

I. Multiple choice

1. The only membrane-bound enzyme in the citric acid cycle is

- a) aconitase
- b) the α -ketoglutarate dehydrogenase complex
- c) malate dehydrogenase
- d) succinate dehydrogenase

2. Control of the citric acid cycle is exercised by each of the following enzymes, except for

- a) citrate synthase
- b) isocitrate dehydrogenase
- c) aconitase
- d) the α -ketoglutarate dehydrogenase complex

3. Another name for Complex II in the electron transport chain is

- a) cytochrome *c* oxidase
- b) NADH-CoQ oxidoreductase
- c) cytochrome *bcl* complex
- d) succinate dehydrogenase

4. The complex in the electron transport chain that does not have a direct link to coenzyme Q in some form is

- a) the succinate dehydrogenase complex
- b) Complex I
- c) cytochrome *c* oxidase
- d) Complex III

5. Redox reactions of NADH-linked dehydrogenases involve

- a) hydride ion transfer
- b) transfer of two-carbon groups
- c) transfer of three-carbon groups
- d) transfer of acetyl groups

6. Which enzymes in the citric acid cycle catalyze oxidative decarboxylation reactions?

- a) isocitrate dehydrogenase and the α -ketoglutarate dehydrogenase complex
- b) aconitase and succinate dehydrogenase
- c) the α -ketoglutarate dehydrogenase complex and succinate thiokinase
- d) fumarase and succinate dehydrogenase

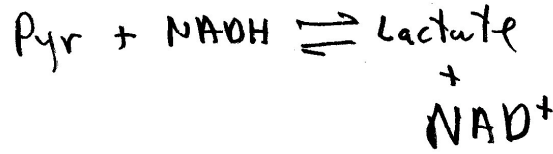
7. A unique feature of the glyoxylate cycle is that it allows the organisms that possess this pathway to

- a) produce fats from carbohydrates
- b) produce carbohydrates from fats
- c) convert acetyl-CoA to pyruvate
- d) do all of the above

2) Below are steady state (not at equilibrium) concentrations of metabolites in red blood cells. Answer the following. (10)

- a) If the ratio of NAD⁺/NADH is 1000/1, what is the ΔG' of the lactate dehydrogenase reaction. The ΔG° is -25.2 kJ/mol.

Steady-State Concentrations of Glycolytic Metabolites in Erythrocytes	
Metabolite	mM
Glucose	5.0
Glucose-6-phosphate	0.083
Fructose-6-phosphate	0.014
Fructose-1,6-bisphosphate	0.031
Dihydroxyacetone phosphate	0.14
Glyceraldehyde-3-phosphate	0.019
1,3-Bisphosphoglycerate	0.001
2,3-Bisphosphoglycerate	4.0
3-Phosphoglycerate	0.12
2-Phosphoglycerate	0.030
Phosphoenolpyruvate	0.023
Pyruvate	0.051
Lactate	2.9
ATP	1.85
ADP	0.14
P _i	1.0



$$\Delta G' = \Delta G^{\circ} + RT \ln \frac{[\text{Lac}]}{[\text{Pyr}]} \frac{1000}{1}$$

$$+ 8.31 \cdot 310 \ln \frac{2.9 \times 1000}{0.051 \times 1}$$

$$-25,200 + 8.31 \cdot 310 \cdot 10.9$$

$$\Delta G' = +2.9 \text{ kJ/mol}$$

- b) Is the phosphoglucosomerase reaction more or less favorable thermodynamically under real erythrocyte conditions as compared to standard conditions? Show why! The ΔG° is -16.7 kJ/mol.

$$\Delta G' = -16,700 + 8.31 \cdot 310 \ln \frac{0.014}{0.083}$$

$$\text{G-6-P} \rightarrow \text{F-6-P}$$

$$= -16,700 + -543$$

$$= -17,24 \text{ kJ/mol}$$

More Favorable

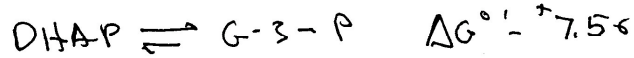
II. Problems, etc-Show all work to receive any credit

1. a) Hunters often claim that meat from game that was run to exhaustion is sour. Explain from a metabolic perspective why this might be so. (9)

Under conditions of anaerobic muscle activity (run to death!), the TCA & ETS cannot use the pyruvate from glycolysis. Thus to maintain glycolysis for ATP NAD^+ must be regenerated by $\text{pyr} + \text{NADH} \rightarrow \text{lactate} + \text{NAD}^+$, or glycolysis will stop. So lactic acid is the sour taste.

b) Yeast in the anaerobic beer brewing process (fermentation) make ethanol to solve a metabolic problem. Explain the problem and how yeast solve it. What other product is produced by this process?

Yeast (anaerobic) have the same problem they need to regenerate NAD^+ to keep making ATP. They instead convert pyruvate \rightarrow ethanol using up NADH in the process. They also generate CO_2 as part of this process.



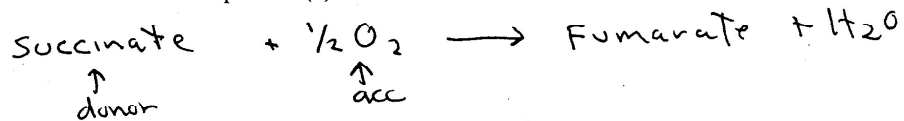
2. a) What would be the ratio of glyceraldehyde-3-phosphate (G-3-P)/dihydroxyacetone phosphate (DHAP) at equilibrium (K_{eq}) at 37°C? (8)

$$K_{eq} = e^{-\left(\frac{+7,560}{8,315 \cdot 310}\right)} = 0.0532$$

b) Under "realistic" cellular conditions [G-3-P]=0.0012 mM and [DHAP]=0.20 mM. What is the $\Delta G'$ at 37°C under these conditions?

$$\begin{aligned} \Delta G' &= +7,560 + (8,315)(310) \ln \frac{0.0012}{0.20} \\ &\quad + -13,200 \\ &= -5,640 \text{ J/mol} = -5.64 \text{ kJ/mol} \end{aligned}$$

3. a) What is the ΔG° for the process where succinate passes on its 2 electrons to O_2 ? b) What would be the K_{eq} for this process? c) What is the maximum number of ATPs which could be synthesized in this 2 electron process? (9)



$$a) \Delta G^{\circ} = 2(96,300)(0.816 - 0.031) = -151 \text{ kJ/mol}$$

$$b) K_{eq} = e^{-\left(\frac{-151,000}{8,315 \cdot 298}\right)} = 2.92 \times 10^{26}$$

(298K)

$$c) \frac{-151}{-30.5} = 4.95 \text{ ATP or 4 in whole numbers, 13 maximum}$$