Chemistry 240A
Prof. B. Hanson
Spring 2018

Name: KEY

Exam #2

1.	_____	10 pts
2.	_____	20 pts
3.	_____	10 pts
4.	_____	30 pts
5.	_____	10 pts
6.	_____	10 pts
7.	_____	10 pts
		100 pts

"If you know a thing only qualitatively, you know it no more than vaguely. If you know it quantitatively grasping some numerical measure that distinguishes from an infinite number of other possibilities you are beginning to know it deeply. You comprehend some of its beauty and you gain access to its power and the understanding it provides. Being afraid of quantification is tantamount to limiting yourself, giving up on one of the most potent prospects for understanding and changing the world."

Carl Sagan
Billion and Billions 1997

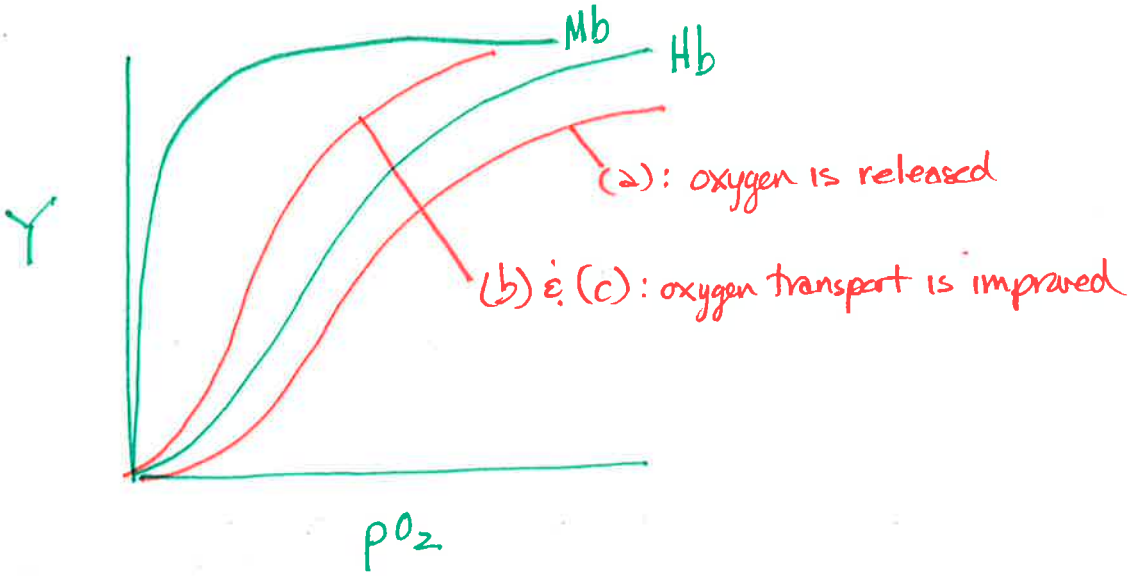
1. (10 points). Draw the structure of met-ala-lys-gly-arg at physiological pH.

2. (20 points) Carefully sketch and fully label an oxygen binding curve which shows the behavior of myoglobin and hemoglobin under typical conditions. Then add and label curves describing the binding curve for hemoglobin in the following situations. Make your diagram large enough so that there is space to see the different curves and labels.

   (a) The pH goes down due to exercise.

   (b) Due to a metabolic disorder, the enzyme synthesizing 2,3-BPG functions poorly.

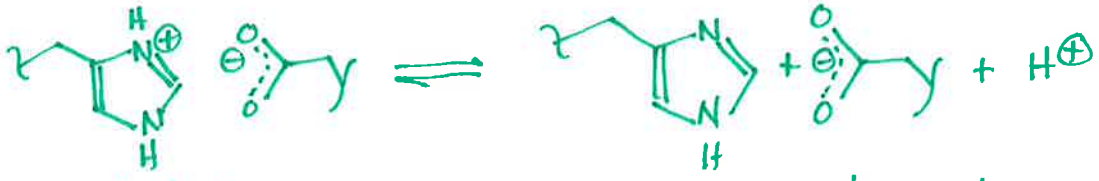
   (c) Due to school stress, you have regressed to a fetal state, so you have fetal Hb.



3. (10 points). The **T** $\rightleftharpoons$ **R** transition in hemoglobin is strongly affected by pH. Let's write this as $Hb_T \rightleftharpoons Hb_R$.

   (a) Rewrite this equilibrium as a balanced reaction which includes O_2. Leave room underneath your equation for the next answer.

$$Hb_T + 4O_2 \rightleftharpoons Hb_R(O_2)_4$$



salt bridge stabilizing Hb_T

salt bridge broken by rising pH (aids in shift to Hb_R)

   (b) The **T** state is stabilized by salt bridges. Underneath the structures in the equation above, draw an example of a salt bridge in a state appropriate to each species. Make sure that your drawings take into account the role of pH in this system, and that the reaction is balanced (so, H^+ is either a reactant or product). Put another way, I want you to illustrate how the salt bridge changes as Hb responds to pH.

4. (30 points). Provide **concise** answers to the following. No rambling! If you go on too long, I won't grade it.

(a) What is the name of the multi-ring organic molecule that coordinates iron in Mb and Hb?

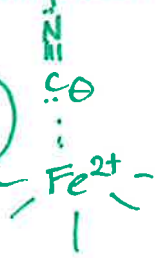
porphyrin (heme is the name once Fe is coordinated)

(b) When comparing Hb sequences among organisms, certain amino acid residues are strongly conserved. Why? Give one example.

This is evidence that the residue is absolutely essential to proper function. proximal his

(c) Humans die when cyanide (NC^-) is ingested. There are several reasons for this, but one is that cyanide binds to Hb. Why does NC^- bind well to Hb? Illustrate if possible.

It is a good ligand (via the C end) for Fe^{2+} & thus competes w/ O_2 binding



(d) Define allostery.

Binding at one site induces changes in binding at a distant site

(e) What information is sought in a Hill Plot?

The coefficient (slope) which measures cooperativity.

(f) What is the difference between k and K?

rate constant* ↖ equilibrium constant‡

(g) Define K_m from two perspectives.

K_m represents the affinity of a substrate/ligand for the protein; it is also the [S] needed for V_2 V_{max}

(h) What is k_{cat}/K_m?

specificity constant or catalytic perfection (preferred)

(i) What are the two components of ΔG?

ΔH (ethalpy) ΔS (entropy)

(j) What is the difference between ΔG and $\Delta G^{\ddagger}$?

free energy change‡ ↖ activation energy*

(k) What is the conceptual difference between K_m and P_{50}?

Nothing! They both represent an amount needed to get 50% of an effect.

5. (10 points). **Concisely** answer the following questions about aspects of an SDS-PAGE experiment.

(a) The reaction mixture contains urea. Why?

Urea is a chaotropic agent which disrupts hydrogen bonds very effectively

(b) The reaction mixture contains β-mercaptoethanol. Why?

BME reduces disulfide bridges to 2 x -SH

(c) The reaction mixture contains SDS (sodium dodecyl sulfate). Why?

SDS is a detergent which solubilizes non-polar side chains.

(d) The protein sample to be analyzed is heated to 95°. Why?

Heat is kinetic energy which disrupts intermolecular forces generally.

(e) The reaction mixture is buffered. Why?

To control the pH, which in turn controls the charges on various species.

* these terms are from the field of Kinetics

‡ these terms are from thermodynamics

6. (10 points). Plants in the mint family (Lamiaceae) have an enzyme called humulene synthase (let's call it HS). HS converts farnesyl pyrophosphate (FPP) into humulene. Shown below are data for wild-type (normal) HS and a mutant form.[1]

protein	k_{cat} s^{-1}	K_m μM	k_{cat}/K_m $M^{-1}s^{-1}$
wild-type	2.36×10^{-2}	4.66	5.07×10^{3}
mutant	1.81×10^{-3}	2.08	8.70×10^{2}

(a) Which enzyme binds FPP more tightly? How do you know?

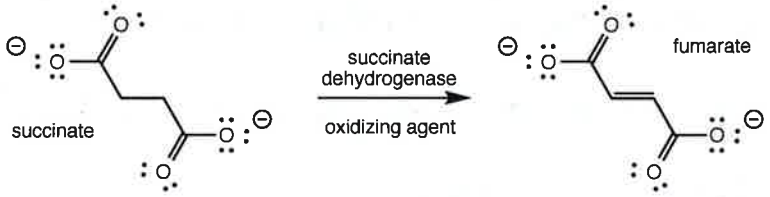
mutant, because K_m is smaller

(b) Which enzyme has a higher V_{max} assuming the same [E]? How do you know?

wild-type, because k_{cat} is larger ($k_{cat} = \frac{V_{max}}{[E]}$)

k_{cat}/K_m is larger for WT, which is another way to look at it.

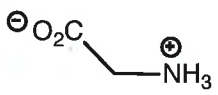
7. (10 points). One of the reactions in the Krebs cycle (tricarboxylic acid cycle) is the conversion of succinate to fumarate:



(a) Based upon the structures involved, postulate what kinds of amino acids might be present at the active site. Either give specific amino acids by name, or, give a very short descriptive phrase.

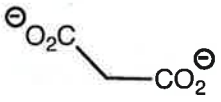
positively charged AAs should be present to interact w/ the negatively charged carboxylate grps (arg, lys, his)

(b) Three inhibitors are shown below. Inhibitors mimic the substrate, but won't undergo reaction for some reason. Rank these inhibitors, assigning 1 to the best inhibitor.



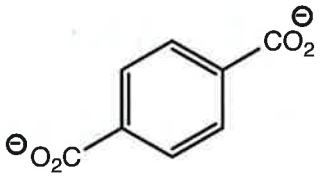
2 or 3

the negatively charged end can fit in the active site but the (-) -ive end should be repelled.



1

should bind well



2 or 3

too big to fit, perhaps only one end can fit in the active site

[1] Yoshikuni *et. al.* doi:10.1038/nature04607