Biochemistry Exam 1 Nov 3, 1997

The following table may be used in answering some of the questions.

Functional Group	pK' (or range)
alpha-carboxyl in a free amino acid	1.8 to 2.4
alpha-carboxyl in a peptide	4.0
alpha-amino group in a free amino acid	9.0 to 10.8
alpha-amino group in a peptide	8.0
beta-carboxyl group of aspartate	3.9
gamma-carboxyl group of glutamate	4.3
ring nitrogen of histidine	6.0
sulfhydryl of cysteine	8.3
phenolic hydroxyl of tyrosine	10.9
epsilon-amino group of lysine	10.8
guanidino-group of arginine	12.5

1. You wish to maintain a solution at pH 7.4. The best buffer for this purpose would be a 50 mM solution of

A. Asparaginyl-glutamyl-alanyl-leucine

B. Isoleucyl-histidyl-prolyl-methionine

C. Aspartyl-glutaminyl-glycyl-valine

D. Both A and B would be equally good

E. Both A and C would be equally good

2. The maximal concentration of the isoelectric form of cysteinyl-threonyl-tyrosine will occur at a pH value of

A. 4.0

B. 6.0

C. 6.15

D. 8.15

E. 9.6

3. At pH 7.9 the net charge on the predominant species of the pentapeptide EFCNR would be

A. +2

B. +1

C. 0

D. -1

E. -2

4. On the basis of your understanding of the properties of the individual amino acids found in proteins, such as their charge, polarity and steric bulk, which of the following mutations is likely to be the least disruptive of the tertiary structure of the protein in which it occurs? (Acknowledging that any change might be disruptive depending on where it occurs)

A. A gly replaces an ala

B. A phe replaces a glu

C. A lys replaces an ile

D. An asp replaces a val

E. A pro replaces an arg

5. Which statement (or statements) concerning posttranslational modification is not true?

A. Normal blood clotting is an example of a major biological function that is dependent in part upon correct posttranslational modification

B. A defect in posttranslational modification may be inherited

C. In some proteins, posttranslational modification may involve more than one type of amino acid residue

D. The hydroxylation of a proline residue will increase the net negative charge on a protein at physiological pH values

6. Which statement concerning the 27-residue peptide shown below is true?

ELEGA - NTNEW - THEME - SAREE - MERGI - NG

A. If the molecule were subjected to three cycles of Edman degradation, a residue of leucine and two residues of glutamate would be released

B. Exhaustive digestion with trypsin will produce only two peptides

C. Residue 20 is a serine

D. The C-terminal residue is glutamic acid

E. None of the above statements is true

7. Which statement concerning the properties of a right-handed alpha helix is <u>not</u> true?

A. The structure will be disrupted by exposure to sodium dodecylsulfate

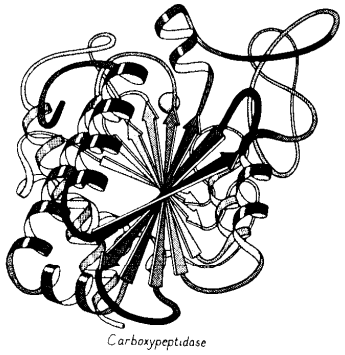
B. Hydrogen bonding between backbone atoms stabilizes the structure

C. The common amino acids vary greatly in the contribution they make to the stability of an alpha helix

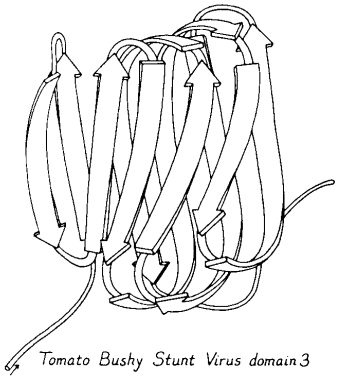
D. There is a translation along the axis of the helix of 3.6 Angstroms per residue

E. The macrodipole generated by the helix results in a positive potential at the N-terminal end of the structure

8. Schematic representations of the supersecondary structure of four proteins are shown below. Which of them belongs in the mixed alpha / beta category?

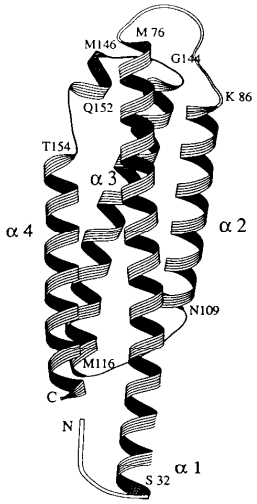


(1)



(2)

Choose the single best answer for the following questions.



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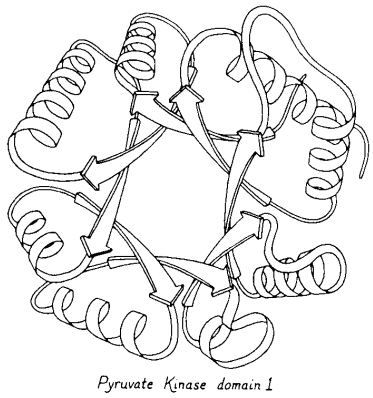


(4)

A. (1)

B. (2)

C. (3)

D. (4)

E. Both (1) and (4)

9. This protein (or these proteins) has no quaternary structure

A. The H_4 form of lactate dehydrogenase

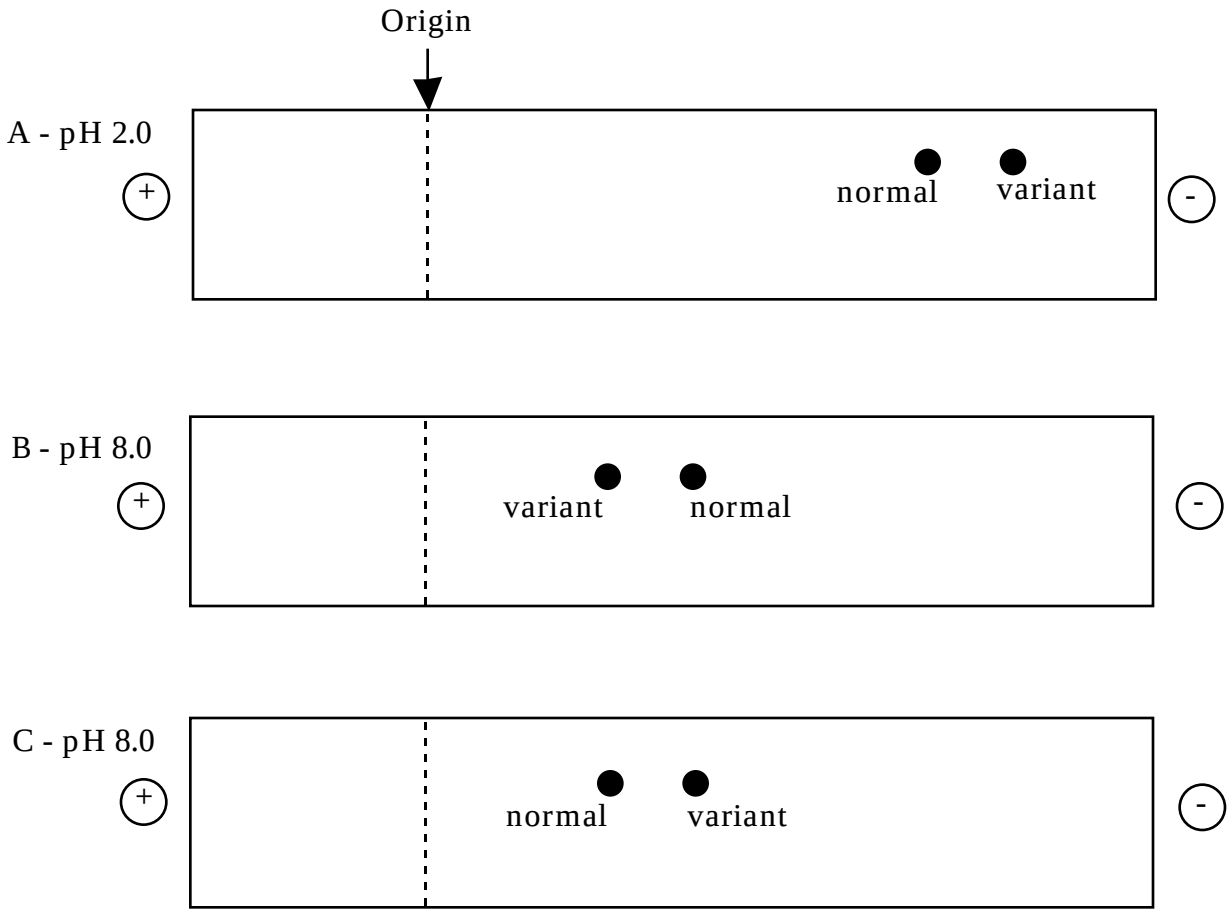
B. The collagens

C. Hemoglobin Portland

D. The immunoglobulins G

E. All of the above proteins have quaternary structure

10. In an electrophoretically detectable variant of hemoglobin A, a histidine was found to have replaced the methionine residue at position 55 in the beta chain. Which of the patterns shown below would be predicted for electrophoretic experiments at the indicated pH values for the beta chains of normal Hb A and of the variant?



A. Pattern "A" only

B. Pattern "B" only

C. Pattern "C" only

D. Both patterns "A" and "B"

E. Both patterns "A" and "C"

11. Myoglobin and hemoglobin A share the following characteristics *except*

A. They utilize an iron-protoporphyrin IX complex as a prosthetic group

B. They bind oxygen reversibly and cooperatively

C. Carbon monoxide binds less tightly to the iron atom (or iron atoms) than it does to a simple heme molecule

D. The iron atom (or iron atoms) remain in the ferrous (+2) state in the presence of oxygen

12. Hemoglobin S

A. is formed as the result of a posttranslational error

B. can polymerize upon deoxygenation

C. is present in significant amounts postnatally in homozygous alpha thalassemia (alpha thalassemia major)

D. contains beta chains in which a glutamate has replaced val-6

E. both B and D

13. Hemoglobin F (HbF) differs from hemoglobin A in the following way:

A. HbF binds oxygen reversibly and cooperatively

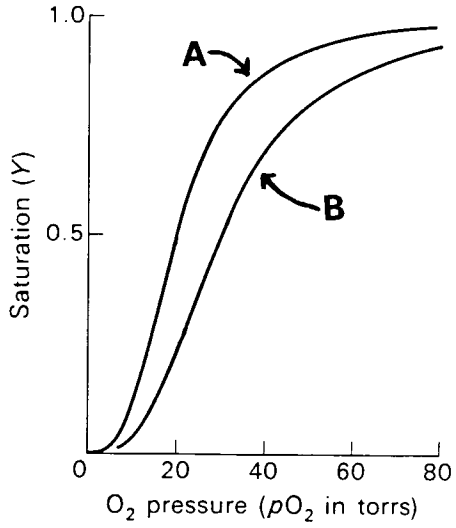
B. HbF's Hill coefficient is greater than one

C. HbF is composed of alpha and gamma subunits

D. HbF has a higher affinity for BPG than does hemoglobin A

E. One of HbF's subunits comes from chromosome 11 and the other comes from chromosome 16

14. If curve B in the figure below is hemoglobin A at pH 7.2 in the presence of one equivalent of 2,3-bisphosphoglycerate (BPG), then curve A could represent the oxygen affinity of



A. hemoglobin A at pH 7.6 in the presence of one equivalent of BPG

B. hemoglobin A at pH 7.2 in the presence of 0.5 equivalent of BPG

C. hemoglobin F at pH 7.2 in the presence of one equivalent of BPG

D. both A and B

E. A, B or C

15. Amino acid analysis of the alpha chain of a variant hemoglobin has revealed that one of its seven phenylalanine residues has been replaced by a tyrosine. To determine where along the chain this replacement has occurred, a sample of the variant chain was digested with trypsin and the resulting mixture of peptides was fractionated by HPLC. A peptide seen in the variant, but not found in a tryptic digest of the normal alpha chain, was composed of 1 lys, 1 ser, 2 thr, 1 pro, 1 met, 1 leu, 1 tyr, and 1 phe. Using the amino acid sequence of the alpha chain of normal hemoglobin given below, determine the location of the phenylalanine to tyrosine replacement.

```
                    5                  10                  15
  1 VAL LEU SER PRO ALA ASP LYS THR ASN VAL LYS ALA ALA TRP GLY
 16 LYS VAL GLY ALA HIS ALA GLY GLU TYR GLY ALA GLU ALA LEU GLU
 31 ARG MET PHE LEU SER PHE PRO THR THR LYS THR TYR PHE PRO HIS
 46 PHE ASP LEU SER HIS GLY SER ALA GLN VAL LYS GLY HIS GLY LEU
 61 LYS VAL ALA ASP ALA LEU THR ASN ALA VAL ALA HIS VAL ASP ASP
 76 MET PRO ASN ALA LEU SER ALA LEU SER ASP LEU HIS ALA HIS LYS
 91 LEU ARG VAL ASP PRO VAL ASN PHE LYS LEU LEU SER HIS CYS LEU
106 LEU VAL THR LEU ALA ALA HIS LEU PRO ALA GLU PHE THR PRO ALA
121 VAL HIS ALA SER LEU ASP LYS PHE LEU ALA SER VAL SER THR VAL
136 LEU THR SER LYS TYR ARG
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A. Tyrosine has replaced phe-33

B. Tyrosine has replaced either phe-33 or phe-36

C. Tyrosine has replaced either phe-43 or phe-46

D. Tyrosine has replaced phe-98

E. Tyrosine has replaced phe-128

16. The standard free energy changes for two reactions are:

	kcal / mol
glucose + ATP -> glucose 6-phosphate + ADP	-4.0
glucose 6-phosphate -> fructose 6-phosphate	+0.4

You discover a new enzyme that converts glucose and ATP into fructose 6-phosphate and ADP. What can you deduce about this new reaction?

A. the enzyme is a phosphorylase

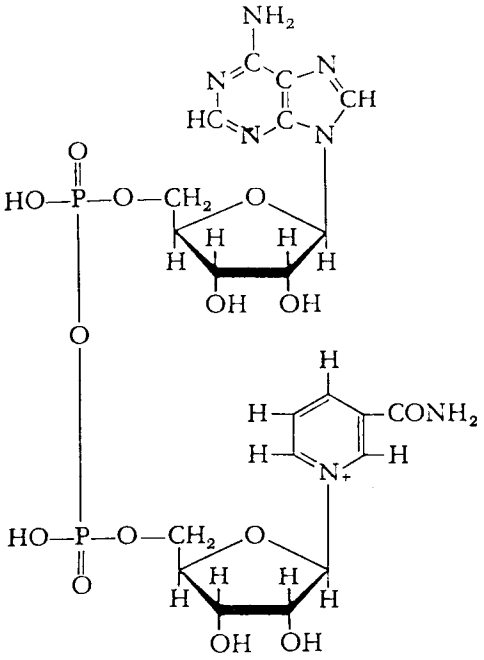
B. the enzyme is a phosphatase

C. the standard free energy change of the reaction is +4.4 kcal / mol

D. the standard free energy of the reaction is -4.4 kcal / mol

E. the equilibrium lies to the right in the standard state

17. The structure below



A. is a vitamin

B. serves as an acetyl carrier

C. contains two fructose rings

D. requires niacin for its synthesis by the body

E. is riboflavin

18. Suppose a person has a mutation in the tandem enzyme that regulates hepatic levels of fructose 2,6-bisphosphate. Specifically, the mutation causes a faster than normal rate of dephosphorylation of the phosphorylated enzyme so that the ratio of the phosphorylated to the dephosphorylated form is inappropriately low. You might logically expect to find any of the following <u>except</u>A. elevated hepatic levels of fructose 2,6-bisphosphate

B. increased uptake of glucose by the hepatocyte

C. an inappropriate activation of liver PFK 1

D. severe hyperglycemia

E. all of the above

19. When water is placed in a freezer at -15˚ C the ensuing process is best described as

A. spontaneous, exergonic and endothermic

B. nonspontaneous, exergonic and endothermic

C. spontaneous, exergonic and exothermic

D. spontaneous, endergonic and exothermic

E. nonspontaneous, endergonic and exothermic

20. What is the net yield of ATP per glucose 6-phosphate when glucose 6-phosphate is converted into lactate by anaerobic glycolysis?

A. 0

B. 1

C. 2

D. 3

E. 4

21. Insulin release from the pancreatic β-cells appears to be favored by all of the following events within the pancreatic cells EXCEPT

A. elevated ATP:ADP levels

B. closing of a K^+ channel

C. increased rate of glycolysis

D. efflux of Ca^{2+} out of the cell

E. decreased polarization of the plasma membrane

22. A severe deficiency in which of the following red cell glycolytic enzymes could lead to hemolytic anemia?

A. hexokinase

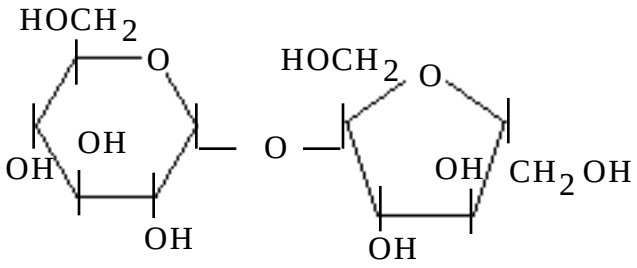
B. glyceraldehyde 3-phosphate dehydrogenase

C. aldolase

D. pyruvate kinase

E. any one of the above

23. The compound below should be restricted in the diet of individuals who



A. are lactose intolerant

B. are fructose intolerant

C. are galactosemic

D. have a severe fumarase deficiency

E. attend medical school

24. Vitamins that contribute to the conversion of pyruvate to acetyl CoA include all of the following EXCEPT

A. niacin

B. thiamine

C. pyridoxal

D. riboflavin

E. pantothenic acid

25. Which *pair* of metabolites require inorganic phosphate in the next step of their catabolism?

A. succinyl CoA and phosphoenol pyruvate

B. succinyl CoA and glyceraldehyde 3-phosphate

C. pyruvate and α-ketoglutarate

D. glucose 6-phosphate and 1,3-bisphosphoglycerate

E. fructose 6-phosphate and succinyl CoA

26. Galactose differs in structure from glucose in which way?

A. only at the configuration at the anomeric carbon

B. galactose is a disaccharide

C. in configuration at carbon 4

D. galactose cannot form cyclic ring structures

E. galactose is a ketose

27. In a widely used method for determining blood glucose, blood glucose is enzymatically oxidized in a test-tube by a reaction which gives a pink color. The intensity of this color is then compared to that of a glucose standard. However, it is essential to age the glucose standard solution after it have been made up from crystalline α-D glucose before the standard is used in this test. What is the most likely explanation for the need for aging based on your knowledge of glucose chemistry?

A. a freshly-prepared solution of glucose will slowly undergo mutarotation to form an equilibrium mixture of both α and β forms. The enzyme is likely to react preferentially with only one form, hence the need to age to attain an equilibrium mixture of a definite composition

B. glucose in solution is hydrolyzed to convert it all into 100% of the open chain form

C. glucose probably reacts with trace amount of protein impurities in the distilled water to form adducts which are the true substrates for the enzyme

D. laboratory technicians always make up solutions the day before use to be sure they have them in hand when needed

E. The solution should be left overnight to be sure it is completely mixed

28. Which enzyme catalyzes the formation of a compound with a high-energy phosphate bond?

A. phosphofructokinase

B. hexokinase

C. enolase

D. aldolase

E. triose phosphate isomerase

29. Suppose a bacterial toxin is produced that inhibits the activity of triose phosphate isomerase in red blood cells, thereby blocking the interconversion of dihydroxy acetone phosphate and glyceraldehyde 3-phosphate. How many net ATP would you expect to be formed per glucose that entered glycolysis if the isomerase activity was completely blocked?

A. 0

B. 0.5

C. 1

D. 1.5

E. 2

30. A compound formed in the mitochondrial matrix that can enter the cytoplasm and inhibit glycolysis is

A. citrate

B. oxaloacetate

C. aspartate

D. succinate

E. malate

31. In a reported case of siblings with a fumarase deficiency the compound that was excreted in high levels in the urine was

A. oxaloacetate

B. citrate

C. α-ketoglutarate

D. fumarate

E. malate

32. An enzyme has a K_M = 0.1 mM. Under conditions in which [S] = 0.1 mM, the velocity of the reaction is 50 µmol / min. What is the V_{MAX} value for this enzyme?

A. 50 µmol / min

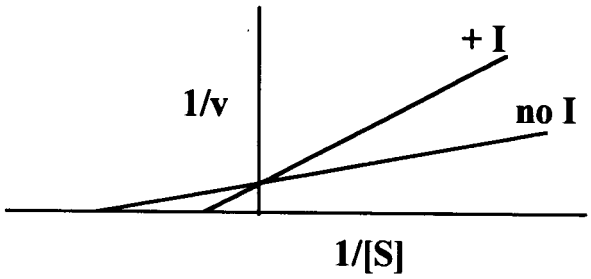
B. 100 µmol / min

C. 500 µmol / min

D. 1000 µmol / min

E. 5000 µmol / min

33. The following plot shows the activity of an enzyme in the absence (no I) and in the presence (+I) of an inhibitor. Which statement is correct?



A. The inhibitor and substrate can be bound simultaneously to the enzyme.

B. The inhibitor decreases the K_M.

C. The inhibition is irreversible.

D. The inhibitor binds to the active site of the enzyme.

E. The inhibitor decreases the V_{MAX}.

34. Two tissue samples (kidney and brain) of equal protein concentrations are assayed for Enzyme X. The K_M and catalytic activity values for Enzyme X are the same in both tissue samples. The rate of the reaction catalyzed by Enzyme X in the kidney sample is found to be one-tenth of the rate measured for Enzyme X in the brain sample. Assume that the molar concentration of substrate is not limiting in both the kidney and brain samples. Which of the following statements offers the best explanation for the observed results?

A. There is ten times more Enzyme X in the brain sample versus the kidney sample.

B. There is two times more Enzyme X in the brain sample versus the kidney sample.

C. The amount of Enzyme X is the same in both samples but kidney Enzyme X requires ten times more substrate to form the enzyme-substrate (ES) complex versus brain Enzyme X.

D. The amount of Enzyme X is the same in both samples but brain Enzyme X requires ten times less substrate to form the enzyme-substrate (ES) complex versus kidney Enzyme X.

E. The amount of Enzyme X is the same in both samples but brain Enzyme X alters the equilibrium constant for the reaction by a factor of ten in favor of product formation.

35. Which of the following can react covalently with an enzyme?

A. cofactor

B. substrate

C. affinity label

D. suicide substrate

E. all of the above

36. Which of the following statements about enzymes is correct?

A. The amino acids that are involved in an enzyme catalytic mechanism are always immediately next to each other in the linear protein sequence.

B. Enzymes are never permanently changed as a result of catalyzing a chemical reaction, except in cases of mechanisms that employ covalent catalysis.

C. Enzymes can be inactivated by the covalent modification of a single amino acid.

D. As a general rule, enzymes are optimally active at all pH values.

E. Enzymes increase the rate of reactions by increasing the energy of activation.

37. The catalytic mechanisms of lysozyme and chymotrypsin both involve

A. stabilization of a positive charge formed during the catalytic event.

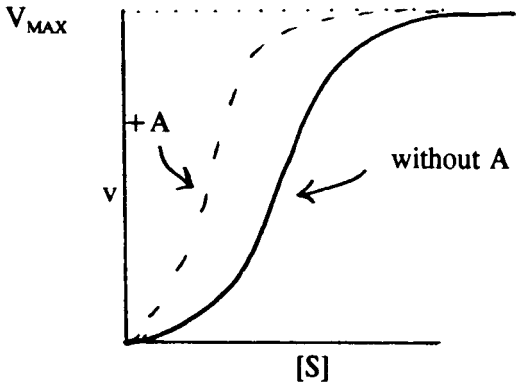
B. formation of a covalent bond between the substrate and enzyme.

C. cleavage of a peptide bond.

D. resonance stabilization of a reaction intermediate.

E. all of the above.

38. An allosteric enzyme has two identical subunits, each of which contains one active site and one regulatory site. The plot below shows the activity of the enzyme in the presence of substrate alone (solid line) and in the presence of substrate plus an additional effector molecule, A (dotted line). Based on the information given, which of the following statements is correct?



A. Compound A must resemble the structure of the substrate to exert its effect.

B. Compound A decreases the K_M for substrate.

C. Compound A competes with substrate for binding to the enzyme.

D. Compound A binds to the active site in one subunit and increases the affinity for substrate at the second active site.

E. Compound A binds to the regulatory sites and decreases the affinity for substrate in the active sites.

39. Which of the following statements about enzyme regulation is NOT correct?

A. Zymogen activation is an irreversible process.

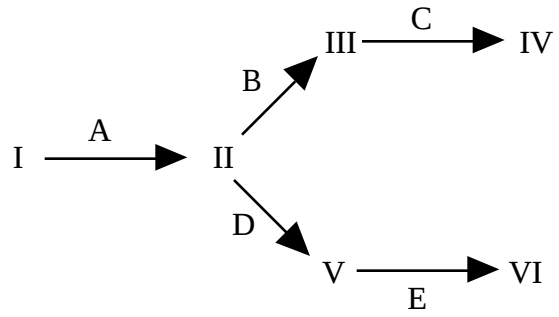
B. Allosteric activation of enzymes is reversible.

C. In a branched chain metabolic pathway, the enzyme that catalyzes the reaction before the branch point is most likely to be feed-back inhibited.

D. Enzyme activity can be regulated through covalent modification.

E. Enzyme activity can be regulated by metabolites that do not resemble the structure of the substrate.

40. Enzymes A to E catalyze the individual steps in the branched metabolic pathway shown. The Roman numerals indicate different metabolites. Product inhibition would be illustrated by compound IV inhibiting which enzyme?



A. A.

B. B.

C. C.

D. D.

E. E.

In each group, for each numbered question select the best lettered answer. Each lettered answer may be selected once, more than once, or not at all.

41. Possess the smallest and the largest of the side chains of the common amino acids

42. A positive (attractive) ionic interaction could occur between the side chains of these two amino acids

43. Both side chains contain sulfur

44. Both side chains carry a positive charge at physiological pH values

A. P and Y

B. A and W

C. F and Y

D. K and D

E. G and W

F. G and Y

G. R and L

H. M and C

I. R and K

J. G and P

In each group, for each numbered question select the best lettered answer. Each lettered answer may be selected once, more than once, or not at all.

45. Formed by a covalent posttranslational modification

46. A motif of secondary structure

A. Peptide bond

B. Disulfide bond

C. Hydrogen bond

D. Hydrophobic core

E. Ionic interaction

F. Beta turn

47. Hb A_2

48. Hb Bart's

A. A hemoglobin in which the replacement of a phe by a ser in the heme pocket of the beta chain weakens heme binding

B. The predominant hemoglobin found in homozygous alpha thalassemia (alpha thalassemia major)

C. A hemoglobin containing two alpha chains and two delta chains

D. A normal embryonic hemoglobin

E. An alpha chain variant in which the iron atom is stabilized in the ferric (+3) form

49. Uses water as one of its substrates

In each group, for each numbered question select the best lettered answer. Each lettered answer may be selected once, more than once, or not at all.

50. Catalyzes a decarboxylation

A. malate dehydrogenase

B. citrate synthase

C. pyruvate dehydrogenase

D. succinate thiokinase

E. succinate dehydrogenase

51. Number of NADH produced from each acetyl CoA for one complete turn of the TCA cycle

52. Number of $FADH_2$ produced from each acetyl CoA for one complete turn of the TCA cycle.

A. 0

B. 1

C. 2

D. 3

E. 4

53. Condition required for a chemical reaction to be spontaneous

In each group, for each numbered question select the best lettered answer. Each lettered answer may be selected once, more than once, or not at all.

54. Condition required for a chemical reaction to produce heat.

A. ΔG should be negative

B. ΔG should be positive

C. ΔH should be negative

D. ΔH should be positive

E. process should be endothermic

F. process should be endergonic

G. ΔS should decrease

55. Catalyzes an irreversible step in the conversion of glucose into lactate

56. Catalyzes the first committed step in glycolysis

A. aldolase

B. phosphoglucoisomerase

C. glyceraldehyde 3-phosphate dehydrogenase

D. lactate dehydrogenase

E. phosphofructokinase 1

F. phosphofructokinase 2