CHEM 527
Final exam, Fall 2004

NAME _____

NOTES:

1. Please stay calm.
2. Where appropriate, show work to receive full credit.
3. This exam contains 10 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.

22

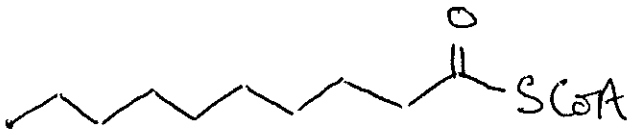
Question 1 (14 pts) Yield of ATP. In the space provided give the yield of ATP (or equivalent e.g. GTP) that would be formed in the following processes:

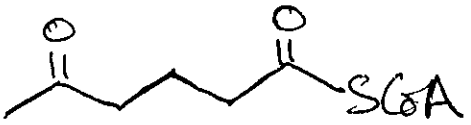
a. per molecule of 1,3-diphosphoglycerate completely oxidized to CO_2 & H_2O _____

b. per citrate in the presence of arsenite _____

c. per molecule of dihydroxyacetone phosphate converted to ethanol _____

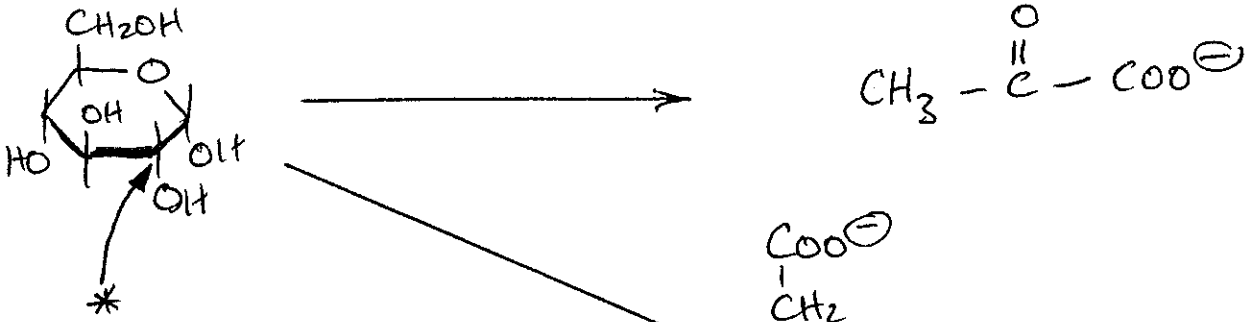
d. per molecule of lactate completely oxidized to CO_2 and water _____

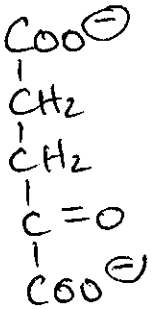
e.. per  to CO_2 and water _____

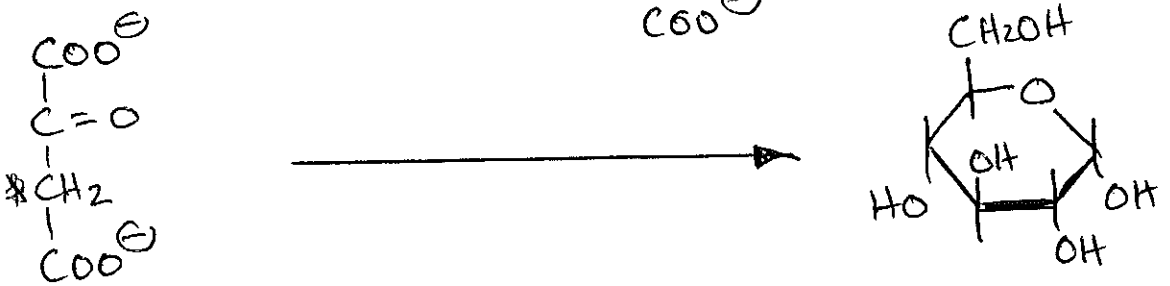
f. per  to CO_2 and water _____

g. per molecule of acetic acid (acetate) oxidized to CO_2 and water _____

Question 2 (6 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".

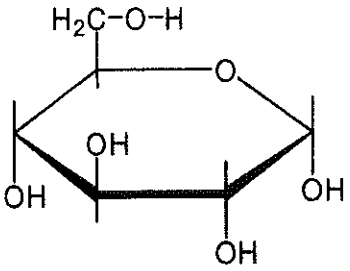
a. 

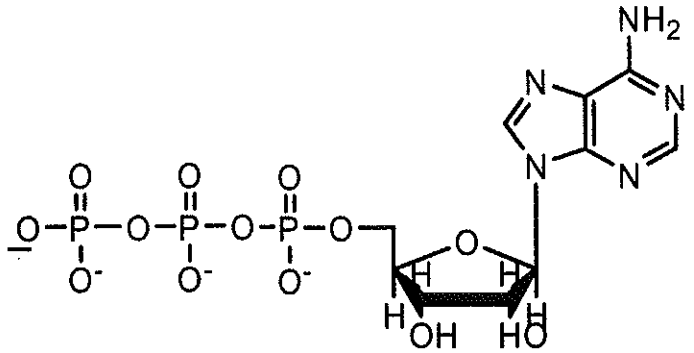
b. 

c. 

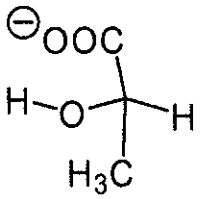
Question 3 (9 pts) Fill in the initial series of curved arrows that start the reactions of the following enzymes. The curved arrows should make chemical sense. Don't draw any more structures. (If you need to deprotonate something, draw the deprotonated group to the side.)

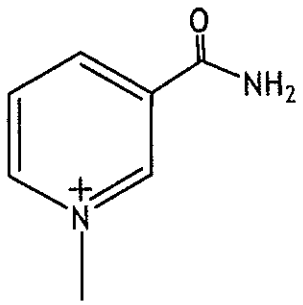
a. hexokinase



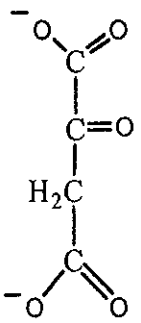


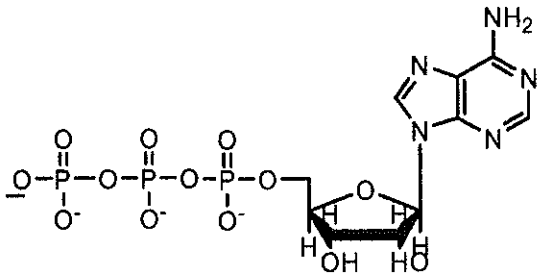
b. lactate dehydrogenase





c. PEP carboxykinase





24

Question 4 (16 pts) Place in the space provided a single number from 0 – 18. Do not put enzyme or substrate product names.

a. Transamination of glutamic acid gives what TCA cycle intermediate _____

b. The synthesis of UDP-glucose from glucose costs the equivalent of how many molecules of ATP _____

c. The complete oxidation of lactate generates how many PAIRS of electrons _____

d. How many phosphorus atoms does one CoA molecule have _____

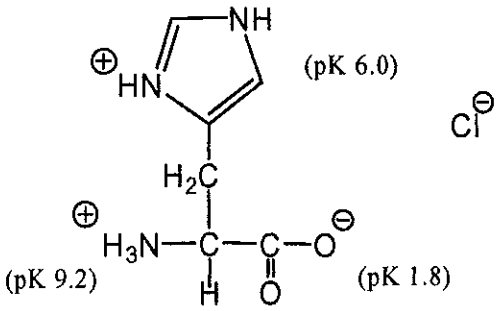
e. This intermediate in the TCA cycle is a substrate for complex II in the electron transport chain _____

f. How many ATPs would you need to make one molecule of glucose from phosphoenolpyruvate _____

g. How many ATPs would you need to make one molecule of glucose from oxaloacetate _____

h. The number of electrons required to reduce one oxygen molecule to water _____

Question 5 (6 pts) The structure of one form of histidine is shown at the right.

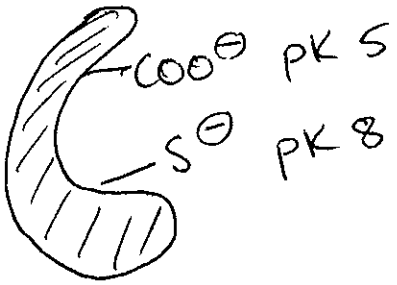


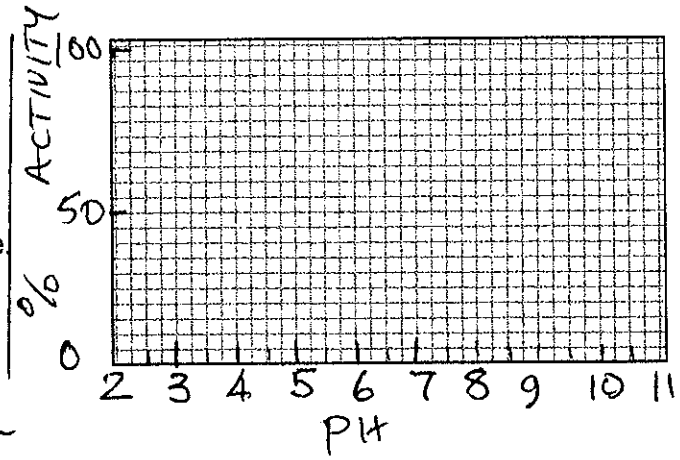
You have 0.7 moles of histidine in the form shown above. How much KOH in moles do you need to take the original 0.7 moles to a pH of:

3.9 _____ 6.0 _____ 9.2 _____

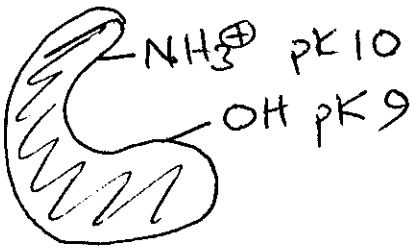
Question 6 (6 pts) Graphs. Draw clear accurate graphs to describe the behavior of the following systems. Clarity and accuracy rewarded.

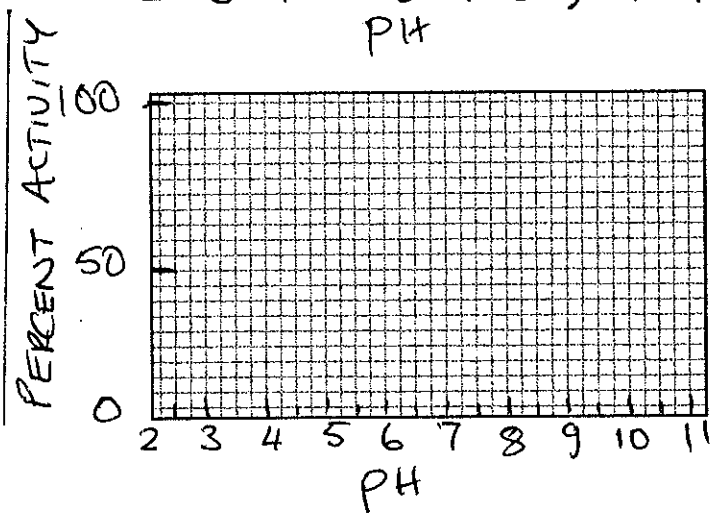
a. only this form of the enzyme show below is active. Show its pH dependence at the right.





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





Question 7 (5 pts.) The following hypothetical enzyme exists as an equilibrium between an active dimer and two inactive monomers. Monomers and dimers have the properties listed below.

DIMER	MONOMER
active	inactive
binds L weakly	binds L tightly
histidine pK = 6	histidine pK = 9

Circle the effect <u>of increasing</u> .... on the ....

a.	L on the enzyme activity	increase	no change	decrease
b.	. pH on the amount of monomer	increase	no change	decrease
c.	protein concentration on enzyme activity	increase	no change	decrease
d.	$[H^+]$ on enzyme activity	increase	no change	decrease
e.	pH on the binding of L	increase	no change	decrease

Question 8 (21 pts). Short problems. Most credit goes for the correct 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 proton concentration?**

_____M

b. **You add 0.22 moles of KOH to 0.8 L of 0.4 M formic acid (pK 3.7). What is the pH of the mixture?**

pH = _____

c. **An enzyme has two disulfide bridges and no free cysteine side chains. After treatment of the protein with 2-mercaptoethanol in 8 M urea, the mercaptoethanol was removed and then disulfide bonds reformed in 8 M urea. The urea was then removed. What percentage of the native activity would you expect?**

_____%

d. **Splittase (15 µg) catalyzes the breakdown of 9 µmol of product formation per minute at room temperature. The molecular weight of the enzyme is 90,000 g/mol, the substrate 580 g/mol and the product 290 g/mol. What is the turnover number of splittase?**

Turnover number _____**/min**

e. **A buffer (pK = 5; 0.6 M) is adjusted to pH 5.2 with a negligible volume of NaOH. 1 L of the resulting solution is diluted with an additional 0.6 L of water. What is the new pH?**

pH_____

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 was found to be 0.019. Calculate the equilibrium constant for the aldolase reaction:**

K_{eq} = _____

i. **How much iron in grams is contained in the average person's hemoglobin. You will need some of the following pieces of information. MW hemoglobin 64,000 g/mol; atomic weight of iron 56 g/mol; number of red cells in human blood 2.5 x 10^{18}; volume of blood 7 L; concentration of hemoglobin in blood 0.16 g/mL**

iron_____g

Question 9 (5 pts). This alpha helical peptide:

TRP-GLU-ALA-ALA-ALA-ARG-GLU-ALA-CYS-CYS-ALA-CYS-CYS-ARG-GLU-CYS-CYS-ALA-ARG-ALA

has been suggested to be an antidote to a poison discussed in class. Poison = _____

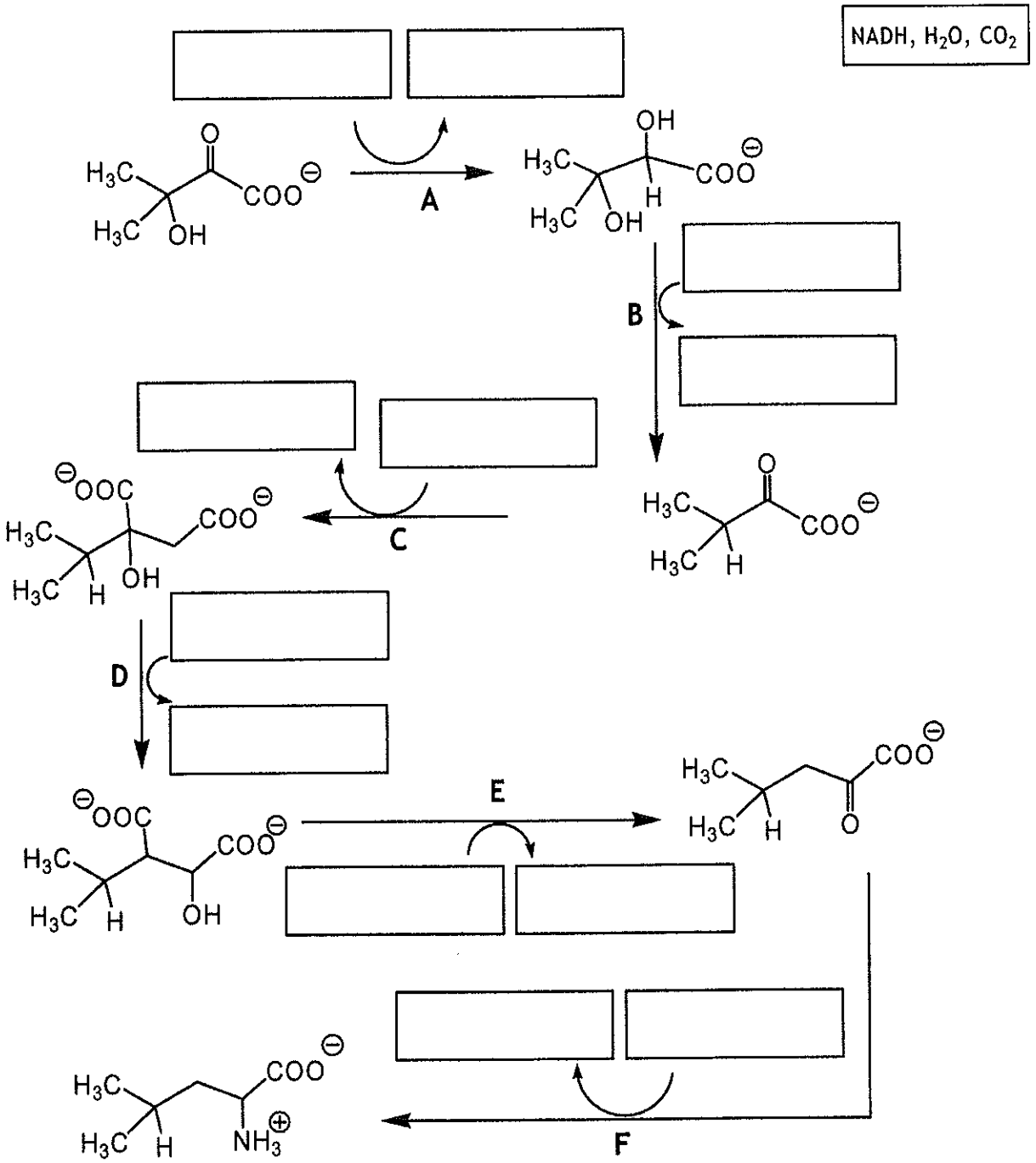
Briefly explain with a diagram how they hoped that the peptide would work:

The antidote was intended to be in "pill" form. Comment

Question 10 (3 pts) Substrate concentrations of 2 and 10 mM for a fixed amount of enzyme give rates of 8 and 39 µmol/min. What is the most appropriate answer?

a. the enzyme is allosteric
b. the enzyme is saturated with substrate
c. both substrate concentrations are well below the Km
d. the enzyme is limited by diffusion
e. all of the above are false.

Question 11 (17 pts) The following is part of the biosynthesis pathway for LEUCINE. Reason by analogy to **clearly indicate in the boxes every substrate and product missing for each reaction A-F. Don't put enzyme names - a hypothetical example for one box is shown at right). If nothing is needed in the box put "NONE".**



What prosthetic group/cofactor would be expected for steps:

D _____ **F** _____

29

Question 12 (6 pts.) In <u>three words or less</u> – what (in terms of mechanism or substrates) do these pairs of enzymes have in common

a. Phosphorylase and glyceraldehyde 3P-dehydrogenase _____

b. Fumarase and enolase _____

c. Phospholipase and chymotrypsin _____

Question 13 (3 pts) Circle a-f to show which compound or combinations of compounds is/are substrate(s) for liver alcohol dehydrogenase:

1= ethanol **2= methanol** **3 = ethylene glycol** **4= D-glucose**

a. 1,2,3,4 **b. 1,2,3** **c. 1,2** **d. 1** **e. 3,4** **f. 2,3**

Question 14 (5 pts) In the following metabolic pathway A-F the enzymes are shown as E1-E5. Two strains of bacteria are identical except that strain 2 has double the amount of E4 compared to strain 1.

$$A \xrightarrow{E1} B \xrightarrow{E2} C \xrightarrow{E3} D \xrightarrow{E4} E \xrightarrow{E5} F$$

a. In strain 2 the rate of formation of F will (circle the appropriate answer)

decrease to 50% of strain 1 remain the same double cannot say

what will happen to the mass action ratio [E]/[D]

increase to 50% of strain 1 remain the same double cannot say

If this is a catabolic pathway - and E1 is an allosteric enzyme
- name a likely allosteric activator of E1 _____

30

Question 15 (12 pts) Fill in the blanks with not more than 3 legible words.

a. reactions that replenish TCA cycle intermediates are called _____

b. This technique rapidly stops metabolism allowing mass mass action ratios to be determined _____

c. Name an enzyme that is involved in thermogenesis in bumble bees _____

d. two transition metals in the electron transport chain _____ and _____

e. he won a Noble prize for his chemiosmotic theory _____

f. A compound useful in the diagnosis of Helicobacter pylori infections _____

g. what protein is at the center of every glycogen granule _____

h. enzyme responsible for activating glucose in glycogen synthesis _____

i. About 2% of sudden infant death is caused by a deficiency in this enzyme _____

j. an amino acid without a chiral center _____

k. every third amino acid in the collagen triple helix must be _____

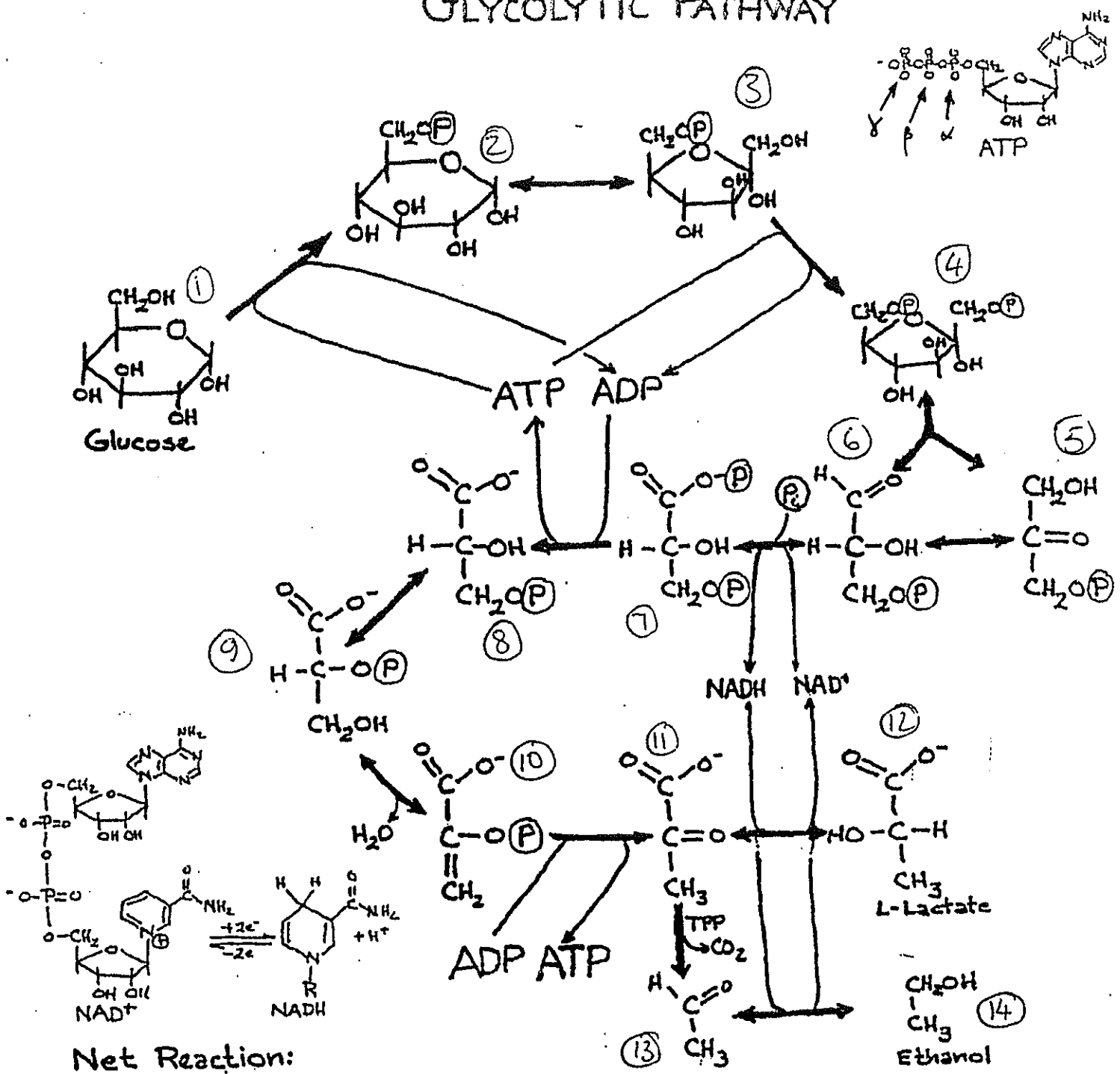
zzz. The word that best describes this exam _____

good luck etc. etc.....

10

51

Glycolytic Pathway



Net Reaction:

in vertebrates

$$\text{Glucose} + 2P_i + 2ADP \longrightarrow 2\,\text{Lactate} + 2ATP$$

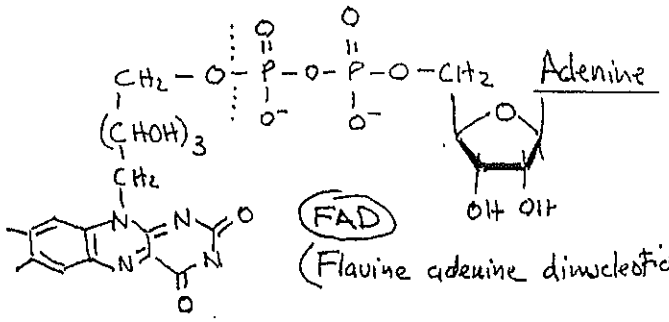
in yeast

$$\text{Glucose} + 2P_i + 2ADP \longrightarrow 2CO_2 + 2\,\text{Ethanol} + 2ATP$$

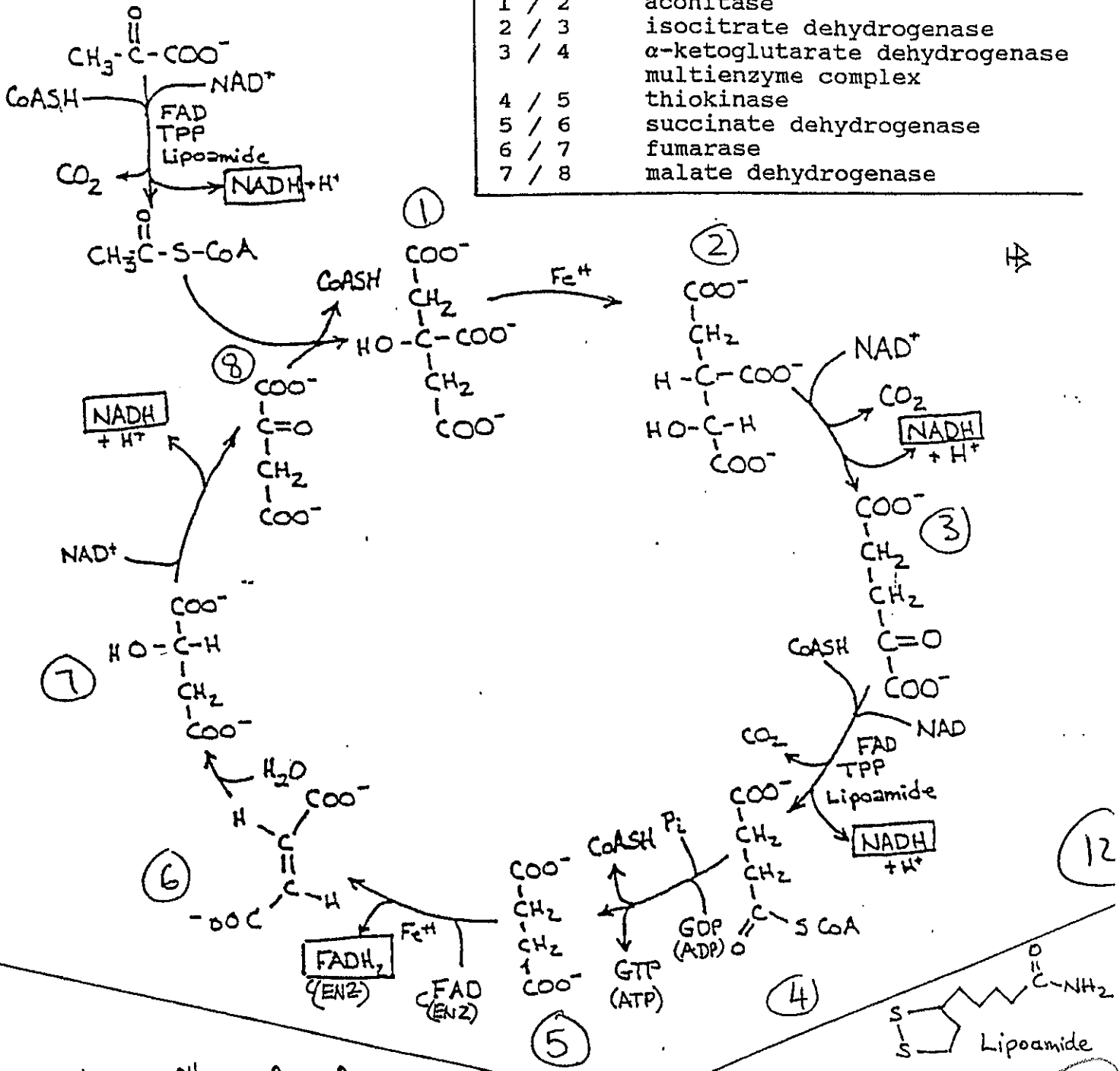
1/2	hexokinase
2/3	phosphoglucoisomerase
3/4	phosphofructokinase
4/5+6	aldolase
5/6	triosephosphate isomerase
6/7	glyceraldehyde 3P dehydrogenase
7/8	phosphoglycerate kinase
8/9	phosphoglyceromutase
9/10	enolase
10/11	pyruvate kinase
11/12	lactate dehydrogenase
11/13	pyruvate decarboxylase
13/14	alcohol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

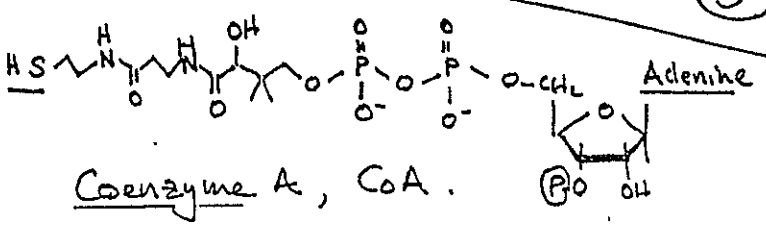
HB

CITRIC ACID CYCLE – TCA CYCLE – KREBS CYCLE

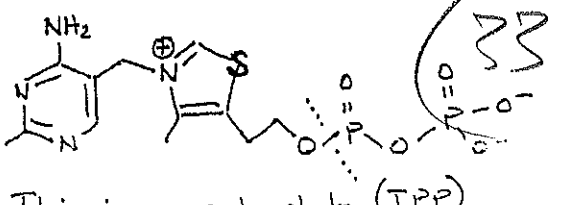


8 / 1	citrate synthase
1 / 2	aconitase
2 / 3	isocitrate dehydrogenase
3 / 4	α-ketoglutarate dehydrogenase multienzyme complex
4 / 5	thiokinase
5 / 6	succinate dehydrogenase
6 / 7	fumarase
7 / 8	malate dehydrogenase





Coenzyme A, CoA.



Thiamine pyrophosphate (TPP)

FATTY ACID OXIDATION

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