C383 Exam 3
Fall 2015

Name Key Seat Number _____

Student ID _____ AI _____

The last page of this exam contains equations, constants,and other information you might find useful.
The exam consists of 34 questions worth 100 points plus 5 bonus points on a total of 13 pages. It will be scored out of 100 points, and you can receive a maximum of 100 point.

1-20 _____/40 multiple choice

21-30 _____/20 fill in the blank

31 _____/10

32 _____/10

33. _____/10

34. _____/10

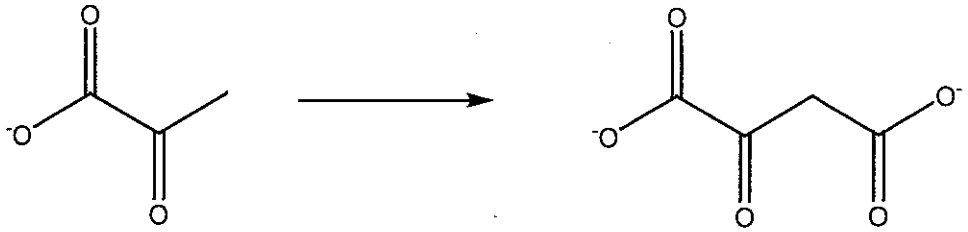
Bonus _____/5

Total:

Regrading: All requests for regrades must be submitted in writing within 48 hours of the return of the exam. You must explicitly state what has been misgraded and why it is an error. The entire exam will be regraded, which could result in points being added or deducted overall.

Section 1: Multiple Choice. 15 questions, 2 points each.

1. D What is the metabolic purpose of this reaction?



A. To produce a citric acid cycle intermediate
B. To produce an intermediate for glycolysis
C. To produce an intermediate for gluconeogenesis
D. More than one of the above
E. None of the above.

2. C Which of these reactions is a near equilibrium reaction of glycolysis?
A. glucose + ATP → glucose-6-P + ADP
B. phosphoenolpyruvate + ADP → pyruvate + ATP
C. 1,3-bisphosphoglycerate + ADP → 3-phosphoglycerate + ATP
D. fructose-6-P + ATP → fructose-1,6-bisphsophate + ADP
E. None of the above

3. B Glucagon regulates the committed step of glycolysis through a signal transduction cascade that
A. raises [fructose 2,6-bisphsophate], turning off glycolysis.
B. lowers [fructose 2,6-bisphsophate], turning off glycolysis
C. raises [fructose 2,6-bisphsophate], turning on glycolysis.
D. lowers [fructose 2,6-bisphsophate], turning on glycolysis.

4. C Which pathway can two high energy electrons from NADH (produced in the cytosol during glycolysis) take to produce a 6 H^+ gradient?
A. malate-aspartate shuttle → Complex 1 → Q pool → complex 3 → Complex 4 → oxygen
B. Complex 2 →Q pool → Complex 3 → Complex 4 → oxygen
C. glycerol-3-phosphate shuttle→ Q pool → Complex 3 → complex 4 → oxygen
D. Complex 1 → Complex 2 → Q pool → Complex 3 → Complex 4 → oxygen

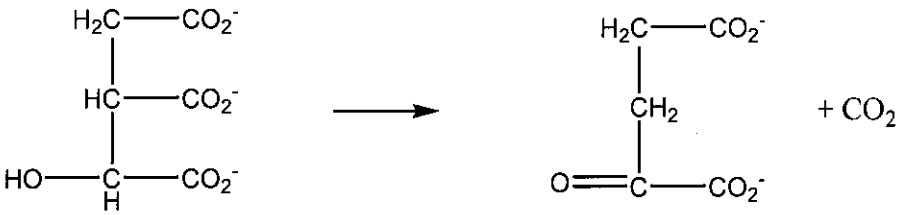
5. D How many ATP can be made (net) from the release of 1 glucose molecule stored in glycogen through glycolysis under anaerobic conditions?

A. 0
B. 1
C. 2
D. 3
E. 4

6. E All of the following are compounds that can serve as sources of carbon to produce net glucose through gluconeogenesis except:

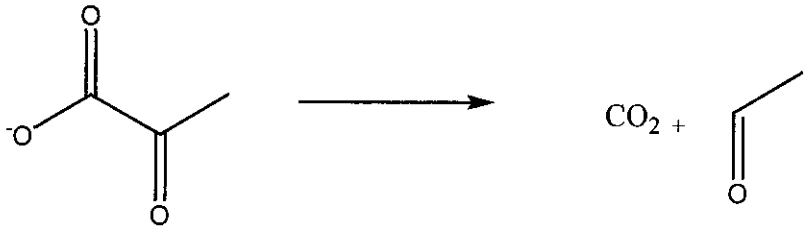
A. glycerol
B. pyruvate
C. lactate
D. amino acids
E. acetyl CoA

7. A The reaction below would require which cofactor(s)?



A. NAD^+
B. biotin
C. TPP
D. more than one of the above
E. None of the above

8. C The reaction below is the first step of yeast fermentation, eventually leading to ethanol. Which cofactor(s) would it require?



A. NAD^+
B. biotin
C. TPP
D. more than one of the above
E. None of the above

9. B Which of these is not a biochemical strategy for making a reaction irreversible under cellular conditions?

A. ATP hydrolysis
B. NADH production
C. pyrophosphate hydrolysis
D. thioester hydrolysis
E. decarboxylation

10. C Which of these reactions is not an anaplerotic reaction?

A. glutamate → α-ketogluterate
B. aspartate → oxaloacetate
C. isocitrate → α-ketogluterate
D. pyruvate → oxaloacetate

11. D Which of these redox reactions is not spontaneous under standard conditions? (See appropriate data on last page. Q = ubiquinone)

A. $NADH + FAD \rightarrow NAD^+ + FADH_2$
B. Cytochrome c (+2) + O_2 → Cytochrome c (+3) + water
C. a-ketoglutarate + NAD^+ → succinate + CO_2 + NADH
D. $QH_2 + FAD \rightarrow Q + FADH_2$

12. A In humans, the flow of ____ protons through ATP synthase can produce ____ ATP.

A. 8, 3
B. 1, 1
C. 1, 2.7
D. 10, 2

13. B In liver cells, glucagon activates release of glucose from glycogen by this transformation:

A. phosphorylase *a* → phosphorylase *b*
B. phosphorylase *b* → phosphorylase *a*
C. phosphorylase *a* (T state) → phosphorylase *a* (R state)
D. phosphorylase *b* (T state) → phosphorylase *b* (R state)

14. A A patient that has an enlarged liver due to storing large amounts of glycogen with normal structure has hypoglycemia (low blood sugar.) This is consistent with a mutation in which enzyme?

A. glycogen phosphorylase
B. branching enzyme
C. debranching enzyme
D. glycogen synthase

15. C Which statement concerning redox cofactors is **false**?

A. Q is capable of being reduced by two electrons, one at a time.
B. NAD^+ has a low reduction potential.
C. NADH can donate one or two electrons at a time in redox reactions.
D. $FADH_2$ can donate one or two electrons at a time in redox reactions.

16. A Starting with 2 pyruvate, the production of glucose through gluconeogenesis costs ___ATP equivalents and ___ NADH.

A. 6, 2
B. 2, 2
C. 0, 4
D. 4, 6
E. 4, 4

17. D The committed step of glycolysis is the conversion of _____ to _____.

A. phosphoenolpyruvate, pyruvate
B. glucose, glucose-6-P
C. pyruvate, acetyl CoA
D. fructose-6-P, fructose-1,6-bP
D. oxaloacetate, phosphoenolpyruvate

18. C Which statement concerning glucokinase is **false**?

A. It is an isozyme of hexokinase.
B. It is found in the liver.
C. It is inhibited by glucose-6-phosphate.
D. It has a high K_M, so it is only active at high [glucose.]
E. It catalyzes the formation of glucose-6-P from glucose.

19. E Which of these reactions does not take place in the mitochondrial matrix?

A. ATP synthesis by ATP synthase.
B. pyruvate → acetyl CoA
C. acetyl CoA + oxaloacetate → citrate
D. NADH donates electrons to Complex 1 of the electron transport chain
E. glucose-1-P + UTP → UDP-glucose + 2 P_i

20. B Which of these statements concerning an uncoupler of the protonmotive force is false?

A. An uncoupler dissipates the proton gradient made by the electron transport chain.
B. An uncoupler will cause NADH levels to build up to high concentration.
C. Adding an uncoupler will cause ATP synthesis by the ATP synthase to slow or stop.
D. When an uncoupler is added, oxygen will continue to be reduced to water.

Section 2: Fill in the blank. 10 questions 2 points each

21. In glycolysis, ATP synthesis does not require oxygen because it is made by substrate-level phosphorylation.

22. The high energy bond found in acetyl CoA is called a thioester.

23. The standard free reduction potential of NADH + FAD → NAD^+ + $FADH_2$ is 0.10 V.

24. Although this transformation cannot be done by humans, the glyoxylate pathway can be used by some organisms to transform acetyl CoA (or fatty acids) into net glucose.

25. In the electron transport chain, oxygen is typically reduced to water, but occasionally produces superoxide, (peroxide, ROS), which can cause oxidative damage to the cell.

26. Two mobile carriers of the electron transport chain are Q (QH_2) and cytochrome c. (NAD^+, NADH acceptable)

27. In addition to driving ATP synthesis, some of the proton gradient of the mitochondrial membrane is used to transport P_i (ADP, ATP acceptable) across the membrane.

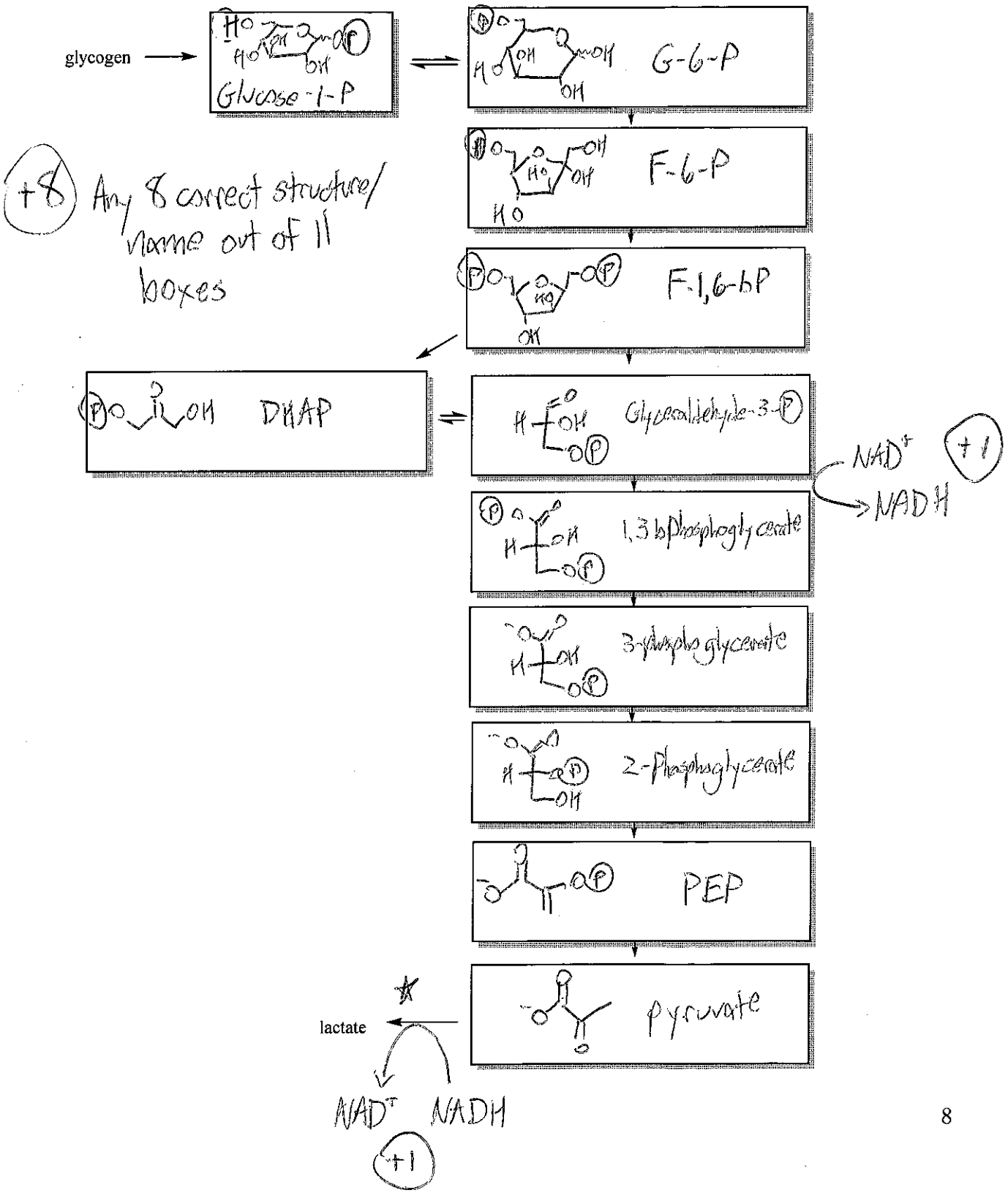
28. Insulin is a hormone that is released in response to (high/low) high blood sugar, and affects the (muscle/liver/both muscle and liver) liver.

29. Protein Phosphatase 1 (phosphatase acceptable) is the enzyme that reverses the regulatory effects of kinases on glycogen metabolism.

30. UDP-glucose is the activated form of glucose that is incorporated into the storage form of glucose.

Section 3. Problems. 4 questions 10 points each.

31. (10pts) A molecule of glucose stored in glycogen can be catabolized to two molecules of lactate under anaerobic conditions in muscle. Fill in each box with the name or structure of the intermediates along this pathway. Then indicate every step that uses NADH or NAD^+ as a cofactor.



32. 10pts (Problem 19.25) The oxidation of malate by NAD^+ to form oxaloacetate is highly endergonic under standard conditions ($\Delta G^{o'}$ = 29 kJ/mol.) The reaction proceeds readily under physiological conditions.

+3 A. Why? The concentration of oxaloacetate is very low under physiological conditions.

or OAA is used up irreversibly in the subsequent rxn (Le Chatelier)

+7 B. Assume an $[NAD^+]/[NADH]$ ratio of 8 and a pH of 7 at 298 °K. What is the lowest [malate]/[oxaloacetate] ratio at which oxaloacetate can be formed spontaneously from malate.

$$\Delta G = \Delta G^{o'} + RT \ln \frac{[P]}{[R]}$$

$$\Delta G = \Delta G^{o'} + RT \ln \frac{[OAA][NADH]}{[malate][NAD^+]} \quad (+2)$$

$$0 \frac{kJ}{mol} = 29{,}000 \frac{J}{mol} + 8.314 \frac{J}{mol\,K}(298\,K) \ln \frac{[OAA]}{[Malate]}\left(\frac{1}{8}\right) \quad (+3)$$

$$-11.7 = \ln \frac{[OAA]}{[malate]}\left(\frac{1}{8}\right)$$

$$6.6 \times 10^{-5} = \frac{[OAA]}{[Malate]}$$

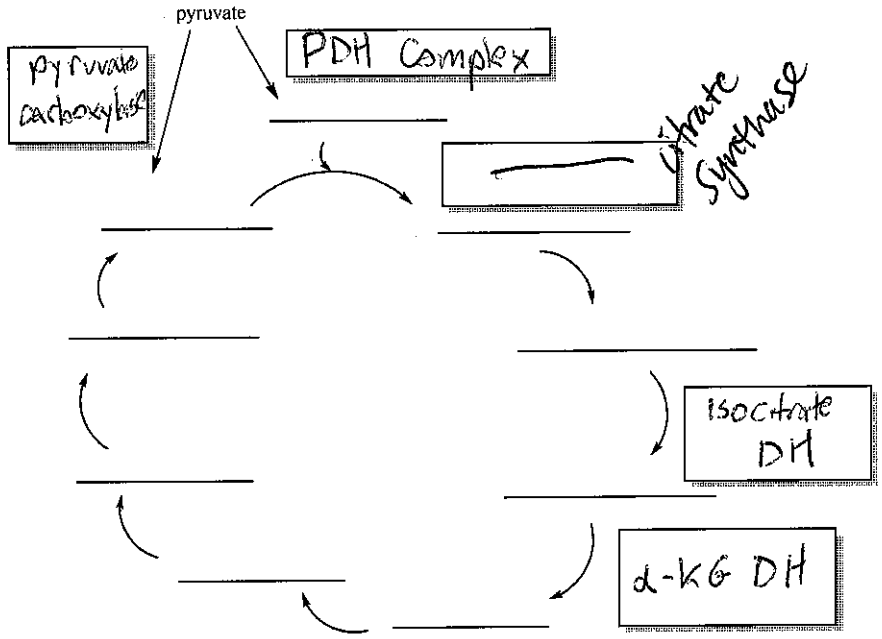
$$\frac{[Malate]}{[oxaloacetate]} = 1.5 \times 10^{4} \quad (+2)$$

33. 10 pts Regulation

A. Would each of the following mutations lead to an increase or decrease in glycolysis in liver cells? (Problem 17.19)

1. loss of allosteric site for ATP in phosphofructokinase increase
2. loss of binding site for citrate in phosphofructokinase increase
3. Loss of phosphatase domain of the bifunctional enzyme that controls the level of fructose 1,6-bisphsophate increase
4. Loss of binding site for fructose 1,6-bisphosphate in pyruvate kinase decrease

B. In the citric acid cycle scheme below, fill in the boxes with these key regulatory enzymes: α-ketoglutarate dehydrogenase complex, Isocitrate dehydrogenase, Pyruvate carboxylase, Pyruvate dehydrogenase complex. (one box will remain blank.)



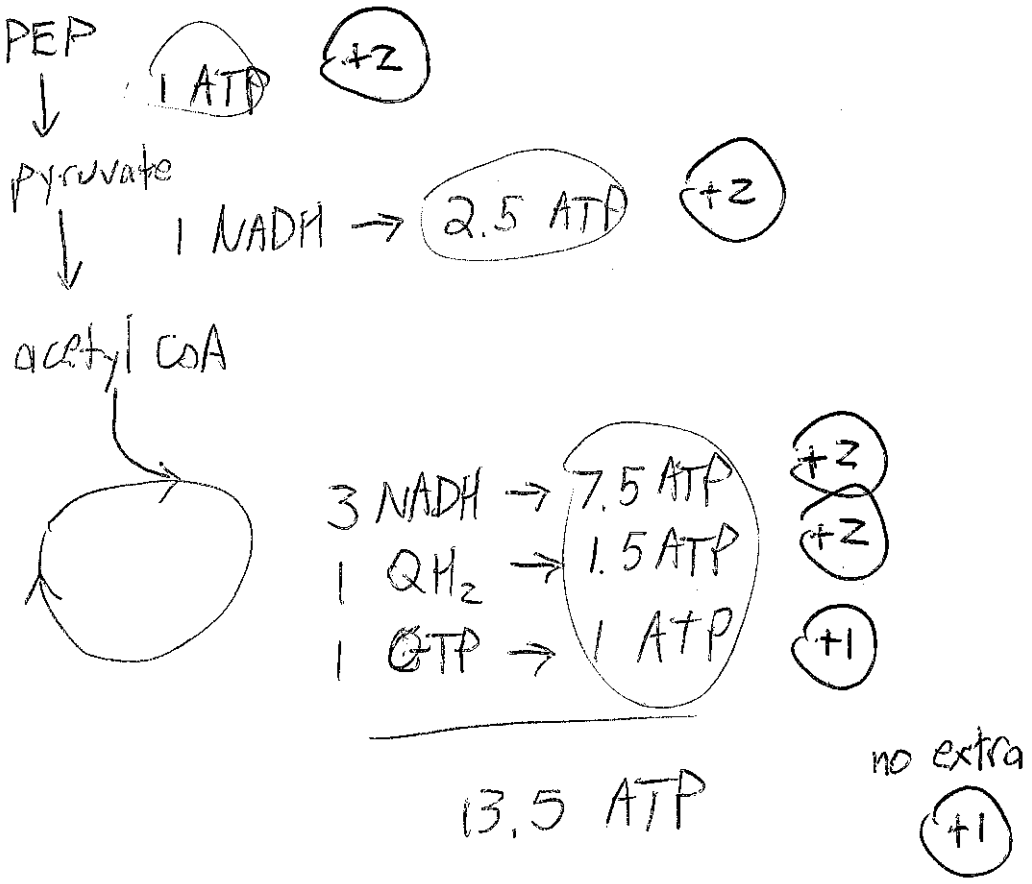
Slow-twitch muscle fibers are for endurance exercise, and will produce ATP aerobically from pyruvate. When these muscles are working, there are relatively high levels of ADP and AMP. Are these enzymes activated or deactivated by high levels of ADP/AMP in muscle?

Pyruvate dehydrogenase complex activated
Isocitrate dehydrogenase activated

Under some conditions, liver cell mitochondria will experience a buildup of acetyl CoA and NADH. Will the following enzymes be activated or deactivated by high concentrations of acetyl CoA and/or NADH?

α-ketoglutarate dehydrogenase complex deactivated
Pyruvate carboxylase activated

34. 10 pts (problem 21.3) What is the yield of ATP when one molecule of phosphoenolpyruvate is completely oxidized to CO_2 by a mammalian cell homogenate? Assume that glycolysis, the citric acid cycle, and oxidative phosphorylation are fully active. Give a full and clear accounting of reduced cofactors and ATP equivalents to credit. A one-number answer will receive no credit.



+3 for correct accounting of glucose

Bonus: (5 pts) How many protons are transferred into the intermembrane space of a mitochondria when one molecule of lactate is fully processed through the citric acid cycle? Give a full and clear accounting of your thought process to receive any credit. (Assume that any cytosolic NADH produced go through the glycerol-3-phosphate shuttle, and therefore can only produce 1.5ATP.)