C383 Exam 3 Version 1
Fall 2016

Name Key Seat Number _____

Student ID _____ Circle your section: **M T 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 _____/10

32 _____/10

33. _____/15

34. _____/15

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. C All of the following factors contribute to the large negative free energy of ATP hydrolysis except
   A. electrostatic repulsion in the triphosphate unit
   B. Resonance stabilization of phosphate produced
   C. Decrease in entropy when one molecule of ATP is made into ADP and P_i
   D. Stabilization due to product hydration

2. D Which of the following glycolytic enzymes catalyzes formation of a high energy bond under irreversible conditions?
   A. hexokinase
   B. phosphofructokinase
   C. glyceraldehyde-3-phosphate dehydrogenase
   D. pyruvate kinase

3. A Which of the following is a glycolytic substrate used to make substrate-level ATP?
   A. 1,3-bisphosphoglycerate
   B. Glucose-6-phosphate
   C. Fructose-1,6-bisphosphate
   D. 2-phosphoglycerate
   E. More than one of the above

4. E The net cost of converting 2 pyruvate into glucose is ____ ATP equivalents.
   A. 2
   B. 3
   C. 4
   D. 5
   E. 6

5. B High concentrations of the following allosteric effectors all favor the rate of gluconeogenesis over glycolysis except
   A. ATP
   B. fructose 1.6-bisphosphate
   C. citrate
   D. alanine

6. C Which of the following cofactors of pyruvate dehydrogenase complex is matched correctly with its function?

A. FAD is a stoichiometric oxidizing agent
B. TPP acts as a linker arm between subunits
C. Lipoamide is a catalytic oxidant that forms a transient high energy thioester
D. Coenzyme A is a high energy 2 electron carrier
E. NADH reduces pyruvate to acetyl CoA

7. D Which of the following reactions of the citric acid cycle is irreversible?

A. succinate + NAD^+ → fumarate + NADH
B. malate + NAD^+ → oxaloacetate + NADH
C. citrate → isocitrate
D. α-ketoglutarate + NAD^+ + CoA → succinyl CoA + CO_2
E. more than one of the above

8. A The major inhibitor of the citric acid cycle is

A. NADH
B. glucose
C. AMP
D. oxygen
E. fatty acids

9. C Which component of the electron transport chain is incorrectly matched with its description?

A. Coenzyme Q: a mobile electron carrier that accepts/donates one electron at a time
B. Complex I: pumps 4 protons from the mitochondrial matrix into the inner-membrane space
C. Complex III: catalyzes the redox reaction that transfers electrons from cytochrome c to coenzyme Q while transferring 4 protons across the mitochondrial membrane
D. Complex IV: catalyzes the reduction of oxygen to water
E. Complex II: catalyzes the redox reaction that transfers electrons from succinate to coenzyme Q

10. E In an organism that has an ATP synthase with a hexameric knob and 12 subunits in its c-ring would require a protonmotive force of _____ protons to produce 1 ATP.

A. 1.5
B. 2.5
C. 2.7
D. 3.3
E. 4.0

11. B In which step of the binding-change mechanism is ATP formed from ADP and P_i?
A. open
B. tight
C relaxed
D. loose

12. E Which of these enzymes is active in liver but not muscle tissue?
A. PFK
B. citrate synthase
C. pyruvate dehydrogenase complex
D. aldolase
E. glucose-6-phosphatase

13. C The hormone glucagon will lead to
A. increased concentrations of phosphorylase *a* in muscle
B. decreased concentrations of phosphorylase *a* in muscle
C. increased concentrations of phosphorylase *a* in liver
D. decreased concentrations of phosphorylase *a* in liver

14. B To store a dietary glucose molecule in glycogen requires ____ ATP. If dietary glucose is taken into the cell, stored in glycogen, and then released and fully oxidized, a net of _____ ATP can be produced.
A. 1, 30
B. 2, 29
C. 1, 29
D. 2, 30
E. 2, 28

15. D The oxidative phase of the pentose phosphate pathway yields
A. NADPH
B. 5-carbon sugar
C. CO_2
D. all of the above

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

16. The free energy of a reaction depends on the difference between the standard free energies of products and reactants and on the ratio of their concentrations.

17. The standard free energy for the phosphorylation of glucose by creatine phosphate to make glucose-1-phosphate would be -22.2 kJ.

18. Glycerol is a precursor for gluconeogenesis found in triacylglycerides.

19. The cofactor biotin is required for carboxylation of pyruvate.

20. When oxygen is scarce in a muscle cell, pyruvate is converted to lactate, but when oxygen is abundant, it is converted to acetyl CoA (OAA).

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

22. The conversion of pyruvate to oxaloacetate is a major anaplerotic reaction, which fills up the citric acid cycle intermediates depleted by anabolism.

23. Mammals cannot convert acetyl CoA into net glucose.

24. α ketoglutarate is the strongest reducing agent listed on Table 20.1 (see the end of the exam.)

25. The change in standard reduction potential for the reaction of FAD with lactate to produce $FADH_2$ and pyruvate is -0.03 V.

26. The enzyme glycogen phosphorylase is prevalent in fast twitch muscle because this type of muscle fiber uses glycogen as a major fuel source and is poor in mitochondria.

27. The activated glucose molecule used in glycogen synthesis is called UDP glucose.

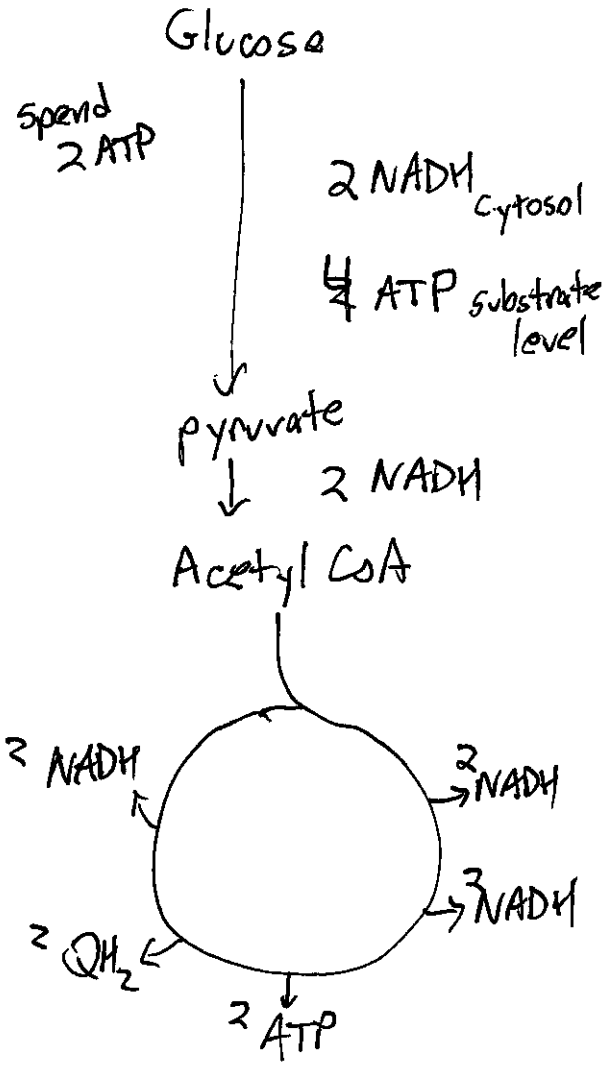
28. Protein kinase A turns on glycogen degradation and turn off glycogen synthesis, while Protein phosphatase 1 does the opposite.

29. Glycogen synthesis and degradation are reciprocally regulated.

30. Excess ribose 5-phosphate formed by the pentose phosphate pathway can be completely converted into 3 and 6 carbon sugars.

Section 3. Problems.

31. (10pts) Explain, in detail, how we arrive at an estimate of 30 ATP per glucose molecule oxidized in aerobic metabolism (assume use of the glycerol-3-phosphate shuttle). Make reference to the pathways or reactions in which cofactors are made and how many ATP can be derived from them through oxidative phosphorylation.



(+2) Glycolysis:
net 2 ATP
3 ATP (NADH g-3-p shuttle)

(+2) PDC:
5 ATP (2.5 ATP/NADH)

(+6) CAC:
~~6~~ 15 ATP (6 NADH)
~~3~~ 3 ATP (2 QH_2)
2 ATP (substrate)

30 ATP

32. (10pts) The enzyme aldolase catalyzes the following reaction in the glycolytic pathway:

Fructose-1,6-bisphosphate ← → dihydroxyacetone phosphate + glyceraldehyde 3-phosphate

The standard free energy for the reaction is +23.8 kJ/mol, whereas ΔG in the cell is -1.3 kJ/mol.

A. Calculate the ratio of the reactants to products under equilibrium conditions.

$\Delta G^{\circ\prime} = -RT \ln K_{eq}$

$23800 \frac{J}{mol} = -8.314 \frac{J}{mol\,K}(298K) \ln K_{eq}$

$K_{eq} = 6.7 \times 10^{-5}$ (+3) $= 1.49 \times 10^{4}$

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B. Calculate the ratio of reactants to products under cellular conditions.

$\Delta G' = \Delta G^{\circ\prime} + RT \ln \frac{P}{R}$

$-1300 \frac{J}{mol} = 23{,}800 \frac{J}{mol} + 8.314 \frac{J}{mol\,K}(298K) \ln \frac{P}{R}$

$\frac{P}{R} = 4.0 \times 10^{-5}$ (+3) $\frac{R}{P} = 2.5 \times 10^{4}$

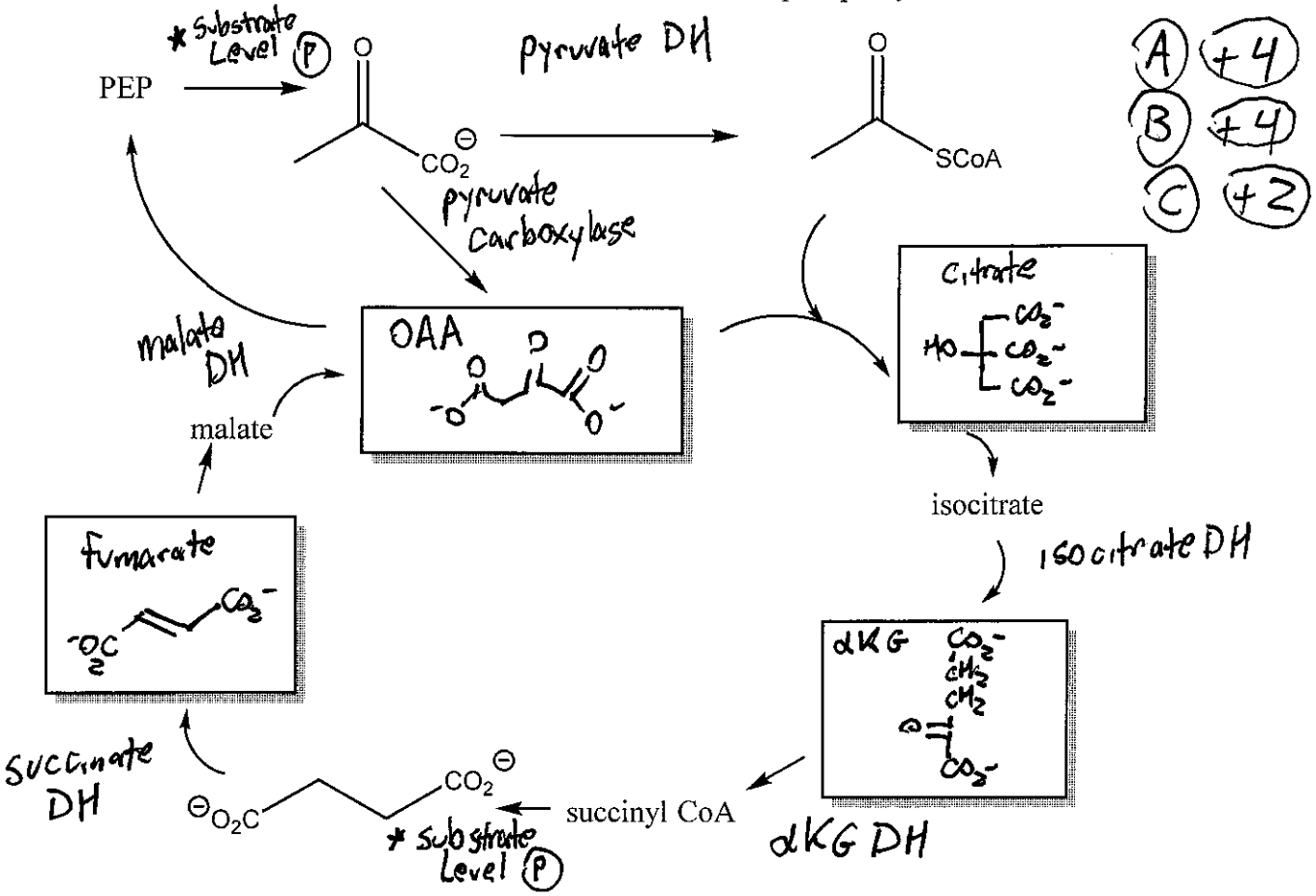
25106

C. Using your results, explain how the reaction can be endergonic under standard conditions but exergonic under cellular conditions.

(+2) - Under standard conditions, the rxn lies far to the left, reaching equilibrium when only a small amount of product (relative to reactant) is formed.

(+2) - Under physiological conditions, though, the relative amount of pdt to rxt is even smaller than equilibrium ratio, so the rxn is spontaneous.

33. (15pts) In the scheme below, **A.** fill in shaded boxes with substrate structures or names. **B.** In the appropriate place, write in the names of three dehydrogenase enzymes and one carboxylase. **C.** Indicate each reaction in which there is a substrate level phosphorylation to form ATP.

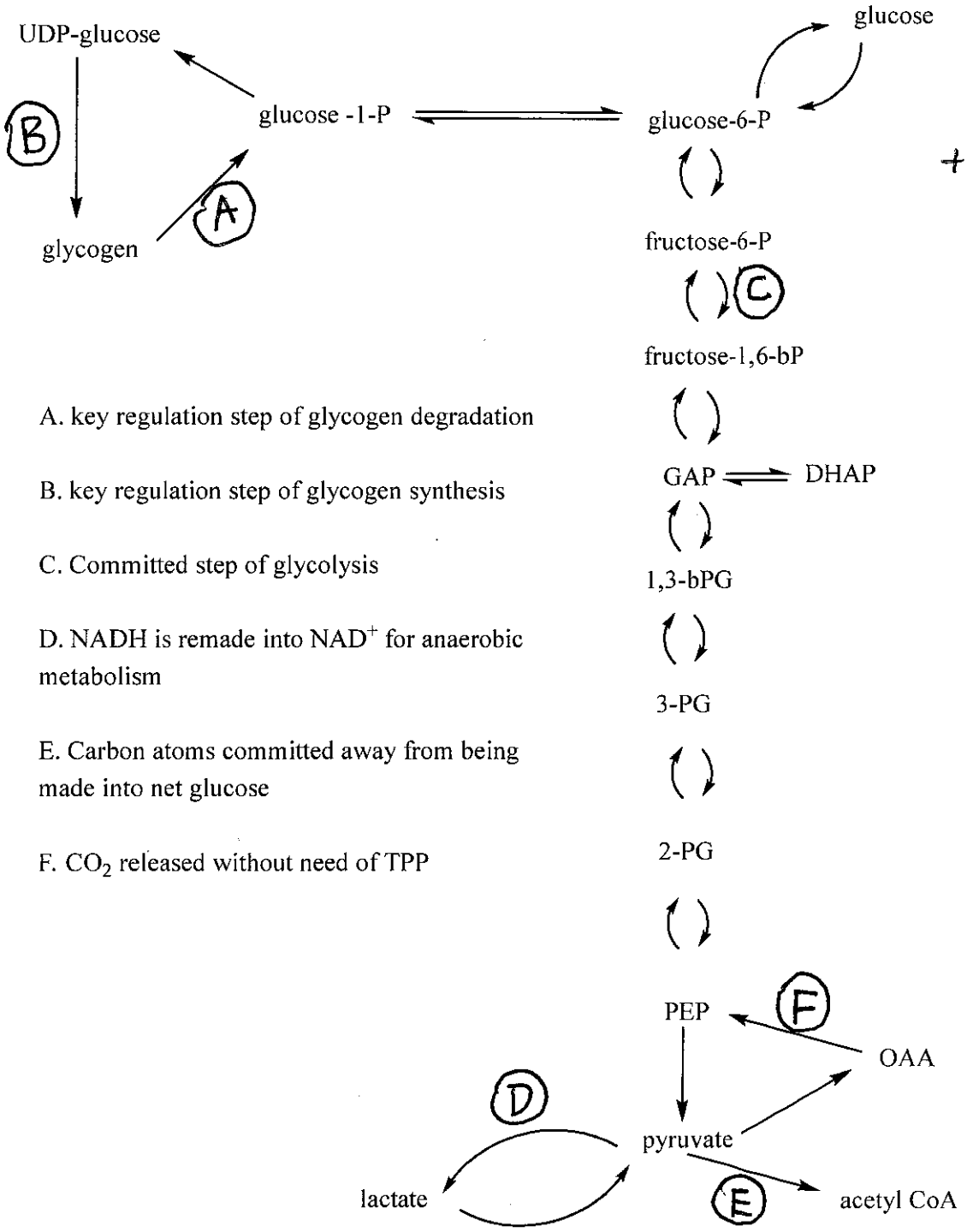


D. If cellular conditions caused a rise in the concentration of acetyl CoA in the mitochondrial matrix, how would the regulation system work to lower the acetyl CoA levels? Refer to the scheme above to indicate any enzymes that would be activated or deactivated and explain how this would lead to lowering of acetyl CoA concentration.

+2 1) Pyruvate DH is deactivated (product inhibition), leading to less acetyl CoA being made

+3 2) Pyruvate carboxylase is upregulated by acetyl CoA, forming Oxaloacetate. OAA serves as a CAC intermediate intermediate to condense with acetyl CoA to form citrate. This lowers [acetyl CoA].

34. (15pts) The overall regulation of carbohydrates occurs in glycogen synthesis, glycogen degradation, glycolysis, and gluconeogenesis. In the partial scheme below, match the letter of each phrase below with the arrow that it represents.



+1 each

A. key regulation step of glycogen degradation

B. key regulation step of glycogen synthesis

C. Committed step of glycolysis

D. NADH is remade into NAD^+ for anaerobic metabolism

E. Carbon atoms committed away from being made into net glucose

F. CO_2 released without need of TPP

34 (continued) B. Explain the effect on carbohydrate metabolism when glucagon initiates signal transduction to deactivate pyruvate kinase.

+1 Pyruvate Kinase catalyzes the last step of glycolysis. When deactivated, [PEP] rises, shutting off PFK.

+2 This ultimately shuts off glycolysis and raising GNG

C. Explain the effect on carbohydrate metabolism when glucagon initiates signal transduction to activate fructose-2,6-bisphosphatase.

(+1) When F26bPase is activated, F26bP levels drop. This reciprocal regulator will no longer activate glycolysis and deactivate GNG. (+1) The Final effect is downregulation of glycolysis and upregulation (+1) of GNG.

D. Explain the effect on carbohydrate metabolism when glucagon initiates signal transduction to activate phosphorylase kinase.

+2 Active phosphorylase Kinase will phosphorylate Glycogen phosphorlyase, making it "usually active" phosphorylase a.

(+1) This will increase release of glucose from glycogen in response to low blood sugar.