A :_____/16
B1:_____/ 8
B2:_____/12
B3:_____/ 8
B4:_____/ 9
B5:_____/ 7
B6:_____/ 8
B7:_____/12
B8:_____/12
B9:_____/ 8
Tot:____/100

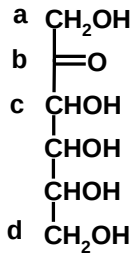
Part A: Multiple Choice. Please select the best single answer (2 pts, 16 total).

1. The following is usually calculated *directly* from X-ray diffraction data:
   a) The number of electrons in the crystal.
   b) The electron density at different locations in the crystal.
   c) The x, y, z coordinates of each atom.
   d) The size of the protein in the crystal.

2. Cholesterol is essential for normal membrane functions because it
   a) carries electrons in electron transport.
   b) spans the thickness of the bilayer.
   c) keeps membranes fluid.
   d) catalyzes lipid flip-flop in the bilayer.

3. The main difference between saturated and unsaturated fatty acids is
   a) the number of carbons.
   b) the presence of keto groups.
   c) the presence of double bonds.
   d) none of the above.

4. The sugar to the right is an _____ and the carbon labeled with ____ will become the anomeric carbon:
   a) ketose, d
   b) aldose, a
   c) ketose, b
   d) aldose, d

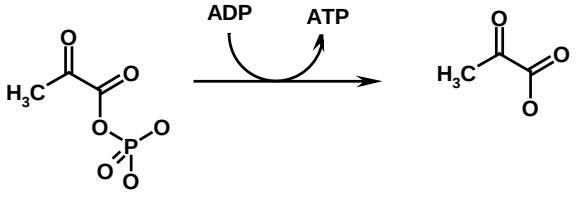


5. Glycogen is more highly branched than starch. Which of the following is the most important characteristic of glycogen?
   a) To provide more compact storage of glucose in animal cells.
   b) To provide more ends for the rapid release of glucose.
   c) To provide additional α (2-3) linkages.
   d) The original statement is false, neither glycogen or starch are branched.

6. In a eukaryotic cell, *activation* of fatty acids occurs in the _____ and *oxidation* occurs in the _____:
   a) cytosol, cytosol.
   b) cytosol, mitochondrial membrane.
   c) cytosol, mitochondrial matrix.
   d) mitochondrial matrix, mitochondrial matrix.

7. Mixing pure O_2 into a yeast culture growing on grape juice will cause the final product (wine) to:
   a) turn to vinegar.
   b) be a nearly alcohol-free 'beverage'.
   c) be no different than that obtained from yeast grown in air.
   d) have a higher ethanol level in the wine.

8. The reaction shown to the right is catalyzed by a:
   a) kinase
   b) phosphatase
   c) dehydrogenase
   d) hydratase



Part B: Short Answer. Please do all of the Questions. In most cases you have choices.

B1. Please do **one** of the following three questions (8 pts)

Choice A:

You work for a company that makes margarine (a common substitute for butter), which consists mostly of triglycerides. Your current formulation, or composition, of margarine melts at 70^{o} C, which is unsuitable for use in the summer (at least in Pittsburgh). How would you change the composition of the margarine such that it will remain *solid* at higher temperatures?

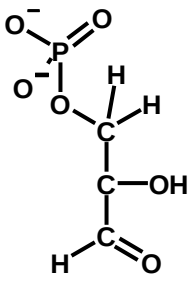
Choice B:

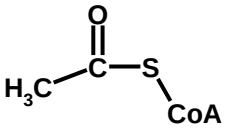
Electron transport within the mitochondrial membrane ceases to function as the temperature of the organism is decreased. Why does this occur and what component or step of the electron transport chain is most likely to be affected by the lower temperature.

Choice C:

What major thermodynamic 'force', or interaction, drives the formation of phospholipid bilayers, as well as the tertiary structure of globular water soluble proteins.

B2. Please do **one** of the following two questions (12 pts):





Choice A:

i) Describe, or illustrate with suitable chemical diagrams, the key energy producing step(s) in either glycolysis or the TCA cycle. (The chemical structures shown to the right may be of some use. The left-hand structure is found in glycolysis while the right-hand structure is found in the TCA cycle.).

ii) What is the general name for this type of reaction?

Choice B:

i) Describe, or illustrate with suitable chemical diagrams the chemical steps by which an alkane (C-C) is converted to a ketone (C=O) in biochemical pathways.

ii) What is the general name for this type of reaction?

iii) In what metabolic pathways does this overall reaction occur?

B3. Many of the chemical changes in metabolic pathways involve large unfavorable changes in the standard free energy difference between the products and the reactants (ΔG^o). However, the reaction can be made favorable by either direct or indirect coupling. Briefly describe *either* direct or indirect coupling. Your answer should include an example from a biochemical pathway we have discussed in this course. You may find half-reactions useful in illustrating your answer in the case of direct coupling (8 pts).

B4. You are a track-and-field coach and you tell your sprinters (those who run short distances very fast) to go on a low carbohydrate/high protein diet. Your team begins to lose races. Why was your advice poor? Your answer should include a discussion of the metabolic pathways by which proteins are utilized by the body and the pathways for carbohydrate utilization and storage. (9 pts)

B5. (7 pts) The properties of the three proteins are listed below.

	Molecular Weight	Solubility in Ammonium Sulfate[1]	# of Asp and Glu residues. (pK_a = 4.0)	# Lys and Arg Residues (pK_a = 9.0)
A	12,000 Da	2.0M	5	10
B	12,000 Da	2.0M	5	8
C	34,000 Da	2.0M	0	10

[1]This is the concentration of ammonium sulfate that will precipitate 50% of the protein, 75% will precipitate when the concentration is 0.5M higher than this value.

Which one of the following three purification schemes will provide pure protein A? You answer should briefly explain which proteins are separated at *each* step in the purification scheme.

Scheme A: Separation by gel filtration, followed by the addition of 1.5 M ammonium sulfate.

Scheme B: Separation by gel filtration, followed by anion exchange chromatography at pH 7.0.

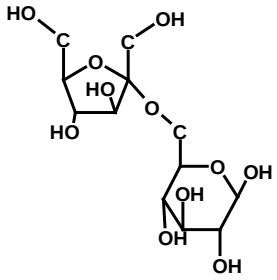
Scheme C: Separation by gel filtration, followed by cation exchange chromatography at pH 7.0

B6. Please answer one of the following four choices in the space below. Please indicate your choice. (8 pts)

Choice A: What are the differences and similarities between glycogen and cellulose?

Choice B: What are the two major differences between cellulose and bacterial cell walls?

Choice C: The disaccharide to the right is composed of the monosaccharide glucose and fructose. Name the sugar.



Choice D: Draw *either* of the following two lipids (hexane=C_6, butane=C_4):

- 1-hexanoyl 2-butanoyl 3-phosphatidylcholine
- 1-hexanoyl 2-butanoyl 3-phosphatidylserine

B7. Please answer **one** of the following two questions (12 pts:)

Choice A: Describe how high energy electrons are processed by the electron transport chain. You answer should include the names of the organic electron carriers, a brief description of the complexes (including their location) that carry the electrons, including some examples of non-organic electron transport mechanisms. Finally, you should describe where the electrons reside at the end of the process and how the energy from electron transport is stored. You should not discuss ATP synthesis (see choice B).

Choice B: Describe how the energy released by electron transport is converted to ATP. You answer should include a diagram of the enzyme that catalyzes this reaction. You should also describe the cellular location of this process and the mechanistic details of ATP synthesis.

B8. Select **one** of the following four choices and indicate your choice (12 pts)

Choice A: Describe or define feedback inhibition and discuss how this process is used to regulate glycolysis or the TCA cycle.

Choice B: Both glycolysis and the TCA cycle are regulated by energy sensing. How does this form of regulation insure efficient use of the celluar resources? Your answer should include an example of a regulated step in either pathway and a discussion of how that step is regulated.

Choice C: Explain how the regulation of glycogen metabolism by protein phosphorylation/dephosphorylation maintains constant levels of blood glucose. Your answer should include a description of the hormones involved and how the hormones regulate protein phosphorylation. You should *not* discuss G-protein coupled receptors or adenyl cyclase production, etc.

Choice D: Under conditions of high glucose levels, the levels of fructose 2,6-bisphosphatase are elevated. Explain how this key regulatory compound regulates glycolysis and gluconeogenesis in a coordinated fashion. You need not explain the regulation of F-2.6-bisphosphate levels by protein phosphorylation.

B9. Please do **one** of the following two choices (8 pts):

Choice A: The reaction of A $\rightarrow$ B in a metabolic pathway has a standard free energy change, ΔG^o, or + 10 kJ/mol. Assuming that the concentration of [A] is 1 mM, what concentration of [B] will insure that this reaction is spontaneous in the direction written.

Choice B: Phosphate ions (PO_4^{3-}) have to transported across the mitochondrial membrane for use in ATP synthesis. If the concentration of phosphate outside the mitochondria is 10 mM, while that inside the mitochondria is 0.001 mM. Given a membrane potential of -100 mV (inside negative), is the transport of phosphate into the mitochondria spontaneous or not? Justify your answer with a numerical calculation.