cannot change the thermodynamics of the reaction.
30. Many enzymes require cofactors such as  $Zn^{+2}$  or NADH to be active.

**Section 3. Problems. 4 questions 10 points each.**

31. The RNA/DNA hybrid pdApU was synthesized. Draw its structure below and indicate the 3' end, a phosphodiester bond, and one potential hydrogen bond donor group on a nucleobase.

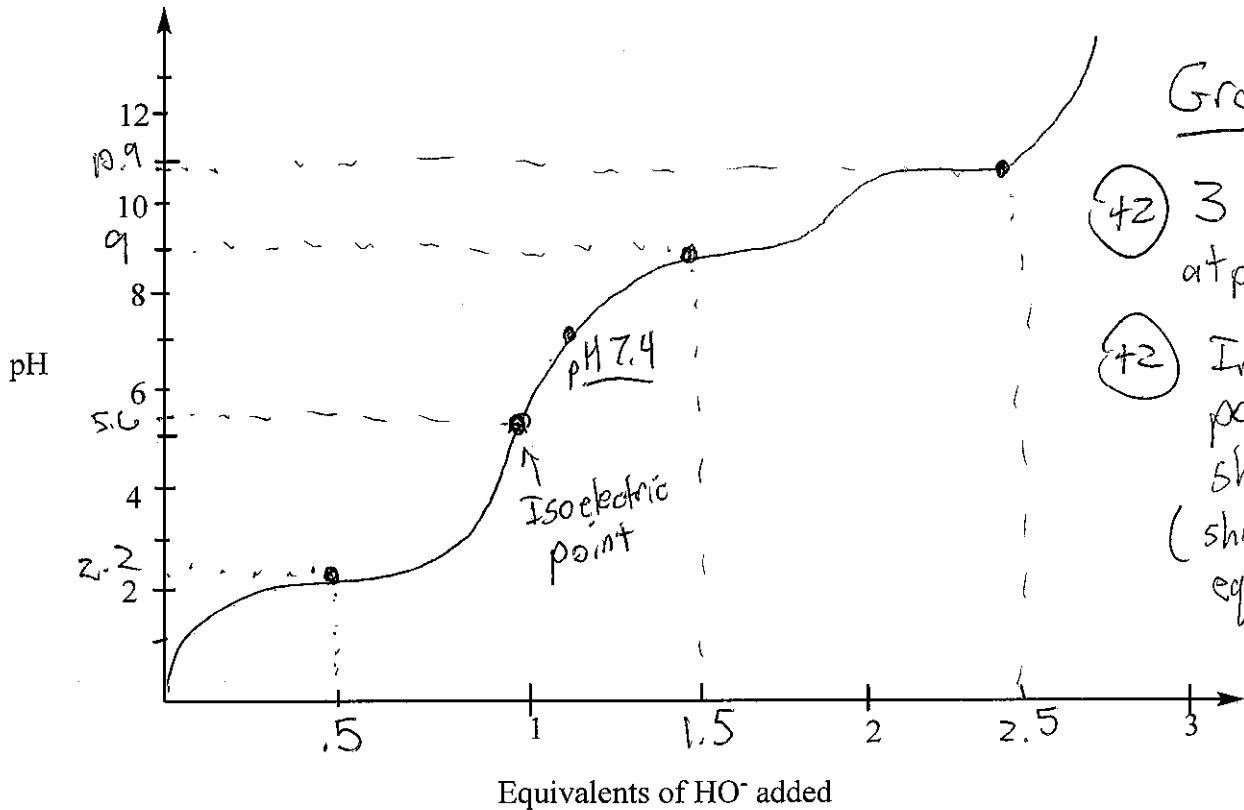


- Structure
- (+1) 5' phosphate
  - (+1) RNA/DNA 2'OH
  - (+1) ribose ring
  - (+1) A base
  - (+1) U base

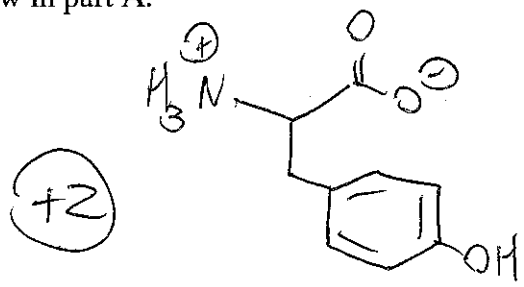
If the similar dinucleotide pUpdA were synthesized, would you expect it to be more or less stable at pH 7? Explain.

(+2) Less<sup>x</sup> stable. The 2'<sup>x</sup>OH would aid in hydrolysis (by acting as a nucleophile)

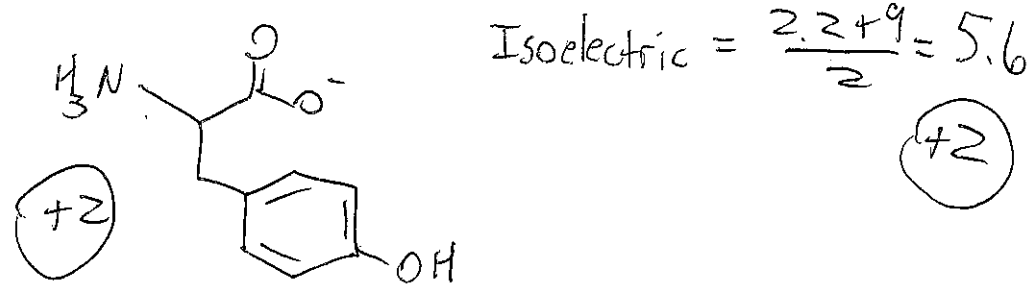
32. A. Draw a titration curve for the amino acid tyrosine. (See the last page for pKa values.)



B. Draw the structure of tyrosine in its predominant ionization state at pH 7.4. Mark this point on the curve you drew in part A.



C. Draw the structure of tyrosine at its isoelectric point. Mark this point on the curve you drew in part A.



33. The isomerization of dihydroxyacetone phosphate (DHAP) to glyceraldehyde 3-phosphate (GAP) has an equilibrium constant of 0.0475 under standard conditions. In the cell, the [DHAP] is  $2 \times 10^{-4}$  M and [GAP] is  $3 \times 10^{-6}$  M.

A. What is the standard free energy for this reaction?

(+4) 
$$\Delta G^{\circ'} = -RT \ln K_{eq}$$

$$= -8.314 \frac{\text{J}}{\text{mol K}} (298\text{K}) (0.0475) = +7.55 \frac{\text{kJ}}{\text{mol}}$$

B. Is this reaction spontaneous or nonspontaneous under standard conditions?

(+2) nonspontaneous (matches)

C. Is this reaction spontaneous or nonspontaneous under cellular conditions? Show all your work in determining this answer.

(+4) 
$$\Delta G^{\phi} = \Delta G^{\circ'} + RT \ln \frac{P}{R}$$

$$= +7550 \frac{\text{J}}{\text{mol}} + 8.314 \frac{\text{J}}{\text{mol K}} (298\text{K}) \ln \frac{3 \times 10^{-6}}{2 \times 10^{-4}}$$

$$= 7550 \frac{\text{J}}{\text{mol}} - 10400 \frac{\text{J}}{\text{mol}}$$

$$= -2.9 \frac{\text{kJ}}{\text{mol}} \quad +3$$

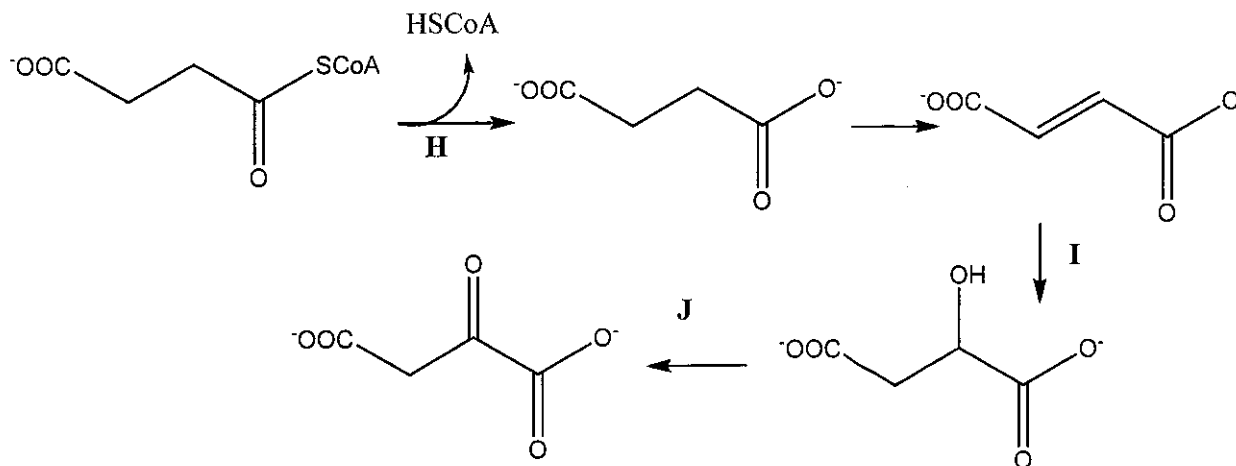
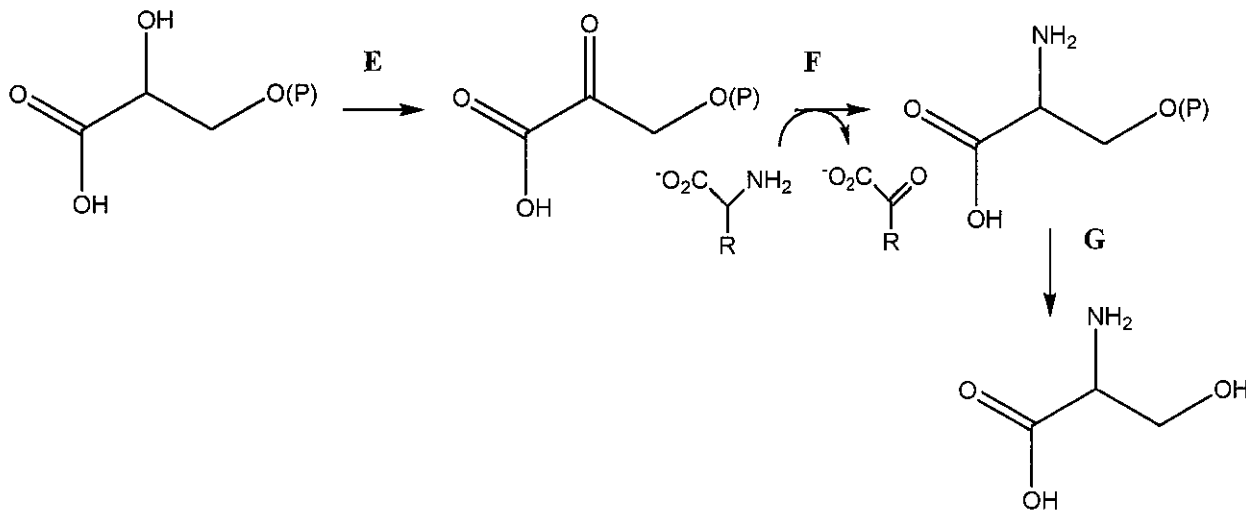
Spontaneous in the cell +1

34. Given the name of the enzyme or the reaction it catalyzes, predict the class to which the enzyme belongs: oxidoreductase, transferase, hydrolase, lyase, isomerase, ligase. Fill in the enzyme classes in the blanks below:

- A. Isomerase (accept transferase) B. Oxidoreductase C. transferase  
 D. ligase E. Oxidoreductase F. transferase  
 G. hydrolase H. hydrolase I. lyase  
 J. oxidoreductase

A. phosphoglycerate mutase  
 C. Protein tyrosine kinase

B. Glyceraldehyde-3-phosphate dehydrogenase  
 D. Gutamine synthetase





**Bonus:** Draw the structure of the hexapeptide in its major ionization state at pH 10 consistent with the following sequencing data. When the sequence is not known, a comma separates the amino acids.

Amino acid composition: (2R, A, S, V, Y)

Amino-terminal analysis: A

Trypsin digest: (R,A, V) and (R,S,Y)

Carboxypeptidase A digestion: no digestion

Chymotrypsin digest: (A, R, V, Y) and (R, S)

+8      A V R Y S R