Name:_____ Class:_____ Date:_____

Chapter 2—Water: The Solvent for Biochemical Reactions

1. The tendency for an atom to attract electrons to itself in a chemical bond is called
   a. polarity.
   b. electronegativity.
   c. hydrophilicity
   d. electrophilicity.

ANSWER: b

2. If atoms with greatly differing electronegativities form a bond, that bond will be
   a. polar.
   b. nonpolar.
   c. amphipathic.
   d. acidic.

ANSWER: a

3. Many of the properties of water can be accounted for by the fact that
   a. it is polar
   b. it forms hydrogen bonds
   c. it is a bent molecule
   d. all of these are true

ANSWER: d

4. Which of the following is true about ionic compounds?
   a. They are more likely to dissolve in non-polar solvents than covalent compounds.
   b. They always dissolve completely in water.
   c. They never dissolve in polar solvents.
   d. Some of them dissolve completely in water or other polar solvents, while others do not.

ANSWER: d

5. Which of the following is a correct listing of electronegativity values, from low to high?
   a. C, H, O, N
   b. N, H, O, C
   c. H, C, N, O
   d. H, C, O, N

ANSWER: c

6. Which of the following elements has the highest electronegativity?
   a. C
   b. H
   c. N
   d. O
   e. P

ANSWER: d

7. The water molecule is polar because:

a. Electrons are not distributed symmetrically in the molecule.
b. The hydrogen atoms are found on one "side" of the molecule.
c. Hydrogen is less electronegative than oxygen.
d. The hydrogen atoms are found on one "side" of the molecule and hydrogen is less electronegative than oxygen.
e. All of these are correct.

ANSWER: e

8. Which of the following molecules is polar?
a. CCl_4
b. CH_4
c. CO_2
d. NH_3
e. None of these molecules is polar.

ANSWER: d

9. Which of the following molecules is amphipathic?
a. sodium chloride
b. acetic acid
c. benzene
d. palmitic acid

ANSWER: d

10. Which of the following classes of compounds is hydrophilic?
a. Sugars
b. Fatty acids
c. Amino acids
d. Sugars and amino acids.
e. All of these

ANSWER: d

11. Which of the following classes of compounds is hydrophobic?
a. Table Salt
b. Cholesterol
c. Phosphate esters
d. Cholesterol and phosphate esters.
e. All of these are hydrophobic.

ANSWER: b

12. Which of the following molecules has polar bonds but is itself not polar?
a. NH_3
b. CO_2

c. CH_4

d. H_2O

ANSWER: b

13. When a carboxylate side-chain of one amino acid in a protein is in close proximity to a charged amino group of another amino acid, we call the resulting interaction a(n)

a. ion - dipole bond

b. ionic bond

c. van der Waal's bond

d. salt bridge

ANSWER: d

14. A London dispersion force is another name for a(n)

a. induced dipole - induced dipole bond

b. ionic bond

c. covalent bond

d. non-polar bond

ANSWER: a

15. Ionic compounds and polar covalent compounds tend to dissolve in water because of

a. ion-dipole and dipole-dipole interactions

b. dipole-induced dipole interactions

c. van der Waals bonds

d. hydrophobic interactions

ANSWER: a

16. Which of the following is not considered a van der Waal's force?

a. dipole - dipole bond

b. dipole - induced dipole bond

c. induced dipole - induced dipole bond

d. ion - dipole bond

ANSWER: d

17. A micelle is a structure which

a. aggregates with other micelles in water.

b. has its polar groups on the outside and non-polar groups on the inside when in water.

c. explains how soaps and detergents work.

d. has its polar groups on the outside and non-polar groups on the inside when in water and explains how soaps and detergents work.

e. All of these are true.

ANSWER: d

18. Which of the following compounds is most likely to form a micelle?

a. Acetic acid.

b. Glucose.
c. Glycerol.
d. Sodium palmitate.
e. Sodium phosphate.

ANSWER: d

19. The substance most likely to form a micelle is
a. acetic acid
b. sodium palmitate
c. methyl alcohol
d. acetone

ANSWER: b

20. Molecules which contain both hydrophilic and hydrophobic regions are:
a. Amphipathic
b. Amphiphilic
c. Able to form micelles
d. Both amphipathic and amphiphilic
e. All of these

ANSWER: e

21. How do hydrogen bonds tend to affect the melting and boiling points of substances?
a. They tend to increase both melting and boiling points.
b. They tend to decrease both melting and boiling points.
c. They tend to increase melting points and decrease boiling points.
d. They tend to decrease melting points and increase boiling points.
e. They do not have any affect on either melting or boiling points.

ANSWER: a

22. Hydrogen bonds
a. play an important role in the solvent properties of water
b. are not involved in protein structure
c. play a role in the properties of DNA, but not of RNA
d. give water a lower boiling point than expected

ANSWER: a

23. Which of the following molecules will not form hydrogen bonds?
a. CH_4
b. NH_3
c. H_2O
d. HF

ANSWER: a

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24. How does the strength of hydrogen bonds compare with covalent bonds?
    a. Hydrogen bonds are much stronger than covalent bonds.
    b. Hydrogen bonds are much weaker than covalent bonds.
    c. Hydrogen bonds and covalent bonds have similar strengths.
    d. The question cannot be answered without knowing which covalent bonds are being referred to

ANSWER: b

25. A hydrogen bond is a special type of
    a. dioole - dipole bond
    b. induced dipole - induced dipole bond
    c. covalent bond
    d. ionic bond

ANSWER: a

26. Which of the following is true regarding hydrogen bonds.
    a. They can only form between two different molecules
    b. They are important in protein folding but not DNA structure
    c. They are important in DNA structure but not protein folding
    d. They can be found within a single molecule

ANSWER: d

27. In a hydrogen bond
    a. three atoms lie in a straight line
    b. there is stronger bonding than in a covalent bond
    c. unpaired electrons play no role
    d. none of the above

ANSWER: a

28. The non-covalent interaction below associated with the strongest force in aqueous solution is
    a. dipole-induced dipole
    b. hydrophobic interactions
    c. hydrogen bonding
    d. van der Waals forces

ANSWER: c

29. Which of the following statements about hydrogen bonds is false?
    a. The donor is a hydrogen atom bonded to a less electronegative atom then hydrogen.
    b. The more linear the bond, the stronger the attraction.
    c. The acceptor must contain a non-bonded pair of electrons.
    d. It is a type of non-covalent bond.

ANSWER: a

30. True hydrogen bonds can NOT form between hydrogen and this element:
    a. N

b. F
c. C
d. O
e. All of these elements can form hydrogen bonds.

ANSWER: c

31. What is the maximum number of hydrogen bonds a single water molecule can form?
a. 1
b. 2
c. 3
d. 4
e. 5

ANSWER: d

32. Which of the following characteristics makes for a good hydrogen bond acceptor?
a. a high electronegativity
b. a nonbonding pair of electrons
c. both of these
d. neither of these

ANSWER: c

33. Which of the following characteristics makes for a good hydrogen bond donor?
a. a high electronegativity
b. a nonbonding pair of electrons
c. both of the above
d. neither of the above

ANSWER: a

34. Which of the following properties of water are related to its ability to form hydrogen bonds?
a. boiling point
b. melting point
c. density
d. solvent potency
e. all of the choices

ANSWER: e

35. Hydrogen bonds explain which of the following properties of water?
a. Water is a great solvent for all ionic and polar molecules.
b. Water has high melting and boiling points for its small size.
c. Ice expands when frozen.
d. Both the abnormal melting and freezing points and that ice expands when frozen.
e. Hydrogen bonds explain all of these properties.

ANSWER: e

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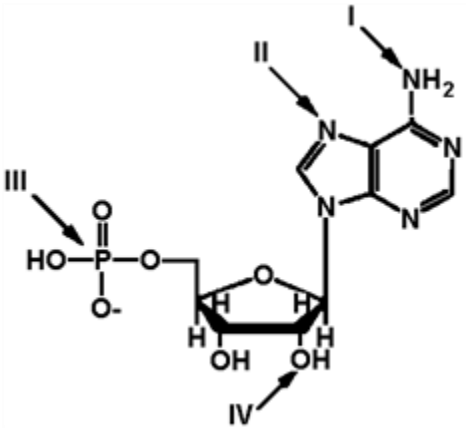
36. Hydrogen bonds can only form when the hydrogen atom is involved in a polar bond.
    a. True
    b. False

ANSWER: a

37. Which of the following is a true statement?
    a. most substances contract when they freeze.
    b. water expands when it freezes.
    c. hydrogen bonding is related to water's tendency to expand as it freezes.
    d. all of these are true

ANSWER: d

Exhibit 2A
The structure of ATP with various groups labeled.
Group III is the entire phosphate group.



38. **Refer to Exhibit 2A.** Which of the functional groups **cannot** function as a hydrogen donor to water?
    a. I
    b. II
    c. III
    d. IV
    e. All can donate a hydrogen to water.

ANSWER: b

39. **Refer to Exhibit 2A.** Which of the functional groups is the most electrophilic?
    a. I
    b. II
    c. III
    d. IV
    e. The answer cannot be determined without further information.

ANSWER: c

40. **Refer to Exhibit 2A.** Which of the groups could **not** act as a proton acceptor in a hydrogen bond?

a. I
b. II
c. III
d. IV
e. All can accept a hydrogen in a hydrogen bond.

ANSWER: e

41. Is water an acid or a base?
a. Water is an acid.
b. Water is a base.
c. Water is both an acid and a base.
d. Water is neither an acid nor a base.

ANSWER: c

42. For an acid that undergoes this reaction:

$HA \leftrightarrow H^+ + A^-$

K_a =
a. $[H^+][A^-]/[HA]$
b. $[H^+][HA]/[A^-]$
c. $[HA][A^-]/[H^+]$
d. $[A^-]/[HA][H^+]$
e. $[H^+]/[HA][A^-]$

ANSWER: a

43. Which will dissociate most in water, a weak acid or a strong acid?
a. A weak acid.
b. A strong acid
c. They should dissociate about the same.
d. It's impossible to predict.

ANSWER: b

44. Bases are
a. proton donors.
b. proton acceptors.
c. hydrogen bond donors.
d. hydrogen bond acceptors.

ANSWER: b

45. Which has the greater K_a, a weak acid or a strong acid?
a. A weak acid.

b. A strong acid
c. They should dissociate about the same.
d. It's impossible to predict.

ANSWER: b

46. Which has the greater pK_a, a weak acid or a strong acid?
a. A weak acid.
b. A strong acid
c. They should dissociate about the same.
d. It's impossible to predict.

ANSWER: a

47. The dissociation constant for an acid with a pK_a value of 6.0 is
a. 1×10^{-6}
b. -1×10^{6}
c. 1×10^{6}
d. -1×10^{-6}

ANSWER: a

48. A buffer solution at pH 10 has a ratio of [HA]/[A–] of 10. What is the pK_a of the acid?
a. 8
b. 9
c. 10
d. 11
e. 12

ANSWER: d

49. The dissociation constant for an acid is 1×10^{-6}. What is its pK_a?
a. −6
b. 6
c. 0.6
d. −0.6

ANSWER: b

50. The pH of a solution of 0.04 M HCl is:
a. 4
b. 1.4
c. 0.4
d. 0.04
e. The pH cannot be determined

ANSWER: b

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51. The pOH a solution of 0.04 M HCl is:
    a. 1.4
    b. 10
    c. 12.6
    d. 13.6
    e. The pOH cannot be determined

ANSWER: c

52. An HCl solution has a pH = 3. If you dilute 10 mL of the solution to 1000mL, the final pH will be:
    a. 1.0
    b. 2.0
    c. The pH does not change.
    d. 4.0
    e. 5.0

ANSWER: e

53. If a solution has a pH = 9.6, the $[H^+]$ is
    a. 2.5×10^{10}
    b. 9.6 M
    c. 2.5 M
    d. 2.5×10^{-10} M
    e. 9.6×10^{-10} M

ANSWER: d

54. What is the pH of a solution with $[H^+]$ = 10 mM?
    a. 10
    b. 1
    c. 2
    d. −2

ANSWER: c

55. Calculate the final pH of a solution made by the addition of 10 mL of a 0.5 M NaOH solution to 500 mL of a 0.4 M HA originally at pH = 5.0 (pKa = 5.0) Neglect the volume change.
    a. 6.10
    b. 5.09
    c. 7.00
    d. 5.55

ANSWER: d

56. If a solution has a pH = 6, the $[H^+]$ is
    a. 6 M
    b. 10^6 M

c. 10^{-6} M

d. 0.6 M

ANSWER: c

57. What is the pH of an acetic acid solution where the concentration of acetic acid is 2 mM and the concentration of sodium acetate is 20 mM. The pK_a of acetic acid is 4.76.

a. 5.76

b. 10.6

c. 12.6

d. 8.8

ANSWER: a

58. The ion product constant for water (K_w) is equal to:

a. 10^{14}

b. 10^{7}

c. 10^{0}

d. 10^{-7}

e. 10^{-14}

ANSWER: e

59. In a titration of a weak acid by a strong base

a. two equivalents of base are always needed to neutralize all the acid present

b. the equivalence point cannot be defined exactly

c. there is a region in which the pH changes slowly

d. the equivalence point depends on the nature of the added base

ANSWER: c

60. A solution at pH 7 contains a weak acid, HA. The pK_a of the acid is 6.5. What is the ratio of [A–]:[HA]?

a. 1:3

b. 1:1

c. 3:1

d. 10:1

ANSWER: c

61. When does a weak acid buffer best?

a. From one pH unit below its pK_a to its pK_a.

b. From its pK_a to one pH unit above its pK_a.

c. Within one pH unit of its pK_a, both above and below.

d. Weak acids do not make good buffers at all.

ANSWER: c

62. The inflection point of the titration curve for a weak monoprotic acid is equal to its pK_a
    a. True
    b. False
ANSWER: a

63. Which of the following is true?
    a. The pH of a solution where the A^- to HA ratio is 1 has a pH = pK_a.
    b. If the pH does not equal the pK_a, the solution is not a buffer.
    c. The best buffer for any experiment will always have a pH equal to the pK_a.
    d. If a buffer has more weak acid than conjugate base, the pH will be higher than the pK_a.
ANSWER: a

64. Using the Henderson-Hasselbalch equation, calculate the pH of an ammonia buffer when the NH_3:NH_4^+ ratio is 0.4 moles:0.6 moles. (pK = 9.75)
    a. 7.40
    b. 9.07
    c. 9.25
    d. 9.43
    e. 11.05
ANSWER: b

65. An ammonia buffer contains NH_3:NH_4^+ in a ratio of 0.4 moles:0.6 moles (pK = 9.75). What will be the pH if you add 0.01 moles of HCl to this buffer?
    a. 8.98
    b. 9.04
    c. 9.25
    d. 9.46
    e. 9.52
ANSWER: a

66. The ratio of a weak acid and its conjugate base at the point of maximum buffering capacity is
    a. 1/1
    b. 1/10
    c. 10/1
    d. no definite ratio is needed
ANSWER: a

67. Which substance would be the best buffer at pH 8 if it had to be able to buffer against either acid or base?
    a. one with a pK_a of 7
    b. one with a pK_a of 8
    c. one with a pK_a of 9

d. The pK_a of a substance doesn't tell you whether it would be a good buffer at this pH.

ANSWER: b

68. Buffering capacity refers to
a. the effectiveness of commercial antacids
b. the extent to which a buffer solution can counteract the effect of added acid or base
c. the pH of a buffer solution
d. the molecular weight of the substance used as a buffer

ANSWER: b

69. If the pH of 1 liter of a 1.0 M carbonate buffer is 7.0, what is the molar ratio of H_2CO_3 to HCO_3^-? (pK = 6.37)
a. 0.234
b. 4.27
c. 6.37
d. 7.00
e. 10.20

ANSWER: b

70. Consider a reaction that produces a significant amount of hydrogen ion and is to be carried out a pH 7. Only two acids are available for making the buffer solution. The pK_a values for acids A and B are 6.3 and 7.3, respectively. Which acid would serve as the optimum buffer for this reaction? Or would carrying out the reaction in water simply serve as well?
a. acid A
b. acid B
c. water
d. both acids would be equally effective

ANSWER: a

71. Which of the following acids would serve as a good buffer for a reaction at pH = 8.0?

		K_a
I.	acetic acid	1.76×10^{-5}
II.	$H_2PO_4^-$	6.31×10^{-8}
III.	bicarbonate	5.6×10^{-11}
IV.	TRIS	5.01×10^{-9}

a. I
b. II
c. III
d. IV

ANSWER: d

72. If the pH of 1 liter of a 1.0 M carbonate buffer is 7.0, what is actual number of moles of H_2CO_3 and HCO_3^-? (pK = 6.37)

	moles of H_2CO_3	moles of HCO_3^-
I.	0.86	0.14
II.	0.81	0.19
III.	0.76	0.24
IV.	0.19	0.81
V.	0.14	0.86

a. I
b. II
c. III
d. IV
e. V

ANSWER: d

73. A buffer solution
a. is used to control the pH of a solution
b. contains at least 100 times more of a weak acid than its conjugate base
c. contains at least 100 times less of a weak acid than its conjugate base
d. always has a pH of 7

ANSWER: a

74. The main intracellular buffer system is
a. $H_3PO_4/H_2PO_4^-$
b. $H_2PO_4^-/ HPO_4^{2-}$
c. HPO_4^{2-}/PO_4^{3-}
d. H_3PO_4/PO_4^{3-}

ANSWER: b

Exhibit 2B
Contains information on the pK's of some common buffers.

Buffer	pK1	pK2	pK3
Acetate	4.75		
Ammonia	9.25		
Carbonic acid	6.37	10.20	
Citric acid	3.09	4.75	5.41
Formic Acid	3.75		
Phosphoric acid	2.14	7.20	12.4
Pyruvic acid	2.50		
Tris	8.3		

75. **Refer to Exhibit 2B.** The enzyme lysozyme has an optimum pH close to 5. A suitable buffer would be:
a. Acetate
b. Carbonate
c. Phosphate
d. Pyruvate

e. None of these is a suitable buffer for this reaction.

ANSWER: a

76. **Refer to Exhibit 2B.** An ammonium buffer would work well at this pH:

a. 5.6
b. 7.0
c. 9.0
d. 11.0
e. None of these

ANSWER: c

77. **Refer to Exhibit 2B.** A carbonate buffer would work well at this pH:

a. 4.0
b. 6.0
c. 8.0
d. 10.0
e. 6.0 and 10.0

ANSWER: e

78. **Refer to Exhibit 2B.** A phosphate buffer would work well at this pH:

a. 5.0
b. 7.0
c. 8.0
d. 10.0
e. 7.0 and 8.0

ANSWER: e

79. **Refer to Exhibit 2B**. Which of the following would make the best buffer at pH =10.0?

a. Acetic acid and sodium acetate
b. Tris and its acid form
c. H_2CO_3 and $NaHCO_3$
d. Na_2HPO_4 and NaH_2PO_4
e. $NaHCO_3$ and Na_2CO_3

ANSWER: e

80. Which of the following is important to know when deciding if a given buffer will be effective for an experiment?

a. the pK_a of the buffer compound
b. the buffer capacity
c. the concentration of the buffer
d. whether the experiment is likely to generate hydrogen ions or hydroxide ions
e. all of these are important considerations

ANSWER: e

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Chapter 2—Water: The Solvent for Biochemical Reactions

81. Nonphysiological buffers such as HEPES and PIPES have come into common use because
    a. they are inexpensive
    b. they can be prepared much more easily than other buffers
    c. they have less tendency to interfere with reactions
    d. they contain nitrogen

ANSWER: c

82. Buffers which lack biological activity and are unlikely to interfere with any biochemical reactions include:
    a. Tris.
    b. Hepes.
    c. Phosphate.
    d. Both Tris and HEPES.
    e. All of these.

ANSWER: d

83. Which of the following is **not** true?
    a. A buffer is a solution which maintains a solution at a neutral pH
    b. Buffer solutions are made to resist change in pH
    c. Zwitterion buffers are less likely to interfere with biological reactions than non-zwitterions
    d. HEPES is a zwitterion buffer

ANSWER: a

84. The main blood buffer system is
    a. H_2CO_3/HCO_3^-
    b. HCO_3^-/CO_3^{2-}
    c. H_2CO_3/CO_3^{2-}
    d. none of the above

ANSWER: a

85. Buffers work to maintain pH because
    a. they obey LeChatlier's principle
    b. weak acids cannot change the pH of a solution
    c. weak bases added to strong bases neutralize each other
    d. they destroy the hydrogen ion that is added

ANSWER: a