



## Chapter 3

### 3.1 Multiple-Choice Questions

1) In a single molecule of water, two hydrogen atoms are bonded to a single oxygen atom by \_\_\_\_\_.

- A) hydrogen bonds
- B) nonpolar covalent bonds
- C) polar covalent bonds
- D) ionic bonds

Answer: C

Bloom's Taxonomy: Knowledge/Comprehension

Concept: 3.1

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 covalent bond
- B) a hydrogen bond
- C) an ionic bond
- D) a van der Waals interaction

Answer: B

Bloom's Taxonomy: Knowledge/Comprehension

Concept: 3.1

3) The partial negative charge in a molecule of water occurs because \_\_\_\_\_.

- A) the oxygen atom donates an electron to each of the hydrogen atoms
- B) the electrons shared between the oxygen and hydrogen atoms spend more time around the oxygen atom nucleus than around the hydrogen atom nucleus
- C) the oxygen atom has two pairs of electrons in its valence shell that are not neutralised by hydrogen atoms
- D) one of the hydrogen atoms donates an electron to the oxygen atom

Answer: B

Bloom's Taxonomy: Knowledge/Comprehension

Concept: 3.1

4) Sulphur is in the same column of the periodic table as oxygen, but has electronegativity similar to carbon. Compared to water molecules, molecules of H<sub>2</sub>S will \_\_\_\_\_.

- A) have greater cohesion to other molecules of H<sub>2</sub>S
- B) have a greater tendency to form hydrogen bonds with each other
- C) have a higher capacity to absorb heat for the same change in temperature
- D) not form hydrogen bonds with each other

Answer: D

Bloom's Taxonomy: Synthesis/Evaluation

Concept: 3.1

5) Water molecules can form hydrogen bonds with \_\_\_\_\_.

- A) compounds that have polar covalent bonds
- B) oils
- C) oxygen gas (O<sub>2</sub>) molecules
- D) chloride ions

Answer: A

Bloom's Taxonomy: Application/Analysis

Concept: 3.1

6) Cohesion, surface tension, and adhesion are the properties of water molecules that \_\_\_\_\_.

- A) increase when temperature increases
- B) increase when pH increases
- C) are a result of hydrogen bonding
- D) are a result of polar covalent bonding

Answer: C

Bloom's Taxonomy: Knowledge/Comprehension

Concept: 3.2

7) Liquid water \_\_\_\_\_.

- A) is less dense than ice
- B) has a specific heat lower than that of most other substances
- C) has a heat of vaporisation higher than that of most other substances
- D) is nonpolar

Answer: C

Bloom's Taxonomy: Knowledge/Comprehension

Concept: 3.2

8) Which of the following can be attributed to water's high specific heat?

- A) Oil and water do not mix well.
- B) A river heats up more slowly than the air around it.
- C) Ice floats on water.
- D) Sugar dissolves in hot tea faster than in iced tea.

Answer: B

Bloom's Taxonomy: Application/Analysis

Concept: 3.2

9) Geraldton, Morowa and Mount Magnet in Western Australia are at about the same latitude, but Mount Magnet has much hotter summers and much colder winters than Geraldton. Why?

- A) They are not at the same exact latitude.
- B) The ocean near Geraldton moderates the temperature.
- C) Fresh water is more likely to freeze than salt water.
- D) Mount Magnet is much windier, due to its location in Western Australia.

Answer: B

Bloom's Taxonomy: Application/Analysis

Concept: 3.2

10) To act as an effective coolant in a car's radiator, a substance has to have the capacity to absorb a great deal of heat. You have a reference book with tables listing the physical properties of many liquids. In choosing a coolant for your car, which table would you check first?

- A) pH
- B) density at room temperature
- C) heat of vaporisation
- D) specific heat

Answer: D

Bloom's Taxonomy: Application/Analysis

Concept: 3.2

11) Water has many exceptional and useful properties. Which is the rarest property among compounds?

- A) Water is a solvent.
- B) Solid water is less dense than liquid water.
- C) Water has a high heat capacity.
- D) Water has surface tension.

Answer: B

Bloom's Taxonomy: Knowledge/Comprehension

Concept: 3.2

12) Which of the following effects can occur because of the high surface tension of water?

- A) Rivers cannot freeze solid in winter, despite low temperatures.
- B) Spiders can walk across the surface of a small pond.
- C) Organisms can resist temperature changes, although they give off heat due to chemical reactions.
- D) Sweat can evaporate from the skin, helping to keep people from overheating.

Answer: B

Bloom's Taxonomy: Knowledge/Comprehension

Concept: 3.2

13) Thermal energy of the water in a bathtub is \_\_\_\_\_ than in freshly brewed coffee because of its \_\_\_\_\_.

- A) higher; greater volume

B) higher; high kinetic energy

C) lower; low temperature

D) lower; low density

Answer: A

Bloom's Taxonomy: Application/Analysis

Concept: 3.2

14) Low humidity in the atmosphere on a hot day \_\_\_\_\_.

A) helps in cooling because skin absorbs water from the atmosphere

B) does not help in cooling because water evaporates from the skin faster

C) helps in cooling because water evaporates from the skin faster

D) does not help in cooling because skin absorbs water from the atmosphere

Answer: C

Bloom's Taxonomy: Knowledge/Comprehension

Concept: 3.2

15) A dietary Calorie equals 1 kilocalorie. One kilocalorie equals \_\_\_\_\_.

A) 1000 calories, or the amount of heat required to raise the temperature of 1 g of water by 1°C

B) 10,000 calories, or the amount of heat required to raise the temperature of 1 kg of water by 1°F

C) 1000 calories, or the amount of heat required to raise the temperature of 1 kg of water by 1°C

D) 1000 calories, or the amount of heat required to raise the temperature of 100 g of water by 100°C

Answer: C

Bloom's Taxonomy: Knowledge/Comprehension

Concept: 3.2

16) Why does ice float in liquid water?

A) The high surface tension of liquid water keeps the ice on top.

B) The ionic bonds between the molecules in ice prevent the ice from sinking.

C) Stable hydrogen bonds keep water molecules of ice farther apart than water molecules of liquid water.

D) The crystalline lattice of ice causes it to be denser than liquid water.

Answer: C

Bloom's Taxonomy: Knowledge/Comprehension

Concept: 3.2

17) Hydrophobic substances such as vegetable oil are \_\_\_\_\_.

A) nonpolar substances that repel water molecules

B) nonpolar substances that have an attraction for water molecules

C) polar substances that repel water molecules

D) polar substances that have an affinity for water

Answer: A

Bloom's Taxonomy: Knowledge/Comprehension

Concept: 3.2

18) Why is a steam burn more severe than a hot water burn?

- A) Burns caused by liquids are always milder.
- B) Steam can penetrate into the skin.
- C) Steam contains more energy than water.
- D) Water evaporates and leaves the surface faster and helps in cooling.

Answer: C

Bloom's Taxonomy: Application/Analysis

Concept: 3.2

19) Melting of ice and thus reduced feeding opportunities for polar bears is occurring because of the \_\_\_\_\_.

- A) increase in phytoplankton population
- B) drying up of rivers and streams
- C) constant breaking and reforming of hydrogen bonds in water
- D) increase in CO<sub>2</sub> and other greenhouse gases in the atmosphere

Answer: D

Bloom's Taxonomy: Knowledge/Comprehension

Concept: 3.2

20) One mole (mol) of glucose (molecular mass = 180 daltons) is \_\_\_\_\_.

- A)  $180 \times 10^{23}$  molecules of glucose
- B) 1 kilogram of glucose dissolved in 1 litre of solution
- C) 180 mL of dissolved glucose
- D) 180 grams of glucose

Answer: D

Bloom's Taxonomy: Application/Analysis

Concept: 3.2

21) When an ionic compound such as sodium chloride (NaCl) is placed in water, the component atoms of the NaCl crystal dissociate into individual sodium ions (Na<sup>+</sup>) and chloride ions (Cl<sup>-</sup>). In contrast, the atoms of covalently bonded molecules (e.g. 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 solute particles (molecules or ions)?

- A) 1 litre of 0.5 M NaCl
- B) 1 litre of 1.0 M NaCl
- C) 1 litre of 1.0 M glucose
- D) 1 litre of 1.0 M NaCl and 1 litre of 1.0 M glucose will contain equal numbers of solute particles.

Answer: B

Bloom's Taxonomy: Application/Analysis

Concept: 3.2

22) The molar mass of glucose is 180 grams per mole (g/mol). Which of the following procedures should you carry out to make a 1 M solution of glucose? In 0.8 litre (L) of water, dissolve \_\_\_\_\_.

- A) 1 g of glucose, and then add more water until the total volume of the solution is 1 L
- B) 18 g of glucose, and then add more water until the total volume of the solution is 1 L
- C) 180 g of glucose, and then add 0.2 L more of water
- D) 180 g of glucose, and then add more water until the total volume of the solution is 1 L

Answer: D

Bloom's Taxonomy: Application/Analysis

Concept: 3.2

23) You have a freshly prepared 0.1 *M* sucrose (molecular mass 342) solution, which means \_\_\_\_\_.

- A)  $6.02 \times 10^{23}$  of sucrose molecules are present in the solution
- B)  $6.02 \times 10^{22}$  of sucrose molecules are present in the solution
- C) 34.2 g of sucrose is present in the solution
- D)  $6.02 \times 10^{22}$  of sucrose molecules or 34.2 g of sucrose is present in the solution

Answer: D

Bloom's Taxonomy: Application/Analysis

Concept: 3.2

24) How does 0.5 *M* sucrose (molecular mass 342) solution compare to 0.5 *M* glucose (molecular mass 180) solution?

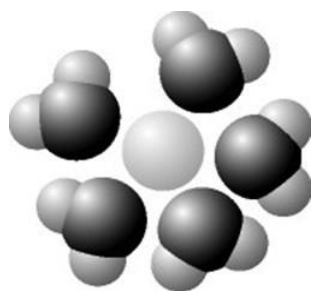
- A) Both have  $6.02 \times 10^{23}$  molecules.
- B) Sucrose has 171 molecules, whereas glucose has 90.
- C) Both have  $3.01 \times 10^{23}$  molecules.
- D) Sucrose has 171 mg/L, whereas glucose has 90 mg/L.

Answer: C

Bloom's Taxonomy: Application/Analysis

Concept: 3.2

25) Use the following figure to answer the question.



Based on your knowledge of the polarity of water molecules, the solute molecule depicted is most likely \_\_\_\_\_.

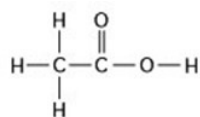
- A) positively charged
- B) negatively charged
- C) without charge
- D) nonpolar

Answer: A

Bloom's Taxonomy: Application/Analysis

Concept: 3.2

26) Use the following figure to answer the question.



Two moles of the compound in the figure would weigh how many grams? (Note: The atomic masses, in daltons, are approximately 12 for carbon, 1 for hydrogen and 16 for oxygen.)

A) 30

B) 60

C) 90

D) 120

Answer: D

Bloom's Taxonomy: Application/Analysis

Concept: 3.2

27) How many grams of the compound in the figure are required to make 1 litre of a 0.5 *M* solution? (Note: The atomic masses, in daltons, are approximately 12 for carbon, 1 for hydrogen and 16 for oxygen.)

A) 30

B) 60

C) 90

D) 120

Answer: A

Bloom's Taxonomy: Application/Analysis

Concept: 3.2

28) How much of 0.5 *M* glucose (molecular mass 180) is needed to provide 100 mg of glucose?

A) 1.11 mL

B) 0.11 mL

C) 100 mL

D) 10 mL

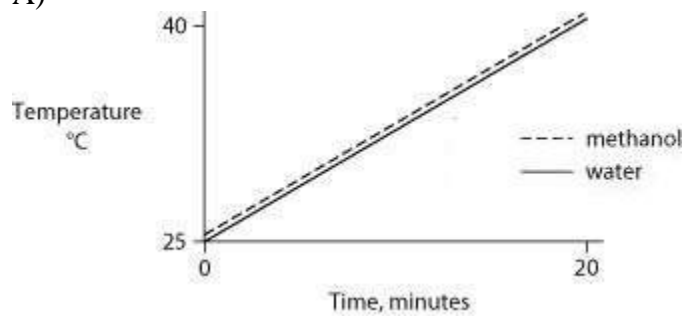
Answer: A

Bloom's Taxonomy: Application/Analysis

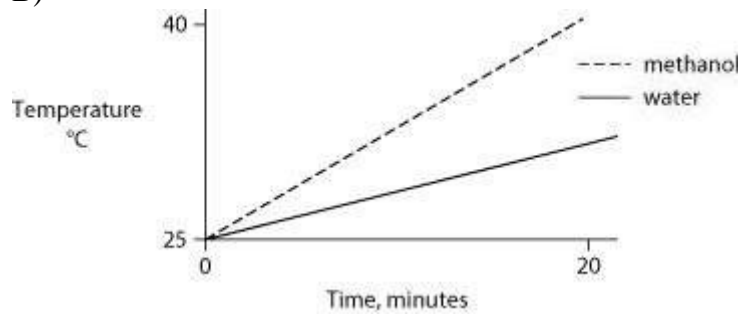
Concept: 3.2

29) Identical heat lamps are arranged to shine on two identical containers, one containing water and one methanol (wood alcohol), so that each liquid absorbs the same amount of energy minute by minute. The covalent bonds of methanol molecules are nonpolar, so there are no hydrogen bonds among methanol molecules. Which of the following graphs correctly describes what will happen to the temperature of the water and the methanol?

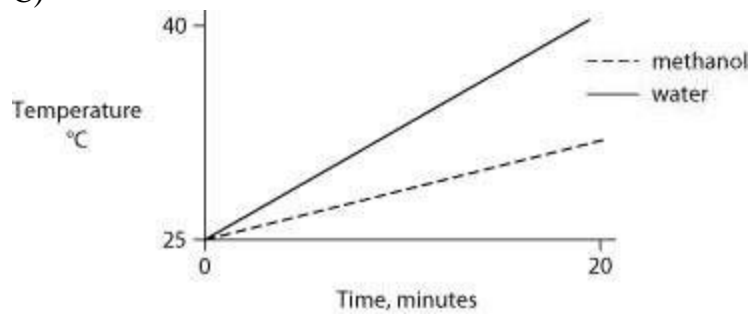
A)



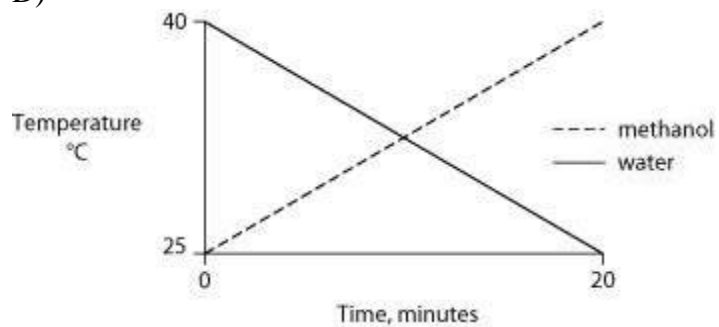
B)



C)



D)



Answer: B

Bloom's Taxonomy: Synthesis/Evaluation

Concept: 3.2



30) Rank, from low to high, the pH of blood, stomach acid, and urine.

- A) blood, urine, and stomach acid
- B) stomach acid, blood, and urine
- C) urine, blood, stomach acid
- D) stomach acid, urine, blood

Answer: D

Bloom's Taxonomy: Knowledge/Comprehension

Concept: 3.3

31) A solution with a pH of 2 has how many more protons in it than a solution with a pH of 4?

- A) 5 times more
- B) 10 times more
- C) 100 times more
- D) 1000 times more

Answer: C

Bloom's Taxonomy: Application/Analysis

Concept: 3.3

32) Consider the following reaction at equilibrium:  $\text{CO}_2 + \text{H}_2\text{O} \rightleftharpoons \text{H}_2\text{CO}_3$ . What would be the effect of adding additional  $\text{H}_2\text{O}$ ?

- A) It would drive the equilibrium dynamics to the right.
- B) It would drive the equilibrium dynamics to the left.
- C) Nothing would happen because the reactants and products are in equilibrium.
- D) Reactions in both the directions will slow down.

Answer: A

Bloom's Taxonomy: Application/Analysis

Concept: 3.3

33) Which of the following is considered to be a strong base (alkali)?

- A)  $\text{HCl} \rightarrow \text{H}^+ + \text{Cl}^-$
- B)  $\text{NH}_3 + \text{H}^+ \rightleftharpoons \text{NH}_4^+$
- C)  $\text{H}_2\text{CO}_3 \rightleftharpoons \text{HCO}_3^- + \text{H}^+$
- D)  $\text{NaOH} \rightarrow \text{Na}^+ + \text{OH}^-$

Answer: D

Bloom's Taxonomy: Knowledge/Comprehension

Concept: 3.3

34) A 0.01 M solution of a substance has a pH of 2. What can you conclude about this substance?

- A) It is a strong acid that dissociates completely in water.
- B) It is a strong base that dissociates completely in water.
- C) It is a weak acid.
- D) It is a weak base.

Answer: A

Bloom's Taxonomy: Application/Analysis

Concept: 3.3

35) A solution contains 0.0000001 ( $10^{-7}$ ) moles of hydrogen ions  $[H^+]$  per litre. Which of the following best describes this solution?

A) acidic:  $H^+$  acceptor

B) basic:  $H^+$  acceptor

C) acidic:  $H^+$  donor

D) neutral

Answer: D

Bloom's Taxonomy: Knowledge/Comprehension

Concept: 3.3

36) What is the pH of a solution with a hydroxyl ion ( $OH^-$ ) concentration of  $10^{-10} M$ ?

A) pH 2

B) pH 4

C) pH 10

D) pH 12

Answer: B

Bloom's Taxonomy: Application/Analysis

Concept: 3.3

37) What is the hydroxyl ion ( $OH^-$ ) concentration of a solution of pH 8?

A) 8  $M$

B)  $8 \times 10^{-6} M$

C)  $10^{-8} M$

D)  $10^{-6} M$

Answer: D

Bloom's Taxonomy: Application/Analysis

Concept: 3.3

38) Which of the following statements is true about buffer solutions?

A) They maintain a constant pH of 7.

B) They maintain a constant pH when acids are added to them but not when bases are added to them.

C) They fluctuate in pH when either acids or bases are added to them.

D) They maintain a relatively constant pH when either acids or bases are added to them.

Answer: D

Bloom's Taxonomy: Knowledge/Comprehension

Concept: 3.3

39) 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 ( $\text{HCO}_3^-$ ) and a hydrogen ion ( $\text{H}^+$ ). (See figure.)



If the pH of blood drops, one would expect \_\_\_\_\_.

- A) a decrease in the concentration of  $\text{H}_2\text{CO}_3$  and an increase in the concentration of  $\text{HCO}_3^-$
- B) the concentration of bicarbonate ions ( $\text{HCO}_3^-$ ) to increase
- C) the  $\text{HCO}_3^-$  to act as a base and remove excess  $\text{H}^+$  by the formation of  $\text{H}_2\text{CO}_3$
- D) the  $\text{HCO}_3^-$  to act as an acid and remove excess  $\text{H}^+$  by the formation of  $\text{H}_2\text{CO}_3$

Answer: C

Bloom's Taxonomy: Knowledge/Comprehension

Concept: 3.3

40) Carbon dioxide in the atmosphere dissolves with the raindrops. The pH of raindrops is \_\_\_\_\_.

- A) slightly acidic
- B) slightly basic
- C) the same as pure water
- D) depends on the altitude where rain drops are formed

Answer: A

Bloom's Taxonomy: Application/Analysis

Concepts: 3.1 and 3.3

41) Assume that acid rain has lowered the pH of a particular river to pH 5.0. What is the hydroxide ion concentration of this river?

- A)  $1 \times 10^{-9}$  mol of hydroxide ions per litre of river water
- B)  $1 \times 10^{-5}$  mol of hydroxide ions per litre of river water
- C) 5.0 M hydroxide ion
- D)  $5.0 \times 10^{-5}$  mol of hydroxide ions per litre of river water

Answer: A

Bloom's Taxonomy: Application/Analysis

Concept: 3.3

42) Consider two solutions: solution X has a pH of 4; solution Y has a pH of 7. From this information, we can reasonably conclude that \_\_\_\_\_.

- A) solution Y has no free hydrogen ions ( $\text{H}^+$ )
- B) the concentration of hydrogen ions in solution Y is 1000 times as great as the concentration of hydrogen ions in solution X
- C) the concentration of hydrogen ions in solution X is 3 times as great as the concentration of hydrogen ions in solution Y
- D) the concentration of hydrogen ions in solution X is 1000 times as great as the concentration of hydrogen ions in solution Y

Answer: D

Bloom's Taxonomy: Application/Analysis

Concept: 3.3

43) As the  $[\text{H}_3\text{O}^+]$  of the solution decreases, the  $[\text{OH}^-]$  \_\_\_\_\_.

- A) increases and thus pH increases
- B) increases and thus pH decreases
- C) decreases and thus the pH decreases
- D) decreases and thus the pH increases

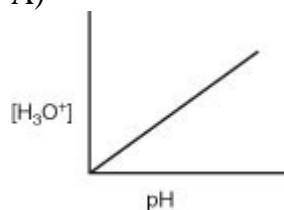
Answer: A

Bloom's Taxonomy: Application/Analysis

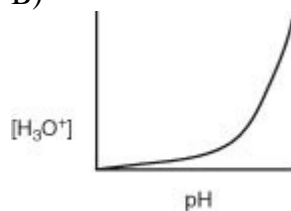
Concept: 3.3

44) Which of the following graphs describes the relationship between  $[\text{H}_3\text{O}^+]$  and pH?

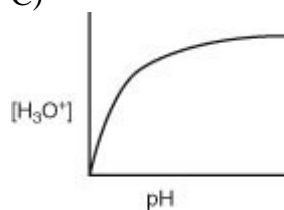
A)



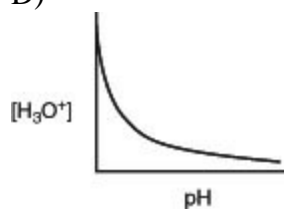
B)



C)



D)



Answer: D

Bloom's Taxonomy: Application/Analysis

Concept: 3.3

45) A beaker contains 100 millilitres (mL) of NaOH solution at pH = 13. A technician carefully pours into the beaker 10 mL of HCl at pH = 1. Which of the following statements correctly describes the result of this mixing?

- A) The concentration of Na<sup>+</sup> ions will rise.
- B) The pH of the beaker's contents will increase.
- C) The pH of the beaker's contents will be neutral.
- D) The pH of the beaker's contents will decrease.

Answer: D

Bloom's Taxonomy: Application/Analysis

Concept: 3.3

46) Increased atmospheric CO<sub>2</sub> concentrations might have what effect on seawater?

- A) Seawater will become more alkaline, and carbonate concentrations will decrease.
- B) There will be no change in the pH of seawater, because carbonate will turn to bicarbonate.
- C) Seawater will become more acidic, and carbonate concentrations will decrease.
- D) Seawater will become more acidic, and carbonate concentrations will increase.

Answer: C

Bloom's Taxonomy: Knowledge/Comprehension

Concept: 3.3

47) How would acidification of seawater affect marine organisms? Acidification of seawater would \_\_\_\_\_.

- A) increase dissolved carbonate concentrations and promote faster growth of corals and shell-building animals
- B) decrease dissolved carbonate concentrations and promote faster growth of corals and shell-building animals
- C) increase dissolved carbonate concentrations and hinder growth of corals and shell-building animals
- D) decrease dissolved carbonate concentrations and hinder growth of corals and shell-building animals

Answer: D

Bloom's Taxonomy: Knowledge/Comprehension

Concept: 3.3

48) If the cytoplasm of a cell is at pH 7, and the mitochondrial matrix is at pH 8, then the concentration of H<sup>+</sup> ions \_\_\_\_\_.

- A) is 10 times higher in the cytoplasm than in the mitochondrial matrix
- B) is 10 times higher in the mitochondrial matrix than in the cytoplasm
- C) in the cytoplasm is 7/8 the concentration in the mitochondrial matrix
- D) in the cytoplasm is 8/7 the concentration in the mitochondrial matrix

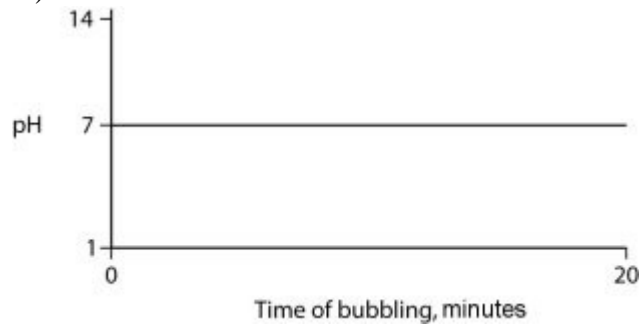
Answer: A

Bloom's Taxonomy: Application/Analysis

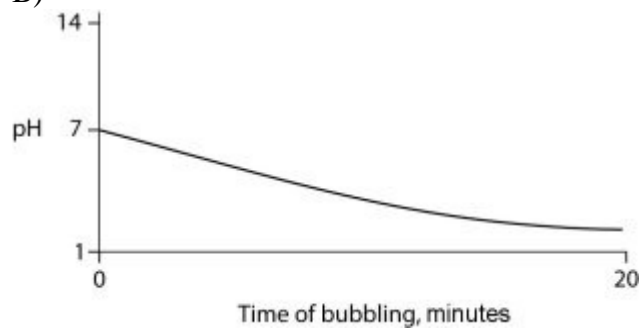
Concept: 3.3

49) Carbon dioxide ( $\text{CO}_2$ ) is readily soluble in water, according to the equation  $\text{CO}_2 + \text{H}_2\text{O} \leftrightarrow \text{H}_2\text{CO}_3$ . Carbonic acid ( $\text{H}_2\text{CO}_3$ ) is a weak acid. If  $\text{CO}_2$  is bubbled into a beaker containing pure, freshly distilled water, which of the following graphs correctly describes the results?

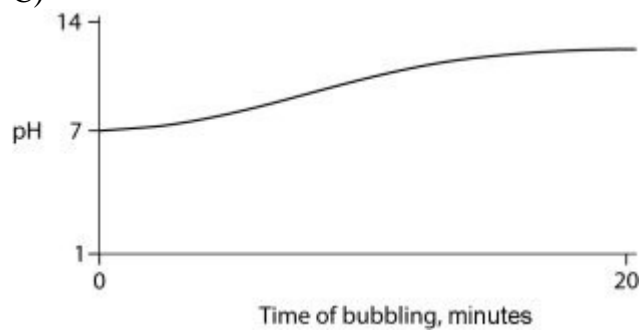
A)



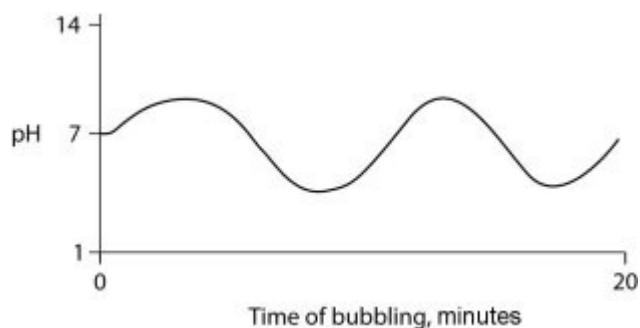
B)



C)



D)



Answer: B

Bloom's Taxonomy: Synthesis/Evaluation

Concept: 3.3

50) The loss of water from a plant by transpiration cools the leaf. Movement of water in transpiration requires both adhesion to the conducting walls and wood fibres of the plant and cohesion of the molecules to each other. A scientist wanted to increase the rate of transpiration of a crop species to extend its range into warmer climates. The scientist substituted a nonpolar solution with an atomic mass similar to that of water for hydrating the plants. What do you expect the scientist's data will indicate from this experiment?

A) The rate of transpiration will be the same for both water and the nonpolar substance.

B) The rate of transpiration will be slightly lower with the nonpolar substance as the plant will not have evolved with the nonpolar compound.

C) Transpiration rates will fall to zero as nonpolar compounds do not have the properties necessary for adhesion and cohesion.

D) Transpiration rates will increase as nonpolar compounds undergo adhesion and cohesion with wood fibres more readily than water.

Answer: C

Bloom's Taxonomy: Synthesis/Evaluation

Concept: 3.2

### 3.2 Student Edition End-of-Chapter Questions

1) Which of the following is a hydrophobic material?

A) paper

B) table salt

C) wax

D) sugar

Answer: C

Bloom's Taxonomy: Knowledge/Comprehension

2) We can be sure that a mole of table sugar and a mole of vitamin C are equal in their

A) mass.

B) volume.

C) number of atoms.

D) number of molecules.

Answer: D

Bloom's Taxonomy: Knowledge/Comprehension

3) Measurements show that the pH of a particular lake is 4.0. What is the hydrogen ion concentration of the lake?

- A) 4.0 M
- B)  $10^{-10}$  M
- C)  $10^{-4}$  M
- D)  $10^4$  M

Answer: C

Bloom's Taxonomy: Knowledge/Comprehension

4) Measurements show that the pH of a particular lake is 4.0. What is the hydroxide ion concentration of the lake?

- A)  $10^{-10}$  M
- B)  $10^{-4}$  M
- C)  $10^{-7}$  M
- D) 10.0 M

Answer: A

Bloom's Taxonomy: Knowledge/Comprehension

5) A slice of pizza has 500 kcal. If we could burn the pizza and use all the heat to warm a 50-L container of cold water, what would be the approximate increase in the temperature of the water? (Note: A litre of cold water weighs about 1 kg.)

- A) 50°C
- B) 5°C
- C) 100°C
- D) 10°C

Answer: D

Bloom's Taxonomy: Application/Analysis