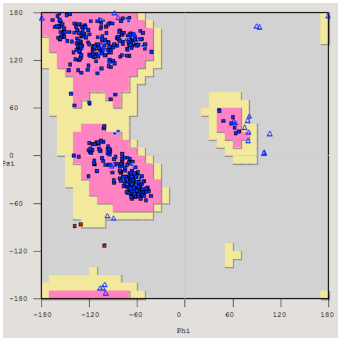
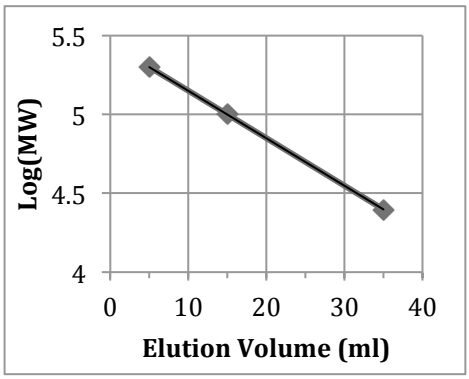
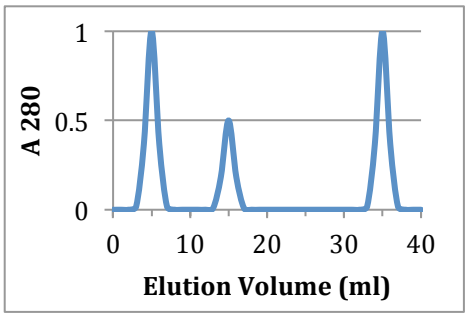
Instructions: this exam consists of 14 questions on 6 pages, for a total of 100 points. On questions with choices, all of your attempts will be graded and you will be awarded the highest grade.

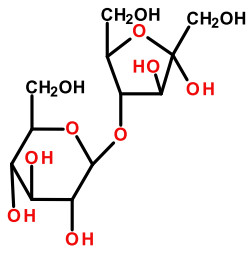
1. (4 pts) X-ray Diffraction: Please do **<u>one</u>** of the following choices:
   Choice A: What is the key principal that allows structures to be determined by the scattering (diffraction) of X-rays.
   Choice B: The Ramachandran plot for a recently determined structure is shown on the right. Is the structure likely correct? Briefly justify your answer.



2. (8 pts) What is the quaternary structure of this protein, based on the following data? *Briefly justify your answer*.
   a) SDS-PAGE, **without** beta-mercaptoethanol (BME) gives two bands: 20 kDa, 30 kDa.
   b) SDS-PAGE, **with** beta-mercaptoenthanol (BME) also gives two bands, 15 kDa, 20 kDa (15 kDa band is twice as intense).
   c) The elution profile and calibration plot for size exclusion chromatography is shown on the right. The size standards were 200 kDa (log 200,000=5.3) and 25 kDa (log 25,000=4.4). The unknown protein elutes at 15 ml.







3. (6 pts) for the dissacharide is shown on the right.
   i) Circle monosaccharide that is a ketose.
   ii) Indicate one anomeric carbon by circling it.
   iii) Do **<u>one</u>** of the following choices
   Choice A: Give the name of the sugar that is drawn.
   Choice B: Draw the following sugar:
   α-fructofuranose (2-6) β-glucopyranose

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4. (6 pts) Please do **one** of the following choices. In either case you should indicate the monosaccharide component(s) and how they are linked together.
   Choice A: What is the difference between lactose and sucrose?
   Choice B: What is the difference between cellulose and glycogen?
   Choice C: Briefly describe the structural features of the bacterial cell wall that result in its high mechanical strength.

5. (6 pts) Draw **and** name a phospholipid of your choice.

6. (6 pts) Please answer **one** of the following two choices:
   Choice A: Considering the structure of phospholipids, describe the thermodynamic/energetic features that explain why they form a bilayer in aqueous solutions.
   Choice B: Explain how the critical micelle concentration changes when fatty acid tail length increases; will there be more or less free lipid in solution?

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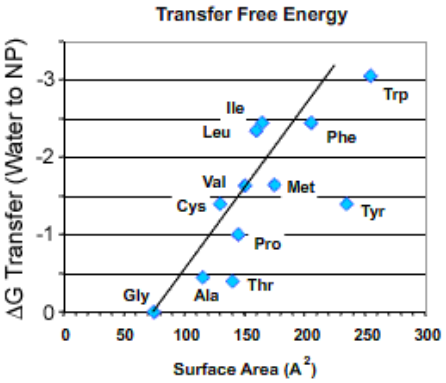
7. (4pts) In order to maintain membrane fluidity, the composition of fatty acids within phopholipids can be varied. Briefly describe the change that would occur to the length and saturation of the fatty acid tails as a cell is shifted to a lower temperature.

8. (10 pts) Please do **<u>one</u>** of the following choices.



Choice A: A peptide is made up of 10 tyrosine residues. Calculate the **partition coefficient** (equilibrium constant) for the peptide inserting into a membrane at 300K.
(Values for the diagram on the right are in kcal/mol. You should assume the transfer of the mainchain atoms is +1 kcal/mol and that RT=600 cal/mol at 300K.)

Choice B: Explain the structural features of integral membrane proteins; your answer should discuss both the secondary structure of the mainchain and the nature of the sidechain groups and the energetic features that are basis for these properties.

Choice C: Describe the overall structure of the potassium channel and explain its selectivity for K^+ ions.

9. (2 pts) A kinase uses _____ to add _____ to its substrate.

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10. (10 pts) Answer **one** of the following questions:

Choice A: The conversion of glucose to glucose-6-phosphate by the addition of inorganic phosphate is an energetically unfavorable reaction. Describe how the cell overcomes this problem.

Choice B: Explain how indirect coupling of a reaction can allow an energetically unfavorable reaction to occur. Include an example from any pathway.

Choice C: Explain how glycolysis and gluconeogenesis can utilize many of the same enzymes in the breakdown and synthesis of glucose and both pathways can have a negative ΔG.

11. (12 pts) Please answer **one** of the following choices on pathway regulation:

Choice A: Glycolysis, gluconeogenesis and the TCA cycle are each regulated by energy sensing. Choose one of these pathways and describe the step(s) where regulation occurs, including the molecules that enhance and/or inactivate enzyme activity and how that regulation makes sense for the cell.

Choice B: Insulin, epinephrine and glucagon each exert hormonal control over liver functions that can lead to the storage or release of glucose in glycogen. Pick one of the three hormones and explain their effect on protein phosphorylation and glycogen metabolism.

Choice C: Insulin, epinephrine and glucagon each exert hormonal control over liver functions that can lead to the metabolism or synthesis of glucose. Pick one of the three hormones and explain their effect on glucose metabolism (glycolysis and gluconeogenesis).

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12. (8 pts) A cell uses a proton gradient to produce ATP, requiring the transit of 3 H^+ for each ATP synthesized. Assuming the pH in the inner membrane space is 6.5 and inside the matrix is 7.5, what is the minimum voltage difference required to provide enough energy to synthesize one ATP? T=300K.

13. (10 pts) Answer **one** of the following questions:

Choice A: Describe how the electron transport chain is utilized to produce a proton gradient. Include a description of the flow of electrons through the transport chain.

Choice B: Describe how the proton gradient generated by the electron transport chain is utilized by ATP synthase to produce ATP. Be sure to describe the roles of the subunits of the F_o and F_1 complex in ATP synthesis.

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14. (8 pts) Please do **one** of the following choices.

Choice A: Briefly describe the steps involved in the metabolism of triglycerides **or** amino acids to produce ATP. Your answer should: i) including the names of major pathways, ii) their location, iii) key intermediates and their products. Feel free to draw a well-labeled diagram.

Choice B: When cellular levels of O_2 are limiting during strenuous exercise, glycolysis becomes the main source of energy. Describe what additional step(s) in either yeast or mammalian cells is (are) needed to allow continued utilization of glucose under the low O_2 conditions.

You may do **two** of the following bonus questions (2 pts each).

B1: Briefly explain how either penicillin or lysozymes kill bacteria.

B2: Why is it important for sprinters to "carbo-load" before a race?

B3: Why is it difficult to convert the carbons in olive oil to glucose?

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