C383 Exam 3
Spring 2016

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 12 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. 20 questions, 2 points each.

1. _____ How many ATP equivalents would be required to transform one molecule of pyruvate into one molecule of glyceraldehyde-3-phosphate through the gluconeogenesis pathway?

A. 1
B. 3
C. 4
D. 6
E. this transformation cannot be done

2. _____ Which of these citric acid cycle reactions is not an oxidation?
A. succinate → fumarate
B. isocitrate→ a-ketogluterate
C. succinyl CoA → succinate
D. malate → oxaloacetate
E. a-ketoglutarate →succinyl CoA

3. _____ In the electron transport chain, Complex III catalyzes the passing of electrons from
A. Q to NADH.
B. QH_2 to cytochrome c.
C. NADH to O_2.
D. iron/sulfur cluster to FMN.
E. FMN to Q.

4. _____ The change in standard reduction potential for the reduction of acetaldehyde to ethanol by NADH is
A. +0.12 V
B. -0.12 V
C. +0.52 V
D. -0.52 V

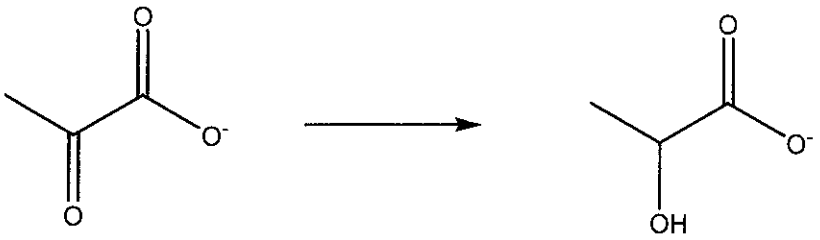
5. _____ Due to electron leaking, the P/O ratio of electrons entering through Complex II *in vivo* is about

A. 8/3
B. 10/3
C. 1.5
D. 2.5
E. 0

6. _____ Which of the following is false concerning the regulation of the pyruvate dehydrogenase complex?

A. PDC is upregulated by pyruvate.
B. PDC is downregulated by NADH
C. PDC is upregulated by acetyl CoA.
D. PDC is downregulated by ATP.

7. _____ The reaction below requires which cofactor(s)?



A. NADH
B. biotin
C. TPP
D. more than one of the above
E. None of the above

8. _____ Which of the following compounds cannot be made into net glucose?

A. oxaloacetate
B. pyruvate
C. succinate
D. a-ketoglutarate
E. acetyl CoA

9. _____ A defect in which of these enzymes would NOT lead to hypoglycemia (low blood sugar)?

A. glucose-6-phosphatase
B. debranching enzyme
C. muscle glycogen phosphorylase
D. phosphorylase kinase
E. Defects in all of the above would lead to hypoglycemia.

10. _____ Which of these reactions has the purpose of preparing a six-carbon sugar to be split into two three carbon sugars in glycolysis?

A. glucose-6-phsophate →fructose-6-phosphate
B. DHAP → GAP
C. PEP→pyruvate
D. 3-phsophoglycerate → 3-phosphoglycerate

11. _____ How many ATP can be produced from one molecule of acetyl CoA entering the citric acid cycle. (Assume full oxidative phosphorylation.)

A. 2
B. 4
C. 5
D. 10
E. 32

12. _____ Glucose can be released from glycogen in the form of glucose-6-phosphate at the cost of _____ ATP.

A. 0
B. 1
C. 2
D. 0 or 1 depending on the tissue.

13. _____ The most highly regulated enzyme in glycolysis is

A. phosphofructokinase
B. GAP dehydrogenase
C. enolase
D. phosphoglycerate mutase

14. _____ Under anaerobic conditions, one molecule of glucose can be used to make net

A. 2 ATP
B. 2 ATP and 2 pyruvate
C. 4 ATP and 2 NADH
D. 4 ATP and 2 NAD^+

15. _____ Gluconeogenesis occurs mainly in the

A. muscle, from precursors such as glycerol and lactate.
B. muscle, from precursors such as acetyl CoA.
C. liver, from precursors such as glycerol and lactate.
D. liver, from precursors such as acetyl CoA.

16. _____ The pyruvate dehydrogenase complex uses all of the following cofactors catalytically except

A. TPP.
B. lipoamide.
C. coenzyme A.
D. FAD.

17. _____ The first step of the citric acid cycle (formation of citrate) is

A. a near equilibrium reaction.
B. exothermic, because a high energy bond is broken.
C. exothermic, because [oxaloacetate] is kept low.
D. endothermic, because a high energy bond is formed.
E. exothermic, because [oxaloacetate] is kept high.

18. _____ The oxygen you breath is incorporated into

A. water.
B. carbon dioxide.
C. An oxidized cofactor.
D. the citric acid cycle intermediates
E. ATP.

19. _____ All of the following conditions increase the activity of glycolysis except

A. increase in [AMP]
B. well-fed state
C. increase in insulin
D. increase in [citrate]

20. _____ Which of the following compounds is an especially appropriate activator for pyruvate carboxylase?

A. acetyl CoA
B. oxaloacetate
C. citrate
D. glucose

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

21. Transformation of pyruvate to oxaloacetate requires the cofactor biotin.

22. The pentose phosphate pathway is essential for the production of NADPH, which provides "reducing power" for anabolism and detoxification.

23. Glycogen phosphorylase and glycogen synthase are reciprocally regulated enzymes.

24. A significant amount of the protonmotive force is expended shuttling ATP out of the matrix in exchange for ADP into the matrix.
H^+ +2 ok

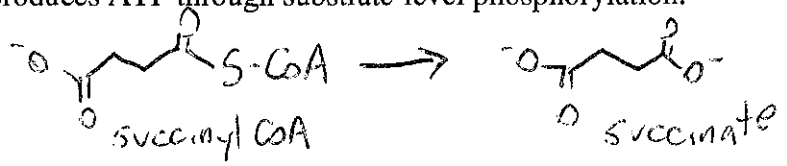
25. One hormone that signals an increase in glycogen breakdown is glucagon or epinephrine.

26. The high energy glucose donor in the synthesis of glycogen is called UDP-glucose.
UDP +1 points UTP +1 points

27. According to the binding change mechanism, ATP is synthesized by ATP synthase when the αβ dimer shifts conformations from open to loose to tight.
loose ok +2 tense ok +2
open ok +2

28. The key means by which glycolysis in the liver responds to changes in blood glucose on the hormone level is through fructose-2,6-bisphosphate, which is a potent allosteric activator of phosphofructokinase.
insulin +1

29. Write a reaction from the citric acid cycle in the space below (names or structures) that produces ATP through substrate-level phosphorylation.



30. Enzymes known as phosphatases reverse the regulatory effects of kinases on glycogen metabolism.

Section 3. Problems. 4 questions 10 points each.

31. (10pts) The final step of glycolysis involves the production of pyruvate and ATP. What is the equilibrium ratio of phosphoenolpyruvate to pyruvate under standard conditions when [ATP]/[ADP] = 10?

PEP + ADP → pyruvate + ATP $\Delta G^{o'} = -61.9\ KJ/mol$

$+\ 30.5\ KJ/mol$

$-31.4\ KJ/mol$

$$\Delta G^{o'} = -RT \ln \frac{[Pyr][ATP]}{[PEP][ADP]}$$

$$-31400\ \frac{J}{mol} = -8.314\ \frac{J}{mol\,K}(298\,K) \ln \frac{Pyr}{PEP}\left(\frac{10}{1}\right)$$

$$\frac{Pyr}{PEP} = 3.2 \times 10^{4}$$

$$\frac{PEP}{Pyr} = 3.1 \times 10^{-5}$$

32. 10 pts What is the yield of ATP when one molecule of fructose-1,6-bisphosphate 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.

F 1,6-bP → 2 NADH = 5 ATP (or 3) (×2)

(×2) ↓ 4 ATP substrate level

2 pyruvate

(×2) ↓ 2 NADH = 5 ATP

2 acetyl CoA

6 NADH = 15 ATP

2 QH_2 = 3 ATP

2 ATP

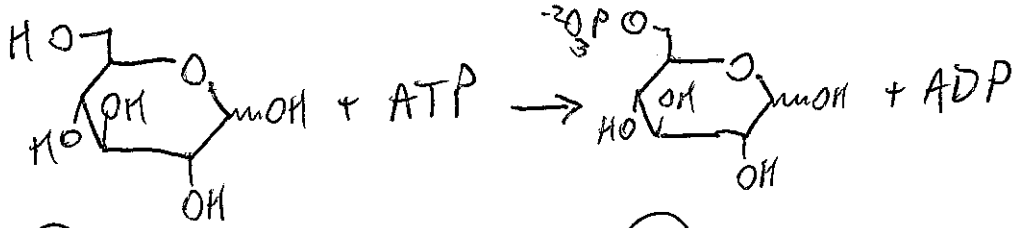
(+4)

Total = 34 ATP

(32 ATP with glycerol-3-P shuttle)

33. 10pts Isozymes

A. Glucose is committed into metabolism by the reaction catalyzed by hexokinase. Draw the structures of the starting materials and products of this reaction. (NTPs can be abbreviated.)



+1 +1

B. Based on the bonds formed and broken, is this reaction exothermic or endothermic? Explain.

+2 exothermic

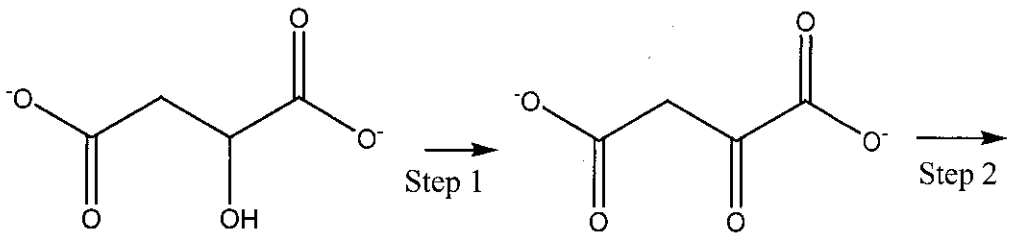
+2 one high energy bond is broken, but none is formed (also accept quantitative answers.)

C. In addition to hexokinase, this reaction is also catalyzed by its isozyme, glucokinase. How are these enzymes different in terms of regulation and K_M? (Be specific.) Why is it advantageous for the liver to have both hexokinase and glucokinase to phosphorylate glucose?

	Hexokinase	glucokinase
+1 K_M	lower	higher
+1 regulation	highly regulated	unregulated

+2 Glucokinase allows the liver to fill its physiological role by bringing glucose out of the blood at high concentration, but not when [glucose] is low.

34. 10 pts In the cytoplasm, there is an enzyme that converts malate into oxaloacetate in a first step and then decarboxylates it in a second step.



A. What cofactor is necessary for step 1 of this enzyme?

+3 NAD+ (actually NADP+)

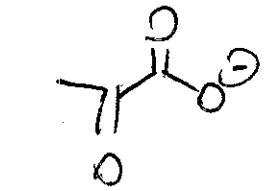
+1 for NADH

B. The decarboxylation step does not require a cofactor. Which carboxylate group will be lost? Explain.

+2

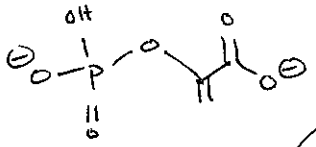
The β keto acid can be decarboxylated without a cofactor because +2 no additional resonance stabilization is needed.

C. Draw the final product of the reaction. What is the name of this product?



pyruvate

+1 +2



PEP

+1

Bonus: (5 pts) A new drug has been developed that can rescue from some respiratory chain poisons. This drug enters the matrix and reacts with NADH to become reduced, and then goes directly to Complex IV to be reoxidized, dumping its high energy electrons into the respiratory chain. What is the P:O ratio for NADH with this drug present?

(+2) { NADH → drug ⟷ Complex 4 = 2 H^+ pumped per Oxygen atom

(+3) $(2H^+)\frac{3\ ATP}{8\ H^+} = \frac{3}{4}\ ATP$ per oxygen atom P/O = 0.75