C383 Exam 3 Version 1
Fall 2017

Name ___Key___ Seat Number ___________

Student ID ______________________ Circle your section: **Wyatt 3:35 4:40**
Joseph 3:35 4:40

The last page of this exam contains equations, constants, and area for scratchwork.

The exam consists of 34 questions worth 110 points on a total of 11 pages, including data sheet and scratch paper. It will be scored out of 100 points, with the maximum score possible being 100.

1-15 ________/30 multiple choice

16-30 ________/30 fill in the blank

31 ________/15

32 ________/15

33. ________/10

34. ________/10

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. __B__ Of the ten steps of glycolysis, how many involve redox cofactors?
   A. 0
   B. 1
   C. 2
   D. 3
   E. it is variable

2. __C__ In which tissue is glucose-6-phosphatase active?
   A. muscle
   B. brain
   C. liver
   D. muscle and liver
   E. most mammalian tissues

3. __E__ Which of the following cofactors found in pyruvate dehydrogenase complex is necessary for decarboxylation of the α ketoacid starting material, pyruvate?
   A. FAD
   B. Q
   C. NAD^+
   D. CoA
   E. TPP

4. __A__ According to the following table, which glucose transporter(s) will be nearly saturated at typical blood sugar levels (5 mM.?)

Table 16.3 Family of glucose transporters

Name	Tissue location	K_M
GLUT1	All mammalian tissues	1 mM
GLUT2	Liver and pancreatic β cells	15–20 mM
GLUT3	All mammalian tissues	1 mM
GLUT4	Muscle and fat cells	5 mM
GLUT5	Small intestine	—

   A. GLUT1 and GLUT3
   B. GLUT2
   C. GLUT4
   D. GLUT1. GLUT3, and GLUT4
   E. GLUT1, GLUT2, GLUT3, and GLUT4

5. __E__ In the citric acid cycle, there are two reactions that use the energy of thioester bond hydrolysis. In these two reactions, the energy is used to

A. do an isomerization.
B. make a reaction irreversible.
C. reduce a substrate.
D. produce one ATP equivalent.
E. more than one of the above

6. __D__ The purpose of the isomerization of citrate to isocitrate is to allow which of the following reactions to happen in the following step?

A. substrate level phosphorylation
B. formation of a high energy thioester
C. oxidative phosphorylation
D. oxidative decarboxylation
E. proton gradient formation

7. __A__ In the electron transport chain, cytochrome *c* accepts ___ electron(s) from ________.

A. one, Complex 3
B. one, Complex 2
C. two, Complex 4
D. two, Complex 3
E. two, Complex 1

8. __D__ In muscle tissue, cytosolic NADH introduces its high-energy electrons into the electron transport chain through a membrane bound complex that makes QH_2. In this case, cytosolic NADH is able to effect the pumping of a total of __ protons through the electron transport chain.

A. 2
B. 2.5
C. 3.7
D. 6
E. 10

9. __A__ In humans, the c-ring of ATP synthase is composed of ___ subunits, making it ______ efficient than yeast, which has 10 subunits.

A. 8, more
B. 8, less
C. 12, more
D. 12, less
E. 14, less

10. __C__ All of the following are advantages of storing fuel as glycogen rather than as triacylglycerides EXCEPT which one?

A. faster energy release and availability
B. provides source of fuel for brain tissue.
C. more energy rich on a per gram basis
D. can be metabolized under anaerobic conditions

11. C Starting from glucose, ______ equivalent(s) of ________ must be spent to store a glucose molecule in branched glycogen.

A. 0, ATP
B. 1, ATP
C. 2, ATP
D. 1, NAD^+
E. 1, FAD

12. A Which of the following is a negative effector for glycogen phosphorylase *a* in the liver?

A. glucose
B. glucose-6-phosphate
C. AMP
D. citrate

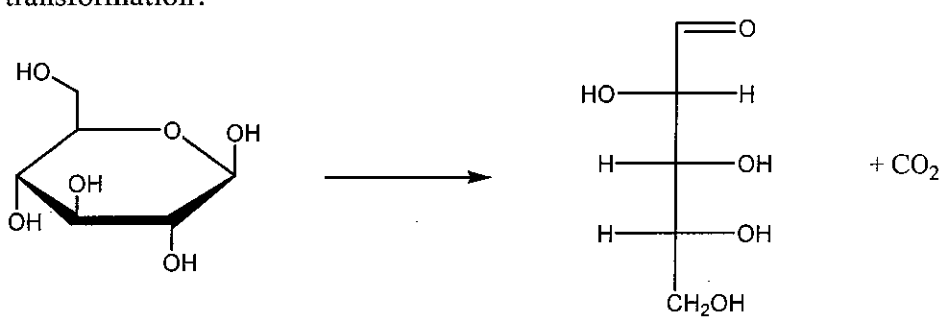
13. D Which type of enzyme of the pentose phosphate pathway is involved in two-carbon transfer reactions?

A. epimerase
B. isomerase
C. transaldolase
D. transketalase

14. E The pentose phosphate pathway is important in maintaining enough ________________ in the cell to suppress damage from reactive oxygen species.

A. NADH
B. ribose-5-phosphate
C.carbon dioxide
D. superoxide
E. glutathione

15. C How many redox cofactors would be needed in a pathway that did this transformation?



A. 0
B. 1
C. 2
D. 4
E. 6

Section 2: Fill in the blank. 15 questions 2 points each. See data tables on last page.

16. In contrast to oxidative phosphorylation, the ATP produced in glycolysis is called _Substrate level_ phosphorylation.

F6P = 1pt

17. If PFK is turned off, levels of _glucose-6-P_ will rise in a muscle cell, which in turn shuts off hexokinase.

18. Gluconeogenesis takes place mostly in _liver_ tissue.

19. Gluconeogenesis and glycolysis are _reciprocally_ regulated so that one is turned off when the other is on.

20. _Succinate DH_ is a citric acid cycle enzyme that is also known as _Complex II_ when considered as a component of the electron transport chain.

21. In the pyruvate dehydrogenase complex, the cofactor _lipoamide_ serves as a flexible linkage to convey the substrate through all the enzyme active sites.

22. One acetyl CoA entering the citric acid cycle can produce a net of _10_ ATP when oxidative phosphorylation is active.

23. The final electron acceptor in the electron transport chain is _O_2_, which is converted to water.

24. The _chemiosmotic_ hypothesis states that electron transport and ATP synthesis are coupled by a proton gradient across the inner mitochondrial membrane.

25. _Glycogen phosphorylase_ is a highly regulated enzyme of glycogen metabolism that uses inorganic phosphate as a nucleophile to break a glycosidic bond.

26. Noncarbohydrate precursors can be made into carbohydrates through the process called _gluconeogenesis_.

PKA = 1pt

27. Epinephrine and glucagon cause signal transduction cascades that activate the enzyme _phosphorylase Kinase_, which in turn activates glycogen phosphorylase.

28. The activated form of glucose that gets incorporated into glycogen is called _UDP-glucose_.

29. _Protein Phosphatase 1_ is the enzyme that opposes the activity of Protein Kinase A in the cell, turning on glycogen synthesis.

30. The oxidative phase of the pentose phosphate pathway oxidizes one carbon atom of glucose to form two molecules of _NADPH_, with biosynthetic reducing potential.

Section 3. Problems.

31. (15pts) Trace the pathway of a glucose molecule stored as glycogen in the muscle through its catabolism under **anaerobic** conditions. (What is the final product?) Give names **OR** structures of each intermediate of the pathway. Indicate steps in which ATP is used or produced and steps in which NADH is used or produced.

Glycogen → G-1-P → G-6-P

↓

F-6-P

↓ * ATP used

F 16 bP

↙ ↓

DHAP → GAP

↓ * NAD+ used/NADH produced

1,3 bP glycerate

↓ * 2 ATP produced

3 P Glycerate

↓

2 P Glycerate

↓

PEP

↓ * 2 ATP produced

pyruvate → lactate * NADH used / NAD+ produced

(+8) intermediated
-1 per mistake

(+2) steps of ATP

(+1) steps of NAD+/NADH

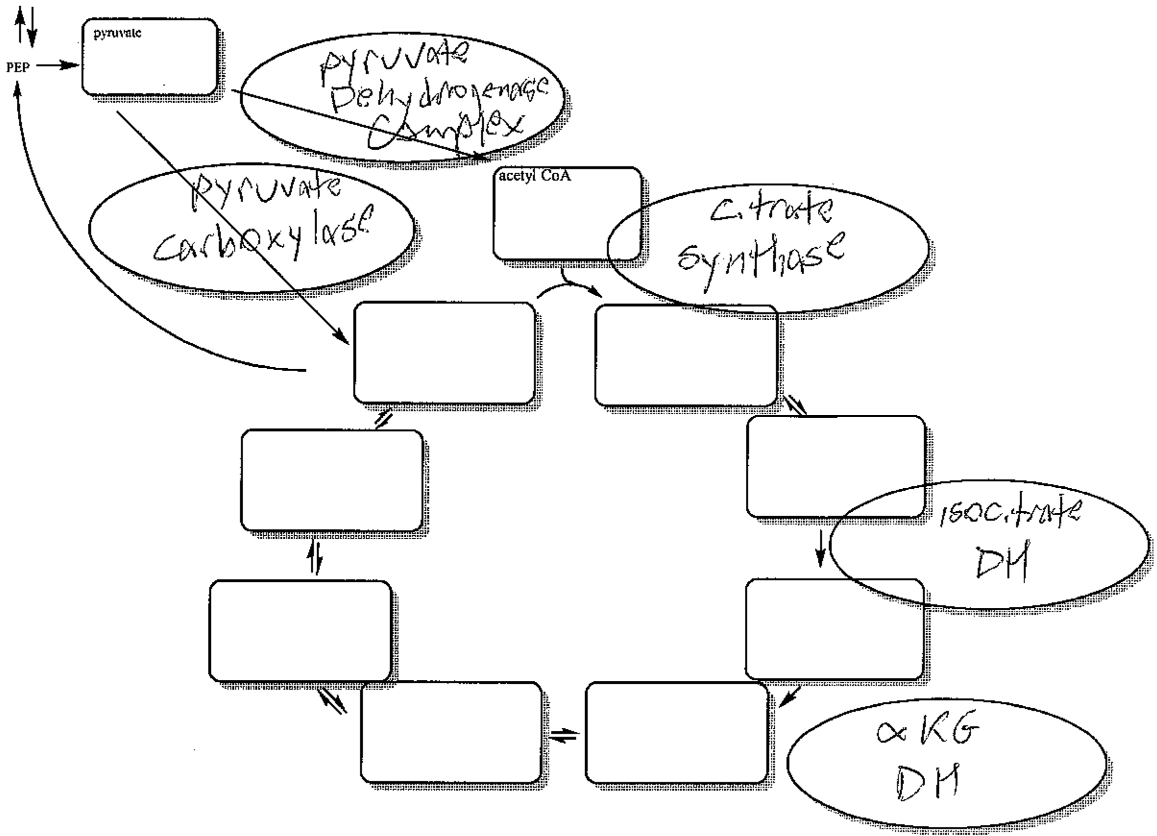
What is the **net** number of ATP produced in this pathway? 3 (+2)

What is the **net** number of NADH produced in this pathway? 0 (+2)

32. (15pts) For each of the following questions, an enzyme or pathway is matched with a potential regulator of that enzyme or pathway. For each pair, write "unregulated" if the enzyme or pathway is unregulated. If the enzyme is activated by the effector, write "upregulated." If it is inactivated by the effector, write "downregulated."

	Enzyme/pathway	Potential regulator	Unregulated, Upregulated, or Downregulated?
A	gluconeogenesis	glucagon	UP
B	phosphofructokinase	F-2,6-bP	UP
C	phosphofructokinase	PEP	DOWN
D	glycolysis	citrate	DOWN
E	hexokinase	Glucose-6-P	DOWN
F	glucokinase	Glucose-6-P	UN
G	Fructose-1,6-bisphosphatase	F-2,6-bP	DOWN
H	Citric acid cycle	ATP	DOWN
I	Citric acid cycle	NADH	DOWN
J	Pyruvate kinase	F-1,6-bP	UP
K	Pyruvate dehydrogenase complex	Low energy charge	UP
L	Glyceraldehyde-3-P dehydrogenase (GAPDH)	ATP	UN
M	Glycogen synthesis	insulin	UP
N	Glycogen degradation	epinephrine	UP
O	muscle glycogen phosphorylase b	AMP	UP

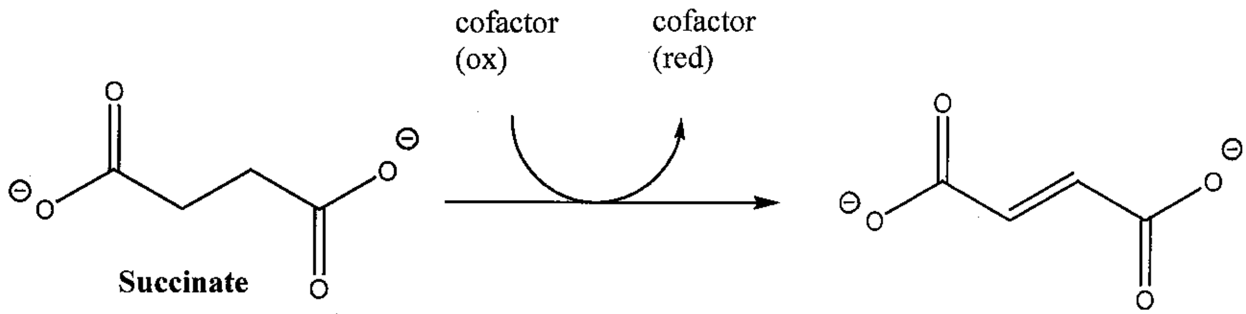
33. (10pts) Fill in the five ovals in the schematic involving the citric acid cycle with the names of enzymes that catalyze thermodynamically irreversible reactions. (You don't have to fill in the squares.)



Why is acetyl CoA an especially appropriate activator for pyruvate carboxylase? As part of your answer, include two conditions in which acetyl CoA levels might be high, and why activation of pyruvate carboxylase would be beneficial.

In both cases in which [acetyl CoA] rises, more OAA is needed. If more ATP is required, activating pyruvate carboxylase will increase flux through CAC, which will lower [acetyl CoA.] If not ATP is needed, activation of pyruvate carboxylase will divert pyruvate to OAA and on to gluconeogenesis (or FA synthesis) because high [acetyl CoA] signals no more need to make acetyl CoA from pyruvate.

34. (10pts) In the citric acid cycle, succinate dehydrogenase catalyzes the oxidation of succinate:



A. Calculate the free energy of the oxidation of succinate using FAD as a redox cofactor. (Hint: Write out the full reaction first and use standard reduction potentials from the table on the last page.)

+4

Succinate + FAD ⇌ Fumarate + FADH

succinate ⇌ Fumarate $\mathcal{E}^\circ = +0.02$

FAD $FADH_2$ $\mathcal{E}^\circ = 0$

$$\Delta G^{\circ\prime} = -nF\Delta\mathcal{E}^{\circ\prime} = -2(96,485)(0.02) = -3900 \frac{J}{mol}$$

B. Calculate the free energy of the oxidation of succinate using NAD^+ as a redox cofactor.

+4

succinate ⇌ Fumarate $\mathcal{E}^\circ = +0.02$

NAD ⇌ NADH $\mathcal{E}^\circ = -0.32$

$$\Delta G^{\circ\prime} = -nF\Delta\mathcal{E}^{\circ\prime} = -2(96485)(-.3) = +58,000 \frac{J}{mol}$$

C. Which redox cofactor does succinate dehydrogenase actually use? How do your calculations explain this?

+2 FAD. The use of NAD^+ as an oxidant is thermodynamically prohibitive → $\Delta G^{\circ\prime}$ is very large, positive number, nonspontaneous.