Quiz 3 Review Guide

Major Topics:

- Denaturation of Proteins
- Common Diseases of Misfolding / Aggregation: Alzheimer's Disease, Cystic Fibrosis, Sickle Cell Anemia
- Protein Binding: Lock-and-Key and Induced Fit Models
- Protein Binding: Key Equation and Interpreting Graphs
- Myoglobin and Hemoglobin: Binding, Allostery, and Cooperativity
- Bioenergetics: physical meaning of enthalpy and entropy, key equations, calculations
- Enzyme Kinetics: reaction rates and catalysis, transition state binding theory, Michaelis-Menten

Book Sections to pay particular attention to:

- Chapter 6.5 (pg. 166-170), Chapter 6A (pg. 183-187), and Chapter 4B (pg. 104-107)
- Chapter 7.8 – 7.11 (pg. 200-214)
- Chapter 3.1 – 3.4 (pg. 50-64)
- Chapter 8.1 – 8.4 (pg. 266-273) and Chapter 8.6 (pg. 281-286)

Particularly important Sapling Questions:

- HW 6: Proteins 3D Structure: Questions 1, 5, 6, 11, 12, 14, 15
- HW 7: Proteins Function Evolution: Questions 2, 3, 5, 6, 7, 9
- HW 3: Thermodynamics: Questions 2, 4, 5, 7, 9, 11
- HW 8: Enzymes: Questions 1 – 4, 6, 7, 8

Review questions:

1. If the free energy change ΔG for a reaction is -46.11 kJ/mol, the reaction is:

A. at equilibrium
B. endergonic
C. endothermic
D. exergonic
E. exothermic

2. In the binding of oxygen to myoglobin, the relationship between the concentration of oxygen and the fraction of binding sites occupied can best be described as:

A. hyperbolic
B. linear with a negative slope
C. linear with a positive slope
D. random
E. sigmoidal

3. The role of an enzyme in an enzyme-catalyzed reaction is to:

A. bind a transition state intermediate, such that it cannot be converted back to substrate
B. ensure that all of the substrate is converted to product
C. ensure that the product is more stable than the substrate
D. increase the rate at which substrate is converted into product
E. make the free-energy change for the reaction more favorable

4. If the $\Delta G'^{\circ}$ of the reaction A ←→ B is –40 kJ/mol, under standard conditions the reaction:
A. is at equilibrium
B. will never reach equilibrium
C. will not occur spontaneously
D. will proceed at a rapid rate
E. will proceed spontaneously from left to right

5. The interactions of ligands with proteins:
A. are relatively nonspecific.
B. are relatively rare in biological systems.
C. are usually irreversible.
D. are usually transient.
E. usually result in the inactivation of the proteins.

6. When a mixture of glucose 6-phosphate and fructose 6-phosphate is incubated with the enzyme phosphohexose isomerase (which catalyzes the interconversion of these two compounds) until equilibrium is reached, the final mixture contains twice as much glucose 6-phosphate as fructose 6-phosphate. Which one of the following statements is best applied to this reaction outlined below?

Glucose 6-phosphate ←→ fructose 6-phosphate

A. □$\Delta G'^{\circ}$ is incalculably large and negative
B. □$\Delta G'^{\circ}$ is –1.72 kJ/mol
C. □$\Delta G'^{\circ}$ is zero
D. □$\Delta G'^{\circ}$ is +1.72 kJ/mol
E. □$\Delta G'^{\circ}$ is incalculably large and positive

7. In glycolysis, fructose 1,6-bisphosphate is converted to two products with a standard free-energy change ($\Delta G'^{\circ}$) of 23.8 kJ/mol. Under what conditions encountered in a normal cell will the free-energy change (ΔG) be negative, enabling the reaction to proceed spontaneously to the right?
A. Under standard conditions, enough energy is released to drive the reaction to the right
B. The reaction will not go to the right spontaneously under any conditions because the□$\Delta G'^{\circ}$ is positive
C. The reaction will proceed spontaneously to the right if there is a high concentration of products relative to the concentration of fructose 1,6-bisphosphate
D. The reaction will proceed spontaneously to the right if there is a high concentration of fructose 1,6-bisphosphate relative to the concentration of products
E. None of the above conditions is sufficient

8. Which one of the following statements is true of enzyme catalysts?
A. They bind to substrates, but are never covalently attached to substrate or product
B. They increase the equilibrium constant for a reaction, thus favoring product formation
C. They increase the stability of the product of a desired reaction by allowing ionizations, resonance, and isomerizations not normally available to substrates
D. They lower the activation energy for the conversion of substrate to product
E. To be effective they must be present at the same concentration as their substrates

9. The benefit of measuring the initial rate of a reaction V_0 is that at the beginning of a reaction:
A. [ES] can be measured accurately
B. changes in [S] are negligible, so [S] can be treated as a constant
C. changes in Km are negligible, so Km can be treated as a constant
D. V_0 = Vmax
E. varying [S] has no effect on V_0

10. The amino acid substitution of Val for Glu in Hemoglobin in sickle cell anemia (Hemoglobin S) results in aggregation of the protein because of _____ interactions between molecules.

A. covalent
B. disulfide
C. hydrogen bonding
D. hydrophobic
E. ionic

11. An allosteric interaction between a ligand and a protein is one in which:

A. binding of a molecule to a binding site affects binding of additional molecules to the same site.
B. binding of a molecule to a binding site affects binding properties of another site on the protein.
C. binding of the ligand to the protein is covalent.
D. multiple molecules of the same ligand can bind to the same binding site.
E. two different ligands can bind to the same binding site.

12. Carbon monoxide (CO) is toxic to humans because:

A. it binds to myoglobin and causes it to denature.
B. it is rapidly converted to toxic CO_2.
C. it binds to the globin portion of hemoglobin and prevents the binding of O_2.
D. it binds to the Fe in hemoglobin and prevents the binding of O_2.
E. it binds to the heme portion of hemoglobin and causes heme to unbind from hemoglobin.

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13. How does 2,3-BPG binding to hemoglobin decrease its affinity for oxygen?

14. For an enzyme called "Testase" that catalyzes the reaction A → B, explain the following:

(I) When [Testase] is at 1 mM, the Vmax is found to be 0.5 mM/s. What is the kcat for this enzyme?

(II) When [A] is present at 200 uM, the rate of the reaction (V_0) is found to be 0.1 mM/s. Given that information, what is the Km of this enzyme?

15. Sketch a Lineweaver-Burke graph of typical enzyme reaction, and illustrate what the presence of an uncompetitive inhibitor would likely do as a dotted line.

16. In cystic fibrosis, what cellular process is disrupted?

17. Given available stock solutions of 0.5 M Tris buffer, pH 7.10 (pKa 8), 4 M HCl, 4 M NaOH, and water, how would you prepare a 800 mL solution of 0.2 M Tris buffer, pH 7.4?

18. In your own words, why is life an unfavorable process in terms of entropy?

19. For a protein that binds to free fatty acids in the bloodstream (such as CH_3-CH_2-CH_2-CH_2-CH_2-CH_2-CH_2-COO^-), list three R-groups that you might expect to be involved in the binding interaction.

20. In your own words, explain the difference between ΔG °' and ΔG.

21. The reaction A + B → C has a $\Delta G'°$ of +13 kJ/mol. What is the K_{eq}' for this reaction, and does it favor products or reactants? Show your work.

22. Draw an example structure that is a good electrophile, and put a star beside the electrophilic atom. Draw an example structure that is a good nucleophile, and put a # beside the nucleophilic atom.

23. The reaction A → B has a Keq of 200. Which is more favorable, A or B? Estimate the $\Delta G'°$ for the reaction.

24. Enzymes are very potent catalysts. In terms of Gibbs free energy, what do enzymes do to the reactions they catalyze?

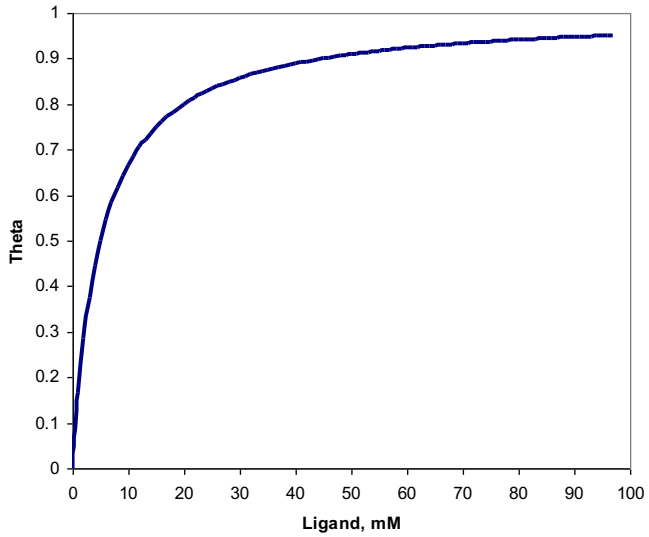
25. Explain what is wrong with this statement: "For the reaction S → P, a catalyst shifts the reaction equilibrium to the right."

26. How does life on Earth thrive despite the 2nd law of thermodynamics?

27. Give a working definition of Enthalpy useful for biochemistry.

28. Describe what, in general, is happening during the binding event of an induced fit mechanism.

29. Estimate the affinity of this protein-ligand interaction:



30. For a given binding reaction, if θ is equal to 0.25, and the K_d for the reaction is $1x10^{-4}$ M, what is the concentration of ligand? Show your work.

31. Describe the difference between a concerted and sequential cooperative mechanism.

32. Given the following data for an enzyme-catalyzed reaction known to follow Michaelis-Menten kinetics, estimate the Km and Vmax. Show how you could use a lineweaver-burke plot to determine these constants.

V_0 (μmol/min)	Substrate added (mmol/L)
217	0.8
325	2
433	4
488	6
647	1,000

33. On a double-reciprocal plot, the Km is derived from which axis intercept?

34. In a plot of 1/V versus 1/S, what will the presence of a competitive inhibitor alter on the graph?

35. How does the total enzyme concentration affect turnover number (kcat) and Vmax?