

This exam contains 9 pages. There are a total of 90 points. Allot 1 min/point.

Part A: (17 pts) Multiple Choice (11 x 1½ pts each = 15.5 pts) and Fill in the blanks (1.5 pts).

Please circle the best answer.

- The subunit molecular weight as well as the number of sub-units in the quaternary structure can be determined by:
 - SDS-PAGE electrophoresis.
 - Ion exchange chromatography
 - Gel filtration chromatography.
 - Combining information from a) and c)
 - Which of the following fatty acids would have the lowest CMC (Critical Micelle Concentration)?
 - C₄-COOH
 - C₆-COOH
 - C₈-COOH
 - C₁₀-COOH
- $$\text{C}_4\text{-COOH} = \text{C}-\text{C}-\text{C}-\overset{\text{O}}{\parallel}\text{C}-\text{OH}$$
- Cholesterol is essential for normal membrane functions because it
 - activates ATP synthase.
 - spans the total thickness of the bilayer.
 - keeps membranes fluid.
 - carries electrons in electron transport.
 - A small 20 residue peptide will be largely found buried in a phospholipid bilayer membrane if:
 - its sidechains are all protons (e.g. glycine).
 - its sidechains are all CH₂-OH groups (e.g. Serine).
 - its sidechains are all CH₃ groups (e.g. Alanine).
 - its sidechains are all isopropyl groups (e.g. Valine).
 - Energy for the synthesis of ATP (Chemical energy) during *oxidative phosphorylation* is obtained from:
 - High energy phosphate compounds, such as phosphoenolpyruvate.
 - A proton gradient across the cell membrane.
 - A proton gradient across the outer mitochondrial membrane.
 - A proton gradient across the inner mitochondrial membrane.
 - Opposing degradative and biosynthetic pathways
 - use the same enzymes for many steps.
 - use different enzymes for steps that require large energy changes.
 - are coordinately regulated at steps that use different enzymes.
 - all of the above.
 - Which of the following compounds is responsible for the coordinated regulation of glycolysis and gluconeogenesis by hormonal control?
 - NADH
 - acetyl-CoA
 - fructose 2,6 bis-phosphate
 - fructose 1,6 bis-phosphate

A : _____ / 17

1 : _____ / 4

2 : _____ / 7

3 : _____ / 12

4 : _____ / 8

5 : _____ / 12

6 : _____ / 8

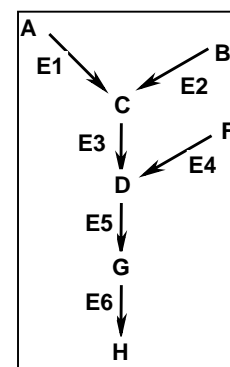
7 : _____ / 10

8 : _____ / 12

TOTAL _____ / 90

= _____ / %

8. The TCA cycle is involved in:
- generation of energy from pyruvate
 - synthesis of amino acids
 - degradation of amino acids
 - all of the above
9. Long-chain fatty acids are oxidized step-wise in ____ carbon units, producing ____.
- 1, formaldehyde
 - 2, pyruvate.
 - 2, acetyl-CoA
 - 4, succinyl-CoA
10. During ATP synthesis, the three otherwise identical β subunits of the F1 complex
- have similar affinities for ADP and ATP.
 - have different affinities for ADP but not for ATP.
 - have different affinities for ATP but not for ADP.
 - have different affinities for ATP and for ADP.
11. In the metabolic pathway shown to the right, enzyme ____ would likely be regulated and ____ would be an example of a feedback inhibitor.
- E1, C
 - E1, H
 - E5, G
 - E5, H



Bonus Question (1 pt): Caffeine is a stimulant because:

- It accelerates the decay of cAMP.
- It accelerates the decay of ATP.
- It slows the decay of cAMP.
- It binds directly to excitatory neurons.

Fill in the blanks: You need only fill in **one** sentence. (½ pt each word, 1.5 pts total.)

1. Anaerobic metabolism produces _____ in humans, _____ in yeast, and
regenerates NAD⁺ for _____ (name of metabolic pathway) in the absence of oxygen.

OR

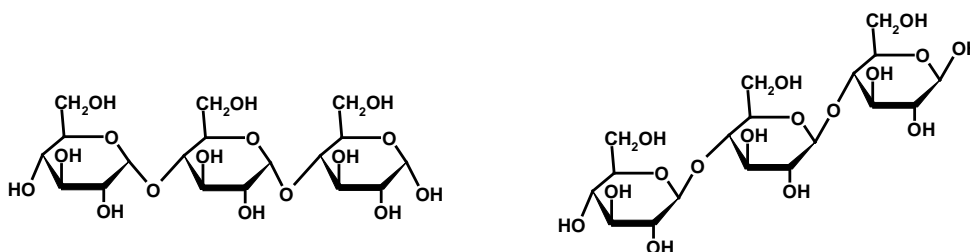
2. The metabolic pathway _____ occurs in the cytosol, as does fatty acid
_____ (activation/oxidation) whereas _____ occurs in the
mitochondrial matrix.

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

2. (7 pts) Please select **one** of the following two choices.

Choice A:

i) Circle the trisaccharide that would be found in starch and glycogen. *Briefly* justify your answer.(3 pts)



ii) Indicate the location of an anomeric carbon.(2pts)

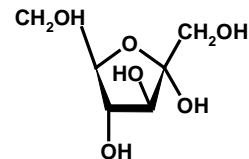
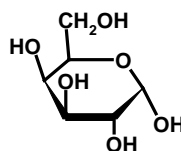
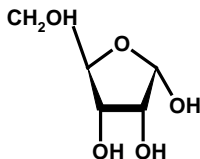
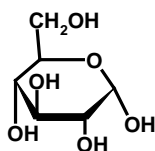
iii) What monosaccharide are these trisaccharides made of (2 pt)?

Choice B:

i) Circle the sugar that is an aldose found in nucleic acids.(2pts)

ii) Underline the two epimers (2 pts)

iii) Indicate the location of an anomeric carbon. What is its configuration in all four sugars? (3 pts)

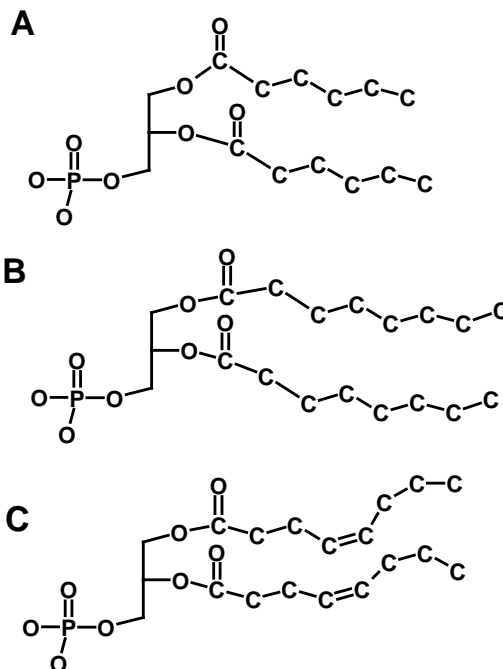


3. (12 pts) The drawing to the left shows three phospholipid molecules, labeled A, B, and C.

- i) (1 pt) Add *any* head group to the top lipid and give its name in the space below (e.g. fill in the following blank):

dihexanoyl phosphatidyl _____

- ii) (3 pts) Briefly describe how would the structure of a triglyceride would differ from these lipids.



- iii) (8 pts) Please do **one** of the following three choices. Please indicate your choice.

Choice A: Describe the role of the hydrophobic effect in the formation of micelles *or* lipid bilayers.

Choice B: Why are the secondary structures of all integral membrane proteins α -helical or β -barrel.

Choice C: The trend in melting temperature, T_M , for the above lipids is: C (lowest), A, and then B. Briefly explain this trend. Your answer should discuss the molecular forces/interactions that affect T_M .

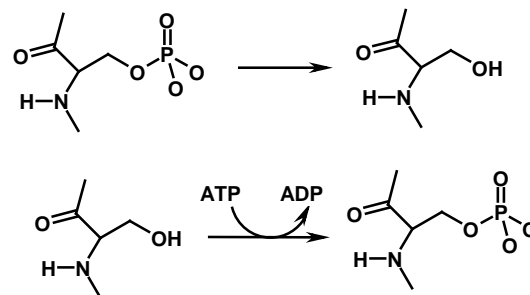
4. (8 pts) Please do **one** of the following two choices. Note that each choice has multiple questions. Answer all of the questions within a choice.

Choice A: Two reactions are shown to the right.

i) (2 pts) *Circle* the reaction catalyzed by a kinase.

ii) (2 pts) What is the general name of the other reaction?

iii) (4 pts) *Briefly* discuss the role of reactions of this type in the *regulation* of enzymes. Give an example.



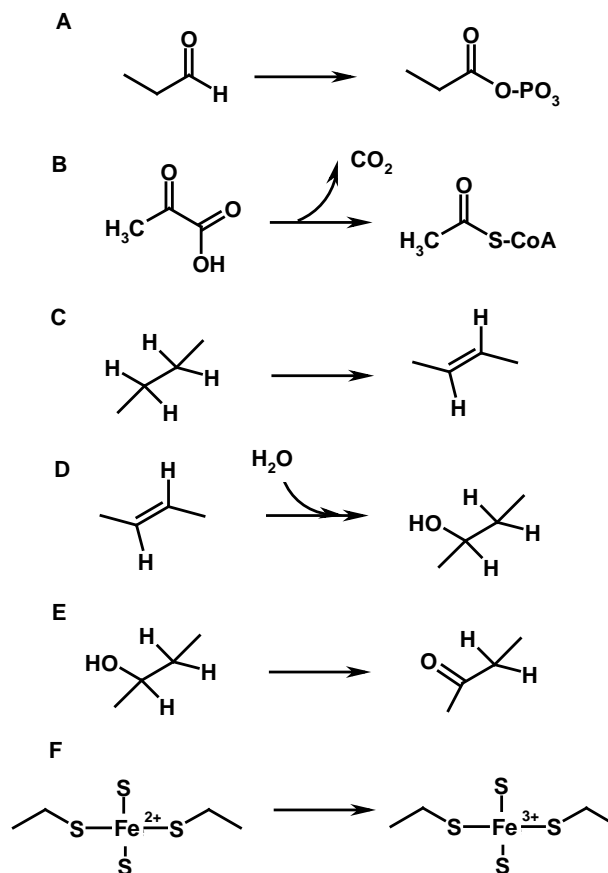
Choice B: Six reactions are shown to the right. Note: not all co-factors/co-substrates are shown.

i) (2 pt) *Circle* the one reaction that is **not** a redox reaction.

ii) (2 pt) What do the remaining redox reactions have in common?

iii) (2 pts) What cofactors or co-substrates would be required for most of these reactions?

iv) (2 pts) For the last reaction (F) and **one other** redox reaction (draw a *box* around your selection), state which metabolic pathway (Glycolysis, TCA, Fatty acid oxidation, electron transport) reactions of these types can be found.



5. (12 pts). Please answer one of the following four choices. Please indicate your choice.

Choice A: The South Beach diet suggests that the dieter completely eliminate carbohydrates from their diet. Should athletes with high energy demands, such as sprinters, go on this diet? Why or why not?

Choice B: List, in the correct order, *all* of the metabolic pathways that would be used in the generation of ATP from cream cheese (fats and proteins) and a bagel (starch).

Choice C: Discuss the electron transport process, beginning with NADH and ending with the production of H_2O . You should *not* discuss ATP synthesis. A *well labeled* diagram is an acceptable answer.

Choice D: 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. A *well labeled* diagram is an acceptable answer.

6. (8 pts) Select **one** of the following **two** questions. Please indicate your choice.

Choice A: The aldolase reaction in glycolysis converts fructose-1-6-P to glyceraldehyde-3-phosphate and dihydroxyacetone phosphate. This reaction has a standard energy (ΔG°) of +24 kJ/M, however during glycolysis the Gibbs free energy, ΔG , is –6 kJ/mol.

- i) Briefly describe why there is a large difference between the standard energy and the Gibbs energy during the normal operation of glycolysis.
- ii) Is this an example of direct or indirect coupling? *Briefly* justify your answer.

Choice B: The standard energy, ΔG° , for the reaction: Glucose-6-P \rightarrow Glucose + P_i , is – 16 kJ/mol. In glycolysis, the addition of phosphate to glucose, producing glucose-6-P, has a ΔG° of –17 kJ/mol.

- i) Briefly describe why the ΔG° for the phosphorylation of glucose in glycolysis is –17 kJ/mol, not +16 kJ/mol, as you might predict from the ΔG° for the release of phosphate from glucose.
- ii) Is the phosphorylation of glucose in glycolysis an example of direct or indirect coupling? *Briefly* justify your answer.

7. (10 pts) Please do **one** of the following two choices. Please indicate your choice.

Choice A: Select any **one** of the following enzymes and describe how it is regulated by *either* energy sensing *or* hormonal control, whichever is appropriate for the particular enzyme. *Briefly* discuss the physiological/metabolic importance of regulating the enzyme in this fashion.

- i) Phosphofructokinase (PFK, Glycolysis)
- ii) Fructose-1-6-bisphosphatase (Gluconeogenesis)
- iii) Pyruvate dehydrogenase (Pyr → Acetyl-CoA).
- iv) Citrate synthase (TCA cycle)
- v) Glycogen Synthase.
- vi) Glycogen phosphorylase.

Choice B: Briefly describe how a liver cell will respond to **one** of the following hormones. Your answer should briefly discuss the role of the liver in maintaining blood sugar levels and the reason why the hormone is present.

- i) glucagon
- ii) epinephrine (adrenaline)
- iii) insulin

8. (12 pts) Please select **one** of the following four questions. Assume $T=300\text{ K}$, $RT=2.5\text{ kJ/mol}$. The formula shown on the right may be useful for questions A-C.

$$\Delta G = \Delta G^0 + RT \ln \frac{[B]}{[A]}$$

$$\Delta G = RT \ln \frac{[X]_{IN}}{[X]_{OUT}} + ZF\Delta V$$

$$\Delta G^0 = -RT \ln \frac{[B]_{Eq}}{[A]_{Eq}} = -RT \ln K_{EQ}$$

$$f_A = \frac{1}{1 + K_{EQ}}$$

$$f_B = \frac{K_{EQ}}{1 + K_{EQ}}$$

- Choice A:** A cell pumps Na^+ out of the cell using an enzyme that is a Na^+ pump. The concentration of Na^+ inside the cell is 0.1M and the concentration outside the cell is 0.15M. The voltage difference across the membrane is 0.1V, with the outside positive. How many ATP molecules are required to pump one Na^+ ion? Please show your calculations.
- Choice B:** The standard free energy for the transfer of a 20 residue Gly peptide (Gly_{20}) into a phospholipid bilayer is +60 kJ/M. The standard free energy for the transfer of the sidechain of Cysteine to a non-polar environment is -3 kJ/mol. You add large amounts of phospholipid to a 1 mM solution of Cys_{20} and allow the system to come to equilibrium. What is the concentration of Cys_{20} free in aqueous solution and what is the concentration of Cys_{20} in the lipid bilayer? Please show your work.
- Choice C:** A reaction in a metabolic pathway, $A \rightarrow B$, has a standard energy, ΔG^0 , of +10 kJ/mol. Assuming that the concentration of [A] in the cell is 1 mM, what must the concentration of [B] be to insure that the flux through this step is in the direction $A \rightarrow B$? Please show your work.
- Choice D:** A *pure* protein of unknown quaternary structure was chromatographed on a gel filtration column. At high protein concentration a single peak, with a molecular weight of 40 kDa, was obtained. At low protein concentrations two peaks were obtained, one with a molecular weight of 20 kDa, and one with a molecular weight of 40 kDa. The same protein was subject to SDS-PAGE and a single band of 20 kDa was obtained. What is the quaternary structure of this protein? Justify your answer and show that it is consistent with *all* of the experimental data.