Name Key

Biochemistry 5700
Fall, 2006
Final Exam
December 13, 2006

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 "comprehensive" questions (25 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: $\Delta G = \Delta G^{\circ\prime} + RT\ln Q$ $\qquad \Delta E = \Delta E^{\circ\prime} - \dfrac{RT}{nF}\ln Q$ $\qquad \Delta G' = -nFE'$

$\mathrm{pH} = \mathrm{p}K_a + \log\dfrac{[A^-]}{[HA]}$ $\qquad v = \dfrac{V_{max}\cdot[S]}{K_m + [S]}$

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)
			pK_a values		
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
$NAD^+ + H^+ + 2e^- \longrightarrow NADH$	−0.320
$NADP^+ + H^+ + 2e^- \longrightarrow NADPH$	−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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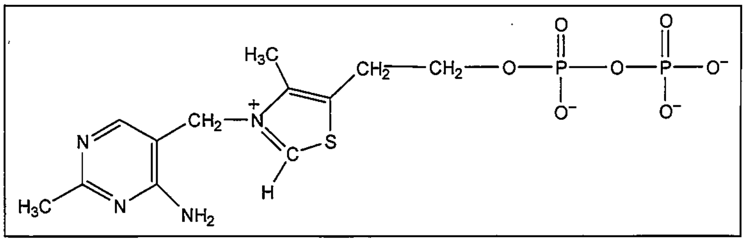

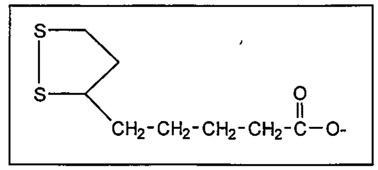

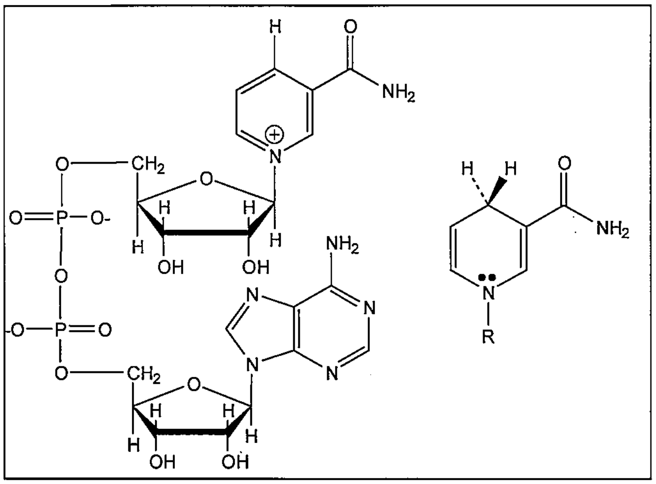

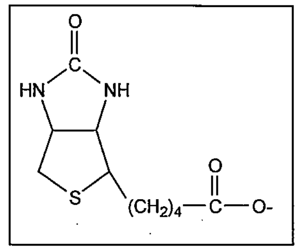

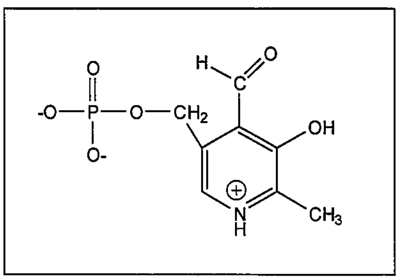

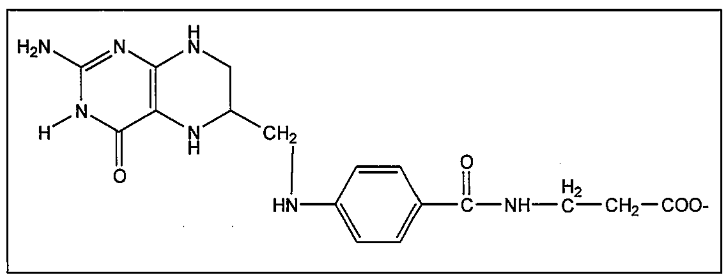

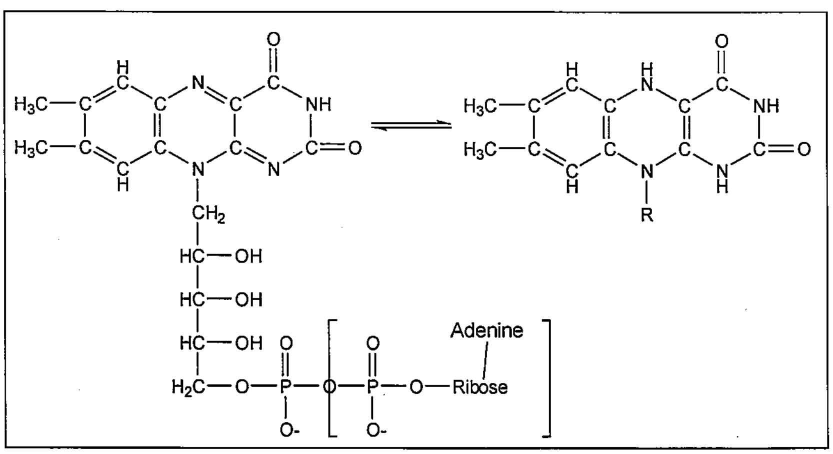

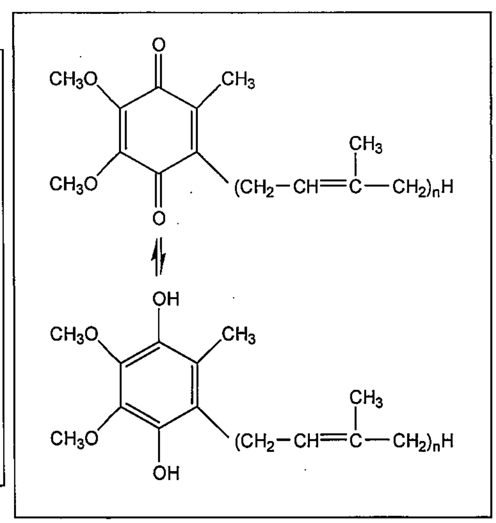

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(1) Which of the following enzymes activate a poor leaving group to a good leaving group, by (i) gamma-phosphoryl group transfer from ATP to the substrate to be activated or (ii) AMP group transfer from ATP to the substrate to be activated?

	Fatty acyl-CoA synthetase -AMP ii	Glutamine synthetase -P i	Carbamoyl phosphate synthetase -P i	Argininosuccinate synthetase -AMP ii
(a)	(i)	(i)	(ii)	(ii)
(b)	(ii)	(ii)	(i)	(ii)
(c)	(ii)	(i)	(i)	(i)
(d)	(i)	(i)	(i)	(ii)
(e)	(ii)	(i)	(i)	(ii)

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

(3) Which of the following compounds is NOT involved in the malate-aspartate shuttle for bringing reducing equivalents from NADH into the mitochondrion?
(a) pyruvate
(b) alpha-ketoglutarate
(c) oxaloacetate
(d) glutamate
(e) both (b) and (d)

(4) C1 units for biosynthetic reactions in mammals are primarily derived from which amino acid?
(a) alanine
(b) glutamate
(c) glutamine
(d) serine
(e) aspartate

(5) 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 → FeS → Q → CytC1 → CytC → CuA → CuB → O_2
(b) NADH → Q → FMN → FeS → FeS → CytC1 → CytC → CuA → CuB → O_2
(c) NADH → FMN → FeS → Q → FeS → CytC1 → CytC → CuA → CuB → O_2
(d) NADH → FMN → FeS → CytC → FeS → CytC1 → Q → CuA → CuB → O_2
(e) NADH → FMN → FeS → Q → CytC1 → FeS → CytC → CuA → CuB → O_2

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(6) What are the correct oxidation states for the following C1-cofactor adducts?
(i) N^5-methyl-THF -2
(ii) S-adenosylmethionine -2
(iii) N^5-N^{10}-methylene-THF 0
(iv) N^5-formyl-THF +2
(v) N^5-formimino-THF +2
(vi) carboxybiotin +4

	+4	+3	+2	0	-2	-4
(a)	none	(vi)	(iv), (v)	(iii)	(i), (ii)	
(b)	(vi)		(iv), (v)	(iii)	(i), (ii)	
(c)	(vi)		(i), (ii), (iii)		(iv), (v)	(ii)
(d)		(iii)	(i), (ii)		(iv), (v)	(vi)
(e)	(iv), (v), (vi)		(iii)		(i), (ii)	

(7) Elevated levels of homocysteine in your blood stream might indicate a lack of which coenzymes in your body?
(a) thiamine pyrophosphate, B12, tetrahydrofolate
(b) pyridoxal phosphate, B12, tetrahydrofolate
(c) thiamine pyrophosphate, biotin, tetrahydrofolate
(d) pyridoxal phosphate, thiamine pyrophosphate, biotin
(e) biotin, B12, tetrahydrofolate

(8) The transport of ATP across the inner mitochondrial membrane occurs by a __________ transport mechanism, and the transport of inorganic phosphate occurs by a __________ transport mechanism.
(a) antiport; antiport
(b) symport; uniport
(c) antiport; uniport
(d) symport; antiport
(e) antiport; symport

(9) Which electron transfer cofactor(s) can transfer electrons either as a hydride OR as a hydrogen atom ($1e^- + 1 H^+$)?
A. NAD^+, FAD, FMN, CoQ
B. cytochromes, FAD, FMN, CoQ
C. FAD, FMN, CoQ
D. iron-sulfur centers, cytochromes, FAD, FMN, CoQ
E. NAD^+, cytochromes, FAD, FMN, CoQ

(10) Of the following lists, which contains compounds that are ALL involved in the coupling of the citric acid and urea cycles?
(a) fumarate, malate, oxaloacetate, glutamate, aspartate
(b) fumarate, succinate, no malate, glutamate, alpha-ketoglutarate
(c) succinate, no malate, oxaloacetate, glutamate, aspartate
(d) fumarate, malate, pyruvate, no alanine, no aspartate
(e) succinate, malate, oxaloacetate, pyruvate, aspartate
no no

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(11) The strategy of beta-oxidation of fatty acids involves what sequence of reactions?

(a) dehydrogenation, dehydrogenation, hydration, thiolysis
(b) dehydrogenation, hydration, dehydrogenation, thiolysis
(c) hydration, dehydrogenation, dehydrogenation, , thiolysis
(d) dehydrogenation, thiolysis, dehydrogenation, hydration
(e) thiolysis, dehydrogenation, hydration, dehydrogenation

(12) What nitrogenous compounds directly enter the Urea cycle and donate their amino groups for urea synthesis?

(a) two ammonias
(b) carbamoyl phosphate, glutamate
(c) ammonia, glutamate
(d) carbamoyl phosphate, aspartate
(e) ammonia, aspartate

(13) 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

(14) Based on your knowledge of the reaction catalyzed by complex I of the respiratory chain, which of the following is the best "proton inventory" equation to describe what reaction complex I catalyzes?

(a) $NADH + Q + 4H^+_N \rightarrow NAD^+ + QH_2 + 3H^+_P$
(b) $NADH + Q + 3H^+_N \rightarrow NAD^+ + QH_2 + 4H^+_P$
(c) $NADH + Q + 5H^+_N \rightarrow NAD^+ + QH_2 + 4H^+_P$
(d) $NADH + Q + 6H^+_N \rightarrow NAD^+ + QH_2 + 4H^+_P$
(e) $NADH + Q + 4H^+_N \rightarrow NAD^+ + QH_2 + 4H^+_P$

(15) The oxidation of glutamate by glutamate dehydrogenase will be initiated by what catalytic step?

(a) general base abstraction of a proton from the alpha-carbon of glutamate
(b) hydrolytic attack of water on the alpha carbon of glutamate, displacing ammonia
(c) general base abstraction of a proton from the beta-carbon (the first carbon atom in the side chain) of glutamate
(d) hydride abstraction from the alpha carbon of glutamate
(e) general base abstraction of a proton from the alpha-amino group of glutamate

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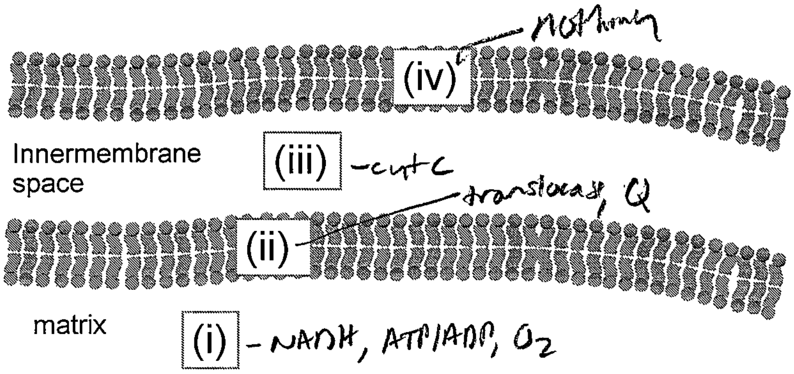
(16) The following is a representation of the portions of the mitochondrion important in respiration and oxidative phosphorylation. In which locations will the following components of these processes reside for proper catalysis to occur?



	NADH	Cytochrome C	ubiquinone	ATP and ADP	O_2	Phosphate translocase	Where H^+ are pumped to
(a)	(i)	(iii)	(ii)	(i)	(i)	(ii)	(iii)
(b)	(i)	(iii)	(ii)	(i)	(i)	(ii)	(i)
(c)	(i)	(iii)	(ii)	(i)	(i)	(iv)	(iii)
(d)	(iii)	(i)	(iv)	(iii)	(iii)	(iv)	(i)
(e)	(iii)	(iii)	(ii)	(iii)	(i)	(iv)	(iii)

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

(18) The alpha-amino acid counterpart of pyruvate is _____(i)__alanine__; the alpha-amino acid counterpart of α-ketoglutarate is ____(ii)__glu__; the alpha-amino acid counterpart of oxaloacetate is ____(iii)__asp__.

(a) (i) alanine (ii) aspartate (iii) glutamate
(b) (i) alanine (ii) aspartate (iii) glutamine
(c) (i) aspartate (ii) alanine (iii) glutamate
(d) (i) alanine (ii) glutamate (iii) aspartate
(e) (i) glutamate (ii) aspartate (iii) alanine

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(19) The oxidation of an amino acid gives rise to acetoacetyl-CoA and acetyl-CoA 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 acetyl-CoA

(20) The oxidation of odd-chain fatty acids requires what two cofactors in order to convert propionyl-CoA to succinyl-CoA?
(a) tetrahydrofolate and B12
(b) B12 and thiamine pyrophosphate
(c) B12 and S-adenosylmethionine
(d) biotin and B12
(e) biotin and tetrahydrofolate

(21) How many high energy phosphodiester bonds must be hydrolyzed in order to take the amino groups from one ammonia and one glutamate , formed in extrahepatic tissue, convert them to glutamine, transport glutamine to the liver, and finally synthesize one urea molecule in the liver from the glutamine that was transported? Assume glutamine is transported by passive transport processes. Don't count any "secondary" hydrolysis of pyrophosphate as a required phosphodiester bond cleavage step for the purposes of this problem.
(a) 1 (b) 2 (c) 3 (d) 4 (e) 5

(22) Which compounds are collectively referred to as "ketone bodies"?
(a) acetoacetyl-CoA and acetyl-CoA only
(b) acetoacetate and beta-hydroxybutyrate only
(c) acetoacetate, acetone, and beta-hydroxybutyrate only
(d) acetoacetate acetoacetyl-CoA and acetone only
(e) acetoacetate and acetone only

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

(24) Which of the following citric acid cycle enzymes does NOT have a counterpart in beta-oxidation of fatty acids?
(a) succinyl-CoA synthetase
(b) fumarase
(c) malate dehydrogenase
(d) succinate dehydrogenase
(e) both (b) and (c)

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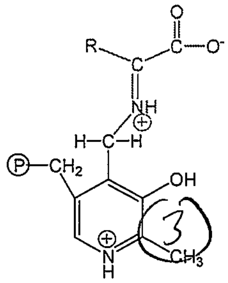
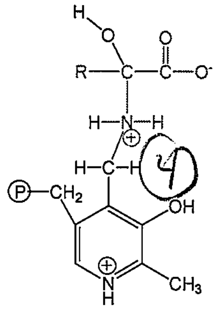
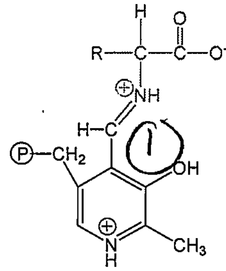
(25) The following compounds are formed during the transaminase-catalyzed formation of an alpha-keto acid from an alpha-amino acid (the first half of a complete transamination reaction). What is the correct order for these compounds, from first to last, in this half-reaction?



(i)

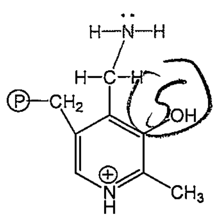


(ii)

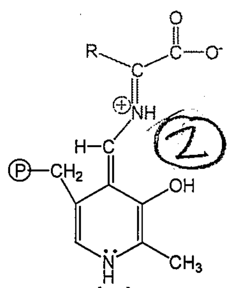


(iii)

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



(iv)



(v)

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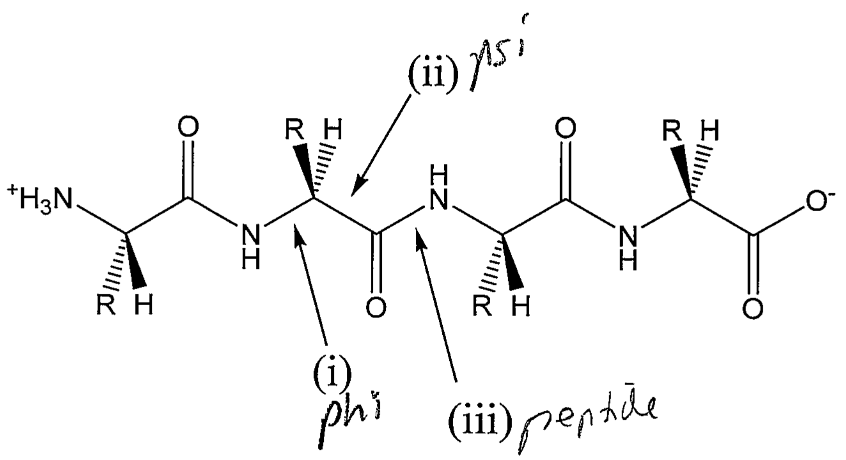
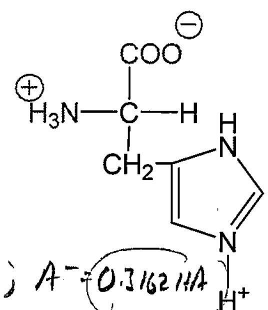
COMPREHENSIVE SECTION

(26) Name the bonds indicated by the arrows and associated numbers.



	peptide	phi	psi
(a)	(i)	(ii)	(iii)
(b)	(iii)	(ii)	(i)
(c)	(ii)	(iii)	(i)
(d)	(iii)	(i)	(ii)
(e)	(ii)	(i)	(iii)

(27) You have an aqueous 0.05 M solution of the amino acid histidine buffered at pH 5.5. Determine the concentration of the following species present in this solution.



$pH = pKa + \log \frac{[A^-]}{[HA]}$

$5.5 = 6.0 + \log \frac{A^-}{HA}$

$\log \frac{A^-}{HA} = -0.5 \quad \frac{A^-}{HA} = 0.3162 \; ; \; A^- = 0.3162\, HA$

$HA + A^- = 0.05$

$1.3162\, HA = 0.05; \quad HA = 0.0380\,M$

(a) 0.0120 M
(b) 0.0380 M
(c) 0.0158 M
(d) 0.0342 M
(e) 0.025 M

0.012

(28) Kinetic analysis of a homodimeric enzyme of 200,000 molecular weight (that is the Mr of the dimer) catalyzing conversion of substrate S to product P provides the following kinetic constants: V_{max} = 7,500 U when 1 mg of protein is assayed, and K_m = 0.10 mM. Assume each subunit contains an active site; i.e. there are two active sites per dimer.
Calculate the turnover number (units of s^{-1}) of the enzyme on the basis of monomeric units (i.e. per active site).

(a) turnover number = $7.50 \times 10^5\ s^{-1}$
(b) turnover number = $3.00 \times 10^6\ s^{-1}$
(c) turnover number = $1.25 \times 10^4\ s^{-1}$
(d) turnover number = $5.00 \times 10^4\ s^{-1}$
(e) turnover number = $4.50 \times 10^7\ s^{-1}$

$\left(\frac{7{,}500\ \mu mol\ P}{min \cdot mg}\right)\left(\frac{200{,}000\ mg}{mmol\ E}\right)\left(\frac{1\ mmol}{1000\ \mu mol}\right)\left(\frac{1\ min}{60\ s}\right)\left(\frac{1\ \mu mol\ E}{2\ \mu mol\ active\ sites}\right)$

$= 12{,}500\ s^{-1}$

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(29) What are the values that belong at the indicated positions in the purification table shown below?

Purification table for a new enzyme						
step of purification	volume (ml)	total protein (mg)	total activity (units)	specific activity (units/mg)	% recovery	fold purification
lysate	1000	20,000	15,000	0.75		
ammonium sulfate precipitation	100	6,000	10,000	(i)		
ion exchange	200	1,000	8,000		(ii)	
gel filtration	25	200	4,000	20		(iii) 26.7

(i): $\frac{10000\ u}{6000\ mg} = 1.7$

(ii) $\frac{8000}{15000} \times 100 = 53$

(iii) $SA_{gf} = 20$ $SA_L = 0.75$

$\frac{20}{0.75} = 27$-fold

	(i)	(ii)	(iii)
(a)	1.7	53	26.7
(b)	10	20	20
(c)	1.7	5.0	3.8
(d)	10	53	20
(e)	0.60	20	27

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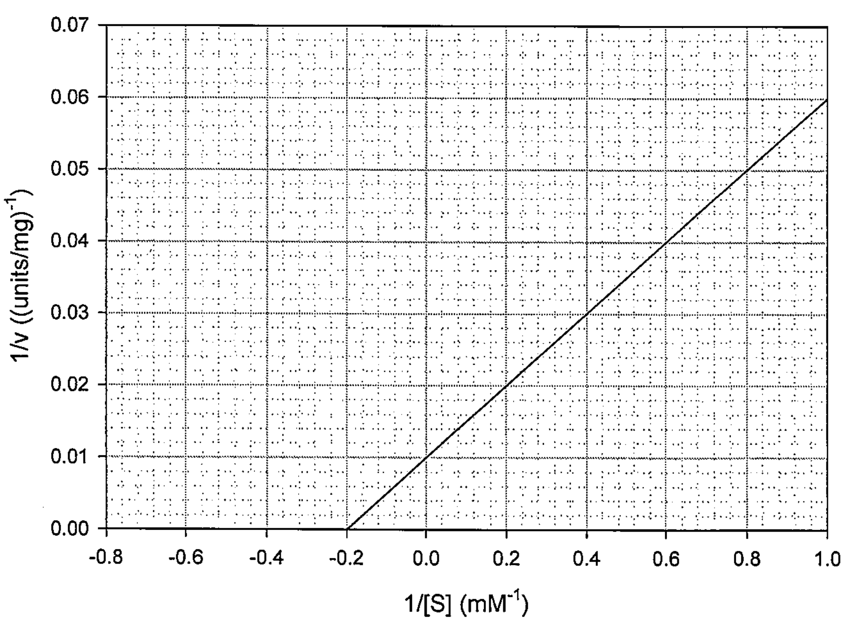
(30) (6) Using information from the following graph of 1/v vs. 1[S] for a particular enzyme, determine the initial rate of reaction if the enzyme were assayed with a concentration of substrate that is three-times greater than K_m.



(a) 75 U/mg
(b) 25 U/mg
(c) 2.5×10^{-3} U/mg
(d) 3.0×10^{2} U/mg
(e) 4.0×10^{2} U/mg

$-1/K_m = -0.2$; $K_m = 5$ mM

$1/V_{max} = 0.01$; $V_{max} = 100$ u/mg

$v = \frac{V_{max}[S]}{K_m + [S]} = \frac{(100\ u/mg)(15)}{5 + 15} = 75$

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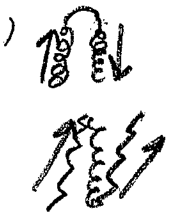
(31) For a protein with the 4-helix bundle structural motif, the approximate orientation of alpha helices is _____(i)_anti //_. For a protein with the alpha-beta barrel structural motif, the approximate orientation of beta strands is _____(ii)_//_____. For a protein with the myoglobin fold structural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

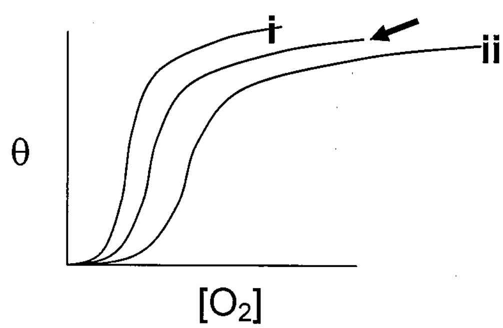
(i)



(32) Given that the line indicated by the arrow corresponds to the normal hemoglobin O_2 dissociation curve at pH 7.6, which lines are consistent with the following change in conditions?

	Increase pH	Decrease pH	decrease [DPG]	Increase [CO2]
(a)	(i)	(ii)	(ii)	(i)
(b)	(ii)	(i)	(i)	(i)
(c)	(i)	(ii)	(ii)	(ii)
(d)	(ii)	(i)	(ii)	(i)
(e)	(i)	(ii)	(i)	(ii)

$>[H^+]$: shift R
$>CO_2$ shift R
decrease DPG : shift L



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

(i) undergoes oxidation to form a disulfide Cys
(ii) achiral amino acid Gly
(iii) often found in cis conformation in proteins Pro
(iv) side chain can form Schiff base adducts with enzyme substrates Lys
(v) has a side chain containing a thioether group Met
(vi) has a side chain containing a guanidinium group Arg
(vii) amino acid whose side chain pKa is closest to 7.0 His

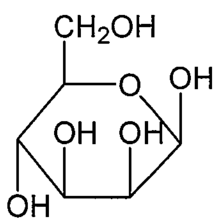
	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)
(a)	Cys	Gly	Pro	Lys	Cys	Gln	His
(b)	Cys	Gly	Pro	Lys	Met	Arg	His
(c)	Met	Gly	Ala	Arg	Cys	Lys	Asp
(d)	Cys	Ala	Gly	Lys	Met	Asn	His
(e)	Cys	Ala	Gly	Asn	Met	Arg	Gln

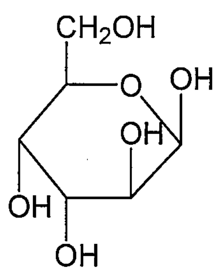
Name ______________________

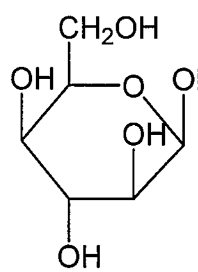
(34) What type of organic functional group is created by the following reactions.
(I) ring cyclization of D-glucose
(II) ring cyclization of D-fructose
(III) formation of trehalose from two D-glucopyranoses
(IV) oxidation of D-glucose at C1 followed by pyran ring formation

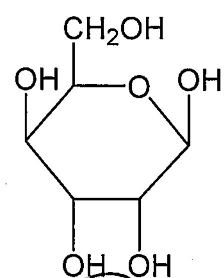
	(I)	(II)	(III)	(IV)
(a)	acetal	hemiketal	hemiacetal	delta-lactone
(b)	hemiacetal	acetal	hemiketal	delta-lactone
(c)	hemiketal	hemiacetal	acetal	delta-lactone
(d)	hemiacetal	hemiketal	acetal	delta-lactone
(e)	hemiketal	hemiketal	delta-lactone	acetal

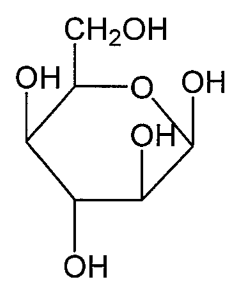
(35) What is the structure of beta-D-gulopyranose, given that D-gulose is a C-3 epimer of D-galactose, and D-galactose is a C-4 epimer of D-glucose.

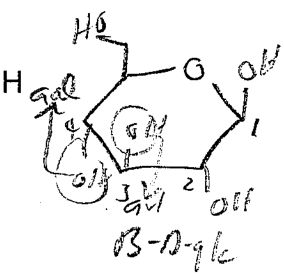

(a)


(b)


(c)


(d)


(e)



(36) What sugar linkages and repeating units are present in the following polysaccharides?
Abbreviations: Glc = glucose; NAG = N-acetylglucosamine; NAM = N-acetylmuramic acid;
(I) cellulose β 1,4 glc
(II) glycogen α 1,4 + α 1,6
(III) peptidoglycan NAM-NAG
(IV) chitin NAG

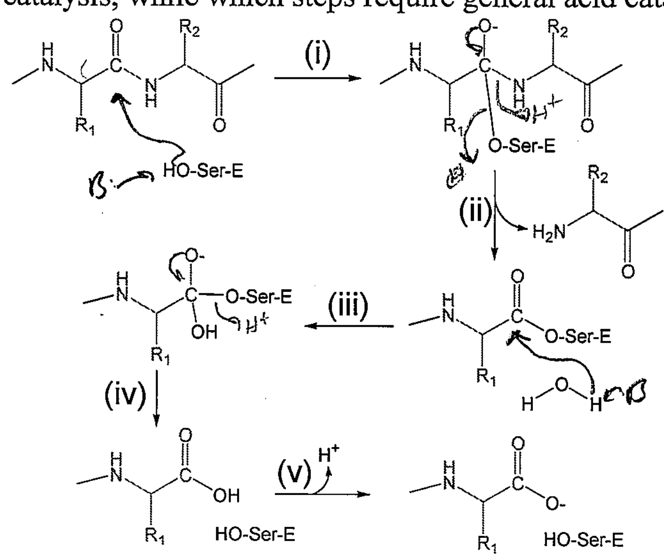
	(I)	(II)	(III)	(IV)
(a)	β-(1,4)-D-Glc	α-(1,4)- and α-(1,6)- D-Glc	β-(1,4)-D-NAM-D-NAG	β-(1,4)-D-NAG
(b)	β-(1,4)-D-Glc	α-(1,4)- and α-(1,6)- D-Glc	β-(1,4)-D-NAG	β-(1,4)-D-NAM-D-NAG
(c)	α-(1,4)-D-Glc	β-(1,4)- and β-(1,6)- D-Glc	β-(1,4)-D-NAM-D-NAG	β-(1,4)-D-NAG
(d)	α-(1,4)-D-Glc	β-(1,4)- and β-(1,6)- D-Glc	β-(1,4)-D-NAG	β-(1,4)-D-NAM-D-NAG
(e)	β-(1,4)- and β-(1,6)- D-Glc	α-(1,4)- and α-(1,6)- D-Glc	β-(1,4)-D-NAG	β-(1,4)-D-NAM-D-NAG

Name ____________________

(37) What type of transporters are the following transporters classified as? 1° = primary; 2° = secondary
(I) sodium-potassium ATPase 1° active anti
(II) glucose permease passive uni
(III) chloride-bicarbonate exchange protein passive anti
(IV) lactose permease 2° active sym

	(I)	(II)	(III)	(IV)
(a)	passive antiport	passive uniport	passive antiport	passive uniport
(b)	1°active antiport	1°active uniport	passive antiport	2° active symport
(c)	1° active antiport	passive uniport	passive antiport	2° active symport
(d)	2° active symport	passive uniport	2° active antiport	passive uniport
(e)	1°active symiport	1°active uniport	passive antiport	2° active symport

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



	Gen. base steps	Gen. acid steps
(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)

(39) Match the lipids to their correct biological functions
(I) controls utilization of calcium. D
(II) membrane plasticizer chol
(III) derived from β-carotene, responsible for vision retinal
(IV) forms micelles FA
(V) forms core structure of lipid bilayer PL

	(I)	(II)	(III)	(IV)	(V)
(a)	Vitamin D	Cholesterol	Vitamin K	sphingolipids	Glycerophospholipid
(b)	Vitamin E	Cholesterol	Vitamin K	Fatty acids	Glycerophospholipid
(c)	Cholesterol	Vitamin D	Retinal	Glycerophospholipid	Fatty acids
(d)	Vitamin D	Cholesterol	Retinal	Glycerophospholipid	Fatty acids
(e)	Vitamin D	Cholesterol	Retinal	Fatty acids	Glycerophospholipid

Name ______________________

(40) In Watson-Crick DNA, the base orientation is ___anti___, the sugar pucker is __C2' endo__, and the two strands are ___anti ||___.

(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

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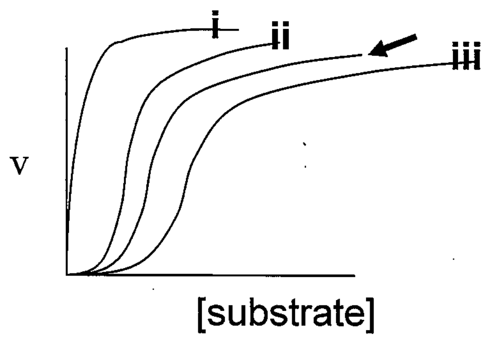
(41) Given that the line indicated by the arrow is the v vs. S plot for an allosteric enzyme in absence of modulators, which lines will represent the result of adding a positive heterotropic modulator or a negative heteroptropic modulator to the enzyme? shift

	Positive heterotropic modulator	negative heterotropic modulator
(a)	(iii)	(ii)
(b)	(ii)	(iii)
(c)	(i)	(ii)
(d)	(ii)	(i)
(e)	(iii)	(i)



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(42) 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)	Coenzyme A	NAD^+	oxidized lipoamide	thiamine pyrophosphate	FAD
(c)	thiamine pyrophosphate	oxidized lipoamide	NAD^+	Coenzyme A	FAD
(d)	FAD	NAD^+	oxidized lipoamide	thiamine pyrophosphate	Coenzyme A
(e)	oxidized lipoamide	NAD^+	FAD	thiamine pyrophosphate	Coenzyme A

Name ________________________

(43) 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

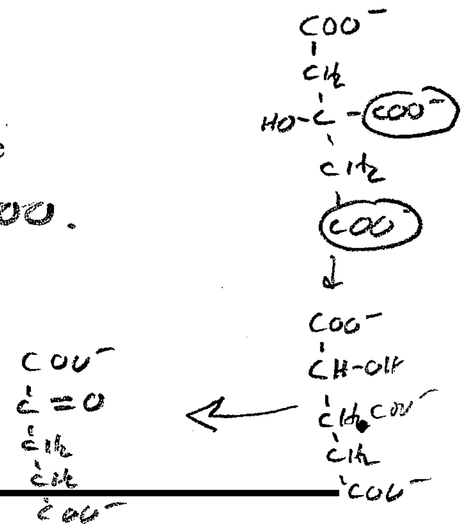
a. liver, inactivation; muscle, activation
b. liver, activation; muscle, inactivation
c. muscle, inactivation; liver, activation
d. muscle, activation; liver, inactivation

---

(44) The two moles of CO_2 produced in the first turn of the citric acid cycle have their origin in the:

a. two carbon atoms of acetate.
b. two carboxyl groups derived from oxaloacetate.
c. carboxyl group of acetate and the keto group of oxaloacetate.
d. carboxyl group of acetate and a carboxyl group of oxaloacetate

I am going to accept this too. but b is technically the correct answer



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(45) Oxidation of glucose to two pyruvate releases __(i)_ electrons; oxidation of one pyruvate to two CO_2 releases _(ii)__ electrons, and the complete oxidation of glucose to CO2 and water releases _(iii)_ electrons?

	(i)	(ii) should be	(iii)
(a)	2	4	16
(b)	2	8	16
(c)	2	8	24
(d)	4	10	24
(e)	4	8	16

4 + 11

$C_6H_{12}O_6 \rightarrow 6CO_2$ 24 24e⁻

---

(46) 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) (iii), (iv), and (v) only
(c) (i), (ii), (vi), and (vii) only
(d) (i) (iii), (iv), and (v) only
(e) (iv), and (v) only

Name ______________________

(47) Succinate dehydrogenase catalyzes the oxidation of succinate with ubiquinone as the electron acceptor. Determine ΔG' for this reaction for the following nonstandard state concentrations of substrates and products: [succinate] = 15.0 mM; [fumarate] = 0.200 mM; [Q] = 5.00 mM; [QH_2] = 1.50 mM.

succ + Q → fum + QH_2

(a) -11.0 kJ/mol
(b) +11.0 kJ/mol
(c) +7.21 kJ/mol
(d) -16.4 kJ/mol
(e) +16.4 kJ/mol

succ → fum + ~~$2H^+ + 2e^-$~~ $\quad \mathcal{E}^{o\prime} = -0.031V$

Q + ~~$2H^+ + 2e^-$~~ → QH_2 $\quad \mathcal{E}^{o\prime} = +0.045V$

$\Delta G^{o\prime} = -nF\mathcal{E}^{o\prime} \quad \mathcal{E}^{o\prime} = 0.014V$

$= -(2)(96.5)(0.014V)$

$= -2.702$ kJ/mol

$\Delta G' = \Delta G^{o\prime} + RT \ln \frac{[fum][QH_2]}{[succ][Q]}$

$\Delta G' = -2.702 \text{ kJ/mol} + \left(8.314 \frac{J}{mol\,K}\right)\left(\frac{kJ}{1000\,J}\right)(298K)\left(\ln \frac{(0.2)(1.50)}{(15)(5)}\right)$

(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)	fumarase	citrate synthase	α-ketoglutarate dehydrogenase	isocitrate dehydrogenase	aconitase
(b)	malate dehydrogenase	succinyl-CoA synthetase	isocitrate dehydrogenase	succinate dehydrogenase	aconitase
(c)	aconitase	citrate synthase	isocitrate dehydrogenase	α-ketoglutarate dehydrogenase	fumarase
(d)	fumarase	citrate synthase	isocitrate dehydrogenase	α-ketoglutarate dehydrogenase	aconitase
(e)	aconitase	citrate synthase	α-ketoglutarate dehydrogenase	isocitrate dehydrogenase	fumarase

Name ____________________

(49) For each of the following carbohydrates, what type of reaction is required as the FIRST STEP allowing that carbohydrate to enter glycolysis?

(I) stored glycogen
(II) dietary sucrose
(III) dietary galactose
(IV) dietary fructose

	(I)	(II)	(III)	(IV)
(a)	hydrolysis	epimerization	hydrolysis	phosphorylation from ATP
(b)	hydrolysis	hydrolysis	epimerization	phosphorylation from ATP
(c)	phospholysis	hydrolysis	epimerization	phosphorylation from ATP
(d)	phospholysis	hydrolysis	hydrolysis	epimerization
(e)	phospholysis	epimerization	phosphorylation from ATP	hydrolysis

(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)	(i)	(ii)	(iii)
(b)	(i)	(i)	(iv)	(ii)	(iii)
(c)	(iv)	(v)	(iii)	(ii)	(i)
(d)	(i)	(v)	(iii)	(iv)	(ii)
(e)	(iv)	(i)	(iv)	(iii)	(ii)