

Biochemistry 5700

Fall, 2003

Final Exam

December 10, 2003

INSTRUCTIONS:

Do not begin until 7:30 AM. The exam must be turned in by 9:20 AM. This exam contains two sections: the “new material” section and the “comprehensive” section. Answer the “new material” questions in the spaces provided. Answer the “comprehensive” questions by marking on the scantron sheet using a #2 pencil. Turn in both the scantron and the entire exam when you are finished. Good Luck!!

Equations: $\Delta G' = \Delta G^\circ + RT \ln Q$ $\Delta E' = \Delta E^\circ - \frac{RT}{nF} \ln Q$ $\Delta G' = -nFE'$

$$\text{pH} = \text{pK}_a + \log \frac{[\text{A}^-]}{[\text{HA}]}$$

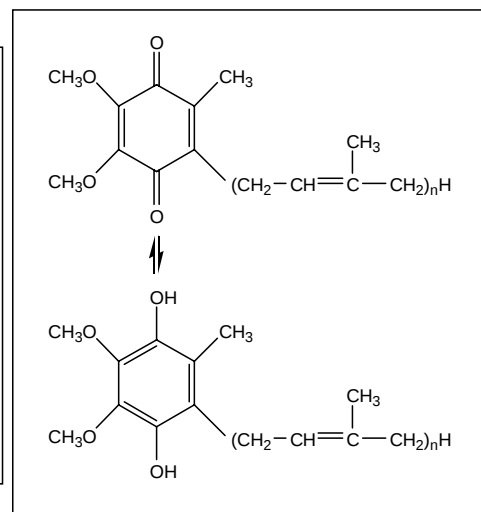
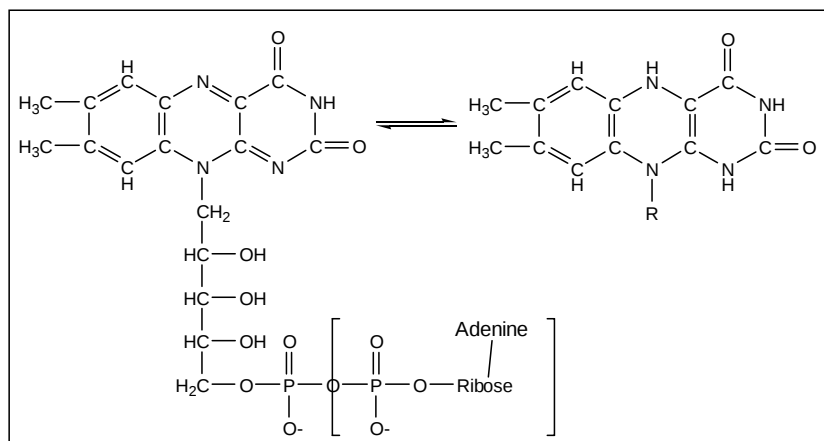
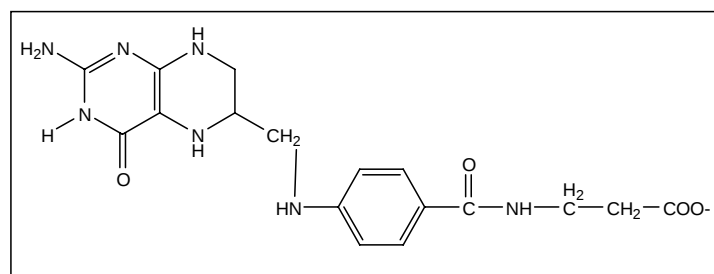
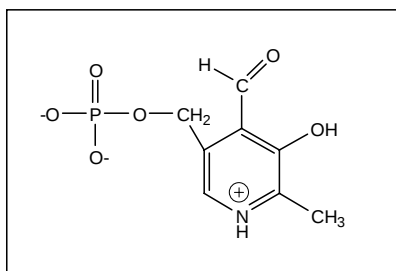
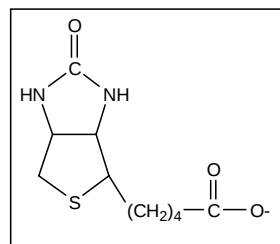
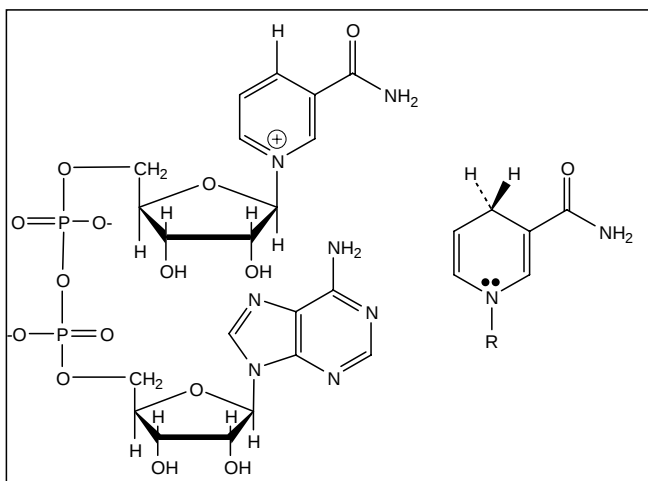
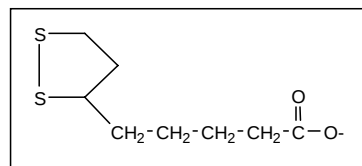
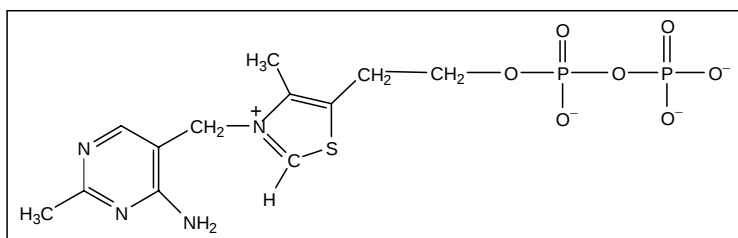
Constants: $F = 96.5 \text{ kJ/V} \cdot \text{mol}$ $R = 8.3144 \text{ J/mol} \cdot \text{K}$

table 5-1

Properties and Conventions Associated with the Standard Amino Acids						
Amino acid	Abbreviated names		M_r	pK_a values		
				pK_1 ($-\text{COOH}$)	pK_2 ($-\text{NH}_3^+$)	pK_R (R group)
Nonpolar, aliphatic R groups						
Glycine	Gly	G	75	2.34	9.60	
Alanine	Ala	A	89	2.34	9.69	
Valine	Val	V	117	2.32	9.62	
Leucine	Leu	L	131	2.36	9.60	
Isoleucine	Ile	I	131	2.36	9.68	
Methionine	Met	M	149	2.28	9.21	
Aromatic R groups						
Phenylalanine	Phe	F	165	1.83	9.13	
Tyrosine	Tyr	Y	181	2.20	9.11	10.07
Tryptophan	Trp	W	204	2.38	9.39	
Polar, uncharged R groups						
Serine	Ser	S	105	2.21	9.15	
Proline	Pro	P	115	1.99	10.96	
Threonine	Thr	T	119	2.11	9.62	
Cysteine	Cys	C	121	1.96	10.28	8.18
Asparagine	Asn	N	132	2.02	8.80	
Glutamine	Gln	Q	146	2.17	9.13	
Positively charged R groups						
Lysine	Lys	K	146	2.18	8.95	10.53
Histidine	His	H	155	1.82	9.17	6.00
Arginine	Arg	R	174	2.17	9.04	12.48
Negatively charged R groups						
Aspartate	Asp	D	133	1.88	9.60	3.65
Glutamate	Glu	E	147	2.19	9.67	4.25

*A scale combining hydrophobicity and hydrophilicity of R groups; it can be used to measure the tendency of an amino acid to seek an aqueous environment (− values) or a hydrophobic environment (+ values). See Chapter 12. From Kyte, J. & Doolittle, R.F. (1982) *J. Mol. Biol.* **157**, 105–132.

¹Average occurrence in over 1150 proteins. From Doolittle, R.F. (1989) Redundancies in protein sequences. In *Prediction of Protein Structure and the Principles of Protein Conformation* (Fasman, G.D., ed) Plenum Press, NY, pp. 599–623.



(1) (8 points) Write the net reactions catalyzed by each of the four electron transfer chain complexes (comp. I-IV). (Please balance protons in the reactions.)

(2) (10 points) Write the balanced chemical equations (NO MECHANISMS) and name the enzymes used for each of the following reactions of amino acid catabolism:

(a) glutamine hydrolysis

(b) glutamine synthesis from glutamate

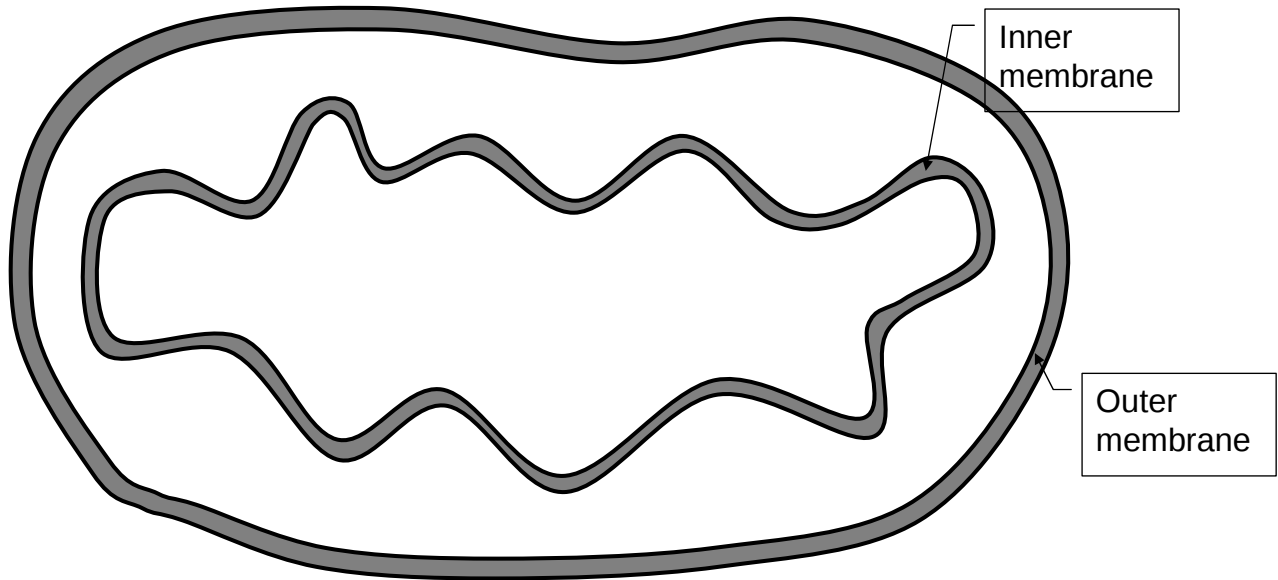
(c) glutamate oxidation using NAD^+ as electron acceptor

(d) transamination of pyruvate and glutamate

(e) carbamoyl phosphate synthesis

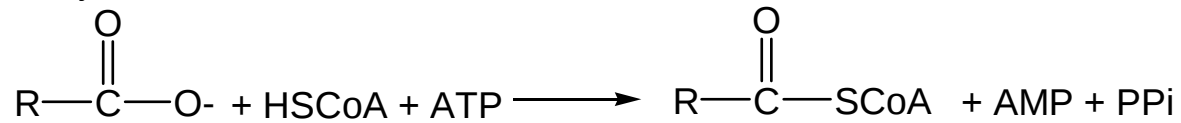
(3) (7 points) Using the indicated letters and arrows, label the mitochondrion shown below to indicate the specific area or portion of the mitochondrion where the following events take place.

- (a) portion of mitochondrion where protons are pumped during electron transfer
- (b) site/location of O_2 reduction
- (c) site/location of NADH oxidation
- (d) location of water soluble cytochrome c
- (e) location of ubiquinone
- (f) site/location of ATP synthesis
- (g) location of citric acid cycle enzymes except succinate dehydrogenase



(4) (6 points) The further oxidation of the NADH produced during glycolysis provides energy for ATP synthesis. Explain why the yield of ATP from glycolytically-produced ATP is 2ATP/NADH in muscle yet 3ATP/NADH in the liver.

(5) (10 points) Fatty acyl-CoA synthetase catalyzes the following reaction, which proceeds through an acyl-AMP intermediate:



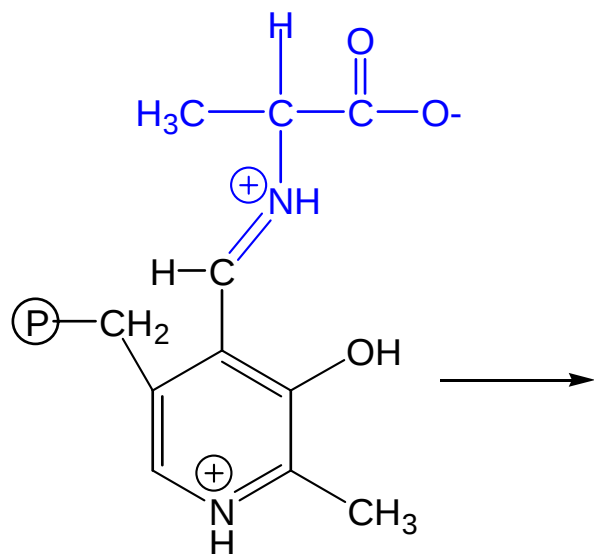
- (a) (7 pts) Diagram the complete catalytic mechanism for this reaction.
- (b) (3 pts) Rather than occurring as shown, this reaction might be expected to proceed through an acyl-phosphate intermediate, producing ADP and Pi as products. Explain in thermodynamic terms why AMP and PPi are formed instead.

(6) 14 points.

(a) (6 points) Draw the structures and name the three compounds collectively referred to as “ketone bodies.”

(b) (8 points) What is the purpose of ketone body formation and breakdown in mammals? In answering your question, explain where ketone bodies are produced, where they are ultimately metabolized, and how they get from the site of production to the site of consumption.

(7) (10 points) Starting with the alanine-PLP adduct shown below, diagram the necessary mechanistic steps required to convert this intermediate to pyridoxamine and pyruvate. Show all intermediates, important resonance structures, and general acids/bases in the mechanism.



(8) (10 points) You have just eaten a big juicy, fatty hamburger. Explain (feel free to diagram) how the portion of the hamburger that is fat eventually arrives in your muscle cell (i.e., what is the biochemical/molecular path from intestine to muscle?

COMPREHENSIVE SECTION 3 points per problem. Mark answers on scantron.

(1) You have an aqueous 0.10 M solution of the amino acid histidine at pH 6.4. Determine the concentration of the protonated form of histidine in this solution.

- (a) 0.028 M
- (b) 0.040 M
- (c) 0.060 M
- (d) 0.072 M
- (e) 0.090 M

(2) Given the information on page 1, what is the pI for the amino acid arginine?

- (a) 5.60
- (b) 7.32
- (c) 7.90
- (d) 10.8
- (e) 12.5

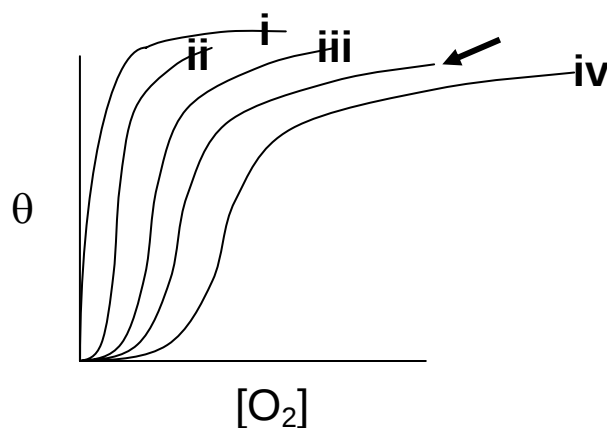
(3) During the purification of a protein, you start with a crude extract (lysate) containing 80,000 units of enzyme activity and 3000 mg of protein. Your final purified enzyme preparation contains 5,000 units of activity and 1.2 mg of protein. What is the fold-purification of your purified enzyme?

- (a) 0.0625
- (b) 16
- (c) 156
- (d) 2500
- (e) 4167

(4) Referring to question (3), given that your protein is a monomer with a turnover number of 2000 s^{-1} , what is the molecular weight of your protein?

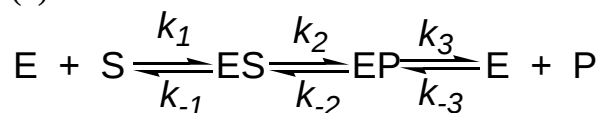
- (a) 28,800
- (b) 34,700
- (c) 125,000
- (d) 1,730,000
- (e) 8,330,000

(5) Given that the line indicated by the arrow corresponds to the normal hemoglobin O_2 dissociation curve at pH 7.6, which line(s) might represent the result of decreasing the pH to 7.0?



- (a) line (i) only
- (b) either line (i), (ii), or (iii)
- (c) either line (ii) or (iii) only
- (d) line (iv) only

(6) For the kinetic mechanism shown below:



If you were to draw the reaction coordinate diagram for this enzyme-catalyzed reaction, how many peaks would be present between S and P?

- (a) 1
- (b) 2
- (c) 3
- (d) 4

(7) Rotation about the bond between which two atoms in a polypeptide chain defines the bond angle phi?

- (a) R- C_α
- (b) N-C_α
- (c) C_(carbonyl)-C_α
- (d) C_(carbonyl)-N

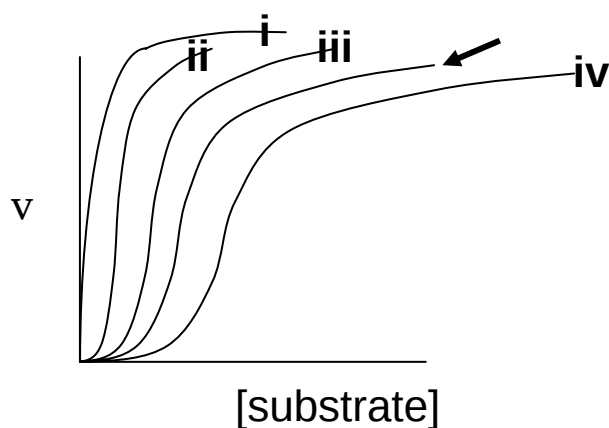
(8) Which amino acid would be most likely to form a salt bridge with Asp at pH 7?

- (a) Arg
- (b) Cys
- (c) Glu
- (d) Pro

(9) What type of motif is most likely to allow two adjacent alpha helices to be largely parallel (not anti-parallel) to each other?

- (a) globin fold
- (b) alpha-beta barrel
- (c) helix-turn-helix
- (d) beta bend

(10) Given that the line indicated by the arrow is the v vs. S plot for an allosteric enzyme, which line(s) might represent the result of adding a positive heterotropic modulator to the enzyme?



- (a) line (i) only
- (b) either line (ii), (iii), or (iv)
- (c) either line (ii) or (iii) only
- (d) line (iv) only
- (e) either line (i) or (ii) only

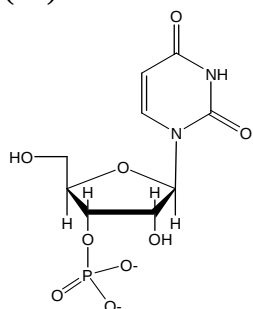
(11) What type(s) of carbohydrate linkage(s) are present in glycogen?

- (a) α (1 $\rightarrow$ 4) only
- (b) β (1 $\rightarrow$ 4) only
- (c) α (1 $\rightarrow$ 4) and α (1 $\rightarrow$ 6)
- (d) β (1 $\rightarrow$ 4) and β (1 $\rightarrow$ 6)

(12) How many stereoisomers are possible for the family of D-aldoses with five carbon atoms?

- (a) 2
- (b) 4
- (c) 8
- (d) 16

(13) What is the best name for the compound shown below?

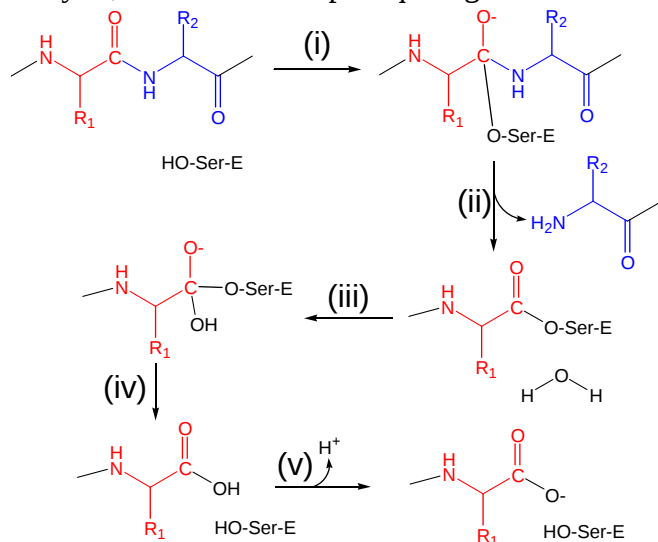


- (a) uracil 3'-monophosphate
- (b) uridine 3'-monophosphate
- (c) cytosine 3'-monophosphate
- (d) cytidine 3'-monophosphate
- (e) thymidine 3'-monophosphate

(14) In aqueous solutions, large concentrations of fatty acids associate to form structures called _____, large concentrations of sphingolipids associate to form structures called _____, and large concentrations of glycerophospholipids associate to form structures called _____.

- (a) micelles, micelles, liposomes
- (b) liposomes, micelles, micelles
- (c) micelles, liposomes, micelles
- (d) micelles, liposomes, liposomes
- (e) micelles, liposomes, micelles

(15) Referring to the mechanistic scheme shown below, which step(s) require general base catalysis, while which steps require general acid catalysis?



	<u>Gen. base steps</u>	<u>Gen. acid steps</u>
(a)	(i), (iii)	(ii), (iv)
(b)	(ii), (iv)	(i), (iii)
(c)	(i), (iv)	(ii), (iii)
(d)	(i), (ii)	(iii), (iv)
(e)	(iii), (iv)	(i), (ii)

- (16) Which polysaccharide is most likely to be a structural polysaccharide in mammals?
- (a) glycogen
 - (b) glycosaminoglycan
 - (c) chitin
 - (d) cellulose
 - (e) peptidoglycan
- (17) The reaction of the side chain of lysine with CO_2 would produce what type of compound?
- (a) Schiff base
 - (b) ester
 - (c) carbamate
 - (d) thioether
- (18) The sodium-potassium ATPase represents what type of transporter?
- (a) primary active, antiport
 - (b) primary active, symport
 - (c) passive, antiport
 - (d) passive, symport
 - (e) secondary active, symport
- (19) For which of the following enzymes is a cis-ene-diolate an important intermediate in the reaction?
- (a) alcohol dehydrogenase
 - (b) citrate synthase
 - (c) aldolase
 - (d) triosephosphate isomerase
 - (e) enolase
- (20) Which of the following reactions of glycolysis results in the formation of a high energy compound?
- (a) aldolase
 - (b) phosphoglycerate mutase
 - (c) phosphohexose isomerase
 - (d) enolase
- (21) Which of the following enzymes forms a Schiff base intermediate during catalysis?
- (a) enolase
 - (b) citrate synthase
 - (c) aldolase
 - (d) triosephosphate isomerase
 - (e) both (b) and (c)

(22) In the hormonal activation of glycogen breakdown, protein kinase is activated by _____ while phosphorylase kinase is activated by _____.

- (a) allostery, allostery
- (b) allostery, covalent modification
- (c) covalent modification, allostery
- (d) covalent modification, covalent modification

(23) How many of the reactions of glycolysis and the citric acid cycle result in substrate level phosphorylation to form a nucleoside triphosphate?

- (a) 2
- (b) 3
- (c) 4
- (d) 5
- (e) 6

(24) Some chemoautotrophic bacteria gain all their energy from the oxidation of nitrite to nitrate (a **two electron** process). In theory at least (biochemical standard state conditions), the free energy provided by the **oxidation of one mol nitrite** in the presence of O_2 is sufficient to form how many mols of ATP?

($E^{\circ} = +0.421$ V for the NO_3^-/NO_2^- couple, $E^{\circ} = +0.816$ V for the O_2/H_2O couple, $\Delta G^{\circ} = -30.5$ kJ/mol for ATP hydrolysis)

- (a) 0.83
- (b) 1.2
- (c) 2.5
- (d) 3.9
- (e) 7.8

(25) Which of the following organic cofactors is used to stabilize a carbanion formed during catalysis?

- (a) thiamine pyrophosphate
- (b) biotin
- (c) lipoamide
- (d) NAD^+
- (e) cofactors are never used to stabilize carbanions