CHEM 527
Final exam, Fall 2002

NAME ______________________________

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:

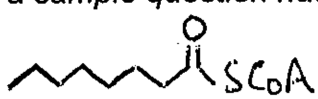
a. per molecule of glucose-1P completely oxidized to CO_2 and water ______

b. per pyruvate in the presence of malonate ______

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

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

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

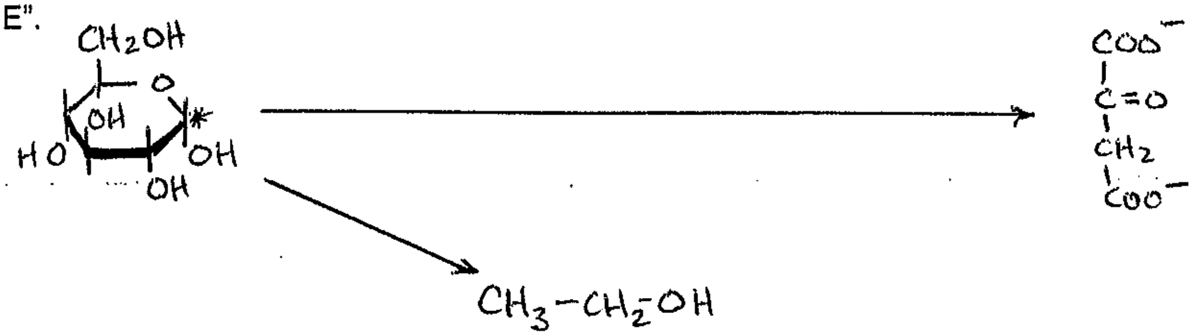
f. per  completely oxidized to CO_2 and water ______

g. per  completely oxidized to CO_2 and water ______

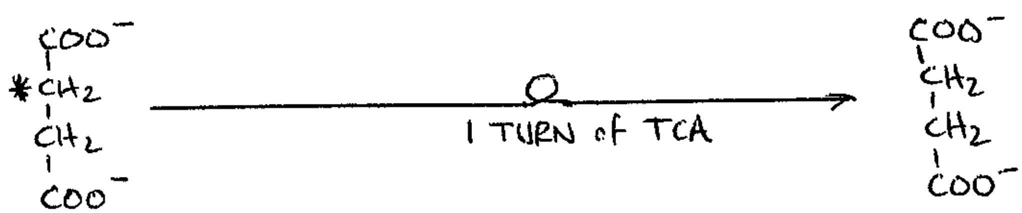
Question 2 (8 pts) Tracing radiolabels. Place asterisks indicating the position of the radiolabel in the molecules shown to the right – if the product contains no radiolabel write "NONE".

a.

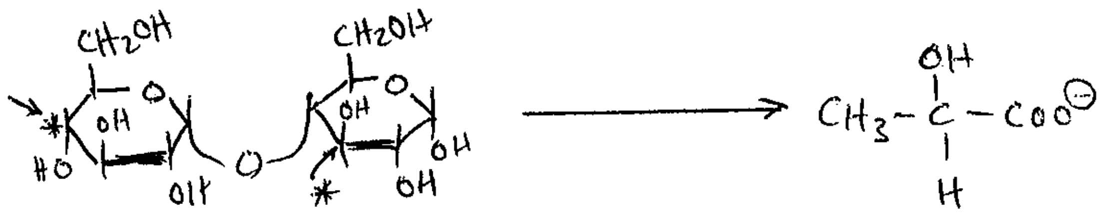
b.



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.

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

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

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 ________ #2 __________

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

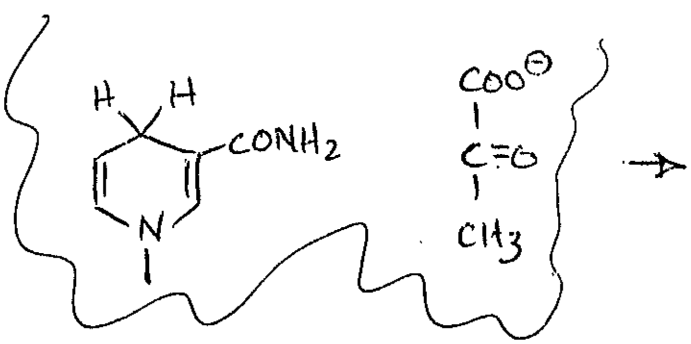
#1 #2 Insufficient information

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

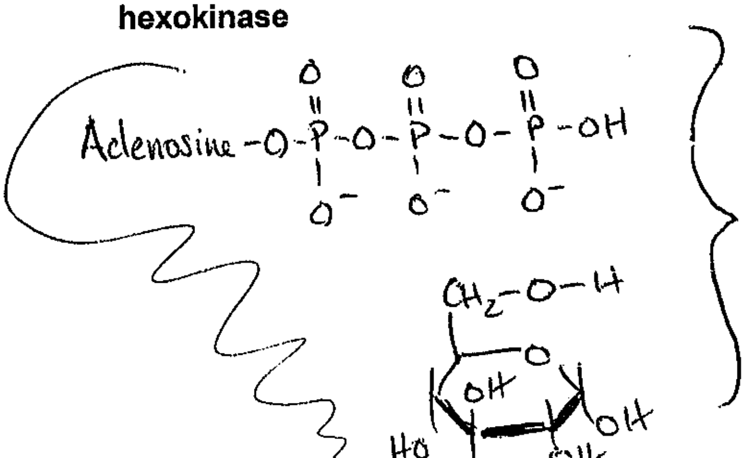
Actually aerobic yeast produce significant amounts of ethanol when they are added to a fresh glucose-containing medium. Suggest an explanation. One clear sentence please.

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.

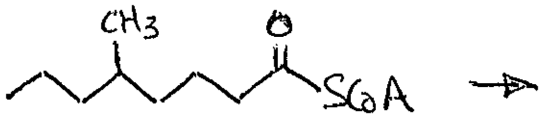
lactate dehydrogenase



hexokinase



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. 

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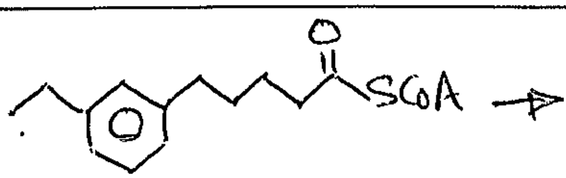
b. 

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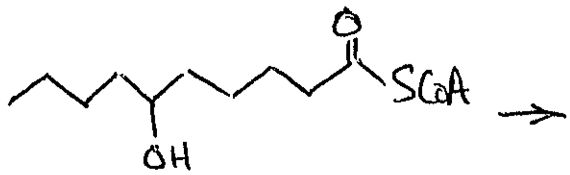
c. 

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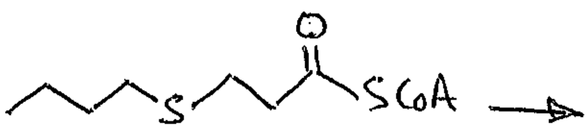
d. 

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 ______

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

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

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

e. Lactate contains _ more electrons than pyruvate ______

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

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

h. Niacin deficiency will cause what intermediate in glycolysis to accumulate ______

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

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

k. How many <u>electrons</u> are removed during the complete oxidation of ethanol to carbon dioxide and water? ______

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

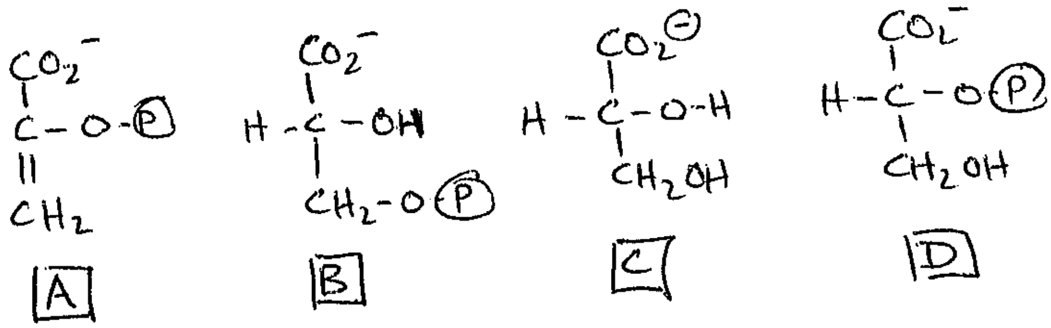
Name an enzyme analogous to reaction "C" ______________________

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 Cannot say

____

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 <u>overall</u> 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?**

_______________M

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?**

pH = _______________

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).**

[total oxygen] = _________mM

[free oxygen concn.] = _________mM

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?**

Number of amino acids____________

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

________________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?**

Turnover number ____________/min

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

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

given:

C	↔	2 B	$\Delta G^{o'}$ = + 8 kcal/mol
B	↔	A	$\Delta G^{o'}$ = + 3 kcal/mol

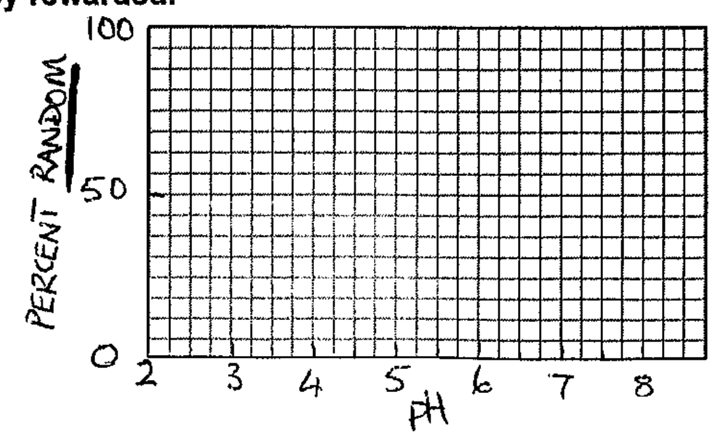
h. a negligible volume of aldolase was added to 0.02 M fructose-1,6-diP and, at equilibrium, the concentration of fructose-1,6-diP <u>declined by</u> 1 mM. Calculate the equilibrium constant for the aldolase reaction: K_{eq} = ________________

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

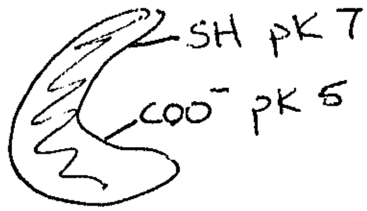
Decreasing the pH on oxygen affinity of normal hemoglobin	**increase**	**nc**	**decrease**
Increasing pH on CO_2 binding to hemoglobin	**increase**	**nc**	**decrease**
Effect of low concentrations of carbon monoxide on oxygen affinity of hemoglobin	**increase**	**nc**	**decrease**
Adding oxygen to an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

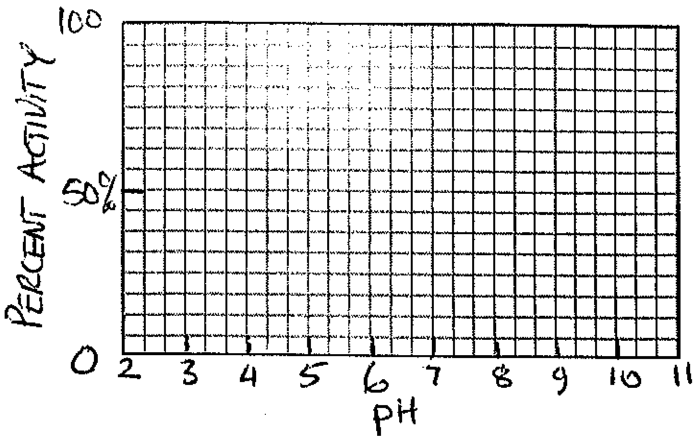
Question 14 (12 pts) Graphs. Draw clear accurate graphs to describe the behavior of the following systems. Clarity and accuracy rewarded.

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.

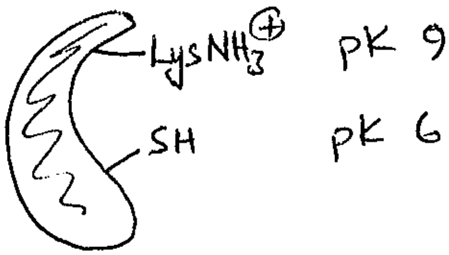


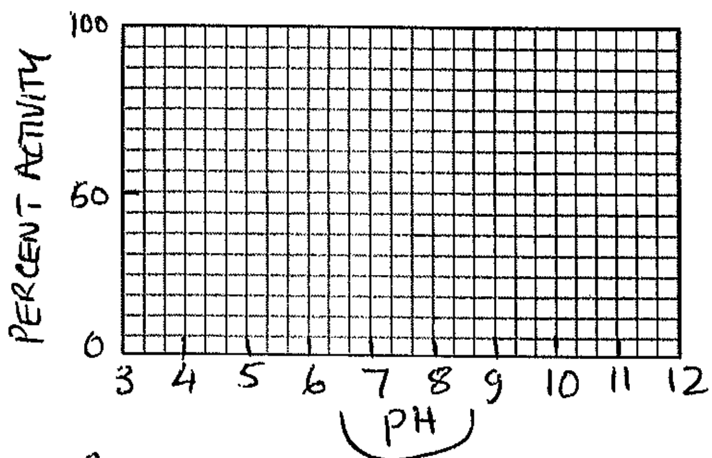
b. only this form of the enzyme show below is active. Show its pH dependence at the right.



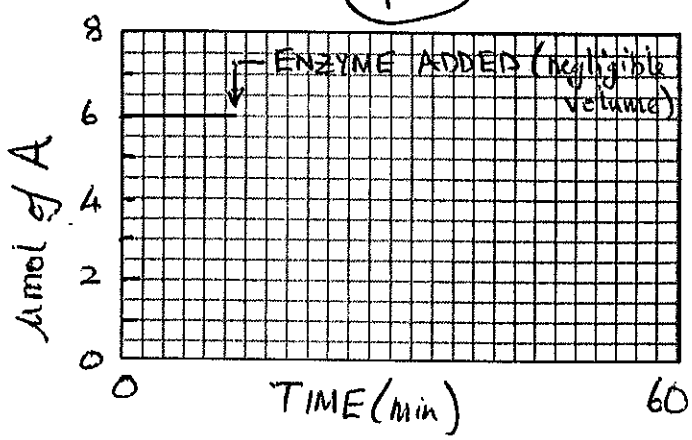


c. only this form of the enzyme show below is active. Show its pH dependence at the right.





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).



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

a. An unnatural uncoupler of oxidative phosphorylation ________________

b. A water insoluble small molecular weight component of the respiratory chain ________________

c. Two transition metals involved in electron transport chain ____________________

d. And the second metal ____________________

e. He won a Nobel Prize for his "chemiosmotic theory" ____________________

f. These foldases usually help undesirable aggregation during protein folding ____________________

g. The compound useful in the diagnosis *of Helicobacter pylorii* infections ____________________

h. More than half of the weight of the ribosome is ____________________

i. A chemical mutagen that promotes deamination of cytosine ____________________

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

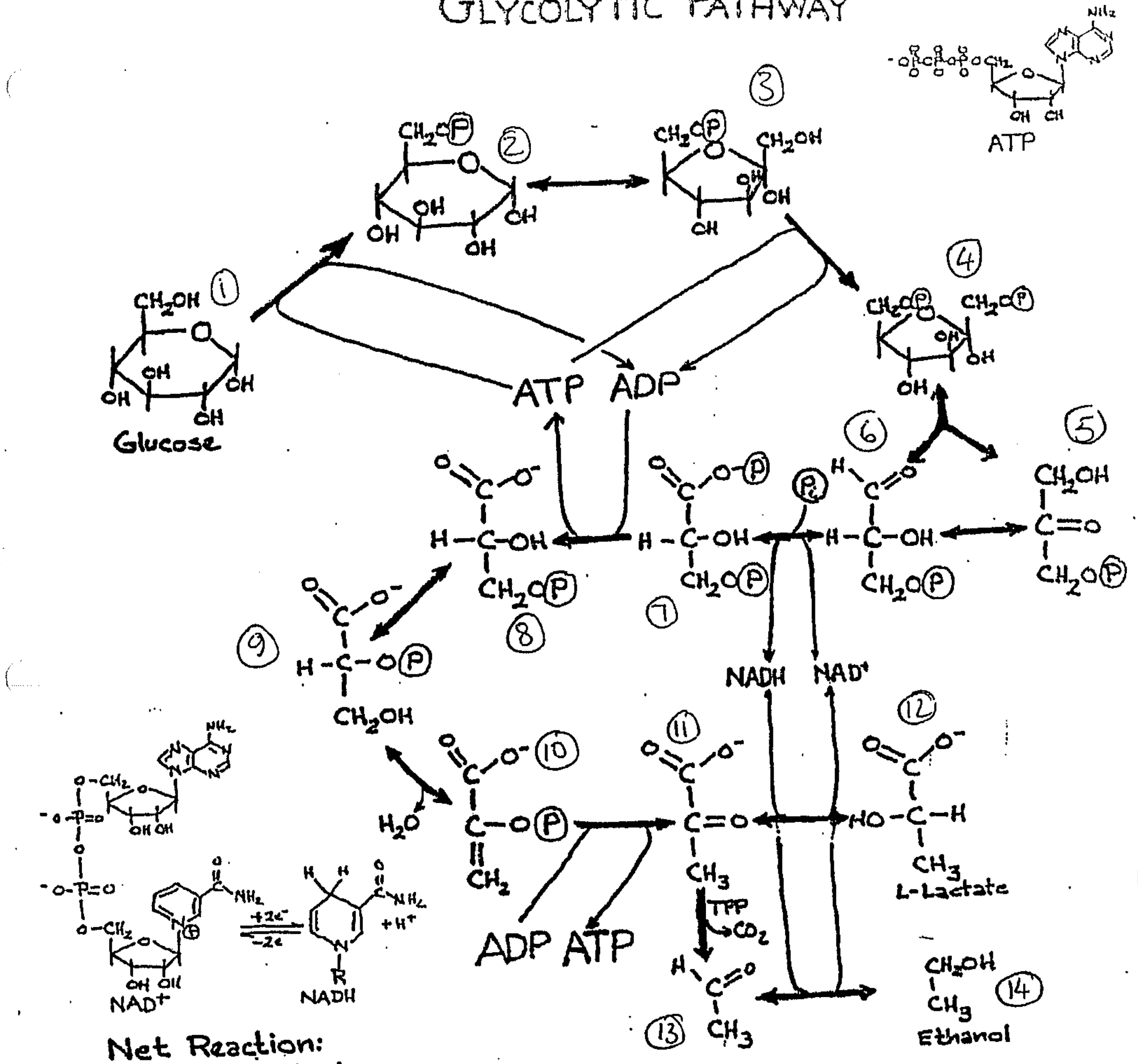
k. These aberrant structures can be repaired by visible light ____________________

l. The word that best describes this exam ____________________

m. The word that best describes this course ____________________

bon voyage

GLYCOLYTIC PATHWAY



Net Reaction:

in vertebrates

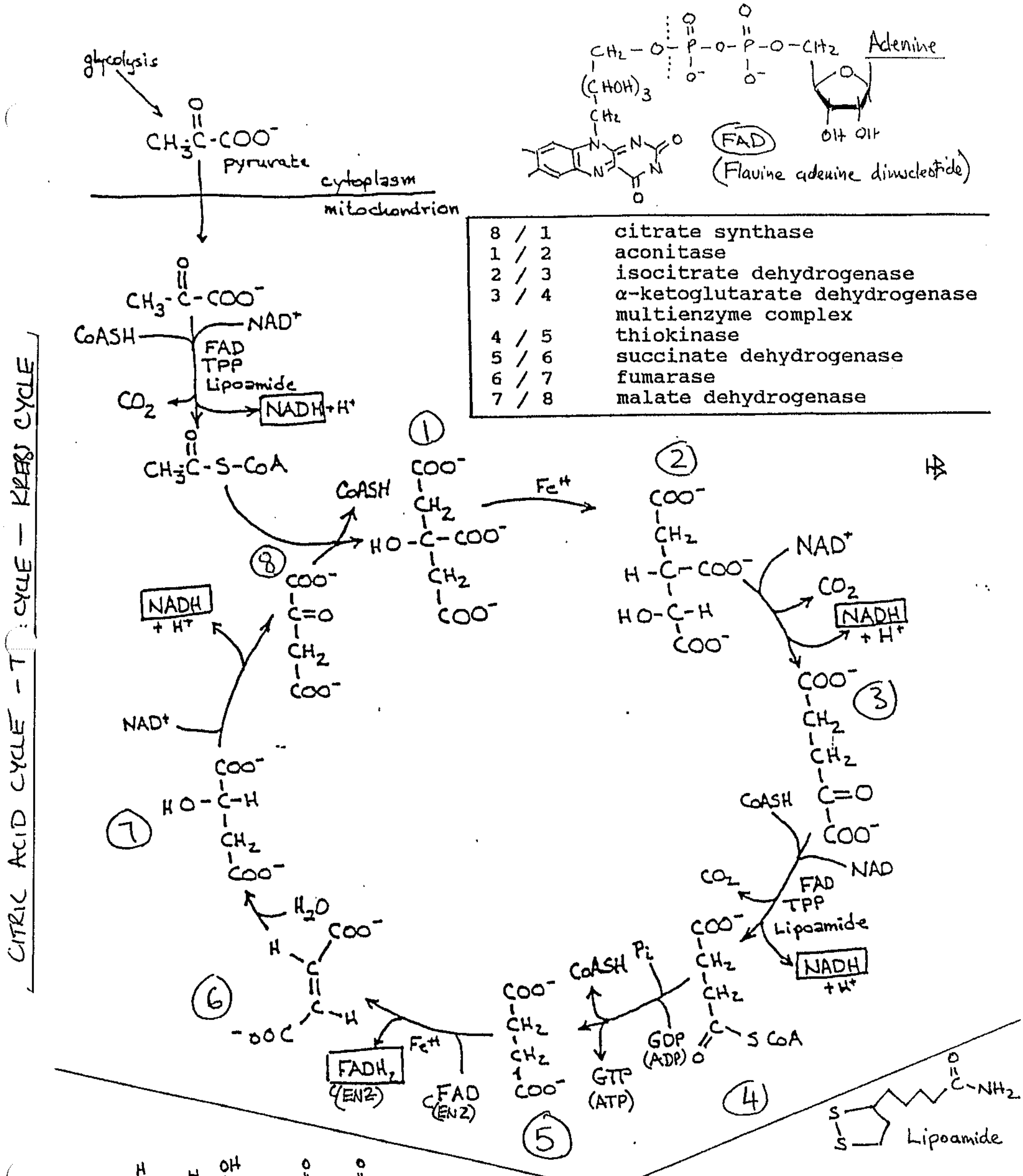
Glucose + $2P_i$ + 2ADP ⟶ 2Lactate + 2ATP

in yeast

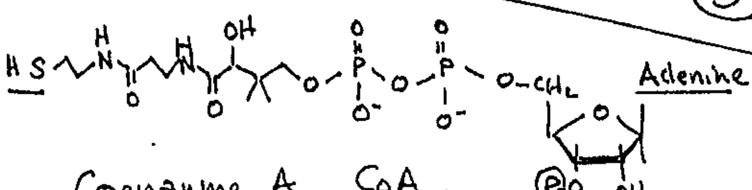
Glucose + $2P_i$ + 2ADP ⟶ $2CO_2$ + 2 Ethanol + 2ATP

1/2	hexokinase
2/3	phosphoglucoisomerase
3/4	phosphofructokinase
4/5+6	aldolase
5/6	triosephosphate isomerase
6/7	glyceraldehyde 3P dehydrogenase
7/8	phosphoglycerate kinase
8/9	phosphoglyceromutase
9/10	enolase
10/11	pyruvate kinase
11/12	lactate dehydrogenase
11/13	pyruvate decarboxylase
13/14	alcohol dehydrogenase

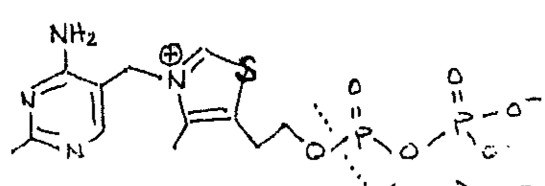
HB



8 / 1		citrate synthase
1 / 2		aconitase
2 / 3		isocitrate dehydrogenase
3 / 4		α-ketoglutarate dehydrogenase multienzyme complex
4 / 5		thiokinase
5 / 6		succinate dehydrogenase
6 / 7		fumarase
7 / 8		malate dehydrogenase



Coenzyme A, CoA.



Thiamine pyrophosphate (TPP)

FATTY ACID OXIDATION

(This handout provided on the test if required)

a. Neutral fat (triglycerides) converted to free fatty acids via lipases.

b. Free fatty acids (R-COOH) enter cell and activated via:

$$R\text{-}COO^- + ATP + CoASH \longrightarrow R\text{-}CO\text{-}SCoA + AMP + P\text{-}P_i$$

[Note this reaction makes AMP and is equivalent to the consumption of 2 ATP molecules if they were converted to ADP]

c. Then the CoA thioester (R-CO-SCoA above) is degraded via the ß-oxidation cycle as shown below. Note each turn releases acetyl-CoA which can enter the TCA cycle. 7 Turns of this pathway releases 8 molecules of acetyl-CoA.

MITOCHONDRIAL FATTY ACID OXIDATION (or ß-oxidation)

E-1 acyl-CoA dehydrogenase

E-2 hydratase

E-3 hydroxyacyl-CoA dehydrogenase

E-4 thiolase