C383 Exam 3 Version 1
Spring 2017

Name Key Seat Number _____

Student ID _____ Circle your section: **Fidel: M R**
Goran: W R

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. 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. E Which statement is true about the complete metabolic oxidation of one molecule of glucose under aerobic conditions?
   A. A total of 6 CO_2 are produced in full oxidation.
   B. All of the CO_2 made is produced in the mitochondrial matrix.
   C. All of the CO_2 is produced in reactions catalyzed by dehydrogenases.
   D. None of the CO_2 is produced in the glycolysis pathway.
   E. All of the above

2. A Which of the following cofactors found in pyruvate dehydrogenase could be described as a catalytic redox cofactor?
   A. FAD
   B. TPP
   C. NAD^+
   D. CoA
   E. Q

3. D Which of these allosteric effectors of pyruvate dehydrogenase complex is not matched with its effect?
   A. ATP: negative effector
   B. NADH: negative effector
   C. ADP: positive effector
   D. acetyl CoA: positive effector
   E. pyruvate: positive effector

4. B The first step in the gluconeogenesis pathway also plays a key role in the citric acid cycle. What is its role?
   A. It produces a reduced cofactor.
   B. It is an anaplerotic reaction.
   C. It produces acetyl CoA.
   D. It produces an allosteric activator of the cycle.

5. E Which of these enzymes is not regulated?
   A. pyruvate kinase
   B. pyruvate carboxylase
   C. fructose-1,6-bisphosphatase
   D. hexokinase
   E. glyceraldehyde-3-phosphate dehydrogenase

6. C A deficiency in which of these enzymes would NOT cause a glycogen storage disease?
   A. Branching enzyme
   B. glycogen synthase
   C. citrate synthase
   D. glycogen phosphorylase
   E. phosphorylase kinase

7. B Mammals cannot convert _____ into net glucose.
   A. succinate
   B. acetyl CoA
   C. pyruvate
   D. glycerol
   E. glyceraldehyde-3-phosphate

8. E Which of the following transfers do not happen spontaneously in the electron transport chain?
   A. NADH donates electrons to Complex I
   B. cytochrome c donates electrons to Complex IV
   C. Complex II donates electrons to Q
   D. Complex I donates electrons to Q
   E. Cytochrome c donates electrons to Complex III

9. C When two electrons from Complex II travel through the electron transport chain to convert ½ O_2 into water, a total of _____ protons are added to the mitochondrial proton gradient.

   A. 2
   B. 4
   C. 6
   D. 8
   E. 10

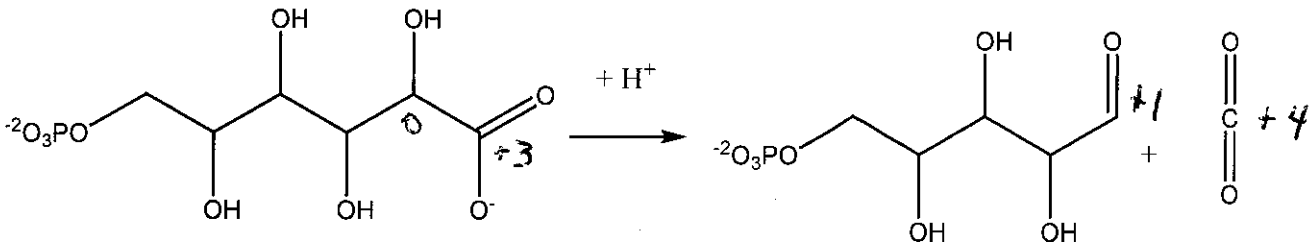
10. A Humans have an F_oF_1 ATP synthase with a hexameric knob and a c ring with 8 subunits. If a synthetic ATP synthase were to be made that was identical to the natural one except that it had an octameric knob, this ATP synthase would be able to produce ____ ATP for every ___ protons that travelled through the ATP synthase.
   A. 1, 2
   B. 3, 8
   C. 8, 8
   D. 8, 3
   E. 2.7, 1

11. A In the human liver, the default form of glycogen phosphorylase is
A. phosphorylase a, which is phosphorylated
B. phosphorylase b, which is phosphorylated
C. phosphorylase a, which is dephosphorylated
D. phosphorylase b, which is dephosphorylated

12. A Which of the following is a positive effector for phosphorylase b in the muscle?
A. AMP
B. ATP
C. glucose
D. glucose-6-phosphate

13. B Which of the following is an effect of Protein Phosphatase 1?
A. activated phosphorylase
B. inactivate phosphorylase kinase
C. inactivated glycogen synthase
D. cause the release of insulin

14. A The reactant in the reaction below is



A. undergoing a two electron oxidation.
B. undergoing a four electron oxidation.
C. not being oxidized or reduced.
D. undergoing a two electron reduction.
E. undergoing a four electron reduction.

15. D The oxygen you breathe is incorporated into which of these molecules?
A. amino acids
B. carbohydrates
C. carbon dioxide
D. water
E. more than one of the above

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

16. The enzyme responsible for the key regulatory step in glycolysis is phosphofructokinase.

17. Coupling of oxidation to the formation of an acyl anhydride in glyceraldehyde-3-phosphate dehydrogenase requires formation of a thioester intermediate and reduction of the coenzyme NAD^+.

18. If PFK is allosterically inhibited, levels of Glucose-6-P will rise in a muscle cell, which in turn shuts off hexokinase.

19. In the liver, the predominant allosteric regulator of glycolysis/gluconeogenesis is Fructose-2,6-bisP.

20. The net oxidation of an acetyl group through the citric acid cycle produces 2 CO_2, 1 substrate level ATP equivalents, 3 NADH, and 1 $FADH_2$ (or QH_2.)

21. Inhibition of isocitrate DH leads to a buildup of citrate, which acts as an inhibitor of the glycolysis pathway.

22. The flow of 2 electrons from NADH to Q (or QH_2) through Complex 1 leads to the pumping of 4 protons out of the mitochondrial matrix.

23. The main storage form of glucose in the muscle is called glycogen.

24. The hormone glucagon signals for the release of stored glucose in the liver but not the muscle.

25. The enzyme that covalently modifies glycogen phosphorylase as a regulatory strategy is called phosphorylase kinase.

26. The activated form of glucose that is incorporated into glycogen is called UDP-glucose.

27. The key regulatory enzyme in glycogen synthesis is called glycogen synthase.

28. The two major products of the pentose phosphate pathway oxidative phase are 5-carbon sugars and NADPH.

29. A structurally unusual tripeptide called glutathione protects cells from oxidative damage by being made into dimers through a disulfide bond.

30. In one sentence, tell an interesting thing you have learned about metabolism:

Any true statement is acceptable

Section 3. Problems.

31. (15pts) Trace the pathway of a glucose molecule stored as glycogen in the muscle through its full oxidation under anaerobic conditions. Give names OR structures of each intermediate of the pathway and indicate steps in which ATP is used or produced. Indicate NADH/NAD+ produced

Glycogen → G-1-P ⇌ G-6-P
↓↑
F 6 P
↓
ATP ** F 1,6 bP
used ↓
↙ ↓
DHAP ⇌ GAP
↓↑ NADH produced
1,3 bPGlycerate
↓↑ ** 2 ATP produced
3 P Glycerate
↓↑
2 P Glycerate
↓↑
PEP
↓ ** 2 ATP produced
Pyruvate
↓ NAD+ produced (NADH used)
lactate

pathway (+10)
- first error free
- after that, -1 each to max of 10

NAD+/NADH (+2)

ATP steps (+2)

What is the **net** number of ATP produced in this pathway? 3 (+1)

+3 each

32. (15pts) Gene mutations can have powerful effects on carbohydrate metabolism. Give a **ONE SENTENCE** explanation of the major consequences of each of these mutations.

A. Loss of the AMP-binding site in muscle phosphorylase

When the enzyme is in its "usually inactive" state, muscle will not be able to degrade glycogen under low energy charge conditions.

B. Phosphorylase kinase mutant is active in its dephosphorylated form in the liver

This will lead to constitutively active phosphorylase which will constantly degrade glycogen

C. Loss of the acetyl-CoA binding site on pyruvate carboxylase

This anaplerotic rxn that forms Oxaloacetate will not be active at times of high [acetyl CoA], so flux through CAC will be low.

D. Liver hexokinase is active, but glucokinase is deficient.

At high [glucose], the liver will not be able to continue to bring glucose into liver cell.

E. isocitrate dehydrogenase and α-ketoglutarate dehydrogenase no longer regulated by NADH

The citric acid cycle will continue to operate even when no ATP is required.

33. (10pts) Matching the citric acid cycle. Write the letter or letters that match the statement to the enzyme. Enzymes may have more than one answer or no answers, but each statement is used only once.

E	malate dehydrogenase	G	aconitase
C J	α-ketoglutarate dehydrogenase	D	fumarase
H	succinate dehydrogenase	A F	citrate synthase
B	succinyl-CoA synthetase	I	isocitrate dehydrogenase

+1 for each letter

A. hydrolyzes a thioester bond to make a reaction irreversible

B. hydrolyzes a thioester bond to produce an ATP equivalent

C. catalyzes a decarboxylation using TPP

D. catalyzes a hydration reaction (addition of water)

E. produces NADH in a reversible step

F. catalyzes the formation of a six carbon tricarboxylic acid

G. isomerization reaction

H. also known as Complex II

I. a spontaneous decarboxylation that requires NAD^+ but no other cofactor

J. analogous to pyruvate dehydrogenase complex

34. (10pts) A. Identify the oxidant and the reactant in this reaction:

$$\text{Pyruvate} + \text{NADH} + \text{H}^+ \rightarrow \text{lactate} + \text{NAD}^+$$

(+2) oxidant reductant

B. Calculate the standard reduction potential for this reaction.

(+3)

pyruvate → lactate $\quad \mathcal{E}^{o'} = -0.19\ V$

NADH → NAD^+ $\quad \mathcal{E}^{o'} = +0.32\ V$

$$\Delta \mathcal{E}^{o'} = +0.13\ V$$

C. Calculate the standard free energy for this reaction.

(+3)

$$\Delta G^{o'} = -n F \Delta \mathcal{E}^{o'}$$

$$= -2\left(96{,}485 \frac{J}{mol\ V}\right)(0.13\ V)$$

$$= -25 \frac{kJ}{mol}$$

D. When does this reaction become important in the muscle? What is its purpose?

(+1) It is active under anaerobic conditions.

(+1) It regenerates NAD^+ for use in glycolysis.

Useful Information:

$$\Delta G_{reaction} = \Delta G^{o\prime}_{reaction} + RT \ln \frac{[products]}{[reactants]}$$

$\Delta G^{0'} = -RT \ln K_{eq}$ R = 8.314 J/mol.K

$\Delta G^{0'} = -nF\Delta E_o'$ F = 96,485 J/mol V

Table 15.1 Standard free energies of hydrolysis ($\Delta G^{o\prime}$) of some phosphorylated compounds

Compound	kJ mol^{-1}	kcal mol^{-1}
Phosphoenolpyruvate (PEP)	−61.9	−14.8
1,3-Bisphosphoglycerate (1,3-BPG)	−49.4	−11.8
Creatine phosphate	−43.1	−10.3
ATP (to ADP)	−30.5	−7.3
Glucose 1-phosphate	−20.9	−5.0
Pyrophosphate (PP$_i$)	−19.3	−4.6
Glucose 6-phosphate	−13.8	−3.3
Glycerol 3-phosphate	−9.2	−2.2

Table 15.1
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Table 20.1 Standard reduction potentials of some reactions

Oxidant	Reductant	*n*	E_o' (V)
Succinate + CO_2	α-Ketoglutarate	2	−0.67
Acetate	Acetaldehyde	2	−0.60
Ferredoxin (oxidized)	Ferredoxin (reduced)	1	−0.43
2 H^+	H_2	2	−0.42
NAD^+	NADH + H^+	2	−0.32
$NADP^+$	NADPH + H^+	2	−0.32
Lipoate (oxidized)	Lipoate (reduced)	2	−0.29
Glutathione (oxidized)	Glutathione (reduced)	2	−0.23
FAD	$FADH_2$	2	−0.22
Acetaldehyde	Ethanol	2	−0.20
Pyruvate	Lactate	2	−0.19
2 H^+	H_2	2	0.00[1]
Cytochrome *b* (+3)	Cytochrome *b* (+2)	1	+0.07
Dehydroascorbate	Ascorbate	2	+0.08
Ubiquinone (oxidized)	Ubiquinone (reduced)	2	+0.10
Cytochrome *c* (+3)	Cytochrome *c* (+2)	1	+0.22
Fe (+3)	Fe (+2)	1	+0.77
½ O_2 + 2 H^+	H_2O	2	+0.82

Note: E_o' is the standard oxidation–reduction potential (pH 7, 25°C, except where noted), and *n* is the number of electrons transferred. E_o' refers to the partial reaction written as Oxidant + $e^- \rightarrow$ reductant
[1]Standard oxidation–reduction potential at pH = 0.

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