

Chapter 1 Biochemistry: An Evolving Science

Matching Questions

Use the following to answer questions 1-10:

Choose the best answer from the list below. Not all of the answers will be used.

- a) uridine
- b) true
- c) ΔG
- d) thymine
- e) ΔH
- f) sugar-phosphate units
- g) covalent
- h) Archaea
- i) entropy
- j) system
- k) 3
- l) 2
- m) false
- n) Fungi
- o) hydrogen bonds
- p) surroundings

1. DNA is made from the building blocks adenine, guanine, cytosine, and _____.

Ans: d

Section: 1.2

2. The DNA backbone is made from repeating _____.

Ans: f

Section: 1.2

3. _____ The number of hydrogen bonds formed between A and T.

Ans: l

Section: 1.2

4. _____ The number of hydrogen bonds formed between G and C.

Ans: k

Section: 1.2

5. The fundamental groups of organisms include Eukarya, Bacteria, and _____.

Ans: h

Section: 1.1

6. _____ The strongest bonds in molecules:

Ans: g

Section: 1.3

7. _____ Hydrogen bonds are usually weaker than covalent bonds (**true/false**).

Ans: b

Section: 1.3

8. _____ Matter within a defined region of space.

Ans: j

Section: 1.3

9. _____ For spontaneous reactions the ΔG must be positive (true/false).

Ans: m

Section: 1.3

10. _____ Gibbs-free energy.

Ans: c

Section: 1.3

Multiple-Choice Questions

11. Which of the following is considered a metabolite, a substance that is chemically transformed in a biochemical process?
- A) deoxyribonucleic acid
 - B) glycerol
 - C) protein
 - D) ribonucleic acid
 - E) polysaccharide
- Ans: B Section: 1.1

12. The structure of DNA described by Watson and Crick included
- A) a double helix.
 - B) the sugar phosphate backbone aligned in the center of the helix.
 - C) the base pairs that are stacked on the inside of the double helix.
 - D) a and b.
 - E) a and c.
- Ans: E Section: 1.2

13. What did Watson and Crick suggest to be significant about the base pairing found in the helix?
- A) It allowed the DNA to twist in a helix.
 - B) The DNA could be circular.
 - C) It was a mechanism for copying.
 - D) All of the above.
 - E) None of the above.
- Ans: C Section: 1.3

14. Approximately what percentage of the human genome encodes for proteins?
- A) 50%
 - B) 90%
 - C) 20%
 - D) 3%
 - E) None of the above.
- Ans: D Section: 1.4

15. What gives proteins such a dominant role in biochemistry?
- A) the rigidity of the peptide backbone
 - B) the ability to act as a blueprint
 - C) their ability to self-replicate
 - D) their ability to spontaneously fold into complex three-dimensional structures
 - E) All of the above.
- Ans: D Section: 1.4

16. If the whole chain is used in a non-overlapping frame, how many amino acids are defined by this DNA sequence: ATGTTTGGACTA?
- A) four B) two C) twelve D) six E) three
- Ans: A Section: 1.4

17. What is the $[H^+]$ concentration in a urine sample that has a pH of 6?

- A) 10^{-6} M
- B) 10^{-8} M
- C) 10^6 M
- D) 10^{-14} M
- E) 8 M

Ans: A Section 1.3

18. Which is the correct order of decreasing bond strengths?

- | | |
|---|---|
| A) hydrogen bonds, covalent bonds, van der Waals interactions | D) covalent bonds, hydrogen bonds, van der Waals interactions |
| B) hydrogen bonds, electrostatic interactions, covalent bonds | E) hydrophobic interactions, hydrogen bonds, electrostatic interactions |
| C) van der Waals interactions, covalent bonds, hydrogen bonds | |

Ans: D Section: 1.3

19. The energies for hydrogen bonds are approximately

- | | |
|--------------------|-----------------------|
| A) 400 kJ/mol. | D) 200 kJ/mol. |
| B) 100–240 kJ/mol. | E) None of the above. |
| C) 4–20 kJ/mol. | |

Ans: C Section: 1.3

20. What pairs of atoms are hydrogen bond donors in hydrogen bonds?

- | | |
|----------------|-----------------------|
| A) N—H and O—H | D) All of the above. |
| B) N—H and S—H | E) None of the above. |
| C) O—H and P—O | |

Ans: A Section: 1.3

21. Typical van der Waals energies are about

- | | |
|-----------------|-----------------------|
| A) 4–20 kJ/mol. | D) 500–1000 kJ/mol. |
| B) 2–4 kJ/mol. | E) None of the above. |
| C) 200 kJ/mol. | |

Ans: B Section: 1.3

22. What two properties of water are important for biological interactions?

- | | |
|-------------------------------------|------------|
| A) the polarity of water | D) a and c |
| B) the density of water | E) b and c |
| C) the cohesive properties of water | |

Ans: D Section: 1.3

23. The First Law of Thermodynamics states

- A) diversity is the result of gradual evolution.
- B) the total entropy of a system and its surroundings always increase for a spontaneous process.
- C) the total energy of a system and its surroundings are constant.
- D) light is both particle and wave.
- E) None of the above.

Ans: C Section: 1.3

24. The Second Law of Thermodynamics states
- A) the total entropy of a system and its surroundings always increases for a spontaneous process.
 - B) temperatures will always decrease in a spontaneous process.
 - C) the total energy of a system and its surroundings is constant.
 - D) diversity is the result of gradual evolution.
 - E) None of the above.
- Ans: A Section: 1.3
25. List atoms commonly found in biological molecules that are often hydrogen-bond acceptors.
- A) carbon B) oxygen C) nitrogen D) b and c E) All of the above.
- Ans: D Section: 1.3
26. Entropy is defined as
- A) a spontaneous reaction.
 - B) the enthalpy of the system.
 - C) the measure of randomness of a system.
 - D) the amount of heat exchanged.
 - E) None of the above.
- Ans: C Section: 1.3
27. If a particular reaction has a negative ΔG , is it likely to occur?
- A) Not unless energy is added to the system.
 - B) Yes, if it is coupled to another reaction.
 - C) Yes, it is spontaneous.
 - D) No, it is not spontaneous.
 - E) Yes, if it takes place within a constrained area.
- Ans: C Section: 1.3
28. What happens to nonpolar molecules in water?
- A) They dissolve independently.
 - B) They aggregate together.
 - C) They precipitate.
 - D) All of the above.
 - E) None of the above.
- Ans: B Section: 1.3
29. What is the $[A^-]/[HA]$ ratio when the weak acid is in a solution one pH unit below its pK_a ?
- A) 1:1
 - B) 1:10
 - C) 10:1
 - D) 2:1
 - E) None of the above.
- Ans: B Section 1.3

30. Why does DNA denature when the pH is raised above 9?
- A) Protons dissociate from guanine bases disrupting the hydrogen bonding to the other strand.
 - B) Protons bind to guanine residues giving them additional positive charges which disrupt the hydrogen bonding to the other strand.
 - C) Protons bind to functional groups that serve as hydrogen-bond acceptors, thus disrupting the hydrogen bonding to the other strand.
 - D) Protons dissociate from the phosphate groups in the backbone, which disrupts the hydrogen-bonding pattern between strands.
 - E) None of the above.
- Ans: A Section 1.3
31. The simplest way to depict stereochemistry is to use:
- A) ball-and-stick models.
 - B) ribbon diagrams.
 - C) space-filling models.
 - D) Fisher projections.
 - E) None of the above.
- Ans: D Section: Appendix
32. Using the Henderson–Hasselbach equation, calculate the pH of a buffer solution made from 0.20 M $\text{HC}_2\text{H}_3\text{O}_2$ and 0.050 M $\text{C}_2\text{H}_3\text{O}_2^-$ that has $\text{p}K_a = 4.7$.
- A) 5.3
 - B) 4.1
 - C) 2.5
 - D) 0.4
 - E) None of the above.
- Ans: B Section 1.3
33. What are the primary chemical components present in a phosphate buffer at pH 7.4?
- A) H_3PO_4 and PO_4^{3-}
 - B) H_2PO_4^- and PO_4^{3-}
 - C) HPO_4^{2-} and PO_4^{3-}
 - D) H_2PO_4^- and HPO_4^{2-}
 - E) H_3PO_4 and HPO_4^{2-}
- Ans: D Section 1.3

Short-Answer Questions

33. What are some of the medical implications of the human genome project?
- Ans: The obvious use is in diagnosing disease and in developing methods to treat and cure diseases. Physicians will be able to account for individual genetic differences in determining the best medical treatment. Other answers may be correct.
- Section: Introduction
34. What is the significance of hydrogen bonding in biochemical structures such as DNA?
- Ans: The bonds are weak enough to be easily disrupted; yet when many are present, they provide the stabilization necessary for larger structures such as DNA.
- Section: 1.2

35. Describe resonance structures.
Ans: Resonance structures are ways of writing covalent bonds in which two or more alternate bonding patterns can be achieved. This is due to the sharing of electrons over several atoms. Common examples are found in peptide bonds, and in some of the DNA/RNA bases. Benzene is shown in the text.
Section: 1.3
36. What is significant about the fact that metabolic processes are common to many organisms?
Ans: These metabolic processes are extremely old, geologically, originating in a common ancestor.
Section: 1.1
37. How is water able to be a solvent for so many biological molecules?
Ans: Many biological molecules have polar characteristics. Water is extremely polar and is capable of competing with other polar molecules by weakening their electrostatic and hydrogen bonds. The oxygen atom can act as a hydrogen-bond acceptor, and the hydrogen can act as a donor.
Section: 1.3
38. What is the net effect of many van der Waals interactions?
Ans: At the interface of two large molecules, the numerous van der Waals interactions can substantially affect and stabilize the interaction.
Section: 1.3
39. If most proteins are found surrounded by water in the cell, what type of functional groups would you expect to find on the surface of a water-soluble protein?
Ans: Polar and charged amino-acid residues would be present on the surface of the protein.
Section: 1.3
40. How are electrostatic forces used in protein folding?
Ans: The attraction of two oppositely charged functional groups would be one of the forces helping to form the three-dimensional shape of the protein.
Section: 1.3
41. If the First Law of Thermodynamics is true, how can biological processes be carried out?
Ans: Although energy cannot be created or destroyed, it can take on different forms, such as heat or chemical energy. Thus, the energy can be stored as chemical bond energy, which can be used to do work.
Section: 1.3
42. How can a cell exist if the Second Law of Thermodynamics is true?
Ans: Entropy in a local area can be decreased, but only at the expense of increased entropy in the larger area, or universe.
Section: 1.3

43. Provide a simple example of a process in which the entropy of a system changes.
Ans: Several examples can be provided, including the random mixture of atoms when two different gases are mixed, or the creation of water molecules from energy gained following the mixture of oxygen and hydrogen under certain conditions.
Section: 1.3
44. When solutions containing complementary single strands of DNA are mixed, a loss of entropy occurs. How is it that the Second Law of Thermodynamics is not violated?
Ans: Heat must be released to the surroundings.
Section: 1.3
45. What is the significance of using ΔG in biochemistry?
Ans: Gibbs-free energy, also called the free-energy change, is used to describe the energetics of a reaction. This symbol is used to determine if particular reactions will be spontaneous or biologically feasible.
Section: 1.3
46. What thermodynamic and free-energy changes participate in protein folding?
Ans: A combination of hydrogen bonds and van der Waals forces affect enthalpy and the entropy associated with hydrophobic interactions.
Section: 1.3
47. How do hydrophobic interactions aid in protein folding?
Ans: Hydrophobic interaction causes some nonpolar amino acids to aggregate and form the interior of the protein. This results in a net release of heat and a favorable change in the system enthalpy.
Section: 1.4
48. What are the enthalpy and entropy changes that accompany the formation of DNA double helices from complementary single strands of DNA?
Ans: There is a loss of entropy from the system because there are fewer degrees of freedom in the double helix as compared to the single strands. Therefore, heat must be released when the two strands combine to form the double helix so as not to violate the Second Law of Thermodynamics.
Section: 1.3
49. Describe the shape of methane.
Ans: Methane is tetrahedral and sp^3 hybridized, with bond angles of about 109° .
Section: Appendix