MCB 102 Quiz #3 Answer Key
Friday, March 9
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1. All of the following contribute to the large, negative, free-energy change upon hydrolysis of "high-energy" compounds *except:*

A) electrostatic repulsion in the reactant.
B) low activation energy of forward reaction. *
C) stabilization of products by extra resonance forms.
D) stabilization of products by ionization.
E) stabilization of products by solvation.

***2. E'°* of the NAD^+/NADH half reaction is –0.32 V. The *E'°* of the oxaloacetate/malate half reaction is –0.175 V. When the concentrations of NAD^+, NADH, oxaloacetate, and malate are all 10^{-5} M, the "spontaneous" reaction is:**

A) Malate + NAD^+ ® oxaloacetate + NADH + H^+.
B) Malate + NADH + H^+ ® oxaloacetate + NAD^+.
C) NAD^+ + NADH + H^+ ® malate + oxaloacetate.
D) NAD^+ + oxaloacetate ® NADH + H^+ + malate.
E) Oxaloacetate + NADH + H^+ ® malate + NAD^+. *

3. Gluconeogenesis must use "bypass reactions" to circumvent three reactions in the glycolytic pathway that are highly exergonic and essentially irreversible. Name the three reactions of glycolysis that must be bypassed, and for each, name the enzymes that carry out the reaction in glycolysis and gluconeogenesis.

Reaction	Enzyme (glycolysis)	Enzyme (gluconeogenesis)
1. Glucose <-> Glucose-6-phosphate	Hexokinase and Glucokinase	Glucose-6-phosphatase
2. Fructose-6-phosphate <-> F 1,6-BP	Phosphofructokinase-1	Fructose 1,6 bisphosphatase
3. Phosphoenolpyruvate <-> Pyruvate	pyruvate kinase	a. pyruvate carboxylase (pyr ->oao) b. PEP Carboxylase (oao -> PEP)

4. At which point in glycolysis do C-3 and C-4 of glucose become chemically equivalent?

Ans: When dihydroxyacetone phosphate is converted into glyceraldehyde 3-phosphate by triose phosphate isomerase, C-3 and C-4 of glucose become equivalent; they are both C-1 of glyceraldehyde 3-phosphate. (See Fig. 15-4, p. 535.)

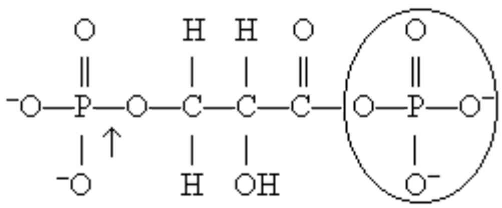
5. Lactate dehydrogenase catalyzes the reversible reaction:
Pyruvate + NADH + H+ → Lactate + NAD+
Given the following facts, (a) tell in which direction the reaction will tend to go if NAD+, NADH, pyruvate, and lactate were mixed, all at 1 M concentrations, in the

presence of lactate dehydrogenase at pH 7; (b) calculate ΔG'° for this reaction. Show your work.
NAD+ + H+ + 2e– → NADH E'° = –0.32 V
pyruvate + 2H+ + 2e– → lactate E'° = –0.19 V
The Faraday constant, I, is 96.48 kJ/V·mol.

Ans: ΔG'° = E'°(acceptor) – E'°(donor) = –0.19 V – (–0.32 V) = +0.13 V
ΔG'° = –n I ΔE'° = (–2)(96.48 kJ/V·mol)(0.13 V)
ΔG'° = –25.1 kJ/mol

6. Draw the structure of 1,3-bisphosphoglycerate. Indicate with an arrow the phosphate ester, and circle the phosphate group for which the free energy of hydrolysis is very high.

Ans:



7. Muscles sometimes produce high levels of lactic acid. Explain.
Ans: Under high levels of activity, muscles must produce high amounts of ATP. At the same time, however, muscles may not have their oxygen demands met to be able to proceed with oxidative phosphorylation, and thus must rely heavily on glycolysis as a source of ATP. Glycolysis requires NAD+ (and produces NADH), and thus the cell must have a way of re-oxidizing NADH to NAD+ in the absence of oxidative phosphorylation. This is done by reducing pyruvate to lactate, in the process regenerating NAD+. Lactate is a waste product, which may be released from the muscle cells and transported to the liver, where it can be metabolized (ie back to pyruvate, or even glucose, via gluconeogenesis).