Chapter 2 Water, Weak Bonds, and the Generation of Order Out of Chaos

Matching Questions

Use the following to answer questions 1–10:

Choose the correct answer from the list below. Not all of the answers will be used.
a) ionic bonds or salt bridges
b) Brownian motion
c) hydrophobic
d) hydrogen
e) polar
f) nonpolar
g) van der Waals
h) entropy
i) zwitterion
j) amphipathic
k) positive
l) dielectric constant
m) negative

1. _____: The type of bond found between an oxygen on one water molecule and hydrogen on a different water molecule.
   Ans: d
   Section: 2.2

2. Movement of particles due to the random fluctuations of energy content of the environment is known as _____.
   Ans: b
   Section: 2.1

3. Electrostatic interactions between atoms with opposite electrical charges are also called _____.
   Ans: a
   Section: 2.3

4. Water weakens the electrostatic interaction of ions due to its high _____.
   Ans: l
   Section: 2.3

5. The distance when two atoms no longer repulse each other yet have the strongest attraction is known as the_____ radii or contact distance.
   Ans: g
   Section: 2.3

6. _____: Thermodynamic force that drives hydrophobic interactions.
   Ans: h
   Section: 2.4

7. _____: A molecule with two distinctive chemical properties or characteristics.
   Ans: j
   Section: 2.4

8. Which type of amino acids are responsible for increasing entropy as a protein folds?
   Ans: f
   Section: 2.4

9. _____: The charge of the side group of aspartate when the pH is more than one pH unit above the p*K*a.
   Ans: m
   Section: 2.5

10. _____: The charge of an amino group when the pH is one pH unit below the pKa.
    Ans: k
    Section: 2.5

Fill-in-the-Blank Questions

11. Molecules that are readily soluble in water are considered _____.
    Ans: polar Section 2.2

12. The force that is quantified by Coulomb's law is called the _____.
    Ans: ionic or electrostatic interaction Section 2.3

13. A solvent with a low dielectric constant would be a _____ solvent for salts.
    Ans: poor Section 2.3

14. The transient force which, while weak, still has a large impact on how macromolecules interact is the _____.
    Ans: Van der Waals interaction Section 2.3

15. Hydrophobic molecules are driven together by _____, not because they have an affinity for each other.
    Ans: entropy Section 2.4

16. Lipids that interact with both the water and the hydrophobic regions of the membrane are considered _____.
    Ans: amphipathic Section 2.4

17. An acid ionizes to form a proton and its _____.
    Ans: base or conjugate base Section 2.5

18. When the pH is more than two pH units above the pKa of a carboxyl group, the acid is _____.
    Ans: unprotonated Section 2.5

19. Buffers are critical in maintaining proper _____ levels in biological systems.
    Ans: pH Section 2.5

20. The source of the key buffering component of blood is _____.
    Ans: carbon dioxide Section 2.5

Multiple-Choice Questions

21. 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: 2.5

22. Which of the following is considered a noncovalent bond?
    A) electrostatic interactions
    B) hydrogen bonds
    C) van der Waals interactions
    D) All of the above.
    E) None of the above.
    Ans: D Section: 2.3

23. What charged group(s) are present in glycine at a pH of 7?
    A) $–NH_3^+$
    B) $–COO^–$
    C) $–NH_2^+$
    D) A and B
    E) A, B, and C
    Ans: D Section: 2.5

24. Water can form hydrogen bonds with the _____ of another molecule.
    A) carbonyl groups
    B) amine groups
    C) aromatic rings
    D) alcohol groups
    E) A, B, and D
    Ans: E Section: 2.3 & 2.4

25. What pairs of atoms in bases are involved in hydrogen bonds?
    A) N–H and O–H
    B) N–H and S–H
    C) O–H and P–O
    D) All of the above.
    E) None of the above.
    Ans: A Section: 2.3

26. Typical van der Waals energies are about:
    A) 4–20 kJ/mol.
    B) 2–4 kJ/mol.
    C) 200 kJ/mol .
    D) All of the above.
    E) None of the above.
    Ans: B Section: 12.3

27. What two properties of water are important for biological interactions?
    A) the polarity of water
    B) the density of water
    C) the cohesive properties of water
    D) A and C
    E) B and C
    Ans: D Section: 2.2

28. 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

29. 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

30. What is the $[A^-]/[HA]$ ratio when the weak acid is in a solution one pH unit above its pK_a?
    A) 1:1
    B) 1:10
    C) 10:1
    D) 2:1
    E) None of the above.
    Ans: C Section 1.3

31. 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

32. What is the concentration of acetic acid in 250 ml of a 100 mM acetate buffer at pH 4.76?
    A) 250 mM
    B) 100 mM
    C) 50 mM
    D) 75 mM
    E) There is not enough information to tell.
    Ans: C Section 2.5

Short-Answer Questions

33. Using Coulomb's law, describe how water is an ideal solvent for the ions found in cells?
    Ans: The force which attracts two oppositely charged ions is measured by a constant a kq_1q_2 Kq1q2 divided the dielectric constant of the solvent × R. This means that a solvent such as water, with a high dielectric constant, will result in a lowered attractive force.
    Section: 2.4

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: 2.3

35. What is an electrostatic interaction? Give an example.
    Ans: It is the attractive force of two oppositely charged atoms. Salts (such as NaCl) are a common example.
    Section: 2.3

36. 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 can act as a hydrogen-bond acceptor, and the hydrogen can act as a donor.
    Section: 2.2

37. 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: 2.3

38. How is protein folding driven?
    Ans: Nonpolar amino acids associate with each other, forming the interior of folded proteins. This causes an increase in the entropy of water and thermodynamically drives protein folding.
    Section: 2.4

39. If noncovalent bonds are so much weaker than covalent bonds, how do they stabilize large biochemical structures?
    Ans: There is stability in numbers.
    Section: Introduction

40. 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: 2.4

41. How do hydrophobic interactions aid in membrane formation?
    Ans: Hydrophobic interaction causes the nonpolar tails to aggregate and form the interior of the membrane. This results in a net release of heat and a favorable change in the system enthalpy.
    Section: 2.4

42. Give examples of key functional groups found in biochemistry.
    Ans: Hydrophobic, hydroxyl, aldehyde, keto, carboxyl, amino, phosphoryl, sulfhydryl
    Section: 2.5, Table 2.1

43. Draw a titration curve for the ionization of acetic acid.
    Ans: The curve should look like Figure 2.12.
    Section: 2.5

44. Why are conjugate acid–base pairs so important in biological systems?
    Ans: The conjugate acid–base pairs in biological systems act as buffers. Many metabolic activities release protons, and these can combine with the conjugate base and so have little effect on the pH.
    Section: 2.5