This test is take-home and open book, and it is intended that all members of the group contribute to completing it. Only one copy is to be submitted by the group, and all members who participated should sign their names below. **Test is due at the end of class on Friday, May 26.**

Please use dark pencil or ink and write legibly.

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Points

1. Draw a titration curve for **Histidine** on the graph below. Locate and identify the points on the curve corresponding to $pK_1$, $pK_2$, and $pK_3$. Calculate the approximate $pI$ value and locate its position on the curve. Indicate the pH region on the graph in which at least 10% of the **histidine side chain** is neutral.
(8) 2. Acetoacetic acid, a ketone body produced by the liver and used as a fuel by other tissues, has a pK of 3.58. What fraction of the acetoacetic acid molecules in urine having a pH of 4.48 would be in the protonated, uncharged form? (Note: I'm looking for fraction, not ratio).

(12) 3. You have solutions of (a) 1.0 M NaOH and (b) 1.0 M H₃PO₄, and you would like to prepare 2 L of 0.05 M phosphate buffer at pH 7.0. Calculate the volume of solutions (a) and (b) and water that must be combined to produce the buffer. (Assume volumes are additive.)

For H₃PO₄: pK₁ = 2.12; pK₂ = 7.21; pK₃ = 12.67
Questions 4 and 5 refer to the following four tetrapeptides:

(A) Trp.Phe.Leu.Gly
(B) A.E.M.P
(C) I.N.S.K
(D) Val.Cys.Asp.Thr

4. Draw the full structure of peptide D in its fully protonated form, indicating the approximate pK of each group which can dissociate a proton.

5. Put in the blank the letter or letters corresponding to the peptides for which each of the following conditions are true:

- ______ Contains an aromatic amino acid
- ______ The most hydrophobic of the four peptides
- ______ Has a +2 charge in the fully protonated form
- ______ Contains a side chain amide group
- ______ Contains a side chain -OH group
- ______ Contains a sulfur atom

6. Underline the following peptides which are negatively charged at pH 7.0. Circle each amino acid which is non-polar.

- gln.val.tyr.al
- lys.arg.glu.trp
- met.his.leu.asp
- cys.pro.gly.asn
- F-A-D-S
- M-I-C-K
7. The following reaction plays an important role in both breakdown of glucose (glycolysis) and synthesis of glucose (gluconeogenesis).

\[ 1,3\text{-bisphosphoglycerate} + \text{ADP} \rightleftharpoons 3\text{-phosphoglycerate} + \text{ATP} \]

(a) From the data in Table 3.3, calculate \( \Delta G'' \) and \( K' \) for the reaction as written.

(b) If the 1,3-bisphosphoglycerate/3-phosphoglycerate ratio were 2/1, what would be the ATP/ADP ratio at equilibrium?

(c) What must \( Q \) (the mass action ratio) be for the reaction to become spontaneous in the reverse direction as that written above (i.e. in the direction of glucose synthesis)?
(6) 8. Calculate $\Delta G$ of hydrolysis of ATP in a liver cell where $[\text{ATP}] = 3.4 \text{ mM}$, $[\text{ADP}] = 1.3 \text{ mM}$, and $[\text{Pi}]=4.8 \text{ mM}$.

(4) 9. Explain the difference between $\Delta G^0$ and $\Delta G^{\circ'}$.

(10) 10. Using data on free energies of hydrolysis from Table 3.3 of the text, calculate $\Delta G^{\circ'}$ for each of the following reactions and predict whether each will be spontaneous or non-spontaneous as written:

(a) creatine phosphate + ADP $\rightleftharpoons$ creatine + ATP

(b) glucose + glycerol-3-phosphate $\rightleftharpoons$ glucose-1- + glycerol phosphate