NOTES:

1. Where appropriate please show work – if in doubt show it anyway.

2. Pace yourself – you may want to do the easier questions first.

3. Please note the point value of questions – adjust your answers and effort accordingly.

4. Some questions may have more data than you need.

5. Please be brief – focus your answers to the space provided.

6. Please write CLEARLY – if I cannot read it – it is wrong.

7. You are welcome to detach the metabolic chart but please don’t decimate your exam in the process.

8. **Good luck.**
Question 1 (6 pts.). Draw clear accurate graphs to describe the behavior of the following systems. Clarity and accuracy rewarded.

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

\[ \text{NH}_3^+ (\text{pK } 9) \]
\[ \text{SH} (\text{pK } 5.0) \]

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

\[ \text{COO}^- (\text{pK } 6.0) \]
\[ \text{NH}_3^+ (\text{pK } 10.0) \]

Question 2. (15 pts.). Short problems. Show work, but most credit goes to the correct numerical answer.

a. An enzyme has a $V_{\text{max}}$ of 1.2 µmol/min and a rate of 0.12 µmol/min at 0.3 mM substrate. What is the $K_m$ for the substrate \[ K_m = \text{___________} \text{mM} \]

b. In “a” above the molecular weight of the substrate and enzyme were 120 and 28,000 g/mol respectively and the amount of enzyme used was 56 µg. What is the maximal turnover number?

\[ TN = \text{___________}/\text{min} \]
c. A single subunit (monomeric) oxygen binding protein shows a $K_p$ of 5 mm. What is the fractional saturation at 15 mm partial pressure of oxygen?

Fractional saturation


d. To answer this question, you will need some of the following: temperature = 37 °C; the oxygen concentration dissolved in pH 7.4 buffer in equilibrium with air is 0.22 mM; hemoglobin is saturated with oxygen at this concentration.

One liter of solution containing $2 \times 10^{-3}$ mol hemoglobin is gently stirred in air until equilibrium is reached. What is the total concentration of oxygen in the solution?

Total concentration = _____________M

What is the free concentration of oxygen in this hemoglobin solution = _____________M

Question 3 (5 pts.). What is the effect of the following on hemoglobin or myoglobin. Circle the most appropriate answer. NC = no change.

Increasing pH on the oxygen affinity of hemoglobin  

<table>
<thead>
<tr>
<th>Effect</th>
<th>Increase</th>
<th>NC</th>
<th>Decrease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increasing pH on CO$_2$ binding to hemoglobin</td>
<td>increase</td>
<td>NC</td>
<td>decrease</td>
</tr>
<tr>
<td>Decreasing pH on DPG affinity of hemoglobin</td>
<td>increase</td>
<td>NC</td>
<td>decrease</td>
</tr>
<tr>
<td>Increasing DPG levels on CO$_2$ affinity of hemoglobin</td>
<td>increase</td>
<td>NC</td>
<td>decrease</td>
</tr>
<tr>
<td>Increasing DPG levels on O$_2$ affinity of myoglobin</td>
<td>increase</td>
<td>NC</td>
<td>decrease</td>
</tr>
</tbody>
</table>
Question 4 (8 pts.). Given the following calculate ΔG°' for equation 1:

1. C ↔ A
   ΔG°' = ______________ kcal

2. C ↔ B
   ΔG°' = +6 kcal

3. A ↔ B
   ΔG°' = +3 kcal

In equation 1... To make ΔG more negative I would: circle all of the following which will definitely accomplish this:

1. increase the concentration of A
2. decrease the concentration of A
3. increase the concentration of C
4. decrease the concentration of C
5. increase the temperature
6. decrease the temperature
7. lower the pH
8. increase the pH
9. add the enzyme that catalyzes the reaction: C ↔ A
10. Dilute the mixture of C and A with an equal volume of water.

Question 5 (5 pts.). Draw the structure of a chemically-credible reversible inhibitor of an HIV-protease. Circle the functional group that is the key aspect of the anticipated inhibition.

Now explain the key feature of the proposed inhibitor:
Question 6 (8 pts.). Linked equilibria. Suppose that an enzyme is a trimer of identical subunits in equilibrium with monomers. The two substrates of the enzyme X and Y bind 5 times more tightly to the monomer. The trimer is 10-times more active than the monomer. An allosteric molecule binds preferentially to the trimer. Finally dissociation of trimer to monomers releases 3 protons into solution at pH 7.

Circle the most appropriate answer for the following. What is the effect of:

a. Increasing [Y] on extent of monomers
   increase NC decrease

b. Lowering pH to 6.0 on percentage of trimer
   increase NC decrease

c. Raising the concentration of the allosteric molecule on enzyme activity
   increase NC decrease

d. Lowering total enzyme concentration on the percentage of trimer
   increase NC decrease

Questions 7 (8 pts.). For the following two parts. Place the name of the relevant enzyme in the space and draw a curved arrow representation of the reaction it catalyzes.

a. Enzyme name

![Enzyme structure](image1.png)

![Enzyme structure](image2.png)
b. Enzyme name_______________________________

Question 8 (6 pts.). Yield of ATP. In the space provided give the yield of ATP that would be formed in the following processes (enter a number from 0-10):

a. per molecule of dihydroxyacetone phosphate to ethanol _______________

b. per molecule of fructose 6-P converted to lactate _______________

c. per molecule of fructose converted to ethanol _______________

Question 9 (8 pts). Tracing radiolabels and etc. 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. In disaccharide “b” number on the structure the carbon marked with an asterisk

d. In disaccharide “b” name the glycosidic linkage ____________________________
Question 10 (10 pts.). Phospholipase A2 catalyzes the breakdown of molecules like the one shown in the box below by attacking the indicated position. Complete the equation with all other reactants and products of the reaction.

When phospholipase A2 is added to a solution of vesicles (a vesicle is a self-sealed bag of membrane as shown to the right) made up of the substrate shown in the box ... the vesicles remains intact. Explain why only 50% of the substrate is converted to product.

Two lines only:
__________________________________________________________
__________________________________________________________

If you did FRAP experiments before and after phospholipase treatment what would you expect:

Question 11 (4 pts.). The osmotic pressure of 1 mL of a 0.1 M solution of glucose is 2.4 atmospheres (about 36 pound per square inch).

a. Calculate the new osmotic pressure if the same amount of glucose were found in 1 mL of amylose (containing 10,000 glucose units per amylose molecule).

    = ________________ atmospheres

b. Calculate the new osmotic pressure if the same amount of glucose were found in 1 mL of glycogen (again containing 10,000 glucose units per glycogen molecule).

    = ________________ atmospheres
Question 12 (16 pts.). Fill in the blanks with not more than 3 legible words.

a. name an irreversible inhibitor of an enzyme ____________________

b. and the enzyme that is the target of your answer in “a” ____________________

c. these enzymes do not follow Michaelis-Menten kinetics ____________________

d. an example of a biological wax ____________________

e. the water-soluble vitamin incorporated into NAD+ is called ____________________

f. accumulation of a solute across a biological membrane is called ____________________

g. a negative allosteric regulator of glycolysis ____________________

h. this process ultimately limits the catalytic efficiency of enzymes ____________________

i. a major regulatory enzyme in glycolysis ____________________

j. the monosaccharides D-glucose and D-galactose are ___ of one another ____________________

k. name a ketotriose ____________________

l. a metal frequently associated with kinases ____________________

m. a non-saponifiable lipid found in mammalian cell membranes ____________________

n. a hormone that indirectly activate phosphoryase ____________________

z. how many times have you been taught “glycolysis” ____________________

zz. the word that best describes this exam ____________________