There are 6 pages on this exam. Please write your name on each page.
Total number of points: 90

Section A: Multiple Choice (3 Pts each, 24 Points Total)

1. The intensity of scattered x-rays depends on
   a) the number of electrons.
   b) the position of electrons.
   c) the number of neutrons.
   d) both a and b.

2. Cholesterol is essential for normal membrane function because it
   a) insures that a bilayer is formed.
   b) neutralizes harmful fatty acids.
   c) keeps membranes fluid.
   d) carries electrons during oxidative phosphorylation.

3. The sugar that forms a major component of nucleic acids (DNA, RNA) is
   a) Glucose.
   b) Fructose.
   c) Galactose.
   d) Ribose.

4. In a eukaryotic cell, the enzymes of glycolysis are located in the ____ and the enzymes of the TCA cycle are located in the ____:
   a) plasma membrane, cytosol.
   b) cytosol, mitochondrial matrix.
   c) cytosol, mitochondrial membrane.
   d) nucleus, cytosol.

5. A kinase is an enzyme that:
   a) adds water to a double bond.
   b) uses $FADH_2$ to change the oxidation state of the substrate.
   c) uses ATP to add a phosphate group to the substrate.
   d) removes phosphate groups off of substrates.

6. The common metabolic intermediate that is shared by both metabolism of glucose and fatty acids is:
   a) oxaloacetate.
   b) lactic acid.
   c) ethanol.
   d) acetyl-CoA

7. A biological reduction reaction *always* involves:
   a) a loss of electrons.
   b) a gain of electrons.
   c) decarboxylation.
   d) the addition of water.

8. Which of the following compounds is responsible for coordinated regulation of glycolysis and gluconeogenesis?
   a) NADH
   b) acetyl-CoA
   c) fructose 2,6 bis phosphate
   d) fructose 1,6 bis phosphate

GRADE:

A: _____

B1: _____

B2: _____

B3: _____

B4: _____

B5: _____

B6: _____

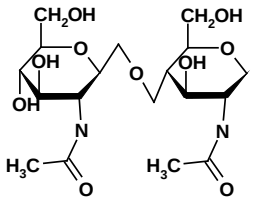
Total:_____

B1. (14 Pts) A solution contains a mixture of three proteins. You are trying to purify lysozyme from this mixture. Some of physical properties of these proteins are given in the table below (Recall that hemoglobin is a tetramer).

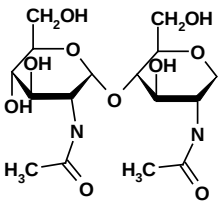
	Molecular Weight	log(MW)	Isoelectric pH
Phospholipase	10 kDa	1.00	5
Lysozyme	15 kDa	1.18	7
Hemoglobin	60 kDa	1.78	7

i) Which of the following three substrates would you use to assay for lysozyme, briefly justify your answer. [Hint: Lysozyme digests bacterial cell walls] (5 pts).

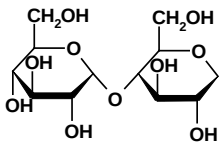
A



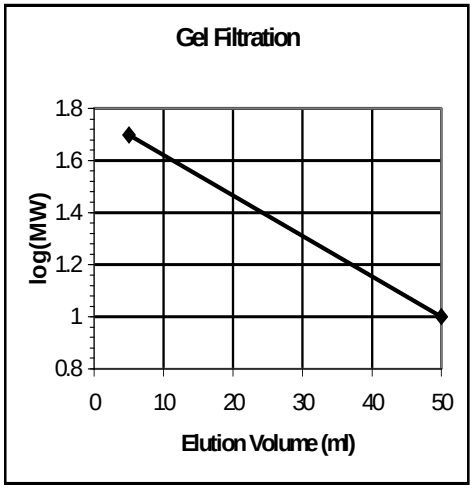
B



C



ii) Sketch, in the space below, the expected elution profile if a gel filtration column was run on the above mixture of three proteins. This particular gel filtration was previously calibrated with a 10 KDa and a 50 KDa protein. The calibration curve is given to the right Be sure to label the axis of your plot as well as the identity of each peak. (6 pts).



iii) Could you separate these three proteins using a Gel filtration column.? Justify your answer. If your answer is no, what additional purification step(s) would be necessary to separate these proteins?(3 pts)

B2: (6 pts) Answer **ONE** of the following two questions, please indicate which one you are answering

i) The principle component of margarine or butter are triglycerides. Both margarine and butter melt on hot summer days. Suggest a way of altering the triglyceride composition to prevent melting in the summer. You answer should include some information on the underlying molecular forces involved.

OR

ii) Compare and contrast the chemical structures and type of structures formed in water for the following two compounds: triglycerides and Phospholipids.

OR

iii) How does the structure of integral membrane proteins differ from that of normal water soluble proteins.

B3: (13 Pts) Answer **ONE** of the following two questions:

i) The aconitase reaction in the TCA cycle converts citrate to isocitrate. The standard free energy for this reaction, ΔG^0, is 0 kJ/mol.

a) Given that the Gibbs free energy for this reaction is -10 kJ/mol, what is the ratio of isocitrate to citrate during normal operation of the TCA cycle? (9 pts)

b) Provide a plausible explanation for the *non-equilibrium* concentration of isocitrate during the normal operation of the TCA cycle.(4 pts)

OR

ii) In anaerobic metabolism pyruvate is reduced to lactate by NADH.

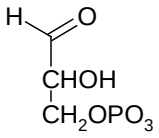
a) Using the 1/2 reactions on the formula page, write a balanced equation for the overall reaction.(3 pts)

b) Calculate the overall standard free energy change, ΔG^o for this reaction.(5 pts)

c) If pyruvate is mixed with NADH (in the presence of a suitable enzyme) some of the pyruvate will be converted to lactate. At *equilibrium* will the concentration of pyruvate exceed that of the lactate or will there be more lactate than pyruvate. Briefly justify your answer. (5 pts)

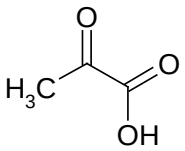
B4: (6 pts) Do **ONE** of the following three questions. Please indicate which question you are attempting. You may want to look at question B5 before attempting this question.

i) The key energy generating step in glycolysis is the conversion of glyceraldehyde-3-Phosphate to 1,3 bisphosphoglycerate. The substrate for this reaction is shown to the right. Draw the chemical structure of the product and indicate any other substrates and/or products (e.g. ATP) that are involved in this reaction.



OR

ii) Most of the key energy generating steps in the TCA cycle generate energy with an identical biochemical mechanism. The substrate for one of these reactions, Pyruvate, is shown to the right. Draw the chemical structure of the product and indicate any other substrates and/or products that are involved in the reaction.



OR

iii) An energy generating scheme that is common to both the TCA cycle and β-oxidation of fatty acids is the conversion of an alkane to a ketone. Beginning from the structure of the alkane, draw the chemical changes that would transform this into a ketone. Indicate any other substrates and/or products that are involved at each step of the reaction.

B5: (12 Pts) Regardless of your choice for problem B4, the answer to the following questions are the *same*.

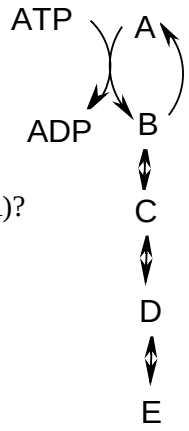
i) What is the *general* name for the reactions described in question B4 (Hint, what is the ultimate fate of carbon in metabolism.) (2 pt)?

ii) All of the above transformations release energy. In what form is this energy stored after the reaction is complete (2 pts)?

iii) *Briefly* describe the final steps of metabolism that converts this stored energy to ATP (8 pts).

B6: (15 pts) Do **ONE** of the following two questions. The **second** choice is given on the **following** page.

B6 Choice 1: A *hypothetical* metabolic pathway is shown to the right. In this pathway compound A is ultimately degraded to E. Compound E can also be used to synthesize A using most of the same enzymes in the pathway. However, it is necessary to perform the conversion of B to A using a different enzyme. The conversion of A to B and B to A is the regulated step in this pathway.



i) Which of the compounds (A-E) would be a product inhibitor for the *biosynthetic* pathway (E→A)? Why?(2 pts)

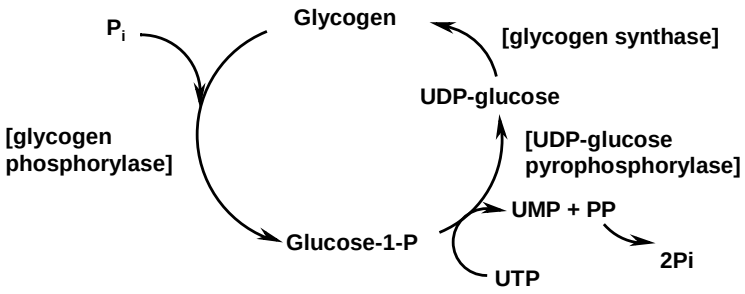
ii) Which of the compounds (A, B, C, D, or E) would function as a feedback inhibitor for the *degradative* pathway? Briefly justify your answer.(3 pts)

iii) Why is it necessary to use one enzyme for the degradation of A to B and a different enzyme for the synthesis of A from B?(3 pts)

iv) Using your knowledge of either the regulation of glycolysis/gluconeogenesis or the regulation of glycogen degradation/synthesis, describe a method to coordinately regulate this metabolic pathway such that both degradation and synthesis did not occur at the same time.(2 pts)

v) If this pathway was involved in the generation of energy in the direction of A→E what additional regulatory features would be desirable? Justify your answer and give an example from either glycolysis or the TCA cycle.(5 pts)

B6 Choice 2: The diagram to the right shows the metabolic pathway for the degradation and synthesis of glycogen.



i) When blood glucose levels are low, which enzyme is active, glycogen phosphorylase or glycogen synthase? Justify your answer in terms of the metabolic needs of the body under condition of low glucose.(4 pts)

ii) Briefly describe *how* this coordinated regulation occurs.(4 pts)

iii) Glycogen storage diseases are often fatal if untreated. Assume that the enzyme for glycogen degradation was missing in an individual due to a genetic mutation. Give two metabolic consequences of this mutation? (3 pts)

iv) How would you modify the diet of an affected individual to reduce the severity of this disease. Clearly state which alternative metabolic pathways would be used to satisfy the energy needs of the individual.(3 pts)

v) What defect(s) in energy production could *not* be corrected by a change in diet?(1 pt)