

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

- 1) In a single molecule of water, the two hydrogen atoms are bonded to a single oxygen atom by
 - A) nonpolar covalent bonds.
 - B) polar covalent bonds.
 - C) ionic bonds.
 - D) hydrogen bonds.
 - E) van der Waals interactions.

- 2) The partial negative charge at one end of a water molecule is attracted to the partial positive charge of another water molecule. What is this attraction called?
 - A) a hydrophobic bond
 - B) an ionic bond
 - C) a hydrogen bond
 - D) a hydrophilic bond
 - E) a covalent bond

- 3) Which of the following is an example of a hydrogen bond?
 - A) the bond between the H of one water molecule and the O of another water molecule
 - B) the bond between C and H in methane
 - C) the bond between Na and Cl in salt
 - D) the bond between Mg and Cl in MgCl_2
 - E) the bond between two hydrogen atoms

- 4) Water is able to form hydrogen bonds because
 - A) oxygen has a valence of 2.
 - B) the water molecule is polar.
 - C) the hydrogen atoms in a water molecule are weakly negative in charge.
 - D) the water molecule is shaped like a tetrahedron.
 - E) the oxygen atom in a water molecule has a strong positive charge.

- 5) What is the maximum number of hydrogen bonds a water molecule can form with neighboring water molecules?
 - A) four
 - B) five
 - C) one
 - D) three
 - E) two

- 6) What determines the cohesiveness of water molecules?
 - A) covalent bonds
 - B) hydrogen bonds
 - C) ionic bonds
 - D) high specific heat
 - E) hydrophobic interactions

- 7) What do cohesion, surface tension, and adhesion have in common with reference to water?
 - A) All increase when temperature increases.
 - B) All have to do with nonpolar covalent bonds.
 - C) All are produced by covalent bonding.
 - D) All are properties related to hydrogen bonding.
 - E) Both A and C are correct.

- 8) Water is transported in plant tissues against gravity due to which of the following properties?
 - A) adhesion
 - B) hydrogen bonding
 - C) cohesion
 - D) two of the above
 - E) all of the above

- 9) Which of the following is possible due to the surface tension of water?
- A) Lakes don't freeze solid in the winter, despite low temperatures.
 - B) The pH remains neutral.
 - C) Water can act as a solvent.
 - D) A waterstrider can walk across a small pond.
 - E) Organisms resist temperature changes although they give off heat due to chemical reactions.
- 10) When an ice cube cools a drink 1eC, which of the following is *true*?
- A) Evaporation of the water increases.
 - B) Kinetic energy in the drink decreases.
 - C) A kilocalorie of heat is transferred to the ice.
 - D) Molecule collisions in the drink increase.
 - E) A kilocalorie of heat is transferred to the water.
- 11) Which of the following is a *correct* definition of a kilocalorie?
- A) A measure of the average kinetic energy of 1 L of water.
 - B) The amount of heat energy required to raise 1 g of water by 1eF.
 - C) The amount of energy in 1 kg of glucose.
 - D) The amount of heat energy required to raise 1 g of water by 1eC.
 - E) The amount of heat energy required to raise 1 kg of water by 1eC.
- 12) The nutritional information on a cereal box shows that one serving of dry cereal has 90 calories (actually kilocalories). If one were to burn a serving of cereal, the amount of heat given off would be sufficient to raise the temperature of 1 kg of water how many degrees Celsius?
- A) 90.0eC B) 0.9eC C) 9000.0eC D) 9.0eC E) 900.0eC
- 13) Water's high specific heat is mainly a consequence of the
- A) fact that water is a poor heat conductor.
 - B) small size of the water molecules.
 - C) inability of water to dissipate heat into dry air.
 - D) high specific heat of oxygen and hydrogen atoms.
 - E) absorption and release of heat when hydrogen bonds break and form.
- 14) Which bonds must be broken for water to vaporize?
- A) hydrogen bonds
 - B) nonpolar covalent bonds
 - C) ionic bonds
 - D) polar covalent bonds
 - E) Both C and D are correct.
- 15) The formation of ice during colder weather helps temper the seasonal transition to winter. This is mainly because
- A) there is less evaporative cooling of lakes.
 - B) ice is warmer than the winter air.
 - C) the formation of hydrogen bonds absorbs heat.
 - D) the formation of hydrogen bonds releases heat.
 - E) ice melts each autumn afternoon.
- 16) Temperature usually increases when water condenses. Which behavior of water is most directly responsible for this phenomenon?
- A) reactions with other atmospheric compounds
 - B) release of heat by the breaking of hydrogen bonds
 - C) high surface tension
 - D) change in density when it condenses to form a liquid or solid
 - E) release of heat by the formation of hydrogen bonds

- 17) Desert rabbits are adapted to the warm climate because their large ears aid in the removal of heat by
- the high surface tension of water.
 - the high heat of vaporization of water.
 - the buffering capacity of water.
 - the dissociation of water molecules.
 - the high specific heat of water.
- 18) At what temperature is water at its densest?
- 32°C
 - 212°C
 - 4°C
 - 100°C
 - 0°C
- 19) Ice is lighter and floats in water because it is a crystalline structure held together by
- hydrogen bonds only.
 - ionic bonds only.
 - covalent bonds only.
 - Both A and C are correct.
 - A, B, and C are correct.
- 20) Why does ice float in liquid water?
- The ionic bonds between the molecules in ice prevent the ice from sinking.
 - The liquid water molecules have more energy and can push up the ice.
 - Ice always has air bubbles that keep it afloat.
 - Hydrogen bonds keep the molecules of ice farther apart than in liquid water.
 - The crystalline lattice of ice causes it to be denser than liquid water.
- 21) Life on Earth is dependent on all the properties of water as well as the abundance of water. Which property of water is probably *most* important for the functioning of organisms at the molecular level?
- high specific heat
 - cohesion and high surface tension
 - versatility as a solvent
 - expansion upon freezing
 - high heat of vaporization
- 22) Hydrophobic substances like vegetable oil are
- non-ionic or nonpolar substances that repel water.
 - ionic or polar substances that have an affinity for water.
 - non-ionic or nonpolar substances that have an affinity for water.
 - ionic substances that readily dissolve in water.
 - ionic or polar substances that repel water.
- 23) One mole (mol) of a substance is equal to
- 6.02×10^{23} molecules of the substance.
 - the largest amount of the substance that can be dissolved in 1 L of solution.
 - Answers A and D are correct.
 - the molecular weight of the substance expressed in grams. One mol of glucose (C₆H₁₂O₆) is equivalent to 180 g of glucose.
 - 1 g of the substance dissolved in 1 L of solution.
- 24) How many molecules of sucrose (C₁₂H₂₂O₁₁) molecular weight, 342, would be present in one mole of sucrose?
- 6.02×10^{23} molecules
 - 45 molecules
 - 1×10^{14} molecules
 - 6.02×10^{14} molecules
 - 342 molecules

25) How many molecules of glycerol ($\text{C}_3\text{H}_8\text{O}_3$) would be present in 1 L of a 1 M glycerol solution?

- A) 14
- B) 1
- C) 92
- D) 1×10^7
- E) 6.02×10^{23}

26) Recall that when sodium chloride (NaCl) is placed in water the component atoms of the NaCl crystal dissociate into individual sodium ions (Na^+) and chloride ions (Cl^-). In contrast, the atoms of covalently bonded molecules (for example: glucose, sucrose, glycerol) do not generally dissociate when placed in aqueous solution. Which of the following solutions would be expected to contain the greatest number of particles (molecules or ions)?

- A) 1.0 M $\text{C}_6\text{H}_{12}\text{O}_6$
- B) 0.5 M glucose
- C) 1.0 M NaCl
- D) 1.0 M glucose
- E) 0.5 M NaCl

27) The molecular weight of glucose is 180 g. To make a 1 M solution of glucose, you should do which of the following?

- A) Dissolve 180 g of glucose in water, and then add more water until the total volume of the solution is 1 L.
- B) Dissolve 1 g of glucose in 1 L of water.
- C) Dissolve 180 mg (milligrams) of glucose in 1 L of water.
- D) Dissolve 180 g of glucose in 100 g of water.
- E) Dissolve 100 g of glucose in 1 L of water.

28) The molecular weight of glucose ($\text{C}_6\text{H}_{12}\text{O}_6$) is 180 g. To make a 0.5 M solution of glucose, you should

- A) dissolve 24 g of glucose in 1 L of water.
- B) dissolve 12 g of glucose in 1 L of water.
- C) dissolve 0.5 g of glucose in 1 L of water.
- D) dissolve 180 g of glucose in a small volume of water, and then add more water until the total volume of the solution is 1 L.
- E) dissolve 90 g of glucose in a small volume of water and then add more water until the total volume of solution is 1 L.

29) How many grams of the molecule in Figure 3.2 would be required to make 1 L of a 1.5 M solution of the molecule? (Carbon = 12, Oxygen = 16, Hydrogen = 1)

- A) 74 B) 55 C) 37 D) 60 E) 90

30) A given solution is found to contain 0.0001 mol of hydrogen ions (H^+) per liter. Which of the following best describes this solution?

- A) neutral
- B) acidic: H^+ acceptor
- C) basic: H^+ donor
- D) basic: H^+ acceptor
- E) acidic: H^+ donor

31) A solution is found to contain 0.000001 mol of hydroxide ions (OH^-) per liter. Which of the following best describes this solution?

- A) neutral
- B) acidic: H^+ acceptor
- C) acidic: H^+ donor
- D) basic: H^+ acceptor
- E) basic: H^+ donor

- 32) Which of the following ionizes completely in solution and is therefore a strong acid?
- A) CH_3COOH
 - B) NaOH
 - C) H_2SO_4
 - D) HCl
 - E) HNO_3
- 33) Which of the following ionizes completely in solution and is therefore a strong base?
- A) NaCl
 - B) H_2SO_4
 - C) HCl
 - D) NaOH
 - E) HNO_3
- 34) Which of the following statements is *completely* correct?
- A) NaOH is a strong base, and HCl is a weak acid.
 - B) H_2SO_4 is a weak acid, and NaOH is a weak base.
 - C) H_2SO_4 is a strong acid, and NaOH is a strong base.
 - D) H_2SO_4 is a weak base, and HCl is a strong acid.
 - E) NaOH is a weak base, and HCl is a strong acid.
- 35) Assume that acid rain has lowered the pH of a particular lake to pH 5.0. What is the hydroxide ion concentration of this lake?
- A) 1×10^{-9} mol of hydroxide ion per liter of lake water
 - B) 1×10^{-5} mol of hydroxide ion per liter of lake water
 - C) 9.0 M with regard to hydroxide ion concentration
 - D) 5.0 M with regard to hydroxide ion concentration
 - E) Both B and D are correct.
- 36) What would be the pH of a solution with a hydroxide ion concentration $[\text{OH}^-]$ of 10^{-10} M?
- A) 4
 - B) 14
 - C) 8
 - D) 10
 - E) 2
- 37) What would be the pH of a solution with a hydrogen ion concentration $[\text{H}^+]$ of 10^{-8} M?
- A) pH 2
 - B) pH 4
 - C) pH 10
 - D) pH 6
 - E) pH 8
- 38) Which of the following solutions has the greatest concentration of hydrogen ions $[\text{H}^+]$?
- A) tomato juice at pH 4
 - B) gastric juice at pH 2
 - C) household bleach at pH 12
 - D) black coffee at pH 5
 - E) vinegar at pH 3
- 39) Which of the following solutions has the greatest concentration of hydroxide ions $[\text{OH}^-]$?
- A) lemon juice at pH 2
 - B) seawater at pH 8
 - C) tomato juice at pH 4
 - D) urine at pH 6
 - E) vinegar at pH 3
- 40) If the pH of a solution is decreased from 7 to 6, it means that the
- A) concentration of H^+ has decreased to 10 times of what it was at pH 7.
 - B) concentration of H^+ has increased to 10 times what it was at pH 7.
 - C) concentration of OH^- has increased to 10 times what it was at pH 7.
 - D) concentration of OH^- has decreased 10 times what it was at pH 7.
 - E) Both B and D are correct.

- 41) If the pH of a solution is increased from pH 8 to pH 9, it means that the
- A) concentration of H^+ to power of (+) is greater and the concentration of OH^- to power of (-) is less than at pH 8.
 - B) concentration of H^+ to power of (+) is 100 times less than what it was at pH 8.
 - C) concentration of H^+ to power of (+) is 10 times greater than what it was at pH 8.
 - D) concentration of OH^- to power of (-) is 10 times greater than what it was at pH 8.
 - E) concentration of OH^- to power of (-) is 100 times less than what it was at pH 8.

- 42) One liter of a solution with a pH of 3 has how many more H^+ than 1 L of a solution with a pH of 6?
- A) 100 times more
 - B) 1,000 times more
 - C) 300 times more
 - D) 10 times more
 - E) 3 times more

- 43) One liter of a solution with a pH of 11 has how many more OH^- than 1 L of a solution with a pH of 6?
- A) 10,000 times more
 - B) 10 times more
 - C) 5 times more
 - D) 100,000 times more
 - E) 50 times more

- 44) Which of the following statements is *true* about buffer solutions? They
- A) tend to maintain a relatively constant pH.
 - B) cause a lowering of pH when acids are added to them.
 - C) maintain a constant pH when bases are added to them but not when acids are added to them.
 - D) will always have a pH of 7.
 - E) are rarely found in living systems.

- 45) Buffers are substances that help resist shifts in pH by
- A) releasing OH^- to power of (-) in basic solutions.
 - B) combining with OH^- to power of (-) in acidic solutions.
 - C) releasing H^+ to power of (+) in basic solutions.
 - D) combining with H^+ to power of (+) in basic solutions.
 - E) releasing H^+ to power of (+) in acidic solutions.

- 46) One of the buffers that contribute to pH stability in human blood is carbonic acid (H_2CO_3). Carbonic acid is a weak acid that dissociates into a bicarbonate ion (HCO_3^-) and a hydrogen ion (H^+). Thus, $H_2CO_3 \rightleftharpoons HCO_3^- + H^+$. If the pH of the blood drops, one would expect
- A) the HCO_3^- to act as a base and remove excess H^+ with the formation of H_2CO_3 .
 - B) a decrease in the concentration of H_2CO_3 and an increase in the concentration of HCO_3^- .
 - C) the concentration of bicarbonate ion (HCO_3^-) to increase.
 - D) the H_2CO_3 to act as an acid and remove excess H^+ with the formation of HCO_3^- .
 - E) the concentration of hydroxide ion (OH^-) to increase.

- 47) One of the buffers that contribute to pH stability in human blood is carbonic acid (H_2CO_3). Carbonic acid is a weak acid that when placed in an aqueous solution dissociates into a bicarbonate ion (HCO_3^-) and a hydrogen ion (H^+). Thus, $H_2CO_3 \rightleftharpoons HCO_3^- + H^+$.

If the pH of the blood increases, one would expect:

- A) an increase in the concentration of H^+ and a decrease in the concentration of H_2CO_3 .
- B) a decrease in the concentration of H^+ and an increase in the concentration of H_2CO_3 .
- C) an increase in the concentration of H^+ and a decrease in the concentration of H_2O .
- D) a decrease in the concentration of H^+ and an increase in the concentration of H_2O .
- E) a decrease in the concentration of H^+ and an increase in the concentration of both H_2CO_3 and H_2O .

48) Recent research indicates that acid precipitation can damage life by

- A) buffering aquatic systems such as lakes and streams.
- B) decreasing the pH and increasing the concentration of lakes and streams.
- C) changing the solubility of soil minerals.
- D) altering the structures of biological molecules required for essential life processes.
- E) Both C and D are true.

The following question is based on Figure 3.1: solute molecules surrounded by a hydration shell of water.

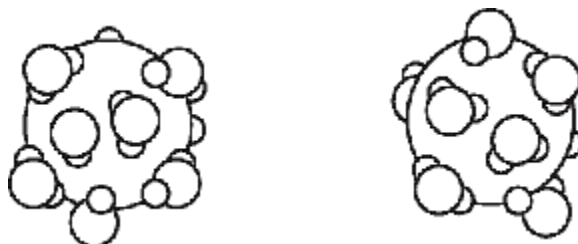


Figure 3.1

49) Based on your knowledge of the polarity of water, the solute molecule is most likely

- A) positively charged.
- B) neutral in charge.
- C) negatively charged.
- D) nonpolar.
- E) hydrophobic.

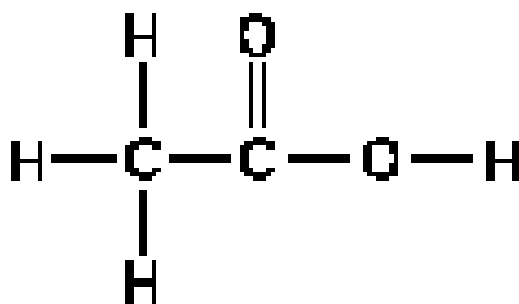


Figure 3.2

50) How many grams of the molecule in Figure 3.2 would be required to make 1 L of a 0.2 M solution of the molecule? (Carbon = 12, Oxygen = 16, Hydrogen = 1)

- A) 32 B) 8 C) 12 D) 24 E) 60

SHORT ANSWER. Write the word or phrase that best completes each statement or answers the question.

The following questions refer to the terms below.

- A. calorie
- B. temperature
- C. heat of vaporization
- D. buffer
- E. mole

- 51) A measure of the average kinetic energy of the molecules in a body of matter
- 52) The number of grams of a substance that equals its molecular mass in daltons
- 53) A weak acid or base that combines reversibly with hydrogen ions

- 1) Answer: B
- 2) Answer: C
- 3) Answer: A
- 4) Answer: B
- 5) Answer: A
- 6) Answer: B
- 7) Answer: D
- 8) Answer: E
- 9) Answer: D
- 10) Answer: B
- 11) Answer: E
- 12) Answer: A
- 13) Answer: E
- 14) Answer: A
- 15) Answer: D
- 16) Answer: E
- 17) Answer: B
- 18) Answer: C
- 19) Answer: A
- 20) Answer: D
- 21) Answer: C
- 22) Answer: A
- 23) Answer: C
- 24) Answer: A
- 25) Answer: E
- 26) Answer: A
- 27) Answer: A
- 28) Answer: E

- 29) Answer: E
- 30) Answer: E
- 31) Answer: D
- 32) Answer: D
- 33) Answer: E
- 34) Answer: E
- 35) Answer: A
- 36) Answer: A
- 37) Answer: E
- 38) Answer: B
- 39) Answer: B
- 40) Answer: E
- 41) Answer: D
- 42) Answer: B
- 43) Answer: D
- 44) Answer: A
- 45) Answer: C
- 46) Answer: A
- 47) Answer: D
- 48) Answer: E
- 49) Answer: C
- 50) Answer: C
- 51) Answer: B
- 52) Answer: E
- 53) Answer: D