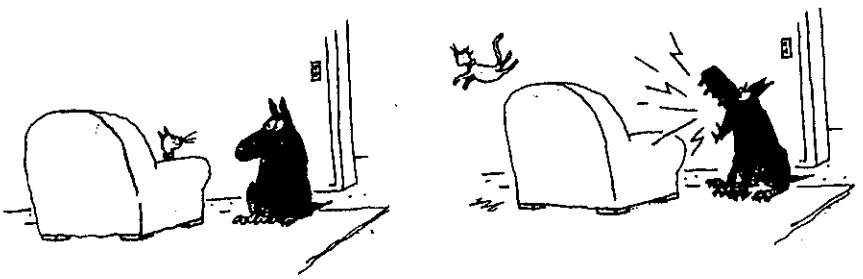
CHEM 527
Final exam, Fall 2002

NAME KEY

NOTES:

1. Please stay calm.
2. Where appropriate, show work to receive full credit.
3. This exam contains 11 pages + metabolic charts (*detach gently, please*).
4. Pace yourself - you may want to do the easiest questions first.
5. Note the point value of questions varies widely - adjust your answers accordingly.
6. Please give concise answers - if there isn't much space allotted - a short answer is appropriate.
7. Questions may have more data than needed to tackle the problem.
8. PLEASE write clearly. If I cannot read it .... it is wrong.
9. As mentioned in class and EMails, you are allowed to refer to a single piece of 8.5 x 11" paper during this exam. It can feature any material distributed over both sides.



Question 1 (14 pts) Yield of ATP. In the space provided give the yield of ATP (or equivalent e.g. GTP) that would be formed in the following processes:

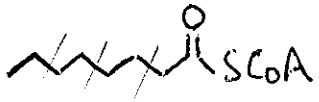
a. per molecule of glucose-1P completely oxidized to CO_2 and water **31**

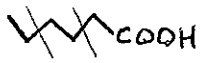
b. per pyruvate in the presence of malonate 8.5

c. per molecule of fructose 1,6-P converted to ethanol 4

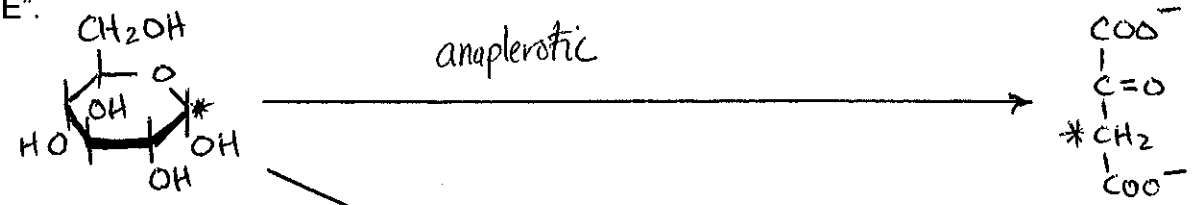
d. per molecule of lactate completely oxidized to CO_2 and water 14

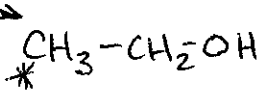
e.. per ethanol completely oxidized to CO_2 and water 11
(note: a sample question had wrong answer for this)

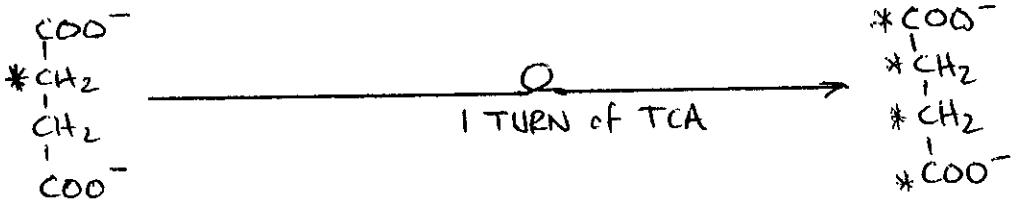
f. per  completely oxidized to CO_2 and water 52

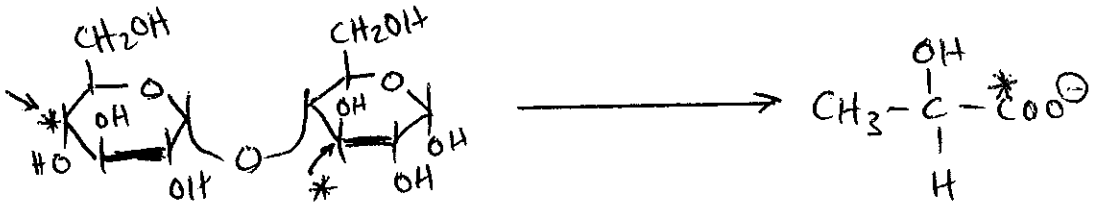
g. per  completely oxidized to CO_2 and water 36

Question 2 (8 pts) Tracing radiolabels. Place asterisks indicating the position of the radiolabel in the molecules shown to the right – if the product contains no radiolabel write "NONE".

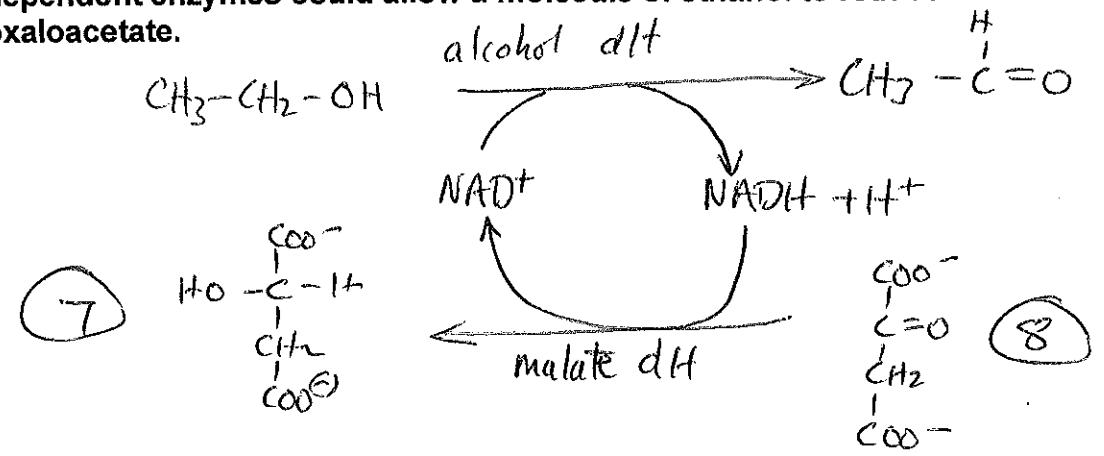
a. 

b. 

c. 

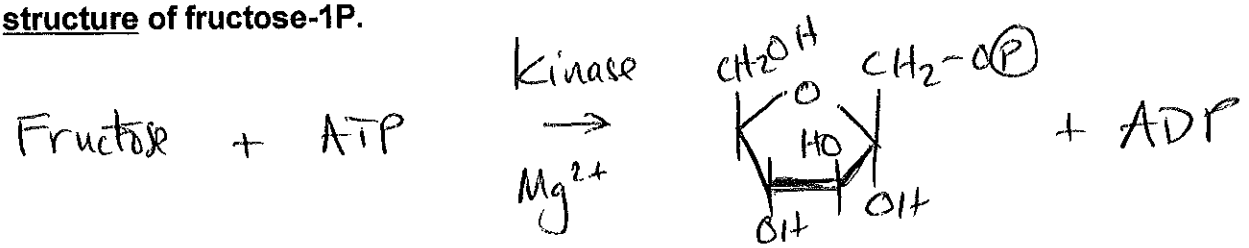
d. 

Question 3 (6 pts.) Draw a clear scheme to show how two different purified NAD+ dependent enzymes could allow a molecule of ethanol to reduce a molecule of oxaloacetate.



Below: write the overall reaction for ethanol reducing oxaloacetate:

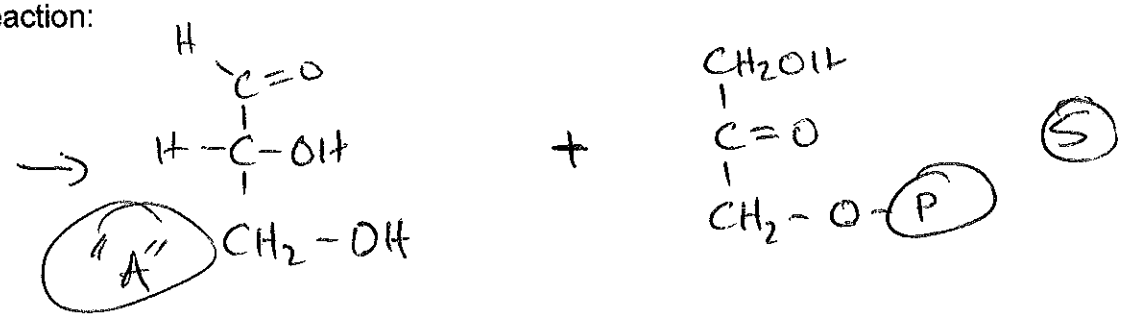
Question 4 (7 pts) Fructose CAN enter glycolysis via a fructokinase which generates fructose-1-P. Show all substrates and products of the fructokinase reaction (include the <u>structure</u> of fructose-1P.



3

Fructose 1P

Fructose-1P is then a substrate of aldolase. Draw the <u>structure</u> of the two products on this reaction:



2

How might these two products continue in the glycolysis pathway. What is the issue here?

2 (5) is OK. Need to phosphorylate "A" w kinase e.g. or ... (anything reasonable)

A = 22 T = 22 G = 28 C = 28

Question 5 (4 pts) Two different microorganisms showed double stranded DNA with differing adenine content. Bacterium #1 contained 22%, bacterium #2 contained 38%.

List the Cytosine content for #1 28 | #2 12 |

Can you predict which organisms is likely the thermophile? (Circle)

(#1) #2 Insufficient information (2)

Question 6 (4 pts.) What major product would you expect to be formed when yeast is grown aerobically on glucose (expect) $CO_2 + H_2O$

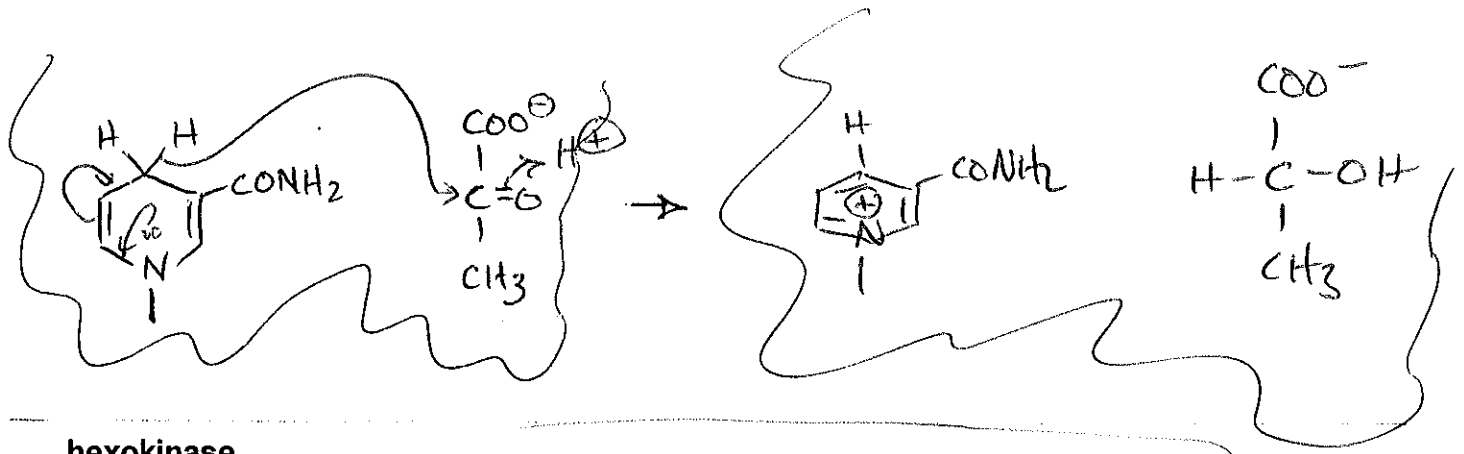
Actually aerobic yeast produce significant amounts of ethanol when they are added to a fresh glucose-containing medium. Suggest an explanation. One clear sentence please.

3 v. rapidly growing (competing) yeast will produce ethanol because they have abundant glucose & glycolysis produces more ATP/sec than TCA.

Question 7 (6 pts) Fill in and complete these partial figures so they show the chemical steps of the appropriate enzyme in an appropriate curved arrow representation.

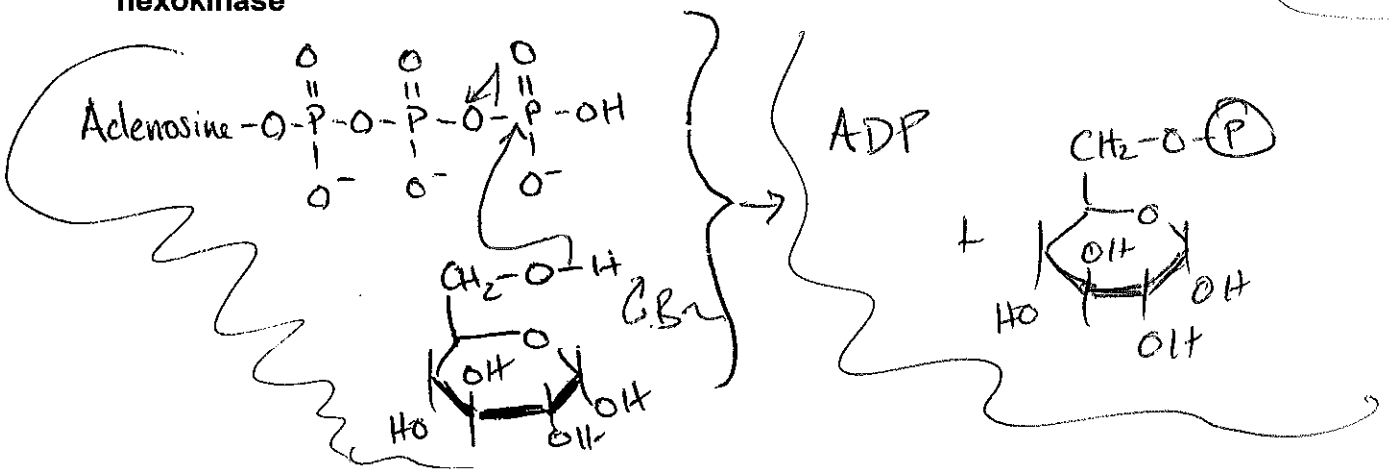
lactate dehydrogenase

3



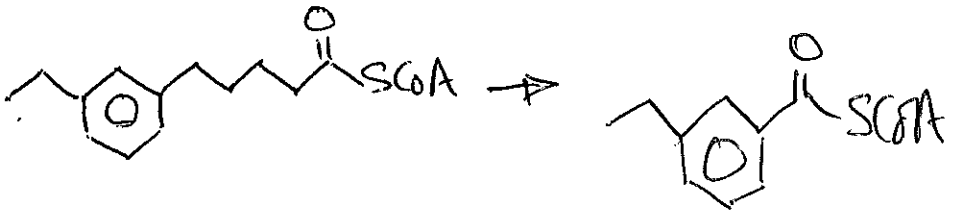
hexokinase

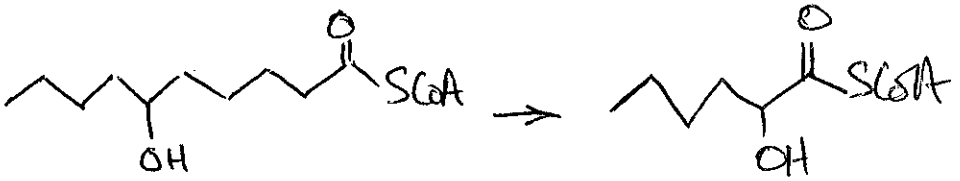
3

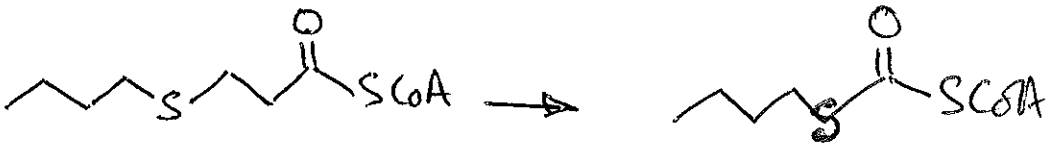


Question 8 (8 pts). Fatty acid oxidation handles unusual fatty acids as well as normal (e.g. straight-chain) ones. For each of these compounds shown to the left show what compound you would expect to accumulate after conventional β-oxidation has finished.

a. 

b. 

c. 

d. 

Question 9 (11 pts) Place in the space provided a single number from 0 – 18. Do not put enzyme or substrate product names.

a. Transamination of aspartic acid gives what TCA cycle intermediate — 8

b. How many pairs of electrons are removed during the complete oxidation of 1 glucose molecule — 12

c. The complete oxidation of pyruvate generates how many molecules of CO_2 — 3

d. What intermediate of the TCA cycle would accumulate at low phosphate concentration — 4

e. Lactate contains _ more electrons than pyruvate 2

f. Reduced coenzyme Q contains _ more electrons than oxidized coenzyme Q 2

g. The number of ATP equivalents used for the synthesis of 1 molecule of glucose from 2 molecules of lactate 6

h. Niacin deficiency will cause what intermediate in glycolysis to accumulate 6 (accept 5/4)

i. The number of electrons required to reduce one oxygen molecule to water 4

j. How many ATP (or equivalents) would you expect to need to make a molecule of succinyl-CoA from succinate and CoA 2

k. How many electrons are removed during the complete oxidation of ethanol to carbon dioxide and water? ~~6~~ 2 = 12

Question 10 (5 pts). Suppose you have an anaerobic bacterium which makes lactate from glucose (i.e. via glucose to pyruvate to lactate). Your boss proposes to convert the organism to one producing acetate instead by:

a. removing the lactate dehydrogenase gene

b. replacing it with genes making a functional pyruvate dehydrogenase multienzyme complex

c. adding an enzyme that catalyzes the following reaction ("C")

C: acetyl-CoA + ADP + P_i → acetate + CoASH + ATP

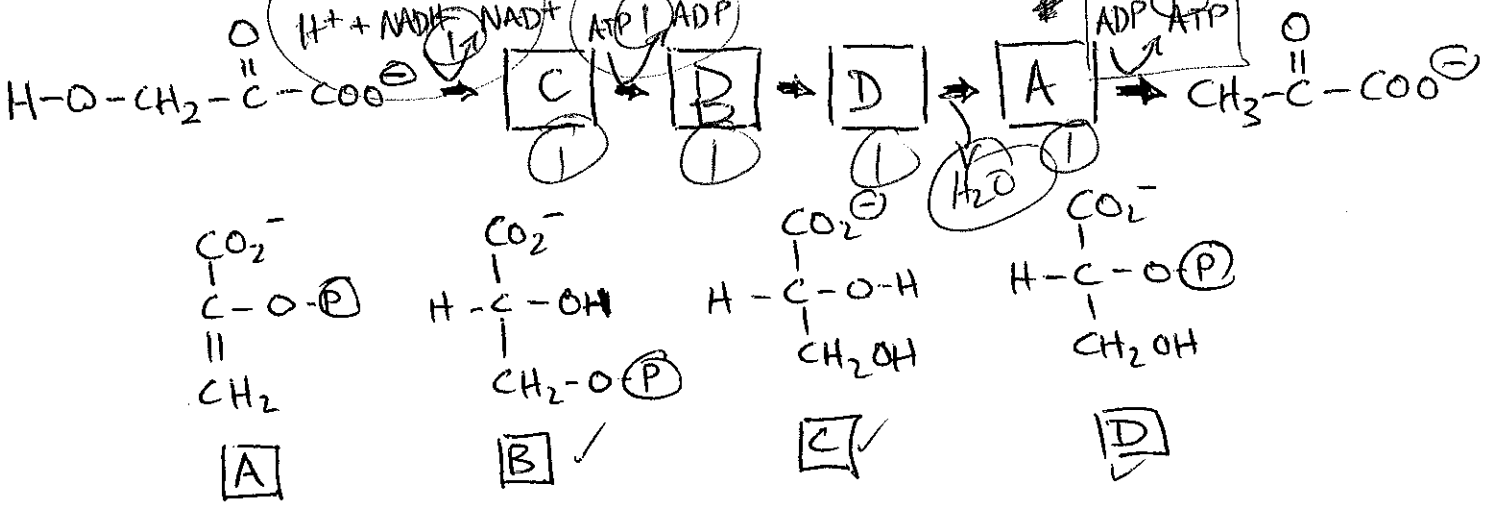
Name an enzyme analogous to reaction "C" thiokinase 2

Assuming all the manipulations could be accomplished successfully. Is this metabolic re-engineering going to work. Circle and then explain in 1 sentence or less:

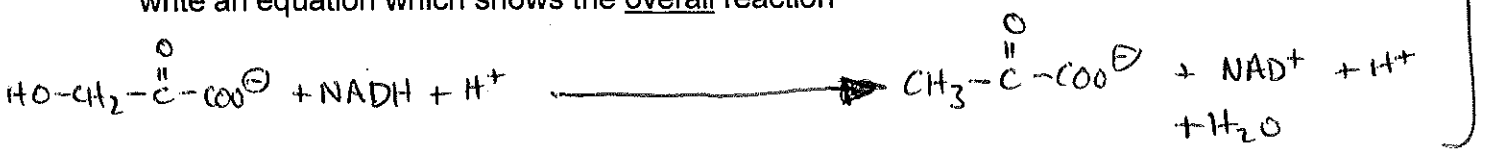
YES (NO) 1 Cannot say

No provision made for reoxidation of NADH generated by PDH multienzyme complex. (Cannot work) 2

Question 11 (8 pts) Hydroxypyruvate (left) is converted to pyruvate via the four intermediates listed below. In the spaces provided place then in the correct order. You will also need to show the involvement of NADH, NAD$^+$ and ATP, ADP.



write an equation which shows the overall reaction



Question 12 (24 pts). Short problems. Most of the credit goes for the correct numerical answer

a. Aspirin (pK 3.5), a weak carboxylic acid, is dissolved in water to give a solution with a pH of 3.5. What is the concentration of aspirin used?

$10^{-3.5} = \frac{(10^{-3.5})(10^{-3.5})}{(conc)}$

3.16×10^{-4} M

3

b. You add 0.2 moles of KOH to 0.8 L of 0.3 M formic acid (pK 3.7). What is the pH of the mixture?

0.24 moles

pH = 4.398

3

formate = 0.2 moles

formic = .04 moles

$pH = 3.7 + \log\left(\frac{0.2}{0.04}\right)$

4.4

c. the concentration of oxygen dissolved in 1L of buffer in equilibrium with air is 0.24 mM. You then add 20 g of myoglobin and stir gently in air until equilibrium is reached. What is the total concentration of oxygen (free and bound) now carried in the solution. (MW oxygen 32, myoglobin, 16,700, water 18).

$\frac{20\,g}{16{,}700\,g/mole}$ = 1.198 mM myo ≡ 1.198 mM bound Oxygen.

[total oxygen] = 1.438 mM

[free oxygen concn.] = 0.24 mM

0.24 mM free

d. if hair grows at a rate of 4 mm/week and the alpha helix has a pitch of 5.4×10^{-8} cm how many amino acids are added to an alpha helix per second?

$$\left(\frac{.4\ cm}{7 \times 24 \times 60 \times 60 \times 5.4 \times 10^{-8}}\right) 3.6$$

Number of amino acids 44/sec

e. A protein has 4 disulfide bridges and one free cysteine residue. How many different combinations of this arrangement are possible?

9 $\quad 8 \times 6 \times 4 \times 2$ 384 combinations

f. Zymase (100 μg) catalyzes the breakdown of 2 μmol of product formation per minute at room temperature. The molecular weight of the enzyme is 15,000 g/mol, the substrate 280 and the product 298 g/mol. What is the turnover number of zymase?

$$\frac{2 \times 10^{-6}}{100 \times 10^{-6} / 15{,}000\ g/mole}$$

Turnover number 300 /min

g. Calculate the standard free energy change for the hypothetical transformation:

2A ↔ **C** $\Delta G^{o'} =$ -14 kcal/mol

given:

C ↔ 2 B $\Delta G^{o'} = +8$ kcal/mol

B ↔ A $\Delta G^{o'} = +3$ kcal/mol

2A ⇔ 2B −6

2B ⇔ C −8

−14

h. a negligible volume of aldolase was added to 0.02 M fructose-1,6-diP and, at equilibrium, the concentration of fructose-1,6-diP declined by 1 mM. Calculate the equilibrium constant for the aldolase reaction:

$K_{eq} = 5.26 \times 10^{-5}$

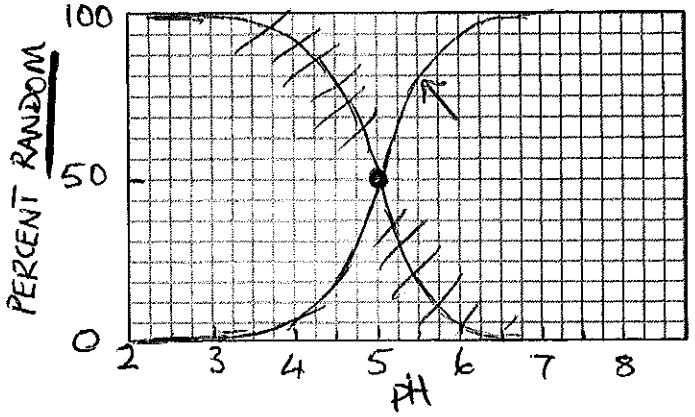
$K_{eq} = \frac{(.001)(.001)}{(.019)}$ 5.26×10^{-5} M.

Question 13 (5 pts) What is the effect of the following on hemoglobin and myoglobin. Circle increase, no change (nc), decrease.

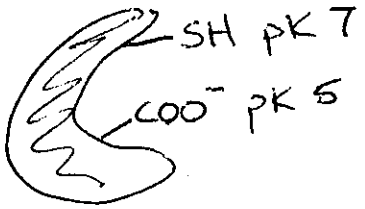
Decreasing the pH on oxygen affinity of normal hemoglobin	**increase**	**nc**	**decrease**
Increasing pH on CO_2 binding to hemoglobin	**increase**	**nc**	**decrease**
Effect of low concentrations of carbon monoxide on oxygen affinity of hemoglobin	**increase**	**nc**	**decrease**
Adding oxygen to an unbuffered solution of deoxy-hemoglobin. The pH will:	**increase**	**nc**	**decrease**
Effect of adding DPG to the oxygen affinity of myoglobin	**increase**	**nc**	**decrease**

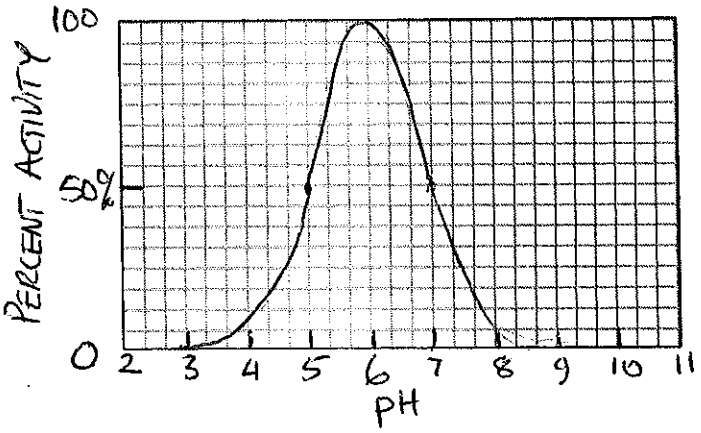
Question 14 (12 pts) Graphs. Draw clear accurate graphs to describe the behavior of the following systems. Clarity and accuracy rewarded.

a. a polymer of aspartic acid (poly-ASP) can exist in either random coil or alpha-helical conformation depending on pH. Assume the pK of asp side chain is 5.

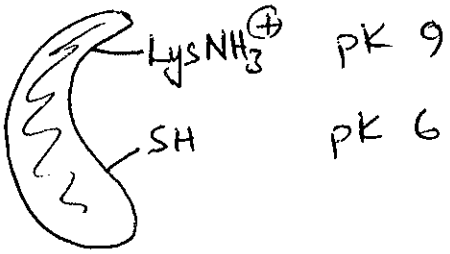


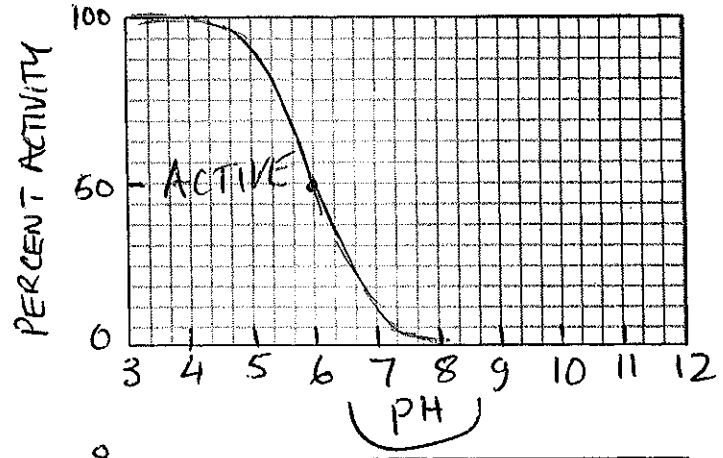
b. only this form of the enzyme show below is active. Show its pH dependence at the right.





c. only this form of the enzyme show below is active. Show its pH dependence at the right.

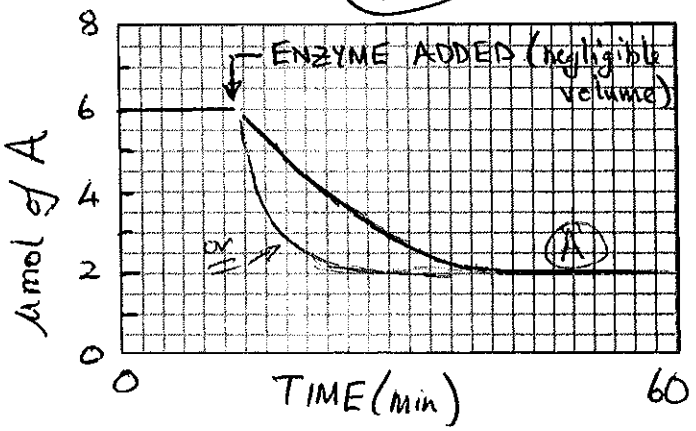




d. The equilibrium constant for A ↔ B is 2.0. In the graph at the right enzyme catalyzing this reaction was added at the time indicated. Complete the graph.

(No B initially).

$\frac{B}{A} = 2$ i.e. $\frac{4\ \mu mol}{2\ \mu mol}$



Question 18 (11 pts) Fill in the blanks with not more than 3 legible words.

a. An unnatural uncoupler of oxidative phosphorylation — Dinitrophenol

b. A water insoluble small molecular weight component of the respiratory chain — Coenzyme Q

c. Two transition metals involved in electron transport chain — Copper

d. And the second metal — iron

e. He won a Nobel Prize for his "chemiosmotic theory" — Mitchell, Peter

f. These foldases usually help undesirable aggregation during protein folding — Chaperones

g. The compound useful in the diagnosis *of Helicobacter pylorii* infections — urea ^{13}C labelled

h. More than half of the weight of the ribosome is — RNA

i. A chemical mutagen that promotes deamination of cytosine — nitrite

j. A scientist whose contribution to the structure of the double helix was slighted — Franklin

k. These aberrant structures can be repaired by visible light — Thymine Dimers

l. The word that best describes this exam — OVC

m. The word that best describes this course — OVC

bon voyage