



**University of Alberta  
Department of Biochemistry**

NAME: KEY

**CLEARLY WRITE YOUR I.D. # ON EACH PAGE INSIDE**

University of Alberta  
Department of Biochemistry  
BIOCH 320  
Midterm Examination I  
Dr. J. Parrish

Time Limit: 70 minutes

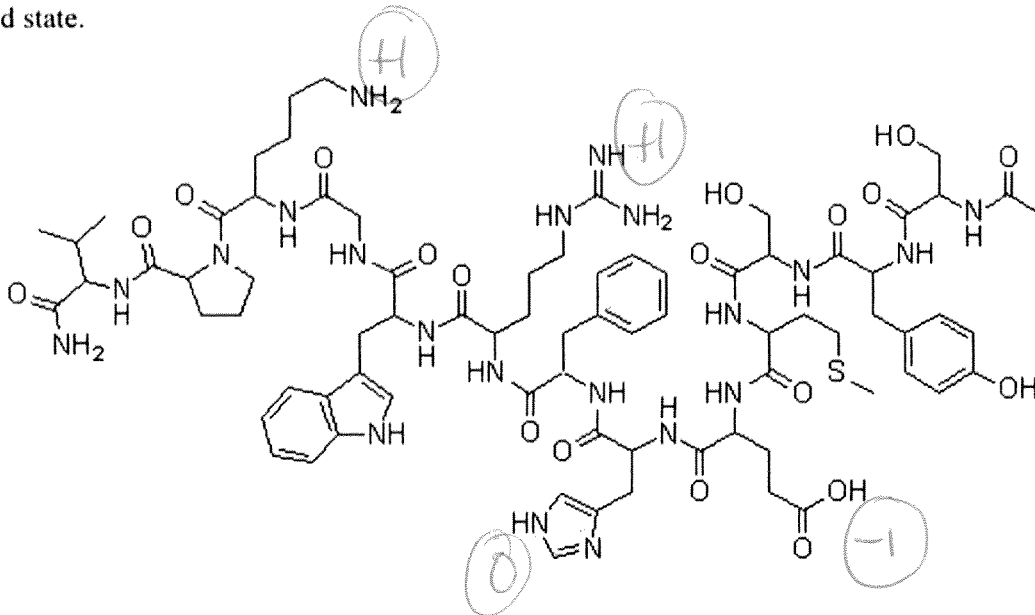
February 4, 2014

**INSTRUCTIONS**

- Enter your **NAME** on this cover page and your **I.D.#** on each page inside.
- This exam has 10 pages with 40 marks worth 20% of your final grade.
- Ensure all multiple choice questions are completed on the scantron sheet.
- Ensure your scantron sheet has your **NAME** and **I.D.#**

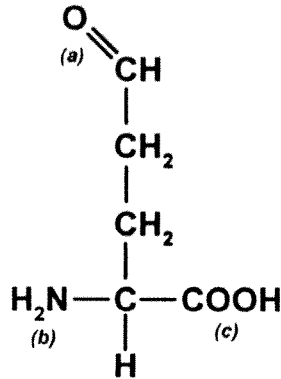
Amino Acid		pK <sub>1</sub>	pK <sub>2</sub>	pK <sub>R</sub>
<b>Ala</b>	<b>A</b>	<b>2.35</b>	<b>9.78</b>	
<b>Arg</b>	<b>R</b>	1.82	8.99	12.48
<b>Asn</b>	<b>N</b>	<b>2.14</b>	<b>8.72</b>	
<b>Asp</b>	<b>D</b>	1.99	9.90	3.90
<b>Cys</b>	<b>C</b>	<b>1.92</b>	<b>10.70</b>	<b>8.37</b>
<b>Gln</b>	<b>Q</b>	2.17	9.13	
<b>Glu</b>	<b>E</b>	<b>2.10</b>	<b>9.47</b>	<b>4.07</b>
<b>Gly</b>	<b>G</b>	2.35	9.78	
<b>His</b>	<b>H</b>	<b>1.80</b>	<b>9.33</b>	<b>6.04</b>
<b>Ile</b>	<b>I</b>	2.32	9.76	
<b>Leu</b>	<b>L</b>	<b>2.33</b>	<b>9.74</b>	
<b>Lys</b>	<b>K</b>	2.16	9.16	10.54
<b>Met</b>	<b>M</b>	<b>2.13</b>	<b>9.28</b>	
<b>Phe</b>	<b>F</b>	2.20	9.31	
<b>Pro</b>	<b>P</b>	<b>1.95</b>	<b>10.64</b>	
<b>Ser</b>	<b>S</b>	2.19	9.21	
<b>Thr</b>	<b>T</b>	<b>2.09</b>	<b>9.10</b>	
<b>Trp</b>	<b>W</b>	2.46	9.41	
<b>Tyr</b>	<b>Y</b>	<b>2.20</b>	<b>9.21</b>	<b>10.46</b>
<b>Val</b>	<b>V</b>	2.29	9.74	

Shown below is the chemical structure of  $\alpha$ -melanocyte stimulating peptide hormone, shown in the uncharged state.



- What is the N-terminal residue in this peptide?
  - V
  - L
  - C
  - S
  - N
- What is the net charge on the predominant form of this peptide at pH 7.5 (assume pKa values are unchanged from the values in the table on page 2)?
  - 2
  - 1
  - 0
  - +1
  - +2
- Which of the following amino acids is NOT found in this hormone?
  - A
  - C
  - G
  - K
  - More than one of the above amino acids is not found in this peptide.

Below is the structure of an uncommon amino acid involved in a catabolic pathway, shown as a Fisher projection. Use this structure to answer the next two questions.

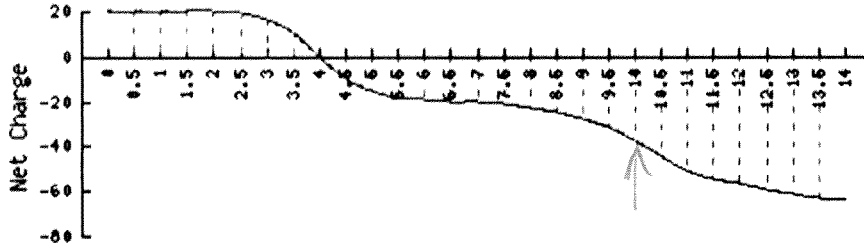


4. Which of the following statements is true for this amino acid?
- A. This amino acid is likely derived from Asp. ✗
  - B. This amino acid is a D amino acid. ✗
  - C. The structure shown above will predominate in solution at pH 7.0. ✗
  - D. The side chain of this amino acid can act as a hydrogen bond donor. ✗
  - E. None of the above statements are true.
5. Which of the following statements is true for the above amino acid?
- A. The pI for this amino acid can be determined by calculation from pKa values for group (b) and (c). ✓
  - B. This amino acid could be classified as polar. ✓
  - C. If incorporated into a peptide, this side chain would carry a negative charge. ✗
  - D. Both A and B are true.
  - E. Both A and C are true.
6. For lysine in solution, at what pH will the neutral form of the sidechain functional group represent 9% of the total species present?
- A. pH 9.16
  - B. pH 9.54
  - C. pH 9.85
  - D. pH 10.54
  - E. pH 11.54
- 1 pH unit below pKa of 10.54*
7. What is the approximate average net charge for tyrosine in solution at pH 9.21?
- A. -1.5
  - B. -1.0
  - C. -0.5
  - D. 0
  - E. +0.5
- @ pKa of amino group.  
-1 COO-      +0.5      R (neutral).*

## Protein A

**Molecular Weight:**  
41975.95

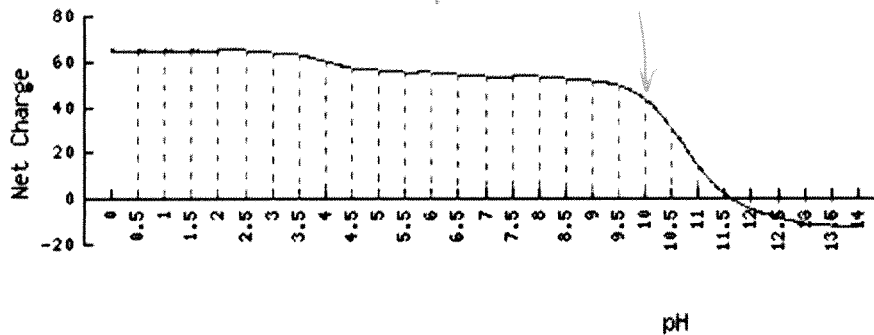
*~382 a.a.*



## Protein B

**Molecular Weight:**  
20862.76

*~190 a.a.*



Above is information listing the  $M_r$  and net charge (as a function of pH) for two monomeric proteins A and B. Use this information to answer the next two questions.

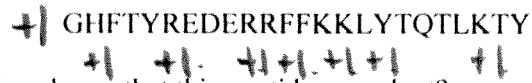
8. Which of the following statements is TRUE regarding these proteins?

- A. Protein A will elute before Protein B from an anion exchange column at pH 10.
- B. Protein B will migrate more rapidly in an SDS-PAGE experiment.
- C. Protein A contains more Asp and Glu residues than Protein B.  (*440 versus 420*)
- D. Protein B will elute before Protein A in a gel filtration column.
- E. Both B and C are true.

9. Which of the following statements is FALSE for Protein A?

- A. Protein A has a pI of approximately 4.0
- B. Protein A contains approximately 460 amino acids.  (*~20 a.a. / 382*)
- C. Protein A contains approximately 4-8% Lys, Arg and His residues.
- D. At pH 7.0 Protein A carries a net negative charge.
- E. Both B and C are false.

10. Consider the following peptide:

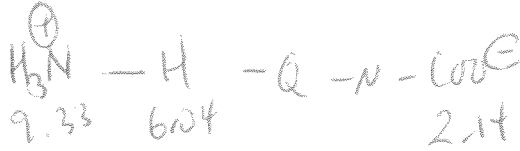


What is the maximum positive charge that this peptide can adopt?

- A. +5
- B. +6
- C. +7
- D. +8
- E. +9

11. Assuming  $pK_a$  values are unchanged for any titratable groups from the table on Page 2, what is the pI of the peptide HQN?

- A. pH 5.5
- B. pH 7.38
- C. pH 7.19
- D. pH 7.55
- E. pH 7.69



12. Which of the following words or phrases does **NOT** describe the side chain of tyrosine? (1 mark)

- A. Potential hydrogen bond acceptor. ✓
- B. Aromatic. ✓
- C. Absorbs light at 280nm. ✓
- D. Potential hydrogen bond donor. ✓
- E. All of these describe tyrosine.

13. For a protein with an isoelectric point of 8.5, over what pH range is cation exchange best carried out?

- A. pH 7-8
- B. pH 8-9
- C. pH 9-10
- D. All of these pH ranges are good choices.
- E. Cation exchange should not be carried out with this protein.

+ charge < 8.5.

14. Which of the following is FALSE regarding SDS PAGE and isoelectric focussing? (1 mark)

- A. Both techniques require application of an electric field. ✓
- B. SDS PAGE separates primarily on the basis of mass while isoelectric focussing separates on the basis of charge. ✓
- C. A detergent is included with samples in both techniques to ensure a consistent charge and shape. ✗
- D. Both A and C are false.
- E. Both B and C are false.

15. Which of the following statements is true for proline?

- A. The value of  $\psi$  (psi) is restricted to the range around  $-120^\circ$ . ~~X~~ ( $\phi$ )
- B. This amino acid could only be found at the C-terminal end of an  $\alpha$ -helix. ~~X~~
- C. This amino acid is aromatic. ~~X~~
- D. Both A and B are true.
- E. None of the above statements are true.

16. Which characteristics do the side chains of the amino acids H and Q share?

- A. Both are charged at neutral pH. ~~X~~
- B. Both are able to act as both H-bond donors at low pH.  $\checkmark$
- C. Both contain an amide structure. ~~X~~
- D. All of these are shared characteristics.
- E. None of these are shared characteristics.

17. Which of the following is false for  $\alpha$ -helices?

- A. ( $\phi$ ,  $\psi$ ) angles near  $(-57^\circ, -47^\circ)$   $\checkmark$
- B. Can be stabilized by Glu at the C-terminal end of the helix ~~X~~
- C. Has approximately 3.6 residues per turn.  $\checkmark$
- D. A 20 residue peptide containing only alanine (i.e. Ala<sub>20</sub>) is likely to adopt this structure.  $\checkmark$

18. Which of the following statements is true for  $\beta$ -sheets?

- A. Parallel sheets have a more extended conformation than antiparallel beta sheets. ~~X~~
- B. Individual strands in an antiparallel sheet will come from a single polypeptide. ~~X~~
- C. Both A and B are true. *may*
- D. None of the above statements are true.

19. A 20-residue peptide containing only lysine residues can form an  $\alpha$ -helix. Under what conditions would you expect this to occur?

- A. At low pH. (pH < 2)
- B. At neutral pH (pH 7.0)
- C. At high pH (pH > 10)
- D. Any of these pH values will allow for helix formation.

20. Which of the following amino acids contains a branched  $\gamma$  (gamma)-carbon?

- A. T.
- B. L.
- C. I.
- D. Both A and B.
- E. Both B and C.

Below is a purification table for an enzyme. Samples listed were analyzed after completion of the procedure. (Use this for the next four questions).

Procedure	Volume of sample (mL)	Total protein concentration (mg/mL)	Total activity (units)	sp-act units/mg
1. Initial Crude extract	120	200	3,000,000	125
2. 40% Ammonium sulphate	80	150	2,000,000	66%
3. Anion exchange	25	80	1,000,000	50%
4. Size exclusion	3	25	55,000	55%
5. Gel filtration	5	10	32,000	58%

21. Which of these steps showed the greatest increase in specific activity?

- A. Step 2
- B. Step 3
- C. Step 4
- D. Step 5

22. Which step could be reasonably excluded from this purification?

- A. Step 2
- B. Step 3
- C. Step 4
- D. Step 5
- E. None of these steps can reasonably be excluded on the basis of this data.

23. What is the specific activity of the final sample?

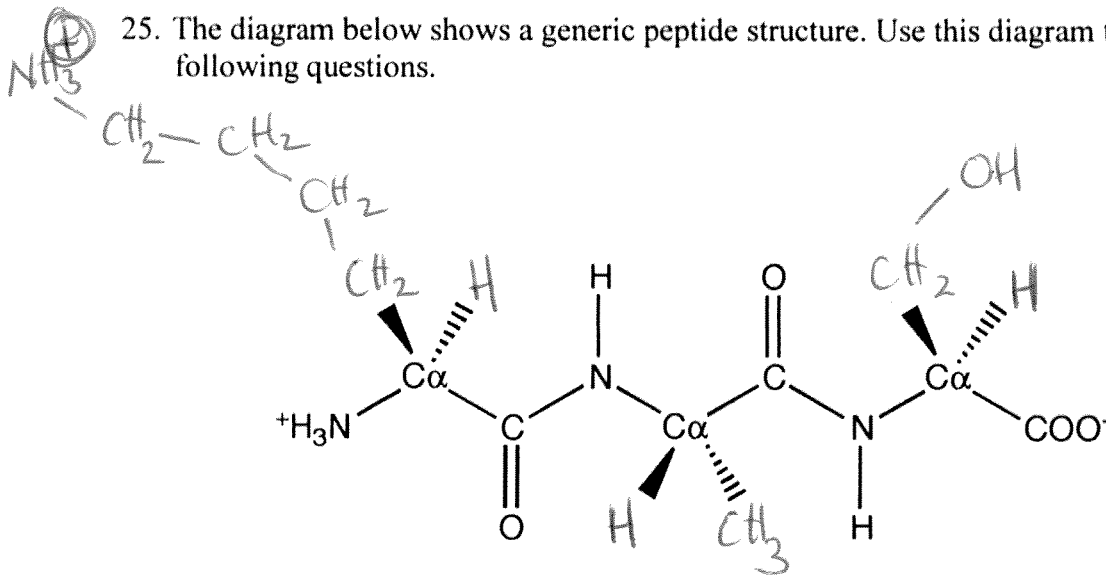
- A. 4 Units/mg
- B. 160 Units/mg
- C. 320 Units/mg
- D. 640 Units/mg
- E. 3200 Units/mg

24. Which step showed the lowest % recovery?

- A. Step 2
- B. Step 3
- C. Step 4
- D. Step 5

## Short Answer Questions:

25. The diagram below shows a generic peptide structure. Use this diagram to answer the following questions.



-0.5 error  
in stereochemistry  
or other  
error in  
sidechains.

- A) On the diagram, add in the sidechains to make the tripeptide Lys-Ala-Ser as it would appear at pH 7.0. Be sure to indicate the correct stereochemistry. (3 marks)
- B) As drawn here, what would be the angles for  $\phi$  and  $\psi$  (phi and psi)? (2 marks)

$180^\circ$ ,  $180^\circ$  (1 mark each).

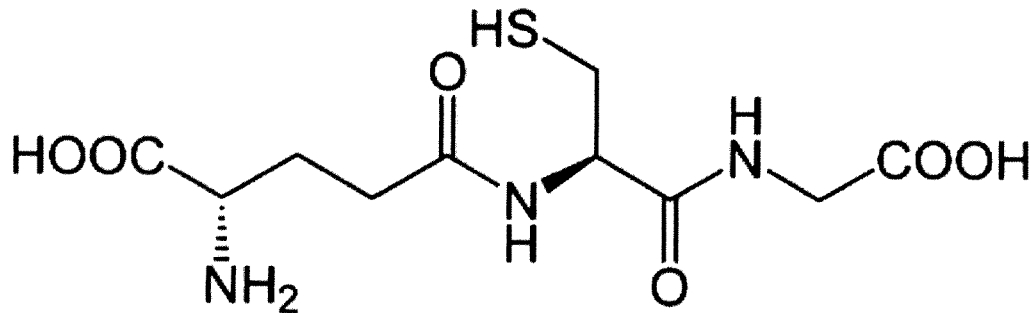
26. A size-exclusion experiment is carried out on a protein preparation. Subsequent SDS-PAGE analysis of fractions from a single peak shows two bands. Give TWO possible explanations for this observation and briefly explain how you might distinguish them. (4 marks)

① Proteins form a complex ( $4^\circ$  structure) (1)  
Apparent size in size-exclusion experiment  
should be larger than size in SDS-PAGE

② Proteins are the same size and elute together (1)  
Bands on SDS-PAGE should be similar size  
to each other + to apparent size in  
size exclusion chromatography.

(2) marks for distinguishing.

27. Glutathione is a compound found in abundance in the cytosol of animal cells (shown below in the uncharged state). It is synthesized from three amino acids, one of which is Glu.



- A) What amino acids (besides Glu) are used to make this compound? (2 marks)

Cys, C, cysteine (1)      Glycine (G, Gly) (1)

- B) What distinguishes glutathione from the tripeptide Glu-X-X (where X-X are the two amino acids from Part A)? (2 marks)

In glutathione, the glutamate binds to the cysteine via the side-chain carboxylate, not the

28. Define each of the following terms: (1 mark each)

- A) Ortholog

A homolog which arises out of a speciation event  
(a homolog which performs the same function in different species).

- B) Specific Activity

The amount of substrate an enzyme preparation consumes in a given amount of time per mg total protein present.

- C) Dalton

A unit of atomic mass equal to 1/12 of the mass of an atom of carbon 12.