85 PTS.

EXAM 1

NAME KEY

I. Multiple Choice: (30)

A 1. Which of the following does **not** participate in, nor is a component of, the electron-transport chain?
   (A) coenzyme A
   B) non-heme, iron-sulfur proteins
   C) coenzyme Q
   D) cytochrome c_1
   E) NADH

A 2. In the malate-aspartate shuttle, electrons from NADH are transferred to ________, forming malate.
   (A) oxaloacetate
   B) aspartate
   C) acetate
   D) glutamate
   E) none of the above

B 3. When glucose is totally oxidized to CO_2 and H_2O, how many ATP molecules are made by oxidative phosphorylation relative to the maximum yield?
   A) 12 out of 30
   (B) 26 out of 30
   C) 26 out of 32
   D) 12 out of 38
   E) None of the above.

E 4. Choose the correct path taken by the flux of electrons as they travel down the electron-transport chain.
   A) NADH → complex I → CoQ → Complex III → Cyt c → complex IV → O_2
   B) $FADH_2$ → complex I → CoQ → Complex III → Cyt c → complex IV → O_2
   C) NADH → complex I → complex II→ Complex III → Cyt c → complex IV → O_2
   D) $FADH_2$ → complex II → CoQ → Complex III → Cyt c → complex IV → O_2
   (E) a and d

B 5. What two 3-carbon molecules are generated by the cleavage of fructose-1,6-bisphosphate?
   A) glyceraldehyde-3-phosphate and 3-phosphoglycerate
   (B) glyceraldehyde-3-phosphate and dihydroxyacetone phosphate
   C) pyruvate and phosphoenolpyruvate
   D) enolase and 2-phosphoglycerate
   E) glyceraldehyde-3-phosphate and pyruvate

B 6. What is substrate level phosphorylation?
   A) phosphorylation of AMP by ATP
   (B) ATP synthesis when the phosphate donor is a substrate with high phosphoryl transfer potential
   C) phosphorylation of glycolytic intermediates
   D) phosphorylation of ATP coupled to an ion gradient
   E) ATP and AMP synthesis from two molecules of ADP

7. What is the function of a thioester intermediate such as the one formed from GAP dehydrogenase?
   A) It speeds up the actual reaction so that more product can be made.
   B) The thioester shifts the equilibrium of the first stage of the reaction.
   C) The thioester allows the two-step reaction to be coupled so the second reaction, the energetically unfavorable phosphorylation, can proceed.
   D) The thioester intermediate induces a conformational change that alters the enzyme specificity.
   E) The thioester prevents the formation of metabolically unfavorable side products.

8. In which reaction is GTP (or ATP) directly formed in the citric acid cycle?
   A) conversion of succinyl CoA to succinate
   B) decarboxylation of a-ketoglutarate
   C) conversion of isocitrate to a-ketoglutarate
   D) All of the above.
   E) None of the above.

9. Approximately how many ATP or GTP equivalents are produced during one turn of the citric acid cycle?
   A) 10 B) 6 C) 9 D) 12 E) None of the above.

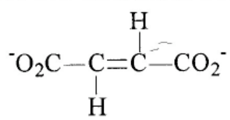
10. What enzyme(s) is (are) required to cleave a-1,6-glycosidic branches in glycogen?
   A) transferase
   B) a-1,6-glucosidase
   C) glycogen phosphatase

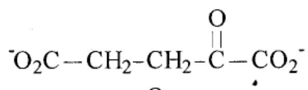
11. Why is the T state of glycogen phosphorylase less active?
   A) The adjacent amino acids are not phosphorylated and thus the catalysis cannot be carried out.
   B) The active site is partially blocked.
   C) ATP cannot be bound by the T state.
   D) All of the above.
   E) None of the above.

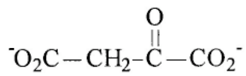
12. What is the normal glucose concentration in blood?
   A) 80-120 g/100 mL (4.4-6.7 mM)
   B) 80-120 mg/100 mL (4.4-6.7 mM)
   C) 80-120 μg/100 mL (4.4-6.7 mM)

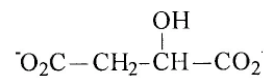
13. Why is glycogen branching important?
   A) Branching significantly alters the melting point.
   B) Branching increases the solubility of glycogen.
   C) Branching increases glycogen synthesis and degradation by increasing the potential sites of action.
   D) a and c.
   E) b and c.

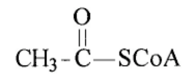
B 14. Which of these compounds is oxidized by a multienzyme complex that requires five different coenzymes?

A) 

(B) 

C) 

D) 

E) 

E 15. Phosphorylase kinase is regulated by
A) calcium ions. ✓
B) cAMP activated PKA (Protein Kinase A). ✓
C) glycogen levels.
D) a, b, and c.
(E) a and b.

II Essay and Problems: Show all work. REALLY!(55)

1. The K_m of muscle hexokinase is much smaller than that of liver. Discuss the functional significance of this phenomenon.(5)

A small Km indicates higher affinity for muscle hexokinase for glucose. Since G + ATP ⇌ G-6-P + ADP primes glucose for breakdown it indicates that the muscle is more concerned with metabolizing glucose for ATP (as you might guess). The liver, on the other hand is more a distributor of glucose rather than a consumer and so is less likely to use it as a fuel (lower affinity, higher Km).

2. . I just found a magazine add for a new athletic performance enhancing pill with "secret ingredients developed by a biochemist". The ad claims that this pill will give you a competitive edge by mobilizing your "sugar reserves" during a race. We analyzed the pill and could only find caffeine and vitamin B6 (pyridoxal phosphate precursor) as the "secret ingredients." Explain how these ingredients could boost performance in some detail and *then* explain why it might NOT work. Diagrams may be helpful. (15)

Epinephrine: This hormone releases glucose by activating adenylate cyclase (by G-protein). The cAMP activates Protein Kinase A which activates Phosphorylase Kinase which turns on Phosphorylase b. This causes glucose release from glycogen. The enzyme phosphodiesterase (PDE) stops the response by hydrolyzing cAMP. Caffeine blocks the PDE and may enhance glucose release. Vitamin B6 is a component of phosphorylase (acts as an acid/base catalyst) and so perhaps more B6 could activate more phosphorylase and thus more glucose released. It may not mobilize enough additional muscle glucose to make a difference and it could deplete glucose sooner. The vit. B6 would not increase the activity of phosphorylase unless the person was deficient in this vitamin. In addition, there are many other regulatory mechanisms in metabolism so increasing one component will not necessarily increase effects down the line.

3. We all know that glycogen phosphorylase b is converted to a more active phosphorylase a by kinase catalyzed phosphorylation. However, many other effectors can also directly influence this enzyme's activity. For each of the effectors below explain briefly the metabolic logic behind these observed effects.(10)

a. AMP stimulates Phosphorylase a or b activity: AMP is the major signal of low energy state in the cell. It's presence indicates serious need for ATP and so even phosphorylase b should be activated in these circumstances.

b. ATP inhibits Phosphorylase a activity

ATP indicates high energy charge and so it's presence should shut down glucose release and so it supercedes the phosphorylation of phosphorylase.

c. Glucose directly inhibits liver Phosphorylase a activity

The liver is the body's glucose sensor and abondance of glucose inhibits further release of glucose into the blood, a process started by glycogen phosphorylase.

4. a. If a bacterium's membrane potential is 150 mV (inside -) and the pH inside the organism is 8.6 and outside is 7.2, what is the minimum whole number of protons flowing in, energetically speaking, needed to spontaneously synthesize 1 ATP (under standard conditions, hydrolysis $\Delta G^\circ = -7.5$ kcal/mol). (15)

$\Delta G = 2.3 \cdot 1.99 \cdot 298 (8.6 - 7.2) + 23{,}000\,(0.15) \Rightarrow 5360$ cal/mol $= 5.36$ kcal/mol

So you need at least **2H+** to come in

$(-5.36 \times 2\ H^+)$ to overcome the

+7.5 kcal/mol synthesis cost.

b. This bacterial organism, *Bacillus subtilis*, can REDUCE fumarate to succinate with NADH for energy generation. It has a special H+ transporting succinate dehydrogenase not found in mammals.

1) Write the chemical equation for this process *in the proper direction*.

Fumarate + NADH + H^+ $\rightleftharpoons$ Succinate + NAD^+

2) What is the $\Delta G^{o'}$ for this process? $\Delta E = (0.03 - -0.32) = 0.35V$

$\Delta G^{o'} = -2 \cdot (23{,}000) \cdot 0.35 = -16{,}100$ cal/mol

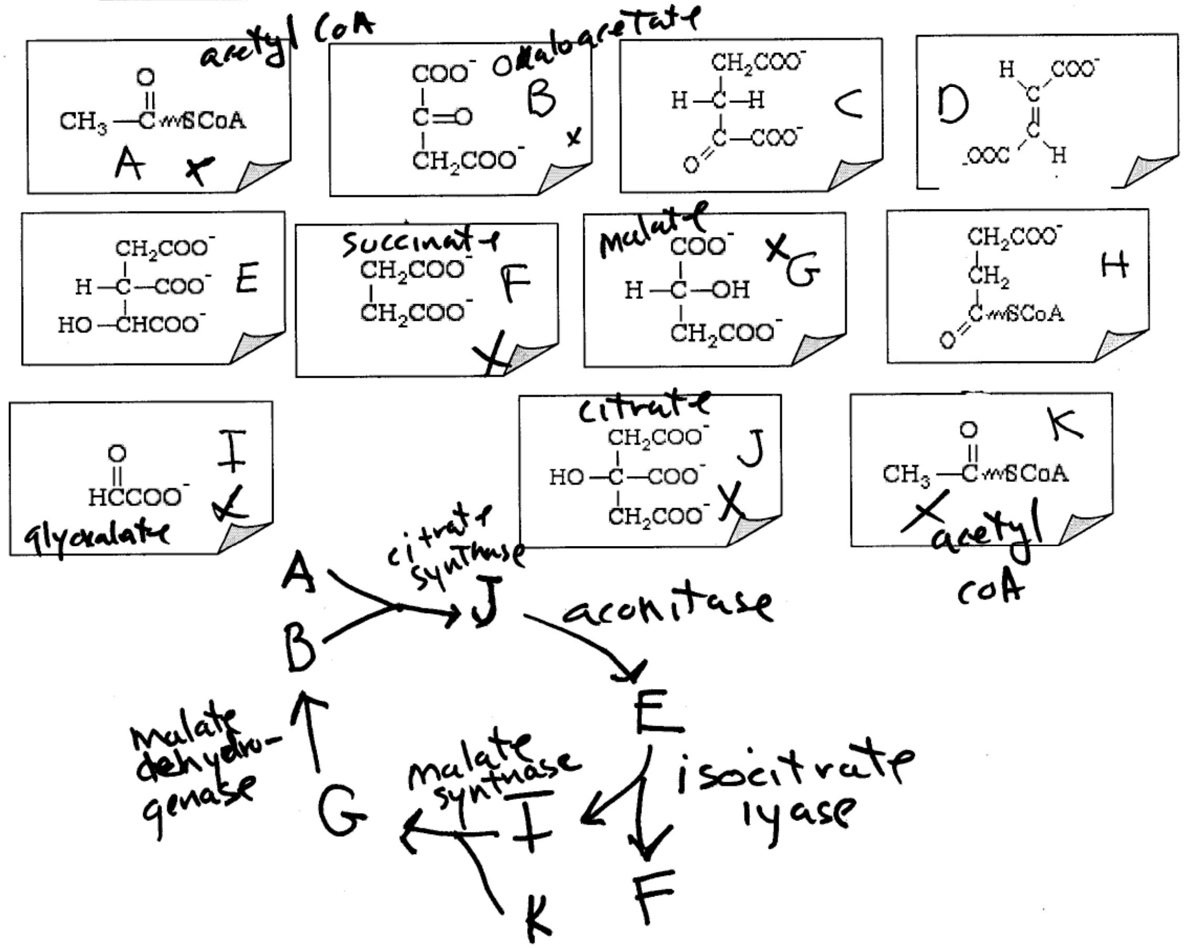
3) What is the maximum (nearest whole) number of protons which could be pumped by this reaction UNDER THE ABOVE CONDITIONS of ΔpH and ΔΨ (part a), assuming succinate and fumarate and NAD and NADH are under standard conditions?

$$\frac{+16100 \text{ cal/mol}}{+5360 \text{ cal/}H^+ \text{ mol pumped}} \cong 3.0\ H^+$$

5) OH NO! I was studying the glyoxylate cycle and TCA cycle at the same time and I dropped my cards on the floor. I should have numbered them! (10)

a) Please reconstruct the glyoxylate pathway for me with all the inputs and outputs and any soluble cofactors or products like NAD, CO_2, ATP, CoASH, etc, etc.? You don't need to name intermediates and enzymes just put them in the correct cyclic order

BONUS POINTS FOR NAMING INTERMEDIATES AND ENZYMES!!!!!!!!!!!



b) What do the glyoxylate cycle and pyruvate carboxylase have in common?

They both can productively replenish oxaloacetate