1. The three-dimensional structure of macromolecules is formed and maintained primarily through noncovalent interactions. Which one of the following is *not* considered a noncovalent interaction?
(A) disulfide bonds (B) hydrogen bonds (C) hydrophobic interactions (D) ionic interactions (E) van der Waals interactions.

2. The enzyme fumarase catalyzes the reversible hydration of fumaric acid to l-malate, but it will not catalyze the hydration of maleic acid, the cis isomer of fumaric acid. This is an example of:
(A) biological activity (B) chiral activity (C) racemization (D) stereoisomerization (E) stereospecificity.

3. The major carrier of chemical energy in all cells is:
(A) acetyl triphosphate (B) adenosine monophosphate (C) adenosine triphosphate (D) cytosine tetraphosphate (E) uridine diphosphate.

4. 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) hydrophobic interaction with lipids that provide a folding framework (D) modification during interactions with ribosomes (E) the sequence of amino acids in the protein.

5. Hydrophobic interactions make important energetic contributions to:
(A) binding of a hormone to its receptor protein (B) enzyme-substrate interactions (C) membrane structure (D) three-dimensional folding of a polypeptide chain (E) all of the above are true.

6. Which of the following statements about buffers is true?
(A) A buffer composed of a weak acid of $pK_a = 5$ is stronger at pH 4 than at pH 6.
(B) At pH values lower than the pK_a, the salt concentration is higher than that of the acid.
(C) The pH of a buffered solution remains constant no matter how much acid or base is added.
(D) The strongest buffers are those composed of strong acids and strong bases.
(E) When pH = pK_a, the weak acid and salt concentrations in a buffer are equal.

7. You have just made a solution by combining 50 ml of a 0.1 M sodium acetate solution with 150 ml of 1 M acetic acid ($pK_a = 4.7$). What is the pH of the resulting solution? (note: log 3 = 0.48)
(A) 6.18 (B) 3.22 (C) 4.22 (D) 5.18 (E) 3.70.

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) 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. 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) a net negative charge. (B) a net positive charge. (C) no charged groups. (D) no net charge.
(E) positive and negative charges in equal concentration.

10. 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 different functions usually differ significantly in their amino acid composition.
(D) Proteins with the same molecular weight have the same amino acid composition.
(E) The average molecular weight of an amino acid in a protein increases with the size of the protein.

11. 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) determine the amino acid composition of the protein (D) preserve a protein's native structure and biological activity (E) separate proteins exclusively on the basis of molecular weight.

12. (1) A nonapeptide was determined to have the amino acid composition of: $(Lys)_2$, $(Gly)_2$, $(Phe)_2$, His, Leu, Met. (2) The native peptide was incubated with 1-fluoro-2,4-dinitrobenzene (FDNB) and then hydrolyzed; 2,4-dinitrophenylhistidine was identified by HPLC. (3) When the native peptide was exposed to cyanogen bromide (CNBr), an octapeptide and free glycine were recovered. (4) Incubation of the native peptide with trypsin gave a pentapeptide, a tripeptide, and free Lys. (5) 2,4-Dinitrophenyl-histidine was recovered from the pentapeptide, and 2,4-dinitrophenylphenylalanine was recovered from the tripeptide. (6) Digestion with the enzyme pepsin produced a dipeptide, a tripeptide, and a tetrapeptide. (7) The tetrapeptide was composed of $(Lys)_2$, Phe, and Gly.
The native sequence was determined to be:
(A) Gly–Phe–Lys–Lys–Gly–Leu–Met–Phe–His. (B) His–Leu–Gly–Lys–Lys–Phe–Phe–Gly–Met.
(C) His–Leu–Phe–Gly–Lys–Lys–Phe–Met–Gly. (D) His–Phe–Leu–Gly–Lys–Lys–Phe–Met–Gly.
(E) Met–Leu–Phe–Lys–Phe–Gly–Gly–Lys–His.

13. Amino acid residues commonly found in the middle of turn structures are:
(A) Ala and Gly (B) hydrophobic (C) Pro and Gly (D) aromatic (E) two Cys.

14. Which of the following statements is *false*?
(A) Collagen is a protein in which the polypeptides are mainly in the α-helix conformation.
(B) Disulfide linkages are important for keratin structure.
(C) Gly residues are particularly abundant in collagen.
(D) Silk fibroin is a protein in which the polypeptide is almost entirely in the β conformation.
(E) α-keratin is a protein in which the polypeptides are mainly in the α-helix conformation.

15. Which of the following is *not* known to be involved in the process of *assisted* folding of proteins?
(A) Chaperonins (B) Disulfide interchange (C) Heat shock proteins (D) Peptide bond hydrolysis

(E) Peptide bond isomerization

16. An allosteric interaction between a ligand and a protein is one in which:
(A) binding of a molecule to a binding site affects binding of additional molecules to the same site.
(B) binding of a molecule to a binding site affects binding properties of another site on the protein.
(C) binding of the ligand to the protein is covalent.
(D) multiple molecules of the same ligand can bind to the same binding site.
(E) two different ligands can bind to the same binding site.

17. In the binding of oxygen to hemoglobin, the relationship between the concentration of oxygen and the fraction of binding sites occupied can best be described as:
(A) hyperbolic (B) linear with a negative slope (C) linear with a positive slope (D) sigmoidal
(E) random.

18. Which one of the following statements is true of enzyme catalysts?
(A) They bind to substrates, but are never covalently attached to substrate or product.
(B) They increase the equilibrium constant for a reaction, thus favoring product formation.
(C) They increase the stability of the product of a desired reaction by allowing ionizations, resonance, and isomerizations not normally available to substrates.
(D) They lower the activation energy for the conversion of substrate to product.
(E) To be effective they must be present at the same concentration as their substrates.

19. Which of the following statements about a plot of V_0 vs. [S] for an enzyme that follows Michaelis-Menten kinetics is *false*?
(A) As [S] increases, the initial velocity of reaction V_0 also increases. (B) At very high [S], the velocity curve becomes a horizontal line that intersects the y-axis at K_m. (C) K_m is the [S] at which $V_0 = 1/2\ V_{max}$. (D) The shape of the curve is a hyperbola. (E) The y-axis is a rate term with units of m/min.

20. In a plot of l/*V* against 1/[S] for an enzyme-catalyzed reaction (also called the Lineweaver-Burk plot), the presence of a competitive inhibitor will alter the:
(A) curvature of the plot. (B) intercept on the l/[S] axis. (C) intercept on the l/*V* axis. (D) p*K* of the plot. (E) V_{max}.

21. When two carbohydrates are epimers:
(A) one is a pyranose, the other a furanose. (B) one is an aldose, the other a ketose. (C) they differ in length by one carbon. (D) they differ only in the configuration around one carbon atom. (E) they rotate plane-polarized light in the same direction.

22. From the abbreviated name of the compound Gal (β1 →4)Glc, we know that:
(A) C-4 of glucose is joined to C-1 of galactose by a glycosidic bond. (B) the compound is a D-enantiomer. (C) the galactose residue is at the reducing end. (D) the glucose is in its pyranose

form. (E) the glucose residue is the β anomer.

23. In glycoproteins, the carbohydrate moiety is always attached through the amino acid residues:
(A) asparagine, serine, or threonine. (B) aspartate or glutamate. (C) glutamine or arginine.
(D) glycine, alanine, or aspartate. (E) tryptophan, aspartate, or cysteine.

24. The phosphodiester bonds that link adjacent nucleotides in both RNA and DNA:
(A) always link A with T and G with C. (B) are susceptible to alkaline hydrolysis. (C) are uncharged at neutral pH. (D) form between the planar rings of adjacent bases. (E) join the 3′ hydroxyl of one nucleotide to the 5′ hydroxyl of the next.

25. In the Watson-Crick model of DNA structure, B-form DNA in vivo is a _____-handed helix, _____ Å in diameter, with a rise of ____ Å per base pair.
(A) left; 20; 3.9 (B) right; 18; 3.4 (C) right; 18; 3.6 (D) right; 20; 3.4 (E) right; 23; 2.6

26. Which of the following best describes the cholesterol molecule?
(A) Amphipathic (B) Nonpolar, charged (C) Nonpolar, uncharged (D) Polar, charged
(E) Polar, uncharged

27. Which of these is a general feature of the lipid bilayer in all biological membranes?
(A) Individual lipid molecules are free to diffuse laterally in the surface of the bilayer.
(B) Individual lipid molecules in one face (monolayer) of the bilayer readily diffuse (flip-flop) to the other monolayer.
(C) Polar, but uncharged, compounds readily diffuse across the bilayer.
(D) The bilayer is stabilized by covalent bonds between neighboring phospholipid molecules.
(E) The polar head groups face inward toward the inside of the bilayer.

28. An integral membrane protein can be extracted with:
(A) a buffer of alkaline or acid pH. (B) a chelating agent that removes divalent cations. (C) a solution containing detergent. (D) a solution of high ionic strength. (E) hot water.

29. Which of the following statements concerning signal transduction by the insulin receptor is *not* correct?
(A) Activation of the receptor protein kinase activity results in the activation of additional protein kinases. (B) Binding of insulin to the receptor activates a protein kinase. (C) Binding of insulin to the receptor results in a change in its quaternary structure. (D) The receptor protein kinase activity is specific for tyrosine residues on the substrate proteins. (E) The substrates of the receptor protein kinase activity are mainly proteins that regulate transcription.

30. The conversion of 1 mol of fructose 1,6-bisphosphate to 2 mol of pyruvate by the glycolytic pathway results in a net formation of:
(A) 1 mol of NAD^+ and 2 mol of ATP. (B) 1 mol of NADH and 1 mol of ATP. (C) 2 mol of NAD^+

and 4 mol of ATP. (D) 2 mol of NADH and 2 mol of ATP. (E) 2 mol of NADH and 4 mol of ATP.

31. Which of the following substrates *cannot* contribute to net gluconeogenesis in mammalian liver?
(A) alanine (B) glutamate (C) palmitate (D) pyruvate (E) α-ketoglutarate

32. Gluconeogenesis must use "bypass reactions" to circumvent three reactions in the glycolytic pathway that are highly exergonic and essentially irreversible. Reactions carried out by which of the following enzymes must be bypassed in the gluconeogenic pathway? (1) Hexokinase (2) Phosphoglycerate kinase (3) Phosphofructokinase-1 (4) Pyruvate kinase (5) Triosephosphate isomerase.
(A) 1, 2, 3 (B) 1, 2, 4 (C) 1, 4, 5 (D) 1, 3, 4 (E) 2, 3, 4

33. The two moles of CO_2 produced in the first turn of the citric acid cycle have their origin in the:
(A) carboxyl and methylene carbons of oxaloacetate (B) carboxyl group of acetate and a carboxyl group of oxaloacetate (C) carboxyl group of acetate and the keto group of oxaloacetate (D) two carbon atoms of acetate (E) two carboxyl groups derived from oxaloacetate.

34. The conversion of palmitoyl-CoA (16:0) to myristoyl-CoA (14:0) and 1 mol of acetyl-CoA by the -oxidation pathway results in the net formation of:
(A) 1 $FADH_2$ and 1 NADH. (B) 1 $FADH_2$ and 1 NADPH. (C) 1 $FADH_2$, 1 NADH, and 1 ATP.
(D) 2 $FADH_2$ and 2 NADH. (E) 2 $FADH_2$, 2 NADH, and 1 ATP.

35. In amino acid catabolism, the first reaction for many amino acids is a(n):
(A) decarboxylation requiring thiamine pyrophosphate (TPP). (B) hydroxylation requiring NADPH and O_2. (C) oxidative deamination requiring NAD^+. (D) reduction requiring pyridoxal phosphate (PLP). (E) transamination requiring pyridoxal phosphate (PLP).

36. The biosynthesis of triacylglycerols from acetate occurs mainly in:
(A) animals but not in plants. (B) humans after ingestion of excess carbohydrate. (C) humans with low carbohydrate intake. (D) plants but not in animals. (E) none of the above.

37. Glutathione is a(n):
(A) enzyme essential in the synthesis of glutamate. (B) isomer of oxidized glutamic acid. (C) methyl-group donor in many biosynthetic pathways. (D) product of glutamate and methionine. (E) tripeptide of glycine, glutamate, and cysteine.

38. A cell that is unable to synthesize or obtain tetrahydrofolic acid (H_4 folate) would probably be deficient in the biosynthesis of:
(A) CMP. (B) GMP. (C) orotate. (D) thymidylate (TMP). (E) UMP.

39. The maturation of insulin from its precursor (preproinsulin) involves:
(A) acetylation. (B) oxidation. (C) phosphorylation. (D) proteolysis. (E) reduction.

40. The Cori cycle is:
(A) the conversion of lactate to pyruvate in skeletal muscle to drive glycogen synthesis.
(B) the interconversion between glycogen and glucose l-phosphate.
(C) the production of lactate from glucose in peripheral tissues with the resynthesis of glucose from lactate in liver.
(D) the synthesis of alanine from pyruvate in skeletal muscle and the synthesis of pyruvate from alanine in liver.
(E) the synthesis of urea in liver and degradation of urea to carbon dioxide and ammonia by bacteria in the gut.

41. Which one of the following statements INCORRECTLY matches a biological process with the cellular organelle in which it normally occurs?
(A) transcription – nucleus
(B) translation – nucleus
(C) synthesis of ATP – mitochondria
(D) protein synthesis and folding – rough endoplasmic reticulum
(E) protein glycosylation – golgi apparatus

42. Which one of the following statements about the RNA is FALSE
(A) Transfer RNA exhibits extensive intrachain hydrogen bonding.
(B) Ribosomal RNA exhibits extensive internal hydrogen bonding
(C) Messenger RNA exhibits extensive intrachain hydrogen bonding
(D) The sequences in a given mRNA determines the sequence of amino acids

43. Which one of the following statements about the basic structure of DNA is FALSE?
(A) Prokaryotic DNA is normally complexed with protein.
(B) Adjacent nucleotides are joined by phosphodiester bonds.
(C) Cellular DNA contains two antiparallel strands.
(D) Each deoxyribose is joined to one of the following bases: adenine, guanine, cytosine, or thymine.
(E) Strands are joined by hydrogen bonds pairing A with T, and G with C.

44. Which one of the following statements describing replication is TRUE?
(A) After one round of replication, the two newly synthesized strands are left hydrogen bonded to each other.
(B) In order to conduct replication, DNA polymerase must use RNA as a template.
(C) The substrates for replication are deoxynucleoside diphosphates (dNDPs).
(D) On the lagging strand, DNA is made in segments that are subsequently joined together by DNA ligase.
(E) DNA ligase normally joins the 5' end of an RNA primer to the 3' end of an Okasaki fragment.

45. What is the complement of 5' ATG 3'?

(A) 5' CAT 3'
(B) 3' CAT 5'
(C) 3' ATG 5'
(D) 5' TAC 3'
(E) 3' GTA 5'

46. If a gene from a newly discovered virus is cloned, it may then be possible to

(A) sequence the gene and infer its function by comparison to the sequence of known genes.
(B) express the gene in *E. coli*, and then purify and characterize the encoded protein.
(C) use the sequence to design an assay for infection, using the polymerase chain reaction.
(D) do all of the above.
(E) do none of the above

47. The promoter of a gene (including its associated transcription factor binding sites) will affect _____.

(A) the position of the 5' end of the transcript
(B) the strength and timing of transcription
(C) the site where RNA polymerase will first bind
(D) the direction of transcription
(E) all of the above

48. Which one of the following statements is FALSE?

(A) Prokaryotic DNA normally exists as a close circle.
(B) Since AAA encodes lysine, poly(A) addition at the 3' end of mRNA causes eucaryotic proteins to end in poly(lysine).
(C) Splicing removes extra sequences called introns or intervening sequences (IVSs) found within genes.
(D) DNA polymerase III is mainly responsible for the synthesis of new DNA.
(E) It takes more energy and higher temperature to denature DNA rich in G-C base pairs

49. The section of the standard genetic code that includes all of the codons for Ile and Met follows:

First base	2nd base	3rd base
	U	
A	Ile	U
	Ile	C
	Ile	A
	Met	G

Which one of the following statements about the table above is FALSE?

(A) Isoleucine (Ile) is encoded with degeneracy, but methionine (Met) is not.
(B) The sequence AUG is called a codon for methionine, and 5' ATG 3' will appear in the sense strand of the gene.
(C) If AUG is in frame, then AUGAUA encodes Met-Ile.
(D) For AUGAUA, if AUG is not in frame, then AUA is also not in frame.
(E) The table may be correct for one human nuclear gene, but incorrect for another

50. Degeneracy of the genetic code denotes the existence of
(A) multiple codons for a single amino acid.
(B) a single codon for each amino acid.
(C) codons that do not code for any amino acid.
(D) a single codon for multiple amino acids.
(E) codons that contain one or more unusual bases