Chapter 2
Water: The Medium of Life

1. The unrivaled ability to form ___ hydrogen bonds per liquid water molecule is the source of the strong intermolecular attractions unique to water.

   a. 1
   b. 2
   c. 3
   d. 4
   e. 5

2. Because of its highly polar nature, water is an excellent solvent for polar substances, but NOT for:

   a. salts.
   b. sugars.
   c. aldehydes and ketones.
   d. hydrocarbons.
   e. alcohols and amines.

3. The solvent with the highest dielectric constant in this group is:

   a. water
   b. acetic acid
   c. ethanol
   d. hexane
   e. benzene

4. The average lifetime of a hydrogen bond connection in water is on the order of:

   a. picoseconds.
   b. microseconds.
   c. milliseconds.
   d. seconds.
   e. nanoseconds.

5. All of the following characteristics are associated with the solvent water EXCEPT:

   a. a high surface tension.
   b. a chemically inert solvent, which has a great capacity to dissolve a diverse spectrum of molecules and ions.
   c. low heat capacity.
   d. a high dielectric constant.
   e. a high capacity to form hydrogen bonds.

6. Amphiphilic (amphipathic) molecules include:

   a. sugars
   b. acidic amino acids
   c. inorganic salts
   d. water
   e. salts of fatty acids

7. In micelles:

   a. polar ends form hydrophobic interactions with water.
   b. non-polar ends form hydrophilic interactions with water.
   c. hydrocarbon tails form hydrophobic interactions with water.
   d. polar ends are hydrophobic and non-polar ends are hydrophilic.
   e. hydrocarbon tails are excluded from the water into hydrophobic domains.

8. Addition of glucose to water results in all of the following effects EXCEPT.

   a. An increase in the osmotic pressure of the solution.
   b. The lowering of the boiling point of the solution.
   c. The lowering of the vapor pressure of the solution.
   d. The lowering of the freezing point of the solution.
   e. None of the above.

9. Introduction of a solute into water has all of the following effects EXCEPT.

   a. Solutes fix nearby water molecules into more ordered arrays.
   b. Solutes dissolved in water make it easier for water to assume its crystalline lattice (freeze).
   c. Ions establish hydration shells creating local order.
   d. Hydrophobic molecules create local structures in water.
   e. Solutes give order to water and diminish the dynamic interplay of pure water.

10. If equal molar amounts of Na_2HPO_4 and Na_3PO_4 are mixed in water, estimate the resulting pH. The pK_as of phosphoric acid are 2.1, 7.2, and 12.4.

    a. 7.2
    b. 12.4
    c. 4.5
    d. 9.5
    e. 2.1

11. If 50 ml of 0.01 M HCl is added to 50 ml of 0.01 M NaH_2PO_4 ($pK_a = 7.2$), the resulting pH will be:

    a. equal to the pK_a.
    b. Above the pK_a, but less than 8.2.
    c. Below the pK_a, but above 6.2.
    d. Above 8.2.
    e. Below 6.2.

12. A plasma pH of 6.8 doesn't seem too far away from a normal pH of 7.4, but at pH 6.8 the H^+ concentration is ___ times greater than at pH 7.4 and results in severe acidosis.

    a. 0.1
    b. 0.6
    c. 4
    d. 10
    e. 20

13. Which of the following would make the best buffer at pH 10.0?

    a. Acetic acid and sodium acetate ($pK_a = 4.8$)
    b. Methylammonium chloride and methylamine ($pK_a = 10.6$)
    c. Na_2HPO_4 / Na_3PO_4 ($pK_a = 12.4$)
    d. Histidine ($pK_a = 6.0$)
    e. *tris*-Hydroxymethyl aminomethane ($pK_a = 8.1$)

14. $pH = pK_a$ when :

    a. $[A^-] / [HA] = 0$
    b. $\log ([A^-] / [HA]) = 1$
    c. $[A^-] >> [HA]$
    d. $[A^-] = [HA]$
    e. $\log ([HA] / [A^-]) = 1$

15. Buffers have all of the following characteristics EXCEPT they:

    a. have relatively flat titration curves at the pH(s) where they buffer.
    b. resist changes in their pH as acid or base is added.
    c. are typically composed of a weak acid and its conjugate base.
    d. buffer best for polyprotic acids half-way between the two pK_a values.
    e. buffer where the amounts of conjugate base are nearly equivalent to the amounts of weak acid.

16. Buffer systems are effective when the pH values are within ___ pH unit(s) of the pK_a value.

    a. 1
    b. 2
    c. 3
    d. 4
    e. 5

17. Intracellular pH is maintained primarily by the _____ and _____ buffer systems, and the extracellular pH by the _____ buffer system.

    a. HPO_4^{2-} / $H_2PO_4^-$, HCO_3^- / H_2CO_3 , histidine
    b. H_3PO_4 / $H_2PO_4^-$, histidine, HCO_3^- / H_2CO_3
    c. HCO_3^- / H_2CO_3 , H_3PO_4 / $H_2PO_4^-$, histidine
    d. HPO_4^{2-}/ $H_2PO_4^-$, histidine, HCO_3^- / H_2CO_3
    e. HCO_3^- / H_2CO_3 , histidine, H_3PO_4 / $H_2PO_4^-$

18. What is the approximate fractional concentrations of $H_2PO_4^-$ / HPO_4^{2-} (pK_a = 7.2) at pH 7.5?

    a. 1/1
    b. 1/2
    c. 5/1
    d. 1/10
    e. 3/1

19. Hyperventilation is a physiological mechanism to:

    a. lower [CO_2 (g)] in the blood and increase blood pH.
    b. raise [CO_2 (g)] in the blood and increase blood pH.
    c. lower [CO_2 (g)] in the blood and decrease blood pH.
    d. raise [CO_2 (g)] in the blood and decrease blood pH.
    e. lower [CO_2 (g)] in the blood and increase [HCO_3^-].

20. Water is particularly suited as a solvent for biosystems because it has all of the following characteristics EXCEPT:

    a. Water is a medium for ionization enhancing the variety of chemical species.
    b. Water is innocuous, yet a powerful solvent.
    c. Water is an excellent solvent for non-polar substances.
    d. Water is relatively chemically inert, yet dissolves a variety of solutes.
    e. Through hydrophobic interactions, lipids coalese into membranes in water.

21. Which of the following weak acids would make the best buffer at pH = 5.0?

    a. acetic acid ($K_a = 1.74 \times 10^{-5}$, $pK_a = 4.76$)
    b. $H_2PO_4^-$ ($K_a = 1.38 \times 10^{-7}$, $pK_a = 7.20$)
    c. bicarbonate ($K_a = 6.3$ X 10^{-11}, $pK_a = 10.24$)
    d. *tris*-hydroxymethyl aminomethane ($K_a = 8.32 \times 10^{-9}$, $pK_a = 8.07$)
    e. lactic acid ($K_a = 1.38$ X 10-4 , $pK_a = 3.86$)

22. What ionic forms of phosphoric acid are present at pH 7.0. The pK_as of phosphoric acid are 2.1, 7.2, and 12.4.

    a. $H_2PO_4^-$
    b. $H_2PO_4^-$ and HPO_4^{-2}
    c. HPO_4^- and PO_4^{-3}
    d. H_3PO_4 and $H_2PO_4^-$
    e. HPO_4^{-2}

23. The enzyme fumarase has a pH optimum of about 7.6. What would be the buffer of choice to study this enzyme?

    a. lactic acid ($K_a = 1.38$ X 10-4 , $pK_a = 3.86$)
    b. bicarbonate ($K_a = 6.3$ X 10^{-11}, $pK_a = 10.24$)
    c. acetic acid ($K_a = 1.74 \times 10^{-5}$, $pK_a = 4.76$)
    d. succinate ($K_a = 2.34 \times 10^{-6}$, $pK_a = 5.63$)
    e. tris-hydroxymethyl aminomethane ($K_a = 8.32 \times 10^{-9}$, $pK_a = 8.07$)

24. When preparing an acetate buffer at pH 4.5 with 0.01 M solutions of acetic acid ($pK_a = 4.8$) and sodium acetate, the volume of acetic acid needed would be _____ the volume of sodium acetate solution.

    a. equal to
    b. less than half of
    c. more than half of
    d. about six times
    e. about twice