Chem153A Final Exam ver. 2

VIBHA GURUNATHAN

TOTAL POINTS

200 / 200

QUESTION 1

1 14 / 14

✓ **- 0 pts Correct**

- 2 pts Does not list isocitrate or it is in the incorrect order

- 2 pts Does not list alpha-ketoglutarate or it is in the incorrect order

- 2 pts Does not list succinyl CoA or it is in the incorrect order

- 2 pts Does not list NADH as the only coenzyme for the circle between isocitrate and alpha-ketoglutarate

- 2 pts Does not list NADH as the only coenzyme for the circle between alpha-ketoglutarate and succinyl CoA

- 2 pts Does not list oxidative decarboxylation for triangle 2

- 2 pts Does not list oxidative decarboxylation for triangle 3

QUESTION 2

2 10 / 10

✓ **- 0 pts Correct**

- 3 pts Did not reference malate aspartate shuttle

- 2 pts Did not reference (or incorrectly referenced) calculation for malate aspartate shuttle (2.5 ATP per NADH)

- 3 pts Did not reference glycerol 3-phosphate shuttle

- 2 pts Did not reference (or incorrectly referenced) calculation for glycerol 3-phosphte shuttle (1.5 ATP per NADH)

QUESTION 3

3 10 / 10

✓ **- 0 pts Correct: A meal rich in glucose will increase the already high levels of pyruvate in an individual with thiamine deficiency.**

- 2 pts Correct, but did not include what role the thiamine deficiency plays as part of the explanation. In the absence of thiamine, the conversion of pyruvate to acetyl-CoA is inhibited and pyruvate cannot enter the Kreb's cycle. Glycolysis can be used anaerobically.

- 4 pts Correct explanation, but did not say if pyruvate levels would increase

- 8 pts incorrectly stated pyruvate would decrease. Pyruvate levels will increase but did acknowledge the role of thiamine. Appeared to not understand the role of PDH, TCA cycle, or lactate fermentation

- 9.5 pts Pyruvate levels would increase, (may not / did not discuss role of thiamine). Pathway incorrectly described

- 5 pts Gave conflicting answers but one was correct

- 10 pts No answer

QUESTION 4

4 10 / 10

✓ **+ 5 pts Correct structure**

✓ **+ 2.5 pts Moiety: Acetyl**

✓ **+ 2.5 pts E2 of PDH Complex**

+ 0 pts Incorrect

+ 0 pts Answer goes beyond reasonable two sentence limit

QUESTION 5

5 3 / 3

✓ **- 0 pts Correct**

- 3 pts Correct Answer: B. anabolic

QUESTION 6

6 10 / 10

✓ **+ 5 pts Deprotonated Form**

✓ **+ 1.25 pts Dissipate Proton Gradient**

✓ **+ 1.25 pts Electrons can continue to flow**

✓ **+ 2.5 pts ATP synthase inhibited by oligomycin**

+ 0 pts Incorrect

+ 0 pts Rest of answer goes beyond reasonable 2 sentence limit

QUESTION 7

7 10 / 10

✓ **- 0 pts Correct**

- 10 pts Does not indicate that proton flow would not likely be affected if Asp residues were replaced with glutamate.

QUESTION 8

8 20 / 20

✓ **- 0 pts Correct**

- 5 pts Did not set equation for standard change in reduction potential

- 5 pts Incorrectly calculated value for standard change in reduction potential

- 5 pts Did not use 2 electrons for calculation of standard change in free energy

- 5 pts Incorrectly calculated value for standard change in free energy

QUESTION 9

9 10 / 10

✓ **- 0 pts Correct**

- 5 pts Did not mention Ubiquinone/ol

- 5 pts Did not mention isoprene chain (polyprenyl), or any sort of hydrophobic, nonpolar long alkyl chain

- 2 pts Mentioned a plausible explanation for the moiety, but was not specific enough or named the wrong group

+ 1 pts Hydrophobicity

- 6 pts Mentioned the right structures, however switched them up (should be Ubiquinone=intermediary, isoprene=moiety)

QUESTION 10

10 10 / 10

✓ **+ 10 pts Correct**

+ 3.3 pts inhibits flow of electrons in ETC

+ 3.3 pts prevents protons from being pumped to the intermembrane space

+ 3.3 pts ADP is NOT phosphorylated

+ 0 pts No answer or no partial

QUESTION 11

11 10 / 10

✓ **+ 5 pts Epinephrine causes an increase in glycolysis in muscle cells because glycolysis yields ATP, which is necessary for muscle contraction.**

✓ **+ 5 pts however, in liver cells, glycolysis is decreases so that the liver can maintain glucose homeostasis._**

+ 0 pts incorret

QUESTION 12

12 6 / 6

✓ **- 0 pts Correct**

- 6 pts incorrect

QUESTION 13

13 10 / 10

✓ **- 0 pts Correct**

- 5 pts Did not state that glycogen synthase is stimulated when energy levels are high

OR

Did not state that glycogen phosphorylase is stimulated when energy levels are low

- 10 pts Did not state that glycogen synthase is stimulated when energy levels are high, glycogen phosphorylase is stimulated when energy levels are low

QUESTION 14

14 10 / 10

✓ **- 0 pts Correct**

- **5 pts** Did not list that the debranching enzyme has transferase activity

OR

Did not list that the debranching enzyme has glucosidase activity

- **10 pts** Did not list that the debranching enzyme has both transferase and glucosidase activity

QUESTION 15

15 10 / 10

✓ **- 0 pts Correct (Acid)**

- **10 pts** Incorrect
- **5 pts** This is solely Acid catalysis, we can't say acid/base because there is a separate Base catalysis
+ **2 pts** Recognized acid R group
- **5 pts** Named the wrong catalysis, but recognized Asp donating a proton

QUESTION 16

16 10 / 10

✓ **- 0 pts Correct**

- **10 pts** Asp52 is performing covalent catalysis. It forms a covalent bond with the substrate during its catalytic functions
- **10 pts** Asp52 is performing covalent catalysis.. Glu35 is performing acid catalysis
- **10 pts** No answer

QUESTION 17

17 10 / 10

✓ **- 0 pts Correct**

- **3 pts** Bottom line is hemoglobin at pH 6.8
- **6 pts** Blue line (middle) is hemoglobin at physiological pH, Red line (bottom) is hemoglobin at pH 6.8
- **10 pts** Top=myoglobin, middle=hemoglobin at phys. pH, bottom= hemoglobin at pH 6.8
- **6 pts** Top=myoglobin. Bottom= Hemoglobin at pH 6.8

QUESTION 18

18 12 / 12

✓ **+ 12 pts Correct**

+ **3 pts** competitive inhibitor
+ **3 pts** greater affinity for enzyme
+ **3 pts** Km app increase
+ **3 pts** Vmax app same
+ **0 pts** No answer or no partial

QUESTION 19

19 5 / 5

✓ **- 0 pts Correct**

- **5 pts** incorrect

QUESTION 20

20 10 / 10

✓ **+ 5 pts Myoglobin is composed of only one polypeptide chain with one heme group, which binds only one molecule of oxygen**

✓ **+ 5 pts therefore cannot participate in cooperative binding that is observed in hemoglobin.**

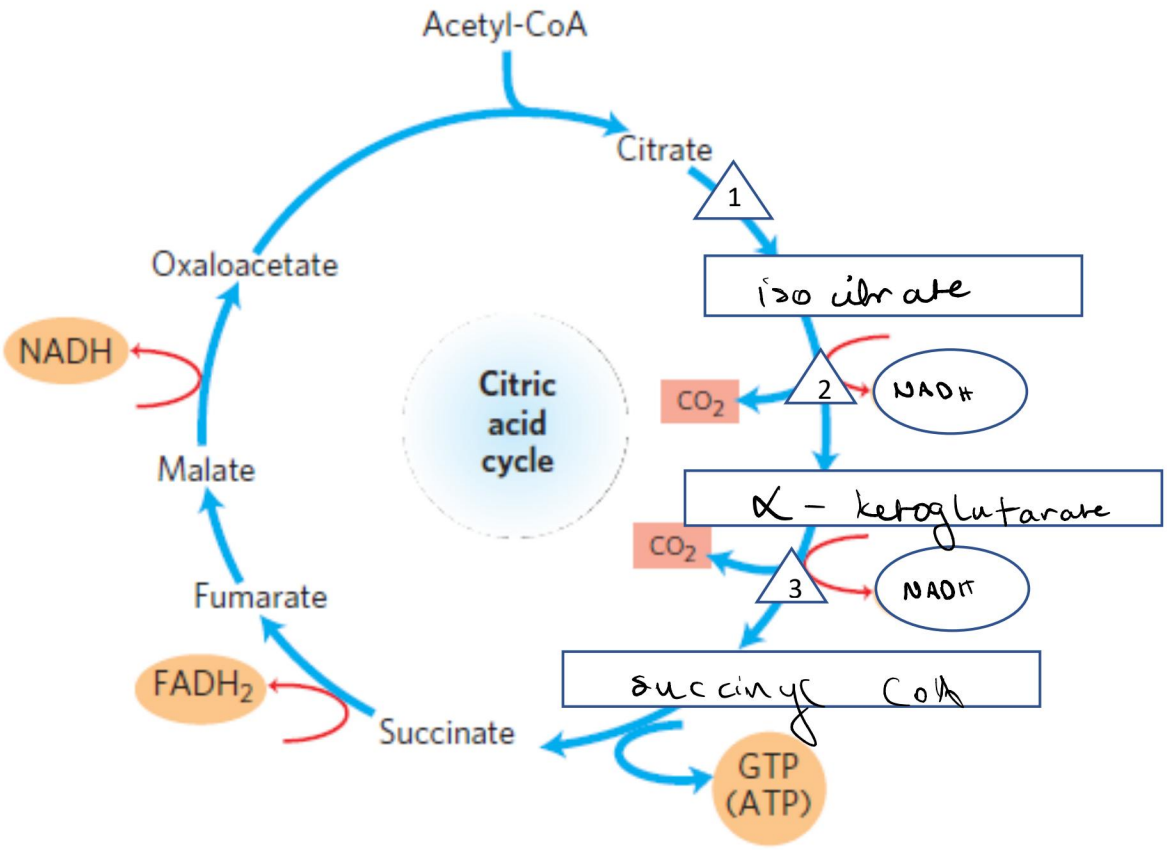
+ **0 pts** incorrect

Vibha Gurunathan

Chem153A
Biochemistry: Introduction to Structure, Enzymes and Metabolism
Final Exam

Instructions: Limit your answers to 2 brief sentences. Graders are not required to grade more than 2 sentences per question. This exam is open notes/ book. Follow the honor code specified in the syllabus.

1. Based upon the citric acid cycle diagram below, fill in the boxes with the correct intermediate(s) and the circles with the correct coenzyme(s). For triangles 2 and 3, write the name of the type of reaction that is being catalyzed by the enzyme on the lines below the citric acid cycle diagram. See the example below for triangle 1. **(14 points)**



1 14 / 14

✓ **- 0 pts** **Correct**

- 2 pts Does not list isocitrate or it is in the incorrect order

- 2 pts Does not list alpha-ketoglutarate or it is in the incorrect order

- 2 pts Does not list succinyl CoA or it is in the incorrect order

- 2 pts Does not list NADH as the only coenzyme for the circle between isocitrate and alpha-ketoglutarate

- 2 pts Does not list NADH as the only coenzyme for the circle between alpha-ketoglutarate and succinyl CoA

- 2 pts Does not list oxidative decarboxylation for triangle 2

- 2 pts Does not list oxidative decarboxylation for triangle 3

1 Isomerization

2 oxidative decarboxylation

3 oxidative decarboxylation

2. NADH from glycolysis can yield 3 or 5 molecules of ATP. Briefly explain why this is the case. **(10 points)**

This difference is due to due to the shuttle used; the malate-aspartate shuttle moves NADH from glycolysis to complex I, and it generates 2.5 ATP per e⁻ pair/NADH molecule, so 5 ATP are produced from the 2 NADH molecules made in glycolysis. However, the glycerol 3-phosphate (from 1 glucose) shuttle can also be used, and it transfers NADH directly to complex II, bypassing complex I, & it generates 1.5 ATP per NADH molecule, so 3 ATP total for 1 glucose molecule/2 NADH molecules.

3. How does eating a meal rich in glucose affect pyruvate levels in an individual with thiamine deficiency, who has relatively high levels of pyruvate? **(10 points)**

This individual's pyruvate levels would increase after eating a meal rich in glucose because glycolysis would break down glucose to get ATP and pyruvate, and the pyruvate would not get broken down further because the pyruvate dehydrogenase complex needs thiamine for one of its cofactor thiamine pyrophosphate (TPP). (2) TPP is bound to enzyme E1, and without a functional TPP, pyruvate cannot be decarboxylated & turned into acetyl CoA, so pyruvate levels will remain high because it can't be broken down.

2 10 / 10

✓ **- 0 pts** **Correct**

- 3 pts Did not reference malate aspartate shuttle

- 2 pts Did not reference (or incorrectly referenced) calculation for malate aspartate shuttle (2.5 ATP per NADH)

- 3 pts Did not reference glycerol 3-phosphate shuttle

- 2 pts Did not reference (or incorrectly referenced) calculation for glycerol 3-phosphte shuttle (1.5 ATP per NADH)

1 Isomerization

2 oxidative decarboxylation

3 oxidative decarboxylation

2. NADH from glycolysis can yield 3 or 5 molecules of ATP. Briefly explain why this is the case. **(10 points)**

This difference is due to due to the shuttle used; the malate-aspartate shuttle moves NADH from glycolysis to complex I, and it generates 2.5 ATP per e⁻ pair/NADH molecule, so 5 ATP are produced from the 2 NADH molecules made in glycolysis. However, the glycerol 3-phosphate (from 1 glucose) shuttle can also be used, and it transfers NADH directly to complex II, bypassing complex I, & it generates 1.5 ATP per NADH molecule, so 3 ATP total for 1 glucose molecule/2 NADH molecules.

3. How does eating a meal rich in glucose affect pyruvate levels in an individual with thiamine deficiency, who has relatively high levels of pyruvate? **(10 points)**

This individual's pyruvate levels would increase after eating a meal rich in glucose because glycolysis would break down glucose to get ATP and pyruvate, and the pyruvate would not get broken down further because the pyruvate dehydrogenase complex needs thiamine for one of its cofactor thiamine pyrophosphate (TPP). (2) TPP is bound to enzyme E1, and without a functional TPP, pyruvate cannot be decarboxylated & turned into acetyl CoA, so pyruvate levels will remain high because it can't be broken down.

3 **10 / 10**

✓ **- 0 pts Correct: A meal rich in glucose will increase the already high levels of pyruvate in an individual with thiamine deficiency.**

- 2 pts Correct, but did not include what role the thiamine deficiency plays as part of the explanation. In the absence of thiamine, the conversion of pyruvate to acetyl-CoA is inhibited and pyruvate cannot enter the Kreb's cycle. Glycolysis can be used anaerobically.

- 4 pts Correct explanation, but did not say if pyruvate levels would increase

- 8 pts incorrectly stated pyruvate would decrease. Pyruvate levels will increase but did acknowledge the role of thiamine. Appeared to not understand the role of PDH, TCA cycle, or lactate fermentation

- 9.5 pts Pyruvate levels would increase, (may not / did not discuss role of thiamine). Pathway incorrectly described

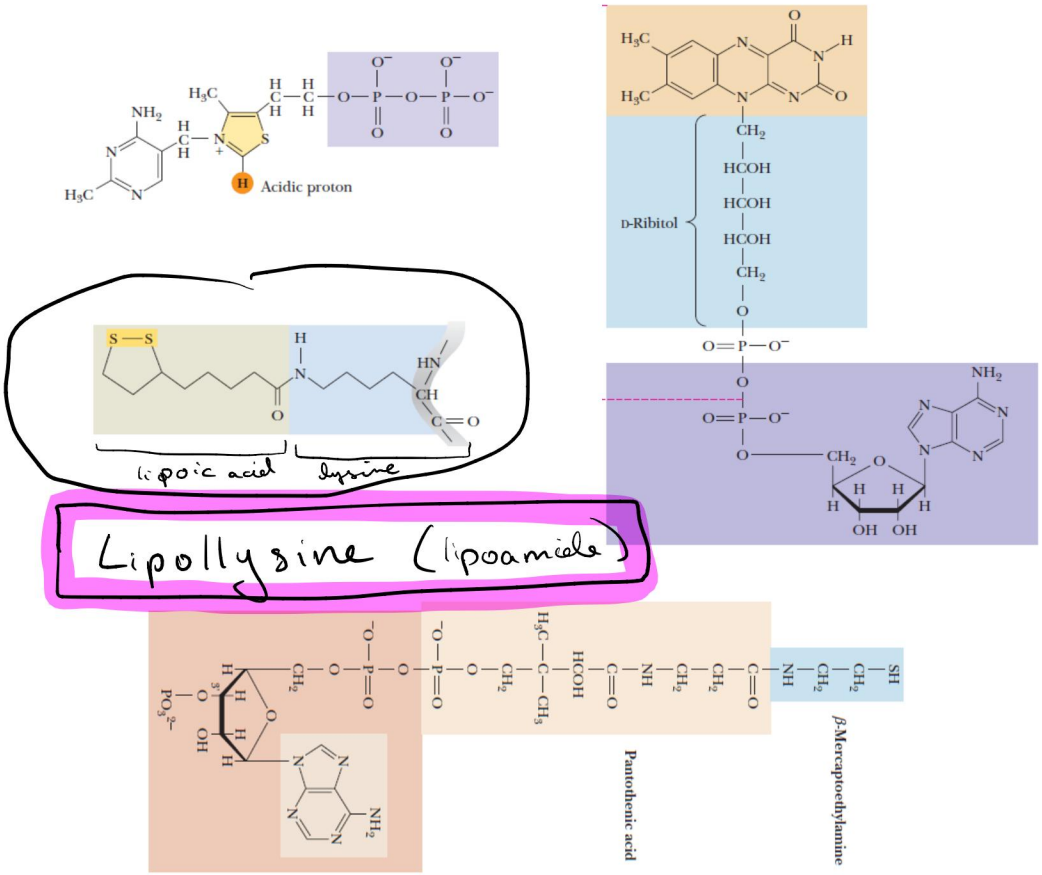
- 5 pts Gave conflicting answers but one was correct

- 10 pts No answer

✓ ✓ lysine ✗ mercaptoethylamine

4. Identify and circle the molecule that serves as the biological tether in substrate channeling. Provide the name of the moiety that gets transferred between different sites of the enzyme complex as well as the enzyme to which the tether belongs. **(10 points)**

✓



Lipollysine (lipoamide)

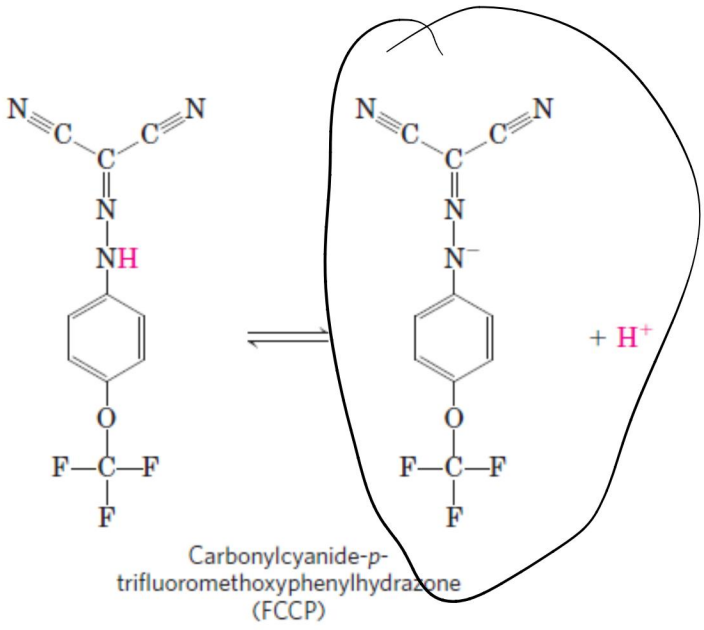
- belongs to enzyme dihydrolipoyl transacetylase (E2) of the pyruvate dehydrogenase complex (PDH)
- acetyl is ↑ transferred between the different sites the moiety of the enzyme complex

4 10 / 10

- ✓ **+ 5 pts** Correct structure
- ✓ **+ 2.5 pts** Moiety: Acetyl
- ✓ **+ 2.5 pts** E2 of PDH Complex
- **+ 0 pts** Incorrect
- **+ 0 pts** Answer goes beyond reasonable two sentence limit

5. Fill in the blank: When oxaloacetate from the citric acid cycle is used as a precursor for the synthesis of aspartate, this process describes a(n)_____ pathway. **(3 points)**
   a. Catabolic
   b. Anabolic
   c. Anaplerotic
   d. All of the above

6. Below is the structure of FCCP, which is an uncoupler. Briefly describe how FCCP functions in the mitochondria after the isolated mitochondria has been treated first with succinate, ADP, and P_i, and then with oligomycin. Circle the structure (on the left or the right of the equilibrium arrows) that exists within the matrix of the mitochondria. **(10 points)**



Carbonylcyanide-*p*-trifluoromethoxyphenylhydrazone (FCCP)

After the mitochondria has been treated w/ succinate, ADP, & P_i, the FCCP will enable e^- flow but will not produce ATP via oxidative phosphorylation. Once oligomycin is added it establishes a proton gradient that stops e^- flow, but FCCP breaks down this proton gradient allowing for e^- flow (although no ATP synthesis).

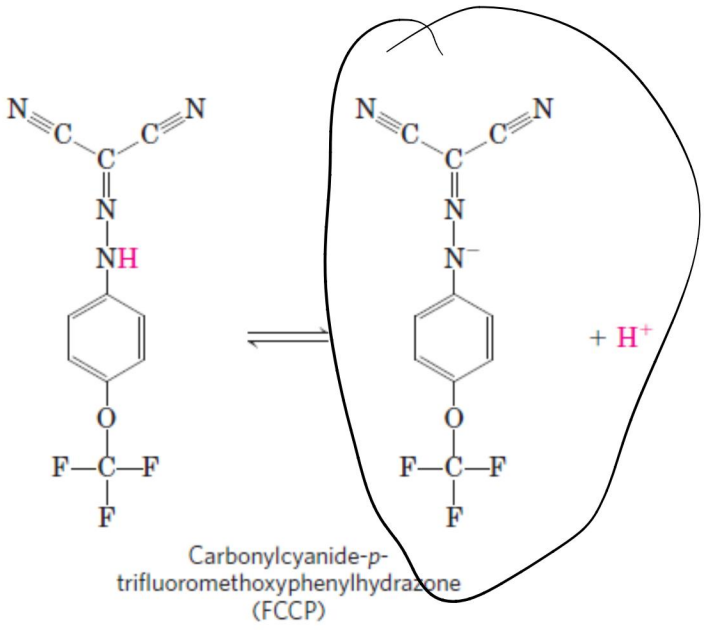
5 3 / 3

✓ **- 0 pts** **Correct**

- 3 pts Correct Answer: B. anabolic

5. Fill in the blank: When oxaloacetate from the citric acid cycle is used as a precursor for the synthesis of aspartate, this process describes a(n)_____ pathway. **(3 points)**
   a. Catabolic
   b. Anabolic
   c. Anaplerotic
   d. All of the above

6. Below is the structure of FCCP, which is an uncoupler. Briefly describe how FCCP functions in the mitochondria after the isolated mitochondria has been treated first with succinate, ADP, and P_i, and then with oligomycin. Circle the structure (on the left or the right of the equilibrium arrows) that exists within the matrix of the mitochondria. **(10 points)**



Carbonylcyanide-*p*-trifluoromethoxyphenylhydrazone (FCCP)

After the mitochondria has been treated w/ succinate, ADP, & P_i, the FCCP will enable e^- flow but will not produce ATP via oxidative phosphorylation. Once oligomycin is added it establishes a proton gradient that stops e^- flow, but FCCP breaks down this proton gradient allowing for e^- flow (although no ATP synthesis).

6 **10 / 10**

- ✓ **+ 5 pts** Deprotonated Form
- ✓ **+ 1.25 pts** Dissipate Proton Gradient
- ✓ **+ 1.25 pts** Electrons can continue to flow
- ✓ **+ 2.5 pts** ATP synthase inhibited by oligomycin
  - **+ 0 pts** Incorrect
  - **+ 0 pts** Rest of answer goes beyond reasonable 2 sentence limit

7. If the aspartate residues of the c units on the F_oF_1 ATP synthase were mutated to glutamate residues, how would this affect proton transport through the F_oF_1 ATP synthase? **(10 points)**

① It should not affect proton transport very much – this is because glutamate & aspartate are very similar amino acids (that differ by only one CH_2), so glutamate can still participate in hydrogen bonding and the same electrostatic interactions as asp has with arginine that cause the subunit to rotate and allow proton transport.

8. Calculate G'° for the passage of electrons from NADH to oxygen, using Table 19-2 below. **(20 points)**

TABLE 19–2 Standard Reduction Potentials of Respiratory Chain and Related Electron Carriers

Redox reaction (half-reaction)	E'° (V)
$2H^+ + 2e^- \longrightarrow H_2$	−0.414
$NAD^+ + H^+ + 2e^- \longrightarrow NADH$	−0.320
$NADP^+ + H^+ + 2e^- \longrightarrow NADPH$	−0.324
NADH dehydrogenase (FMN) + $2H^+ + 2e^- \longrightarrow$ NADH dehydrogenase ($FMNH_2$)	−0.30
Ubiquinone + $2H^+ + 2e^- \longrightarrow$ ubiquinol	0.045
Cytochrome b (Fe^{3+}) + $e^- \longrightarrow$ cytochrome b (Fe^{2+})	0.077
Cytochrome c_1 (Fe^{3+}) + $e^- \longrightarrow$ cytochrome c_1 (Fe^{2+})	0.22
Cytochrome c (Fe^{3+}) + $e^- \longrightarrow$ cytochrome c (Fe^{2+})	0.254
Cytochrome a (Fe^{3+}) + $e^- \longrightarrow$ cytochrome a (Fe^{2+})	0.29
Cytochrome a_3 (Fe^{3+}) + $e^- \longrightarrow$ cytochrome a_3 (Fe^{2+})	0.35
$\frac{1}{2}O_2 + 2H^+ + 2e^- \longrightarrow H_2O$	0.8166

acceptor – donor

$$\Delta G^{\circ\prime} = -nF\Delta E'_0$$

$\Delta E'^\circ$: $\Delta E'_0 = 0.8166 - (-0.32)$

$\Delta E'_0 = 1.1366$

$\Delta G^{\circ\prime} = (-2)(96500\ J/V\,mol)(1.1366\ V)$

$\Delta G^{\circ\prime} = -219363.8\ J/mol$

7 10 / 10

✓ **- 0 pts** **Correct**

- 10 pts Does not indicate that proton flow would not likely be affected if Asp residues were replaced with glutamate.

7. If the aspartate residues of the c units on the F_oF_1 ATP synthase were mutated to glutamate residues, how would this affect proton transport through the F_oF_1 ATP synthase? **(10 points)**

① It should not affect proton transport very much – this is because glutamate & aspartate are very similar amino acids (that differ by only one CH_2), so glutamate can still participate in hydrogen bonding and the same electrostatic interactions as asp has with arginine that cause the subunit to rotate and allow proton transport.

8. Calculate G'° for the passage of electrons from NADH to oxygen, using Table 19-2 below. **(20 points)**

TABLE 19–2 Standard Reduction Potentials of Respiratory Chain and Related Electron Carriers

Redox reaction (half-reaction)	E'° (V)
$2H^+ + 2e^- \longrightarrow H_2$	−0.414
$NAD^+ + H^+ + 2e^- \longrightarrow NADH$	−0.320
$NADP^+ + H^+ + 2e^- \longrightarrow NADPH$	−0.324
NADH dehydrogenase (FMN) + $2H^+ + 2e^- \longrightarrow$ NADH dehydrogenase ($FMNH_2$)	−0.30
Ubiquinone + $2H^+ + 2e^- \longrightarrow$ ubiquinol	0.045
Cytochrome b (Fe^{3+}) + $e^- \longrightarrow$ cytochrome b (Fe^{2+})	0.077
Cytochrome c_1 (Fe^{3+}) + $e^- \longrightarrow$ cytochrome c_1 (Fe^{2+})	0.22
Cytochrome c (Fe^{3+}) + $e^- \longrightarrow$ cytochrome c (Fe^{2+})	0.254
Cytochrome a (Fe^{3+}) + $e^- \longrightarrow$ cytochrome a (Fe^{2+})	0.29
Cytochrome a_3 (Fe^{3+}) + $e^- \longrightarrow$ cytochrome a_3 (Fe^{2+})	0.35
$\frac{1}{2}O_2 + 2H^+ + 2e^- \longrightarrow H_2O$	0.8166

acceptor – donor

$$\Delta G^{\circ\prime} = -nF\Delta E'_0$$

$\Delta E'^\circ$: $\Delta E'_0 = 0.8166 - (-0.32)$

$\Delta E'_0 = 1.1366$

$\Delta G^{\circ\prime} = (-2)(96500\ J/V\,mol)(1.1366\ V)$

$\Delta G^{\circ\prime} = -219363.8\ J/mol$

8 20 / 20

✓ **- 0 pts** **Correct**

- 5 pts Did not set equation for standard change in reduction potential

- 5 pts Incorrectly calculated value for standard change in reduction potential

- 5 pts Did not use 2 electrons for calculation of standard change in free energy

- 5 pts Incorrectly calculated value for standard change in free energy

9. Which molecule serves as an intermediary linker between the flavoproteins and cytochromes in the electron transport chain? Name the moiety of this intermediary molecule that allows it to be mobile within the inner membrane. **(10 points)**

Ubiquinone serves as an intermediary linker between the flavoproteins and cytochromes; it's the isoprenoid chain is hydrophobic & the moiety that allows it to be mobile w/in the inner membrane.

10. How does CO, an inhibitor of complex IV of the electron transport chain, affect the pumping of protons into the intermembrane space, hence the proton gradient, and oxidative phosphorylation? **(10 points)**

Complex IV transfers e^- to the final e^- acceptor, oxygen, and reduces it to water and pumps H^+ out to create the proton gradient that is necessary to drive ATP production. Inhibiting complex IV will stop e^- flow and will will result in no protons being pumped, so no proton gradient, and thus no ATP being produced / no oxidative phosphorylation.

11. Why does epinephrine cause an increase in glycolysis in muscle cells, however a decrease in glycolysis in liver cells? **(10 points)**

Epinephrine is used to increase glycolysis in the muscle cells so ATP can be produced for muscle contraction (by activating glycogen breakdown) because ATP is produced to fuel the muscles for a fight or flight response (which is why epinephrine is released). In contrast, epinephrine decreases glycolysis in the liver so that glucose can be used for raising blood glucose levels.

9 **10 / 10**

✓ **- 0 pts** **Correct**

- 5 pts Did not mention Ubiquinone/ol

- 5 pts Did not mention isoprene chain (polyprenyl), or any sort of hydrophobic, nonpolar long alkyl chain

- 2 pts Mentioned a plausible explanation for the moiety, but was not specific enough or named the wrong group

+ 1 pts Hydrophobicity

- 6 pts Mentioned the right structures, however switched them up (should be Ubiquinone=intermediary, isoprene=moiety)

9. Which molecule serves as an intermediary linker between the flavoproteins and cytochromes in the electron transport chain? Name the moiety of this intermediary molecule that allows it to be mobile within the inner membrane. **(10 points)**

Ubiquinone serves as an intermediary linker between the flavoproteins and cytochromes; it's the isoprenoid chain is hydrophobic & the moiety that allows it to be mobile w/in the inner membrane.

10. How does CO, an inhibitor of complex IV of the electron transport chain, affect the pumping of protons into the intermembrane space, hence the proton gradient, and oxidative phosphorylation? **(10 points)**

Complex IV transfers e^- to the final e^- acceptor, oxygen, and reduces it to water and pumps H^+ out to create the proton gradient that is necessary to drive ATP production. Inhibiting complex IV will stop e^- flow and will will result in no protons being pumped, so no proton gradient, and thus no ATP being produced / no oxidative phosphorylation.

11. Why does epinephrine cause an increase in glycolysis in muscle cells, however a decrease in glycolysis in liver cells? **(10 points)**

Epinephrine is used to increase glycolysis in the muscle cells so ATP can be produced for muscle contraction (by activating glycogen breakdown) because ATP is produced to fuel the muscles for a fight or flight response (which is why epinephrine is released). In contrast, epinephrine decreases glycolysis in the liver so that glucose can be used for raising blood glucose levels.

10 10 / 10

✓ **+ 10 pts Correct**

+ 3.3 pts inhibits flow of electrons in ETC

+ 3.3 pts prevents protons from being pumped to the intermembrane space

+ 3.3 pts ADP is NOT phosphorylated

+ 0 pts No answer or no partial

9. Which molecule serves as an intermediary linker between the flavoproteins and cytochromes in the electron transport chain? Name the moiety of this intermediary molecule that allows it to be mobile within the inner membrane. **(10 points)**

Ubiquinone serves as an intermediary linker between the flavoproteins and cytochromes; it's the isoprenoid chain is hydrophobic & the moiety that allows it to be mobile w/in the inner membrane.

10. How does CO, an inhibitor of complex IV of the electron transport chain, affect the pumping of protons into the intermembrane space, hence the proton gradient, and oxidative phosphorylation? **(10 points)**

Complex IV transfers e^- to the final e^- acceptor, oxygen, and reduces it to water and pumps H^+ out to create the proton gradient that is necessary to drive ATP production. Inhibiting complex IV will stop e^- flow and will will result in no protons being pumped, so no proton gradient, and thus no ATP being produced / no oxidative phosphorylation.

11. Why does epinephrine cause an increase in glycolysis in muscle cells, however a decrease in glycolysis in liver cells? **(10 points)**

Epinephrine is used to increase glycolysis in the muscle cells so ATP can be produced for muscle contraction (by activating glycogen breakdown) because ATP is produced to fuel the muscles for a fight or flight response (which is why epinephrine is released). In contrast, epinephrine decreases glycolysis in the liver so that glucose can be used for raising blood glucose levels.

11 10 / 10

✓ **+ 5 pts** **Epinephrine causes an increase in glycolysis in muscle cells because glycolysis yields ATP, which is necessary for muscle contraction.**

✓ **+ 5 pts** **however, in liver cells, glycolysis is decreases so that the liver can maintain glucose homeostasis._**

+ 0 pts incorret

12. Which hormone is most dominant after one eats a carbohydrate/ glucose rich meal? **(6 points)**

a. Epinephrine
b. Glucagon
c. Insulin
d. None of the above

13. Fill in the blanks with one word each: While glycogen phosphorylase is stimulated when energy levels are low, glycogen synthase is stimulated when energy levels are high. **(10 points)**

14. Fill in the blanks with one word each: In order to degrade glycogen, the debranching enzyme has both transferase and glucosidase activities. **(10 points)**

12 **6 / 6**

✓ **- 0 pts** **Correct**

- 6 pts incorrect

12. Which hormone is most dominant after one eats a carbohydrate/ glucose rich meal? **(6 points)**

a. Epinephrine
b. Glucagon
c. Insulin
d. None of the above

13. Fill in the blanks with one word each: While glycogen phosphorylase is stimulated when energy levels are low, glycogen synthase is stimulated when energy levels are high. **(10 points)**

14. Fill in the blanks with one word each: In order to degrade glycogen, the debranching enzyme has both transferase and glucosidase activities. **(10 points)**

13 **10 / 10**

✓ **- 0 pts** **Correct**

- 5 pts Did not state that glycogen synthase is stimulated when energy levels are high

OR

Did not state that glycogen phosphorylase is stimulated when energy levels are low

- 10 pts Did not state that glycogen synthase is stimulated when energy levels are high, glycogen phosphorylase is stimulated when energy levels are low

12. Which hormone is most dominant after one eats a carbohydrate/ glucose rich meal? **(6 points)**

a. Epinephrine
b. Glucagon
c. Insulin
d. None of the above

13. Fill in the blanks with one word each: While glycogen phosphorylase is stimulated when energy levels are low, glycogen synthase is stimulated when energy levels are high. **(10 points)**

14. Fill in the blanks with one word each: In order to degrade glycogen, the debranching enzyme has both transferase and glucosidase activities. **(10 points)**

14 10 / 10

✓ **- 0 pts** **Correct**

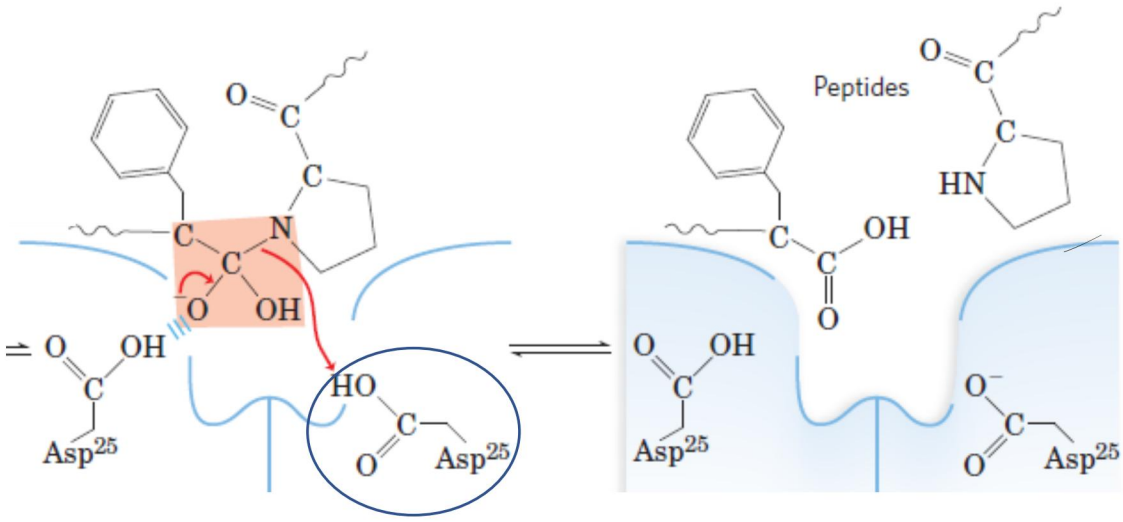
- 5 pts Did not list that the debranching enzyme has transferase activity

OR

Did not list that the debranching enzyme has glucosidase activity

- 10 pts Did not list that the debranching enzyme has both transferase and glucosidase activity

15. What type of catalysis is depicted by Asp^{25} circled in the diagram below? **(10 points)**



general acid catalysis

15 **10 / 10**

✓ **- 0 pts Correct (Acid)**

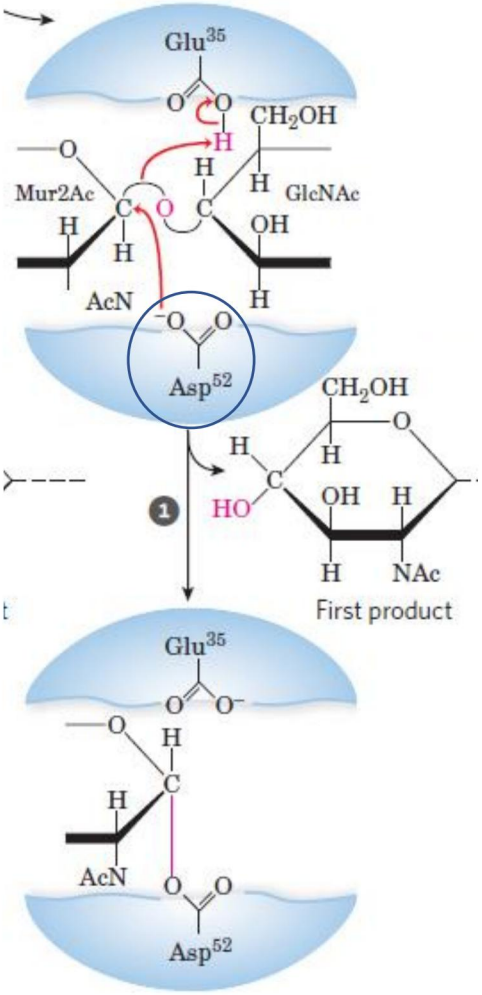
- 10 pts Incorrect

- 5 pts This is solely Acid catalysis, we can't say acid/base because there is a separate Base catalysis

+ 2 pts Recognized acid R group

- 5 pts Named the wrong catalysis, but recognized Asp donating a proton

16. What type of catalysis is depicted by Asp^{52} circled in the diagram below? **(10 points)**



Covalent catalysis

16 **10 / 10**

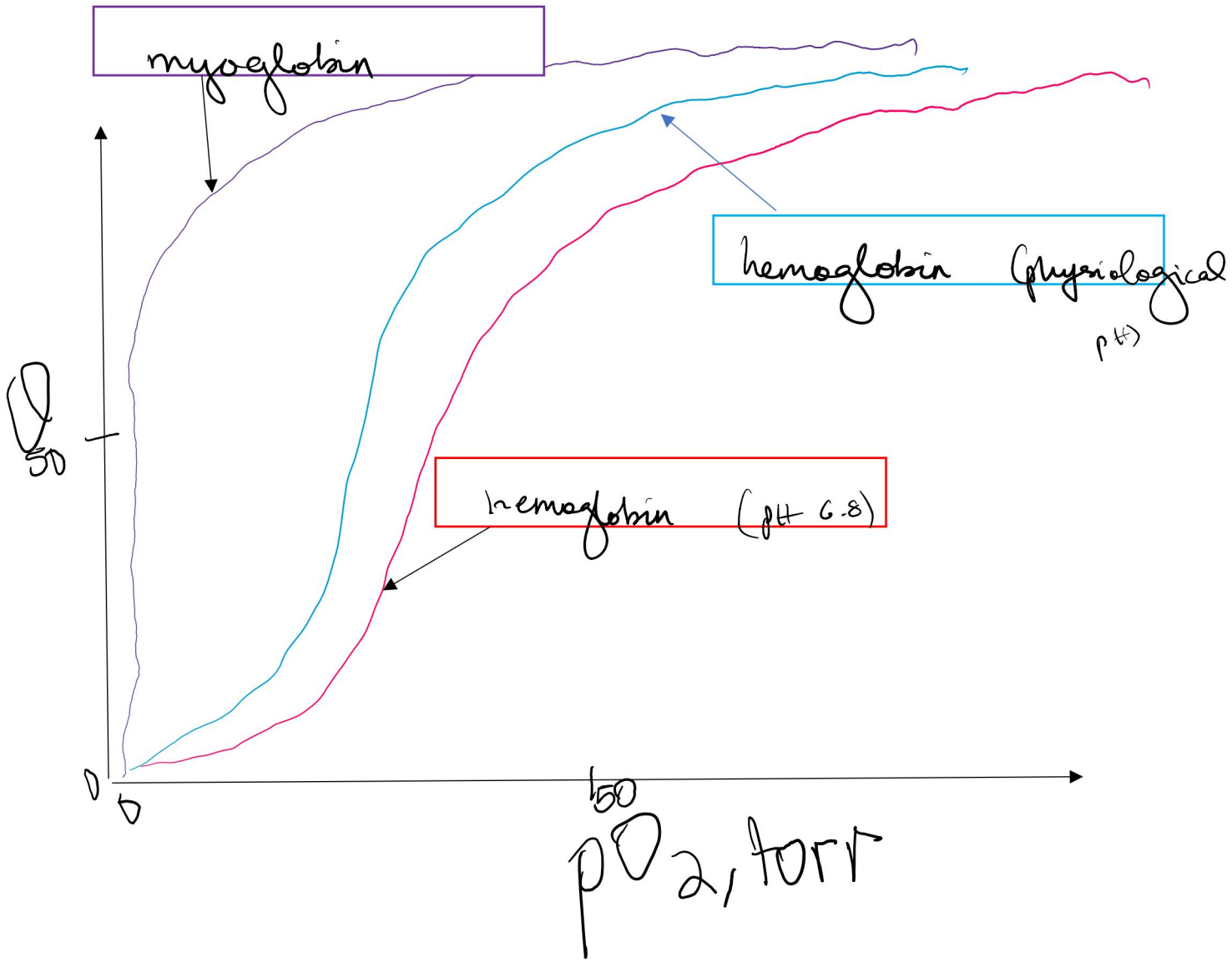
✓ **- 0 pts** **Correct**

- 10 pts Asp52 is performing covalent catalysis. It forms a covalent bond with the substrate during its catalytic functions

- 10 pts Asp52 is performing covalent catalysis.. Glu35 is performing acid catalysis

- 10 pts No answer

17. Below is the fractional saturation curve for myoglobin, hemoglobin at physiological pH and hemoglobin at pH 6.8. Label each curve with the correct hemeprotein in the box. **(10 points)**



17 10 / 10

✓ **- 0 pts** **Correct**

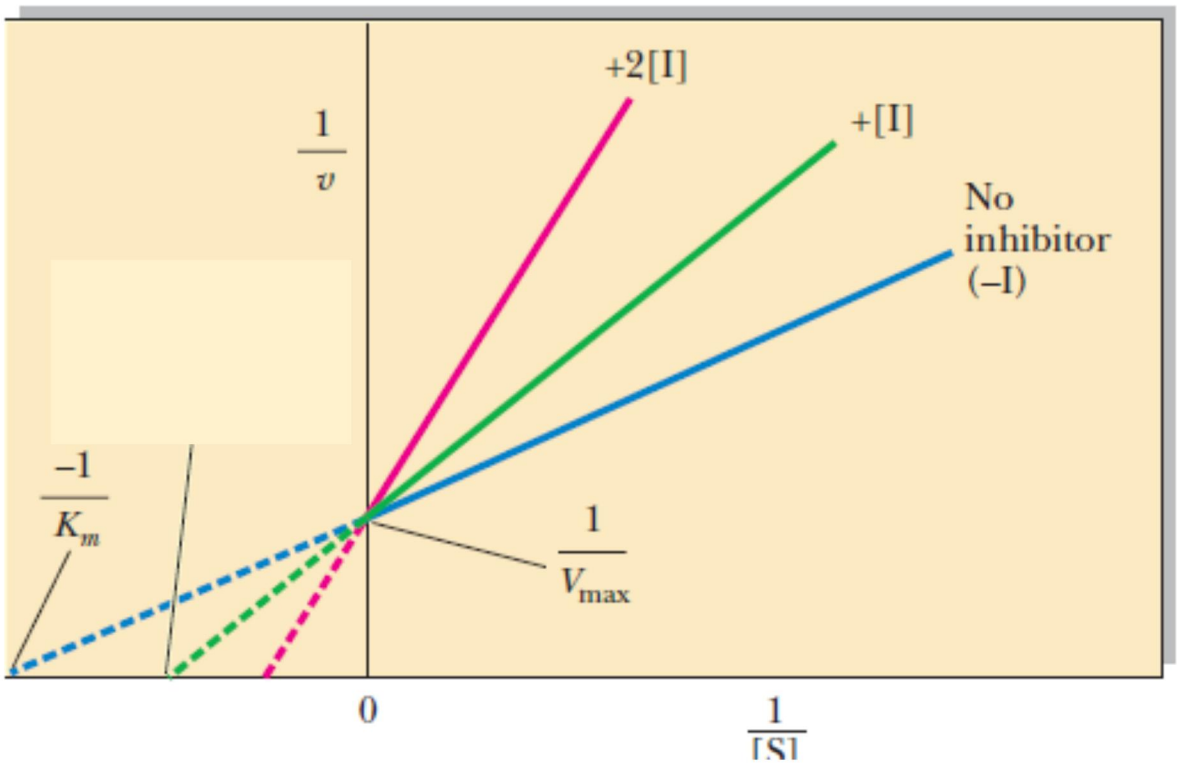
- 3 pts Bottom line is hemoglobin at pH 6.8

- 6 pts Blue line (middle) is hemoglobin at physiological pH, Red line (bottom) is hemoglobin at pH 6.8

- 10 pts Top=myoglobin, middle=hemoglobin at phys. pH, bottom= hemoglobin at pH 6.8

- 6 pts Top=myoglobin. Bottom= Hemoglobin at pH 6.8

18. Based upon the graph below, what type of inhibitor is being depicted and does the inhibitor have a greater affinity for the enzyme or enzyme-substrate complex? What happens to Km apparent and Vmax apparent in the presence of the inhibitor? **(12 points)**



- Competitive inhibitor, greater affinity for enzyme
- In the presence of the inhibitor, Kmax apparent would increase and Vmax apparent

18 **12 / 12**

✓ **+ 12 pts Correct**

+ **3 pts** competitive inhibitor

+ **3 pts** greater affinity for enzyme

+ **3 pts** Km app increase

+ **3 pts** Vmax app same

+ **0 pts** No answer or no partial

19. Circle the following statement that is incorrect **(5 points)**

a. Fetal hemoglobin has a higher affinity for oxygen than maternal hemoglobin because of decreased affinity for 2,3-BPG.
b. Fetal hemoglobin has a lower affinity for oxygen than maternal hemoglobin because of decreased affinity for 2,3-BPG.
c. The globin chain for fetal hemoglobin is $\alpha_2\gamma_2$
d. All of the above

↓ BPG, ↑ oxy

20. How does the structure of myoglobin prevent it from functioning in the cooperative binding that is observed in the hemeprotein hemoglobin? **(10 points)**

Myoglobin is a monomer with one subunit, while hemoglobin is a tetramer with four subunits. Cooperative binding is where one subunit can facilitate greater O_2 binding for the other subunits; myoglobin cannot participate in it because it only has one subunit.

19 **5 / 5**

✓ **- 0 pts** **Correct**

- 5 pts incorrect

19. Circle the following statement that is incorrect **(5 points)**

a. Fetal hemoglobin has a higher affinity for oxygen than maternal hemoglobin because of decreased affinity for 2,3-BPG.
b. Fetal hemoglobin has a lower affinity for oxygen than maternal hemoglobin because of decreased affinity for 2,3-BPG.
c. The globin chain for fetal hemoglobin is $\alpha_2\gamma_2$
d. All of the above

↓ BPG, ↑ oxy

20. How does the structure of myoglobin prevent it from functioning in the cooperative binding that is observed in the hemeprotein hemoglobin? **(10 points)**

Myoglobin is a monomer with one subunit, while hemoglobin is a tetramer with four subunits. Cooperative binding is where one subunit can facilitate greater O_2 binding for the other subunits; myoglobin cannot participate in it because it only has one subunit.

20 **10 / 10**

✓ **+ 5 pts** **Myoglobin is composed of only one polypeptide chain with one heme group, which binds only one molecule of oxygen**

✓ **+ 5 pts** **therefore cannot participate in cooperative binding that is observed in hemoglobin.**

+ 0 pts incorrect