

Chapter 2: Aqueous Solutions

Matching

- A) hydrogen bond(s)
- B) rotational
- C) H_3PO_4
- D) H_2PO_4^-
- E) HPO_4^{2-}
- F) disordered
- G) positive entropy
- H) negative entropy
- I) higher electronegativity
- J) insoluble
- K) tetrahedral structure arrangement
- L) acid versus base
- M) base versus acid
- N) dissolved but only partially ionized

1. Translational and _____ thermal motion causes liquid water molecules to reorient approximately every 10^{-12} seconds.

Ans: B

Level of Difficulty: Easy

Section: **2-1. Properties of Water**

2. The 104.5° bond angle in the water molecule is the result of the _____ of electron orbitals around oxygen.

Ans: K

Level of Difficulty: Easy

Section: **2-1. Properties of Water**

3. The polarity of the O–H bond is caused by the _____ of oxygen.

Ans: I

Level of Difficulty: Easy

Section: **2-1. Properties of Water**

4. Octane molecules dispersed in water tend to aggregate because that allows water molecules to be more _____.

Ans: F

Level of Difficulty: Easy

Section: **2-1. Properties of Water**

5. A strong acid is completely ionized in water, whereas a weak acid is _____.

Ans: N

Level of Difficulty: Easy

Section: **2-2. Acids, Bases, and Buffers**

6. Phosphate, with a pK_2 of = 6.82, will be mostly in the HPO_4^{2-} form at pH 7.2. At pH 5.82 it is mostly in the _____ form.

Ans: D

Level of Difficulty: Easy

Section: **2-2. Acids, Bases, and Buffers**

7. A solution of buffer at a pH of 8.5 with a pK of = 7.5 would have more capacity to buffer the addition of _____.

Ans: L

Level of Difficulty: Easy

Section: **2-2. Acids, Bases, and Buffers**

8. A phosphate buffer solution at a $\text{pH} = pK_1 = 2.15$ would have equal amounts of phosphate in the _____ form and the H_2PO_4^- form.

Ans: C

Level of Difficulty: Easy

Section: **2-2. Acids, Bases, and Buffers**

Multiple Choice

9. Hydrogen bonds within liquid water:

- A) are attractions between the protons of the oxygen nuclei.
- B) are attractions between two hydrogen atoms.
- C) are attractions between the H^+ and OH^- ions of the liquid.
- D) are ion-induced dipole attractions.
- E) are dipole-dipole attractions.

Ans: E

Level of Difficulty: Easy

Section: **2-1. Properties of Water**

10. In a hydrogen bond between a water molecule and another biomolecule:

- A) a hydrogen ion on the water molecule forms an ionic bond with a hydride ion on the other molecule.
- B) the partial charge on a hydrogen of the water interacts with the partial charge on a hydrogen of the other molecule.
- C) the hydrogen bond will typically form between a hydrogen atom and either a nitrogen, sulfur, or oxygen atom.
- D) a hydrogen on the water molecule forms a covalent bond to a hydrogen atom on the other molecule.
- E) the hydrogen atom is located between an oxygen atom of the water and a carbon atom of the other molecule.

Ans: C

Level of Difficulty: Easy

Section: **2-1. Properties of Water**

11. Hydrophobic interactions between nonpolar molecules or groups:

- A) result from the tendency to maximize water's contact with nonpolar molecules.
- B) are the result of strong attractions between nonpolar regions.
- C) are the result of strong repulsion between water and nonpolar regions.
- D) depend on strong permanent dipoles in the nonpolar molecules.
- E) require the presence of surrounding water molecules.

Ans: E

Level of Difficulty: Easy

Section: **2-1. Properties of Water**

12. Weak acids:

- A) are only partially ionized in aqueous solution.
- B) give solutions a high pH.
- C) do not provide hydronium ions .
- D) are almost insoluble in water.
- E) are of no value in a buffering system.

Ans: A

Level of Difficulty: Easy

Section: **2-2. Acids, Bases, and Buffers**

13. To make a phosphate buffer at pH 6.82 starting with one liter of 10 mM phosphoric acid (pK_s are of 2.15, 6.82, and 12.38), you could add

- A) You can't make a buffer by adding HCl or KOH.
- B) 5 millimoles of HCl.
- C) 20 millimoles of K^+ .
- D) 25 millimoles of HCl.
- E) 15 millimoles of KOH.

Ans: E

Level of Difficulty: Easy

Section: **2-2. Acids, Bases, and Buffers**

14. To make an acetate buffer at pH 4.76 ($pK = 4.76$) starting with 500 mL of 0.1 M sodium acetate ($pK = 4.76$), you could add:

- A) 0.1 moles of NaOH.
- B) 0.2 moles of HCl.
- C) 0.025 moles of HCl.
- D) You can't make a buffer by adding HCl or NaOH.
- E) 0.1 moles of HCl.

Ans: C

Level of Difficulty: Easy

Section: **2-2. Acids, Bases, and Buffers**

15. Amphiphilic molecules:

- A) have both oxidizing and reducing groups.
- B) are micelles.
- C) have chromophores in two different wavelength regions.
- D) have both acidic and basic groups.
- E) have both hydrophilic and hydrophobic groups.

Ans: E

Level of Difficulty: Easy

Section: **2-1. Properties of Water**

16. If you added a drop (about 0.05 mL) of 1.0 M HCl to one liter of pure water (assume pH 7.0), the pH would become .

- A) 2.7
- B) 4.3
- C) 9.7
- D) 7.0 (there would be no significant change)
- E) 5.0

Ans: B

Level of Difficulty: Easy

Section: **2-2. Acids, Bases, and Buffers**

17. If you add 1.0 mL of 1.0 M acetic acid ($pK = 4.76$, $K = 1.74 \times 10^{-5}$) to one liter of pure water, the resulting pH would be approximately:

- A) 10.1
- B) 3.0
- C) 1.0
- D) 3.9
- E) 1.32

Ans: D

Level of Difficulty: Easy

Section: **2-2. Acids, Bases, and Buffers**

18. The pH of a 0.1M solution of sodium acetate would be:

- A) basic, because the acetate ion reacts with water to form acetic acid and OH^- .
- B) acidic, because the acetate ion is acidic.
- C) acidic, because the acetate ion forms acetic acid.
- D) neutral, because salts are neither acidic nor basic.
- E) basic, because the Na^+ ionizes and combines with OH^- .

Ans: A

Level of Difficulty: Easy

Section: **2-2. Acids, Bases, and Buffers**

19. Which of the following statements is not true about water?

- A) It has a high dielectric constant
- B) It dissolves salts and polar substances
- C) It can form two hydrogen bonds per water molecule
- D) It packs in a hexagonal (honeycomb) shaped lattice in ice
- E) In the liquid state is only 15% less hydrogen bonded than in the solid state

Ans: C

Level of Difficulty: Easy

Section: **2-1. Properties of Water**

20. Which of the following statements is not true about hydrophobic interactions?

- A) They are caused by hydrophobic molecules interacting strongly with each other

- B) They are the driving force for micelle formation in amphiphilic substances where micelle formation is due to the desire of water molecules to exclude the hydrophobic regions –forcing them to interact with themselves instead of water molecules
- C) When a non-polar solute dissolves in water, it causes a highly-ordered shell of water molecules to form at the interface between it and water: A hydrophobic interaction is caused by the desire of water molecules to regain entropy lost during this organization around the non-polar substance by excluding the substance from interaction with water molecules
- D) They are entropy driven
- E) They are the main driving force for protein folding into 3D structures

Ans: A

Level of Difficulty: Easy

Section: **2-1. Properties of Water**

21. Which of the following is not true about water?

- A) The electron-rich oxygen atom of one water molecule can interact with the electron-poor proton on another water molecule to form a hydrogen bond.
- B) Liquid water is only 15% less hydrogen bonded than ice
- C) Water is a non-polar molecule that with a bent molecular geometry
- D) Water can form caged, highly ordered structures around small non-polar molecules like methane that are called clathrates
- E) Water is a key player in the energetics of hydrophobic interactions

Ans: C

Level of Difficulty: Easy

Section: **2-1. Properties of Water**

22. What is the ratio of citric acid ($pK_1 = 3.09$) to monosodium citrate in a 1.0 M citric acid solution with a $pH = 2.09$?

- A) 10:1
- B) 1:1
- C) 1:10
- D) 10:11
- E) 1:11

Ans: A

Level of Difficulty: Easy

Section: **2-2. Acids, Bases, and Buffers**

23. Which of the following statements about water is incorrect?

- A) Water is an excellent solvent for polar molecules
- B) Pure water has a concentration of approximately 55.5 M

- C) Cations are solvated by shells of water molecules oriented with their hydrogen atoms pointed toward the ions
- D) Non-polar molecules do not dissolve in water, but form a separate phase
- E) Amphiphilic detergents often form micelles with the polar groups on the outside exposed to the water (solvent) and the non-polar groups sequestered in the interior

Ans: C

Level of Difficulty: Easy

Section: **2-1. Properties of Water**

24. Which of the following statements about water is incorrect?

- A) It is a small, polar molecule with a low dielectric constant
- B) It has a marked dipole moment of 1.85 Debyes
- C) It is largely hydrogen bonded, although any single H-bond exists only for a very short period of time ($\sim 10^{-12}$ s)
- D) Acid-base reactions are very fast due to the mobility of hydronium ions in water – a consequence of the ability of individual protons to “jump” from one water molecule to another
- E) It has a bent geometry with each O-H bond approximately 0.958 Å long and with an O-H bond energy of approximately 460 kJ/mol

Ans: A

Level of Difficulty: Easy

Section: **2-1. Properties of Water**

25. Approximately how many grams of monosodium succinate (FW = 140 g/mol; succinic acid $pK_2=5.64$) and disodium succinate (FW = 162 g/mol) must be added to 1L of water to produce a solution with a pH 5.28 and a total solute concentration of 100 mM. (Answer in grams monosodium succinate, grams disodium succinate)

- A) 11.3, 4.2
- B) 9.7, 4.9
- C) 4.9, 9.7
- D) 14.9, 1.1
- E) 1.1, 14.9

Ans: B

Level of Difficulty: Medium

Section: **2-2. Acids, Bases, and Buffers**

26. The strongest *non-covalent* interactions are:

- A) ionic interactions
- B) hydrogen bonds
- C) dipole-dipole interaction
- D) London dispersion forces

E) van der Waal forces

Ans: A

Level of Difficulty: Easy

Section: 2-1. Properties of Water

27. Which of the following is the best explanation for the hydrophobic effect?

A) It is caused by an affinity of hydrophobic groups for each other

B) It is caused by the affinity of water for hydrophobic groups

C) It is an entropic effect, caused by the desire of water molecules to increase their entropy by forming highly ordered structures (called clathrates) around the hydrophobic groups

D) It is an entropic effect, caused by the desire of water molecules to increase their entropy by excluding hydrophobic groups, which they must otherwise surround with highly ordered structures (called clathrates)

E) It is an entropic effect caused by the desire of hydrophobic groups to increase their entropy by associating with other hydrophobic groups

Ans: D

Level of Difficulty: Easy

Section: **2-1. Properties of Water**

28. What is the approximate pK of a weak acid HA if a solution 0.1 M HA and 0.3 M A⁻ has a pH of 6.5?

A) 5.8

B) 6.0

C) 6.2

D) 6.4

E) 6.6

Ans: B

Level of Difficulty: Medium

Section: **2-2. Acids, Bases, and Buffers**

29. Ice

A) is a crystal of water molecules packed in an open structure of hydrogen bonds

B) is less dense than liquid water

C) Is H-bonded to a similar extent as liquid water

D) all of the above

E) none of the above

Ans: D

Level of Difficulty: Easy

Section: **2-1. Properties of Water**

30. Hydrogen bonds are approximately ____% of the bond strength of covalent C-C or C-H bonds?

- A) 1%
- B) 5%
- C) 20%
- D) 50%
- E) 95%

Ans: B

Level of Difficulty: Easy

Section: **2-1. Properties of Water**

31. _____ is exceptionally soluble in water due to the formation of hydrogen bonds.

- A) NaCl
- B) benzene
- C) sodium palmitate
- D) ethanol
- E) oxygen

Ans: D

Level of Difficulty: Easy

Section: **2-1. Properties of Water**

32. In water solvent, globules of up to several thousand amphiphilic molecules arranged with the hydrophilic groups on the surface and the hydrophobic groups buried in the center are called:

- A) micelles
- B) liposomes
- C) vacuoles
- D) bilayer membranes
- E) none of the above

Ans: A

Level of Difficulty: Easy

Section: **2-1. Properties of Water**

33. K_w , the ionization constant of water, is _____ at _____.

- A) 10^{-7} ; 25°C
- B) 10^7 ; 25K
- C) 10^{14} ; 25°C
- D) 10^{-14} ; 25°C

E) 10^{-14} ; 0°C

Ans: D

Level of Difficulty: Easy

Section: **2-2. Acids, Bases, and Buffers**

34. The pH at the midpoint of an acid/base titration is:

- A) equal to the pK of the corresponding acid
- B) equal to the pK of the corresponding base
- C) equal to 14 minus the pK of the corresponding acid
- D) equal to 14 plus the pK of the corresponding base [note: if pK means pK_b here, this answer is correct, so I changed the answer so that it would be false no matter what]
- E) none of the above

Ans: A

Level of Difficulty: Easy

Section: **2-2. Acids, Bases, and Buffers**

35. The blood buffering system is based on:

- A) the reaction of CO_2 with H_2O to form carbonic acid
- B) the ionization of aqueous carbonic acid to H^+ and the bicarbonate anion
- C) the decrease of the blood pH due to the production of H^+
- D) the excretion of bicarbonate and ammonium from the kidneys
- E) all of the above

Ans: E

Level of Difficulty: Easy

Section: **2-2. Acids, Bases, and Buffers**