A PART

Single-choice questions: (34 points)

1. Enzymes are biological catalysts that enhance the rate of a reaction by:
   (A) decreasing the amount of free energy released.
   (B) increasing the activation energy.
   (C) increasing the amount of free energy released.
   (D) decreasing the activation energy.
   (E) increasing the energy of the transition state.

2. The three-dimensional structure of a protein is determined primarily by:
   (A) electrostatic guidance from nucleic acid structure.
   (B) how many amino acids are in the protein.
   (C) the sequence of amino acids in the protein.
   (D) hydrophobic interaction with lipids that provide a folding framework.
   (E) modification during interactions with ribosomes.

3. The bacterium *E. coli* requires simple organic molecules for growth and energy—it is therefore a:
   (A) chemoheterotroph.
   (B) chemoautotroph.
   (C) lithotroph.
   (D) photoautotroph.
   (E) photoheterotroph.

4. Which of the following is true about the properties of aqueous solutions?
   (A) A pH change from 5.0 to 6.0 reflects an increase in the hydroxide ion concentration ([OH⁻]) of 20%.
   (B) A pH change from 8.0 to 6.0 reflects a decrease in the proton concentration ([H⁺]) by a factor of 100.
   (C) Hydrogen bonds form readily in aqueous solutions.
   (D) Charged molecules are generally insoluble in water.
   (E) The pH can be calculated by adding 7 to the value of the pOH.
5. The pH of a sample of blood is 7.4, while gastric juice is pH 1.4. The blood sample has:
   (A) a million times lower $[H^+]$ than the gastric juice.
   (B) 6,000 times lower $[H^+]$ than the gastric juice.
   (C) 6 times lower $[H^+]$ than the gastric juice.
   (D) 0.189 times the $[H^+]$ as the gastric juice.
   (E) 5.29 times lower $[H^+]$ than the gastric juice.

6. For amino acids with neutral R groups, at any pH below the pI of the amino acid, the population of amino acids in solution will have:
   (A) no charged groups.
   (B) a net negative charge.
   (C) a net positive charge.
   (D) no net charge.
   (E) positive and negative charges in equal concentration.

7. Which of the following is correct with respect to the amino acid composition of proteins?
   (A) Larger proteins have a more uniform distribution of amino acids than smaller proteins.
   (B) Proteins contain at least one each of the 20 different standard amino acids.
   (C) Proteins with the same molecular weight have the same amino acid composition.
   (D) Proteins with different functions usually differ significantly in their amino acid composition.
   (E) The average molecular weight of an amino acid in a protein increases with the size of the protein.

8. In a conjugated protein, a prosthetic group is:
   (A) a fibrous region of a globular protein.
   (B) a nonidentical subunit of a protein with many identical subunits.
   (C) a subunit of an oligomeric protein.
   (D) synonymous with "protomer."
   (E) a part of the protein that is not composed of amino acids.

9. In a mixture of the five proteins listed below, which should elute first in size-exclusion (gel-filtration) chromatography?
(A) cytochrome c \( M_r = 13,000 \)
(B) immunoglobulin G \( M_r = 145,000 \)
(C) ribonuclease A \( M_r = 13,700 \)
(D) RNA polymerase \( M_r = 450,000 \)
(E) serum albumin \( M_r = 68,500 \)

10. By adding SDS (sodium dodecyl sulfate) during the electrophoresis of proteins, it is possible to:
   (A) determine a protein’s isoelectric point.
   (B) determine an enzyme’s specific activity.
   (C) separate proteins exclusively on the basis of molecular weight.
   (D) determine the amino acid composition of the protein.
   (E) preserve a protein’s native structure and biological activity.

11. The term “proteome” has been used to describe:
   (A) regions (domains) within proteins.
   (B) the complement of proteins encoded by an organism’s DNA.
   (C) regularities in protein structures.
   (D) the structure of a protein-synthesizing ribosome.
   (E) the tertiary structure of a protein.

12. Compare the following sequences taken from four different proteins, and select the answer that best characterizes their relationships.

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DVEKGGKIDMKCS</td>
<td>HTVEKGGKHKTGPNLH</td>
</tr>
<tr>
<td>2</td>
<td>DVQRALKIDNNLGQ</td>
<td>HTVEKGAHKTAPNVH</td>
</tr>
<tr>
<td>3</td>
<td>LVTRPLYIFPGEGQ</td>
<td>HTLEKAAKHKTGPNLH</td>
</tr>
<tr>
<td>4</td>
<td>FFMNEDALVARSSN</td>
<td>HQFAASSIHKNAPQFH</td>
</tr>
</tbody>
</table>

   (A) Comparing proteins 1 and 2 in column A reveals that these two proteins have diverged the most throughout evolution.
   (B) Protein 4 is the protein that shows the greatest overall homology to protein 1.
   (C) Proteins 2 and 3 show a greater evolutionary distance than proteins 1 and 4.
   (D) The portions of amino acid sequence shown suggest that these proteins are completely unrelated.
13. In the $\alpha$ helix the hydrogen bonds:
(A) are roughly perpendicular to the axis of the helix.
(B) occur mainly between electronegative atoms of the R groups.
(C) occur only between some of the amino acids of the helix.
(D) are roughly parallel to the axis of the helix.
(E) occur only near the amino and carboxyl termini of the helix.

14. An average protein will not be denatured by:
(A) a detergent such as sodium dodecyl sulfate.
(B) heating to 90°C.
(C) pH 10.
(D) urea.
(E) iodoacetic acid.

15. Which of the following is not correct concerning cooperative binding of a ligand to a protein?
(A) It rarely occurs in enzymes.
(B) It is usually a form of allosteric interaction.
(C) It is usually associated with proteins with multiple subunits.
(D) It results in a nonlinear Hill Plot.
(E) It results in a sigmoidal binding curve.

16. The concept of “induced fit” refers to the fact that:
(A) substrate binding may induce a conformational change in the enzyme, which then brings catalytic groups into proper orientation.
(B) enzyme specificity is induced by enzyme-substrate binding.
(C) enzyme-substrate binding induces an increase in the reaction entropy, thereby catalyzing the reaction.
(D) enzyme-substrate binding induces movement along the reaction coordinate to the transition state.
(E) when a substrate binds to an enzyme, the enzyme induces a loss of water (desolvation) from the substrate.
17. A hydropathy plot is used to:
   (A) determine the water-solubility of a protein.
   (B) predict whether a given protein sequence contains membrane-spanning segments.
   (C) deduce the quaternary structure of a membrane protein.
   (D) determine the water content of a native protein.
   (E) extrapolate for the true molecular weight of a membrane protein.

B PART

Single-choice questions: (34 points)

1. In a bacterial cell, the DNA is in the:
   A) cell envelope.
   B) cell membrane.
   C) nucleoid.
   D) nucleus.
   E) ribosomes.

2. Consider an acetate buffer, initially at the same pH as its pKa (4.76). When sodium hydroxide
   (NaOH) is mixed with this buffer, the:
   A) pH remains constant.
   B) pH rises more than if an equal amount of NaOH is added to an acetate buffer initially at pH
      6.76.
   C) pH rises more than if an equal amount of NaOH is added to unbuffered water at pH 4.76.
   D) ratio of acetic acid to sodium acetate in the buffer falls.
   E) sodium acetate formed precipitates because it is less soluble than acetic acid.

3. Which of the following does not apply to the construction or use of a DNA library?
   A) Determining the location of a particular DNA sequence in a DNA library requires a suitable
      hybridization probe.
   B) Genomic libraries are better for expressing gene products than cDNA libraries.
   C) Many segments of DNA from a cellular genome are cloned.
   D) Specialized DNA libraries can be made by cloning DNA copies of mRNAs.
The DNA copies of mRNA found in a cDNA library are made by reverse transcriptase.

4. The term specific activity differs from the term activity in that specific activity:
   A) is measured only under optimal conditions.
   B) is the activity (enzyme units) in a milligram of protein.
   C) is the activity (enzyme units) of a specific protein.
   D) refers only to a purified protein.
   E) refers to proteins other than enzymes.

5. Restriction enzymes:
   A) act at the membrane to restrict the passage of certain molecules into the cell.
   B) are highly specialized ribonucleases that degrade mRNA soon after its synthesis.
   C) are sequence-specific DNA endonucleases.
   D) are very specific proteases that cleave peptides at only certain sequences.
   E) catalyze the addition of a certain amino acid to a specific tRNA.

6. Which of the following statements regarding plasmid cloning vectors is correct?
   A) Circular plasmids do not require an origin of replication to be propagated in E. coli.
   B) Foreign DNA fragments up to 45,000 base pairs can be cloned in a typical plasmid.
   C) Plasmids do not need to contain genes that confer resistance to antibiotics.
   D) Plasmid vectors must carry promoters for inserted gene fragments.
   E) The copy number of plasmids may vary from a few to several hundred.

7. Which of the following statements about the polymerase chain reaction (PCR) is false?
   A) DNA amplified by PCR can be cloned.
   B) DNA is amplified at many points within a cellular genome.
   C) Newly synthesized DNA must be heat-denatured before the next round of DNA synthesis begins.
   D) The boundaries of the amplified DNA segment are determined by the synthetic oligonucleotides used to prime DNA synthesis.
   E) The technique is sufficiently sensitive that DNA sequences can be amplified from a single animal or human hair.

8. In genetic engineering, in vitro packaging is used to:
   A) cut a desired region out of the host bacterium's chromosome.
B) ensure that genetically engineered bacteria are not accidentally released into the environment.
C) incorporate recombinant DNA into infectious bacteriophage particles.
D) place an antibiotic resistance gene in a plasmid.
E) splice a desired gene into a plasmid.

9. Which one of the following analytical techniques does not help illuminate a gene’s cellular function?
A) DNA microarray analysis
B) Protein chip analysis
C) Southern blotting
D) Two-dimensional gel electrophoresis
E) Two-hybrid analysis

10. Membrane proteins:
   A) are sometimes covalently attached to lipid moieties.
   B) are sometimes covalently attached to carbohydrate moieties.
   C) are composed of the same 20 amino acids found in soluble proteins.
   D) diffuse laterally in the membrane unless they are anchored.
   E) have all of the properties listed above.

11. The specificity of signaling pathways includes all of the following except:
   A) flippase-catalyzed movement of phospholipids from the inner to the outer leaflet.
   B) migration of signal proteins into membrane rafts.
   C) phosphorylation of target proteins at Ser, Thr, or Tyr residues.
   D) the ability to be switched off instantly by hydrolysis of a single phosphate-ester bond.
   E) the assembly of large multiprotein complexes.

12. Based on Chargaff’s rules, which of the following are possible base compositions for double-stranded DNA?

<table>
<thead>
<tr>
<th>%A</th>
<th>%G</th>
<th>%C</th>
<th>%T</th>
<th>%U</th>
</tr>
</thead>
</table>
   A) | 5  | 45 | 45 | 5  | 0  |
   B) | 20 | 20 | 20 | 20 | 0  |
   C) | 35 | 15 | 35 | 15 | 0  |
   D) All of the above.
13. Which of the following is not a reducing sugar?
   A) Fructose
   B) Glucose
   C) Glyceraldehyde
   D) Ribose
   E) Sucrose

14. Which of the following statements apply (applies) to the β oxidation of fatty acids?
   1. The process takes place in the cytosol of mammalian cells.
   2. Carbon atoms are removed from the acyl chain one at a time.
   3. Before oxidation, fatty acids must be converted to their CoA derivatives.
   4. NADP⁺ is the electron acceptor.
   5. The products of oxidation can directly enter the citric acid cycle for further oxidation.
   A) 1 and 3 only
   B) 1, 2, and 3
   C) 1, 2, and 5
   D) 3 and 5 only
   E) 4 only

15. Almost all of the oxygen (O₂) one consumes in breathing is converted to:
   A) acetyl-CoA.
   B) carbon dioxide (CO₂).
   C) carbon monoxide and then to carbon dioxide.
   D) none of the above.
   E) water.

16. The light reactions in photosynthetic higher plants:
   A) do not require chlorophyll.
   B) produce ATP and consume NADH.
   C) require the action of a single reaction center.
   D) result in the splitting of H₂O, yielding O₂.
   E) serve to produce light so that plants can see underground.
17. The compound that condenses with CO₂ in the first reaction of carbon dioxide assimilation is:
   A) 3-phosphoglycerate.
   B) ribose 1,5-bisphosphate.
   C) ribulose 1,5-bisphosphate.
   D) ribulose 5-phosphate.
   E) rubisco.

C PART

Single-choice questions: (32 points)

1. A major component of RNA but not of DNA is:
   A) adenine.
   B) cytosine.
   C) guanine.
   D) thymine.
   E) uracil.

2. In a double-stranded nucleic acid, cytosine typically base-pairs with:
   A) adenosine.
   B) guanine.
   C) inosine.
   D) thymine.
   E) uracil.

3. In double-stranded DNA:
   A) only a right-handed helix is possible.
   B) sequences rich in A-T base pairs are denatured less readily than those rich in G-C pairs.
   C) the sequence of bases has no effect on the overall structure.
   D) the two strands are parallel.
   E) the two strands have complementary sequences.

4. In nucleotides and nucleic acids, syn and anti conformations relate to:
   A) base stereoisomers.
   B) rotation around the phosphodiester bond.
C) rotation around the sugar-base bond.
D) sugar pucker.
E) sugar stereoisomers.

5. In an α helix, the R groups on the amino acid residues:
   A) alternate between the outside and the inside of the helix.
   B) are found on the outside of the helix spiral.
   C) cause only right-handed helices to form.
   D) generate the hydrogen bonds that form the helix.
   E) stack within the interior of the helix.

6. How is trypsinogen converted to trypsin?
   A) A protein kinase-catalyzed phosphorylation converts trypsinogen to trypsin.
   B) An increase in Ca²⁺ concentration promotes the conversion.
   C) Proteolysis of trypsinogen forms trypsin.
   D) Trypsinogen dimers bind an allosteric modulator, cAMP, causing dissociation into active trypsin monomers.
   E) Two inactive trypsinogen dimers pair to form an active trypsin tetramer.

7. The PCR reaction mixture does not include:
   A) all four deoxynucleoside triphosphates.
   B) DNA containing the sequence to be amplified.
   C) DNA ligase.
   D) heat-stable DNA polymerase.
   E) oligonucleotide primer(s).

8. Which of the following statements about aromatic amino acids is correct?
   A) All are strongly hydrophilic.
   B) Histidine’s ring structure results in its being categorized as aromatic or basic, depending on pH.
   C) On a molar basis, tryptophan absorbs more ultraviolet light than tyrosine.
   D) The major contribution to the characteristic absorption of light at 280 nm by proteins is the phenylalanine R group.
   E) The presence of a ring structure in its R group determines whether or not an amino acid is aromatic.
9. Which of the following statements concerning protein domains is true?
   A) They are a form of secondary structure.
   B) They are examples of structural motifs.
   C) They consist of separate polypeptide chains (subunits).
   D) They have been found only in prokaryotic proteins.
   E) They may retain their correct shape even when separated from the rest of the protein.

10. Proteins are classified within families or superfamilies based on similarities in:
    A) evolutionary origin.
    B) physico-chemical properties.
    C) structure and/or function.
    D) subcellular location.
    E) subunit structure.

11. A repeating structural unit in a multimeric protein is known as a(n):
    A) domain.
    B) motif.
    C) oligomer.
    D) protomer.
    E) subunit.

12. A small molecule that decreases the activity of an enzyme by binding to a site other than the catalytic site is termed a(n):
    A) allosteric inhibitor.
    B) alternative inhibitor.
    C) competitive inhibitor.
    D) stereospecific agent.
    E) transition-state analog.

13. Which of the following has not been shown to play a role in determining the specificity of protein kinases?
    A) Disulfide bonds near the phosphorylation site
    B) Primary sequence at phosphorylation site
    C) Protein quaternary structure
14. Which of the following deoxyoligonucleotides will hybridize with a DNA containing the sequence (5')AGACTGGTC(3')?

A) (5')CTCATAGAG(3')
B) (5')GACCAGTCT(3')
C) (5')GAGTCAACT(3')
D) (5')TCTGACCAG(3')
E) (5')TCTGGATCT(3')

15. The formation of a peptide bond between two amino acids is an example of a(n) ___ reaction.

A) cleavage
B) condensation
C) group transfer
D) isomerization
E) oxidation reduction

16. Amino acid residues commonly found in the middle of \( \beta \) turn are:

A) Ala and Gly.
B) hydrophobic.
C) Pro and Gly.
D) those with ionized R-groups.
E) two Cys.