

A. Multiple Choice: Please circle the best answer (2 pts each, 14 points total)

1. In a eukaryotic cell, most of the enzymes of the citric acid (TCA) cycle are located in the _____, and the enzymes of involved in electron transport are located in the _____.
 - a) mitochondrial matrix, inner mitochondrial membrane
 - b) inner mitochondrial membrane, mitochondrial matrix
 - c) intermembrane space, outer mitochondrial membrane.
 - d) outer mitochondrial membrane, cytosol.
2. The TCA cycle is involved in:
 - a) generation of energy from pyruvate
 - b) synthesis of amino acids
 - c) degradation of amino acids
 - d) all of the above
3. Which of the following metal ions are often used in electron transport?
 - a) Fe^{2+} .
 - b) Mg^{2+} .
 - c) Mn^{2+}
 - d) all of the above.
4. Long-chain fatty acids are oxidized step-wise in ___ carbon units starting from the ___ end.
 - a) 1, either
 - b) 2, aliphatic
 - c) 2, carboxyl
 - d) 3, carboxyl
5. Pyruvate, the end product of glycolysis, is converted to _____ in humans and to _____ in yeast under *anaerobic* conditions.
 - a) acetaldehyde and methanol.
 - b) lactic acid and ethanol.
 - c) acetic acid and ethanol.
 - d) acetyl-CoA and ethanol
6. Epimers are carbohydrates with the same number of carbons but
 - a) one is an aldose and one is a ketose.
 - b) they differ in the configuration of their anomeric carbon.
 - c) they differ in the configuration of one of their non-anomeric carbons
 - d) they are mirror images of each other.
7. The hormones glucagon, epinephrine, and insulin regulate glycogen levels by
 - a) directly binding to the active site of glycogen synthase.
 - b) by binding to glucose, preventing its incorporation into glycogen
 - c) by affecting the phosphorylation level of enzymes.
 - d) by elevating levels of Fructose 2,6 phosphate.

Bonus (+1 pt)

Caffeine is a stimulant because:

- a) it binds to receptors in the brain.
- b) it can be oxidized to produce lots of NADH.
- c) it inhibits the decay of cAMP.

A : _____ / 14

1 : _____ / 4

2 : _____ / 6

3 : _____ / 6

4 : _____ / 9

5 : _____ / 8

6 : _____ / 8

7 : _____ / 8

8 : _____ / 10

9 : _____ / 5

10 : _____ / 10

11 : _____ / 12

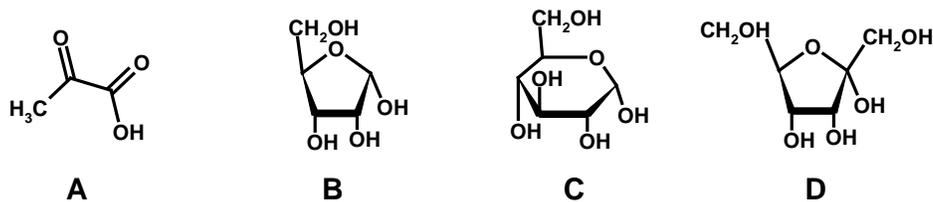
Tot : _____ / 100

1. Briefly describe how X-ray diffraction is used to determine the structure of a protein (4 pts).

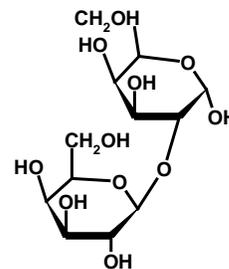
2. Please answer **one** of the following **two** questions (6 pts)

Choice A: Answer the following questions using the letter underneath each compound. Note that there may be more than one correct answer.

- i) Which of the following compound(s) are aldoses?
- ii) Which of the following compound(s) are ketoses?
- iii) Draw an arrow that points to the anomeric carbon in compound 'D'
- iv) What is the configuration of the anomeric carbon in compound 'D'?



Choice B: Name the disaccharide shown to the right, given that the monomeric units are both galactose.



3. Answer **one** of the following **three** questions in the space provided, clearly indicate your selection (6 pts).

Choice A: How does starch differ from glycogen? How are they similar?

Choice B: How do bacterial cell walls differ from cellulose? How are they similar?

Choice C: How does cellulose differ from starch? How are they similar?

4. (9 pts)

i) Draw the structure of *any* phospholipid (4 pts).

ii) Using the structure of your molecule to illustrate concepts/features, briefly discuss the *major* energetic term that drives the formation of the lipid bilayer (5 pts).

5. Please answer **one** of the following **three** questions in the space provided. Clearly indicate your choice (8 pts).

Choice A: How does the presence of *cis* double bonds in unsaturated fatty acids affect the phase transition of the membrane? What intermolecular interaction is affected by the presence of these groups in the bilayer?

Choice B: Compare and contrast the structure of a membrane protein (e.g. bacteriorhodopsin) to that of a soluble protein (e.g. myoglobin)?

Choice C: Explain why it is important for biological membranes to be fluid, and discuss the role of cholesterol in this property of the membrane.

6. Select the purification scheme that will separate protein "C" from a mixture of the following three proteins. Justify your answer by showing that the scheme will actually work. (8 pts).

Protein	Molecular Weight	Solubility in ammonium sulfate (conc required to ppt 50% of the protein).	#Asp + Glu	#Lys & Arg
A	50,000 Da	4.0	5	10
B	100,000 Da	3.0	10	5
C	50,000 Da	4.0	10	5

Scheme 1: Gel filtration chromatography → precipitation with 4 M ammonium sulfate.

Scheme 2: Gel filtration chromatography → ion exchange chromatography at pH=7.

7. (8 pts) Please do one of the following two questions. Note that in choice B, you have additional choices.

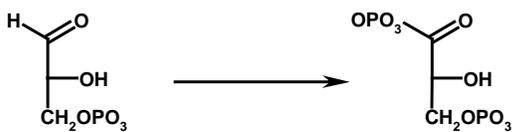
Choice A:

- Compare and contrast the reaction catalyzed by a kinase and a phosphatase (3 pts)
- In what metabolic pathway(s) are reactions of this type prevalent? (2 pt)
- Explain how direct coupling in kinase reactions reduces the overall ΔG° of phosphorylation of compounds, provide an example (3 pts).

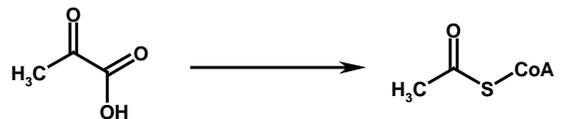
Choice B: Selection **one** of the following **three** reactions. Note that some of the transitions between substrate and product may involve more than one step, but only the first and last compounds are given below.

- State the *general* nature of the chemical changes that occur to produce the shown product and discuss how the energy associated with this change is captured (3 pts).
- Indicate any missing co-substrates/co-factors, products, etc. (3 pts).
- State the metabolic pathway in which the reaction occurs (2 pts).

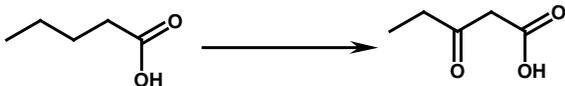
A



B



C



8. Select **one** of the following **two** questions. A *well labeled* diagram is an acceptable answer. Please indicate your choice (10 pts).

Choice A: *Briefly* discuss the electron transport process, beginning with NADH and ending with the production of H₂O. You should *not* discuss ATP synthesis.

Choice B: *Briefly* discuss the mechanism of ATP synthesis in the mitochondria. Your answer should indicate the source of energy for ATP synthesis. You should *not* discuss electron transport.

9. Please do **one** of the following **two** choices. Please indicate your choice (5 pts).

Choice A: Compare and contrast direct versus indirect coupling in metabolic pathways. Provide one example of indirect coupling.

Choice B: Compare and contrast a feedback versus a product inhibitor. Provide an example of one.

10. (10 pts) Select **one** of the following **two** questions. Please indicate your choice T=300 K, RT=2.5 kJ/mol

Choice A: The conversion of 2-phosphoglycerate to 3-phosphoglycerate is a step in glycolysis that is reversed in gluconeogenesis. In a cell, the concentration of 2-phosphoglycerate is 0.1 mM and the concentration of 3-phosphoglycerate is 1 mM. Assuming ΔG° for this reaction is 0 kJ/mol, is this cell undergoing glycolysis or gluconeogenesis? Justify your answer using the Gibbs free energy..

Choice B: The cells in the lining of your stomach pump hydrogen ions into your stomach in order to acidify the contents of your stomach. Assume that the hydrogen ion concentration is 10^{-2} M (pH = 2) in your stomach and 10^{-7} M (pH = 7) inside the cell, how many moles of ATP are required to pump one mole of protons. The free energy of hydrolysis of ATP is -30 kJ/mol. You can assume $\Delta\psi = 0$.

$$(\Delta G = \Delta G^\circ + RT \ln[B]/[A] + ZF\Delta\psi)$$

11. Please select **one** of the following **four** questions. Please indicate your choice (12 pts).

Choice A: Discuss the general concept of *coordinate* regulation of pathways using *either* the regulation of glycolysis/gluconeogenesis *or* glycogen metabolism as an example. Be sure to discuss the compound(s) that regulate either of these pathways and how the compounds regulate the pathways in a useful manner.

Choice B: You recently consumed a candy bar, elevating your blood glucose levels. Briefly describe the steps that would lead to storage of that glucose into glycogen in the liver. Your answer should include a brief discussion of hormonal and other regulatory signals that are important to this process.

Choice C: You have not eaten in 8 hours, yet the concentration of glucose in your blood remains constant because of the release of glucose from glycogen. Explain how this occurs. Your answer should include a brief discussion of hormonal and other regulatory signals that are important to this process.

Choice D: You are a long-distance runner. One hour into the race your glycogen supplies in the liver and muscle have become depleted, yet your body is still able to produce ATP to drive your muscles. What is the major source of this ATP? Your answer should include a brief description of the major pathways that are being used to generate ATP, in the order that they would occur.