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Biochemistry 5700
Fall, 2007
Final Exam
December 14, 2007

INSTRUCTIONS:

Do not begin until 9:30 AM. The exam must be turned in by 11:20 AM. This exam contains two sections: the "new material" section and the "comprehensive" section.
Answer the questions by marking on the scantron sheet using a #2 pencil. Turn in the scantron when you are finished. Good Luck!!

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

$pH = pK_a + \log\frac{[A^-]}{[HA]}$ $\quad v = \frac{V_{max}\cdot[S]}{K_m + [S]}$

Constants: F = 96.5 kJ/V•mol R = 8.3144 J/mol•K

table 5–1

Properties and Conventions Associated with the Standard Amino Acids

Amino acid	Abbreviated names	M_r	pK_1 (—COOH)	pK_2 ($—NH_3^+$)	pK_R (R group)
Glycine		75	2.34	9.60	
Alanine		89	2.34	9.69	
Valine		117	2.32	9.62	
Leucine		131	2.36	9.60	
Isoleucine		131	2.36	9.68	
Methionine		149	2.28	9.21	
Phenylalanine		165	1.83	9.13	
Tyrosine		181	2.20	9.11	10.07
Tryptophan		204	2.38	9.39	
Serine		105	2.21	9.15	
Proline		115	1.99	10.96	
Threonine		119	2.11	9.62	
Cysteine		121	1.96	10.28	8.18
Asparagine		132	2.02	8.80	
Glutamine		146	2.17	9.13	
Lysine		146	2.18	8.95	10.53
Histidine		155	1.82	9.17	6.00
Arginine		174	2.17	9.04	12.48
Aspartate		133	1.88	9.60	3.65
Glutamate		147	2.19	9.67	4.25

TABLE 13–7 Standard Reduction Potentials of Some Biologically Important Half-Reactions, at pH 7.0 and 25°C (298 K)

Half-reaction	E'° (V)
$\frac{1}{2}O_2 + 2H^+ + 2e^- \longrightarrow H_2O$	0.816
$Fe^{3+} + e^- \longrightarrow Fe^{2+}$	0.771
$NO_3^- + 2H^+ + 2e^- \longrightarrow NO_2^- + H_2O$	0.421
Cytochrome *f* (Fe^{3+}) + e^- ⟶ cytochrome *f* (Fe^{2+})	0.365
$Fe(CN)_6^{3-}$ (ferricyanide) + e^- ⟶ $Fe(CN)_6^{4-}$	0.36
Cytochrome a_3 (Fe^{3+}) + e^- ⟶ cytochrome a_3 (Fe^{2+})	0.35
$O_2 + 2H^+ + 2e^- \longrightarrow H_2O_2$	0.295
Cytochrome *a* (Fe^{3+}) + e^- ⟶ cytochrome *a* (Fe^{2+})	0.29
Cytochrome *c* (Fe^{3+}) + e^- ⟶ cytochrome *c* (Fe^{2+})	0.254
Cytochrome c_1 (Fe^{3+}) + e^- ⟶ cytochrome c_1 (Fe^{2+})	0.22
Cytochrome *b* (Fe^{3+}) + e^- ⟶ cytochrome *b* (Fe^{2+})	0.077
Ubiquinone + $2H^+$ + $2e^-$ ⟶ ubiquinol	0.045
Fumarate^{2-} + $2H^+$ + $2e^-$ ⟶ succinate^{2-}	0.031
$2H^+ + 2e^- \longrightarrow H_2$ (at standard conditions, pH 0)	0.000
Crotonyl-CoA + $2H^+$ + $2e^-$ ⟶ butyryl-CoA	−0.015
Oxaloacetate^{2-} + $2H^+$ + $2e^-$ ⟶ malate^{2-}	−0.166
Pyruvate$^-$ + $2H^+$ + $2e^-$ ⟶ lactate$^-$	−0.185
Acetaldehyde + $2H^+$ + $2e^-$ ⟶ ethanol	−0.197
FAD + $2H^+$ + $2e^-$ ⟶ $FADH_2$	−0.219*
Glutathione + $2H^+$ + $2e^-$ ⟶ 2 reduced glutathione	−0.23
$S + 2H^+ + 2e^- \longrightarrow H_2S$	−0.243
Lipoic acid + $2H^+$ + $2e^-$ ⟶ dihydrolipoic acid	−0.29
$NAD^+ + H^+ + 2e^-$ ⟶ NADH	−0.320
$NADP^+ + H^+ + 2e^-$ ⟶ NADPH	−0.324
Acetoacetate + $2H^+$ + $2e^-$ ⟶ β-hydroxybutyrate	−0.346
α-Ketoglutarate + CO_2 + $2H^+$ + $2e^-$ ⟶ isocitrate	−0.38
$2H^+ + 2e^- \longrightarrow H_2$ (at pH 7)	−0.414
Ferredoxin (Fe^{3+}) + e^- ⟶ ferredoxin (Fe^{2+})	−0.432

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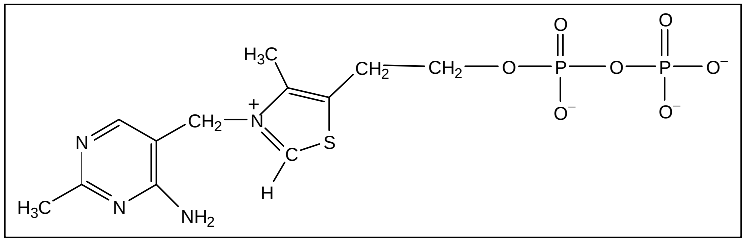

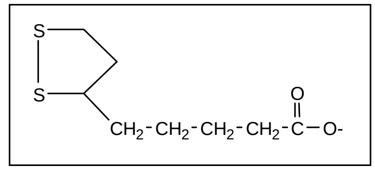

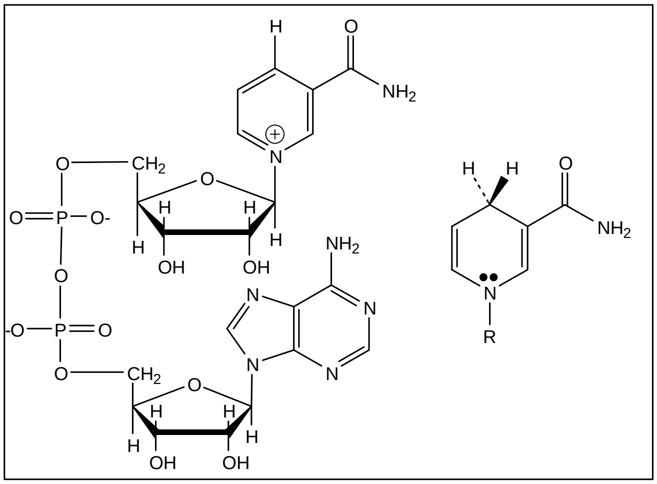

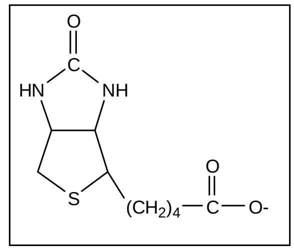

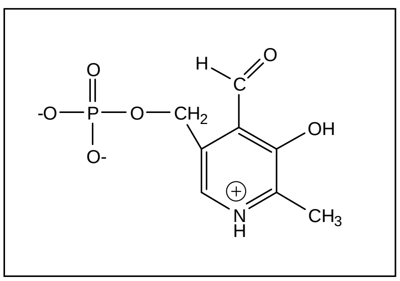

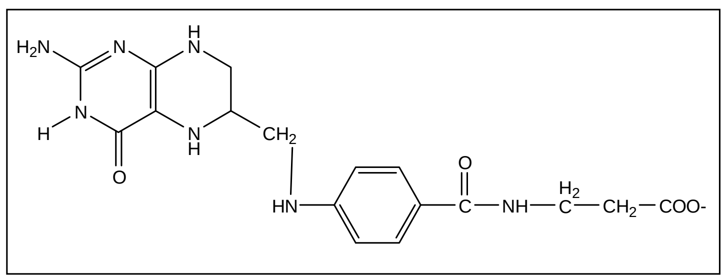

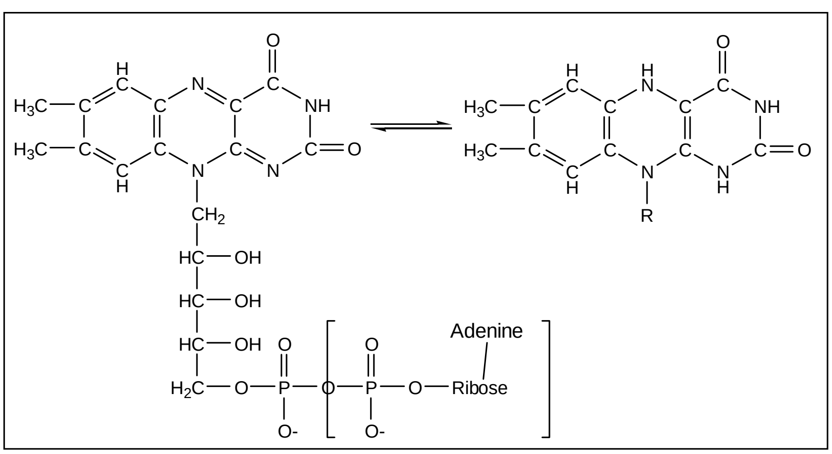

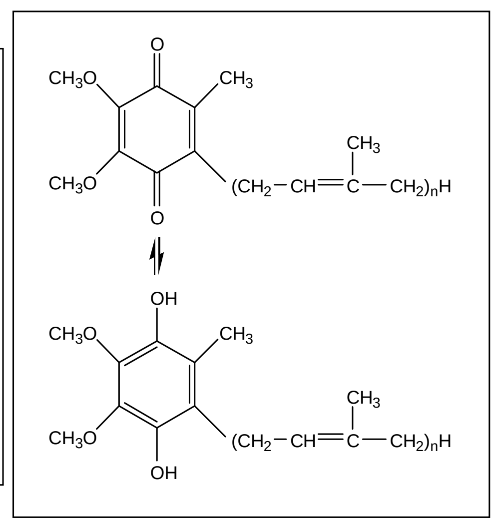

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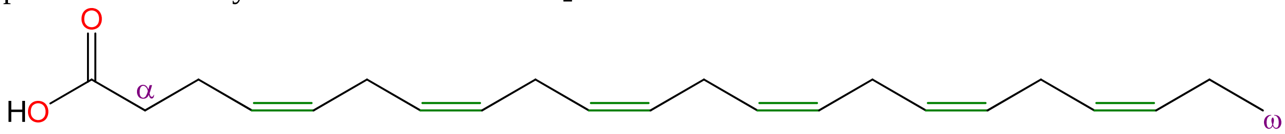
(1) The complete beta-oxidation of the omega-3 fatty acid shown below to acetyl-CoA would also produce how many total NADH and $FADH_2$?



22:6 cis$\Delta^{4,7,10,13,16,19}$ docosahexaenoic acid

(a) 11 NADH and 11 $FADH_2$
(b) 10 NADH and 10 $FADH_2$
(c) 10 NADH and 4 $FADH_2$
(d) 11 NADH and 4 $FADH_2$
(e) 11 NADH and 5 $FADH_2$

(2) What is the high energy intermediate formed by the enzyme fatty acyl-CoA synthetase?

(a) fatty acyl-phosphate
(b) fatty acyl-AMP
(c) fatty acyl-CoA
(d) fatty acyl-carnitine
(e) fatty acyl-pyrophosphate

(3) What is the correct order in which the following cofactors or substrates participate in beta oxidation, from first to last?

(a) NAD^+,	H_2O,	FAD,	CoASH
(b) NAD^+,	FAD,	H_2O,	CoASH
(c) NAD^+,	FAD,	CoASH,	H_2O
(d) FAD,	NAD^+,	H_2O,	CoASH
(e) FAD,	H_2O,	NAD^+,	CoASH

(4) Dietary fatty acids are transported through the blood stream bound to structures called ___________ while fatty acids mobilized and exported from adipocytes are transported bound to structures called ___________.
(a) chylomicrons; albumin
(b) carnitine; albumin
(c) chylomicrons; cholesterol
(d) albumin; chylomicrons
(e) albumin; carnitine

(5) Which of the following answers contains correct chemical formulas for the compounds collectively referred to as "ketone bodies"?

(a) $C_3H_3O_3^-$;	$C_4H_6O_3^-$;	$C_4H_7O_3^-$
(b) $C_2H_3O_2^-$;	C_3H_6O;	$C_4H_8O_2^-$
(c) C_3H_5O;	$C_4H_5O_3^-$;	$C_4H_8O_2^-$
(d) C_3H_6O ;	$C_4H_5O_3^-$;	$C_4H_7O_3^-$
(e) C_3H_6O;	$C_2H_3O_2^-$	$C_3H_3O_3^-$

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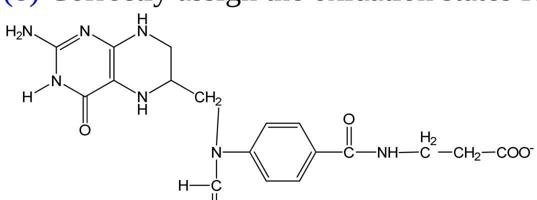
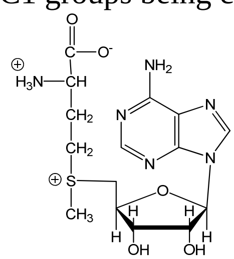
(6) Which citric acid cycle enzyme does not have a counterpart (i.e., catalyzing the same reaction type) in beta-oxidation?
(a) malate dehydrogenase
(b) fumarase
(c) isocitrate dehydrogenase
(d) succinate dehydrogenase
(e) both (a) and (d)

(7) Which of the following molecules NEVER crosses the inner mitochondrial membrane
(a) ATP, ADP, Pi
(b) Coenzyme A, NAD^+
(c) ADP, Coenzyme A, NAD^+
(d) pyruvate, Coenzyme A, NAD^+
(e) None of the above can cross the inner mitochondrial membrane; the metabolite pools are completely isolated.

(8) Correctly assign the oxidation states for the C1 groups being carried by the following molecules


(i)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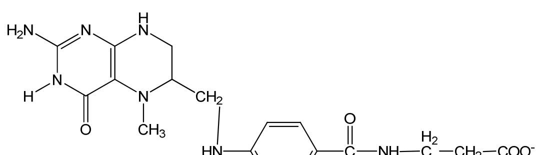
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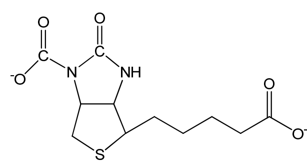
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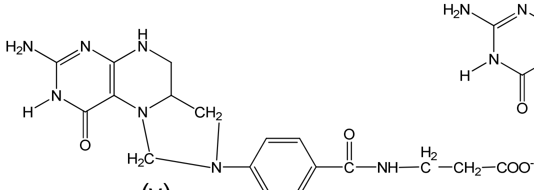
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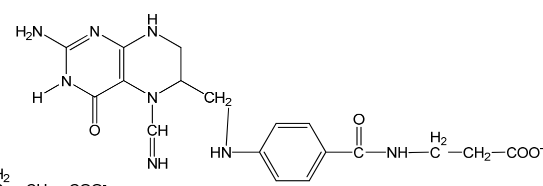
(vi)

	(i)	(ii)	(iii)	(iv)	(v)	(vi)
(a)	+2	-2	-2	+4	0	+2
(b)	+2	-3	-2	+3	0	+2
(c)	+3	-2	-2	+3	-2	+4
(d)	+4	0	0	+3	+2	+3
(e)	+2	-2	-2	+3	-2	+4

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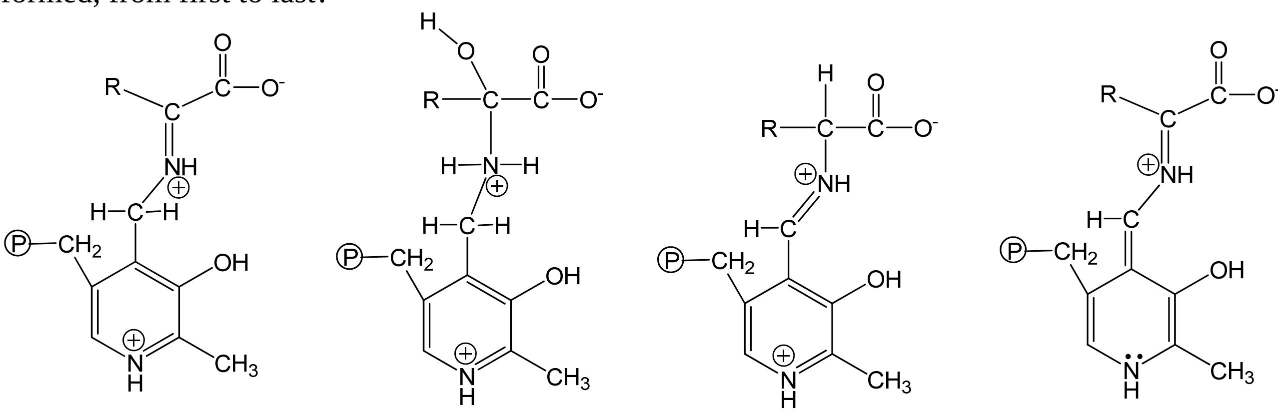
(9) Shown below are intermediates formed in the second half of a transamination reaction that will result in formation of an amino acid. What is the correct order in which these compounds are formed, from first to last?



(i) (ii) (iii) (iv)

(a) (i) > (ii) > (iv) > (iii)
(b) (ii) > (i) > (iii) > (iv)
(c) (iii) > (ii) > (iv) > (i)
(d) (iii) > (iv) > (i) > (ii)
(e) (ii) > (i) > (iv) > (iii)

(10) The conversion of glutamate to glutamine by glutamine synthetase will be initiated by what catalytic step?
(a) nucleophilic attack of an oxygen from the gamma carboxyl group of glutamate on the gamma-phosphorus of ATP
(b) nucleophilic attack of ammonia on the gamma carbonyl carbon of glutamate
(c) nucleophilic attack of an oxygen from the gamma carboxyl group of glutamate on the alpha-phosphorus of ATP
(d) hydride abstraction from the alpha-carbon of glutamate to form an imine.
(e) nucleophilic attack of an oxygen from the gamma carboxyl group of glutamate on ammonia

(11) The oxidation of an amino acid gives rise to acetoacetyl-CoA and pyruvate as products. This amino acid is:
(a) glucogenic only
(b) both glucogenic and ketogenic
(c) ketogenic only
(d) neither glucogenic or ketogenic
(e) amino acids are never oxidized to acetoacetyl-CoA

(12) The α-keto acid counterpart of glutamate is _____(i)_____; the α-keto acid counterpart of alanine is ____(ii)_____; the α-keto acid counterpart of aspartate is ____(iii)_____.

(a) (i) pyruvate	(ii) α-ketoglutarate	(iii) oxaloacetate
(b) (i) α-ketoglutarate	(ii) oxaloacetate	(iii) pyruvate
(c) (i) α-ketoglutarate	(ii) pyruvate	(iii) oxaloacetate
(d) (i) oxaloacetate	(ii) pyruvate	(iii) α-ketoglutarate
(e) (i)oxaloacetate	(ii) α-ketoglutarate	(iii) pyruvate

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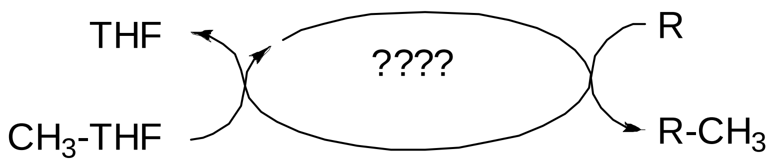
(13) The following intermediates or products of the Urea cycle are formed by what type of enzyme?

	argininosuccinate	fumarate	urea
(a)	kinase	synthase	lyase
(b)	synthase	hydrolase	lyase
(c)	lyase	synthetase	hydrolase
(d)	synthase	lyase	lyase
(e)	synthetase	lyase	hydrolase

(14) Of the following lists, which contains compounds that are ALL involved in the coupling of the citric acid and urea cycles?
(a) fumarate, malate, pyruvate, alanine, aspartate
(b) fumarate, succinate, malate, glutamate, alpha-ketoglutarate
(c) succinate, malate, oxaloacetate, glutamate, aspartate
(d) fumarate, malate, oxaloacetate, glutamate, aspartate
(e) succinate, malate, oxaloacetate, pyruvate, aspartate

(15) How many amino acids or amino acid derivatives (standard or nonstandard) are involved in the complete catalytic cycle resulting in the net transfer of a methyl group from methyl-THF to an acceptor such as uracil?

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



(16) Under normal physiological conditions, amino groups are transferred from extrahepatic tissue to the liver in the form of _____________. Under conditions of physiological stress (e.g. strenuous exercise) the amino groups might be transferred additionally in the form of ______________.
(a) glutamate; alanine
(b) alanine; glutamate
(c) glutamine; alanine
(d) glutamine; asparagine
(e) glutamate; aspartate

(17) Based on your knowledge of the reaction catalyzed by complex III of the respiratory chain, which of the following is the best properly balanced “proton inventory” equation to describe the catalytic (complete) reaction complex III catalyzes in one reaction cycle?

(a) $QH_2 + 2CytC_{ox} + 2H^+_N \rightarrow Q + 2CytC_{red} + 4H^+_P$

(b) $2QH_2 + 4CytC_{ox} + 4H^+_N \rightarrow 2Q + 4CytC_{red} + 8H^+_P$

(c) $2QH_2 + 2CytC_{ox} + 2H^+_N \rightarrow 2Q + 2CytC_{red} + 4H^+_P$

(d) $QH_2 + 2CytC_{ox} + 4H^+_N \rightarrow Q + 2CytC_{red} + 6H^+_P$

(e) $QH_2 + 2CytC_{ox} \rightarrow Q + 2CytC_{red} + 2H^+_P$

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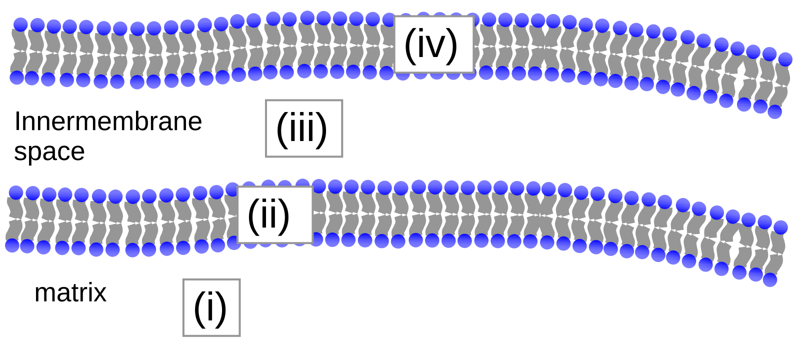
(18) The following are some electron transfer cofactors. Which selection accurately describes the strategy of electron transfer of the cofactor?

Choices: (i)single, free electron transfer
(ii) e^- + H^+ (or hydrogen atom)
(iii) hydride ion

	Heme	FMN	NAD^+	Q_{10}	FeS cluster
(a)	(i)	(ii)	(iii)	(ii)	(i)
(b)	(i)	(ii), (iii)	(iii)	(ii), (iii)	(i)
(c)	(i)	(ii)	(ii), (iii)	(iii)	(i)
(d)	(i), (ii)	(ii)	(iii)	(iii)	(i)
(e)	(i), (ii)	(iii)	(iii)	(iii)	(i), (ii)

(19) The following is a representation of the portions of the mitochondrion important in metabolism, respiration and oxidative phosphorylation. In which locations will the following components of these processes reside for proper catalysis to occur?



	NADH	ATP and ADP	ubiquinone	Cytochrome C	Succinate dehydrogenase	Pyruvate translocase	adenine nucleotide translocase
(a)	(i)	(iii)	(ii)	(i)	(i)	(ii)	(ii)
(b)	(iii)	(i)	(ii)	(i)	(ii)	(iv)	(iv)
(c)	(i)	(i)	(ii)	(iii)	(ii)	(iv)	(iv)
(d)	(i)	(i)	(ii)	(iii)	(ii)	(ii)	(ii)
(e)	(iii)	(i)	(ii)	(iii)	(ii)	(iv)	(iv)

(20) What is the most proper name for complex IV of the mitochondrial electron transfer chain?
(a) cytochrome C: O_2 oxidoreductase
(b) ubiquinone: O_2 oxidoreductase
(c) NADH: O_2 oxidoreductase
(d) O_2: ubiquinone oxidoreductase
(e) O_2: Cu_A oxidase

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(21) What is a correct sequence of electron transfer events involved in transferring electrons from NADH to molecular oxygen in the electron transfer chain? Note: Not every electron carrier in every complex is included (some are omitted)

(a) NADH → FMN → FeS → Q → $CytB_L$ → $CytB_H$ → CytC → CuB → CuA → O_2
(b) NADH → FeS → FMN → Q → FeS → CytC1 → CytC → CuA → CuB → O_2
(c) NADH → FMN → FeS → Q → $CytB_L$ → $CytB_H$ → CytC → CuA → CuB → O_2
(d) NADH → FMN → FeS → CytC → FeS → CytC1 → Q → CuA → CuB → O_2
(e) NADH → FMN → FeS → Q → FeS → CytC1 → CytC →CuA → CuB → O_2

(22) During the Q cycle, QH_2 directly reduces _____(i)______ , QH· directly reduces ____(ii)______, and Q is directly reduced by ______(iii)_________.

(a) (i) cytochrome B_L (ii) rieske FeS (iii) cytochrome B_H
(b) (i) cytochrome B_H (ii) cytochrome B_L (iii) rieske FeS
(c) (i) rieske FeS (ii) cytochrome B_L (iii) cytochrome B_H
(d) (i) cytochrome C (ii) cytochrome B_H (iii) cytochrome B_L
(e) (i) rieske FeS (ii) cytochrome C (iii) cytochrome B_H

(23) How many protons are pumped per electron pair transferred to molecular oxygen for electron pairs derived from the reactions catalyzed by the following enzymes?

	Isocitrate dehydrogenase	Succinate dehydrogenase	Fatty acyl-CoA dehydrogenase	β-hydroxyacyl-CoA dehydrogenase
(a)	9	6	9	6
(b)	10	6	10	6
(c)	8	4	8	4
(d)	10	6	6	10
(e)	10	10	6	6

(24) How many total enzymes and transporters participate in the malate-aspartate shuttle?
(a) 2 (b) 4 (c) 5 (d) 6 (e) 7

(25) What effects will the following compounds have on the rate of ATP synthesis (no effect, slow down, stop completely) after several minutes exposure to isolated mitochondria oxidizing succinate? Compare each set of choices before choosing the best available answer.
(i) a protonophore
(ii) a potassium ionophore
(iii) rotenone (an inhibitor of complex I)
(iv) cyanide (inhibitor of complex IV)

	(i) protonophore	(ii) K^+ ionophore	(iii) rotenone	(iv) cyanide
(a)	slow down	stop	stop	stop
(b)	slow down	stop	stop	no effect
(c)	stop	slow down	no effect	stop
(d)	slow down	no effect	no effect	stop
(e)	stop	slow down	no effect	no effect

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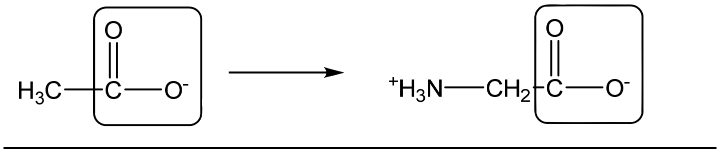
COMPREHENSIVE SECTION

(26) Of the twenty standard amino acids, how many will bear an AVERAGE charge of “0” in an aqueous solution buffered at pH 7?
(a) 13 (b) 14 (c) 15 (d) 16 (e) 17

(27) Predict how the pKa of the ionizable group (inside the box) will be affected by the indicated change of environment (going from left to right side).

(i)


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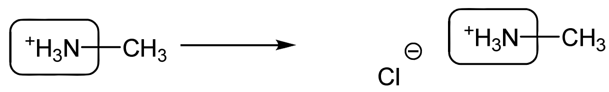

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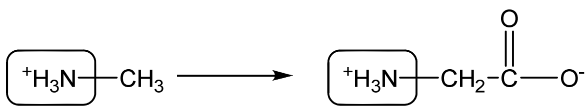

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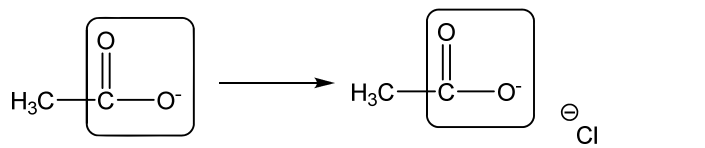

	(i)	(ii)	(iii)	(iv)
(a)	increase	decrease	increase	decrease
(b)	decrease	increase	decrease	increase
(c)	decrease	increase	increase	decrease
(d)	decrease	decrease	increase	increase
(e)	increase	increase	decrease	decrease

(28) Kinetic analysis of a homodimeric enzyme of 350,000 molecular weight (that is the Mr of the α_2 dimer) catalyzing conversion of substrate S to product P provides the following kinetic constants: V_{max} = 5,000 U when 1 mg of protein is assayed, and K_m = 0.15 mM. Assume each subunit contains an active site; i.e. there are two active sites per dimer. Calculate the catalytic efficiency (units of $M^{-1}\cdot s^{-1}$) of the enzyme on the basis of monomeric units (i.e. per active site).

(a) Catalytic efficiency = 9.7×10^{7} $M^{-1}\cdot s^{-1}$
(b) Catalytic efficiency = 1.9×10^{8} $M^{-1}\cdot s^{-1}$
(c) Catalytic efficiency = 2.2×10^{6} $M^{-1}\cdot s^{-1}$
(d) Catalytic efficiency = 5.8×10^{9} $M^{-1}\cdot s^{-1}$
(e) Catalytic efficiency = 5.8×10^{6} $M^{-1}\cdot s^{-1}$

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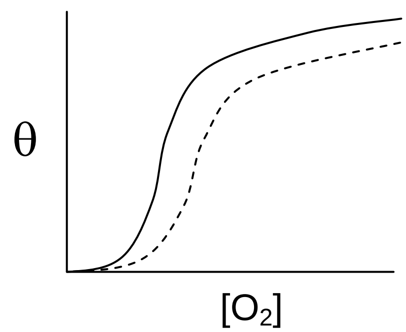
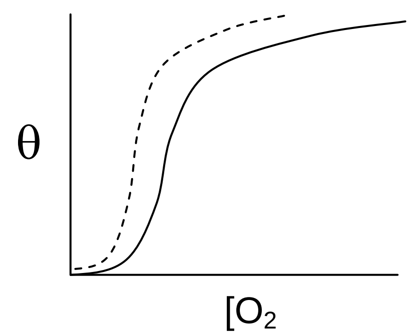
(29) Are the following statements correct descriptions of the steady state assumption used to derive the Michaelis-Menten equation? Match the correct answers.
(i) The concentration of enzyme in an assay is much lower than the concentration of substrate
(ii) the equilibrium between E, S, and ES is rapidly established
(iii) The concentration of the ES complex does not change during the time frame where enzyme activity is being measured
(iv) ES breaks down faster towards E and P than towards E and S
(v) product formed during the reaction does not react with E to reform ES at a significant rate

	(i)	(ii)	(iii)	(iv)	(v)
(a)	False	True	True	False	True
(b)	True	False	False	True	True
(c)	True	True	True	False	True
(d)	True	True	True	False	False
(e)	False	True	False	True	False

(30) For the two graphs shown at right, the solid lines represent the oxygen dissociation curves observed for hemoglobin under a certain set of conditions, while the dashed lines represent the dissociation curves observed after changing a parameter. Which parameter change will give the indicated dissociation curve?



(i)



(ii)

	decrease $[CO_2]$	decrease pH	decrease [DPG]
(a)	(ii)	(i)	(i)
(b)	(ii)	(i)	(ii)
(c)	(i)	(ii)	(i)
(d)	(i)	(i)	(ii)
(e)	(ii)	(ii)	(i)

(31) Which bonds correctly correspond to the peptide, phi, and psi bonds of a polypeptide chain?

	peptide	phi	psi
(a)	C_α-N	$C_{(carbonyl)}$-N	C_α- $C_{(R)}$
(b)	C_α-N	C_α- $C_{(carbonyl)}$	$C_{(carbonyl)}$-N
(c)	$C_{(carbonyl)}$-N	C_α- $C_{(carbonyl)}$	C_α-N
(d)	C_α-N	$C_{(carbonyl)}$-N	C_α- $C_{(carbonyl)}$
(e)	$C_{(carbonyl)}$-N	C_α-N	C_α- $C_{(carbonyl)}$

Name ________________________

(32) Match the following properties with the correct amino acid

(i) crosslinks side chains of α-ketatin
(ii) secondary alcohol on side chain
(iii) often found in cis conformation in proteins
(iv) side chain can form Schiff base adducts with enzyme substrates
(v) has a side chain containing a thioether group
(vi) has a side chain containing a guanidinium group
(vii) fused rings on side chain

	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)
(a)	K	S	P	K	C	R	T
(b)	C	S	G	L	M	R	T
(c)	P	T	P	H	C	K	Y
(d)	C	T	P	K	M	R	W
(e)	L	Y	L	K	C	W	R

(33) For a protein with the alpha-beta barrel structural motif, the approximate orientation of alpha helices is _____(i)________. For a protein with the 4-helix bundle structural motif, the approximate orientation of beta strands is _____(ii)________. For a protein with the myoglobin fold structural motif, the approximate orientation of alpha helices is _____(iii)________.

	(i)	(ii)	(iii)
(a)	antiparallel	antiparallel	perpendicular
(b)	antiparallel	perpendicular	parallel
(c)	antiparallel	parallel	perpendicular
(d)	parallel	antiparallel	perpendicular
(e)	parallel	parallel	perpendicular

(34) What type of transporter is generally used to accomplish each of the following?
(I) move CO_2 generated from respiration to the lungs
(II) move phosphate into the mitochondrial matrix
(III) establish and maintain the electrochemical potential within a cell
(IV) bring lactose into a cell
(V) bring glucose into a cell

	(I)	(II)	(III)	(IV)	(V)
(a)	antiport	symport	antiport	symport	uniport
(b)	antiport	antiport	uniport	symport	symport
(c)	symport	uniport	ant iport	symport	antiport
(d)	antiport	antiport	antiport	symport	uniport
(e)	uniport	antiport	antiport	uniport	uniport

(35) In Watson-Crick DNA, the base orientation is ______________, the sugar pucker is ___________, and the two strands are ________________.

(a) anti; C2' exo; antiparallel
(b) syn; C2' endo; antiparallel
(c) anti; C2' endo; antiparallel
(d) anti; C2' exo; parallel
(e) syn; C2' exo; antiparallel

Name ___________________________

(36) What role does the metal ion pay in each of the following enzyme-catalyzed reactions?

	esterase	hexokinase	Alcohol dehydrogenase	Carbonic anhydrase
(a)	Charge shielding	Charge stabilization	Lower pK_a of water	Charge stabilization
(b)	Lower pK_a of water	Charge shielding	Charge stabilization	Charge stabilization
(c)	Charge stabilization	Charge stabilization	Lower pK_a of water	Charge shielding
(d)	Charge stabilization	Charge shielding	Charge stabilization	Lower pK_a of water
(e)	Charge stabilization	Charge shielding	Lower pK_a of water	Charge stabilization

(37) Which one of the following nucleic acid sequences could, by itself, form a hairpin structure?

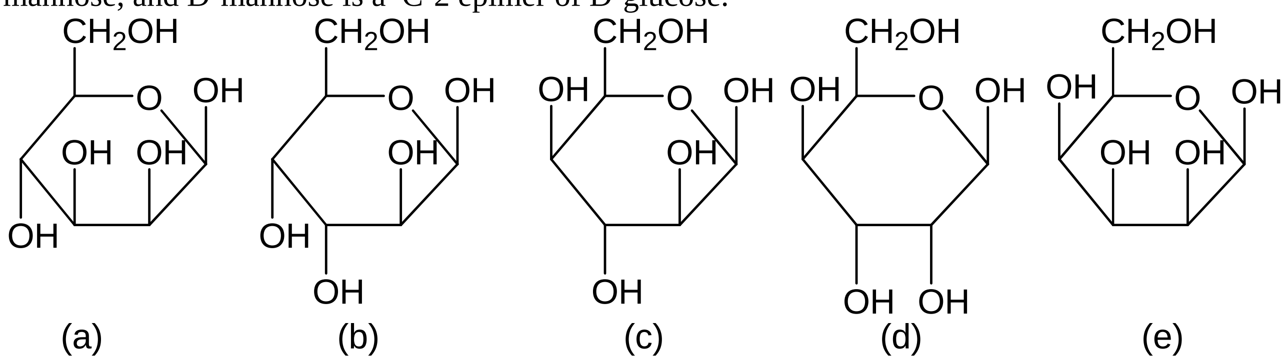
(a) GUGCCAGAUCAGAGACCGUG

(b) GUGCCAGAUCAGGUGCCAGA

(c) GUGCCAGAUCAGUCUGGCAC

(d) GUGCCAGAUCAGCACGGUCU

(38) What is the structure of beta-D-talopyranose, given that D-talose is a C-4 epimer of D-mannose, and D-mannose is a C-2 epimer of D-glucose.



(39) The addition of more long chain fatty acids to a lipid bilayer will ______(i)_________ the transition temperature; The addition of more unsaturated fatty acids to a lipid bilayer will _____(ii)__________ the transition temperature;

(a) (i), increase (ii), decrease
(b) (i), decrease (ii), increase
(c) (i), increase (ii), increase
(d) (i), decrease (ii), decrease

Name ___________________________

(40) What type of organic functional group is created by the following reactions.
(I) ring cyclization of D-galactose
(II) ring cyclization of D-fructose
(III) reaction of C1 of D-galactopyranose with C4 of D-glucopyranose
(IV) reaction of C1 of D-glucopyranose with C2 of D-fructofuranose

	(I)	(II)	(III)	(IV)
(a)	acetal	ketal	hemiacetal	hemiketal
(b)	hemiacetal	hemiketal	acetal and ketal	ketal
(c)	hemiketal	hemiacetal	acetal	acetal and ketal
(d)	hemiacetal	hemiketal	acetal	acetal and ketal
(e)	hemiketal	hemiacetal	acetal and ketal	acetal

(41)What type of functional groups will be present at the indicated position of the following lipids?
(i) on C3 of glycerol in phosphatidylcholine
(ii) on C1 of glycerol in a triacylglycerol
(iii) on C1 of sphingosine in sphingomyelin
(iv) on C2 of sphingosine in sphingomyelin
(v) on C2 of glycerol in a glycerophospholipid

	(i)	(ii)	(iii)	(iv)	(v)
(a)	phosphodiester	ester	amide	phosphodiester	ester
(b)	phosphodiester	ester	phosphodiester	amide	ester
(c)	phosphodiester	ester	amide	ester	ester
(d)	ester	ether	phosphodiester	amide	ester
(e)	ester	phosphodiester	alcohol	amide	phosphodiester

(42) For each of the following proteins activated during the regulatory cascade leading to glycogen breakdown in the muscle, what is a specific protein (may or may not be an enzyme), or small molecule ligand (effector), that directly interacts with and activates that particular protein.

	Phosphorylase kinase	G_α	Adenyl kinase	Protein kinase A	Glycogen phosphorylase
(a)	cAMP	GTP	G_α	Phosphorylase kinase	Protein kinase A
(b)	Protein kinase A	epinephrine	GTP	cAMP	Phosphorylase kinase
(c)	Protein kinase A	GTP	G_α	cAMP	Phosphorylase kinase
(d)	cAMP	epinephrine	G_α	Phosphorylase kinase	cAMP
(e)	cAMP	GTP	GTP	Phosphorylase kinase	Protein kinase A

Name ___________________________

(43) Match the following roles to the correct cofactors in the reaction catalyzed by pyruvate dehydrogenase.

(I) Accepts the acetyl group from reduced lipoamide.
(II) Oxidizes $FADH_2$.
(III) Initial electron acceptor in oxidation of pyruvate.
(IV) Attacks and attaches to the central carbon in pyruvate.
(V) Oxidizes the reduced form of lipoic acid.

	(I)	(II)	(III)	(IV)	(V)
(a)	Coenzyme A	oxidized lipoamide	NAD^+	FAD	thiamine pyrophosphate
(b)	oxidized lipoamide	NAD^+	FAD	thiamine pyrophosphate	Coenzyme A
(c)	thiamine pyrophosphate	oxidized lipoamide	NAD^+	Coenzyme A	FAD
(d)	FAD	NAD^+	oxidized lipoamide	thiamine pyrophosphate	Coenzyme A
(e)	Coenzyme A	NAD^+	oxidized lipoamide	thiamine pyrophosphate	FAD

(44) Select the correct terms from each pair to complete the sentence. Glucose binds an allosteric site on glycogen phosphorylase in the ________ which results in ______ of the enzyme, while AMP binds an allosteric site on glycogen phosphorylase in the ________ which results in ______ of the enzyme
(a) liver, activation; muscle, inactivation
(b) muscle, inactivation; liver, activation
(c) liver, inactivation; muscle, activation
(d) muscle, activation; liver, inactivation

(45) Using information from the first page of the exam, determine the equilibrium constant for the reduction of two molecules of cytochrome C by QH_2.
(a) 1.2×10^7
(b) 3.4×10^3
(c) 20.2
(d) 16.3
(e) -16.3

(46) Oxidation of glucose to two acetyl-CoA releases __(i)_ electrons; oxidation of one pyruvate to two CO_2 releases _(ii)__ electrons, and the complete oxidation of glucose to CO_2 and water releases _(iii)_ electrons?

	(i)	(ii)	(iii)
(a)	4	4	16
(b)	8	10	24
(c)	4	10	24
(d)	6	8	22
(e)	8	8	16

Name ___________________________

(47) Which of the following is/are not correctly designated as a "high energy compound"?
(i) succinyl-CoA (ii) 1,3-diphosphoglycerate (iii) 2-phosphoglycerate
(iv) 3-phosphoglycerate (v) glucose-1-phosphate (vi) phosphoenolpyruvate
(vii) creatine phosphate

(a) they are all high energy compounds
(b) (iv), and (v) only
(c) (i), (ii), (vi), and (vii) only
(d) (i) (iii), (iv), and (v) only
(e) (iii), (iv), and (v) only

(48) What enzyme(s) from the citric acid cycle catalyze reactions matching the following?
(I) isomerization
(II) claisen condensation
(III) oxidative decarboxylation using thiamine pyrophosphate (TPP)
(IV) oxidative decarboxylation not requiring TPP
(V) net substrate hydration

	(I)	(II)	(III)	(IV)	(V)
(a)	aconitase	citrate synthase	isocitrate dehydrogenase	α-ketoglutarate dehydrogenase	fumarase
(b)	malate dehydrogenase	succinyl-CoA synthetase	isocitrate dehydrogenase	succinate dehydrogenase	aconitase
(c)	fumarase	citrate synthase	α-ketoglutarate dehydrogenase	isocitrate dehydrogenase	aconitase
(d)	aconitase	citrate synthase	α-ketoglutarate dehydrogenase	isocitrate dehydrogenase	fumarase
(e)	fumarase	citrate synthase	isocitrate dehydrogenase	α-ketoglutarate dehydrogenase	aconitase

(49) The two molecules of CO_2 released in one turn of the citric acid cycle are derived from which carbon atoms on which of the substrate(s) that feed into the cycle? To answer this, draw the structure(s) of the compound(s) that provide the two CO_2, and label the carbon atoms that end up in the two CO_2.

(a) the two carboxyl groups of oxaloacetate
(b) the two carbon atoms of acetyl-CoA
(c) the carbonyl carbon of acetyl-CoA and one of the carboxyl groups of oxaloacetate
(d) the keto group of oxaoloacetate and the carbonyl carbon of acetyl-CoA
(e) it is impossible to predict exactly since the atoms become "scrambled" during the citric acid cycle

Name ___________________________

(50) The following is a list of mechanistic strategies that glycolytic enzymes employ. Match the following enzymes with the correct mechanistic strategies.

Mechanistic strategy
(i) cis-ene-diolate intermediate
(ii) thiohemiacetal intermediate
(iii) phosphoenzyme intermediate
(iv) dehydration
(v) Schiff base adduct

	enolase	aldolase	Triose phosphate isomerase	Glyceraldehyde 3-phosphate dehydrogenase	Phospho-glycerate mutase
(a)	(iv)	(v)	(iii)	(ii)	(i)
(b)	(i)	(i)	(iv)	(ii)	(iii)
(c)	(iv)	(v)	(i)	(ii)	(iii)
(d)	(i)	(v)	(iii)	(iv)	(ii)
(e)	(iv)	(i)	(iv)	(iii)	(ii)