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| *Indicate the answer choice that best completes the statement or answers the question.* |

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| 1. What is p*K*a of a buffer solution (pH = 5.05) containing 0.2 M sodium acetate and 0.1 M acetic acid?   |  |  |  | | --- | --- | --- | |  | a. | 4.75 | |  | b. | 0.2 | |  | c. | 0.3 | |  | d. | 4.45 | |  | e. | 1.58 | |

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| 2. What is FALSE regarding the laws of thermodynamics?   |  |  |  | | --- | --- | --- | |  | a. | Energy can be neither created nor destroyed. | |  | b. | The local decrease in enthalpy will increase the entropy of the surroundings. | |  | c. | Heat is a manifestation of the kinetic energy associated with the random motion of molecules. | |  | d. | Within chemical systems, potential energy is related to the likelihood that atoms will store energy in some form. | |  | e. | Ordered structures can be formed within a system only if the entropy of the surroundings will proportionally increase. | |

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| 3. What gives proteins such a dominant role in biochemistry?   |  |  |  | | --- | --- | --- | |  | a. | rigidity of the peptide backbone | |  | b. | ability to act as a blueprint | |  | c. | ability to self-replicate | |  | d. | ability to spontaneously fold into complex three-dimensional structures | |  | e. | usage of 40 different building blocks | |

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| 4. Which statement about DNA is INCORRECT?   |  |  |  | | --- | --- | --- | |  | a. | The most fundamental role of DNA is to encode the sequences of proteins. | |  | b. | The genetic code is the set of rules that links the DNA sequence to the encoded protein sequence. | |  | c. | Gene is the fundamental unit of hereditary information. | |  | d. | The control regions account for only a small portion of the human genome. | |  | e. | There are about 100,000 protein-coding genes in the human genome. | |

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| 5. Which statement about the microbiome is CORRECT?   |  |  |  | | --- | --- | --- | |  | a. | There are about 10 times more human cells than microbial cells in the body. | |  | b. | The human microbiome does not play a role in obesity. | |  | c. | The microbiome present on a body remains constant throughout a human life. | |  | d. | The microbiome present on different body surfaces is largely distinct. | |  | e. | Many species of the human microbiome have been grown in cultures. | |

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| 6. Which component of DNA bases is the most susceptible to hydroxide ions?   |  |  |  | | --- | --- | --- | |  | a. | proton of N-1 atom of guanine base | |  | b. | proton of O atom of guanine base | |  | c. | proton of N-3 atom of thymine base | |  | d. | proton of O atom of adenine base | |  | e. | proton of N-1 atom of adenine base | |

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| 7. What is a p*K*a value in an acid–base reaction?   |  |  |  | | --- | --- | --- | |  | a. | the equilibrium constant for proton dissociation | |  | b. | concentration of hydrogen ions in the solution | |  | c. | a quantitative measure of the strength of an acid in the solution | |  | d. | the equilibrium constant for the dissociation of water | |  | e. | concentration of hydroxide ions in the solution | |

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| 8. What is the number of hydrogen bonds formed between A and T nucleotides?   |  |  |  | | --- | --- | --- | |  | a. | 1 | |  | b. | 2 | |  | c. | 3 | |  | d. | 4 | |  | e. | 5 | |

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| 9. Why are free interactions of water molecules in bulk water more favorable than more ordered interactions with nonpolar compounds?   |  |  |  | | --- | --- | --- | |  | a. | The total entropy in such interactions increases because the Gibbs free energy is positive. | |  | b. | The total entropy in such interactions decreases because the Gibbs free energy is negative. | |  | c. | The enthalpy of the ordered state is lower than the enthalpy of the bulk state. | |  | d. | The total entropy in such interactions increases because the Gibbs free energy is negative. | |  | e. | The total entropy in such interactions decreases because the Gibbs free energy is positive. | |

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| 10. What makes water a versatile solvent?   |  |  |  | | --- | --- | --- | |  | a. | stabilization of large molecular complexes | |  | b. | ease of breaking different bonds | |  | c. | irreversible breakage of different bonds | |  | d. | simultaneous formation of a large number of hydrogen bonds | |  | e. | stabilization by large molecular complexes | |

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| 11. What are the primary chemical components present in a phosphate buffer at pH = 7.4?   |  |  |  | | --- | --- | --- | |  | a. | H3PO4 and PO43– | |  | b. | H2PO4– and PO43– | |  | c. | HPO42– and PO43– | |  | d. | H2PO4– and HPO42– | |  | e. | H3PO4 and HPO42– | |

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| 12. Which set of nutrients corresponds to a healthy diet (based on the nutritional value, in descending order)?   |  |  |  | | --- | --- | --- | |  | a. | protein, carbohydrates, fats, vitamins and minerals | |  | b. | carbohydrates, fats, proteins, vitamins and minerals | |  | c. | grains, fats, proteins, vitamins and minerals | |  | d. | vitamins and minerals, carbohydrates, fats, proteins | |  | e. | carbohydrates, dairy, proteins, vitamins and minerals | |

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| 13. Which statement about DNA structure is INCORRECT?   |  |  |  | | --- | --- | --- | |  | a. | It is a branched polymer with a flexible backbone. | |  | b. | The DNA backbone is built of repeating sugar–phosphate units. | |  | c. | Each DNA strand has directionality due to identical orientation of the sugar–phosphate units. | |  | d. | Each sugar is connected to two phosphate groups through different linkages. | |  | e. | Its structure is a double helix composed of two intertwined strands. | |

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| 14. If a particular reaction has a negative Δ*G*, is it likely to occur?   |  |  |  | | --- | --- | --- | |  | a. | Not unless energy is added to the system. | |  | b. | Yes, if it is coupled with another reaction. | |  | c. | Yes, it is spontaneous. | |  | d. | No, it is not spontaneous. | |  | e. | Yes, as long as the temperature increases. | |

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| 15. If the whole chain is used in a nonoverlapping frame, how many amino acids are defined by the DNA sequence ATGTTTGGACTA?   |  |  |  | | --- | --- | --- | |  | a. | 2 | |  | b. | 3 | |  | c. | 4 | |  | d. | 6 | |  | e. | 12 | |

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| 16. What is the direct consequence of the bent shape of a water molecule?   |  |  |  | | --- | --- | --- | |  | a. | Water is highly cohesive. | |  | b. | Distribution of charge is asymmetric. | |  | c. | Hydrogen atoms possess a net negative charge. | |  | d. | The oxygen atom possesses a net positive charge. | |  | e. | The water molecule is able to form hydrogen bonds. | |

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| 17. Using the Henderson–Hasselbalch equation, calculate the pH of a buffer solution made from 0.20 M CH3COOH and 0.05 M CH3COO– that has p*K*a = 4.7.   |  |  |  | | --- | --- | --- | |  | a. | 5.3 | |  | b. | 4.1 | |  | c. | 2.5 | |  | d. | 0.4 | |  | e. | 5.0 | |

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| 18. Which of the following is a hydrogen bond donor?   |  |  |  | | --- | --- | --- | |  | a. | the N in H- - -N—HD | |  | b. | the S in S—H- - -O | |  | c. | the O and P in P—O- - -H | |  | d. | the H in O—H- - -O | |  | e. | the O in O—H- - -NN | |

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| 19. What is the reason for the existence of the hydrophobic effect?   |  |  |  | | --- | --- | --- | |  | a. | the tendency of water molecules to make a bond with hydrophobic proteins | |  | b. | the tendency of polar molecules to self-associate in the presence of an aqueous solution | |  | c. | the tendency of nonpolar molecules to self-associate in the presence of an aqueous solution | |  | d. | the inability of charged molecules to dissolve in water | |  | e. | the property of nucleic acids to dissolve in water | |

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| 20. What is the CORRECT description of human migrations as supported by DNA sequence comparisons?   |  |  |  | | --- | --- | --- | |  | a. | Modern human beings originated in Africa about 50,000 years ago  migrated first to Asia  then to Europe, Australia, and North and South America about 12,500–19,000 years ago. | |  | b. | Modern human beings originated in Africa about 150,000 years ago  migrated first to Europe  then about 46,000 years ago to Asia, Australia, and North and South America. | |  | c. | Modern human beings originated in Australia about 150,000 years ago  migrated first to Asia  then to Africa, Europe, and North and South America. | |  | d. | Modern human beings originated in Africa about 150,000 years ago  migrated first to Asia  then to Europe, Australia, and North and South America about 12,500–19,000 years ago. | |  | e. | Modern human beings originated in Africa about 100,000 years ago  migrated first to Asia  then to Europe, Australia about 40,000 years ago, and North and South America. | |

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| 21. What is the energy of an ionic interaction?   |  |  |  | | --- | --- | --- | |  | a. | the product of a proportionality constant and charges of two atoms divided by the product of the dielectric constant and the distance between atoms | |  | b. | the product of the dielectric constant and a sum of two charges divided by the product of the proportionality constant and the distance between charges | |  | c. | the product of the dielectric constant and the distance between atoms divided by the product of the proportionality constant and charges of two atoms | |  | d. | the product of the dielectric constant and two charges subtracted from the product of the proportionality constant and the distance between charges | |  | e. | the difference between the proportionality constant and charges of two atoms multiplied by the dielectric constant | |

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| 22. What are molecules A and B called, if molecule A is large and transforms into a low-molecular-weight molecule B?   |  |  |  | | --- | --- | --- | |  | a. | A and B are both biological macromolecules. | |  | b. | A and B are both metabolites. | |  | c. | A is a biological macromolecule and B is a metabolite. | |  | d. | A is a metabolite and B is a biological macromolecule. | |  | e. | A is a protein and B is deoxyribonucleic acid. | |

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| 23. What is the [A–]:[HA] ratio when a weak acid is in a solution one pH unit below its p*K*a?   |  |  |  | | --- | --- | --- | |  | a. | 1:1 | |  | b. | 1:10 | |  | c. | 10:1 | |  | d. | 2:1 | |  | e. | 1:2 | |

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| 24. The structure of DNA described by Watson and Crick includes:   |  |  |  | | --- | --- | --- | |  | a. | a triple helix. | |  | b. | a triple helix composed of three intertwined strands. | |  | c. | base pairs that are stacked on the inside of the double helix. | |  | d. | a sugar-phosphate backbone that lies on the inside of the helix. | |  | e. | base pairs that are stacked on the outside of the triple helix. | |

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| 25. What is the number of hydrogen bonds formed between G and C nucleotides?   |  |  |  | | --- | --- | --- | |  | a. | 1 | |  | b. | 2 | |  | c. | 3 | |  | d. | 4 | |  | e. | 5 | |

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| 26. Order the type of interactions by the bond strength in descending value.   |  |  |  | | --- | --- | --- | |  | a. | hydrogen bonds, covalent bonds, van der Waals interactions | |  | b. | covalent bonds, van der Waals interactions, hydrogen bonds | |  | c. | van der Waals interactions, covalent bonds, hydrogen bonds | |  | d. | covalent bonds, hydrogen bonds, van der Waals interactions | |  | e. | hydrophobic interactions, hydrogen bonds, electrostatic interactions | |

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| 27. Which studies helped to reveal neural circuits and biochemical pathways that are important related to behavioral aspects?   |  |  |  | | --- | --- | --- | |  | a. | studies of developed world diseases | |  | b. | studies in comparative genomics | |  | c. | studies of drug addiction | |  | d. | studies of environmental chemicals | |  | e. | studies of predispositions | |

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| 28. When did life on Earth begin and when did human beings emerge, respectively?   |  |  |  | | --- | --- | --- | |  | a. | 3 billion years ago and 1 billion years ago | |  | b. | 3.5 billion years ago and 0.5 billion years ago | |  | c. | 3.5 billion years ago and 0.2 billion years ago | |  | d. | 3.5 billion years ago and less than 0.1 billion years ago | |  | e. | 3.5 billion years ago and 0.1 billion years ago | |

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| 29. Which statement about nonpolar interactions in the formation of the DNA double helix is INCORRECT?   |  |  |  | | --- | --- | --- | |  | a. | Van der Waals interactions are nearly optimal in a double-helical structure. | |  | b. | Nonpolar surfaces of the bases are moved into contact with each other due to a more complete base stacking. | |  | c. | Nucleotide bases tend to stack even in single-stranded DNA molecules. | |  | d. | The separation distance of the planes of adjacent bases needs to be adjusted for the favorable van der Waals contacts. | |  | e. | Surface complementarity maximizes the formation of hydrogen bonds and van der Waals interactions while minimizing the nonpolar surface area exposed to the aqueous environment. | |

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| 30. Which statement about ionic interactions in the formation of the DNA double helix is CORRECT?   |  |  |  | | --- | --- | --- | |  | a. | Separation of negatively charged phosphate groups with distances greater than 10 Å prevents unfavorable interactions. | |  | b. | Only favorable ionic interactions take place when two strands of DNA come together. | |  | c. | Ionic interactions cause the formation of the double helix. | |  | d. | Disposition of negatively charged phosphate groups with distances greater than 10 Å provides only favorable interactions. | |  | e. | Some unfavorable ionic interactions take place when two strands of DNA come together. | |

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| 31. What principle is comparative genomics based on?   |  |  |  | | --- | --- | --- | |  | a. | Biological polymers are evolutionary and functionally related in all living organisms. | |  | b. | There is a link between evolution and biochemistry. | |  | c. | DNA can be isolated from previously known organisms. | |  | d. | Biological polymers are greatly variable between single-celled and multicellular organisms. | |  | e. | The sequence variation between remotely related individuals is quite substantial compared to differences in populations. | |

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| 32. What are the main paths of the tree of life?   |  |  |  | | --- | --- | --- | |  | a. | eukarya and prokarya | |  | b. | eukarya and archea | |  | c. | bacteria, prokarya, eukarya, and archea | |  | d. | bacteria and eukarya | |  | e. | bacteria, eukarya, and archea | |

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| 33. What did Watson and Crick suggest to be significant about the base-pairing found in the DNA helix?   |  |  |  | | --- | --- | --- | |  | a. | It allowed the DNA to twist in a helix. | |  | b. | The DNA could be circular. | |  | c. | It was a good base for the mechanism of copying genetic information. | |  | d. | Only one of the strands could act as a template. | |  | e. | The DNA sequence was determined by the sequence of RNA. | |

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| 34. Which statement about noncovalent bonds is CORRECT?   |  |  |  | | --- | --- | --- | |  | a. | Five fundamental noncovalent bonds differ in their geometry, strength, and specificity. | |  | b. | In the strongest hydrogen bonds, all their components lie along a straight line. | |  | c. | The transient asymmetry in the electronic charge distribution of one atom can induce a complementary asymmetry in the neighboring atoms due to hydrophobic interactions. | |  | d. | The release of water from more ordered structures is unfavorable. | |  | e. | Very strong repulsive forces become dominant at distances greater than the van der Waals contact distance. | |

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| 35. The heat content of a system is called:   |  |  |  | | --- | --- | --- | |  | a. | entropy. | |  | b. | enthalpy. | |  | c. | kinetic energy. | |  | d. | potential enthalpy. | |  | e. | kinetic entropy. | |

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| 36. What is the concentration of hydrogen ions in a urine sample that has a pH of 6?   |  |  |  | | --- | --- | --- | |  | a. | 10–6 M | |  | b. | 10–8 M | |  | c. | 106 M | |  | d. | 10–14 M | |  | e. | 6 M | |

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| 37. Which statement about acid–base relations is CORRECT?   |  |  |  | | --- | --- | --- | |  | a. | If [H+] is higher than 10–3, pH is above 3. | |  | b. | If [OH–] is 10–9, pH is 7. | |  | c. | If [H+] is lower than 10–9, pH is below 9. | |  | d. | If [OH–] is higher than 10–3, pH is below 3. | |  | e. | If [OH–] is 10–7, pH is 7. | |

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| 38. What is the average difference in the genome sequence between each pair of individuals?   |  |  |  | | --- | --- | --- | |  | a. | 1 different base per 200 bases | |  | b. | 1 different base per 20 bases | |  | c. | 1 different base per 100 bases | |  | d. | 1 different base per 1000 bases | |  | e. | 1 different base per 2000 bases | |

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| 39. Which statement about covalent bonds is INCORRECT?   |  |  |  | | --- | --- | --- | |  | a. | A covalent bond is formed by the sharing of a pair of electrons between adjacent atoms. | |  | b. | If more than one electron pair is shared, then a covalent bond becomes stronger. | |  | c. | Existence of several resonance structures of nearly equal energies decreases stability of a compound. | |  | d. | Some molecules possess several patterns of covalent bonding. | |  | e. | The key properties of a bond are length and energy. | |

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| 40. A proton exists in a solution as:   |  |  |  | | --- | --- | --- | |  | a. | H+. | |  | b. | a water molecule. | |  | c. | a deprotonated water molecule. | |  | d. | a hydronium ion. | |  | e. | H2O+. | |

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| 41. By which factor will the 1 M buffer sodium acetate (p*K*a = 4.75) increase the amount of acid required to produce a drop of pH from 7.4 to 7.3 in comparison with pure water where a respective change in [H+] is equal to 1 × 10–8 M?   |  |  |  | | --- | --- | --- | |  | a. | 5,600 | |  | b. | 60 | |  | c. | 60,000 | |  | d. | 1 | |  | e. | 600 | |

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| 42. Which animal metabolic process is highly similar to the plant process of capturing and converting light energy?   |  |  |  | | --- | --- | --- | |  | a. | capturing energy released from acid dissociation | |  | b. | capturing energy released from DNA double helix formation | |  | c. | capturing energy released from resisting the change in pH | |  | d. | capturing energy released from glucose breakdown | |  | e. | capturing energy released from the breakage of noncovalent bonds | |

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| 43. Which statement about genetic variations is CORRECT?   |  |  |  | | --- | --- | --- | |  | a. | Predisposition inevitably results in the onset of a disease. | |  | b. | Only a few genetic variations are connected to some ailments. | |  | c. | Several genetic variations are required to cause a disease. | |  | d. | The average difference between two people within one ethnic group is lower than the difference between the averages of two different ethnic groups. | |  | e. | A particular variation can lead to a predisposition to the development of a particular disease rather than to its inevitable development. | |

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| 44. What is the concentration of hydroxide ions [OH–] in an aqueous solution with pH 9?   |  |  |  | | --- | --- | --- | |  | a. | 10–9 M | |  | b. | 10–14 M | |  | c. | 105 M | |  | d. | 9 M | |  | e. | 10–5 M | |

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| 45. Which statement about biological diversity is FALSE?   |  |  |  | | --- | --- | --- | |  | a. | The plant kingdom includes species as relatively simple as algae and as complex as sequoias. | |  | b. | No species can live in seemingly hostile environments such as hot springs and glaciers. | |  | c. | Animal kingdom species range from nearly microscopic to very large. | |  | d. | Organisms such as protozoa, yeast, and bacteria are present with great diversity in water and soil. | |  | e. | Microscopic organisms can live on or within larger organisms. | |

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| 46. How was the fact that formation of the double helix does not violate the second law of thermodynamics experimentally confirmed?   |  |  |  | | --- | --- | --- | |  | a. | in a water bath monitoring the change in entropy to check whether it remains constant | |  | b. | in a water bath monitoring the change in heat to sustain a constant temperature in the bath | |  | c. | in a water bath monitoring the change in entropy to sustain a constant temperature in the bath | |  | d. | in a water bath monitoring the free energy to sustain constant heat content in the bath | |  | e. | in a water bath monitoring the change in heat to sustain constant Gibbs energy in the bath | |

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| 47. Why does a spontaneous chemical process always increase the entropy of the universe?   |  |  |  | | --- | --- | --- | |  | a. | The system entropy will increase if and only if the entropy of surroundings is greater than the ratio of the heat transferred to the surroundings and their temperature. | |  | b. | The total entropy will increase if and only if the product of temperature and the change in system entropy is lower than zero. | |  | c. | The total entropy will increase if and only if the change in enthalpy is lower than zero. | |  | d. | The system enthalpy will increase only when the change in temperature is greater than zero. | |  | e. | The total entropy will increase if and only if the entropy of a system is greater than the ratio of the heat transferred to surroundings and their temperature. | |

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| 48. Which statement is INCORRECT if the buffer capacity is not consumed upon addition of a strong acid to the solution?   |  |  |  | | --- | --- | --- | |  | a. | There are more protonated forms of the buffer compound than deprotonated ones. | |  | b. | When hydrogen ions are added to this buffer solution they remain free. | |  | c. | The pH differs from the p*K*a value of the buffer's base component. | |  | d. | There are more deprotonated forms of the buffer compound than protonated ones. | |  | e. | Such a buffer is not actually a buffer and cannot mitigate the pH changes. | |

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| 49. Which statement about the role of hydrogen bonds in DNA double helix formation is INCORRECT?   |  |  |  | | --- | --- | --- | |  | a. | The hydrophobic effect contributes to the favorability of base stacking. | |  | b. | Hydrogen bonds contribute greatly to the overall process of double helix formation. | |  | c. | There are more hydrogen bonds with water than bonds between the bases in single-stranded DNA. | |  | d. | When two single strands come together, hydrogen bonds with water are broken and new hydrogen bonds between the bases of two DNA strands are formed. | |  | e. | Hydrogen bonds contribute greatly to the specificity of bases binding. | |

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| 50. Consider the conventional description of bonds in a Fischer projection. What is the CORRECT statement about the bonds in a Fischer projection?   |  |  |  | | --- | --- | --- | |  | a. | Horizontal bonds project behind the page away from the viewer. | |  | b. | A solid wedge with the broad end away from the carbon atom denotes a bond coming away from the viewer. | |  | c. | The bonds to the central atom are represented by lines from that atom to the substituents. | |  | d. | Vertical bonds project behind the page away from the viewer. | |  | e. | A dashed wedge with its broad end at the carbon atom represents a bond going toward the viewer. | |

**Answer Key**

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| 1. a |

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| 2. d |

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| 3. d |

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| 4. e |

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| 5. d |

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| 6. a |

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| 7. c |

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| 8. b |

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| 9. d |

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| 10. d |

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| 11. d |

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| 12. b |

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| 13. a |

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| 14. c |

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| 15. c |

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| 16. b |

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| 17. b |

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| 18. d |

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| 19. c |

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| 20. d |

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| 21. a |

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| 22. c |

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| 23. b |

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| 24. c |

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| 25. c |

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| 26. d |

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| 27. c |

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| 28. d |

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| 29. d |

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| 30. e |

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| 31. a |

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| 32. e |

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| 33. c |

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| 34. b |

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| 35. b |

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| 36. a |

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| 37. e |

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| 38. a |

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| 39. c |

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| 40. d |

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| 41. c |

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| 42. d |

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| 43. e |

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| 44. e |

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| 45. b |

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| 46. b |

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| 47. e |

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| 48. d |

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| 49. b |

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| 50. d |